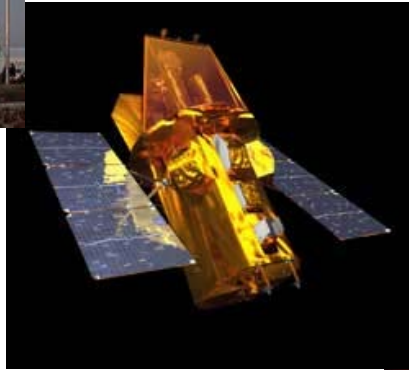




PennState

Department of Astronomy and Astrophysics



Graduate Student Handbook

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Table of Contents

1. Introduction.....	4
1.1 Guiding Principles	5
1.2 Goals	7
1.3 Overview of Graduate Student Opportunities in the Department.....	8
2. General Student Information	8
2.1 Contacting the Department of Astronomy & Astrophysics.....	8
2.2 Who's Who.....	9
2.3 Committees and Advisors	10
2.4 Health Services and Insurance	12
3. Procedures for the Entering Student	12
3.1 Housing.....	13
3.2 Keys, ID Cards, Computer Accounts, and Forms.....	13
3.3 Course Registration	14
4. International Students	14
4.1 English Language Competency.....	14
4.2 Guidelines on F-1 Visas	15
5. Degree Requirements.....	16
5.1 PhD Requirements.....	17
5.2 English Proficiency	17
5.3 Policies Concerning Graduate Courses	18
5.4 Three-Credit Course Offerings.....	19
5.5 One-Credit Course Offerings.....	19
5.6 Candidacy Examination	20
5.7 Comprehensive Examination	21
5.8 Residency Requirements and Continuous Registration	23
5.9 PhD Thesis and Final Oral Examination	23
5.10 Master's Degree Requirements.....	24
5.11 Dual-Title Degree in Astrobiology	24
5.12 Graduate Minor in Computational Science	25
6. Your Path Through Graduate School.....	25
6.1 Summer Prior to the First Year	25
6.2 Fall of the First Year	25
6.3 Spring of the First Year	27
6.4 Summer of the First Year.....	28
6.5 The Second Year.....	28
6.6 The Third Year.....	29
6.7 Subsequent Years	30
6.8 Progress Reports and Oversight.....	31
7. Course Descriptions.....	32
7.1 Astronomy Graduate Courses	32
7.2 Courses in Physics and Allied Fields	38
7.3 Courses in Teaching and Pedagogy	40
8. Policies for Academic Classes.....	40
8.1 Course Registration	41
8.2 Assessment and Examinations	41
8.3 Grading	41
8.4 Evaluations of Teaching Effectiveness.....	42

8.5 Academic Integrity.....	42
9. Guidelines for Teaching Assistants	43
9.1 General Guidelines for All TAs	43
9.1.1 General Duties of a TA	44
9.1.2 Materials Needed by a Teaching Assistant	45
9.2 Specific Guidelines for Laboratory TAs.....	45
9.2.1 Laboratory Duties	45
9.2.2 Rules for the Labs	46
9.3 Relationships Between TAs and Students	47
9.4 Evaluations of Teaching Effectiveness.....	48
9.5 Instructional Development Program	48
10. Assistantships and Support.....	48
10.1 TAs and RAs.....	49
10.2 Awards and Fellowships.....	49
10.2.1 Penn State Fellowships and Awards.....	49
10.2.2 Fellowships from External Agencies	50
11. Research Facilities and Resources	51
11.1 Library Facilities	51
11.2 Computing Facilities	52
11.3 Observing Facilities.....	53
11.3.1 The Hobby-Eberly Telescope	53
11.3.2 Davey Roof Telescopes	53
11.3.3 Chandra X-ray Observatory.....	53
11.3.4 Swift Gamma Ray Burst Explorer	53
11.4 Interdisciplinary Research Centers.....	54
11.4.1 Institute for Gravitation and the Cosmos	54
11.4.2 Astrobiology Research Center	54
11.4.3 Center for Astrostatistics	54
12. Other Topics	54
12.1 Colloquia, Seminars, and Other Gatherings	55
12.2 Printing and Photocopying.....	56
12.3 Telephones	57
12.4 Graduate Research Exhibition	57
12.5 American Astronomical Society	57
Appendix A University Information and Regulations for Graduate Students	58
Appendix B Academic Integrity Policy.....	60
1 Introduction	60
2 Faculty Conduct.....	60
3 Student Conduct.....	61
4 Infractions.....	61
Appendix C Department Forms and Checklists.....	66
Petition for Astronomy & Astrophysics Graduate Degree Requirements.....	70
Assessment of English Competency: Oral.....	1 -
Assessment of English Competency: Written	2 -
Ph.D. Course Requirements Checklist.....	3 -

Graduate Handbook

Department of Astronomy & Astrophysics

The Pennsylvania State University

1. Introduction

This handbook is for the use of current and future graduate students in the Department of Astronomy & Astrophysics of the Pennsylvania State University (Penn State), University Park campus. Although designed as a reference, graduate students are encouraged to familiarize themselves with the contents of the entire handbook. The handbook outlines the department and university's expectations of a graduate student, the students' rights and responsibilities, and explains the procedures to be followed in various situations. Sections 2, 3, and 4 provide general information and procedures. Section 5 and 6 describe the graduate degree requirements and typical path through the program. Section 7 presents the graduate courses, and sections 8-12 provide a variety of additional information.

This handbook is also for the use of the faculty who have responsibility for guiding and advising students, and of the fair and consistent administering of the graduate program. It is the definitive statement of Astronomy & Astrophysics Department rules and procedures. Together with the University's [Graduate Degree Programs Bulletin](#) and other policies of the [Graduate School](#), this handbook gives official policy regarding the graduate student experience in the Department. Many rules have occasional exceptions, as student backgrounds and goals differ. Students should not be discouraged from seeking flexibility in their graduate program; they should first consult their advisor and then the Associate Department Head for the Graduate Program. Any individual or policy matters may be discussed with the Associate Head, Prof. Michael Eracleous (414 Davey, 3-6041, mxe17@psu.edu).

The department strongly values student feedback on possible improvements to the graduate program. Students are encouraged to communicate openly with their peers and with the Associate Department Head for the Graduate Program on issues relating to astronomy as well as those of common concern to the graduate program. Such issues may include TA workloads, graduate student benefits, computing and office facilities, departmental degree requirements, advanced course offerings, or future job opportunities. Announcements of interest to graduate students are routinely sent out through the department listserve (l-astro-grads@lists.psu.edu).

1.1 Guiding Principles

The Department of Astronomy & Astrophysics adheres to the following “Guiding Principles for Good Practice in Graduate Education” as adopted from a statement of principles endorsed by the Graduate Council on May 8, 1996:

Working relationships between faculty, staff, and students are an important component of graduate education at Penn State. The quality of these relationships can make or break the graduate school experience. Thus, the Eberly College of Science has summarized its recommendations for building a good relation between students and their advisors into a set of guidelines that can be found [at this link](#). These guidelines can also be found in Appendix C of this handbook.

The development of a positive learning environment depends on a shared vision of educational values, objectives, and expectations. It is the joint responsibility of faculty, staff, and students to work together to nurture this vision, encourage freedom of inquiry, demonstrate personal and professional integrity, and insure a climate of mutual respect. The following six principles are essential elements in a productive environment for graduate education at Penn State.

Understanding the work environment. Faculty, staff, and students must each take the initiative to learn the policies, rules, regulations, and practices that affect them, their work, and the units in which they work. Graduate program handbooks, pertinent University publications, funding agency references, and other resources can typically be obtained from graduate program officers, the Internet, registered student organizations, department faculty, other students, faculty advisors, and thesis committee chairs.

Academic honesty, professional integrity, and confidentiality. These qualities are the responsibility of all faculty, staff, and students. Each member of the graduate community must endeavor to adhere to the highest level of these ideals in all their personal and professional activities.

A clear course of study. The student and his/her faculty advisor should develop and agree upon a clear plan of academic study and the responsibilities associated with it. Careful planning and discussion throughout a graduate program are the best way to avoid later misunderstandings and problems.

An atmosphere of openness. Students and faculty must work to establish and maintain an environment that is open, sensitive, and encourages free discussion between members of the graduate community. Clear, two-way communication is a critical ingredient in a successful graduate experience.

Acknowledgment of intellectual rights and property. Students and faculty should discuss issues associated with academic freedom, intellectual property, authorship, and publication as part of the student's academic plan. Resolution of these issues early in the graduate program is often the best way to avoid later disputes.

Opportunities for evaluation. Evaluation, reflection, and feedback are integral parts of the academic process. These items should be a regular part of every graduate program.

Early, frequent, and constructive feedback helps to prevent small differences from becoming serious problems.

While the above guiding principles are not exhaustive, they do reflect a spirit that can make the graduate education process at Penn State a rewarding, stimulating, and productive experience.

The Eberly College of Science is committed to the academic success of students enrolled in the College's courses and undergraduate programs. When in need of help, students can utilize various College and University wide resources for learning assistance. <https://science.psu.edu/current-students/support-network/learning-support>

The Eberly College of Science Code of Mutual Respect and Cooperation" science.psu.edu/climate/code-of-mutual-respect-and-cooperation embodies the values that we hope our faculty, staff, and students possess and will endorse to make The Eberly College of Science a place where every individual feels respected and valued, as well as challenged and rewarded.

The Family Educational Rights and Privacy Act

[The Family Educational Rights and Privacy Act](#) (FERPA) (20 U.S.C. § 1232g; 34 CFR Part 99) is a Federal law that protects the privacy of student education records. Parents or eligible students have the right to inspect and review the student's education records maintained by the school. Schools are not required to provide copies of records unless, for reasons such as great distance, it is impossible for parents or eligible students to review the records. Schools may charge a fee for copies.

Parents or eligible students have the right to request that a school correct records which they believe to be inaccurate or misleading. If the school decides not to amend the record, the parent or eligible student then has the right to a formal hearing. After the hearing, if the school still decides not to amend the record, the parent or eligible student has the right to place a statement with the record setting forth his or her view about the contested information.

Generally, schools must have written permission from the parent or eligible student in order to release any information from a student's education record. However, FERPA allows schools to disclose those records, without consent, to the following parties or under the following conditions (34 CFR § 99.31):

School officials with legitimate educational interest;

Other schools to which a student is transferring;

Specified officials for audit or evaluation purposes;

Appropriate parties in connection with financial aid to a student;

Organizations conducting certain studies for or on behalf of the school;

Accrediting organizations;

To comply with a judicial order or lawfully issued subpoena;

Appropriate officials in cases of health and safety emergencies; and

State and local authorities, within a juvenile justice system, pursuant to specific State law.

Schools may disclose, without consent, "directory" information such as a student's name, address, telephone number, date and place of birth, honors and awards, and dates of attendance. However, schools must tell parents and eligible students about directory information and allow parents and eligible students a reasonable amount of time to request that the school not disclose directory information about them.

1.2 Goals

The principal goals of the Penn State's Department of Astronomy & Astrophysics are to

effectively and conscientiously educate students at all levels;

perform creative, high quality research at the frontiers of astronomy and astrophysics;

provide resources to the community, government, university, and industry in areas relevant to astronomy and astrophysics.

Specific goals of the graduate students in the Department of Astronomy & Astrophysics include: learning astronomy and astrophysics, developing research and technical skills, learning the techniques of good teaching, and becoming prepared for future employment. The vast majority of graduate students are here because they aspire to careers involving astronomy and astrophysics. Therefore, it is important to understand various facts concerning employment in such careers. In the U.S., only about 50% of PhDs in astronomy end up in a college/university position; the rest go onto careers in government labs or support positions at observatories or industry. A much higher proportion start out in temporary postdoctoral positions. Frequently, the ultimate career does not directly involve the specific research area of the PhD, but does use the skills acquired during the graduate education. [Recent graduate employment](#) includes prestigious fellowships, postdoctoral scientists, and tenure-track faculty positions at colleges. Currently, open positions are advertised in the [AAS Job Register](#).

What are the skills sought by universities and other employers? There is an emphasis, of course, on scientific ability and technical skills such as advanced computing. Very important also is the ability to communicate clearly. It is important for students in the job market to possess these capabilities. Students in the department develop oral communication skills through Tuesday lunch talks, teaching, outreach presentations, and by discussing science with colleagues. The students' writing skills are honed by writing critically assessed reports and papers. It should be noted that employers regard publications favorably. However, the specific number of papers tends not to be a critical

variable. More important are the quality of the work and the assessments in reference letters of the individual's research skills and contributions.

1.3 Overview of Graduate Student Opportunities in the Department

The following summary appears in the [Graduate Degree Programs Bulletin](#):

The graduate program in Astronomy & Astrophysics prepares students for careers in astronomy, space science, and education. Graduate instruction and research opportunities are available in theoretical, observational, and instrumental astronomy and astrophysics. Currently, active areas of theoretical research include high-energy astrophysics (including theory of neutron stars, black holes, and gamma ray bursts), relativity and cosmology, stellar dynamics and planet formation, and computational methodology. Observational areas include spectroscopic and photometric observations of high-redshift quasars, galaxies and the intergalactic medium; gamma-ray bursts; X-ray and visible light studies of quasars, starbursts, and other active galaxies; visible light studies of nearby galaxies and their stellar populations; infrared study of brown dwarfs and protoplanetary disks; spectroscopy and modeling of binary, magnetically active, pre- and post-main sequence stars; and spectroscopic searches for planetary systems. Instrumental areas include the development of X-ray telescopes and detectors, and high-precision visible light spectrographs. Department faculty members participate in several university cross-disciplinary organizations, including: the [Penn State Astrobiology Research Center \(PSARC\)](#), Center for Astrostatistics, and Institute for Gravitation and the Cosmos (IGC) and its associated Center.

The Department played a seminal role in and leads many science investigations using two NASA-launched satellites – the Chandra X-ray Observatory and the Swift panchromatic gamma-ray burst mission – and the innovative 9-meter Hobby-Eberly Telescope located at the McDonald Observatory in Texas. Faculty and students also observe with other space-based observatories (GALEX, Hubble Space Telescope, Spitzer Space Telescope, XMM-Newton) and ground-based telescopes (Gemini and other national facilities, Magellan, Keck, South Africa Large Telescope, Very Large Telescopes). Physics faculty members closely associated with the Department are involved in particle and gravitational wave observations using the Auger, AMANDA, Ice Cube, and LIGO instruments. The Department has extensive computing facilities, and research is also conducted with university and national supercomputing resources.

Graduate students also have ample opportunity to acquire experience in undergraduate teaching and public outreach.

2. General Student Information

General information about the Graduate School at Penn State is available through the [Graduate Degree Programs Bulletin](#) and the [Graduate School Web site](#). The University's [Academic Calendar](#), [LionPATH Class Search](#), [Graduate Student Policies](#), and other Web sites outlined in Appendix A, are particularly useful.

2.1 Contacting the Department of Astronomy & Astrophysics

Mailing Address:

Kaylee Harter, Graduate Staff Assistant or
Prof. Michael Eracleous, Associate Department Head for the Graduate Program
Department of Astronomy & Astrophysics
525 Davey Laboratory
Penn State University
University Park, PA 16802 U.S.A.

Phone: +1 (814) 865-0419

FAX: +1 (814) 863-3399

FAX (confidential): +1 (814) 863-2842

E-mail: kah281@psu.edu or mxe17@psu.edu

World-Wide-Web: <http://astro.psu.edu>

Directions: Penn State University ([University Park campus](#)) is located adjacent to the town of State College, Pennsylvania. The local airport is the [State College/University Park Airport](#) (airport code SCE), and daily connections exist to the international airports in Philadelphia via [American](#), Washington, D.C. (Dulles) and Chicago (O'Hare) via [United Express](#), and Detroit via [Delta](#). The closest [Amtrak](#) rail stops are in the Pennsylvania towns of Lewistown and Altoona, but train service is poor. State College has [Greyhound bus](#) and [Megabus](#) connections to New York, Pittsburgh, Philadelphia, and Washington, D.C. The postal address for the campus is University Park, PA, however, your local home address is likely to be in the adjacent town of State College, PA.

2.2 Who's Who

Most relevant faculty officers and staff members:

Department Head: Dr. Donald Schneider (dps7@psu.edu)

Associate Head of the Graduate Program: Prof. Michael Eracleous (414 Davey, 3-6041, mxe17@psu.edu). The Head of the Graduate Program has overall responsibility for the Graduate Program in Astronomy & Astrophysics. Questions that are not answered in this handbook, and cannot be answered by the Graduate Staff Assistant, should be directed to him. The Head of the Graduate Program is always open to suggestions and concerns you may have about any aspect of the graduate program. He can be found in 414 Davey or by phone at (814) 863-6041.

Chair of Graduate Admissions Committee: Prof. Kevin Luhman (kll207@psu.edu). The Chair of Graduate Admissions has overall responsibility for admitting and recruiting graduate students.

Graduate Staff Assistant: Kaylee Harter (525 Davey, 5-0419, kah281@psu.edu). The Graduate Staff Assistant can be found in the main office of the Department of Astronomy & Astrophysics, located in 525 Davey Lab. Kaylee Harter administers the graduate program; questions regarding admissions, requirements, etc., should be directed to her

Teaching Assistant Supervisor: Dr. Chris Palma (cpalma@psu.edu)

Chair of the Department Computer Committee: Prof. John Nousek (nousek@swift.psu.edu)

Office Staff and Their Duties:

Christine Selders, Administrative Assistant (428B Davey, 863-7351, cqs3@psu.edu).— Responsible for the general management of the department office and budget which includes budget planning, execution and audits. Assist with financial matters involving research grants, working closely with principal investigators. Support for outreach and development activities. Works with facility assignments and utilization planning.

Laurie Dasher, Administrative Assistant to the Department Head (525 Davey, 3-7350, lad31@psu.edu). Processes human resource and graduate appointments, visa applications and renewals, works with faculty affairs including faculty recruiting. Reviews and approves all IBIS forms. Supervises the main office staff.

Kaylee Harter, Academic Administrative Support Assistant (525 Davey, 5-0419, kah281@psu.edu). Assists the Directors of Undergraduate Studies and Graduate Studies. Assists with student recruitment. Provides information and requirements regarding Undergraduate and Graduate Programs. Department course scheduling, student scheduling and records.

