Graduate Handbook

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1 Purpose of this Document

This handbook is intended as a supplement to the Graduate School Bulletin. It summarizes Astrophysics degree requirements and answers frequently asked questions about student goals and student-faculty relations. Although every effort has been made to maintain accuracy, you should always defer to the Graduate School Catalog in the event of any conflict with that document.

The M.S. and Ph.D. programs in Astrophysics are designed primarily to train individuals for careers in modern astrophysical or related research. Increasingly, Ph.D.s in the physical sciences are pursuing a broader range of careers, bringing to them both their technical knowledge as well as their skills and experience in research and problem-solving. All of these careers are very demanding and competitive. Hence, independent of what career path you follow, your principal goal throughout your graduate career should be to learn and get first-hand experience with the broad range of tools of a research scientist.

For many scientists, teaching is a critical component of their job. In the Astrophysics program, most students will receive training and experience in teaching. There are also a growing number of opportunities for enhancing this training and documenting your experience for help in your future employment.

This handbook should serve as a reference guide and a place to start. However, it cannot replace the invaluable information you can obtain by talking with your adviser, faculty members, or other graduate students. This handbook is also an evolving document, and your comments and suggestions for its improvement are always welcome.

2 Graduate Students and Faculty - Mutual Expectations

The purpose of this section is to provide graduate students with an idea of what is expected of them and also what they might reasonably expect from the faculty. In general terms, the faculty expect all graduate students to be working hard and making no less than “satisfactory progress”, as described further below, toward their intended degree. Graduate students can reasonably expect that the faculty provide them with instruction, advice, and
access to resources which allow them to make reasonable progress.

Due to the highly competitive nature of the job market in astronomy, there are multiple, sometimes competing department goals for the graduate program. While not all of our graduates proceed on to employment in astronomy, all of the goals of our program are designed to best prepare a graduate student for such a career. This is based, in part, on the expectation that all entering graduate students have the long range goal of a career in astronomy. However, it is also the aim of the faculty to help the graduate students develop skills which are “transferable: (e.g., communication skills, computing expertise, etc) with the goal to enhance their prospects for future employment, regardless of field.

2.1 What is “Satisfactory Progress”?

At one level, this is a simple question. The guidelines and requirements spelled out in Sections 3 and 6 describe the timelines for various goals to be accomplished. Graduate students should be familiar with these. The Graduate Faculty conduct an Annual Review each Spring to review the progress of each graduate student. Before this review, all graduate students submit a self-evaluation to the DGS (see next section). The DGS is then responsible for providing to each graduate student a short written summary of the faculty’s discussion. This should not replace continuing discussions between faculty and advisees concerning the student’s progress. Any questions should be directed to your adviser and/or the DGS.

However, at a broader level, what constitutes “satisfactory progress” depends on the goals of the individual graduate student, and can be far more complex than the single characterization of an M.S. or Ph.D. degree. If eventual employment as a research astronomer is the desired goal (as is often assumed), the job market can be much more demanding than the formal university requirements for a Ph.D. (successful post-doctoral candidates generally have research accomplishments in addition to their required thesis work). Thus, it is reasonable for the graduate students to discuss their goals with faculty members and ask them for informal evaluations not only on the progress of their research, but also on their employment prospects.
2.2 The Faculty Roles

Faculty members have many different responsibilities for the graduate program; these fall within three main categories. For the most part, it is the faculty’s responsibility to provide access to first-rate physical resources for learning and research. Whether this is in the form of observing time on the world’s best telescopes, state-of-the-art computing facilities, library facilities, or adequate office space, this is where the faculty spend a great deal of effort. Clearly, it is in the best interest of the graduate students to help in this effort, when possible.

It is also the faculty’s responsibility to provide a curriculum which includes a large range of exposure to fundamental concepts, areas of important current research, and experiences with methods of research and problem solving.

Finally, it is the faculty’s responsibility to provide feedback to the student. Formally, this is achieved through the Spring Annual Review of all graduate students by the faculty. Here the student’s progress is reviewed and goals are identified for the next year (i.e., “satisfactory progress” is defined). Graduate students participate directly in this evaluation by submitting a self-evaluation to the DGS prior to the review. The self-evaluation consists of answering 9 questions which serve as an overview of the last year’s progress (see Appendix 2). It is not expected that all graduate students will have accomplishments in every category, (especially true for students in their first year), but the evaluation should be seen as a list of what types of accomplishments the faculty are looking for. This self-evaluation also allows the graduate student an opportunity to define what they believe are reasonable goals for the next year. Since satisfactory progress is a pre-requisite for departmental employment, the graduate student’s qualification for departmental support is part of this review process.

For first and second year graduate students, some feedback is also available in the form of grades in graduate course work. However, graduate students should be aware that grades of A and B are common in graduate courses; a grade of C should be considered unsatisfactory. To be competitive for fellowships later on, students usually need a g.p.a. of no less than 3.5.

To get the most out of graduate school, graduate students need to go beyond these formal feedback mechanisms, and to work with their faculty adviser(s) to establish well-defined goals and evaluate progress on a regular basis. Getting feedback on academic, technical, communications, and
research skills are all of value for the student. Since, by definition, the results of research are unpredictable, a frequent review of progress and the re-evaluation of goals in this area is critical. Informal feedback from other faculty members, and even from fellow students, can help a student identify strengths and areas that need improvement.

The graduate students can also look to the faculty for evaluation of their work and professional development. When possible, the faculty attempt to provide the financial support necessary for this progress.

3 Registration and Student Status

For many reasons, such as deferment of student loans, eligibility for University employment, health benefits, access to University facilities, it is important for graduate students to maintain their full-time registration. Students must register each semester; summer registration is usually reserved for thesis credits.

