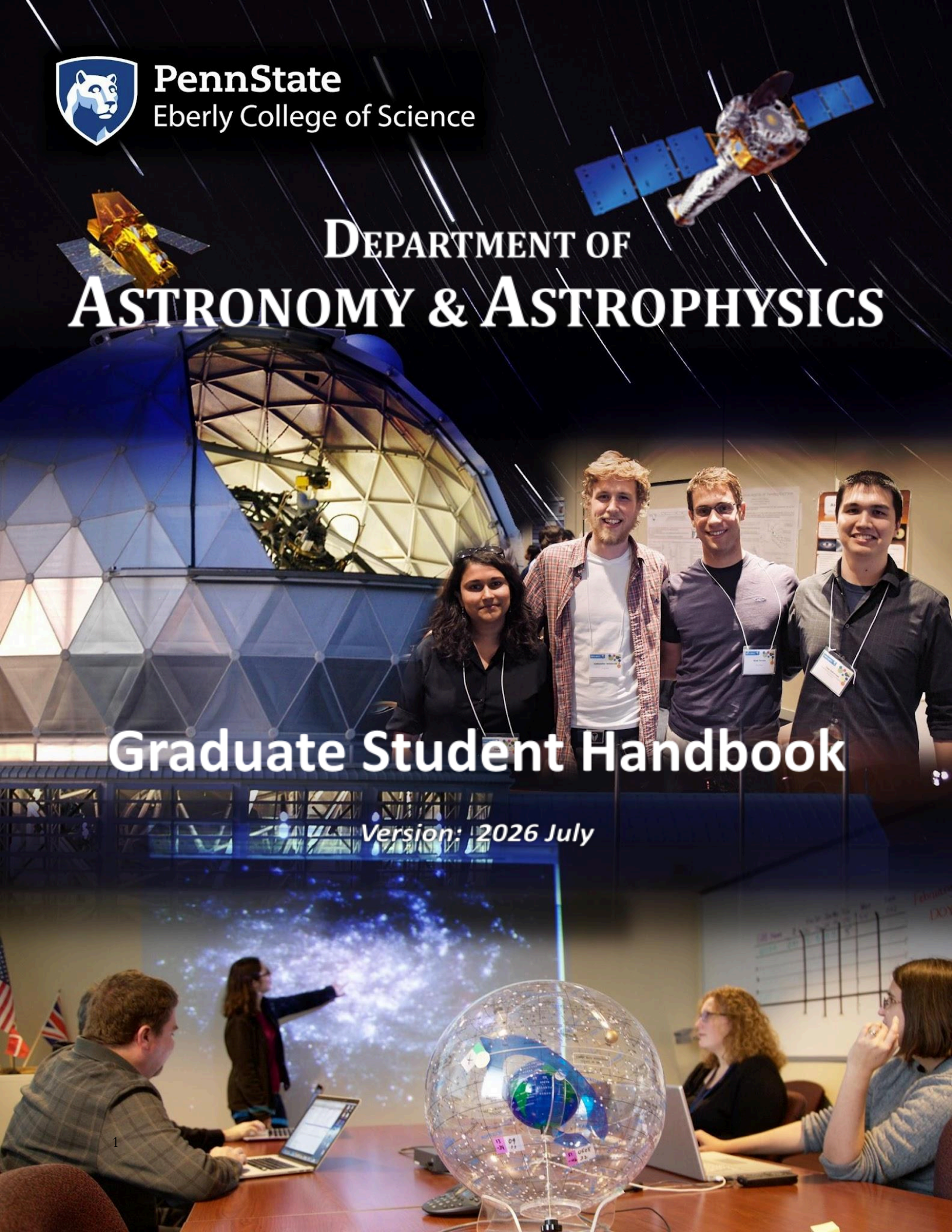

PennState
Eberly College of Science
Department of
Astronomy & Astrophysics
Graduate Student Handbook
Version: 2026 July

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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's 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. Abe Falcone (516 Davey, adf15@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.

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 ensure 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.

Academic Support Network: 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.

The Eberly College of Science 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 of 1974 identifies the rights of students and their families with respect to student educational records kept by institutions.

1.2 Goals and Learning Objectives

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 (see Section 1.3).

The program learning objectives are:

- ☐ **Know/Think:** Graduates will have demonstrated command of basic observational astronomy and astrophysics, including observing techniques, methods of data analysis, and common theoretical frameworks and techniques. This will include the ability to apply physics and mathematics knowledge to standard problems in astrophysics, as well as application of statistical principles to data analysis. Assessment mechanisms: Qualifying exam, GPA in 3-credit ASTRO 5xx courses

- ☐ **Apply/Create:** Graduates will be able to carry out original research in theoretical astrophysics, observational astronomy, or laboratory astrophysics (including but not limited to instrumentation development). This entails identifying and evaluating the status of outstanding questions, developing strategies to answer them, and formulating hypotheses and testing them through one or more of the following means: calculations or simulations, model development, analysis of existing data, acquisition and analysis of new data, and design and/or construction of new instruments. Assessment mechanisms: Dissertation and final oral examination

- ☐ **Communicate:** Graduates will be able to clearly and cogently describe the background and motivation of their research, describe their research methodology, and present and defend their arguments and conclusions in oral presentations, written papers and reports, and, where applicable, proposals. Assessment mechanisms: Second year report, first and second year oral presentations, comprehensive exam

- ☐ **Ethical Professional Conduct:** Graduates will demonstrate working knowledge of the standards for ethical conduct in research through their professional behavior and work. Assessment mechanisms: Completion of ethics trainings, grade in ASTRO 588

1.3 Future Employment

Astronomy PhDs bring their skills and talents to a variety of careers and sectors. Although most advisors and mentors in our department who are in permanent positions are, by consequence of being at Penn State, R1 tenure-track or research-track faculty, most of our PhD students will

ultimately choose different careers. For example, Perley 2019 finds that 77% of astronomy PhDs in 2000-2012 are now positions besides R1 tenure-track faculty. 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 spans a wide range of sectors, from prestigious postdoctoral fellowships to lucrative data science positions to teaching positions at undergraduate-focused institutions to NASA engineers. For academic jobs, open positions are advertised in several places including the AAS Job Register, APS job listing, Academic Jobs Online, etc. The American Institute of Physics provides updates on the placement of Astronomy PhD recipients. Career Seminars will be held each semester to showcase recent alums in a variety of exciting careers.

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 class presentations, 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. The number of recommended publications varies between specialties so students should consult their research advisor for guidance in this area. Also of high importance are the quality of the work and the assessments in reference letters of the individual's research skills and contributions.

1.4 Overview of Department Research

The following summary appears in the Graduate Degree Programs Bulletin:

The graduate program in Astronomy and 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, starburst 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; spectroscopic searches for planetary systems. Instrumental areas include: development of X-ray telescopes and detectors; and high-precision visible and near-infrared light spectrographs. Department faculty members participate in several university cross-disciplinary organizations: Astrobiology Research Center, Center for Astrostatistics, Center for Exoplanets and Habitable Worlds, and the Institute for Gravitation and the Cosmos.

The department played a seminal role in and leads many science investigations using two NASA-launched satellites, the Chandra X-ray Observatory and the Neil Gehrels Swift Observatory, 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 (e.g. GALEX, Hubble Space Telescope, Spitzer Space Telescope, XMM-Newton) and ground-based telescopes (e.g. 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 Graduate School website. Other particularly useful websites are listed in Appendix A.

2.1 Contacting the Department of Astronomy & Astrophysics

Mailing Address:
Chelsey Fisher, Graduate Staff Assistant or
Prof. Abe Falcone, 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
E-mail: cms5933@psu.edu or adf15@psu.edu
Website: https://science.psu.edu/astro

Directions: Penn State University (University Park campus) is located adjacent to the town of State College, Pennsylvania. The local airport is the University Park Airport (airport code SCE), and daily connections exist to the international airports in Philadelphia (PHL) via American, Newark (EWR) and Chicago (O'Hare, ORD) via United, and Detroit (DTW) via Delta. The closest Amtrak rail stops are in the Pennsylvania towns of Lewistown and Altoona, but train service is infrequent. 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: Prof. Donald Schneider (dps7@psu.edu).

- Associate Head of the Graduate Program: Prof. Abraham Falcone (516 Davey, 3-5364, adf15@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 the Head of the Graduate Program. The Head of the Graduate Program is always open to suggestions and concerns you may have about any aspect of the graduate program.

- Chair of Graduate Admissions Committee: Prof. Robin Ciardullo (rbc3@psu.edu). The Chair of Graduate Admissions has overall responsibility for admitting and recruiting graduate students.

- Associate Head of Climate and Diversity: James Tutt (jht12@psu.edu).

- Graduate Staff Assistant: Chelsey Fisher (525 Davey, 5-0419, cms5933@psu.edu). The Graduate Staff Assistant can be found in the main office of the Department of Astronomy & Astrophysics, located in 525 Davey Lab. The Graduate Staff Assistant administers the graduate program; questions regarding admissions, requirements, etc., should be directed to the Graduate Staff Assistant.