Kaitlin Kessling, Financial Administrative Assistant, (428 Davey, 5-2957). Primary department contact for financial accounting operations and procedures; duties include but not limited to, processing wage payroll, work study forms and all financial forms in the Integrated Business Information System (IBIS), reconciling departmental purchasing card transactions, processing departmental travel reimbursements through the Employee Reimbursement System (ERS).

Amy Corbett, Administrative Assistant (525 Davey, 5-0418, auh243@psu.edu). Coordinates department colloquia program and endowed lectures series, assists with planning and arranging outreach events, meetings and workshops. Backup for financial staff assistant in processing wage payroll and financial forms in IBIS. Assists Department Head Staff Assistant in preparing materials for various academic activities; gathering and compiling information for various reports. Facilities management and key custodian.

2.3 Committees and Advisors

A number of committees within the Department of Astronomy & Astrophysics have official responsibility for different aspects of the graduate program:

Graduate Program Committee: The committee in the Department of Astronomy & Astrophysics that makes the overall policy on issues concerning the graduate program. It is chaired by the Associate Department Head for the Graduate Program, Prof. Michael Eracleous.

Candidacy Exam Committee: The committee in the Department of Astronomy & Astrophysics that administers the PhD Candidacy Exam. This committee is distinct from the graduate committee and consists of members of the Graduate Faculty.

Comprehensive Exam Committee: The faculty committee in the Department of Astronomy & Astrophysics that evaluates the Comprehensive Exam given to each student prior to beginning work on their PhD thesis. This committee consists of the student's research advisor, three other members of the Graduate Faculty of the Department of Astronomy & Astrophysics, and one Penn State faculty member from outside the department. The composition of this committee will be different for each person. The Comprehensive Exam Committee normally evolves into the Doctoral Committee, which supervises the student's dissertation work, though the membership may be changed if the circumstances warrant. The Chair of the Doctoral Committee may be from outside the Astronomy department. In the event that the Chair is an outside member, the Associate Head will, in consultation with the student and outside member, appoint a co-Chair from within the department of Astronomy, and the co-Chair will closely co-ordinate with the Chair, and monitor the student's academic progress.

Academic Advisor: Each incoming graduate student is assigned an academic advisor who advises the student through the completion of the Comprehensive examination. All first year students should meet with their advisor several times during their first year, especially in order to seek guidance in deciding on a course plan (see [Section 3.3](#)) that is appropriate to their preparation and interests. This person will usually not be the student's research advisor. Junior students are *required* to meet with their academic advisors before the beginning of classes in their first year and immediately after the end of final exams in the spring of their first and second year. Before the each spring meeting, the student must prepare an activity report, make it available to the advisor before the meeting, and discuss it with the advisor during the meeting. Activity reports are discussed further in Section 6.8, below.

Research Advisor: Advanced students have an individual faculty member as their research advisor. For students who have passed the Comprehensive Examination, the Research Advisor usually serves as Chair of the student's Doctoral Committee.

Department Ombudspersons: Currently, Dr. Derek Fox and Dr. Julia Kregenow. Each department in the College of Science has two ombudsmen who have been charged to provide a safe and informal environment for individuals to discuss problems and issues outside of formal channels. Any issue may be brought to the attention of the ombudspersons.

Students are encouraged to seek advice from their academic or research advisors, the Associate Head of the Graduate Program, or one of the ombudspersons, when they feel this is necessary. Delicate issues of interpersonal relations can be referred to any one of the above persons that the student is comfortable consulting with.

The Eberly College of Science also includes staff responsible for graduate student matters. These fall under the jurisdiction of the office of the [Associate Dean for Graduate Education](#). A [dedicated web](#) site provides information for graduate students from the Eberly College of Science, including [guidelines for Advisor-Graduate Students Interactions](#)

2.4 Health Services and Insurance

[University Health Services](#) on campus provides outpatient, inpatient, and urgent care, as well as health education programs for University Park students. A wide range of services are available: doctor and nursing care, ambulance service, clinical laboratory, X-rays, physical therapy, pharmacy, allergy immunization, health promotion, and wellness including issues relating to alcohol, nutrition, sexuality, contraception and self-care. Mental health services are provided by the [Center for Counseling and Psychological Services \(CAPS\)](#). Most health services provided through UHS are without cost to the student. Students should note that privacy of health issues is protected by Federal law, and faculty and academic advisors are not informed of any relevant health issues. Students may volunteer information on health issues they consider pertinent to advisors, instructors and the Associate Head of Graduate Studies, with the expectation that any information is treated as confidential.

In situations of extreme emergency, such as an accident or a life threatening situation, the closest major hospital with full facilities is the [Mount Nittany Medical Center](#) located ~3 miles north of campus up Park Avenue (814-23-7000). Ambulance or police services are available through the local 911 system (remember to dial 8-911 if using a University phone) or the University Police at 863-1111 (3-1111 from a University phone). Please inform the Graduate Program Head (Michael Eracleous, home phone 231-2975) or the Department Head (Donald Schneider) in any emergency situation.

Teaching Assistants and Research Assistants (collectively called Graduate Assistants) and Fellows will be automatically enrolled in the [Penn State Graduate Assistant and Graduate Fellow Health Insurance Plan](#), which includes dental and vision coverage. Please read this complex insurance plan thoroughly. The Web site gives current costs of the [student's contributions](#), forms with which the student can decline this insurance or can enroll their family, and the accompanying deadlines to the forms. International students, in particular, are required to have health insurance for themselves and their accompanying dependents. The University will not supplement, nor will a payroll deduction be made for, any other insurance policy. Generally, Penn State pays 80% of the annual premium expense for students enrolled in the GA/TA/Fellow plan, and 70% of the premiums for spouses and children. The remaining costs are deducted from your monthly payroll check.

3. Procedures for the Entering Student

Upon arrival on campus, incoming students should start at the Department Office, 525 Davey Laboratory. Please make every effort to introduce yourself to the Associate Head of the Graduate Program, Prof. Michael Eracleous, your academic advisor (assigned to you in advance), and the Graduate Staff Assistant, Kaylee Harter. Feel free to introduce

yourself to faculty members and, of course, other graduate students. You will also be assigned an office in Davey Lab, typically shared with other graduate students. You will be sent a schedule for Orientation which takes place over 1-2 days before classes start. International students will need to contact the [Office of Global Programs](#). The [Graduate Student Association](#) is a good resource on graduate student life, as is the Graduate Commons located in the Kern Building. Addresses for these and other useful offices appear in Appendix A.

3.1 Housing

Graduate students are not provided housing automatically and must make their own arrangements after accepting admission to the program and prior to arrival on campus. Some students live in [on-campus, graduate housing](#), available for both singles and families, while most students live [in apartments off-campus](#) owned by commercial realtors. Additional useful information for graduate students moving to town is provided by the Graduate Students Association [Guide to Graduate Life](#).

3.2 Keys, ID Cards, Computer Accounts, and Forms

New graduate students must go to the ID+ office in the HUB-Robeson Center (just across from Davey Lab) to get a [Penn State photo identification \(ID+\) card](#). A form of identification (driver's license, passport) and PSU ID number must be provided before you can receive a card. Your Penn State ID can be used to check out library books, enter into sporting events, access certain rooms on campus, obtain keys and computer accounts, etc. You can also put money onto your card ([LionCash+](#)) and use the credit to pay for food on campus and various locations in State College.

Keys are issued, as needed, by the Department-office staff for the building, classrooms, planetarium, and roof/domes, etc. with the approval of a faculty member. A \$10.00 deposit and your Penn State ID+ card are required for each key. Teaching Assistants typically require additional keys for their lab classrooms. Keys are not to be lent to anyone, and it is unlawful to duplicate these keys. All keys must be returned before a student leaves the University; key deposits are refunded at that time. Failure to return keys will result in substantial costs.

Each student is assigned a mailbox in the Department which is accessed with a key provided by the office staff. The mailboxes, located in the hallway outside of the main office/525 Davey are small and shared by two or three graduate students.

You will need two computer accounts: a [Penn State ACCESS account](#) on the University network and a local account on the Department of Astronomy & Astrophysics network, which is the primary network used for research purposes. For the University account, follow the instructions sent via email. The ACCESS account is needed to register for classes (via the [LionPATH](#) system); for Teaching Assistantship duties; the [CANVAS](#) learning management system ; and to take advantage of the following services provided by the University: University email, the software web site, high-performance computing, free and discounted software, on-line and physical library resources, and many other computing services. For the Department computer account, see the [ECoS IT staff](#). Please read the [Be Safe Guide](#) for computer use guidelines and information.

New students receive some combination of Teaching Assistantship, Research Assistantship, or Fellowship and must fill out the following appropriate employment forms:

[I-9 Employment Eligibility form](#). You will need one or two forms of identification, such as your driver's license and social security card, or passport.

[W-4 Employee's Withholding Allowance Certificate](#)

[Salary Direct Deposit Request](#). For this, you will need to provide your bank's routing number and your bank account number. (These numbers are on your checks, so it's best just to bring a cancelled or voided check with you.) Penn State can direct deposit into any bank in the U.S.

[Intellectual Property Agreement](#)

(optional) W-4E Employee Claim for Exemption from Withholding of Federal Income Taxes and an RIT-214 State Income Tax Non-Withholding Application form

3.3 Course Registration

Course registration is accomplished after discussion with your academic advisor. The typical first semester program is discussed in section 6.1. Entering students will be registered for fall courses by the Graduate Staff Assistant, but for subsequent semesters, students register themselves on-line via the [LionPATH](#) system using the information on the [LionPATH Class Search](#). It is critical that ongoing students register at least 45 days before the end of the previous semester, in order to both help the Department manage its course offerings, and to avoid a substantial late-registration fine from the University. Note that students may change their schedule and add or drop courses without penalty up to 5 days into the semester.

4. International Students

The Graduate Staff Assistant and/or the Global Programs office will be in touch with you before your arrival on campus regarding immigration and naturalization matters. All incoming international students are highly encouraged to review the [Global Penn State website](#) and to attend the [New International Student Orientation](#) scheduled during the weeks before fall semester begins.

Upon arrival, an international student will need to apply for a Social Security Number, fill out a tax Withholding form, and open a bank account in order to receive a paycheck. Information on such matters can always be obtained from the Graduate Staff Assistant.

4.1 English Language Competency

International students are strongly encouraged to gain full proficiency with the English language at the earliest possible opportunity. This should be given high priority in the

first year of graduate school. The University offers the following services to help international students in this matter: an [Intensive English Communication Program](#) (IECP), the graduate-level English as a Second Language courses ([ESL 115G-118G](#)), and the [Graduate Writing Center](#). Please discuss your options with your academic advisor, as your needs may affect your academic program.

International students who are to be Teaching Assistants (TA's) must demonstrate fluency in English either by taking the [AEOCPT test](#) of oral English proficiency, administered by the Center for English as a Second Language (ESL), or by other means, as determined by the Associate Head of the Graduate Program. Students who take and fail this test must take ESL 118G and receive a grade of "A" before they will be allowed to assume teaching responsibilities. This test must be taken upon arrival on campus. International students whose native language is English or who attended an undergraduate institution where the official language of instruction is English, may be granted an exemption from actually taking the test.

The Graduate School requires that Departments evaluate English competency for all graduate students, U.S. and foreign born. The criteria are given in Appendix D-2 and D-3. Competency in written English is assessed using essays written for Astronomy 501 and 502 during the fall semester. Toward the end of the semester, you will be asked to submit several of these essays or other course material to the Graduate Program Head for assessment. Oral competency in English is assessed on the basis of a 20-minute "Journal Club" or "Research" presentation, which should be scheduled with the Tuesday Lunch faculty organizer during the spring semester of the first year. These talks will give you experience in speaking and will help faculty members, who will be writing letters of reference for you, evaluate your speaking skills. Your oral English will be assessed by two faculty representatives, and the results will be made known to you shortly after your presentation. Students who are determined by the Graduate Program Head to have no deficiencies in their English speaking ability and have passed, or been deemed exempt from, the ESL exam will have completed their spoken English proficiency requirement.

4.2 Guidelines on F-1 Visas

The [U.S. Citizenship and Immigration Services](#) has regulations that pertain to international students with F-1 visas. Each student is responsible for learning about and abiding by these regulations (described in detail at the Penn State Office of International Students). International students are obligated to keep the university informed of their local address, which can be done easily via [LionPATH](#).

The INS views students holding assistantships as having on-campus employment. On-campus employment is permitted as long as the student is pursuing his/her program of study full-time. Once the student completes the program of study and has no plans to continue, the student must stop working.

An F-1 student who is unable to complete a full course of study in a timely manner must apply for a program extension with the Penn State Office of International Students (INS). This must be done within a 30-day period before the completion date on the Form I-20 A-B. An F-1 student who is unable to meet the program completion date on Form I-20 A-B may be granted a program extension by Penn State if the Foreign Student

Advisor certifies on Form I-538 that the student has continually maintained regular student status and that the delays were caused by compelling academic or medical reasons, such as changes of major or research topics, unexpected research problems, or documented illnesses. Delays caused by academic probation or suspension are not acceptable reasons for program extension.

The Foreign Student Advisor must notify the INS within 30 days of any approved program extensions by forwarding to the INS Data Processing Center both a certification on Form I-538 and the top page of a new Form I-20 A-B showing a new program completion date. Because of the required paperwork, students who need to apply for an extension of stay should begin the application process 45 to 60 days before the original completion date. Students should submit the following documents: (1) a letter from the academic advisor explaining the delay in completion of the program and giving a new completion date, and (2) a financial guarantee. F-1 students who have not maintained regular student status and who will not finish the program by the completion date must apply for reinstatement.

5. Degree Requirements

The goal of our graduate program at Penn State is to prepare you for a career in astronomy and astrophysics. This is a challenging and competitive field, and the program is designed to develop the skills you will need to succeed. We provide here rules and guidelines to the milestones you need to achieve in order to receive a PhD or MS in Astronomy & Astrophysics. The requirements of the different degrees are a combination of course work, departmental examinations, and a thesis (required for the doctoral degrees, and optional for the master's degrees).

Each course counts for a certain number of credits; one credit corresponds to one 50-minute class per week, plus associated out-of-class study. There are requirements on the number of credits that a student registers for in order to maintain his/her status as a full-time student.

We realize each student is unique, and the timing of a milestone or the specific course requirement can be revised to suit individual needs. Deviations from the norm are discussed by the student and academic advisor (pre-Comprehensive) or Doctoral Committee chair (post-Comprehensive), and are approved by the Associate Head for the Graduate Program. The course petition form (Appendix D-1) is used when waivers or substitutions of course requirements are sought. The Associate Head is always available to discuss options. More detailed information, and the precise rules on the university's requirements, can be found in Penn State's [Graduate Degree Programs Bulletin](#). Graduate School degree requirements, along with other University rules about residency, registration, etc., are given throughout this bulletin. Each student is responsible for knowing and fulfilling the requirements for graduation. This Handbook also represents official policy and gives complete details.

Students may also complete a dual-title degree or graduate minor. The addition of a dual-title degree must be requested before completing the candidacy exam as the dual-title field must be integrated into the exam. The addition of a graduate minor should be

requested before scheduling the comprehensive exam as the doctoral committee must include a member representing the minor. [Graduate Bulletin degree requirements](#)

The [Astrobiology Dual-Title Degree](#) and the [Computational Science Minor](#) are commonly added by Astronomy & Astrophysics graduate students.

5.1 PhD Requirements

To obtain a PhD in Astronomy & Astrophysics, students must satisfy the following requirements:

Demonstrate proficiency in oral and written English

Complete ten 3-credit, 500-level courses including: ASTRO 501, ASTRO 502, at least four additional ASTRO 500-level courses, and at least two 500-level courses from a closely related discipline (these are typically physics courses but other possibilities exist, depending on the student's goals, e.g., statistics, engineering, computer science, astrobiology, geosciences; one may be at the 400-level). The department of Astronomy & Astrophysics requires students to achieve a minimum cumulative grade point average (GPA) of 3.20 in these ten 3-credit courses.

Complete 3 distinct 1-credit Seminars in Current Research (ASTRO 589)

Complete 3 credits of Individual Studies for the 2nd Year Research Project (ASTRO 596)

Complete 1-2 credits of Colloquium (ASTRO 590)

Complete 1 credit of in-classroom teaching experience (ASTRO 602)

Pass the Department's Candidacy Examination at the PhD level

Pass the Department's Comprehensive Examination

Satisfy the Graduate School's residency requirement and arrange for tuition payments

Maintain continuous registration after passing the Comprehensive Examination

Complete a PhD dissertation and pass the oral PhD thesis defense

Submit a final, signed copy of the PhD dissertation to the [Graduate Thesis Office](#).

These requirements are discussed more fully below and are summarized in the checklist in Appendix D-4.

And 5.2 English Proficiency

According to University policy, a PhD candidate must demonstrate high-level competence in the use of the English language, including reading, writing, and speaking, as part of the language and communications requirements for the PhD. This requirement applies to both international and domestic students; all students should read section 4.1 above. The Department evaluates English proficiency during the first and second years: assessment of writing is based on ASTRO 501/502 assignments, and assessment of speech is based on a Tuesday Lunch “Journal Club” or “Research” presentation. Assessment forms are given in Appendix D-2 and D-3. Competence must be formally attested before the Comprehensive Examination may be scheduled.

5.3 Policies Concerning Graduate Courses

Topical graduate courses are numbered from 500–599; the Department’s 500-level offerings are presented in section 7 below. ASTRO 596 (Individual studies) and 600-level courses do not have a classroom component, but represent research and teaching work. A student carrying out research must register for an appropriate number of credits. Several course numbers are used by the Graduate School: ASTRO 596 (Individual Studies), 599 (Foreign Studies), 600 (Thesis Research, on-campus, pre-Comprehensive Exam), 601 (Full-time Thesis Preparation, post-Comprehensive Exam, on-campus thesis preparation), 603 (Foreign Academic Experience), 610 (Thesis Research, off-campus, pre-Comprehensive Exam), and 611 (Part-time Thesis Preparation, post-Comprehensive Exam). Typically, students who have passed the Comprehensive Exam should register for ASTRO 601; they may then register for three additional credits for “Audit” (rather than A-F grade) without extra tuition charge. Students working off-campus should register for one credit of 610 to maintain continuous registration; post-Comprehensive tuition (roughly \$2000/yr) must still be paid even if the thesis student is off-campus. Undergraduate courses are numbered from 1–499. Graduate students would take courses numbered 1–399 only to rectify deficiencies; such courses cannot be applied to graduate degree requirements.