You should register whether or not you are taking regular classes. When you are not taking any regular coursework, you should register for AST 8990 (directed research), AST 8777 (M.S. thesis credits — 10 in total are required), AST 8666 (Doctoral pre-thesis credits), or AST 8888 (Doctoral thesis credits — if you have passed your Preliminary Oral Exam — 24 in total are required). When you have completed all of your thesis credits and are ABD (all but dissertation), register for 1 credit of 8444 each semester. All graduate students are required to register in the Graduate School every fall and spring term in order to maintain active status.

Registration lasts through the first week of classes in each semester. There is a late fee charged after a certain date - see the Class Schedule. Registration is completed on-line via OneStop. Some of the 8000 level classes will require a permission number for registration; permission numbers are obtained from the departmental office. For advice on classes, talk to your adviser and DGS. However, it is possible that you will have a “hold” on your registration. These can be academic, financial, or bureaucratic in nature and you will not be able to register until it is resolved. Also available at onestop.umn.edu is your student account (where you pay your fees), access to your transcript, financial aid information, etc.
3.1 Holds

Students occasionally will have a hold placed on their registration, preventing them from registering until the cause of the hold has been addressed. The established criteria are:

1. GPA: your GPA has fallen below 2.8.
2. Incompletes: you have incompletes exceeding 6 credits.
3. You are overdue in submitting a degree program or thesis proposal.

Normally you will receive a warning the first semester the problem arises. The second semester your registration materials will be withheld and can be obtained in 316 Johnston Hall only after the reason for the hold is removed or the DGS has approved your continued registration.

3.2 Resident Status and Tuition

The fee differential between “resident” and “non-resident” students is substantial. Regardless of your place of legal residency you are entitled to resident tuition rates if you are employed by the University at least 25% of full time. Students on appointments of at least 25% full time get tuition rebates at a rate equal to two times their fractional appointment. This also entitles members of your immediate family to resident rates. Otherwise, to obtain “legal” resident status as a student you must demonstrate that you came to Minnesota primarily for some purpose other than education. For students who must pay, the tuition structure is complicated; you should obtain the official policies from the Graduate School.

Most TA & RA appointments are at the 50% level and receive a 100% tuition waiver. Graduate students holding assistantships will have tuition benefits capped at a maximum of 14 credits per semester during the academic year and 14 credits per term during the summer. Summer registration is generally reserved for Thesis Credits; ABD students should register for one credit of 8444 each summer for fringe and tax benefits. Credits over 14 will be charged directly to any graduate student exceeding the cap.

4 Formal Requirements for the Ph.D.

You have been specifically admitted to the Ph.D. program.
Both the Astrophysics Program and the Graduate School have formal requirements for completion of the Ph.D. Graduate students are responsible for being familiar with and completing both of these sets of requirements. In the summary below, GS refers to forms that must be submitted to the Graduate School. In case of a conflict between the requirements, see the DGS.

We encourage all graduate students to consider obtaining a Master’s Degree, on their way to a Ph.D. Although this involves some additional work, it officially recognizes your accomplishments to that stage, and may allow alternative career and educational options in the future.

4.1 Summary of Requirements

Below is a summary of the Ph.D. requirements. You should also see section 7 for a timeline and appendix 5 for the Graduate School requirements.

4.1.1 Course Requirements - Major

You must complete a minimum of 40 course credits, including a year of Classical Physics (Phys 5011-5012). You will also specify a supporting program as described below.

4.1.2 Course Requirements - Minor

You may declare a specific minor or specify a “supporting program” which can include courses from several fields. The minor or supporting program must contain at least 12 credits (out of the 40 course credits mentioned above). Several examples of possible minors to enhance your background for Ph.D. work and to broaden career options are physics, mathematics, scientific communication, education (including the Preparing Future Faculty courses), and various engineering disciplines such as electrical engineering or computer science. For a minor, you should see the DGS of the specific minor program to get a complete description of the minor requirements.

4.1.3 The Written Examination

A comprehensive examination to be taken during the Spring. See section 3.4.
4.1.4 The Second Year Project

A research project to be completed or near completion by the end of Fall of the third year of study. The DGS should be given a project title and adviser by the end of Spring semester of the first year of study. This research is then defended as your Preliminary Oral Exam.

4.1.5 The Degree Plan - GS

Immediately after passing the Written Examination, you must complete the Degree Program Transmittal forms from the Graduate School. These will document which courses form the basis of your Ph.D. program, and also set up your examining committee for the Preliminary Oral Exam. Any transfer credits from graduate work at other institutions will be included on this form.

4.1.6 The Preliminary Oral Exam

To be taken in the Fall of the third year of study or earlier. A written version of the Second Year Project is to be submitted to your committee two weeks prior to the exam. The Degree Program Transmittal form from the GS must be processed prior to taking the exam (this can take a couple of months). After this form is processed, further GS authorization forms must be obtained.

4.1.7 Course Requirements - Thesis Credits

You must register for 24 Ph.D. thesis credits. Your Preliminary Oral Exam paperwork (with a ‘pass’ or ‘pass with reservations’ mark) must be submitted and processed before you can register.

A minimum GPA of 3.0 is expected by the department.

4.1.8 Ph.D. Thesis Title and Abstracts

By the Spring of the third year (prior to the spring Annual Review), you must submit the Thesis Proposal form for the Graduate School, which includes a 250 word abstract. You must also submit a Astrophysics Thesis Proposal, a 1000 word description of your proposed thesis work, written for an expert audience, and submitted to the DGS.
4.1.9 The Ph.D. Thesis

A substantial work of original research done under the supervision of an adviser from the Graduate Faculty, and submitted in writing according to GS standards. The Final Oral Exam: A public presentation of your thesis work, followed by a private examination. GS authorization forms based on review of the thesis by three “readers” must be obtained at least two weeks in advance of the exam.

There is no foreign language requirement.

4.1.10 GS Doctoral Degree Requirements

1. At least one semester before your Preliminary Oral Exam, file a Degree Program form.

2. After completion of all Preliminary Written Exams and at least one week before the Preliminary Oral Exam, submit the Preliminary Written Examination Report form. (This is usually done by the DGS.)