- Administrative Support Coordinator: Laurie Dasher (525 Davey, 3-7350, lad31@psu.edu). Responsible for the general management of the department office and budget which includes budget planning, execution and audits. Assists with financial matters involving research grants, working closely with principal investigators. Support for outreach and development activities. Works with facility assignments and utilization planning.

- Financial Team: (525 Davey, astro-financial@psu.edu). Primary department contact for our department's financial team, which handles 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).

- Undergraduate Staff Assistant: Jennifer Marsh (525 Davey, 5-0410, jne5039@psu.edu). Provide support for undergraduate student issues, schedules undergraduate courses, and provides support for hiring undergraduates/wage payrolls.

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:

- Academic Advisor (first year only): Each incoming graduate student is assigned an academic advisor. First year students are required to meet with their academic advisors before the beginning of classes. 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.

- Research Advisor: Students performing research have an individual faculty member as their research advisor. Starting in the summer after the first year, the research advisor also becomes the academic advisor/supervisor for the student, including for the purpose of the student's first graduate activity report. For students who have passed the Comprehensive examination, the research advisor usually serves as Chair of the student's Doctoral Committee.

- Mentor: Each student is assigned a mentor, who is a faculty member (tenureline, research, or teaching) or postdoc for professional development conversations. See 2.4 Mentoring Program for more details on the mentoring program.

- PhD Committee: The faculty committee in the Department of Astronomy & Astrophysics that evaluates the Comprehensive Exam and supervises the student's dissertation work. See Formation of PhD Committee for details.

- Department Ombudspersons: Currently, Dr. John Nousek and Dr. Julia Kregenow. Each department in the College of Science has two ombudspersons 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.

- 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.

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

Students are encouraged to seek advice from their academic or research advisors, mentor, the Associate Head of the Graduate Program, or one of the ombudspersons, whenever they feel it is helpful. 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 website provides information for graduate students from the Eberly College of Science, including guidelines for Advisor-Graduate Students Interactions (these guidelines are also included in Appendix C of this handbook) The Graduate School has developed a set of recommended practices similar to those of the Eberly College of Science, which are available at this link.

2.4 Mentoring Program

- ☐ Respond to annual mentor matching form
- ☐ Review Mentoring Guide Sheet
- ☐ Meet with mentor as needed
- ☐ Consider taking part in senior-junior graduate student mentoring program

Each student is assigned a mentor. Mentor assignments are revisited each year depending on students' needs and mentors' availability. Mentors help and support graduate students in ways customized to each student. Some students will meet with their assigned mentor regularly and find that this mentor becomes an important source of advice and support. For other students who might find this advice and support elsewhere, the mentor is waiting in the wings to provide advice or a

different perspective if the student ever needs it. Some common topics of conversation include career paths, writing, life outside of work, job search/applications (for senior students), mental health, department life and climate, time management, and professional development opportunities. Additional topic ideas are listed in the Mentoring Guide Sheet.

First year students are assigned a senior graduate student mentor, and other junior graduate students can opt into the program as well. This mentoring program aims to connect junior students to the rich network of advice and support from more senior students in the program. Matches are made based on mentees' needs and interests and mentors' experiences and areas of expertise.

2.5 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 or the Department Head 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.

2.6 Paid and Unpaid Leaves of Absence

- ☐ Contact advisor and Head of Graduate Studies as soon as need for a leave is known

If a graduate student experiences a significant life event that is likely to disrupt their progress toward their degree, then they may apply for a leave of absence. These may be short-term (<3 weeks), extended (>3 weeks, but within a semester), or a full semester to longer. The procedure to apply for a leave of absence is described in Graduate School policy GSAD-906.

Graduate students are now entitled to a six week paid leave upon birth or adoption of a child. Students should contact their advisor and the Head of Graduate Studies ASAP once the approximate dates are known to arrange for a leave. Child care subsidies are available for student parents.

3. Procedures for the Entering Student

Upon arrival on campus, incoming students should start at the Department Office, 525 Davey Laboratory. You will be assigned an office in Davey Lab, typically shared with other graduate students. You will be sent a schedule for the department Orientation which takes place the week before classes start. International students will receive information about the International Student Orientation, which takes place earlier in the week, from Penn State Global. Additional useful information for graduate students is provided by the Graduate and Professional Student Organization.

- ☐ Secure housing on or off campus
- ☐ Register for Penn State ACCESS account
- ☐ Complete employment forms through Workday. (First paycheck issued at the end of August.)
- ☐ Get virtual Penn State photo identification (ID+)
- ☐ Get office and mailbox key from Davey 525
- ☐ Register for classes

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.

Computer accounts: 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 https://lionpath.psu.edu/ system); for Teaching Assistantship duties; the https://canvas.psu.edu learning management system ; and to take advantage of the following services provided by the University, including University email, high-performance computing, free and discounted software, on-line and physical library resources, and many other computing services. For the Department computer account, your name and University ID number will be used by Eberly College of Science Information Technology to provide access to departmental computing resources.

Employment forms: New students receive some combination of Teaching Assistantship, Research Assistantship, or Fellowship and must fill out the appropriate employment forms through Workday. It is important to complete these forms ASAP once you receive them to ensure you receive your first paycheck on time (end of August). See 10. Assistantships and Support for more details.

ID Card: 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 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: 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. 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.

Mailbox: Students can request 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.

Registering for Your First Semester: Course registration is accomplished after discussion with your academic advisor. Course requirements, including the typical two year course rotation, are listed in 5.1 Required coursework. The typical first semester program is discussed in Section 6. Your Path Through Graduate School. See 8.1 Course Registration for details on registration.

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 are required to attend the New International Student Orientation scheduled during the week 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 Proficiency

- ☐ Incoming international students: schedule AEOCPT test to take upon arrival to campus

International students who are English language learners are strongly encouraged to gain full proficiency with the English language at the earliest possible opportunity. Gaining full proficiency 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 by taking the AEOCPT test of oral English proficiency, administered by the Center for English as a Second Language (ESL), regardless of the language of instruction at their undergraduate institution. This requirement includes students who received their undergraduate degree in the US. 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 may be granted an exemption from taking the test.

4.2 F-1 Visas

- ☐ Consult ISSA website and advisors for latest policies
- ☐ Verify timelines for thesis defense, graduation, and program completion with ISSA

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 on the Penn State International Students and Scholars Advising (ISSA) website). International students are obligated to keep the university informed of their local address, which can be done easily via LionPATH. Students should consult the ISSA website and/or advisors for information about F-1 visas, including procedures for extensions.

It is important for finishing students to be aware of how the timing of their PhD defenses affects their completion date (which may be earlier than their graduation date) and how the completion date interplays with post-graduation plans involving the Optional Practical Training work authorization. Students should verify timelines for their thesis defense, graduation, etc. with ISSA, since the deadlines for international students may differ from the general Graduate School deadlines.

5. Degree Requirements

The goals of our graduate program at Penn State are for graduate students to learn astronomy and astrophysics, develop research and technical skills, learn the techniques of good teaching, and become prepared for future employment. We provide here rules and guidelines to the milestones you need to achieve in order to receive a PhD in Astronomy & Astrophysics, including course work, departmental examinations, and a thesis.

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 advisor 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. University requirements can be found in Penn State's Graduate Degree Programs Bulletin and Graduate Policies. Department requirements are described in this Handbook and in some cases go beyond university requirements. This Handbook also represents official policy. Each student is responsible for knowing and fulfilling the requirements for graduation.

PhD requirements:

- ☐ Required coursework with minimum grades and enrollment
- ☐ Ethics training
- ☐ English competency (all students, domestic and international)
- ☐ First Year Oral Presentation
- ☐ Pre-comps annual activity report
- ☐ Qualifying examination
- ☐ Second Year Research Project and Report
- ☐ Second Year Oral Presentation
- ☐ Form PhD Committee
- ☐ Comprehensive examination
- ☐ Annual PhD Committee Meeting and Activity Report

- ☐ Maintain continuous registration after passing the Comprehensive Examination
- ☐ Pass the oral PhD final examination, complete a PhD dissertation approved by committee, including any required revisions, and submit PhD dissertation to the Graduate Thesis Office.

Requirements for the Master's Degree (including both Masters-along-the-way and terminal Masters), Computational Science Minor, and Astrobiology Dual Title are also described in this chapter.

5.1 Required coursework

Coursework (GPA >=3.00 total):
A GPA OF 3.2 IN THE FOLLOWING TEN 3-CREDIT COURSES IS REQUIRED:

- ☐ ASTRO 501 (3 credits)
- ☐ ASTRO 502 (3 credits)
- ☐ 4 additional ASTRO 500-level courses (3 credits each)
- ☐ 4 additional 3-credit 500-level courses, in any of the following fields: Astronomy & Astrophysics, Physics, Statistics, Mathematics, Applied Mathematics, Biology, Chemistry, Astrobiology, Geosciences, Meteorology, Materials Science and Engineering, Computer Science, or one of the Engineering or Information Science and Technology disciplines. One 400-level course may be substituted.