Students who have graduate assistantships (TAs or RAs) or who are supported by a Fellowship are required to enroll for at least nine credits each semester. Failure to do so may jeopardize the student’s academic status and funding. Half-time graduate assistants can take no more than 12 credits per semester. The responsibility for being properly registered for courses rests with the student, but options should be discussed with the student’s academic advisor.

Penn State operates on a letter grade system, discussed in section 8.3. For graduate courses, any grade below a B- is considered poor. The Graduate School requires a minimum grade point average of 3.00 for a student to take the Comprehensive Exam and obtain an MS or PhD degree. Our Department insists on a minimum GPA of 3.20 at the completion of the ten required 3-credit courses. These courses include ASTRO 501, 502, at least four other ASTRO 500-level courses, and at least two PHYS 500-level courses (with one possible 400-level substitution). Occasional substitutions may be allowed upon submission and approval of a course waiver/substitution petition (Appendix D-1). The GPA calculation does not include ASTRO 596 or 602, any ESL courses (English as a Second Language), or any courses in non-related fields (such as music). Normally the ten courses will have been completed by the end of the student’s second year; though in some cases it may take longer.

Students with unusual academic backgrounds or educational goals should not hesitate to discuss possibilities for individualized course programs. Requests for waiver or substitution of required courses should be made using the form in Appendix D-1. Students should first consult their advisor and then the Associate Department Head for the Graduate Program. Such requests should be made as early as possible and not be delayed until graduation approaches.

5.4 Three-Credit Course Offerings

The Department currently offers eleven 3-credit 500-level courses, scheduling three or four each fall and spring semester. Each fall, two required fundamental courses (ASTRO 501 and 502) are offered for the entering students. Other courses are: two on extragalactic astronomy and cosmology (ASTRO 504 and 545), two on stellar astrophysics (ASTRO 530 and 534), one on exoplanets (ASTRO 577), one on the interstellar medium (ASTRO 542), one on high-energy astrophysics (ASTRO 550), two on research techniques (ASTRO 513 and 527), and other topics in astronomy and astrophysics (ASTRO 585). Each student must take at least 3 credits of directed research (ASTRO 596) as part of a Second Year Research Project; this is discussed further in section 6.5. In addition, 1-credit seminars on current research that are not cross-listed as ASTRO courses, may also substitute for one required 3-credit ASTRO course (see the regularly offered ASTRO 589), after proper approval. Official descriptions of the courses appear in section 7 below. Courses have no prerequisites except for ASTRO 501 and 502.

At present, two 500-level courses are cross-listed with another Department (ASTRO 527 = PHYS 527, ASTRO 545 = PHYS 545), and more may be offered in the future. Generally, students taking these courses should register for the ASTRO designation. No more than one cross-listed course can be taken with PHYS or other Departmental designation during a student's career.

5.5 One-Credit Course Offerings

Students are required to enroll in at least three distinct 1-credit ASTRO 589 "courses," Seminars in Current Research. These need not all be taken before the Comprehensive Examination. See section 6.6 below for arrangements to take these classes after this Examination.

Students must register for the 1-credit ASTRO 590 Colloquium for one or two semesters during the first two years, as directed by the Associate Head of the Graduate Program. ASTRO 590 students are expected to attend all Wednesday colloquia (and meet the speaker for informal discussion), the Tuesday lunch talks, and, if given that semester, Marker Lectures in Astronomy. The student's grade is based on attendance and participation.

Every semester that a student teaches, they should register for 1 credit of ASTRO 602. Students must register for ASTRO 602 AND conduct in-class teaching for a minimum of one semester during their graduate career. During the first semester a student teaches, which should preferably be a Fall semester, a Teaching Assistant training course will be held, which typically meets once per week for 50 minutes. In the semester when a

student attends this training course, they should register for 2 credits of ASTRO 602, instead of the usual 1 credit. Students may continue teaching beyond the requisite one semester if they desire additional teaching experience. The ASTRO 602 course requirement is usually, but not necessarily, coupled with a paid Teaching Assistantship which provides stipends and tuition waivers. Experience in classroom teaching carries a number of benefits for graduate students. More details about the duties and expectations of a TA are given in Section 9. Recall from section 4 that international students must be certified by Penn State in English competency prior to teaching.

5.6 Candidacy Examination

The Candidacy Examination is an examination required by the Graduate School early in a student's graduate education. Currently, in our Department, it consists of a written exam, administered approximately one year after the students arrive, and covering a broad range of topics in astronomy and astrophysics, including material covered in courses, colloquia, and other presentations.

Students interested in the Dual-Title Degree in Astrobiology (see section 5.11 of this handbook) should inform the department of their intentions and formally apply for admission to that program well in advance of taking the candidacy exam. This is necessary in order to include questions relevant to astrobiology on the candidacy exam.

The exam is set and evaluated by the departmental Candidacy Exam Committee, which consists of members of the graduate faculty and is distinct from the graduate committee. The Chair of the Candidacy Exam Committee will communicate the exact timing, nature, and general form of the exam to the graduate student candidates.

The Committee's assessment is based on whether the student has demonstrated sufficient general knowledge and ability, so as to signify readiness to engage in research for the PhD degree. A two thirds majority affirmative vote by the examining Committee is needed to pass. After the completion of the exam, the Chair of the Candidacy Exam Committee will communicate the outcome of the exam to the student and the Associate Head of Graduate Studies.

The student may attempt the Candidacy Exam twice. Normally, the first attempt is made at the beginning of the second year. There are two possible results of the Candidacy Exam on the first try:

Pass: This signifies that the student has become a candidate in the PhD program, providing the other requirements are also met.

Fail/Retake: The performance is not adequate for the PhD program, but the student is encouraged to retake the exam 3-6 months later.

If a second attempt is necessary, the exam should be retaken no less than 3 months but no more than 6 months after the first attempt. There are three possible results of the Candidacy Exam on the second try:

Pass: This signifies that the student has become a candidate in the PhD program, providing the other requirements are also met.

Master's Pass: Although the performance is not adequate for candidacy in the PhD program, the level of accomplishment is sufficient to lead to a Master's degree (see section 5.10).

Fail/Dismissal: The level of performance indicates that the background of the student is insufficient to continue in the program. The Department Head, who may consult the full Department Graduate Faculty, will then decide if the student should be dismissed from the Doctoral program.

The examination outcome is forwarded by the Candidacy Committee to the Associate Head for insertion into the student's file. If the Associate Head determines that the student has also met the University requirements for candidacy, including residency and English competency, the student and Graduate School are notified of the student's advancement to Candidacy.

5.7 Comprehensive Examination

After the student is advanced to Candidacy, his or her Doctoral Committee of Graduate Faculty members is named by the Graduate School Dean upon recommendation of the Department Associate Head, whose choice is based on close consultation with the student and the research advisor. When the student has completed a significant amount of original research, the Doctoral Committee will administer a Comprehensive Examination. The purpose of this exam is to test the student's mastery of the chosen field of research. Official requests to add a minor to a doctoral candidate's academic record must be submitted to Graduate Enrollment Services prior to establishment of the doctoral committee and the scheduling of the comprehensive examination. The exam must be scheduled by the Graduate School at least two weeks before exam date.

The Comprehensive Examination Committee will consist of five members of the Graduate Faculty and should include members who have expertise in the material being presented. 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." 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/performance 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." (The Outside Field Member and the Outside Unit Member may be the same person). The Examination will be scheduled by the Chair of the student's Doctoral Committee, at such a time as the student has a body of research work to present and defend, but in no case later than the end of the student's second year in the program. The recommended time for this exam is the academic year following advancement to Candidacy. By Graduate School rules, at this

time, the student's GPA (as calculated by the Graduate School) must be 3.0 or higher. By Department rules, the GPA of the 3-credit courses in astronomy and related fields must be 3.2 or higher.

All students are expected to take and pass the comprehensive examination within 24 months of entering the graduate program. Students who meet this timetable will be considered to be making adequate progress towards the PhD degree. The department of Astronomy & Astrophysics cannot guarantee financial support to students who do not meet this timetable. However, the evaluation of student progress and the decision to provide departmental support past 24 months for students who have not passed the comprehensive exam will be based on the totality of circumstances, including their work load in the first two years in the program and the scope and challenges of their research project(s).

The Comprehensive Examination is oral with a minimum duration of 2 hours. The examination has two parts. First, the student briefly presents the results of his or her research, which supplements an extended written report of the work that has been made available to the Committee at least one week in advance. This report should include motivation, literature review, methods, results, interpretation and implications. The student is examined on the research, its implications, and the quality of the report. The work presented by the student need not be related to dissertation work to be undertaken later. Second, the student is examined on closely related areas of astronomy and astrophysics, for example, the scope of the examination might be active galactic nuclei, star formation, or infrared instrumentation.

The research to be presented must be substantially finished and at a standard comparable to that of a work ready to be submitted for publication. The work may have started before the student joined the Penn State graduate program in Astronomy & Astrophysics but the bulk of the work should have been carried out after joining the program under the supervision of the member of the graduate faculty. This research may be (a) the same as what was presented in the Second Year Research Project, (b) related to or an extension of work done during the Second Year Research Project, or (c) different work, unrelated to the Second Year Research Project, but of the required high standard, nonetheless. In case (a) the student should have done outstanding work as part of the Second Year Research Project and should have met the high standard of work expected for the comprehensive exam. It is understood that in case (a) the student will seek to take the comprehensive exam early in the spring semester following the submission of the Second Year Research Project report.

There are three possible outcomes of the Comprehensive Exam:

Pass: The student is now ready to select a thesis project and proceed with the PhD program. Passage requires a two thirds affirmative vote of the Committee (e.g., four out of five committee members must agree to a pass).

Fail/Retake: The performance was not acceptable, but the student may retake the exam. Only one retake is allowed, and will result in either a Pass or a Fail/Dismissal. The student is eligible to seek an MS degree. Any combination of votes from the committee members, other than the combinations noted in the

previous and next paragraphs, results in the student failing the exam with the option of re-taking it.

Fail/Dismissal: The performance was not acceptable, and the student is dismissed from the program. The student is eligible to seek an MS degree. This option requires 60% of the committee members (i.e., three out of five) to agree that the student has failed and should not be given the opportunity to re-take the exam.

If the student is taking the comprehensive exam for the second time, there are only two possible outcomes.

Pass: The student is now ready to select a thesis project and proceed with the PhD program. Passage requires a two thirds affirmative vote of the Committee (i.e., four out of five committee members) must agree to a pass.

Fail/Dismissal: The performance was not acceptable, and the student is dismissed from the program. The student is eligible to seek an MS degree. Any committee vote other than a two thirds affirmative vote results in this outcome.

5.8 Residency Requirements and Continuous Registration

University policy requires that graduate degree recipients spend at least two semesters as a registered, full-time student engaged in academic work at the University Park Campus (or Hershey or Harrisburg campuses) during a twelve-month period. In addition, the student must register continuously for each fall and spring semester (beginning with the first semester after the two semester residence requirement has been met) until the PhD thesis is accepted and approved by the doctoral committee; this includes payment of appropriate tuition each semester. Note that tuition is substantially reduced after the Comprehensive Exam is passed.

5.9 PhD Thesis and Final Oral Examination

A written dissertation of thesis work must be produced in accordance with the rules established by the Penn State [Thesis Office](#). Each student must defend the thesis orally before a Doctoral Committee and secure the Committee's approval of the written dissertation following the rules established by the Graduate School. The final oral examination, or Thesis defense, must be scheduled by the Graduate School at least two weeks before exam date. Students should contact Committee members to find a satisfactory date and make arrangements with the Associate Department Head for the examination. The Thesis must be provided to the Doctoral Committee at least two weeks in advance of the scheduled defense.

After a successful defense, the thesis is submitted to the Thesis Office on the eTD website. There is a fee charged for this service, which is paid by the student. The dissertation fee is applied towards multiple necessary costs. The University Libraries receives a portion of the fee which is used to pay for the actual costs charged to the University to convert the document to microfilm for long-term archiving; to maintain the archiving of the dissertation as it is stored within the University's News and Microfilms

Library; and for submission and inclusion of the dissertation in Dissertation Abstracts/ProQuest Dissertations and Theses database, published by University Microfilms International (UMI/ProQuest). The Graduate School retains a portion of the fee to offset the costs incurred during the format review; final review; management of embargoed eTDs; and collection and management of all materials submitted with the dissertation.

5.10 Master's Degree Requirements

The MS degree in Astronomy & Astrophysics is awarded according to the following Departmental requirements and procedures.

The candidate must satisfy all Graduate School requirements for the MS degree given in the [Graduate Degree Programs Bulletin](#). These include 30 credits which have two restrictions: 18 credits must be at the 500- or 600-level; and 12 credits must be from the Department's offerings. If the student elects to submit a thesis, at least 6 credits of ASTRO 600 or 610 must be included. Up to 4 total credits for ASTRO 602, Supervised Experience in College Teaching may be applied toward meeting the 30 credit requirement, but no more than one credit per semester will apply. The Associate Head will certify completion of the University course requirements.

A minimum GPA of 3.00 is required for work done at the University, as well as minimum credit requirements for coursework and research.

An ad hoc Master's Committee, consisting of at least three Graduate Faculty members, will be appointed by the Associate Head for the Graduate Program to provide guidance to the Master's candidate and clarify the expectations. If the thesis option is chosen (following appropriate faculty consultation), one member of the committee will normally be the supervisor of the thesis.

The student must prepare a suitable thesis, essay, or paper. The nature of this paper will be decided by the Master's Committee in consultation with the Associate Head. The Committee will decide by majority vote whether the thesis, essay, or paper is of acceptable quality.

5.11 Dual-Title Degree in Astrobiology

Astronomy and Astrophysics PhD students have the opportunity to obtain an interdisciplinary [Dual-Title Graduate Degree in Astrobiology \(ABIOL\)](#). *Students must notify the department accordingly and apply for this program by the middle of the spring semester of the student's first academic year.*

Administered by the Department of Geosciences, this program is devoted to the exploration of life outside of Earth and to the investigation of the origin and early evolution of life on Earth. Students must take ABIOL 574 (Planetary Habitability, 3 credits), ABIOL 590 (Astrobiology Seminar, 2 credits), ABIOL 570 (Astrobiology Field Experience, 2 credits), and at least 2 credits of 400- or 500-level course work outside of the student's major program in an area relevant to Astrobiology. ABIOL 574 can count towards the ASTRO course requirement of the Astronomy & Astrophysics graduate

degrees. Astrobiology must be included in the Candidacy and Comprehensive Examinations. The successful student will obtain a PhD in “Astronomy and Astrophysics and Astrobiology.”

5.12 Graduate Minor in Computational Science

Astronomy and Astrophysics PhD students have the opportunity to obtain an interdisciplinary [Graduate Minor in Computational Science](#). Computational science focuses on scientific or engineering problems and draws from computer science and mathematics to gain an improved understanding of the problem. A computational scientist must have expertise in an applied discipline and must also be familiar with leading-edge computer architectures and the data structures issues associated with those architectures. A computational scientist must also have a good understanding of both the analysis and implementation of numerical algorithms and the ways that algorithms map to data structures and computer architectures. Additionally, a computational scientist must be comfortable with networking technologies that permit access to remote computers, massive databases, and visualization facilities. Recently, scientific visualization has become an essential tool of the computational scientist for the preprocessing of data sets and the interrogation of massive amounts of computational results. In summary, a computational scientist, using networking and visualization tools, works at the intersection of 1) an applied science or engineering discipline; 2) computer science; and 3) mathematics. This multi-disciplinary activity has given rise to a new way of conducting research.

6. Your Path Through Graduate School

In this section, the typical path through the PhD program in the Department of Astronomy & Astrophysics is described in detail with the various milestones discussed sequentially.

6.1 Summer Prior to the First Year

After accepting admission to the Department, students occasionally make arrangements with a faculty member for research employment during the summer. This has no formal impact on your academic progress, but is valuable experience.

6.2 Fall of the First Year

This semester is spent mainly on coursework. The idea is to provide intensive coverage of the key ideas and tools of astronomy and astrophysics in preparation for advanced courses and research, and to enable the student to get full benefit from the Department’s colloquia and seminars. The first fall semester is also the best time to make up any deficiencies in undergraduate preparation in astronomy or physics. Although variations are common, entering students will typically sign up for 10-12 credits following:

Astro 501 Fundamental Astronomy (3-credits)

Astro 502 Fundamental Astrophysics (3-credits)

Elective course (typically ASTRO 500-, PHYS 500- or 400-level, 3-credits)

ASTRO 589 Seminar in current research (1 credit), if offered

ASTRO-589 Seminar in professional development and responsible conduct of astronomical research (1 credit); this must be taken in addition to any research seminar

ASTRO 590 Colloquium (1 credit)

ASTRO 602 Supervised Experience in College Teaching (1-2 credits, specifically for T.A.s)

ASTRO 501 and 502 constitute the “core curriculum” of our Graduate Program and, with rare exception, are required for all entering graduate students. Examples of elective classes are given in section 7.2 below. Students usually choose a 500-level physics class, although 400-level classes may be appropriate for students without a strong physics background. You can self-test yourself in physics using the [Physics Dept Candidacy Exams](#). It is also possible to take graduate level courses in allied fields (such as math, statistics, geosciences or engineering) as electives with advanced approval of your advisor and the Graduate Program Head.

If there is an ASTRO 589 Seminar in Current Research (1 credit) offered, first year students are encouraged to take the Seminar if they feel adequately prepared. The Seminars provide unique opportunities for enrichment, and take advantage of the particular expertise of a faculty member. Wednesday afternoon Colloquia are offered during all semesters, and the Distinguished Lectures are usually once a year. Attendance at these talks is strongly encouraged for all students in order to increase their breadth and exposure to expert scientists. Students may register for an ASTRO 590 credit during any of the first four semesters; students must attend the lectures during the semester they register for ASTRO 590, and are still strongly encouraged to attend these lectures any other times.

Entering students who are Research Assistants or Fellows have the option of registering for 1 credit of ASTRO 602 and attend the weekly ASTRO 602 training class even if they are not currently teaching. For the ASTRO 602 class, students will participate in weekly training and assessment sessions on teaching techniques (such students will be required to take ASTRO 602 later, if they have not taken it in their first semester). Entering students who have Teaching Assistantships assigned to ASTRO 11 laboratory instruction must register for 2 credits of ASTRO 602, because they will be both attending the ASTRO 602 class AND teaching a section of undergraduate ASTRO 11. As ASTRO 11 TAs, graduate students get direct experience teaching laboratories as the instructor of record of their own class.