3. Schedule the Preliminary Oral with the Graduate School at least one week in advance of the exam. The Preliminary Oral must take place at least one academic semester (15 weeks) before the Final Oral Defense.

4. Within one working day of completion of the Preliminary Oral exam, submit the signed Preliminary Oral Examination Report form.

5. The semester after passing the Preliminary Oral Examination, submit the Thesis Proposal form.

6. After the Thesis Proposal has been approved by the Graduate School, you can request your graduation packet on-line or by visiting 316 Johnston Hall. The Thesis Reviewer’s Report form will be issued at that time.

7. Submit an Application for Degree to 200 Frasier or 130 Coffey by the first working day of the intended month of graduation.

8. Submit the signed Thesis Reviewer’s Report and schedule the Final Oral Defense at least one week prior to the exam.
9. Return the signed Final Oral Examination Report form no later than one working day following completion of the Final Oral.

10. Submit a copy of the dissertation abstract and a copy of the dissertation (all signed by the adviser[s]) plus the Microfilm Agreement Form and the Survey of Earned Doctorates by the last working day of the intended month of graduation.

4.2 Classes

There are several things to consider in choosing classes. One is the formal requirements of the major and minor programs; it is our aim to retain considerable flexibility in defining courses which can be included in major and minor programs — see the DGS with questions.

For new students, the DGS will look over your current transcript, and talk with you about any deficiencies in your undergraduate physics / astrophysics background. During your first year, it may be necessary to reinforce some of this undergraduate work, so that you can be successful in your graduate studies. Such classes may or may not count in your Ph.D. program, depending on their level.

An important consideration for beginning students is what will be included on the Written Examination. Courses marked with a * below are considered the Astrophysics “core”, and material from them will be included on the exam. Most courses are offered only every other year, so careful planning of your schedule is required.

Each year, the faculty run special topics courses (AST 8110-8120). These are an opportunity to investigate cutting-edge research and techniques in a specific area, and you are encouraged to take them, after all or most of your required coursework is complete. Different courses are taught in different styles, and they are all valuable for a graduate student to experience. Some will be taught in a traditional lecture format, although the class will be small and there will be more time for questions and discussions. Others may be more project or problem-solving oriented, with students participating and presenting their work. Others may be seminar style, where a general focus is provided, but students provide much of the course content through their individual literature research. Each of these formats can be useful; however, both the instructor and student should make clear at the beginning of each course exactly what the expectations are.
An important consideration for beginning students is what will be included on the Written Examination. Listed below are some courses that have been commonly used as part of the “Major”. Pay special attention to the (*) courses, whose subject matter is usually included on the Written Examination. Prior to the exam, students will be provided with a list of classes that will be covered on the exam, though past exam questions and basic astrophysics are also included. Brief descriptions of these courses are found in the Graduate School Bulletin; past syllabi for the Astrophysics courses are available from the DGS.

4.2.1 Graduate Courses of Interest to Astrophysics Students

- AST 4001 (Stellar Interiors to Galactic Structure)
- AST 4002 (Galaxies - From Active Galactic Nuclei to Cosmology)
- AST 4101 (Computational Astrophysics)
- AST 5012 (The Interstellar Medium) *
- AST 5022 (Relativity, Cosmology, and the Universe) *
- AST 5201 (Methods of Experimental Astrophysics) *
- AST 8001 (Astrophysical Radiative Processes) *
- AST 8011 (High Energy Astrophysics) *
- AST 8021 (Stellar Astrophysics) *
- AST 8031 (Astrophysical Fluid Dynamics) *
- AST 8110 (Topics in Astrophysics)
- AST 8120 (Topics in Astrophysics)
- AST 8200 (Seminar)
- AST 8333 (FTE: Master’s)
- AST 8444 (FTE: Doctoral)
- AST 8666 (Doctoral Pre-Thesis Credits)
• AST 8777 (Master’s Thesis Credits)
• AST 8888 (Doctoral Thesis Credits)
• AST 8990 (Research in Astronomy and Astrophysics)

(may be taken in any order and more than once as topics vary)

• PHY 5001-5002 (Intro Quantum Mechanics I, II)
• PHY 5011-5012 (Classical Physics I, II) *
• PHY 8011-8012 (Quantum Mechanics I, II)
• PHY 8502 (General Relativity & Cosmology)
• PHY 8601-8602 (Plasma Physics I, II)
• PHY 8611 (Cosmic Rays and Space Physics)

Virtually any 4000-8000 level physics course could in principle be included in minor programs. Some not listed above which have obvious value in astrophysics are courses in statistical mechanics, nuclear physics, atomic and molecular structure, and elementary particles. Various courses from the mathematics and other departments are also frequently included in minors.

4.3 The Second Year Project

Each candidate for the Ph.D. in Astrophysics must complete or have near completion a research project under the supervision of a member of the Astrophysics Graduate Faculty prior to taking their Preliminary Oral Examination. The purpose of this project is to give the student experience in research and to demonstrate their potential for Ph.D. thesis work. This project, known as the Second Year Project (SYP) is to be completed, and the Preliminary Oral taken, no later than Fall of the student’s 3rd year of enrollment.

The nature and extent of the project is agreed upon by the student and their project supervisor. Preferably, the student will submit to their adviser a written abstract of the SYP which clearly defines the project (goals, methods, and timeline). Supervisors and students should consult with the DGS with any questions regarding the suitability of work to be submitted as the SYP.
The general goal, as is the goal of all research, is that the work should be of publishable quality. However, the deadline of defending the SYP within the Fall semester of the third year is strict and an integral part of the overall program design (it is important that the faculty meet, assess the student’s progress, and provide feedback to the student on the timeline of the SYP). Thus, recognizing that research cannot always be forced to meet deadlines (e.g., bad weather can prohibit observations, disk crashes can cause set-backs, discoveries can alter the direction of the research, collaborators may be slow in responding) actual publication is not a requirement. Even if the research project is not complete, the student should be able to write up what they have accomplished so far, defend their research within the context of the oral examination, and be prepared to discuss their future plans. Thus, results of the SYP should be written up in the form of a paper to be submitted to a journal, although actual submission is not required. This write-up will then be presented to the Orals Committee.