IN ADDITION, THE FOLLOWING COURSES ARE REQUIRED:

- ☐ ASTRO 588 first year seminar (1 credit)
- ☐ ASTRO 589 research seminars (3 credits total; ABIOL 590 may be substituted for one of these courses if not used to fulfill other requirement)
- ☐ ASTRO 590 colloquium: requires attendance of weekly colloquium, Tuesday seminar, and, if offered, Marker lecture (1 credit)
- ☐ ASTRO 596 for directed research in the second year (3 credits)
- ☐ ASTRO 602 fall pedagogy course (1 credit)

- ☐ Submit checklist: When all of the required courses have been taken or when a plan has been developed, the student should submit the course requirement checklist to the Graduate Staff Assistant and Graduate Program Head for approval.

Credits: One credit corresponds to one 50-minute class per week, plus associated out-of-class study.

Credits per semester: A graduate student who is registered for at least 9 credits in a semester is considered to be engaged in full-time academic work for that semester. The maximum credit load per semester is 15 credits. See GCAC-501 for further details. (The formal maximum credit load for graduate assistants is 12 credits, but lionpath will allow for enrollments up to 15 credits.) Courses with numbers <400 do not count toward the 9 credit minimum.

Cross-listed courses: 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.

5.1.1 ASTRO 602

Every student – regardless of whether they ever TA – needs to complete the fall teaching pedagogy seminar, ASTRO 602 (1 credit). Serving as a TA is not a program requirement, but taking the pedagogy course at least once is a requirement. A student who is a TA for the first time in the fall will take the fall pedagogy seminar during that semester. If a student is not a TA, then they should take Astro 602 in either their 1st or 2nd year of graduate school, ensuring that this 1-credit seminar is taken prior to comprehensive exams.

5.2.2 Anticipated Schedule of 500-level ASTRO courses and Astrobiology Dual Degree Courses

Anticipated schedule of 3-credit 500-level ASTRO courses (subject to modification):

Fall Even Years (2024, 2026, etc.) ★ ASTRO 501: Fundamental Astronomy ★ ASTRO 502: Fundamental Astrophysics ★ ASTRO 550: High Energy Astrophysics ★ ASTRO 545: Cosmology ★ ASTRO 576: The Search for Extraterrestrial Intelligence	**Spring Odd Years (2025, 2027, etc.)** ★ ASTRO 504: Extragalactic ★ ASTRO 515: Astrostatistics ★ ASTRO 534: Stellar Structure and Evolution ★ ASTRO 597: Relativistic Astrophysics
Fall Odd Years (2025, etc.) ★ ASTRO 501: Fundamental Astronomy ★ ASTRO 502: Fundamental Astrophysics ★ ASTRO 528: High-Performance Scientific Computing for Astrophysics ★ ASTRO 542: Interstellar Medium and Star Formation	**Spring Even Years (2026, etc.)** ★ ASTRO 527: Computational Physics and Astrophysics ★ ASTRO 530: Stellar Atmospheres ★ ASTRO 570: Particle Astrophysics ★ ASTRO 577: Exoplanets

Anticipated schedule of 3-credit 500-level Astrobiology dual courses (subject to modification)

See the Graduate Bulletin for course descriptions.

5.2.3 Course waivers and substitutions

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. Courses that were counted toward an earlier degree may not be transferred to Penn State, but the Associate Department Head for the Graduate Program will consider requests to waive one or more of our course requirements on the basis of earlier graduate-level work; such requests should be accompanied by a syllabus for the course, a copy of the transcript from the institution showing the grade earned, and the course number of an equivalent Penn State graduate-level course.

Up to 6 credits of Astro 596 (including the 3 that are separately required for the Fall Project) may be used to fulfill the "ten 3-credit course" requirement. Acquiring a broad knowledge of Astronomy &

Astrophysics will typically be achieved with non-596 courses, and therefore, students who use 596 toward the 10 course requirement should consult with their advisor and thesis committee to determine whether they should take additional 3-credit courses post-comps.

If any student wishes to schedule their comps exam but is missing 589, 590, or 602, the Assoc. Head for the Graduate Program will approve substitutions (i.e., credits that aren't already being counted toward the other requirements) on a case by case basis. The student will be strongly encouraged to take the missing course post-comps.

5.2 SARI Ethics training

- ☐ CITI RCR online training
- ☐ ASTRO 588 discussions
- ☐ Two SARI workshops
- ☐ Ethics reflection

During the fall of the first year, students must also go through the Scholarship And Research Integrity (SARI) training program. This training is mandatory and is incorporated into the Seminar in Astronomical Research Development and Responsible Conduct (ASTRO 588). The training includes CITI RCR, three hours of discussion-based activities in ASTRO 588, and two hours of SARI workshops. As part of ASTRO 588, students will submit a short reflection on applications of ethical reasoning and principles.

5.3 English competency

- ☐ Written (based on first year coursework)
- ☐ Oral (based on First Year Oral Presentation)
- ☐ Student does not need to complete any paperwork but will be notified of outcomes

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. The Department evaluates English competency during the first year: assessment of writing is based on assignments from first year courses, and assessment of speech is based on the First Year Oral Presentation. Competence must be formally attested before the Comprehensive Examination may be scheduled and a report of English competency is included in the assessment of the Qualifying Exam.

5.3 First Year Oral Presentation

- ☐ Sign up in late Fall or Spring when contacted
- ☐ Present 20 minute journal club or research presentation during Spring of first year

To gain speaking experience, first years give a 20 minute journal club or research presentation during the Spring Semester. The talk can either be about a journal article, research planned for the summer, or (if applicable) research conducted during the first year. English competency and oral communication skills will be assessed by two members of the graduate faculty. The student will be provided with a short summary of feedback on their oral communication.

5.4 Pre-comps annual activity report

To document their progress, students must submit annual activity 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 the student's advisor. These annual reports serve as our way of tracking yearly student progress and they become integrated into the annual committee meetings that students hold with their PhD committees post-comps. They also serve as a repository of information that can be used when considering students for internal awards. For all of these reasons, the students should do their best to fill them out accurately. The activity report is also an official prompt for a conversation about professional development, goals, and mentoring between the student and their advisor.

- ☐ Submit activity report at the end of the spring semester, after grades are posted
- ☐ Step 1: The student fills out the report, including (if applicable): a brief assessment of their academic performance, plans for completing their course requirements, summer research plans, research progress.
- ☐ Step 2: The research advisor reviews the report and meets with the student to discuss the report and, more broadly, professional development, goals, and mentoring, including the Eberly College of Science Guidelines for Advisor-Graduate Student Interactions.
- ☐ Step 3: The research advisor submits comments about the student's progress and performance.
- ☐ Step 4: The student responds to the advisor's comments and confirms that they have met and discussed the report.
- ☐ Step 5: The head of the graduate program reviews everything, writes final comments and submits the final report.

5.5 Qualifying Examination

- ☐ Written exam typically scheduled directly after first year, just after spring semester in the early summer
- ☐ Qualifying Exam committee will contact first year students about date and format late in first year

The Qualifying 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. The goals of the qualifying exam are:

- Cement the knowledge of first year material
- Make connections across courses
- Apply critical thinking skills to problem solving and evaluation of results, and
- Instill the philosophy of science and journal articles being a conversation in the field, rather than a definitive source of knowledge.

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

Qualifying Exam Committee will communicate the outcome of the exam to the student and the Associate Head of Graduate Studies, who notifies the Graduate School.

The student may attempt the Qualifying Exam twice. Normally, the exam is scheduled for summer after the first year. There are two possible results of the Qualifying Exam on the first try:

- Pass: The student is allowed to progress in the PhD program and move toward the Comprehensive Exam.
- 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 Qualifying Exam on the second try:

- Pass: The student is allowed to progress in the PhD program and move toward the Comprehensive Exam.
- Master's Pass: Although the performance is not adequate for qualifying in the PhD program, the level of accomplishment is sufficient to lead to a Master's degree.
- 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.

5.6 Second Year Research Project and Report

- ☐ Register for Astro 596 with advisor for Fall of second year
- ☐ Develop research and carry out research project with direction from advisor
- ☐ Submit preliminary title and abstract to Associate Head of Graduate Studies
- ☐ Associate Head of Graduate Studies will notify student of deadline (typically late November/early December) and readers
- ☐ Write and submit project report to advisor, readers, Associate Head of Graduate Studies, and Graduate Staff Assistant by deadline.

The 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. Second year projects 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 culminates with the student independently writing a substantial report, which is due during the last week of classes (typically, late November or early December; the exact date will be set by the Associate Department Head for the graduate program and communicated to the students). The report need not be a submitted journal article but should be similar in form; it can be a work-in-progress toward a publishable paper. It is important to delineate the student's work from work done previously or by other members of the research group. 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 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 in time to be graded, 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.