During this semester, students should meet with their advisors to plan their spring semester courses, discuss any difficulties that have arisen, and probe directions for the future. Coursework alone will not provide students with “everything they will ever need

to know.” Reading on-line journal articles on the [ADS](#) and [arXiv/astro-ph](#); attending lunch talks, colloquia, research group meetings, and morning coffees; talking with faculty and other students about their research; and doing research yourself are essential in graduate school and throughout the rest of one’s career. These informal learning environments provide a general knowledge of how science is done, experience with good and bad talks, and a basis for a decision on a research topic and advisor. Formal courses in graduate school are, nevertheless, very important, as they are a way to learn many standard results in a systematic manner, and will introduce students to a variety of fields and faculty members. Be warned that graduate courses are not easy and often move at a rapid pace. The demands of coursework, research, and informal learning must be balanced with the need to broaden interests and knowledge; in astrophysics there is substantial overlap between disciplines, and students often change subfields during their careers.

During the fall or spring of the first year, students must also go through the [Scholarship And Research Integrity \(SARI\)](#) training program. This training is mandatory and is incorporated in ASTRO 589, the seminar on Professional Development and the Responsible Conduct of Research, typically offered every fall.

6.3 Spring of the First Year

Coursework is again emphasized. Students typically take two or three 3-credit ASTRO 500-level courses, as well as one or two 1-credit courses; 500-level classes in physics or allied fields might also be included. ASTRO 11 Teaching Assistants will also need to register for 1 credit of Astro 602; weekly training associated with the 2-credits of ASTRO 602 is no longer necessary. Students are generally expected to give a short Tuesday Lunch “Journal Club” or “Research” talk during the semester.

Early in the spring semester, students should begin to consider what area of research they would like to pursue in the summer and the Second Year Research Project. Students are generally supported in the summer by research supervisors on fixed term appointments. It is the students’ responsibility to knock on doors of potential research supervisors to find funding and a project that interests you. This project is not expected to continue through one’s graduate career; however, it often connects naturally to one’s Second Year Research Project. The multiple opportunities to pursue research (summer research, Second Year Research Project, and thesis research) should be looked upon as means to explore potential specialty areas.

Midway through the spring semester students also need to consider what academic program to pursue in the fall. Arrangements for financial support should also be made; many second year students continue as TAs, but some find support as Research Assistants. One’s academic advisor should be closely consulted on these matters. Most students will also complete their English Competency requirement during the first two semesters (section 5.2). International students who do not have sufficient English language fluency for teaching and other aspects of the graduate program should address their deficiency quickly during the first year.

Students interested in the [Dual-Title Degree in Astrobiology](#) should declare this officially to the Department by the middle of the spring semester of the first year and also apply formally for this program.

6.4 Summer of the First Year

This is often one's first opportunity to delve full-time into a research project. The nature of the project will depend upon the particular circumstances, and it may extend past the summer. Students should discuss what is expected with their advisor or research supervisor. This includes not only expectations about the scope and progress of the research activity, but also expectations about the working schedule, which can vary depending on the needs of the research and the schedule of the supervisor. It is common to give a 20-30 minute lunch presentation of one's summer project sometime during your second year. It is the student's responsibility to seek out research projects, to find out what is available within the department and to approach individual faculty or senior research associates. The department seeks to provide information on available projects through web pages and occasional e-mails announcing current opportunities, but the availability of research positions is necessarily dynamic and can change rapidly.

6.5 The Second Year

At the beginning of the fall semester of the second year, students will be taking the Candidacy Examination, as described in section 5.6. This required exam assesses students' preparation to perform doctoral work by testing their knowledge and preparation in astronomy and physics. The Chair of the Candidacy Exam Committee will communicate with the students early in the spring semester of the first year about the detailed scheduling of the exam, as well as any pertinent information on the content and format.

A typical fall program consists of two ASTRO or PHYS 500-level courses supplemented with 3-6 credits of ASTRO 596 (Independent Studies) for the Second Year Research Project. Many faculty members will have Second Year Research Project suggestions and will be willing to serve as supervisors. Second Year Research Project plans should be developed beforehand with the research supervisor and consulting one's faculty advisor; the Associate Head will request the Project title and supervisor name about three weeks into the semester. The work done may be related to research performed during the previous summer, and may also be related to work done as part of a Research Assistantship (RA). Some RA responsibilities are inappropriate as Second Year Projects, which must be science projects with significant implications and appropriate scope for significant progress by the end of the semester. It need not result in a journal publication in itself, but should be at a similarly high level. The project may not rely on data that cannot be obtained within the appropriate timescale. A Project title and one-page description should be submitted to the Graduate Staff Assistant by the third week of the Fall semester.

The directed Second Year Research Project is a very important component of the graduate program, effectively testing whether students are capable of carrying out a research program from beginning to end. The work may have started before the student joined the Penn State graduate program in Astronomy & Astrophysics but the bulk of

the work should be carried out under the supervision of the member of the graduate faculty after joining the program. The supervisor will meet regularly with the student throughout the semester and provide guidance for the research effort. The project culminates with the student independently writing a substantial report, which is due during the final exam week (typically, mid-December; the exact date will be set by the Associate Department Head for the graduate program and communicated to the students). The ASTRO 596 course grade will be based on the quality of the report, evaluated by the research supervisor with input from two other faculty members. The report will also be considered by the Graduate Program Committee in evaluation of second-year students for the Brumbach Fellowship (section 10.2.1). The research done during the Second Year Research Project, and associated summer research, may also form the stepping stone for further work that will be presented at the student's Comprehensive Exam. Students who are not able to complete and submit their report by the due date will receive a [deferred grade \(DF\)](#) for ASTRO 596. This means that such students will have 10 weeks from the end date of the course to complete and submit the report, otherwise the grade will automatically become a failing grade (F). Students and their advisors are strongly encouraged to communicate as early as possible with the Associate Head of the Graduate Program if they anticipate a delay in completing the Second Year Research Project report.

During the spring semester, students will complete most – if not all – of the remaining required coursework. Full-time registration requires that you take at least 9 credits, but these can include ASTRO 596 credits. Every spring semester, students should make sure that they understand their source of funding for the summer and the following academic year. They may continue to work with their Second Year Research Project supervisor, or move on to another research topic and advisor – these options are equally acceptable. At the end of the semester, please request the course requirement checklist (Appendix D-4) from the Graduate Assistant to be reviewed, signed, and returned to the Graduate Staff Assistant for your student file.

6.6 The Third Year

Most students have completed their course requirements and passed their Candidacy Exam by the beginning of this fall semester. These students are now taking ASTRO 596 credits supported as RAs under the supervision of a faculty member. They are thinking about their thesis area of research and are preparing for their Comprehensive Examination (section 5.7). This exam is taken when a student has a body of research to present and defend. The recommended time for this exam is the spring semester of the second year, but generally it should be no later than the end of the summer of the second year. Preparation for the Comprehensive Exam includes writing a substantial research document; it may or may not be related to the earlier Second Year Project report, as the student chooses. The work presented and defended in the comprehensive exam should be of publication quality.

Before the Comprehensive Exam, the student's Doctoral Committee is formed by the Associate Head of the Graduate Program in close consultation with the student and research advisor. The chair of the Doctoral Committee is usually the thesis and research advisor.

Students doing full-time dissertation work generally register for ASTRO 601 (0 credits) rather than the pre-Comprehensive ASTRO 596. This entails a much-reduced tuition charge. Students who have passed the Comprehensive Exam begin full-time work on a thesis topic. There should be a clear understanding between student and supervisor as to what is expected. Students are encouraged to take ASTRO 589, Seminars in Current Research, and are expected to attend regular Department colloquia, Marker Lectures, and lunch talks; however, students are now mostly concentrating on research.

For a student who has not passed the Comprehensive Exam, the fall of the third year will be a combination of study and research. Students should register for ASTRO 596 credits, and any additional coursework needed to meet the graduation requirements. Students may continue taking ASTRO 589 1-credit seminars and ASTRO 585 3-credit topic courses (see sections 5.4–5.5) during their third and later years. If the course contributes towards the PhD Course Requirements (Appendix D-4), the additional tuition will be paid by the research supervisor or the Graduate Program. For other courses, students should consult their research supervisors. When all of the required courses have been taken, the student should request the [course requirement checklist](#) (Appendix D-4) from the Graduate Assistant to be reviewed, signed, and returned to the Graduate Staff Assistant for the student's file.

6.7 Subsequent Years

Within one year of passing the Comprehensive Exam, and often sooner, you are expected to meet with your Doctoral Committee to propose your thesis topic. The thesis topic may be instrumental, observational, theoretical, interdisciplinary, or any combination of these. The meeting requires document and presentation of the context and plan of your thesis with discussion of the merit, feasibility, and timescale of the research.

You are now fully involved in thesis research, making clear progress through the research plan, and often publishing papers. You will meet with your Doctoral Committee at least once a year (every six months is recommended) to discuss your progress on the thesis. It is crucial that Doctoral Committee meetings not be repeatedly postponed; it is not required that any particular milestone be met for a meeting, nor is it required that all members attend the meeting if their schedules are full. Members who cannot be present must be provided presentation materials by the student, and may attend electronically. It is required without option that Committees meet at least once a year. At each meeting, the Committee chair will prepare a brief progress report with copies sent to you and your file in the office. Meetings with your thesis advisor, who is normally the chair of your Committee, should be far more frequent. Students should plan to complete and defend their dissertation work 4-6 years after entering the graduate program. The Graduate School permits considerably longer durations, but this is not recommended and rarely occurs in our Department.

See sections 5.8–5.9 above for an outline of the requirements of the residency/registration requirement, the written thesis, and the final oral thesis defense. Confirm with the Graduate Staff Assistant that you are approaching completion of all requirements for graduation. Since you have been consulting regularly with your thesis supervisor and Doctoral Committee, the Final Oral Examination should contain very few

surprises. The careful reading and questioning by your Committee at the defense may necessitate revisions before the written version is signed and submitted to the Graduate School. When the signatures are fixed on the official thesis page... Congratulations! You have now achieved a doctorate in Astronomy & Astrophysics at The Pennsylvania State University!

6.8 Progress Reports and Oversight

To document their progress, the students must submit periodic reports. These forms should be prepared and submitted electronically via the [ECoS Graduate Student Activity Report system](#). Reports are due every year and should be submitted to and discussed with either the academic advisors or the thesis committee members. All reports should also be submitted to the Academic Administrative Support Assistant. These reports will be used to assess the progress of students that are considered for awards.

Junior students must prepare a report at the end of each academic year and make them available to their academic advisors prior to a face-to-face meeting with them. Students are required to meet with their academic advisor before the beginning of classes in their first year and immediately after the end of final exams in the spring of their first and second year. This practice should continue until a thesis committee is constituted. Here is a flow chart of relevant actions:

The student fills out the report electronically by the deadline given by the head of the graduate program and submits it.

The *academic* advisor reviews the report and meets with the student. Then the advisor submits comments about the student's academic performance (and research performance, if applicable, after consultation with the research advisor).

The student responds to comments immediately thereafter.

The head of the graduate program reviews everything, writes final comments and submits the final report.

After a thesis committee has been constituted, that committee has the responsibility of monitoring student progress through annual meetings. It is also the responsibility of the students to ensure that they meet with their committee regularly. Students should prepare reports well in advance of the committee meetings and discuss them with the committee during the meeting. After the meeting, the committee chair will write a report giving the committee's assessment of the student progress and response to the student report (if appropriate) and submit it to the Academic Administrative Support Assistant. Here is a flow chart of relevant actions:

The student fills out the report electronically well in advance of the thesis committee meeting. The timetable should allow for iteration with the advisor and submission of the report to the committee a week ahead of the meeting.

The *research* advisor, typically also the chair of the committee, reviews the report and iterates with the student so that all relevant and necessary information is

included. **The advisor should now write and submit any comments at this stage.**

The student produces a PDF version of the report and sends it to the committee members a week ahead of the committee meeting.

Immediately following the committee meeting, the advisor writes a complete report including the committee's assessment of the student progress and its recommendations for future work and submits it through the on-line system (this report plays the role of the advisor's comments).

The student reads the committee's report immediately thereafter and submits a response.

The head of the graduate program reviews everything, writes final comments and submits the final report.

7. Course Descriptions

7.1 Astronomy Graduate Courses

ASTRO 501 – FUNDAMENTAL ASTRONOMY (3 credits). Concepts, tools and techniques, and essential background in stellar, Galactic, extragalactic astronomy, and cosmology. Prerequisites: None

This course, together with its companion, ASTRO 502 Fundamental astrophysics, constitutes the required core curriculum for first-year graduate students in Astronomy & Astrophysics. It is designed to give a wide-scope treatment of fundamental methods, results, and issues in our observational study of celestial objects. It provides a broad understanding of how modern astronomy has elucidated the nature of stars, our Milky Way Galaxy, other galaxies, and the Universe.

Telescopes and detectors at all wavelengths of light are reviewed, along with the basics of positional astronomy. Intrinsic stellar properties are derived from detailed study of stellar positions, colors, spectra, and variability. The Hertzsprung-Russell diagram provides a key to stellar evolution, which is outlined from star formation through post-main sequence stages. The internal structure of the Sun and main sequence stars is explained. The many facets of stellar death are investigated: red giants, white dwarfs, supernova explosions, neutron stars, black holes, and ejecta. The structure of the Milky Way Galaxy, including the complex interstellar medium, is explored. The formation of stars and their planetary systems is introduced. Galaxy properties are presented along with their active nuclei. Observational aspects of cosmology are discussed, including galaxy redshifts, cosmic microwave background, and large-scale structure. A simplified model of the expanding universe is presented.

ASTRO 502 – FUNDAMENTAL ASTROPHYSICS (3 credits). Modern astrophysical theory, including gravitation, gaseous processes, radiative processes, and atomic structure. Prerequisites: None

This course, together with its companion, ASTRO 501 Fundamental astronomy, constitutes the required core curriculum for first-year graduate students in Astronomy & Astrophysics. It is designed to give a wide-scope treatment of fundamental methods, results, and issues in our interpretation of astronomical phenomena using the laws of physics. It provides a broad understanding of how the atomic constituents interact to give the structures of the Universe and produce the radiation observed with contemporary telescopes. The student is assumed to have a strong background in undergraduate-level physics and associated mathematics.

Gravitational physics includes interactions of point particles, hydrostatic equilibrium, Keplerian disks, and polytropes. Gas physics is reviewed, including collisional equilibrium, equations of state, and fluid flow. Radiative processes include elements of radiative transfer, thermal radiation, and radiation from accelerated particles, including bremsstrahlung, synchrotron, and Compton effects. These astrophysical processes will be applied to astronomical structures, such as stellar interiors and atmospheres, star clusters, white dwarf and neutron stars, HII regions and ionized plasmas, spiral galaxy and accretion disks, and galaxy clusters.

ASTRO 504 – EXTRAGALACTIC ASTRONOMY (3 credits). Properties and evolution of galaxies, including their stellar, interstellar, black hole, and Dark Matter components. Prerequisites: ASTRO 501, ASTRO 502

External galaxies were not discovered until the 1920s, but are now understood as a keystone of structures in the Universe. This course considers both the observational characteristics of galaxies and their astrophysical interpretation. It starts with the morphologies of galaxies, such as spiral structure in disks, and proceeds with the dynamics of gravitating stellar systems, gravitational models of galactic structure and dynamics, and galaxy interactions. Galaxy stellar populations, hot and cold interstellar media, supermassive black holes, and Dark Matter are investigated.

The origin of galaxies from collapsing large-scale structures in the expanding Universe, the properties of galaxy clusters, evidence for an intergalactic medium, and continued galaxy mergers, are elucidated. The cosmic evolution of galaxy structure, star formation, galactic chemistry, and nuclear activity is studied.

Additional topics can include: galaxy clustering; galaxy distance scales; gravitational lensing, radio, infrared and X-ray properties of galaxies; supernovae; the origins and dynamics of elliptical galaxies; the detailed modeling of quasar emission and absorption line systems; and cosmic jets.

ASTRO 513 – OBSERVATIONAL TECHNIQUES IN ASTRONOMY (3 credits). Theoretical and practical aspects of modern multiwavelength observational astrophysics including detector physics, imaging techniques, spectroscopic techniques, and data analysis principles. Prerequisites: ASTRO 501, ASTRO 502

This course investigates technologies and techniques essential for modern astronomical observations. The course starts with an overview of telescopes, detectors, and spectroscopes. Principles of data analysis and statistical methods are examined,

including Gaussian and Poisson processes, least-squares, and Fourier analysis. Other topics selectively covered in different offerings of the course include:

optics and design of visible light telescopes, large-telescope design, echelle spectroscopes, CCD detectors

adaptive optics systems, influences of the atmosphere and space environments

radio telescope design, antennas and receivers, single-dish and interferometric systems, aperture synthesis methods

high energy space observatories, X-ray mirrors and detectors, gamma-ray imaging and detectors

cosmic ray, neutrino, and gravitational wave observatories

hands-on laboratories with hardware or tutorials with astronomical software, such as IDL, IRAF, AIPS and R.

ASTRO 515 – ASTROSTATISTICS (3 credits). Prerequisites: None

Modern astronomical research involves many complex tasks in the observational study of planets, stars, and galaxies in the Universe. Large datasets need to be reduced, empirical properties need to be characterized, and the results often need to be modeled with astrophysical theory. These steps require a wide array of nontrivial methods of statistical inference. This course provides concepts, methods, and practical software tools for achieving these goals of astronomical research. The course starts with conceptual foundations of statistical inference including least squares, maximum likelihood, and Bayesian approaches. It then proceeds with discussion of central areas of modern statistics including nonparametric analysis, regression, and multivariate analysis and classification. The course ends with a selection of topics of interest to the class. At every stage, the methodology is linked to problems arising in astronomical research. Classroom experience and textbook study are complemented by training in powerful statistical software environments. The student gets substantial experience with hands-on analysis of contemporary astronomical datasets. Although designed for graduate students in Astronomy & Astrophysics, the course can be useful to graduate students in allied fields of physical science and to advanced undergraduates.