The results of the SYP are presented at the Preliminary Oral Examination for the Ph.D. (see section 3.5). The Examining Committee will determine whether the student is qualified to continue on to the Ph.D., based on the SYP, their responses to questions at the examination and record of performance in the Astrophysics Program, including course work, the Written Examination, and other research experience. The SYP supervisor is responsible for presenting supporting documentation for this discussion.

For a student to be considered as making “satisfactory progress” in the Astrophysics program, the following timelines must be followed:

1. Notification of the DGS of the title and supervisor of the Second Year Project by the end of the first year Spring Semester;

2. Submission of the written version of the SYP to the Examining Committee two weeks prior to the examination.

3. Passing the Ph.D. Preliminary Oral Examination by Fall Semester of the third year.

It is expected that students will begin working on their SYP no later than the summer of the first year. The Second Year Project may or may not lead directly into Ph.D. thesis work; there is no presumption either way. Students may sometimes be able to obtain financial support as a Research Assistant, either during the academic year or summer, for work on their Second Year
The Second Year Project may also be used as a plan A Master’s Thesis, upon agreement of the student and supervisor. A formal written Master’s Thesis must then be submitted, and a Final Oral Examination conducted. Students wishing to pursue this option should consult as early as possible with the DGS to ensure that proper registration and other Graduate School procedures are followed.

4.4 The Written Examination

All Ph.D. students must pass the Written Examination in Astrophysics, which takes place in the Spring of your second year. It covers graduate astrophysics, as defined by the material in our core courses, as well as a general familiarity with all of modern astronomy, as taught in our introductory undergraduate courses. It also includes physics at the advanced undergraduate level, especially those portions with direct astrophysical application.

Preparing for this examination should be done in a careful and systematic way over an extended period of time. Last minute cramming is unlikely to be useful. Copies of recent exams are available, and are your best guide as to the content and style of the exam.

All students are strongly encouraged to take the Written Examination in the Spring of their first year, on a trial basis. Some students do pass in their first year, and if you don’t, it does not count against you in any way. If you do not pass the exam at your second sitting (Spring of your second year), you may take the exam only once more. If you do not pass at that time, you may not continue on to the Ph.D.

The Written Examinations are first graded blindly, and then the Graduate Faculty meet as a whole to discuss the results. Students with scores above 65% of the maximum have generally passed the exam, depending on its difficulty. For all students, but especially those with marginal scores, other information concerning your professional development can be used to support a recommendation for passing the examination. Such factors include your classwork, research work and other information faculty may have about your likely success in Ph.D. research.
4.5 The Preliminary Oral Examination

Admission to Ph.D. candidacy requires that you pass a preliminary oral examination. In order to be making “satisfactory progress”, this exam must be taken in the Fall of your third year. Two weeks prior to the examination, you must submit a written version of your Second Year Project to your examining committee. During your Orals you will present the results of your Second Year Project, and answer questions loosely based on this work. You will be expected to demonstrate your understanding of that area, as well as any related background astrophysics and physics. The Committee will also be looking at the research techniques and thinking skills that you have developed. Since the Graduate School requires that you file your Degree Program one semester in advance of taking your “Orals”, the Degree Program should be filed no later than the spring of your second year.

The examining committee consists of four faculty members, one of whom must be from outside the Astrophysics graduate faculty. Normally the committee is selected by the Director of Graduate Studies with your help, subject to approval by the Graduate School. It is your responsibility to obtain the necessary forms and arrange with the committee a suitable time and place to take the exam. The Graduate School must be notified (625-5833) at least a week in advance of the time and place for the exam. All members of the committee must attend the examination, and at least three of the four must agree in order for you to pass the exam. Once the Preliminary Oral Exam paperwork is processed, you may register for the Doctoral Thesis Credits.

4.6 The Ph.D. Thesis

Each graduate student must identify a thesis adviser and topic and secure the agreement of the adviser. This is a serious commitment for both parties, and is usually done as part of a long-term discussion that may include small research projects, reading, etc. It is common for students to explore a few potential advisers / topics before making a final decision. Students and advisers should discuss the content and scope of the intended project, working styles and financial support expectations. The clearer the understandings are on these issues at the beginning (including what is uncertain), the smoother the working relationship will be.

In the semester after your oral exam, the student must fill out the Graduate School Thesis Proposal form, which includes a 250 word abstract. Also
submit a 1000 word abstract to the DGS. The DGS, with your help, will then select a final examination committee (subject to Graduate School approval; consisting of 4 faculty), and chaired by someone other than your adviser. Three members of the committee will be designated reviewers and will read your thesis before the final examination.

4.7 Thesis Work in Absentia

Sometimes a student during his/her graduate career develops an interest in an area of research not directly performed by a faculty member in the department, or finds an opportunity at a national observatory or other research institution. In these cases, it may be in the student’s best interest to finish his/her thesis in absentia so he/she can directly work with an astronomer at another institution or use the equipment and expertise located at a research institute. This is encouraged by the department.

The in absentia student must have completed all of his/her course work, passed the Preliminary Oral Exam and have a thesis topic before leaving Minnesota. He/she is also advised to visit the host institution for some time before deciding on the change of venue.

The faculty expects that he/she will continue to register for thesis credits and keep his faculty adviser and/or the DGS informed of his/her progress periodically through E-mail or telephone correspondences. The faculty also expects that he/she will participate in the corresponding informal expectations at the host institute as are required here. For example: attending colloquia, participating in public outreach and volunteering to give talks at the local equivalent of the journal club.