5.7 Second Year Oral Presentation

- ☐ Sign up in late Fall or Spring when contacted
- ☐ Present 20 minute research presentation during Spring of second year

To gain further speaking experience and help prepare for the comprehensive exam, second years give a 20 minute presentation during the Spring Semester on their Second Year project research. Oral communication skills are assessed by two members of the graduate faculty. The student is provided with a short summary of feedback on their oral communication.

5.8 Formation of PhD Committee

- ☐ Work with advisor to select committee members
- ☐ Contact Graduate Assistant to file paperwork
- ☐ Paperwork must be filed no later than one calendar year after passing the Qualifying Exam

After the student is advanced to Qualifying, they must submit paperwork for their PhD Committee, which is approved by the Department Associate Head and the Graduate School Dean. A student's Ph.D. Committee shall be nominated to the Graduate School by the student's major Graduate Program Head as soon as possible after the student has secured an adviser, but in no event later than one calendar year following the date of the student's successful completion of the Qualifying Examination. The PhD Committee administers the Comprehensive Examination. The membership can be changed by paperwork following the examination if the circumstances warrant (for example, if a student's dissertation topic is different from their comprehensive exam project).

The PhD Committee shall consist of at minimum of four members of the Graduate Faculty, each of whom shall be in a position to contribute substantially to the student's education. At least two of these four members shall be from the student's major graduate program. A listing of Graduate Faculty can be found using the PSU Grad Faculty Search tool. 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 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 coordinate with the Chair, and monitor the student's academic progress. Ph.D. Committees may include Special Members who are not members of the Graduate Faculty but are otherwise qualified and have particular expertise in the student's research area. Special Members do not have to be affiliated with Penn State. See GCAC-602 for a comprehensive list of requirements.

5.9 Summer Registration

- ☐ Only necessary if scheduling 5.10 Comprehensive Examination or 5.12 PhD Dissertation and Final Oral Examination for the summer
- ☐ Contact Graduate Staff Assistant to register
- ☐ Apply for Summer Tuition Assistant Program (STAP)

Graduate students are required to register for the summer if taking the comprehensive exam or PhD oral examination. Their tuition is covered by STAP, but it is important to apply for STAP well in advance.

5.10 Comprehensive Examination

- ☐ Complete required coursework with total GPA >=3.00 and GPA >=3.20 in 10 3-credit courses in astronomy and related fields. (Students may continue to take courses after the exam, but must have completed the minimum requirements.)
- ☐ Contact Graduate Staff Assistant at least one month before exam date to file paperwork and reserve a room for the oral component
- ☐ Typically completed in spring or summer of second year, within 24 months of starting graduate program.
- ☐ Write and submit report to committee at least one week before exam
- ☐ Prepare presentation for the oral component
- ☐ Post-comprehensive pay will take effect at the beginning of the semester following the successful completion of the comprehensive exam

When the student has completed a significant amount of original research, typically at the end of their second year, the PhD 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 or dual degree 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 with the Graduate School at least two weeks before the exam date, so students should coordinate with the Graduate Staff Assistant on paperwork at least one month in advance.

By Graduate School guidelines, the Comprehensive Examination should be scheduled within a year of completion of all required coursework. The Department strongly encourages students to take the exam within 24 months of entering the graduate program, but the timeline will depend on the totality of circumstances, including their work load in the first two years in the program, course scheduling and offerings, and the scope and challenges of their research project(s). The Graduate School has a hard cut-off of no later than five years following the passing of the Qualifying Examination.

The comprehensive exam has several parts:

- Comprehensive exam written report submitted at least 1 week in advance. This report should include motivation, literature review, methods, results, interpretation and implications.
- Oral presentation of research
- Oral examination on the research and its implications
- Oral examination 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.

Style of Exam: The comprehensive examination may be held fully in-person or in hybrid mode. For hybrid exams, the department expects that students and committee members will work to arrange for at least 50% of the examiners to be present in person. In rare cases (e.g., illness of a committee member, severe weather, etc.), the Graduate Program Head may approve an exception and allow a reduced number of in-person committee members or even a fully remote exam. Decisions concerning remote participation should be made by the student's advisor, in consultation with both the student and the participating examiners. If the student and adviser cannot agree on the

mode, the Graduate Program Head will make the decision after consulting with each of the interested parties.

Either the student or adviser can appeal the decision of the Graduate Program Head to the Department Head.

Scope of research: The work presented by the student need not be related to dissertation work to be undertaken later. 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 >2/3 affirmative vote of the Committee (i.e., at least 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 that at least 60% of the committee members (i.e., at least three out of five) 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.

5.11 Annual PhD Committee Meeting and Activity Report

- ☐ Propose dissertation topic within one year of passing Comprehensive Exam
- ☐ Meet annually with PhD committee
- ☐ Complete activity report in tandem with meeting (details below); the final activity report serves as the formal report on the committee meeting. No other paperwork is necessary at the department or College level.

The 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.

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

Subsequent meetings: 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.

Activity report: prepared and submitted electronically via the ECoS Graduate Student Activity Report system. These annual reports serve as our way of tracking yearly student progress and they are integrated into the annual committee meetings that students hold with their PhD committees. They also serve as a repository of information that can be used when considering students for internal awards. For all of these reasons, the students should do their best to fill them out accurately. The activity report is also an official prompt for a conversation about professional development, goals, and mentoring between the student and their advisor.

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 provide a summary of the committee's assessment of the student progress and response to the student report (if appropriate) in the annual activity report. Here is a flow chart of relevant actions:

Before meeting

- ☐ **Student submits report:** 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 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 may write comments but should not yet submit the report.
- ☐ The advisor meets with the student to discuss the report; professional development, goals, and mentoring, including the Eberly College of Science Guidelines for Advisor-Graduate Student Interactions; and discuss what might be beneficial to discuss with the entire committee.
- ☐ **Student sends PDF of report to committee:** The student produces a PDF version of the report and sends it to the committee members a week ahead of the committee meeting.

After meeting

- ☐ **Advisor submits report with summary of committee meeting:** Within a week following the committee meeting, the advisor writes a summary including the committee's assessment of the student progress and its recommendations for future work and includes it in the annual report. The advisor submits the report.
- ☐ **Student acknowledges report:** The student reads the committee's report within a week thereafter and submits a response.
- ☐ **Grad program head approves report:** The head of the graduate program reviews everything, writes final comments and submits the final report.

5.12 Post-Comps Residency Requirements and Continuous Registration

- ☐ Maintain continuous registration
- ☐ Additional coursework beyond requirements

Once a student is a PhD Candidate, their registration each semester will be performed by the Graduate Assistant. The student will be enrolled in ASTRO 601 with the research advisor as the instructor. Students enrolled in ASTRO 601 are automatically considered full-time (9 credits) with a much-reduced tuition. (Typically, students who have passed the Comprehensive Exam will typically be registered for ASTRO 601: Ph.D. Dissertation Full-Time but under some special circumstances may register for ASTRO 611: Ph.D. Dissertation Part-Time.) PhD Candidates should verify their enrollment each semester and contact the Graduate Assistant if there is an error.

Post-Comprehensive tuition (roughly $2000/semester, referred to as the dissertation fee) must still be paid even if the thesis student is off-campus. Students may audit up to 3 units of additional coursework (i.e., courses not at the 600-level). Students may take up to 3 units of additional coursework (i.e., courses not at the 600-level), but additional tuition (roughly $1000/semester) is incurred. Please refer to the latest tuition schedule for details.

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. Over the course of their PhD, University policy requires that graduate degree recipients spend at least two consecutive semesters as a registered, full-time student engaged in academic work at the University Park Campus during a twelve-month period; typically pre-comps residency would count toward this requirement but any students interested in remote work should verify with the graduate program head that they've met residency requirements. Teaching Assistants are required to be on campus. Research Assistants are required to be on campus but may apply for an exception with approval of their RA supervisor and the graduate program head.

5.13 PhD Dissertation and Final Oral Examination

- ☐ Contact Graduate Staff Assistant at least one month before exam date to file paperwork and reserve a room for the final oral examination.
- ☐ Submit written dissertation to committee at least two weeks before exam
- ☐ Prepare public oral presentation
- ☐ Program must be completed within eight years after passing the qualifying exam, not including approved leaves of absence. Our department recommends a much shorter total degree time (from entering the program) of 4–6 years.

A written dissertation of thesis work must be produced in accordance with the rules established by the Penn State Thesis Office. Generally, the thesis consists of a collection of the student's work along a connected theme, complete with a scientific introduction and a concluding discussion on the findings of their thesis work.

Each student must defend the thesis orally before a PhD Committee. The final oral examination, or Thesis defense, must be scheduled by the Graduate School at least two weeks before the exam date. The final oral examination shall consist of a public oral presentation of the dissertation followed by a

closed discussion between the student and the student's Ph.D. Committee. Students should contact Committee members to find a satisfactory date and make arrangements with the Graduate Staff Assistant for the examination. The dissertation must be provided to the Doctoral Committee at least two weeks in advance of the scheduled defense.