ASTRO/PHYS 527 – COMPUTATIONAL PHYSICS AND ASTROPHYSICS (3 credits). Introduction to numerical methods for modeling physical phenomena in condensed matter, atomic and high energy physics, gravitation, cosmology, and astrophysics. Prerequisites: None

This course provides an introduction to applications of numerical methods and computer programming to physics and astrophysics. Numerical calculations provide a powerful tool for understanding physical phenomena, complementing laboratory experiment, and analytical mathematics. The main objectives of the course are: to survey the computational methods used for modeling concrete physical and astrophysical systems; to assess the reliability of numerical results using convergence tests and error

estimates; and to use scientific visualization as a tool for computer programming development and for physical understanding of numerical results.

Topics to be covered include numerical approximations for functions, numerical calculus and ordinary differential equations, numerical methods for matrices, spectral analysis, and partial differential equations. Examples of advanced topics in physics which will be selectively covered include: molecular dynamics simulations, modeling continuous systems, Monte Carlo simulations, genetic algorithms, and numerical renormalization. Advanced topics in astrophysics include: accretion disks, cosmology, gravitational physics, N-body simulations of galaxies and large-scale structures, and stellar structure models.

ASTRO 528 – HIGH-PERFORMANCE SCIENTIFIC COMPUTING FOR ASTROPHYSICS (3 credits). Training in software development for performing astrophysical simulations and analyzing astronomical data, including attention to reproducibility, parallelization, and computing architectures. Prerequisites: None; Concurrent Courses: ASTRO 501

This course provides an introduction to scientific software development and high-performance computing for the efficient use of modern computing architectures to perform complex astrophysical simulations and analyze large astronomical data sets. Through regular exercises and a final project solving problems in astronomy and astrophysics, students will gain experience applying established software development practices (e.g., version control, coding standards, testing, debugging, profiling, documenting and reviewing code) and optimizing the performance for multiple computer architectures (e.g., serial and multicore CPUs, GPU accelerators, clusters, cloud) in a discipline relevant context.

ASTRO 530 – STELLAR ATMOSPHERES (3 credits). The structure, physics, and observational manifestations of atmospheres of stars. Prerequisites: ASTRO 501, ASTRO 502

The profound success in understanding the physics of stars largely depends on our ability to interpret the continuum and line spectra emerging from their surfaces. This course begins with a treatment of the interaction of atoms, gravity and light including atomic transitions, radiative transfer, and equilibrium atmosphere models. Stellar properties, such as temperature, radii, rotation, and elemental abundances are derived. Transfer in dynamic atmospheres such as, winds and jets are discussed.

Additional topics may include: spectrographic methods; solar and stellar magnetic activity; non-LTE atmospheric models; atmospheres of brown dwarfs and Jovian planets; and dynamic outflowing atmospheres, including stellar winds and jets, and accretion disk atmospheres.

ASTRO 534 – STELLAR STRUCTURE AND EVOLUTION (3 credits). Physics of stellar interiors, stellar structure, and evolutionary changes of stars from pre-main sequence through final states. Prerequisites: ASTRO 501, ASTRO 502

Perhaps the greatest accomplishment of astrophysics from the late-19th through the 20th century is a profound understanding of the physical nature of stars. We understand their generation of prodigious luminous energy, their internal structure, their complex and fascinating evolution. This course starts with the equations of stellar structure and the physics of stellar interiors, including nuclear fusion and nucleosynthesis, opacities and radiative transfer, convection, and equations of state. Models of stellar structure are developed from analytic polytropes to more realistic computational models. The models are applied to the well-established properties of main sequence stars and our contemporary Sun.

The evolutionary stages of stars are then examined including: the nascent pre-main sequence phases; the long-lived main sequence phase; the complex red giant phases; and the death throes leading to the dense white dwarfs and neutron stars. The observational manifestations of these changes are traced on the Hertzsprung-Russell diagram.

Additional topics may include understanding stellar oscillations and pulsations, stellar rotation, binary star evolution, supernovae, and degenerate matter.

ASTRO 542 – INTERSTELLAR MEDIUM AND STAR FORMATION (3 credits). Theory and observation of the interstellar medium of our Galaxy and the process of star and planet formation. Prerequisites: ASTRO 501, ASTRO 502

This course examines the complex ecology of stars, gas, and dust that exist in the disk of the Milky Way Galaxy. The interstellar medium consists of gas and solid particles in rough pressure equilibrium but with temperatures ranging from ten to millions of degrees Kelvin. Observations from telescopes sensitive to the entire electromagnetic spectrum, from radio to gamma-rays, are utilized to examine interstellar matter in solid, molecular, atomic, and ionized states.

The course covers the physics of gas heating (e.g., collisional and photoionization excitation), gas cooling (e.g., atomic and molecular line emission), molecular cloud chemistry, and properties of interstellar dust. Deviations from simple equilibrium resulting from gravitational and thermal instabilities, shocks, turbulence, magnetic fields, photoionization, and cosmic rays are considered. Properties of particular components, such as star forming clouds, HII regions, planetary nebulae, and supernova remnants, are discussed from both observational and theoretical viewpoints. The gravitational collapse of stars from the coldest and densest components of the interstellar material is highlighted, together with the formation of planets in the dense disks around the youngest stars.

ASTRO/PHYS 545 – COSMOLOGY (3 credits). Modern cosmology of the early universe, including inflation, the cosmic microwave background, nucleosynthesis, dark matter, and energy. Prerequisites: None

Cosmology is the scientific study of the universe as a whole: its physical contents, principal physical processes, and evolution through time. Modern cosmology, which began in the early 20th century, is undergoing a renaissance as a precision science as powerful ground- and space-based telescopes allow us to observe the following

phenomena: the formation of the first stars, galaxies, and galaxy clusters; the echoes of the inflationary epoch as they are impressed upon the cosmic-microwave background; and evidence for and clues to the nature of the mysterious dark energy, which is driving the accelerating expansion of the universe. This course will introduce students to the key observations and the theoretical framework through which we understand the physical cosmology of the early universe.

The course will begin with a description of the observational evidence for universal expansion and its interpretation based on the Cosmological Principle, Newtonian cosmology, and the relativistic theory of spacetime. Upon this foundation it will develop the theory of the Big Bang, including the first principles of inflation, and the physical processes that it drives, including the thermal history of the early universe, primordial nucleosynthesis, the formation of the cosmic microwave background and of large scale structure. The observational importance of the cosmic microwave background and its structure in determining the process of the very early universe will be explored. The mysteries of Dark Matter and Dark Energy will be probed. Advanced topics, such as multiple universes, the transition out of inflation, the Dark Ages after recombination, and astroparticle physics may also be treated.

ASTRO 550 – HIGH ENERGY ASTROPHYSICS (3 credits). Theory and observations of X-rays, gamma-rays, and other high energy radiation from Galactic and extragalactic sources. Prerequisites: ASTRO 501, ASTRO 502

With the advent of space-based observatories and new technologies in the late-20th century, astronomers have discovered a wealth of extremely energetic phenomena in the universe. The course starts with an overview of findings from radio, X-ray, gamma-ray, and particle astronomy. High-energy physical processes are reviewed, such as bremsstrahlung, inverse Compton, synchrotron, and atomic line emission. Topics in the astrophysics of energetic environments are investigated, such as magnetic reconnection, compact objects (white dwarfs, neutron stars, black holes), accretion disks, supernova remnants, gamma-ray bursts, active galactic nuclei, and jets. Issues in non-photon astronomy, such as cosmic rays, neutrinos, and gravitational waves, may be examined.

ASTRO 577 – EXOPLANETS (3 credits). Prerequisites: None

Since the early 1990s, thousands of exoplanets have been discovered orbiting other stars beyond our solar system. The properties of these planets have challenged our understanding of how planetary systems form and evolve. This course will cover theories of exoplanets' formation and evolution, the discovery and characterization of exoplanets via exoplanet signals, and the physical properties of exoplanets, including prospects for habitability. Students will learn about exoplanets through a combination of lectures, problem sets, in class collaborative activity, discussion and analysis of the exoplanet literature and talks given at Penn State, and final projects exploring a mini research problem.

ASTRO 585 – TOPICS IN ASTRONOMY AND ASTROPHYSICS (3 credits). Prerequisites: None

These 3-credit Topics courses will be offered as part of the regular sequence of graduate offerings, and can be used to fulfill the graduate degree course requirement on an equal basis with ASTRO 501-550, 3-credit courses. The purpose here is to provide a flexible environment for full courses on subjects that are important to Penn State faculty, research Centers, and students, but that are not covered in the courses with fixed curricular content.

Examples of Topics courses are: Planetary Systems, Dynamics of Stellar Systems, Plasma Astrophysics, Particle Astrophysics, and Astrostatistics.

ASTRO 589 – SEMINAR IN CURRENT ASTRONOMICAL RESEARCH (1 credit). Prerequisites: None

These Seminars will be offered as part of the regular sequence of graduate offerings, and are used to fulfill the graduate degree course requirement for 1-credit Seminars. Their purpose is to treat focused issues of current research interest. Examples include: Physics of Gamma-ray Bursts, Design of Precision Spectrographs, Quasar Surveys, Protoplanetary Disks. These courses are taught by Department faculty, researchers, and visitors.

ASTRO 589 – SEMINAR IN PROFESSIONAL DEVELOPMENT AND RESPONSIBLE CONDUCT OF ASTRONOMICAL RESEARCH (1 credit). Prerequisites: None

This seminar is typically offered every fall semester in addition to any topical research seminar offered in the same semester. All first-year graduate students are required to take it. It comprises mandatory training in Scholarship and Research Integrity ([SARI](#)) and a discussion of a variety of topics related to professional development in Astronomy & Astrophysics.

7.2 Courses in Physics and Allied Fields

Graduate students in the Department of Astronomy & Astrophysics must take at least two 500 level Physics courses. All graduate Physics courses are listed in the table on the following pages. Some courses in allied departments which may interest some students are also listed. Students may take any course in the University for which they are qualified, but the acceptance of a non-standard course for a Graduate Degree Requirement requires that the student submit a petition and receive approval from their advisor and the Associate Department Head. This Petition is given in Appendix D-1. Students should choose their courses in consultation with their academic advisor.

Courses in Physics and Allied Fields

COURSE	TITLE	PREREQUISITES
PHYS 510	General Relativity I	PHYS 557
PHYS 511	Topics in General Relativity	PHYS 510

PHYS 512	Quantum Theory of Solids I	PHYS 412*; PHYS 517 concurrent
PHYS 513	Quantum Theory of Solids II	PHYS 512
PHYS 514	Physics of Surfaces, Interfaces and Thin Films	PHYS 412*
PHYS 517	Statistical Mechanics	PHYS 561
PHYS 518	Critical Phenomena and Field Theory	PHYS 517, PHYS 563
PHYS 524	Physics of Semiconductors and Devices	PHYS 412*
PHYS 525	Methods of Theoretical Physics I	none
PHYS 526	Methods of Theoretical Physics II	PHYS 525
PHYS 527†	Computational Physics	none
PHYS 530	Theoretical Mechanics	PHYS 419*
PHYS 532	Theoretical Continuum Mechanics	PHYS 530
PHYS 533	Theoretical Acoustics	none
PHYS 537	Vacuum Physics	none
PHYS 541	Elementary Particle Phenomenology	PHYS 562
PHYS 542	Standard Model of Elementary Particle Physics	PHYS 564
PHYS 545†	Cosmology	none
PHYS 555	Polymer Physics I	none
PHYS 557	Electrodynamics I	PHYS 400*
PHYS 558	Electrodynamics II	PHYS 557
PHYS 559	Graduate laboratory	none
PHYS 561	Quantum Mechanics I	PHYS 410*
PHYS 562	Quantum Mechanics II	PHYS 561
PHYS 563	Quantum Field Theory I	PHYS 562
PHYS 564	Quantum Field Theory II	PHYS 563
PHYS 565	Interface of General Relativity and Quantum Physics	PHYS 510, PHYS 563
PHYS 571	Atomic, Molecular, and Optical Physics	PHYS 561
PHYS 572	Laser Physics and Quantum Electronics	PHYS 562
ABIOL 574‡	Planetary Habitability	none
STAT 500	Applied Statistics	none
GEOSC 474	Astrobiology	Intro biology & chem
GEOSC 531	Origin of the Earth and Moon	none
CHEM 452	Physical Chemistry – Quantum Chemistry	Intro chem, phys & math
CHEM 464	Chemical Kinetics and Dynamics	CHEM 452
AERSP 401A	Spacecraft Design – Preliminary	Astronautics
AERSP 490	Introduction to Plasmas	Quantum mechanics

AERSP 492	Space Astronomy and Introduction to Space Science	PHYS 400
AERSP 508	Foundations of Fluid Mechanics	none
AERSP 550	Astroynamics	PHYS 419
EE 450	Signal and Image Processing	Fourier & related math
EE 485	Digital Image Processing and Computer Vision	Fourier & related math
EE 551	Wavelets, Filter Banks, and Multiresolution Analysis	Digital signal processing
EE 555	Digital Image Processing II	Digital image processing
MATH 505	Mathematical Fluid Mechanics	Analysis
MATH 513	Partial Differential Equations I	Differential equations
MATH 577	Stochastic Systems for Science and Engineering	Probability
SCI ED 411	Teaching Secondary Science I & II	Teaching course

* Undergraduate Physics Prerequisite Courses: PHYS 400 (Intermediate E&M I), PHYS 410 (Introduction to Quantum Mechanics), PHYS 412 (Solid State Physics I), PHYS 419 (Theoretical Mechanics), PHYS 420 (Thermal Physics)

† PHYS 527 and PHYS 545 are cross-listed as ASTRO 527 and ASTRO 545. Graduate students should register for the ASTRO designations.

‡ ABIOL 574 is approved to substitute for a required ASTRO 500-level course

7.3 Courses in Teaching and Pedagogy

As noted in section 9.5, the [Schreyer Institute for Teaching Excellence](#) acts as a catalyst for instructional improvement by providing programs, service and information including: seminars and consultation services for instructional improvement strategies, mid-semester teaching evaluation, new teacher orientation (including the award-winning [Penn State Course in College Teaching](#)), workshops on teaching technologies (including the [CANVAS Learning Management System](#) and the [Teaching and Learning with Technology](#) program), and more.

The Penn State Graduate School offers the [Graduate School Teaching Certificate](#), which requires a combination of the above courses, offered by the Schreyer Institute, as well as other accomplishments. Details of the requirements and steps of the process can be found at the link above.

8. Policies for Academic Classes

The material in this section will be of use both to students taking classes and to Teaching Assistants.

8.1 Course Registration

Students will normally register well in advance of the registration deadline of 1 day before classes begin — late September for the following spring semester, in February for the following summer session, and late March for the following fall semester; instructions and dates may be found in the [LionPATH Class Search](#). Once preliminary course schedules have been made, schedule adjustments can be performed prior to the first day of class. Students may register for or drop courses during the first 7 days of classes at no charge, but after that there is a \$6.00 fee for each add/drop. Students who register after the registration deadline (typically the day before classes begin) will be charged a \$250.00 late registration fee. **Make sure to register on time every semester to avoid this fee.**

Students not on assistantships who are paying their own tuition and who wish to drop classes must do so before the first day of class in order to get full reimbursement. For drops after classes have begun, a 20% tuition penalty will be assessed during the first week, with 10% more for each subsequent week through the eighth week.

8.2 Assessment and Examinations

Faculty may require any of a variety of assessment tools in the Penn State classroom: quizzes, in-class exams, take-home exams, problem sets, essays, term papers, oral presentations, and so forth. Written notification of required work and assessment procedures (e.g., formulae showing how the course grade will be calculated) for each class must be included in the syllabus and made available to the students during the first ten calendar days of a semester. Syllabi must also summarize ethical standards concerning plagiarism and related matters (Appendix B). Syllabi must be provided to the Department Office at the beginning of each semester.

All courses have a final examination or some other means of testing the student integration of the instructional material (e.g., term paper, final project report, take-home examination, etc.) during Final Exam Week. Course instructors determine which of these methods is most appropriate. Term papers, take-home exams, etc., when used in place of a standard final examination, must be due no earlier than the first day of the final exam period. Written final examinations must be scheduled in the final examination period. No examinations may be given during the last week of classes, with the exception of quizzes and narrowly limited tests in support of classroom instruction.

Graduate students, either as students or TAs, should not make travel plans which prevent them from being present for a final exam. Note that the schedule for final exams is not published by the Registrar before mid-semester, and **cannot** be changed by a faculty member. TAs must also reserve time to help with the assessment of the Final Exam and construction of the course grades with the supervising faculty member.

8.3 Grading

In normal courses, the following “quality” grades can be assigned: A, A-, B+, B, B-, C+, C, D, or F. The meanings of the grades are: A = excellent, B = good, C = satisfactory, D = poor, F = failure. Grade point averages are based on a four-point scale, with A = 4.00,

A- = 3.67, B+ = 3.33, B = 3.00, B- = 2.67, C+ = 2.33, C = 2.00, D = 1.00, F (fail) = 0.00. All graduate students are required to maintain at least a B average (i.e., a 3.0 GPA) by the University. In addition, for advancement to PhD candidacy, the Department of Astronomy & Astrophysics requires a 3.2 GPA in core courses. An “R” (Research) grade is sometimes used in 600-level courses; this denotes satisfactory progress and is not used in calculating a grade point average.

There are three circumstances under which a course grade, once assigned, can be changed: a calculation error; an R grade converted to an A-F grade; and a deferred grade. Deferred (DF) grades are temporary and apply only if work is incomplete at the end of a semester because of extenuating circumstances. The student must complete the course work by the 10th week following the end date of the course, when the instructor must replace the DF with a letter grade; otherwise the DF automatically converts to an F. It is not appropriate to use the DF either casually or routinely; e.g., to extend a course for a student who is failing or who wants to improve their grade. DF grades may not be present when a graduate student seeks a milestone (i.e., Candidacy Exam, Comprehensive Exam, Final Oral Exam, MS or PhD degree).

A student doing research needs to register for an appropriate number of credits in 596, 599, or 600-level courses (see section 5.3 for details). The student should consult with their advisor and the Graduate Staff Assistant on the appropriate course number, credit load, and registration procedure. There is a limit to the number of research credits that can be assigned letter grades: 6 credits for master’s candidates and 12 credits for doctoral candidates. Beyond these limits a grade for satisfactory research is reported as R.

