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Welcome to the Graduate Program in Physics and Astronomy! If you are like most students in our program, then you are undertaking graduate study to accomplish several goals: first, to develop a broad and sophisticated knowledge of the field as a whole; second, to acquire a deep and thorough understanding of some specialized field; to contribute to the body of knowledge of that field through your own research; and finally, to prepare the foundation for a rewarding career in Physics, Astronomy, or one of the many diverse fields of industry and finance to which physicists contribute.

We offer a number of options to achieve these goals. Most of our students seek a Ph.D. in Physics, but we also confer Ph.D.s in Chemical Physics and Physics with formal emphasis in Medical Physics or Physics Education. We offer several types of Master’s degrees as well: the M.S. in Instrumentation Physics (MSI), the M.S. in Computational Physics, and a Master’s degree in Physics. We admit students into our program as Master’s degree candidates only for the first two M.S. degrees. The role of the Master’s in Physics is to provide either a milestone or an alternative to the Ph.D. for predoctoral students.

Your choice of research specialization can define your career. We offer a wide range of subject areas including Astronomy & Astrophysics, Atomic physics, Biophysics, Chemical Physics, Condensed Matter, and High-energy/Particle Physics. In addition some of us work in multidisciplinary specializations, for example, nanoscience and medical physics. A current list of our specializations, with links to the names faculty working in those areas is here: http://www.physics.utah.edu/research.html

A big part of your graduate experience will be related to how you financially handle being in grad school. It is typical for your tuition to be covered under the University’s Tuition Benefits Program, which is available to you if you serve as a Teaching Assistant (TA) or work as a Research Assistant (RA) for your thesis advisor. While there are time limitations, you will find that the benefits offered by the University enable you to keep focused on progress toward your degree, meanwhile providing allowance for day-to-day expenses, including health insurance.

This handbook contains information on the graduate experience in the Department of Physics and Astronomy. We cover the rules—namely degree requirements such as which courses to take, and what exams you’ll need to pass—as well as policy regarding teaching assistantships (TA), the all-important rules of tuition benefits, and even a little about life as a graduate student. Along the way, you will find links to resources, which we compile toward end of this handbook (Section 4). We start you off with this link:

http://www.gradschool.utah.edu

It points to the Graduate School, the ultimate authority on policy concerning all of the University of Utah’s graduate programs. Please peruse it for the wealth it contains! Then explore this handbook. We hope that it helps make your graduate experience here in our own Department rich and rewarding!

— Director of Graduate Studies (DoGS)
Department of Physics and Astronomy

http://www.gradschool.utah.edu
2. GRADUATE STUDY

There are certain common points in the administrative and academic flow of our graduate degree offerings and we describe them here. The goal is to give you a sense of what your obligations are, and to provide tips on how to most efficiently complete your degree program. Specific degree requirements are in Section 3.

2.1. DEGREE OVERVIEW

To begin, here are two rough timetables that outline the things that you will have to do in order to obtain your degree. These are sketches only (details may vary, depending on your degree specialization), but they give you a broad sense of what is involved. The next subsection contains the gory details.

<table>
<thead>
<tr>
<th>Ph.D. program example timetable</th>
<th>Year 1-2</th>
<th>Year 2-3</th>
<th>Year 3-4</th>
<th>Year 4-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Meet assigned advisor</td>
<td>*Take Courses</td>
<td>*Electives (?)</td>
<td>*Write thesis</td>
<td></td>
</tr>
<tr>
<td>*Common exam (if req'd)</td>
<td>*Program of Study <em>(form)</em></td>
<td><em>Research (yes!)</em></td>
<td>*Apply to Graduate <em>(form)</em></td>
<td></td>
</tr>
<tr>
<td>*Take Courses</td>
<td>*Qualifying Exam</td>
<td>*Thesis Defense!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Seek thesis project</td>
<td>*Milestone M.S. degree!</td>
<td>*Report of Final Exam <em>(form)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Set up Thesis Supervisory Committee <em>(form)</em></td>
<td></td>
<td>*Final Thesis Reading <em>(form)</em></td>
<td></td>
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</tr>
</tbody>
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<table>
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<tr>
<th>M.S. program example timetable</th>
<th>Year 1-2</th>
<th>Year 2-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Meet assigned advisor/Common Exam (if recommended)</td>
<td>*Research + elective coursework</td>
<td></td>
</tr>
<tr>
<td>*Take Courses</td>
<td>*Write thesis/Project report</td>
<td></td>
</tr>
<tr>
<td>*Seek M.S. project</td>
<td>*Apply to Graduate <em>(form)</em></td>
<td></td>
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<tr>
<td>*Set up Supervisory Committee <em>(form)</em></td>
<td>*Thesis Defense/Final exam</td>
<td></td>
</tr>
<tr>
<td>*Program of Study <em>(form)</em></td>
<td>*Report of Final Exam <em>(form)</em></td>
<td></td>
</tr>
<tr>
<td>*Project Proposal</td>
<td>*Final Thesis Reading, if applicable <em>(form)</em></td>
<td></td>
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</tbody>
</table>
2.2. Research Areas and Degree Options

Here we summarize the areas of specialization in our Department and the different graduate programs that we offer. This list is intended to highlight the possibilities as you consider your own interests. (See Section 6 for more information about course offerings and research areas of individual faculty.)

**Research Areas**

**Astronomy.** Optical, IR and γ-ray observation, cosmochemistry, star clusters, black holes, galaxy evolution, quasars and AGN, large-scale structure of the Universe, dark energy, cosmology.

**Astrophysics Theory.** Cosmology, dark matter, galaxy evolution, large-scale structure, planetary systems, relativistic astrophysics.