The final dissertation defense may be held fully in-person, fully remote, or hybrid with some individuals participating in-person while others participating remotely. The decision on which of the above modes is used shall be made by the thesis advisor in consultation with the student. If the student and adviser cannot agree on the mode, the Graduate Program Head will make the final decision. Either the student or adviser can appeal the decision of the Graduate Program Head to the Department Head.

After a successful defense, the final thesis is submitted to the Thesis Office on the eTD website. Committee members will receive an email to electronically sign the form. The outside unit member will also receive an email to complete their input on LionPath. There is a fee charged for final submission, 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.

5.14 Master's Degree Requirements

- ☐ Contact Graduate Staff Assistant to enroll in the Masters-along-the-way program. A student may enroll anytime prior to comps, and are required to enroll at least 1 semester prior to intended Masters degree conferral. Students are advised to enroll ASAP (i.e. in 1st semester, well before completing requirements). Also see GCAC-209 for Fox Graduate School policies.
- ☐ Contact Graduate Staff Assistant to switch from a PhD to a terminal Masters, if exit from PhD program becomes imminent for some reason and if Masters degree requirements are expected to be completed
- ☐ Complete requirements (below)

Coursework (GPA >=3.00 total):
A GPA OF 3.2 IN THE FOLLOWING TEN 3-CREDIT COURSES IS REQUIRED:

- ☐ ASTRO 501 (3 credits)
- ☐ ASTRO 502 (3 credits)
- ☐ 4 additional ASTRO 500-level courses (3 credits each)
- ☐ 4 additional 3-credit 500-level courses, in any of the following fields: Astronomy & Astrophysics, Physics, Statistics, Mathematics, Applied Mathematics, Biology, Chemistry, Astrobiology, Geosciences, Meteorology, Materials Science and Engineering, Computer Science, or one of the Engineering or Information Science and Technology disciplines. One 400-level course may be substituted.

IN ADDITION, THE FOLLOWING COURSES ARE REQUIRED:

- ☐ ASTRO 590 colloquium: requires attendance of weekly colloquium, Tuesday seminar, and, if offered, Marker lecture (1 credit)
- ☐ ASTRO 596 for directed research in the second year (3 credits)
- ☐ ASTRO 602 fall pedagogy course (1 credit)

Additional requirements:

- ☐ Qualifying examination
- ☐ Second Year Research Project and Report

5.15 Graduate Minor in Computational Science

- ☐ Complete paperwork prior to establishing PhD committee and scheduling comprehensive examination
- ☐ Complete course requirements (15 credits, some of which can overlap with our department's course requirements)

Astronomy and Astrophysics PhD students have the opportunity to obtain an interdisciplinary Graduate Minor in Computational Science. The linked website contains an updated list of course requirements and options. The elective options include several options within the Astronomy department (ASTRO/Physics 527, Computational Physics; ASTRO 515, AstroStatistics; ASTRO 528, High-Performance Scientific Computing for Astrophysics).

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.

5.16 Dual-Title Degree in Astrobiology

- ☐ Complete paperwork **during or prior to the fourth semester** and prior to establishing PhD committee and scheduling comprehensive examination
- ☐ Complete course requirements (15 credits, some of which can overlap with our department's course requirements)
- ☐ Our Qualifying Examination will satisfy the dual degree Qualifying Exam requirement, even if it does not cover Astrobiology.
- ☐ Include at least one member of the Astrobiology Graduate Faculty on the PhD Committee. If the chair of the Ph.D. committee is not also a member of the Graduate Faculty in

Astrobiology, the member of the committee representing Astrobiology must be appointed as co-chair.

- ☐ Dissertation topic should fall under both Astronomy & Astrophysics AND Astrobiology

Astronomy and Astrophysics PhD students have the opportunity to obtain an interdisciplinary Dual-Title Graduate Degree in Astrobiology (ABIOL). 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. The successful student will obtain a PhD in "Astronomy and Astrophysics and Astrobiology."

Anticipated schedule of courses:

Fall Even Years (2022, etc.) ★ ASTRO 576: The Search for Extraterrestrial Intelligence ★ GEOSC 502: Evolution of the Biosphere	**Spring Odd Years (2023, etc.)** ★ ABIOL 574: Planetary Habitability
Fall Odd Years (2023, etc.) ★ GEOSC 502: Evolution of the Biosphere	**Spring Even Years (2024, etc.)** ★ ABIOL 590: Astrobiology Seminar ★ ASTRO 577: Exoplanets

6. Your Path Through Graduate School

The chart below shows a typical path through graduate school, which can be customized based on students' needs, goals, and assistantship responsibilities. For example, students serving as TAs and/or coming from non-astronomy undergraduate programs may need additional time to complete the requirements outlined in the first two years below. Another example schedule with a comprehensive exam taken in the 3rd year is shown in Appendix B.2 Example Alternative Extended Timeline.

Typical Path

Year	Fall 8/1- 12/31	Spring 1/1 - 5/31	Summer 6/1 - 7/31
1	• ASTRO 501 (3 credits) • ASTRO 502 (3 credits) • One 3-credit elective • ASTRO 588 (1 credit) • ASTRO 589, 590, and/or 602 (TA) • Ethics training	• Three 3-credit electives • ASTRO 589, 590, and/or 602 (TA) • Find summer research advisor (typically provides RA summer funding) • First Year Oral Presentation • Pre-comps activity report	• Research • Qualifying exam

2	• Astro 596 (3 credits) • Two 3-credit electives • ASTRO 589 and/or 602 • Second Year Report • If applicable and not completed: enroll in Masters-along-the-way , Computational Science Minor, and/or Astrobiology dual title	• Two 3-credit electives • ASTRO 596, 589 , and/or 602 • Second Year Oral Presentation • Form PhD Committee • Pre-comps activity report • Comprehensive exam • Determine source of funding for summer and upcoming academic year	• Research • If not completed: comprehensive exam (must enroll in ASTRO 596 and apply for STAP)
3+	• Research for dissertation • If not yet completed: required coursework and/or comprehensive exam • Continuous registration • Additional coursework, beyond requirements, of interest to student and/or recommended by PhD committee • Yearly PhD committee meeting and activity report • Spring: determine source of funding for summer and upcoming academic year		

Summer Research 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.

Summer Research Directly Following First Year: 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 does not need 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. 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.

Informal learning through departmental events: 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; and talking with faculty and other students about their research 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. 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.

7. Purchasing

7.1 Research Travel

- ☐ Have advisor use purchasing card for major expenses
- ☐ All International Travel MUST be registered with the Travel Safety Network (TSN) at least 30 days prior to departure.
- ☐ Book flights through Anthony Travel or Travel Onlion; perform flight comparison (if applicable) on date of booking
- ☐ Submit paperwork promptly upon return

Students traveling for work purposes are advised to coordinate for someone with a purchasing card (such as their advisor) to purchase all major expenses such as flights, hotel rooms, and conference registrations. Using the purchasing card (pcard_ facilitates reimbursements and avoids incurring large out-of-pocket expenses. The one exception is meals -- typically travelers pay for meals out of pocket and receive a per diem reimbursement. An advisor's pcard can still be used if the student is using other university funds, such as a Zaccheus Daniel Foundation award; indicate where the expenses should be charged when submitting reimbursement paperwork.

Flights: An easy way to book your flights is through Anthony Travel (email them describing your flight needs). They can also provide comparison documentation. Once you and they have figured out the flights, you can CC your advisor for permission and have the expenses charged to their pcard. Keep in mind that international travel on federal funds must comply with the Fly America Act. See Penn State travel policy for details.

Other Major Expenses: An easy way to book hotels, registrations, etc. is to either fill out all the information except the credit card number and have your advisor enter the number at an in person meeting, or, if they prefer or if meeting remotely, send them all the details of the form to fill out.

Airfare comparisons: Do an airfare comparison through Anthony Travel or Penn State Travel Services OnLion on the same day the actual booking is complete. Doing this after the trip often results in reimbursement delays and possibly a lower amount reimbursed. Flight comparisons are required if:

- Any part of the trip includes personal time
- You used other than Travel Service onLion, Concur or Anthony Travel AND…
    - airfare is being charged to FEDERAL FUNDS (research grant)
      OR
    - airfare is being charged to GENERAL FUNDS (start up or overhead) AND is over $1,000
- You fly in or out of an airport other than State College and you will claim expenses getting to or from that airport (except if you live and work in a location other than State College)
- Instead of flying, you will drive over 375 miles one way or 750 miles round trip using your personal vehicle

After trip: Send the Financial Team (astro-financial@psu.edu) the following documents:

- ☐ Completed Travel Questionnaire
- ☐ Completed Employee Reimbursement Form
- ☐ Receipts, flight comparison

See our department Travel Tips for further details.