8.4 Evaluations of Teaching Effectiveness

Each Teaching Assistant who is assigned as an instructor of an ASTRO 11 laboratory or other course must enroll in **ASTRO 602, Supervised Experience in College Teaching** during a **Fall** semester prior to or concurrent with their first semester of teaching. As part of the grade, each TA will be evaluated by the Astro 11 Laboratory Supervisor. In addition, the students in each section of every course complete the University-wide Student Ratings of Teaching Effectiveness (SRTEs), including Department-specific questions. These are assessed by the Department’s Teaching Committee and by the Department Head. Continuation of TA support is contingent upon satisfactory performance as an educator as evaluated both by the faculty and students. The SRTE and other evaluations are administered within the last three weeks of a semester. Every effort should be made to obtain maximum participation from the Astro 11 students – this will be discussed in the ASTRO 602 class, and in short, weekly, TA planning meetings.

8.5 Academic Integrity

Academic integrity is the pursuit of scholarly activity in an open, honest, and responsible manner. Academic integrity is a basic guiding principle for all academic activity at The Pennsylvania State University, and all members of the University community are expected to act in accordance with this principle. Consistent with this expectation, the University’s Code of Conduct states that all students should act with personal integrity,

respect other students' dignity, rights, and property, and help create and maintain an environment in which all can succeed through the fruits of their efforts. Academic integrity includes a commitment *not* to engage in or tolerate acts of falsification, misrepresentation, or deception. Such acts of dishonesty violate the fundamental ethical principles of the University community and compromise the worth of work completed by others.

To protect the rights and maintain the trust of honest students and to support appropriate behavior, faculty and administrators should regularly communicate high standards of integrity and reinforce them by taking reasonable steps to anticipate and deter acts of dishonesty in all assignments (e.g., by proctoring examinations). At the beginning of each course, it is the responsibility of the instructor to provide students with a statement clarifying the application of University and College academic integrity policies to that course.

The University procedures provide for two types of sanctions: academic sanctions and disciplinary sanctions. Academic sanctions range from a warning to removal from the academic program, and include deductions of points or alterations in grades. Academic sanctions are determined and assigned by the instructor or by the instructor together with the College Academic Integrity Committee. Disciplinary sanctions may be recommended by the instructor, the College Committee, or the Associate Dean, and are assigned by the Office of Judicial Affairs. The XF grade is a disciplinary sanction that is only assigned with the concurrence of the instructor, the College of Academic Integrity Committee, and Judicial Affairs. Grades shall be assigned to individual students on the basis of the instructor's judgment of the student's scholastic achievement.

Please read the University and Eberly College of Science Integrity policies in Appendix B.

9. Guidelines for Teaching Assistants

The purpose of this section is to establish a set of rules for graduate Teaching Assistants (TAs) in the Department of Astronomy & Astrophysics. The guidelines presented here are primarily intended to ensure that the teaching of undergraduate level astronomy be done in a uniform manner. This is important as virtually all the students in the ASTRO 11 laboratories are also taking an astronomy lecture course, either ASTRO 1, 5, 6, or 10, and the learning that occurs in the laboratories should complement that which occurs in the lectures.

9.1 General Guidelines for All TAs

These guidelines apply to ASTRO 11 laboratory instructors. They will be presented in outline form. As a preface to the outline it is noted that the 1/2 time assistant is expected to devote an average over the semester of 20 hours per week to his/her teaching duties. The teaching assistant is expected to work for 17 weeks per semester (one week before classes start and one week after they end).

Most TAs will be involved in teaching the **ASTRO 11 Elementary Astronomy Laboratory**. This is a 1-credit lab course that meets once per week for two hours. The standard curriculum is a series of in-class experiments, most of which are completed on computers using online data and resources, plus some out-of-class roof-top observing. While the core of the curriculum is uniform across all sections, TA creativity is encouraged and deviations from or additions to the curriculum are welcome to be discussed with the supervising faculty. Typically, a teaching assistant will be assigned two distinct ASTRO 11 labs per week or one ASTRO 11 lab and another supporting TA role. Although ASTRO 11 TAs report to the Teaching Assistant Supervisor, the TA is the instructor of record of his or her class, and as such has complete authority and responsibility for what goes on inside their classroom.

Information on each semester's ASTRO 11 Labs may be obtained by contacting the Teaching Assistant Supervisor.

Instructions on how to prepare for the start of a semester will be discussed in great detail during the new TA orientation and planning meeting the week before classes start – so don't miss it!

9.1.1 General Duties of a TA

The following pertains to TAs who are teaching ASTRO 11 Labs:

All scheduled classes are expected to be taught. If you are ill or unavoidably required to miss your assigned class, you **must** arrange for another teacher (preferably a TA for the same course) to teach your class effectively. You must also advise the course or laboratory supervisor of any such arrangement.

Arrive at class a few minutes before the class starts and begin class promptly at the scheduled time. End on time as well, but be prepared to stay a few minutes after class to answer extra questions from your students.

Frequently remind your students to take advantage of regular office hours when you (and other TAs) are available to help them outside of class. All TAs and supervising faculty will coordinate office hours as a group during the weekly TA planning meetings at the beginning of the semester; details will be given then.

Attend the weekly meetings held by the Teaching Assistant Supervisor.

Be prepared when you show up to teach your class. Be professional and courteous to your students.

Grade and return your students' lab work within one week. When grading, include brief written comments to provide your students with feedback about their work.

Complete and return the forms which indicate the progress of student athletes.

Complete and submit final grades in [LionPATH](#) promptly during final exam week. A copy of your grades must also be provided to the graduate staff assistant in hardcopy or electronic format.

In addition to teaching ASTRO 11, several duties associated with the associated lecture courses are typically assigned to a teaching assistant, including one or more of the following:

holding office hours to support general ASTRO course instruction

attending all of a professor's lectures, and sometimes assisting the professor with an activity during lecture

proctoring exams

suggesting and writing exam questions, and proofreading exams

grading assignments and exams

preparing and posting solutions sets

preparing student grades

keeping the roster of student grades up to date; the professor may need this at any time in electronic format

Matters to be brought to the attention of the Teaching Assistant Supervisor include:

cheating by students (For academic integrity guidelines, see Appendix B.)

excessive absences by students

aberrant behavior by students which disrupts the classroom

9.1.2 Materials Needed by a Teaching Assistant

Electronic access to and/or a hardcopy of the Astro 11 lab manual will be provided by the Teaching Assistant Supervisor. Other general supplies as needed may be obtained from the main office. Electronic access to your class roster will be provided to each TA as soon as teaching assignments are finalized at the beginning of the semester on Penn State's learning management system, "[CANVAS](#)". All course logistics (roster, grades, syllabus, etc.) should be centrally managed on CANVAS, which is automatically backed up.

9.2 Specific Guidelines for Laboratory TAs

9.2.1 Laboratory Duties

Re-familiarize yourself with the lab before class starts, and check that any needed links are working.

Report any typos, errors, or broken links to the Teaching Assistant Supervisor and other TAs in the weekly TA planning meeting before that lab, AND record it on the “Master list of Errata for lab manual” list on the “Astronomy 11 TA materials repository” group on CANVAS, which all TAs should have write access to.

Learn the names of your students as soon as possible. In addition, every effort should be made to give the students the strongest possible impression that the instructor knows and cares how well each student is doing. The best way to do this is to sincerely know and care how well each student is doing.

Be available to the students for help, and encourage them to ask you questions.

Move about the room continuously during class and engage the students with pertinent and probing questions to check on their progress. This should motivate them to think about what they are doing.

Do not grade lab reports in class or do other work while you are teaching. This sort of activity makes the students feel that they are disturbing you when they ask questions, and discourages interactivity.

Grade all lab reports and return them to the students at their **next** laboratory class meeting.

Do all the experiments yourself before teaching them AND WRITE OUT FULL ANSWERS TO ALL QUESTIONS. (First-time TAs will be expected to complete them all prior to the beginning of the semester, but returning TAs should repeat each week’s lab before class.) Outline your results and note any difficulties, so that you are prepared to help the students through the rough spots.

Take your own write-up of the lab activity and your complete written answers to class with you when you teach, as it is a useful reference. Bring it to the weekly TA planning meeting as well for discussion.

It is expected that the lab instructors will refrain from:

Talking on their phones or with non-students while lab is in session.

Grading papers, doing other work, or surfing the web while class is in session.

Spending large amounts of time absent from their assigned classroom while the lab is in session.

9.2.2 Rules for the Labs

The following rules govern the students' behavior in the lab. The teaching assistant should make these rules very clear to the students at the lab's first meeting.

No horseplay by students is to be tolerated.

No smoking, eating, or drinking is allowed in the laboratory rooms. (Since labs meet in computer rooms, this policy is likely to be posted in the room as well.)

All labs start on time. Students who are habitually late will be penalized.

Students are expected to complete all work and turn in their lab papers before leaving. Activities are designed to be completed within two hours, so students who stay on task should be able to finish. The instructor may, at their discretion, allow a student to occasionally turn in a lab late for a legitimate reason. Under no circumstances should you advertise this to the whole class! If a student is routinely not finishing on time, discuss the reason and work together on a solution that does not involve them handing it in late.

Students will receive official notification of any changes in their scheduled lab time. Students wishing to make schedule changes, such as switching sections, must do so through LionPATH. TAs cannot do this for them.

Students will take all labs at the times assigned, unless written permission is granted by their lab instructor. At their discretion, TAs may allow a student to make up a missed lab.

Only legitimate reasons with written documentation will be accepted for students wishing to make up a missed lab.

Make-up labs should, if possible, be done in one of the other labs taught by the same instructor. If this can't be done, the student can be sent to another instructor's section to make up the lab during that same week. The other instructor must be notified in advance and in writing that this is what the original lab instructor intends. No students shall be accepted in an instructor's classes for make-up without prior notification by the student's regular lab instructor or the Teaching Assistant Supervisor.

Students will be penalized for missed labs and late work that was not explicitly permitted by the instructor. The amount of the penalty will be specified by the lab instructor.

9.3 Relationships Between TAs and Students

Romantic or sexual relationships between faculty/staff and students have potential for adverse consequences, including the filing of sexual harassment charges. The apparent consensual nature of a relationship may be inherently suspect when one party has the power to give grades, thesis advice, recommendations, or performance evaluations. Even when both parties have consented to the relationship, there may be serious concerns about conflict of interest as well as unfair treatment of others. Refrain from any

kind of social or romantic involvement with your students until after final grades are submitted.

9.4 Evaluations of Teaching Effectiveness

ASTRO 11 TAs usually enroll in **Astro 602, Supervised Experience in College Teaching**. Your grade for ASTRO 602 will be determined by the Teaching Assistant Supervisor, based on the Supervisor's visits to the labs, TA attitude, timeliness, participation in planning meetings, and completion of any other non-Astro 11 TA duties.

The results of the evaluations are assessed by the department's Teaching Committee and by the Department Head. Continuation of teaching assistant support is contingent upon satisfactory performance as a teaching assistant, including results of SRTEs. If the Teaching Assistant Supervisor determines that a teaching assistant is failing to meet acceptable standards, the graduate student's teaching assistantship may be terminated.

9.5 Instructional Development Program

Penn State has a training facility for college teaching that is available to all Teaching Assistants. The [Schreyer Institute for Teaching Excellence](#) acts as a catalyst for instructional improvement by providing programs, service and information including: seminars and consultation services for instructional improvement strategies, mid-semester teaching evaluation, new teacher orientation (including the award-winning [Penn State Course in College Teaching](#)), workshops on teaching technologies (including [Teaching and Learning with Technology](#) program), and more.

10. Assistantships and Support

Students who maintain regular academic status and who make adequate progress toward completing their degrees can generally expect continued financial support, either in the form of a Graduate Teaching Assistantship (TA), Research Assistantship (RA), or Fellowship. Fellowships can derive from University (e.g., the University Graduate Fellowships) or external sources (e.g., the NSF or NASA Graduate Fellowships). You can always obtain information on the terms of your appointment from the Graduate Staff Assistant.

During the fall and spring semesters, graduate students are usually appointed as TAs or RAs. These appointments also cover tuition fees associated with course registration. A student's salary is divided into ten equal installments, August through December (fall semester) and January through May (spring semester), and is paid on the last work day of each month. Penn State requires that all employees have their paychecks deposited directly into a checking or savings account.

During the summer session, June, July, and part of August, graduate students are usually supported as RAs on fixed term appointments. Graduate students are not required to register for the summer session; so, no tuition is charged. The one exception to this rule is that any student scheduling their oral comprehensive exam or final thesis

defense must be registered during the semester in which their exam is scheduled, including the summer session. If a student plans to schedule either of these exams during the summer, they will be appointed as a graduate research assistant and tuition will be covered.

10.1 TAs and RAs and General Expectations

Most first and second year students in the Department are supported via TAs for their fall and spring semesters (August 16 through May 15). Stipends are often set at Grade Level 14 where the [stipend pay rates](#) are determined annually by the University. After the first year, it is common for students to be appointed one semester at a time, since their funding sources can often change.

RAs are funded by specific grants from agencies such as NASA and the National Science Foundation to individual faculty members or research groups, although the funds are processed through the University. The specific terms of employment depend on their direct research supervisor; RAs should discuss their specific job expectations with their research supervisor well in advance. It is the expectation of the Department that a graduate student will provide prior notice of any planned absences from the Department (e.g., personal or work travel) to the supervisor of their teaching or research assistantship to ensure that the duties of their assistantship are fulfilled. A student is also expected to contact their supervisor in the event of an unplanned absence (i.e., illness or emergency) that would interfere with the duties of their assistantship, as allowed by circumstances.

RA stipends are usually set at Grade 14 before the student passes their Comprehensive Exam and raised to Grade 15 after passing the exam.

10.2 Awards and Fellowships

A number of fellowship opportunities exist for students in the Department of Astronomy & Astrophysics. Some are full fellowships, which provide salary and research support for 2 or 3 years, some are small grant awards for a specific purpose, and others are general awards based on achievement. Most external fellowships are open to US nationals only, but some can also support foreign students. Funding selection criteria and the number of available awards are highly variable; the list below (section 10.2.1) is not meant to be comprehensive. For internal Penn State Fellowships, eligible students will be informed of application procedures by the Associate Department Head. Application for these fellowships by current students is usually made in April-May. For externally funded Fellowships, the Department will forward relevant announcements it receives, but the student is responsible for finding on-line information and deadlines. The University [Office of Graduate Fellowships and Awards Administration](#) coordinates some funding opportunities, including the NSF Graduate Fellowships.

10.2.1 Penn State Fellowships and Awards

[University Graduate Fellowships \(UGF\)](#) are awarded by Penn State University to incoming graduate students based on their academic and research record as undergraduates. UGF Fellowships are for one year and carry a full stipend plus a full

tuition waiver. The Department of Astronomy & Astrophysics nominates students for this award using their application packet.

Homer F. Braddock and Nellie H. and Oscar L. Roberts Fellowships are \$4,000-\$6,000 income supplements that are usually awarded by the Eberly College of Science to selected students entering its graduate programs. These awards are based on a number of criteria, including the student's academic and research records as undergraduates, and typically last for 1-2 years. On occasion, a Braddock/Roberts fellowship may also be given to a continuing student. The number of Braddock/Roberts awards available per year is highly variable.

Stephen B. Brumbach Fellowships in Astrophysics are income supplements issued by the Department to recognize "Excellence in academic performance and research during the first two years at Penn State." All second-year students are automatically considered for this Fellowship. Evaluation is based on Penn State transcripts, the second-year research project report, and performance on the Candidacy Exam. Typically 1-2 fellowships are awarded each year, each with value around \$4000, depending on availability of funding. On occasion, the Department may issue a Brumbach New Graduate Fellowship to recognize an "outstanding entering or first-year graduate student."

Downsbrough Graduate Fellowships in Astrophysics are income supplements issued by the Department to recognize "Outstanding scholarly achievement at Penn State." Applicants must be nominated by a Graduate Faculty member. Third year and later students are eligible providing they have passed their Comprehensive Examination and are registered for the following semester. A student can win the fellowship only once. Evaluation is based on a faculty nomination letter(s), a detailed resume, and full-text documents of major accomplishments (e.g., published or submitted papers, instrument or code descriptions). Typically one fellowship is awarded each year with value around \$4000.

Zaccheus Daniel Fellowships are awards by the Zaccheus Daniel Trust, a Pittsburgh foundation seeking to "promote the study of the science of astronomy in Pennsylvania." The fellowships awarded by the Department provide "Small travel or research grants for graduate student research." Expenditures can cover travel, equipment, and similar needs, but not salary. Typically 5-10 fellowships are awarded each year with values around \$1000, but requests up to \$5000 can be made. Repeated applications are permitted.

TA of the Year Award is presented yearly by the Department in recognition of outstanding teaching by a graduate student. The award has a value of \$500.

10.2.2 Fellowships from External Agencies

National Science Foundation Graduate Research Fellowships are three-year fellowships for entering and first year graduate students in science, mathematics, and engineering. About 900 are awarded each year, and the fellowship provides \$30,000 a year for the student (plus \$10,500 to cover university expenses, such as tuition). The

deadline for applications is the beginning of November. For US citizens and permanent resident aliens.

Pennsylvania Space Grant Consortium awards fellowships to outstanding students in fields of study that promote the understanding, assessment, and utilization of Space or the NASA Strategic Enterprises. These fields include Aero-Space Technology, Earth Science, Human Exploration and Development of Space, Space Science, Biological, and Physical Research. Several new fellowships are given to Penn State students each year, and some are extended for a second year. The application deadline is usually the end of March. For US citizens only.

National Defense Science and Engineering Graduate (NDSEG) Fellowships are three-year awards by the Department of Defense to students entering or in their first year of graduate school. Between 100 and 200 fellowships are awarded each year in areas such as Physics, Geosciences, Chemistry, Astronomy, Oceanography, Aeronautics, Computer Science, Mathematics, Biosciences, and Engineering. The stipend is very generous and includes tuition. The application deadline is early January. For US Citizens only.

Zonta Amelia Earhart Fellowship Program granted annually to women pursuing graduate degrees in aerospace-related sciences and aerospace-related engineering. About 35 awards are given out each year; these scholarship are for \$10,000, and may be used for tuition, books, fees, or living expenses. The application deadline is November 15.

SPIE Scholarships recognize, assist, and encourage student members of the Society for Photo-Optical Instrumentation Industrial Engineers and academic organizations with outstanding potential for long-range contribution to the field of optics and photonics. The deadline for applications is the end of January.