4.8 The Final Oral Examination

When your adviser agrees that the thesis is ready for defense you must fill out the appropriate forms at the Graduate School and distribute copies of the thesis to the reviewers. When the thesis readers all certify that the thesis is ready for defense you may schedule the exam with your committee. Each member of the committee must have two weeks to review the thesis prior to the examination. This time can be modified only by unanimous consent of the committee.

The Graduate School must be notified a week in advance of the time and place for the exam. The final exam report form will be sent to your adviser.
The first part of the examination is a publicly advertised and attended presentation of your work. This is followed by a private examination by your committee. No more than one of the five examining faculty may dissent in approving your thesis defense.

The Final Oral Defense must take place at least one academic term (15 weeks) after the Preliminary Oral Defense and within 5 years of the Preliminary Oral Defense. Your must submit your application for degree by the first working day of the intended month of graduation.

5 Formal Requirements for the Masters Degrees

You have been specifically admitted to the Ph.D. program. To change programs (e.g., add an M.S. before obtaining a Ph.D.) you must make formal application for transfer through the Graduate School. If you are thinking of obtaining an M.S. degree on the way to a Ph.D., and, again, this is encouraged, please talk to the DGS as early as possible.

You are required to file the Degree Program including a list of courses and a thesis title (for Plan A) by the end of your first year in the program. You must take a total of at least 30 credits. You have to take one semester of classical Physics (Phys 5011). For Plan A, the credits are divided as follows: 14 credits in astronomy, 6 credits in a related field (e.g., Physics or Mathematics), and 10 Master’s thesis credits. Plan B requires 30 course credits.

The Graduate School requires a minimum GPA of 2.8 on all course work in the program.

5.1 Plan A (Thesis)

In the M.S. Plan A program you will be required to submit a research title with your Degree Program. Minor changes in the thesis title are acceptable without subsequent re-approval. Requires 10 Master’s thesis credits.

The M.S. thesis topic should be something of scientific merit which is suitable for publication in a serious scientific journal. When your adviser agrees that your thesis is ready for review and defense, you must acquire a “readers report form” from the Graduate School, which must be signed by all three members of your final examining committee. This certifies that you are
ready for final examination. Then you may obtain the examination report form from the Graduate School. You must arrange a time and place for the exam. All members of the committee must agree that you have passed the exam.

5.1.1 GS Plan A Master’s Degree Requirements

1. After completion of about 10 credits, file a Degree Program form.

2. Once the Degree Program has been approved by the Graduate School and the thesis is ready to go to the reviewers, request a graduation packet on-line or by visiting 316 Johnston Hall. The Thesis Reviewers Report form will be issued at that time. Remember to allow your committee at least 2 weeks to read the thesis.

3. Submit the Application for Degree to 200 Fraser or 130 Coffey by the first working day of the intended month of graduation.

4. Submit the signed Thesis Reviewer’s Report form to 316 Johnston Hall. The Final Examination Report Form will be given to you at that time. You must have the Final Exam Form before you report for the exam.

5. Return the Final Examination Report form by the last working day of the intended month of graduation.

6. Submit two unbound copies of your thesis, both signed by your advisor(s), by the last working day of the intended month of graduation.

5.2 Plan B (Non-Thesis)

Requires 30 semester credits of coursework

The Plan B Master’s degree requires completion of from one to three papers written in connection with three courses in your program. These three courses must total at least nine credits and each course must be designated by an asterisk in the Graduate School Bulletin. At least two of these courses must be in astrophysics. The official expectation is that about 120 working hours are necessary in preparing your Plan B papers. A paper may be written for each course separately, or you may combine courses. You should clear your topic(s) with the instructors in the specified courses and with the DGS and get their approval of the final result. Although there is no formal mechanism
for this approval, you do not want to wait until the final oral to find out whether or not the topics were acceptable.

You must pass a final oral examination, primarily based on your Plan B papers. The examination committee is chosen by the DGS, with your help, and approved by the Graduate School. Copies of your Plan B papers must be made available to the committee members at least 7-10 days before your exam. You are responsible for arranging the time and place for the examination. All committee members must agree that you have passed the exam.

The plan B option for the Master’s degree is normally chosen when a graduate student has decided not to pursue a Ph.D. in Astrophysics, has completed the required course work, but has not made significant progress on original research. For example, in the past, graduate students that have transferred into other graduate programs have found the plan B option desirable, as it allows them to show tangible credit for their accomplishments, while not requiring the extra effort of writing a Master’s thesis.

5.2.1 GS Plan B Master’s Degree Requirements

1. After completion of about 10 credits, file a Degree Program form.

2. Once the Degree Program has been approved by the Graduate School, pick up the Final Examination Report for and the graduation packet before your final oral examination.

3. Submit an Application for Degree to 200 Fraser or 130 Coffey by the first working day of the intended month of graduation.

4. Return the Final Examination Report form by the last working day of the intended month of graduation.

6 Life in the Astronomy Department

In addition to all the formal requirements for graduate degrees in Astrophysics, graduate students are encouraged and expected to become a full part of our professional community. This means participating in a variety of informal activities, like joining discussions about the department’s programs and facilities, helping out where it is needed, and receiving help from other students and faculty.
6.1 Colloquia, Seminars, and Journal Club

The Astronomy Department and the School of Physics and Astronomy offer a large number of scientific presentations every week. A weekly calendar of events can be found on-line, and is posted on the board outside the Department office.

Graduate students and Faculty are expected to be active participants in these programs. Astrophysics Colloquia, scheduled for Friday afternoons, generally feature outside speakers presenting current research on a wide variety of topics (schedule). These form a critical part of the continuing professional development of both faculty and students. Often, a separate time is set aside for graduate students to meet with the speaker; you are encouraged to participate in these sessions. Dinner arrangements for speakers are made with that week’s host — in many cases graduate students are welcome to attend (and their meals are subsidized at the rate of 50%).