7.2 Software Purchases

BEFORE the software purchase:

- ☐ Visit Software at Penn State. or Lion Marketplace Software Store to check if the software you need is available there. These locations offer software that has already been approved by the University and can generally be bought in a faster manner than the traditional software procurement process.

If you have to purchase a software from a different source:

- ☐ The Software Request Form needs to be filled out and approved by Purchasing prior to making any software or software-related purchase. Purchasing will review the Terms of the Agreement to make sure everything is within university policy and that there's adequate protection for the University and the Department. The Software Request Form Checklist can help you decide what information you may need to complete the request form.
- ☐ The form needs to be completed and approved even if the software is free.
- ☐ Please note that the software is not permitted to be purchased on a personal card, so no reimbursement will be authorized if you've used your personal card.

Approval process:

- ☐ Complete the software request form
- ☐ Send it to the Software Inbox (purchasesoftware@psu.edu) as a PDF file together with any additional documentation that requires review.
- ☐ You will receive an email about the approval for the software purchase.

AFTER the software purchase, please submit:

- ☐ The receipt of the purchase,
- ☐ The Software Approval email,
- ☐ Your budget information,
- ☐ Justification for purchasing

Software approval expiration

Software approvals are usually given for 12 months (one-time authorization). If you completed the software request form the prior year AND there are no changes to the use of the software or to the responses on the software request form, you do not need to complete a new software request form. A review would need to be completed each year by Purchasing Software Agreements, but a new form would not be required unless there were changes. Follow the instructions on the final page of the Software Request Form to route the form. If you no longer have the prior software request form you would need to complete a new form, save the PDF and follow the instructions at the end.

Other considerations for software

1. Courseware: Courseware is broadly defined as a software or digital application used by students or educators in a class. Courseware requires added reviews to ensure it meets the Family Educational

Rights and Privacy Act (FERPA) and accessibility requirements. Additional information on Courseware can be found at courseware.psu.edu
2. Canvas Integrations: If integrations or enhancements are needed to Canvas, the University's Learning Management System, a separate request to that group may be needed. Additional information can be found in the Integrations and Enhancements section of the Canvas website.
3. Additional information on data security is available in Policy AD95. If you need assistance determining the classification of data, you can refer to this security website for assistance.
4. Information on Accessibility concerns is available in Policy AD96.
5. Information regarding Export Compliance considerations can be found on their website or in their FAQs.
6. Looking for something specific? Check out the contracts listing page.

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 via LionPath well in late September for the following spring semester, in February for the following summer session, and late March for the following fall semester. See Registration Timetable for details. Students may register for or drop courses during the first 5 days of classes at no charge, but after that there is a late registration 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. See the tuition adjustment policy for further details.

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. Students must be provided with a syllabus on or before the first class meeting describing assessments, learning objectives, and other required information. 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. See Final Examination policy for details.

Graduate students enrolled in or TAing courses 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 through the last day of the final examination period.

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 used in some 600-level courses, such as ASTRO 601 and 611 (see for 5.11 Post-Comps Residency Requirements and Continuous Registration for details); 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., Qualifying Exam, Comprehensive Exam, Final Oral Exam, MS or PhD degree).

8.4 Evaluations of Teaching Effectiveness

The students in each section of every course complete the University-wide Student Ratings of Teaching Effectiveness (SRTEs), including Department-specific questions. The SRTE and other evaluations are administered within the last three weeks of a semester. These are read by the instructor and assessed by the Department Head. Students are highly encouraged to complete their SRTEs, which provide valuable feedback to the instructor for improving the course and are used in assessing the instructor for performance evaluations, tenure, and promotion.

8.5 Academic Integrity

All Penn State policies regarding ethics, honorable behavior, and academic integrity apply. Academic integrity is the pursuit of scholarly activity free from fraud and deception and is an educational objective of this institution. Academic dishonesty includes, but is not limited to, cheating, plagiarizing, fabricating of information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students. For any material or ideas obtained from other sources, such as the text or things you see on the web, in the library, etc., a source reference must be given. Direct quotes from any source must be identified as such. All exam answers must be your own, and you must not provide any assistance to other students during exams. Any instances of academic dishonesty will be pursued under the University and Eberly College of Science regulations concerning academic integrity.

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.

9.1 General Guidelines for All TAs

A 1/2 time assistant (typical TA appointment) is expected to devote an average over the semester of 20 hours per week to their 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).

Depending on the assignment, TA duties may include:

- holding office hours to support general ASTRO course instruction or for a specific course
- assisting with lecture activities
- proctoring exams
- suggesting and writing exam questions, and proofreading exams
- grading assignments and exams
- preparing and posting solutions sets
- tracking student participation and completion of activities

It is essential that TAs contribute to an environment that is respectful, fair, and free from harassment and discrimination. Any harassment or discrimination of students – including pursuing a romantic relationship with a student in a TA's course – will be reported and prosecuted under University regulations. TAs must also refrain from any kind of social involvement with students in their course. If a student you are assigned to grade or instruct is a family member, partner, or close friend, notify the course instructor or TA Supervisor immediately.

Continuation of TA support is contingent upon satisfactory performance as an educator as evaluated both by the faculty and students. Student evaluations include SRTEs completed at the end of the semester. SRTEs may also be helpful to summarize or quote from for future job applications, particularly for courses in which the TA is the instructor of record.

9.2 Guidelines for TAs leading labs and problem sessions and instructors of record

- 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 to teach your class effectively.
- All course logistics (roster, grades, syllabus, etc.) should be centrally managed on CANVAS.
- 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.
- Be prepared when you show up to teach your class. Be professional and courteous to your students.
- Be available to the students for help, and encourage them to ask you questions. Frequently remind your students to take advantage of regular office hours when you (and/or other TAs) are available to help them outside of class.
- 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.

For instructors of record specifically:

- Grade and return your students' work within one week.

- If applicable, complete the forms which indicate the progress of student athletes. You will be contacted via email if this applies.
- Complete and submit final grades in LionPATH promptly during final exam week.
- Matters to be brought to the attention of the Teaching Assistant Supervisor include: cheating by students (see 8.5 Academic Integrity), excessive absences by students, aberrant behavior by students which disrupts the classroom

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 course instructor or Teaching Assistant Supervisor.
- 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. 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.

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 rough or boisterous play 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.
- For introductory astronomy labs, 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.
- 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 Pedagogy

The Schreyer Institute for Teaching Excellence provides 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 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.

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, RAs, or Fellows. 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 unless taking the comprehensive exam or final thesis defense.

10.1 General Expectations for TAs and RAs

- ☐ Respond ASAP to Graduate Staff Assistant's emails asking student's funding source for each semester and summer
- ☐ Discuss work expectations with supervisor and communicate about planned and unplanned absences.

Pre-comprehensive exam stipends are currently set at Grade Level 18 (RAs) and 19 (TAs) where the stipend pay rates are determined annually by the University. The difference is to compensate for higher state taxes for TAs. Post-comprehensive exam stipends are currently set at Grade Level 19 (RAs) and 20 (TAs)

RAs are funded by research supervisors' external grants (e.g., NASA, National Science Foundation) or internal funds (e.g., start-up funds). 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.

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.

10.2.1 Penn State Fellowships and Awards

For internal Penn State Fellowships, eligible students will be informed of application procedures by the Associate Department Head.

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.

Science Achievement Graduate Fellowships recruit, recognize and promote outstanding graduate students who are seeking a doctoral degree in the sciences and mathematics, interested in the advancement of women in the sciences and related fields, have a record of significant professional achievements in their field, and are role models for other students in the college.

Bunton-Waller Graduate Awards are a type of merit award support that is paid as an assistantship. The department's stipend level for Bunton-Waller awardees is pegged to the annual stipend for University Graduate Fellows. This match is typically accomplished through assistantship pay grade.

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.

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. All students are eligible providing they are registered for the following semester. 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 several fellowships awarded each year with value around $3000.

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 $500-1000, but requests up to $2000 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

For externally funded Fellowships, the Department will forward relevant announcements it receives, but the student is responsible for finding on-line information and deadlines. Some external fellowships have requirements for US citizenship and/or permanent residency. Funding selection criteria and the number of available awards are highly variable; the list below is not meant to be comprehensive. The University Office of Graduate Fellowships and Awards Administration website maintains a database of external fellowships.

NASA FINESST grants offer three years of funding for graduate student-designed and performed research projects. The proposal must present a well-defined research problem/activity and a justification of its scientific significance to NASA, as well as a detailed approach for its solution/conduct. Proposals are typically due in February. As of 2022, there are no citizenship requirements for this funding opportunity.

National Science Foundation Graduate Research Fellowships are multi-year fellowships for graduate students in science, mathematics, and engineering that cover stipend and tuition. The deadline for applications in October. For US citizens, US nationals, and permanent residents who have completed no more than one academic year of full-time graduate study. Graduate students are limited to only one application to the GRFP while in graduate school, submitted either in the first year or in the second year of graduate school

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. Current or past PSGC Fellows may apply for up to one additional year of funding Individuals may receive a maximum of two PSGC Fellowship awards. The application deadline is usually early March. For US citizens only.