Sigma Xi Grants in Aid of Research (GIAR) program awards grants of up to \$1,000 to students in all areas of science and engineering. Designated funds from the National Academy of Sciences allow for grants of up to \$5,000 for astronomy or vision related research. Students may use the funds to pay travel expenses to and from a research site, or for purchase of non-standard laboratory equipment necessary to complete a specific research project. The deadlines for application are March 15 and October 15.

Dr. Gerald A. Soffen Memorial Fund for the Advancement of Space Science Education sponsors a travel grant “to students pursuing undergraduate or graduate degrees in aerospace-related sciences or engineering fields to attend a meeting at which they will present their research.” The deadline for application is Oct 15.

11. Research Facilities and Resources

11.1 Library Facilities

The second floor of Davey Lab houses the **Physical and Mathematical Sciences Library** (PAMS). This library has an outstanding collection of astronomy books and periodicals,

most under the Library of Congress rubric “QB”. The main university library is the Pattee/Paterno Library, a short walk from Davey Lab. Browsing through the [University Library’s on-line catalog](#) is recommended, as it shows holdings at all locations (including the Annex with historical collections) and permits recall of books that are currently in use.

Today, members of the Department obtain most of their library resources, including full-text articles in most journals, on-line. Most are available through Penn State’s subscription to the [NASA Astrophysics Data System](#) (ADS) Astronomy and Astrophysics Abstract Service and the [astro-ph arXiv e-Print archive](#). Full-text access to all articles in the ADS requires login from a computer within the astro.psu.edu or library network. On-line text for some general science journals, such as *Science and Nature*, are not available through the ADS, but *are* available through Penn State’s extensive on-line library resources and e-journals.

11.2 Computing Facilities

Department computing resources include several dozen workstations and personal computers on the astro.psu.edu network. The system is heterogeneous with machines from different manufacturers and capabilities. The Department officially supports systems running Linux, MacOS or Windows. Important astronomical, mathematical, and scientific software packages are available from a central server including IDL (limited licenses), MatLab, Mathematica (limited licenses), R, IRAF (via the Ureka suite), CIAO, HEASOFT (including FTOOLS), CLOUDY, and more. Many general purpose and open source packages are also supported in the Department (TeX/LaTeX, browsers, editors, compilers, etc.), and others can be purchased at low cost for individual machines from [Software@PennState](#). Graduate students receive an email account (abc123@psu.edu); this should be a UCS IMAP account, which is allotted 3 GB for email storage. Students also receive 15 GB of on-line space for their home directories, which are regularly backed up to local and remote RAID units; large datasets and their analysis should be pursued using the bulk disks attached to individual machines – these drives are not backed up. Many of the workstations have been outfitted with extra processors and memory so that faculty and graduate students can intensively process data sets from various ground- and space-based observing platforms from around the world. Intra-Department hardware problems can be addressed to [helpdesk@science.psu.edu](#).

The department has a wired 1 GB/s intranet with a 1 GB/s fiber optic connection to the University backbone which it linked to the Internet via a T3 line. Department members can also access the University backbone through a wireless connection using their personal [Penn State ACCESS account](#) (prior registration is required) and [Penn State’s VPN client](#) with host “ITS Wireless at University Park.” Generally, users have fast and unlimited access within the Department network and out into the Internet from all machines.

Graduate students are usually provided with individual computers, either by the Department or by their research supervisor. Department accounts for new students are activated by the IT staff. Graduate students also have access to University-level high-performance computing and data visualization through the [Research Computing and](#)

[Cyberinfrastructure](#) group. These include Linux clusters with over 1000 processors, immersive Virtual Reality facilities, and extensive associated software. Departmental storage allocations and bandwidth is subject to change as resources permit.

11.3 Observing Facilities

11.3.1 The Hobby-Eberly Telescope

The [Hobby-Eberly Telescope](#) (HET) is a 9-meter class, Arecibo-like optical telescope located at McDonald Observatory, near Ft. Davis, Texas. The telescope project is an international collaboration involving Penn State, The University of Texas at Austin, and Stanford University, in the U.S., and the Ludwig-Maximilians-Universitaet Muenchen and Georg-August-Universitaet Goettingen, in Germany. The Penn State share of the telescope is 25%. The telescope saw first light in December 1996 and the first scientific results were obtained in the spring of 1999 with the Marcario Low-Resolution Spectrograph (LRS), a focal plane imaging spectrograph with a resolving power of $300 < R < 1300$ and multi-object capability. Other facility instruments include the High-Resolution Spectrograph (HRS; $30,000 < R < 120,000$) and a medium-resolution optical/near-IR multi-object spectrograph (MRS, $5000 < R < 20,000$). Information to the current status of the telescope and its instruments can be found at the [PSU HET Web site](#). HET time is allocated three times each year with proposal deadlines of 15 February, 15 June, and 15 October. Graduate students are often Principal Investigators on HET proposals.

11.3.2 Davey Roof Telescopes

There are three domes on the roof of Davey lab, each housing a telescope. The largest telescope is a 24-inch, computer-controlled Cassegrain reflector, which is equipped with a CCD camera and a set of broad-band and narrow-band imaging filters. Another dome houses a 12-inch Meade LX200 Schmidt-Cassegrain telescope, equipped with a CCD camera, autoguider, and a variety of eyepieces and objective filters. These telescopes are primarily used for upper division undergraduate astronomy courses and public outreach. The third dome currently holds several smaller telescopes including 8-inch Schmidt-Cassegrain (Celestron) telescopes and a 4-inch Astroscan. Additional smaller telescopes belong to the Penn State Astronomy Club and are stored in the Davey domes.

11.3.3 Chandra X-ray Observatory

NASA's [Chandra X-ray Observatory](#), launched in 1999, is one of NASA's four Great Observatories. It is dedicated to obtaining high resolution X-ray images and spectra. Evan Pugh Professor Gordon Garmire led the team that built Chandra's prime instrument, the [Advanced CCD Imaging Spectrometer](#) (ACIS). As a result, Penn State astronomers can use Guaranteed Time Observations as well as the General Observer program. Subjects actively studied at Penn State include: ultra-deep cosmological surveys, supernova remnants and neutron stars, star forming regions and young stars, quasar lensing, and more.

11.3.4 Swift Gamma Ray Burst Explorer

[Swift](#), the Gamma Ray Burst Explorer satellite, was launched in December 2004. Penn State researchers played critical roles in fabricating the satellite, and now operate it for NASA at the Mission Operations Center (MOC) at Bristol Park, a few miles south of the Department. This facility has three co-aligned instruments: a wide field coded-aperture gamma-ray imager (BAT), an arcsecond resolution X-ray imager (XRT), and a UV/optical telescope (UVOT). When a gamma-ray burst goes off, the BAT detects the glow and produces an arcminute position for the object within seconds of the event. Within a minute, the spacecraft executes a rapid autonomous slew and focuses the XRT and UVOT telescopes on the target. These instruments then create a multiwavelength lightcurve for the afterglow, while simultaneously transmitting the position of the source to the MOC and to the scientific community via the Internet.

11.4 Interdisciplinary Research Centers

11.4.1 Institute for Gravitation and the Cosmos

The [Institute for Gravitation and the Cosmos](#), located in the Department of Physics, includes the Center for Fundamental Theory, the Center for Gravitational Wave Physics, and the Center for Particle Astrophysics. Several faculty members in Astronomy & Astrophysics are deeply involved in Institute management and activities. It provides a forum for the cross-disciplinary interaction of scholars in several fields. Some of the work concerns the underpinnings and applications of gravitational theory. Other work is observational, involving the LIGO gravity wave, Auger cosmic ray, and IceCube neutrino observatories. The Institute provides a wide range of opportunities for graduate student training and research.

11.4.2 Astrobiology Research Center

The [Penn State Astrobiology Research Center](#) was established in 1998 as part of the NASA Astrobiology Institute (NAI) to promote the frontier science field of Astrobiology. More than 100 people, from the departments of Chemistry, Physics, GeoScience, Biology, Paleontology, Biochemistry, Microbiology, and Astronomy & Astrophysics are involved in the center. PSARC not only conducts research projects, but also supports a wide variety of education and outreach events.

11.4.3 Center for Astrostatistics

The [Center for Astrostatistics \(CAST\)](#) is cross-disciplinary research and outreach organization hosted by the Departments of Statistics and Astronomy & Astrophysics. Led by Statistics Professor G. Jogesh Babu and Astronomy & Astrophysics Professor Eric Feigelson, CAST organizes cross-disciplinary conferences and research workshops including, the Statistical Challenges in Modern Astronomy conferences and the SAMSI Astrostatistics program. It teaches the annual Summer School in Statistics for Astronomers serving graduate students at Penn State and worldwide, and provides a variety of Web resources, including statistical software.

12. Other Topics

12.1 Colloquia, Seminars, and Other Gatherings

Astronomy colloquia, seminars, and special lectures, and other events are listed on the department [calendar](#).

Department Colloquia are talks by external speakers that are offered every week (usually on Wednesday at 4 p.m. in room 538 Davey) and cover a variety of topics. Their purpose is to provide up-to-date knowledge to students and faculty on a variety of topics in astronomy and astrophysics. Colloquia are intended to be accessible to astronomers who are not specialists in the subject matter. It is expected that all students will attend most of the departmental colloquia. They are preceded (15 minutes) by a short cookies and coffee break in the Reading Room (Room 530). In addition, graduate students are often invited to have dinner with the colloquium speaker immediately after the talk.

Tuesday Lunch Talks Every Tuesday, from 12:15-1:00 pm, a member of the department (a faculty member, postdoc, or graduate student) gives a science talk in room 538 (Research Talk), or two members each give short (20-minute) reports. These lunch talks are less formal than a colloquium, and often describe projects that are “in progress.” The purpose of these talks is to bring members of the department up to date on research currently being performed in the Department. Graduate students can either give short research reports or, particularly for first year students, a “journal club” talk. Journal Club talks review and analyze an important recent scientific article. Second year graduate students are expected to present the results of their summer or second-Year Project. Note that these talks usually serve as the test of oral English Competency for first year graduate students.

Chemerda Lectures This is a series of 3 lectures occurring annually with sponsorship rotating between physical sciences, biological sciences, and mathematical sciences. One is a public lecture, and the other two are private lectures for the department.

Marker Lectures Once a year, every department in the Eberly College of Science invites a distinguished scientist to visit Penn State for a week and present a series of lectures. Typically, the first of these lectures will be at a level suitable for the public; the latter 2-3 talks will be at a level for graduate students and faculty.

Friedman Lectures Friedman Lectures are free lectures in astronomy for the general public. Typically, one of the lectures each year will feature a distinguished scientist from outside Penn State.

Daily Coffee Break The Department of Astronomy & Astrophysics provides ample opportunity for informal interaction among students, faculty, and staff. The department maintains espresso and coffee machines and tea at nominal cost in the Reading Room (530 Davey Lab). The department holds a coffee break each morning from 11:00-11:30 am, and a short coffee and cookie break just prior to the weekly [colloquium](#). These gatherings allow for interactions with a broad spectrum of graduate students, postdocs, and faculty.

Reading Room 530 Davey is a multi-purpose room for informal reading, chatting, lunch, and coffee. It houses magazines and a small library, a coffee machine, microwave ovens, and a refrigerator. These are all available for general use, and everyone is invited to lunch or gather in this room.

Other Events From time to time, there will be other special events that involve the department. These include social occasions, such as the Student Awards Reception in April, Undergraduate Research Symposium, and ice cream socials on the roof (weather permitting). Graduate students will generally receive notice of such events by email via the email listserv.

12.2 Printing and Photocopying

Please see the department's [Printing and Copying Charges policy](#). This policy sets the per- page rate of copies and printed pages by department copiers and printers and defines an allotment for faculty, researchers, and graduate students. You will need a code to use the copy and fax functions. See the staff in room 525 to retrieve your code. These codes are applied individually and should not be shared with anyone else.

If there is any type of an issue with the machines, contact the IT staff at helpdesk@science.psu.edu. If a machine runs out of paper, see the office staff in 525. You are not permitted to edit or change any settings on these machines, nor are you allowed to add or edit email addresses or phone numbers. For any requests, see the office staff in 525. If a paper jam occurs, the screen will highlight the areas that need cleared. Open the doors and pull or adjust the appropriate blue handles until all the paper has been removed. The screen will continue to highlight problems until it is fixed.

We have 2 multi-function machines in rooms 532 and 416 which you may use to print, copy, scan, and fax. There is an additional machine in 525.

The 416 copier/printer/scanner/fax room is locked around 4:30P, Monday through Friday. You can access this room after hours by using your "F" key. If you do unlock this room after hours, you MUST relock it when you leave the room.

Scan: Documents are scanned directly to your email address, which is already programmed into the machines.

Fax: The fax number for the machine in 416 is 814-863-3399. Remember to dial an 8 to get off campus and a 1 to dial long distance. If the fax line is busy, press "stop" and try again later. If the fax line is continually busy, try calling the department/office to which you are sending. Often, it is a problem with their machine. The fax will not tell you if a fax was sent successfully. You must press the TX File Status button to see if the fax went successfully. If it does not send, the machine will print an error report. Faxes should only be used for departmental business and research.

Mass Copying: For a large volume of copying (50 pages or more), we send the order to Copy Central. We accept hard copies or electronic copies to place the order. Please see Kaylee Harter in 525 at least one week in advance to order copies.

Please be aware of Federal regulations concerning photocopying copyrighted material. “Fair use” copying in an academic setting is permitted, but the law is complicated. See the University [policy on copyright clearance](#) and the useful document “[Copyright Law and Graduate Research](#)” or [Copyright Law for Librarians and Educators: Creative Strategies and Practical Solutions](#) by Kenneth D. Crews.

12.3 Telephones

Telephones in offices can be used for intra-University calls by dialing the last 5 digits (5-XXXX or 3-XXXX), and for local, off-campus calls with an “8” prefix (e.g., 8-238-XXXX). Long distance (8-1-XXX-XXX-XXXX) and international calls (8-011-XX-city-number) are only allowed for research and departmental purposes; these require a 7 digit authorization code. The University’s telephone system is VOIP (Voice Over Internet Protocol) and calls are quite inexpensive.

12.4 Graduate Research Exhibition

The [Graduate Research Exhibition](#) is open to all Penn State graduate students. Any sound, scholarly research or creative activity can be entered, as long as a well-defined part of the project is complete. Exhibits are judged on their quality in three areas: content, display, and oral presentation. All exhibitors receive certificates of appreciation; those whose exhibits are judged best receive award scrolls as well as monetary awards in the form of budget support, which can be used to attend professional meetings or purchase books or equipment needed for research.

12.5 American Astronomical Society

Most U.S. astronomers are members of the [American Astronomical Society](#) (AAS). Junior membership is available to graduate students and is required for attendance at the semi-annual meetings of the Society. Hard copy subscriptions to the Society’s journals, the [Astronomical Journal](#) and the [Astrophysical Journal](#) are available at reduced rates to members. This, however, is less important now than in the past, as the University Libraries has paid for a full-text access to these journals through [NASA’s Astrophysics Data System](#). Other benefits of membership include subscriptions to the monthly magazine [Physics Today](#), the AAS News Digest, and the monthly e-mails of the [AAS Job Register](#). Nomination forms can be found in the back of the AAS Membership Directory which is available in the Department office.

Graduate students might also want to become members of the [Astronomical Society of the Pacific \(ASP\)](#). ASP publishes the general-interest [Mercury](#) magazine, the professional Publications of the ASP, and numerous professional conference proceedings. It also provides a wide variety of educational material and astronomical products for sale.

Appendix A

University Information and Regulations for Graduate Students

[Graduate degree bulletin](#) includes: general information and student services; admissions; regulations and conduct standards; academic information and procedures; graduate degree requirements; graduate programs, faculty and courses. Click on “University Course Descriptions”, then “[Astronomy and Astrophysics \(ASTRO\)](#)” to see course titles and descriptions.

[LionPATH Class Search](#) shows course offerings, times, and locations for the current and next semester.

Academic integrity policies and procedures of [Penn State University](#) and the [Eberly College of Science](#) (see Appendix B).

[University Police and Public Safety](#) – Annual Security Reports:
<http://www.police.psu.edu/clery/index.cfm>

[Thesis information](#) includes calendar, submission/approval forms, and format requirements.

[Graduate assistant information](#) includes stipend and tuition grants, workload and credits, medical insurance, dental plan, and FICA exemption. Also see [forms for graduate fellowships and awards](#).

[Graduate Student Association](#) provides information on student government, insurance, housing, and career services. See their comprehensive [Guide to Graduate Life](#).

International students can find information on [student services](#) (including visa, tax, finance, health information and forms), [housing](#), and [health services](#).

[Tuition and charges](#), click on schedules and cost calculator.

Schreyer Institute for Teaching Excellence provides training and resources for teaching, including course design, pedagogy and assessment strategies, and tools for student evaluation. This includes the [Penn State Course in College Teaching](#) plus seminars and workshops.

[Information Technology Services](#) has information and training seminars involving educational and professional software. [Software @ Penn State](#) sells selected software at low prices.

Professional development opportunities include [Graduate School Teaching Certificate](#), [Graduate Exhibition](#), [Graduate Writing Center](#), and [commencement](#).

Assistance on research regulations and technology transfer are available at the [Office of Research Protection](#) and [Office of Technology Management](#) based on the University’s [intellectual property policy](#).

Contact Information for Some Campus Services

Emergencies: University Police 863-1111 or
Town police, fire, ambulance (8-) 911

Penn State University:

Phone: +1 (814) 865-4700

Penn State Thesis Office:

Address: 115 Kern Bldg.

Phone: 865-5448

Graduate School Information Center:

Address: 114 Kern Bldg.

Phone: 865-2516

Mount Nittany Medical Center (hospital):

Address: 1800 E. Park Ave.

Phone: 231-7000

University Office of Global Programs:

Address: 410 Boucke Bldg.

Phone: 865-7681

Affirmative Action Office:

Address: 328 Boucke Bldg.