The astrophysics and cosmology group have weekly lunchtime seminars (typically around noon on Mondays) and occasional seminars (typically on Tuesdays at 2:30 pm). The lunchtime seminars usually feature local speakers and the seminars usually feature outside speakers (schedule for both seminars).

School of Physics and Astronomy Colloquia are scheduled each Wednesday afternoon at 4 pm during the academic year. These colloquia are intended for non-specialists and often contain topics of interest to astrophysics. Given the close links between much of astrophysics research and basic physics, and the need to think broadly in terms of future employment, graduate students and faculty are encouraged to attend these colloquia (schedule).

Journal Club, at Thursday lunchtime, is a key opportunity for faculty and graduate students to hear about interesting research from around the world, either through reviews of published articles, preprints, or meeting reports. They also present an important opportunity for graduate students to practice their communication skills in front of a supportive audience, but one that can provide critical feedback for improvement. All graduate students are expected to make at least one (and preferably two) Journal Club presentation each year, and to attend each weekly session.

In preparing for a Journal Club (JC) presentation, the following guidelines may be useful:

1. **Choice of paper** The choice of the paper can be crucial to the success of the JC presentation. Choose a paper which is interesting to
you and which you judge will be interesting to the audience. Ask faculty or other graduate students for suggestions if you are stuck on this. “Discovery” papers are more likely to be of general interest than “technical” papers. For example, it is often the case that we hear about astrophysical discoveries through press releases which give very little information. Reviewing the relevant journal article will generally be appreciated. The length of the paper can also be important. If you choose a very short paper (e.g., a Nature paper or an ApJ letter) you may find that most of the background has been left out so that you have to read a number of other articles just to set the stage. On the other hand, it may be difficult to do justice to a very long paper in the time allotted. Choosing a paper outside your direct area of research is often a good idea. It will broaden your horizons and is likely to be of more general interest to those present. Often it is easy to find an article which peripherally relates to your studies, and therefore is of use to you outside the scope of the presentation. There are now suggestions for articles listed on the journal club website.

2. **Allot enough time** Usually it is best to pick the article up to a week in advance. This allows you to give the paper a quick read (and reject it if it isn’t as interesting as you had hoped), note the background articles that you’ll need to read, and identify the parts of the paper on which you will have to work to understand. Often discussing the article with another grad student or faculty member will help you to sort out which bits need further work.

3. **Prepare a clear presentation** There are many points to this. Some may seem obvious, but violations are frequent. Prepare visual aids (view graphs and powerpoint are both available) that can be read easily from the back of the room (this includes the labeling on the axes of graphs). Speak clearly and loudly so that everyone can hear. Highlight important points. Maintain eye contact. Prepare a presentation which is appropriate to the time allotted (20 minutes) and allow for (and encourage) questions from the audience.

4. **Seek feedback** When your presentation is over, seek out advice on how you could improve your presentation style.
6.2 Getting Involved in Research

Most beginning graduate students have only vague notions of the area of research they wish to pursue seriously. Some have had extensive exposure to active research as undergraduates, but many have not. It is important for each of you to become familiar with serious research in the Department from the very beginning of your career. You are expected to participate in weekly colloquia and “journal clubs”; in addition you should peruse current journals and preprints in the reading room and Walter Library, and discuss research activities with other graduate students and faculty. Most important, you should take initiatives to become directly involved in meaningful research.

Personal involvement may develop in several ways. For example, in the Fall after you arrive the Director of Graduate Studies (DGS) can discuss your research leanings with you and help you make arrangements with a faculty member to work on a research project. In addition, be alert for possibilities such as a scientific argument over tea which suggests a short, but critical observation or calculation that you can perform. Sometimes, new students are invited to accompany faculty members on observing trips to Mt. Lemmon or some other observatory.

Other observing projects develop that are suitable for O’Brien Observatory, as well. These observational opportunities are valuable even if you hope to become a theorist, because of the insights they provide into observational methods and limitations. Of course, other activities around the Department include instrument development and computing. Ask around. Don’t be afraid to propose projects of your own. Many good research projects are initiated by graduate students. The faculty will assist you in developing projects and preparing proposals.

When your academic and teaching responsibilities are going “smoothly”, and definitely by the summer after your first year, you should be getting involved with small research projects. These short projects can lead into the Second Year Project, but may well have a different focus from your eventual Ph.D. thesis work. By the second year all except those students doing a Plan B M.S. should begin to be involved in the more extensive Second Year Project.
6.3 Financial Aid

The department tries as best it can to provide financial support for all graduate students who are making satisfactory progress toward a degree, so that they can concentrate on their studies and research. This support currently comes in five forms:

- Teaching Assistantships (TA’s) — awarded by the Department;
- Research Assistantships (RA’s) — arranged with individual faculty members using research grant funds
- Graduate School and Dissertation Fellowships, by Department nomination for college-wide competitions
- Miscellaneous fellowships — watch Bulletin boards and see the DGS
- Tuition and other subsidies, awarded through the Department.

Most graduate students will be supported initially through teaching assistantships. Provided you make satisfactory progress toward your degree, and provided your teaching is satisfactory, the Department will make every effort to supply TA support for two academic years. Our ability to provide this support depends, of course, upon the department’s ability to obtain sufficient funding for TA’s from the Institute of Technology. Beyond the second year you should try to obtain support as an RA, if at all possible.

Some summer TA support has been available to graduate students who were not yet supported full time as RA’s. However, its nature and extent are variable, so you should discuss this with the DGS early in the spring. Every effort will be made to find you support for at least part of the summer. (Faculty members must also find salary money during the summer, since they are paid only 9 months by the University.)

As part of the Ph.D. program, you are required to participate in research projects. Some of these can be supported through external research grants, but others may not. By your third year you should ordinarily plan on finding support as an RA. You should expect to establish yourself as a “good risk” through an informal work arrangement with a faculty member before any long-term financial commitments are made.