American Astronomical Society International Travel Grants provide funding for airline travel to international science meetings by individuals at US institutions. AAS membership is not a requirement. There are typically two deadlines a year, one in the spring and one in fall.

National Defense Science and Engineering Graduate (NDSEG) Fellowships are three-year awards by the Department of Defense to students entering or in their first or second 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 and Nationals 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 scholarships may be used for tuition, books, fees, or living expenses. The application deadline is typically mid November.

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 typically in January or February.

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 typically in March or October.

10.2.3 Important Caveats for External Funding

- ☐ Contact the Graduate Staff Assistant and Associate Head of Graduate Studies when applying for external funding to determine a plan for tuition and summer appointments

We support and applaud students who pursue external fellowship, internships, and other opportunities. However, there are in some cases university rules that can make such funding sources challenging to navigate. Our department is committed to work with you to come up with the best possible plan to take advantage of these opportunities.

Tuition can only be covered when a student is on an approved external fellowship or if the fellowship itself covers tuition. Students applying for external fellowships or other types of external funding should contact the Graduate Staff Assistant and Associate Head of Graduate Studies as early as possible (i.e., at the time of application) to determine a plan and if/how tuition can be covered.

When a student is directly paid from an external source (for example, from a fellowship that is not channeled through Penn State or paid as a full time research consultant), they cannot be appointed as an assistant and department funds cannot be used to cover their tuition. A couple options are for the student to take a leave of absence or, in rare cases, to pay tuition themselves.

Students are required by College HR policy to be appointed as assistantships for the entire spring semester to be eligible for a summer RA appointment, so students who do not have a Penn State appointment for the entire spring semester will need to complete additional paperwork and be paid hourly over the summer, if supported by a Penn State RA over the summer.

10.3 Income Taxes

The information presented here is intended to help students become more comfortable with understanding information provided by PSU and is provided specifically for the Department of Astronomy and Astrophysics; other departments may offer different interpretations. For this reason, please do not circulate outside of the department. The guidelines listed here may or may not be

applicable for your specific case. The information here is intended strictly as a compilation of potentially useful information for understanding how your income is taxed at the federal, state, and local levels. This information does not constitute tax advice; for information on how to complete and file your tax returns, please consult an accountant or other tax expert. Further, this information is based on an understanding gained for tax years 2019 and prior. If changes have occurred for tax year 2020 and beyond, then they are not included here.

10.3.1 Tax Forms

Students employed as a TA or RA by internal funding (department or advisor grants) will generally receive a W-2 that lists income earned, taxes withheld, etc.

Students on fellowships will possibly receive NO tax form from the University or external funding source. You are still responsible, however, for reporting that income where appropriate.

Scholarships, grants, and other internal fellowship awards will typically be reported to you on Form 1098-T, provided by PSU. Form 1098-T will also list amounts paid by you (or on your behalf via your appointment) for qualified tuition and expenses. Generally speaking, if you received no additional income beyond your TA/RA appointment, the amounts in Box 1 on the 1098-T should equal the amount in Box 5. The amount in Box 5 is not considered taxable except to the extent that it exceeds the amount in Box 1. If your Box 5 amount is greater than Box 1, the difference is taxable and you are responsible for reporting that amount on your return.

10.3.2 Federal Income Tax

All income earned as a graduate student, including TA and RA stipends and graduate fellowships, is generally considered taxable at the federal level. Any scholarship or award income, to the extent that it exceeds payments for tuition and required fees (see note in 10.3.1 Tax Forms), is also considered taxable.

Your stipend (monthly pay) is taxable. If federal taxes are not being withheld then grad students can change their withholdings (this can be done online in Workday), pay estimated taxes, or have a tax burden when they file. Generally speaking, students on a TA or grant-supported RA will have taxes withheld and can check Workday for further information. Students on external fellowships will not typically have taxes withheld. In that case, you must either pay estimated tax payments each quarter (Federal Form 1040-ES), or risk having both a tax due burden and a late payment penalty when you file taxes.

Whether you receive a W-2 or not, the income earned as a TA, RA, or fellow should be reported on line 1 of your federal tax return. Just because you do not receive a W-2 does NOT mean you do not have taxable income.

10.3.2 State and Local Income Tax

PA's stance on taxes on stipends is here, and also applies to local, Centre county income tax returns (filed separately from PA income tax). It appears that criterion c ("The recipient is a candidate for a degree and the same activities are required for all candidates for that degree as a condition for receiving such a degree.") is what PSU is using as their determining factor for tax or no tax. Generally speaking, because a TA appointment is not considered to meet any of the criteria shown above, TAs will pay state and local taxes (2019 rates were 3.07% state and 1.45% local). TAs in our

department are paid at a slightly higher pay grade to compensate. Typically, the correct amount of state and local tax will be withheld from your paychecks so that you will not have a tax burden due at filing.

RAs will typically not pay state and local taxes if their research work is related to their degree. If the work is not related to their degree, then the RA is taxable. Whether your RA is taxable or not will be determined by the research advisor's definition of the RA, which will be provided to the department when assigning your assistantship (it is rare that an RA is taxable).

The linked regulation states "In order to substantiate that a scholarship or fellowship is not taxable, include a letter with an original signature of the department head or other official detailing the description of the program under which the award was received. A form letter is not acceptable." Though it is rare for a student to obtain that letter at the time of filing, several students each year are contacted and asked for that information, so you should be aware of that requirement and be prepared to obtain supporting documentation if required. The letter has been previously obtained by contacting Ray Burke (rmb135@psu.edu) in the payroll office in the case that you have received notification that one will be required.

For errors on the 1098-T or W2, grads should contact the Bursar's office. However, getting tax advice or guidance from PSU is difficult, and there is precedent for the PSU Bursar's Office to provide advice that can lead one astray or has been outright incorrect. Ultimately tax advice should be sought only from tax professionals.

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 online 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, online. Most are available through NASA Astrophysics Data System (ADS) Astronomy and Astrophysics Abstract Service and the astro-ph arXiv e-Print archive. For articles behind a paywall, use the Penn State Library Link Builder or ADS Library Link Server.

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.

For information about university and department computing accounts, see 3. Procedures for the Entering Student. For assistance with computing, contact the Eberly College of Science Information Technology Help Desk.

Students have access to the supercomputing cluster Roar through the Institute for Computational and Data Sciences. See 11.4.4 The Institute for Computational and Data Sciences (ICDS) for details.

11.3 Observing Facilities

11.3.1 The Hobby-Eberly Telescope

The Hobby-Eberly Telescope (HET) is a 10-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. HET time is allocated three times each year with proposal deadlines in February, June, and 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 a 16-inch Dobsonian (donated by an alumnus), 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, Emeritus 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), a few miles away from 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.

11.3.4 Other Telescopes and Instrumentation

Through the department, Penn State is a partner in a number of prominent multi-institution and international research collaborations built around world-class instrumentation, including Cosmic Ray Energetics and Mass, High Energy Instrumentation, the Hobby-Eberly Dark Energy Experiment, IceCube, the Vera Rubin Observatory, MINERVA, the Habitable Planet Finder, the NEID spectrograph, Pierre Auger Cosmic Ray Observatory, and Sloan Digital Sky Survey - III.

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 The Center for Exoplanets and Habitable Worlds

The Center for Exoplanets and Habitable Worlds seeks to discover planets beyond our solar system, to characterize planetary systems and their host stars, and to understand the implications of the abundance of potentially habitable planets for the possibility of life beyond Earth and the origins of our own solar system. The Center for Exoplanets and Habitable Worlds is devoted to broad, interdisciplinary research in this exciting, rapidly developing field. Members of the Center, who come from the Department of Astronomy and Astrophysics in the Eberly College of Science, the College of Earth and Mineral Sciences, and the College of Engineering, are experts in several critical areas of extrasolar planet research. The Department of Astronomy and Astrophysics also has substantial access to the Hobby-Eberly telescope, which is recognized as a premier planet-searching facility. The Center promotes collaborations among scientists at Penn State and between Penn State and other institutions, attracts young, capable researchers to Penn State, and provides a solid platform for a coordinated effort to improve science education on campus and among the general public. Events include a weekly seminar and weekly journal club.

11.4.3 Center for Astrostatistics

The Center for Astrostatistics 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, the Center 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.

11.4.4 The Institute for Computational and Data Sciences (ICDS)

The Institute for Computational and Data Sciences aims to build capacity to solve problems of scientific and societal importance through interdisciplinary, cyber-enabled research. As computation and data science become increasingly vital modes of inquiry, ICDS enables researchers to develop innovative computational methods and to apply those methods to research challenges. Graduate students may be particularly interested in ICDS training events (https://www.icds.psu.edu/computing-services/roar-training-series/), an interdisciplinary seminars as part of the Penn State Data Science Community (https://datascience.psu.edu/), several ICDS Centers (https://www.icds.psu.edu/research/icds-centers/ with their own seminar series), and the annual ICDS Symposium (https://www.icds.psu.edu/news-events/icds-symposium/). The ICDS Symposium typically includes a poster session that provides an excellent opportunity to get experience presenting your research and describing your methodology to an interdisciplinary audience (even when their research isn't a great match to that year's theme).