Phone: 863-0471

Graduate Student Association Office:

Address: 312 HUB

Phone: 865-4211

University Health Services:

Address: Student Health Center

Phone: 865-6556

Health Services Student Insurance Office:

Address: 302 Health Center

Phone: 865-7467

Appendix B Academic Integrity Policy

(Excerpted from <http://senate.psu.edu/policies-and-rules-for-undergraduate-students/47-00-48-00-and-49-00-grades/#49-20>

and <http://science.psu.edu/current-students/Integrity/Policy.html>)

University Policy (49-20)

Academic integrity is the pursuit of scholarly activity in an open, honest, and responsible manner. Academic integrity is a basic guiding principle for all academic activity at The Pennsylvania State University, and all members of the University community are expected to act in accordance with this principle. Consistent with this expectation, the University's Code of Conduct states that all students should act with personal integrity, respect other students' dignity, rights and property, and help create and maintain an environment in which all can succeed through the fruits of their efforts.

Academic integrity includes a commitment by all members of the University community not to engage in or tolerate acts of falsification, misrepresentation or deception. Such acts of dishonesty violate the fundamental ethical principles of the University community and compromise the worth of work completed by others.

To protect the rights and maintain the trust of honest students and support appropriate behavior, faculty and administrators should regularly communicate high standards of integrity and reinforce them by taking reasonable steps to anticipate and deter acts of dishonesty in all assignments (Senate Policy 44-40: Proctoring of Examinations). At the beginning of each course, it is the responsibility of the instructor to provide students with a statement clarifying the application of University and College academic integrity policies to that course.

G-9 Academic Integrity Procedure

1 Introduction

To implement University policy on academic dishonesty in the most clear and unambiguous manner, the Eberly College of Science and its member departments encourage the following procedures to minimize dishonest behavior by students. These procedures include educating the faculty as to "best practices" for maintaining a classroom atmosphere that fosters honest scholarship. In addition, this policy seeks to clearly define dishonest actions and to provide a standard protocol to be used by all instructors in handling cases of suspected academic dishonesty.

2 Faculty Conduct

Although students should be aware of the fact that they are expected to be honest, faculty are responsible for stating their expectations for academic honesty as part of the grading policy in every course. Therefore, consistent with University policy, all course syllabi will be required to contain a statement on this topic. In addition, the instructor will be responsible for insuring that all exams are adequately proctored. Each instructor shall be present at all exams; when this not possible, the instructor shall arrange for another appropriate supervising proctor to substitute. Each exam shall have a minimum of one qualified proctor for every 125 students (including the instructor). It will be assumed that all teaching assistants assigned to the course will receive guidelines on how to proctor exams. If insufficient teaching assistants are assigned to the course, the College will pay for additional qualified proctors. For make-up or conflict exams, instructors should provide adequate supervision for the exam setting. Again, it is the responsibility of the instructor to arrange for adequate proctoring of all exams.

3 Student Conduct

All course work by students will be done on an individual basis unless an instructor clearly states that an alternative is acceptable. Any reference materials used in the preparation of an assignment, whether quoted or paraphrased, must be explicitly cited. In an examination setting, unless the instructor gives explicit prior instructions to the contrary, regardless of whether the examination is in-class or take-home, violations of academic integrity shall consist of any attempt to receive assistance from any person or papers or electronic devices, or of any attempt to give assistance, whether the student doing so has completed his or her own work or not. Other violations include, but are not limited to, any attempt to gain an unfair advantage in regard to an examination, such as tampering with a graded exam or claiming another's work to be one's own.

4 Infractions

4.1 Uncontested Cases ([ACUE policy G-9](#), revision 11-2-00)

The instructor should arrange a meeting with the student(s) involved, confront them with the information suggesting inappropriate conduct, and ask for an explanation. In cases where more than one student participated in the infraction, it is usually best to confront them together. If the student does not deny the allegation(s) of academic dishonesty, the instructor shall assign an academic sanction using the Eberly College of Science guidelines (see below) and have the student(s) sign the ECoS Academic Integrity Form in the required places. In appropriate cases, the instructor may recommend that the Office of Judicial Affairs assign a disciplinary sanction. The instructor should forward the [ECoS Academic Integrity Form](#) to the Associate Dean of the Eberly College of Science. This completes the instructor's tasks. Any follow-up issues should be directed to the Associate Dean's office. The instructor may then impose the indicated sanction.

4.2 Contested Cases ([ACUE policy G-9](#), revision 11-2-00)

If the student denies the allegation(s) of academic dishonesty, the student is to be provided with an explanation of the information in support of the allegation(s). If the student continues to deny the allegation(s), the instructor should have the student(s) sign the [ECoS Academic Integrity Form](#) indicating that they contest the accusation(s).

The instructor should forward the Academic Integrity Form and copies of all supporting documentation to the College Committee on Academic Integrity, which may be asked to review the information and positions, and to recommend possible resolutions. This completes the instructor's tasks.

4.3 Failure to Sign the Academic Integrity Form

If after notification of a violation of academic integrity, a student fails to sign the [ECoS Academic Integrity Form](#), the instructor should forward the form to the College Committee on Academic Integrity, with a brief explanation of the circumstances. The Committee will attempt to meet with the student. Refusal of the student to sign the Academic Integrity Form will result in an entry of "uncontested" on the student's behalf.

4.4 Guidelines for Supporting Documentation

The instructor has the responsibility to gather information and documentation which indicates in a clear and convincing way that the student's conduct did violate the academic integrity policies of the University. Since criminal law principles do not apply to the academic living-learning environment, the burden is not on the instructor to 'prove guilt beyond a reasonable doubt', as in the courts. Clear and convincing documentation ("supporting information") typically requires the following conditions to be met:

- 1- If the supporting information is circumstantial, or subjective in nature, then two corroboratory pieces of information will be required. For example, if a student was observed looking at another student's test during an exam, then a statement by a proctor attesting to this shall constitute a single piece of supporting information. The second piece of information could be the scantrons from the exams showing a significant number of the same incorrect answers.
- 2- Single pieces of supporting information are acceptable if they constitute a "smoking gun", e.g., a cheat sheet, possession of two exam copies, formulae programmed into calculators, another student's name appearing on the exam or the same student observed attending two exams at different times.
- 3- In cases of blatant plagiarism, only copies of the plagiarized material (annotated as needed) will be required as supporting documentation. In cases where the plagiarism is not word for word, the supporting information should provide a clear, and significant, link between the two students' work. For example, copies of two similar term papers, lab reports, or projects might show consistent sentence or paragraph structures throughout.

In cases where these conditions are met, the instructor is encouraged and authorized to maximally sanction the student, using the guidelines described below. The instructor should meet with the student to describe the infraction and the information supporting the allegation, and have the student sign the [ECOS Academic Integrity Form](#), indicating whether they contest the allegation(s) or not. The Academic Integrity Form shall then be forwarded according to the instructions under "Contested Cases" or "Uncontested Cases" above. Unless specifically authorized by the Committee on Academic Integrity following an investigation and hearing, the student will not be allowed to late-drop the course or retroactively withdraw from the course.

If sufficient supporting documentation (as outlined above) is NOT available to warrant academic sanction, but the instructor nonetheless feels a dishonest act has occurred, then the instructor may ask the Eberly College of Science Committee on Academic Integrity to send the student a letter of warning in which the College policy on Academic Integrity is outlined. Copies of all information, documents, and records pertaining to the case should be forwarded to the College Committee on Academic Integrity for placement of the letter in the student's file. This letter will remain confidential and may ONLY be used if a second case against this student is later brought to the attention of the Department, College, or Judicial Affairs. This warning letter cannot be used to establish responsibility retroactively, but can be used to assign a sanction.

4.5 Categories of Infractions

Listed below are guidelines that instructors should use to determine the severity of the dishonest action. These are guidelines only. If an instructor feels it is appropriate to upgrade a violation they may do so upon consultation with the College Committee on Academic Integrity.

In general, minor infractions involve errors in judgment without a clear intent by the student to violate academic integrity. Moderate infractions are unpremeditated, dishonest acts that directly affect only one student. Major infractions are premeditated dishonest acts, or dishonest acts that directly affect the grade of other students.

Minor Infractions

A student paraphrases or copies a sentence (or two) without citing the source or provides an improper citation.

A student places, or allows his/her name to be placed, on a group project to which they contributed little or nothing.

A student copies part of the work of another student exactly on an assignment on which collaboration is allowed but copying is not.

Moderate Infractions

A student collaborates on an assignment when clearly asked to work alone.

A student hands in an identical written assignment (such as a term paper, lab report, or other project) to two classes without obtaining prior approval from the instructor, or stating explicitly that he/she did so.

A student cheats, or facilitates the cheating of another, on an examination (in cases where there is *no evidence of premeditation*).

A student places his/her name on a written assignment he/she did not write. This includes copying of "old" assignments, such as term papers and lab reports that were written in previous years.

A student tries to gain an advantage for an exam by removing reserved materials from a lab or library to have additional study time at home.

A student fabricates a false reason to miss an exam, report deadline, or other academic obligation (e.g., the “dying grandmother” story, false sickness or family obligations, causing or fabricating a computer problem).

Major Infractions

A student poses as, or facilitates the posing of, someone else during an exam.

A student cheats, or facilitates another in cheating, on an examination, *in a premeditated manner* (e.g. using a cheat sheet, a prearranged system of sharing answers, or some similar method that was planned in advance).

A student steals the work of another and uses it as his/her own.

A student steals an examination.

A student places his/her own name, or allows his/her name to be placed, on an honors thesis to which they contributed little or nothing.

A student causes another student’s score to be lower through their actions (e.g., rearranging locating pins on a lab practical, stealing public copies of sample examinations, tampering with data sets).

A student changes the answer on an examination after it is returned and attempts to gain additional points because of a “grading error.”

A student attempts to take the same exam more than once: one time under a fictitious name, one time under their real name.

A student claims to have taken an exam (when, in fact, they did not) then claims the instructor “lost” the exam.

A student tampers in any manner with any course or University record.

4.6 Assignment of Sanctions

Sanction assignment is at the discretion of the instructor, within the guidelines set out by the College and the University. In general, minor infractions involve the subtraction of points for an assignment. Moderate infractions generally involve the lowering of a course grade (downward maximally to an "F"). Major infractions generally involve failure in the course, sending the case to the College Committee on Academic Integrity for determination of sanction, or sending the case to Judicial Affairs for possible assignment of an "XF" grade in the case where a disciplinary sanction is warranted. The instructor may, at their own discretion, reduce the sanction from these recommendations. Likewise, the instructor may, upon consultation with the College Committee on Academic Integrity, upgrade the sanction. In addition, the instructor may

ask the student to perform an additional assignment or take a make-up exam; this work can then be used to help assign a final course grade.

Appendix C

Eberly College of Science Guidelines for Advisor-Graduate Student Interactions

(excerpted from [this link](#))

Effective advising, open communication, and ethical professional conduct are essential for a high quality graduate education and research environment. Effective research advising must be based on a commitment to provide every student access to supportive guidance on a range of professional, ethical, and collegial issues. A productive research mentorship requires that students are treated respectfully and fairly and that the research advisor serve as a role model, upholding the highest ethical and professional standards. These guidelines embody many of the best practices used by the majority of our faculty here and elsewhere. They are intended to provide a heightened awareness of the need to consciously establish an effective and productive advisor-student relationship that starts with trust, courtesy, two-way communications, and shared expectations.

Faculty Research Advisors should:

- promote an environment that is intellectually stimulating and free of harassment;
- be supportive, equitable, accessible, encouraging, and respectful;
- recognize and respect the cultural backgrounds of students;
- be sensitive to the power imbalance in the student–advisor relationship;
- avoid assigning duties or activities that are outside students’ academic/professional responsibilities;
- respect students’ needs to allocate their time among competing demands while maintaining timely progress toward their degree;
- advise graduate students on the selection of an appropriate thesis topic and assist them in selecting a thesis committee;
- set clear expectations and goals for students regarding their academic performance and research progress;
- discuss policies and expectations for work hours, vacation time, and health contingencies;
- meet regularly and often with students to provide feedback on research activities and progress;
- provide students with training and oversight in all relevant aspects of research, including the design of research projects, the development of necessary skills, and the use of rigorous research techniques;
- avoid placing pressure on students to produce results that support particular hypotheses;
- devise effective ways of providing students with guidance and supervision during their prolonged absence;

- provide and discuss clear criteria for authorship at the beginning of all collaborative projects;
- encourage participation in professional meetings and try to secure funding for such activities;
- provide career advice, offer help with interview and application preparation, and write letters of recommendation in a timely manner;
- ensure students receive training in the skills needed for a successful career in their discipline, including oral and written communication and grant preparation as appropriate;
- acknowledge that some students will pursue careers outside of academia and/or outside their research discipline and assist them in achieving their chosen career goals;
- schedule meetings to discuss topics other than research, such as professional development, career objectives and opportunities, climate, laboratory personnel relations, etc;
- be a role model by acting in an ethical, professional, and courteous manner toward other students, staff, and faculty.

Graduate Students should:

- recognize that they bear the primary responsibility for the successful completion of their degree;
- exercise the highest ethical standards in all aspects of their research (including but not limited to collection, storage, analysis, and communication of research data);
- complete all tasks assigned by the department, including teaching, grading, and other assistantship responsibilities;
- know the policies governing graduate studies in the department and the graduate school and take responsibility for meeting departmental and graduate school deadlines;
- be proactive about communicating with the advisor and thesis committee, understanding that communication is a two-way endeavor;
- be considerate of other time constraints imposed on faculty and staff, including competing demands;
- take an active role in identifying and pursuing professional development opportunities;
- clearly communicate with their advisor(s) regarding their career preferences;
- be proactive about improving their research skills, including written and oral presentation skills;
- inform faculty advisors of potential and/or existing conflicts and work toward their resolution;

- seek mentoring and support resources beyond their faculty advisor(s), including other faculty members, peers, and organizations;
- obtain outside help from ombudsmen, graduate chairs, or other faculty if conflicts arise with their advisor;
- be aware that if they feel compelled to change advisors or research direction, they have options and should consult with their advisor, other mentors, or department officers;
- always act in an ethical, professional, and courteous manner toward other students, staff, and faculty.

Departments and Programs will:

- provide students with up-to-date information that includes policies, practices, degree requirements, and resources;
- assist students with selection of their advisors as needed and provide students with contacts and resources for potential conflict resolution (e.g., ombudsperson, director of graduate studies, or department head);
- provide pedagogical training and regular assessment of their teaching and other assistantship activities;
- monitor graduate student progress toward their degrees and professional development, including mentoring meetings, committee meetings, exam completions, and other benchmarks appropriate to their discipline;
- provide and monitor training in the ethical conduct of research;
- provide appropriate infrastructure to allow students to complete their education and research in a timely and productive manner;
- provide opportunities for professional development that will be relevant to students seeking careers outside academia and/or their research discipline;
- establish and communicate policies for emergencies and unplanned situations that may disrupt the work of students and/or faculty;
- incorporate these guidelines and recommendations into their departmental policies or handbooks and actively promote their observance.

Appendix D Department Forms and Checklists

D-1 Petition for Substitution/Waiver of Graduate Degree Requirement

D-2 Oral English Competency

D-3 Written English Competency

D-4 PhD Course Requirements Checklist

Petition for Astronomy & Astrophysics Graduate Degree Requirements

Name _____

Degree sought _____ Arrival semester _____

Expected graduation semester _____

Request for graduate degree requirement waiver or substitution:

Student signature _____ Date _____

Faculty advisor approval: Y / N

Signature _____ Date _____

Associate Department Head approval: Y / N

Signature _____ Date _____

(Copies of completed petition to student, advisor, and student file)

Assessment of English Competency: Oral

Student _____ Semester _____

Dear Faculty Member:

Thank you for agreeing to help in the assessment of competency in oral English, mandated by the Graduate School for students entering in or after Fall 1992. As approved by the Graduate School, our assessment will be based on a short talk by the student, using the checklist below. Our standard of adequacy should be close to the level demonstrated by (average to good) speakers in our own field, giving prepared talks. This assessment is not about the content of the talk, per se, or about the choice of subject matter.

We expect that the great majority of our students will be graded adequate or above, with no more than one category rated deficient. This oral assessment, and a similar assessment of written English together provide the basis for an overall assessment of Pass/Fail. A failing assessment requires appropriate remedial action and reassessment prior to scheduling the comprehensive examination. Please return your assessment to Kaylee Harter or Michael Eracleous

Date of Presentation _____

Topic _____

	Deficient	Adequate	Exemplary
Clear pronunciation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mastery of spoken grammar	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mastery of everyday and technical vocabulary	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Exposition appropriate to subject	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Conversational give-and-take; dealing with questions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

REMARKS AND RECOMMENDATIONS:

Faculty Member Signature: _____

Assessment of English Competency: Written

Student _____ Semester _____

Dear Faculty Member:

Thank you for agreeing to help in the assessment of competency in written English, mandated by the Graduate School for students entering in or after Fall 1992. As approved by the Graduate School, our assessment will be based on a piece of original writing by the student, using the checklist below. Our standard of adequacy should be close to the level demonstrated by (average to good) writers in our own field. This assessment is not based on paper content or choice of subject matter.

We expect that the great majority of our students will be graded adequate or above, with no more than one category rated deficient. This written assessment, and a similar assessment of oral English, provide the basis for an overall assessment of Pass/Fail. A failing assessment requires appropriate remedial action and reassessment prior to scheduling the comprehensive examination.

Please return your assessment to me Kaylee Harter or Michael Eracleous

Date of Paper _____

Topic _____

	Deficient	Adequate	Exemplary
Spelling	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Vocabulary	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Grammar - Mastery of everyday and technical vocabulary	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Style	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reasoning	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

REMARKS AND RECOMMENDATIONS:

Faculty Member Signature: _____

Ph.D. Course Requirements Checklist

Student Name: _____ Year: _____

A. Ten 3-credit courses			Semester	Grade
ASTRO	501	Fundamental Astronomy	_____	_____
ASTRO	502	Fundamental Astrophysics	_____	_____
ASTRO			_____	_____
ASTRO			_____	_____
ASTRO			_____	_____
ASTRO			_____	_____
PHYS			_____	_____
PHYS			_____	_____
			_____	_____
			_____	_____

GPA for 3-credit courses (>3.20) _____

B. Five 1-credit courses				
ASTRO	589	Seminar	_____	_____
ASTRO	589	Seminar	_____	_____
ASTRO	589	Seminar	_____	_____
ASTRO	590	Colloquium	_____	_____
ASTRO	602	Supervised Teaching	_____	_____

C. 2nd year research project
 Advisor: _____
 Title: _____

D. Waiver/substitution petitions

Student's and advisor's signatures indicating the above Ph.D. course requirements have been met:

_____ Date: _____

_____ Date: _____

(Copies of completed checklist to student, advisor and student file)