It is important to realize that all RA support in the Department comes through externally funded research grants (primarily through the NSF and
Faculty members must write proposals every one to three years; this involves a large amount of effort, and must be done 8 months to 1 year in advance. The actual cost of an RA to a grant is approximately twice what the student receives in salary, because it includes University overhead and fringe benefit costs for health care, tuition, etc. Funding is very competitive, and RA support for students must be justified to the funding agencies upon their real scientific value to the proposed research.

6.4 Advising

Initially, the DGS will serve as your adviser. At any time, you are welcome to informally seek advice from other faculty members. You may also have another faculty member officially designated as your adviser at any time — see the DGS. The supervisor of your Second Year Project may serve as your official academic adviser or not, by mutual agreement. All changes in adviser must be done officially through the DGS.

Before beginning M.S. or Ph.D. thesis work, you must obtain a ‘thesis adviser’ who will supervise your thesis work and serve as your official academic adviser. Early in the year you should identify a faculty member with whom you wish to work and through discussions and/or a “work study project” identify a suitable thesis topic. It is not necessary for your PhD adviser to be the same faculty member as your second year project adviser.

6.5 Travel Support

Each year, the Department applies for “Block Grant” funds from the Graduate School, which can be used for a variety of purposes. Most of our funds go to subsidize student travel to observatories. Beginning students are specifically encouraged to use these funds to enable travel that would otherwise not be possible. Assisting a more experienced graduate student or a faculty member in an observing run is an excellent way to get experience and determine where your talents and interests lie.

Generally, part of the costs will be provided by a research grant, and Block Grant funds can be used for the remainder. Students wishing to apply for these funds should contact the DGS informally at first, and then will be asked to write up a specific request and justification. Guidelines for the use of these funds may change from year to year. GAPSA and COGS also offer travel grants for presentations and/or research travel.
6.6 Access to Computers

There are several major computer systems available to graduate students. Since computing forms the basis of much of modern astrophysics as well as a much broader range of technical careers, students are encouraged to take advantage of these systems to learn as much as possible.

The Departmental computing system consists of a network of Unix and Windows workstations. All students will automatically be given an account on these systems, and are expected to use them within the guidelines set up by the Department and the System Manager. Each faculty member contributes to the operating cost of this network, but no specific accounting is done, except for color laser copies.

Individual research groups may have their own computing networks, sometimes interfaced with the Department system. The largest of these are the Automated Plate Scanner system and the Graphics System at the Laboratory for Computational Science and Engineering. Access to these systems is restricted; contact the appropriate faculty member if you have a need to use them.

The Minnesota Supercomputer Institute provides access for faculty and students to a range of supercomputers. Time is awarded through a proposal process. Graduate students can only gain access to these systems through participation with a faculty member’s research. For other information, contact the DGS.

The University maintains a variety of other computer systems. For access, contact Academic and Distributed Computing Services. There is also a Microcomputer Help Center in Shepherd Labs, which provides assistance and advice on PCs and Macintosh computers, runs a lab where you can try out various computers, and maintains a list of software site licenses and recommended software titles.

6.7 Public Outreach Programs

Part of the mission of the Astronomy Department is to serve the citizens of Minnesota through various public outreach programs. All professional members of the department — faculty, post-docs, graduate students — are expected to participate in these activities. Some of these responsibilities are also folded into the Teaching Assistant positions.

Current activities in outreach include:
• Minnesota Starwatch - a newsletter about the night sky and other interesting facts.

• Departmental web site.

• Classroom visits to local schools for presentations.

• Public evenings at the telescope.

• Visits from Girl Scouts and other groups.

• Talks to other local organizations as requested.

• Mentoring programs with local school children.

• Joint projects with the Minnesota Astronomical Society, the Planetarium, Newton’s Apple, the Science Museum of Minnesota, etc.

• Answering questions on the phone.

At present, we are developing a system to better document this broad range of activities. Please keep track of programs in which you participate.

6.8 When Problems Arise

Graduate student life should be both challenging and enjoyable, in varying combinations. If either of these elements is missing for an extended period of time, it’s time to talk to your adviser or the DGS.

It is not uncommon for stresses, academic, personal, financial, etc., to reach a level where they affect a student’s work. It is very important that you do not let such problems reach a critical stage — instead, you should address them promptly when they’re easiest to deal with. You may feel embarrassed or uncomfortable raising these issues; please be assured that you are not alone — many other students have dealt with difficult problems, and we can help with discretion and confidentiality. It is in the interests of the Department and University to have its students be successful, so please ask for help when you need it.

Your first contact in case of academic problems should be your adviser. Other faculty members, the DGS, and the Chair may also be useful to you. On personal issues, it may be useful for you to talk with the DGS, who can refer you to other services. Or, you can go directly to such services yourself.
— we have had very good experience with the Counseling Center in Eddy Hall. Some of the specialized services offered by the University include:

- Disability services
- International student services
- Writing help
- Statistics help
- Grievance resolution
- Sexual harassment/sexual assault and Counseling services.

You may find out about these from the DGS or the Council of Graduate Students, or simply by looking in the University Phone Directory.

6.8.1 Equal Opportunity Statement

The University of Minnesota is committed to the policy that all persons shall have equal access to its programs, facilities, and employment without regard to race, color, creed, religion, national origin, sex, age, marital status, disability, public assistance status, veteran status, or sexual orientation. In adhering to this policy the University abides by the requirements of Title IX of the Education Amendments of 1972, by Sections 503 and 504 of the Rehabilitation Act of 1973, by Executive Order 11246, as amended: 38 U.S.C. 2012, the Vietnam Era Veterans Readjustment Assistance Act of 1972, as amended; and by other applicable statutes and regulations relating to equality of opportunity.