Graduate students can request an account on the Roar supercomputing system (https://www.icds.psu.edu/computing-services/account-setup/) and get significant computing resources and short-term storage for free. If students need faster job start times, a larger number of cores, more long-term storage, access to hardware accelerators or high-memory nodes or consulting services, then they should talk to their faculty sponsor about finding funding and/or writing an ICDS Seed grant proposal (https://www.icds.psu.edu/resources-for-researchers/icds-funding-opportunities/).

11.4.5 Other Centers and Institutes

Some of the largest astronomy research efforts at Penn State are coordinated through the department's centers and institutes, several of which are world renowned for their pioneering work.

Center for Fundamental Theory
Center for Multimessenger Astrophysics
Center for Theoretical and Observational Cosmology (CTOC)
Consortium for Planetary and Exoplanetary Science and Technology (CPEST)

Penn State Astrobiology Research Centers (PSARC)
Penn State Extraterrestrial Intelligence Center (PSETI)
Planetary System Science Center (PSSC)

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 3:45 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 Room 530. Graduate students have lunch with the colloquium speaker and can sign up to meet individually with the speaker and/or attend the colloquium speaker dinner.

Tuesday Lunch Talks Every Tuesday, from 12:15-1:00 pm, a member of the department (a faculty member, postdoc, graduate student, or undergraduate student) gives a science talk in room 538 (Research Talk), or two members each give short (20-minute) talks. 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' 5.3 First Year Oral Presentation, 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 during their 5.7 Second Year Oral Presentation.

Center and Institutes: Many centers and institutes have their own talk series; students should check the schedules for the relevant centers and institutes.

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 Hour 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 530 Davey Lab. The department holds a coffee break each morning from 9:30-10:30 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.

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 departmental picnic, Student Awards Reception, Undergraduate Research Symposium, and ice cream socials. Graduate students will generally receive notice of such events by email via the email listserv.

12.2 Printing and Photocopying

We have 3 printers in the department located in rooms 525, 532, and 416. All three of these printers can also serve as a copier and a scanner. The machines in 525 and 416 have fax capability. 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.

The department does not have the equipment for large poster printing. There are 3 places that can accommodate poster printing at this time:
Engineering Copy Center
PSU Multimedia and Print Center
FedEx Office Print & Ship Center

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.

The 416 copier/printer/scanner/fax room is locked around 4:30P, Monday through Friday. You can access this room after hours by using an "F" key (see faculty or staff). 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 the staff 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

Graduate student membership in the American Astronomical Society (AAS) is available and significantly reduces the registration fee for attendance at the semi-annual meetings of the Society and its divisions. This cost can only be charged to grants or general funds when it is coupled with a corresponding reduced AAS or division meeting registration fee (resulting in a net savings to the travel expenses). Other benefits of membership include subscriptions to the monthly magazine Physics Today; the AAS News Digest emails; the monthly e-mails of the AAS Job Register, a 15% discount on one article in AAS Journals every year one renews membership; access to the NASA Federal Credit Union; eligibility for the Chambliss Astronomy Achievement Student Awards at meetings; and eligibility to vote in society and division elections. You may direct questions about the society to the departmental AAS Agent, currently Jason Wright.

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

Emergencies:

- University Police 814-863-1111 or
- Town police, fire, ambulance (8-) 911
- Mount Nittany Medical Center (hospital):

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.

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 8.5 Academic Integrity).

University Police and Public Safety – Annual Security Reports:

Thesis information includes calendar and format requirements.

Graduate assistant information includes stipend and tuition grants, workload and credits, medical insurance, dental plan, and FICA exemption.

Graduate and Professional Student Association provides information on student government, insurance, housing, and career services.

International student services (including visa, tax, finance, health information and forms).

Health services including health insurance

Tuition and charges, choose a semester and choose the University Park location.

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 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, 12.4 Graduate Research 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 policies.

Affirmative Action, including resources to report discrimination and harrassment

Appendix B: Pre-Approved Courses in Allied Fields and Example Extended Timeline

B.1 Pre-Approved Courses in Allied Fields

Graduate students in the Department of Astronomy & Astrophysics will likely take multiple courses in approved allied fields. Such courses are listed in the table on the following pages. 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: Department Forms and Checklists. Students should choose their courses in consultation with their academic advisor.

COURSE	TITLE	PREREQUISITES
ABIOL 574‡	Planetary Habitability	none
ABIOL 590‡	Astrobiology Seminar	none
AERSP 401A	Spacecraft Design – Preliminary	Astronautics
AERSP 424	Advanced Computer Programming	Computer programming
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	Astrodynamics	PHYS 419
CHEM 452	Physical Chemistry – Quantum Chemistry	Intro chem, phys & math
CHEM 464	Chemical Kinetics and Dynamics	CHEM 452
CMPSC 450	Concurrent Scientific Programming	
CSE 557	Concurrent Matrix Computation	
EDSGN 468	Engineering Design and Analysis with CAD	Mechanics
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
GEOSC 474	Astrobiology	Intro biology & chem
GEOSC 502	Evolution of the Biosphere	none
GEOSC 531	Origin of the Earth and Moon	none
MATH 505	Mathematical Fluid Mechanics	Analysis
MATH 513	Partial Differential Equations I	Differential equations
MATH 523	Numerical Analysis I	
MATH 550/ / CSE 550	Numerical Linear Algebra	
MATH 577	Stochastic Systems for Science and Engineering	Probability
NUCE 530	Parallel/Vector Algorithms for Scientific Applications	
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

COURSE	TITLE	PREREQUISITES
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 410, PHYS 561/CHEM 565
PHYS 580	Elements of Network Science and Its Applications	none
SCIED 411	Teaching Secondary Science I & II	Teaching course
STAT 511	Regression Analysis and Modeling	STAT 500**
STAT/IST 557	Data Mining I	STAT 318 or STAT 416**

‡ ABIOL 574 is approved to substitute for a required ASTRO 500-level course. ABIOL 590 is approved to substitute for one of the three ASTRO 589, if not already used to fulfill another requirement.

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

***** 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)

** Our students are generally prepared for STAT 511 without having taken STAT 500 and find STAT 511 more beneficial than STAT 500. STAT 511 is recommended for students who do not take ASTRO 515. STAT/IST 557 is recommended for students who have taken ASTRO 515, and our

students are generally prepared without the undergraduate-level prerequisites. Consult with the Associate Head of Graduate Studies for further recommendations

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B.2 Example Alternative Extended Timeline

The example timeline below shows a case where coursework is completed and the comprehensive exam is taken in the third year. Typically it is recommended that students complete their coursework and take their comprehensive exam within 24 months of starting the program (see typical timeline in 6. Your Path Through Graduate School), but in some cases a more extended timeline is beneficial.

Alternative Extended Timeline Path

Year	Fall	Spring	Summer
1	• ASTRO 501 (3 credits) • ASTRO 502 (3 credits) • One 3-credit elective • ASTRO 588 (1 credit) • ASTRO 589, 590, and/or 602 (TA) • Ethics training	• Two 3-credit electives • ASTRO 589, 590, 596, and/or 602 (TA) • Find summer research advisor (typically provides RA summer funding) • First Year Oral Presentation • Pre-comps activity report	• Research • Qualifying exam
2	• Astro 596 (3 credits) • One 3-credit elective • ASTRO 589, 596, and/or 602 • Second Year Report • If applicable and not completed: enroll in Masters-along-the-way , Computational Science Minor, and/or Astrobiology dual title	• Two 3-credit electives • ASTRO 596, 589 , and/or 602 • Second Year Oral Presentation • Form PhD Committee • Pre-comps activity report • Determine source of funding for summer and upcoming academic year	• Research
3	• One 3-credit elective • ASTRO 589, 596, and/or 602	• One 3-credit elective • ASTRO 589, 596, and/or 602 • Determine source of funding for summer and upcoming academic year	• Research • ASTRO 596 • Comprehensive exam
4+	• Research for dissertation • Continuous registration • Additional coursework, beyond requirements, of interest to student and/or		

	recommended by PhD committee • Yearly PhD committee meeting and activity report • Spring: determine source of funding for summer and upcoming academic year

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

Petition for Substitution/Waiver of Graduate Degree Requirement, submit to Associate Head of Graduate Studies and Graduate Staff Assistant
PhD Course Requirements Checklist (make your own copy or download), submit to Associate Head of Graduate Studies and Graduate Staff Assistant
Travel Questionnaire, submit to astro-financial@psu.edu
Travel Reimbursement Form, submit to astro-financial@psu.edu

Appendix E: Eberly College of Science Graduate Handbook Addendum