6.8.2 Sexual Harassment Policy (May, 1984)

Sexual harassment in any situation is reprehensible. It subverts the mission of the University, and threatens the careers of students, faculty, and staff. It is viewed as a violation of Title VII of the 1964 Civil Rights Act. Sexual harassment will not be tolerated in this University. For purposes of this policy, sexual harassment is defined as follows: “Unwelcome sexual advances, requests for sexual favors, and other verbal or physical conduct of a sexual nature constitutes sexual harassment when (1) submission to such conduct is made either explicitly or implicitly a term or condition of an individual’s
employment or academic advancement, (2) submission to or rejection of such conduct by an individual is used as the basis for employment decisions or academic decisions affecting such individual, (3) such conduct has the purpose or effect of unreasonably interfering with an individual’s work or academic performance or creating an intimidating, hostile, or offensive working or academic environment.”

A copy of the full policy and guidelines may be obtained from the Office of Equal Opportunity and Affirmative Action.

7 The Teaching Assistant Position and Professional Development

Most graduate students will work as Teaching Assistants (TAs) sometime during their graduate career. TAs are an integral part of our teaching faculty, and play a critical role in the education of our introductory astronomy students. In this role, you are a professional educator, seen by your students as a source of knowledge, support and authority. The University, IT, and the Department have a variety of training and evaluation programs set up to help you understand the expectations of you in this professional capacity.

A 50% TA appointment carries the obligation to work 20 hours per week. If the demands on your time exceed that, on average, please speak to your supervisor and/or the DGS.

The following sections are meant to offer a rough guide to the job of TA; the requirements and expectations of your supervisor take precedence. There is also a head TA handbook that describes responsibilities in more detail. In case of difficulties with your teaching responsibilities, there are a variety of people who can help - the Head TA, the Faculty TA Supervisor, the DGS, and the Department Chair.

7.1 TA Responsibilities

Astronomy TAs typically teach small classes (15-25 students) that meet once per week, in which the students perform laboratory (Lab) exercises. These classes are part of the introductory astronomy class which also meets three times per week in lecture format. TAs are expected to prepare for their classes, conduct them, and grade the students’ work. They are expected to attend all TA meetings and turn in all paperwork in a timely fashion.
Other TA responsibilities are assigned by the Head TA, and include proctoring of exams, conducting office hours, occasional grading assignments, assisting in public telescope viewing evenings, assisting with Lab manual revisions, and carrying out public outreach programs, in which other members of the department also participate.

7.1.1 Teaching Philosophy and Student Goals

The small sections taught by the TAs are established on the understanding, through a great deal of educational research, that students need to construct their own knowledge from the information and experiences we offer them. In the labs, the students both work with equipment and also perform exercises on paper to simulate astronomical measurements, solve problems, etc. In the Astronomy Lab Sections, students perform a variety of paper and computer exercises to reinforce some of the fundamental, but difficult concepts covered in the lectures and text.

We are also using a cooperative learning group format in our labs. In these groups, the students work together, take on different responsibilities, and are assigned a common grade. Again, the education research is unambiguous that such cooperative learning can increase comprehension and improve student attitudes. You will be given training and feedback in the use of these cooperative groups.

Our academic goals for the students are under continuous discussion. It is critical for you as an instructor to participate in these discussions and to have in your own mind what you are trying to accomplish with the students. This is true both for the course as a whole, and also, on a more specific basis, for each class meeting.

7.2 Professional Growth and Evaluation

It is the responsibility of every instructor to obtain evaluations of their teaching performance in order to improve their work on a continuing basis. Learning how to use evaluations for professional growth will benefit not only your current teaching, but will create life-long habits whether you have a teaching or research or other career. You should always have a list of professional goals for yourself, things you would like to improve on, informed by student and faculty evaluations of your work, as well as your own priorities. You are required to obtain formal student evaluations each semester. You will
also be visited by a faculty member who will write up an evaluation for your personnel file. It is important that you view these as both opportunities for professional growth, as well as documenting your experience for when you are looking for a job.

The University offers a variety of informal and formal opportunities for graduate students to improve their teaching, and you are recommended to take advantage of these. See the DGS or TA supervisor for how to obtain information on these programs.

8 Outlines of Typical Yearly Academic Goals

8.1 MS Plan A

8.1.1 1st year

1. Complete Phys 5011-5012

2. Complete AST 4001-4002 or AST 5012-5022 (If similar classes have already been taken, consult the DGS.)

3. Obtain a thesis adviser and file degree plan

8.1.2 2nd year

1. Complete course requirements

2. Write thesis

3. Take final oral exam

8.2 MS Plan B

8.2.1 1st year

1. Complete Phys 5011

2. Complete AST 4001-4002 or AST 5012-5022 (If similar classes have already been taken, consult the DGS.)

3. Identify topics for Plan B papers and file degree plan
8.2.2 2nd year
1. Complete course requirements
2. Write Plan B papers
3. Take final oral exam

8.3 Ph.D.
8.3.1 1st year
1. Complete Phys 5011-5012
2. Complete AST 4001-4002 and AST 5012-5022 (If similar classes have already been taken, consult the DGS.)
3. Work on small research projects
4. Begin second year project by summer

8.3.2 2nd year
1. Complete course requirements
2. Complete second year project
3. Pass Astrophysics Written Exam
4. Identify thesis adviser and topic

8.3.3 3rd year
1. Take preliminary oral exam
2. File thesis title and description
3. Work on thesis and related research
8.3.4 4th year and onward

1. Complete thesis and related research
2. Write thesis and papers for publication
3. Take final oral exam
4. Celebrate!!!!!

A Graduate School Links

- The Department’s List of Graduate Faculty
- The Graduate School
- The Graduate School’s List of Graduate Faculty
- The Graduate School’s Degree Completion Page
- The Graduate School’s General Information

B The Graduate Student Self-Evaluation Form

1. Brief description of research projects in which you participated.
2. List of papers published or submitted.
3. List of presentations made at meetings.
4. List of observing runs in which you participated.
5. Journal club presentations.
6. (a) Assigned teaching
   (b) Outreach activities
   (c) Other teaching/curricular activities
7. Other university activities.
8. Brief self-evaluation (1 paragraph) of your progress this past year.