**Atomic physics.** Hyperpolarized gases.

**Biophysics.** Near-field fluorescence microscopy, molecular motors, enveloped virus budding, MRI.

**Chemical Physics.** Quantum chemistry.

**Condensed Matter Experiment.** Nanotubes, quantum dots, spin electronics, photonics.

**Condensed Matter Theory.** Graphene, nanotubes, magnetism, superconductivity.

**High Energy Physics Experiment.** Cosmic rays.

**High Energy Physics Theory.** Lattice QCD, LHC phenomenology, dark matter, string theory.

**Medical Physics.** MRI, hyperpolarized gas imaging, Raman spectroscopy, retinal imaging.

**Nanoscience.** Nanoscale optics and imaging, atomic force microscopy.

**Large-scale experiments/facilities/consortia:**
- Sloan Digital Sky Survey III (www.sdss3.org)
- Telescope Array (cosmic ray)
- HiRes Cosmic Ray Experiment
- Frisco Peak Observatory (32” telescope)
- Center for High Performance Computing
- Center for Acoustic Cooling
- Dixon Laser Institute
  - In house AFM, SEM, Raman spec.

(www.physics.utah.edu/research.html)

**Degrees**

**Ph.D. Physics.** This degree is the choice for most of our students, with the many specializations offered by our faculty, from nanoscience to cosmology. Graduates have gone on to positions in a wide variety of areas, from traditional academia to finance.

**Ph.D. Medical Physics.** Students in medical physics work with our own faculty or with outside researchers. Elective course work is geared to medicine (e.g., physiology, radiology). This program offers unique opportunities in medical technologies.

**Ph.D. Physics Education.** Students seeking this degree can engage in Physics Education Research toward expanding the innovative teaching strategies used in the Department.

**Ph.D. Chemical Physics.** This interdisciplinary degree enables students to work in areas of overlap between physics and chemistry including materials science, nanoscience, and atomic or molecular physics.

**M.S. Computational Physics.** With this degree you to learn cutting-edge numerical techniques and to apply them to problems in physics and astrophysics, with access to the University’s world-class high-performance computers.

**M.S. Instrumentation Physics.** Students take part in the design, characterization and production of instruments, electronics, sensors, or algorithms for research and industrial application. This is the most sought-after degree of our Master’s offering.

**M.S. Physics.** A Master’s in Physics is offered to students on their way to obtaining a Ph.D. or to those who leave the Ph.D. program. Research topics can be drawn from the varied specializations of our faculty.
2.3. Administrative and Academic Tasks

This section presents a to-do list, more or less in chronological order, of things that you will need to complete your degree. Unless otherwise noted, these items apply to all our Ph.D. and M.S. programs.

- **Prepare for and take COMMON EXAM.** (May be required for Ph.D., depending on GRE Physics score, and encouraged for all grad students as a diagnostic test). This exam is given just before the beginning fall semester. It may help you to choose the right courses. (See Section 3.1.)

- **Attend Graduate Advising session; Choose your courses.** At the beginning of every semester meet with your Graduate Advisor (assigned to you when you arrive) or your thesis advisor to go over your plan for that semester (and beyond). If you are a full-time student, you must take 9-12 credit-hours per semester (5000 level or above); below there is a list of required and elective courses for each of our degree programs. These courses are described in the University course catalog:
  - Physics courses: [http://www.acs.utah.edu/GenCatalog/crsdesc/phys.html](http://www.acs.utah.edu/GenCatalog/crsdesc/phys.html)
  - Astronomy courses: [http://www.acs.utah.edu/GenCatalog/crsdesc/astr.html](http://www.acs.utah.edu/GenCatalog/crsdesc/astr.html)

Additional courses in other departments may be useful in your area of specialization. Also, are there any required courses you may not need if you have already had equivalent classes elsewhere? Your advisor will help. However, note that only your Supervisory Committee determines the Program of Study, which specifies those courses you need and any requirements that can be waived. Therefore, form your committee as soon as you can.

- **Arrange for your Tuition Benefits.** For you to receive Tuition Benefits, your advisor MUST sign a Tuition Benefits form by a well-publicized date each semester. Be very aware of the rules of the Tuition Benefits Program (TBP). Here is just a sample of the rules that affect our students the most:
  - You must keep your cumulative GPA at or above 3.0 to receive benefits.
  - The number of semesters during which you can receive benefits is limited:
    - 4 semesters for Master’s degree
    - 10 semesters for Ph.D. admitted without M.S.
    - 8 semesters for Ph.D. admitted with M.S. from another University
  - Teaching Assistants (TA’s) must take 9-12 credit-hr (Fall, Spring semesters only)
  - Ph.D. students (no incoming M.S.) who TA 4 semesters get 2 more semesters of benefits
  - Research Assistants (RA’s) must take 9-11 credit-hr (Fall, Spring) or 3 credit-hr (Summer)
  - For RA’s with 84+ accumulated credit-hours, the TBP covers “in-state” tuition only.

Thus, *if you are in the Tuition Benefits Program, know its details:* [http://www.gradschool.utah.edu/tbp](http://www.gradschool.utah.edu/tbp)

- **Set up your Supervisory Committee.** (aka Graduate Student Committee.) Seek a research advisor (talk with fellow students, meet with faculty, attend seminars, group meetings and the yearly Graduate Symposium). Then, with his or her help, ask faculty to serve on your Supervisory Committee. Do this as soon as possible, definitely by the start of your third year for a Ph.D. There are rules, as described in the degree requirements sections for each program. This step requires the submission of information to the Department and Graduate School. Please ask our Graduate Coordinator Jackie Hadley how to do this; at the time of this writing the procedure is not well.
defined, as the Electronic Graduate Record File system has been on-line for only a short period of time. Note: once forms have been submitted, the Director of Graduate Studies and the Graduate School must approve the make-up of the Committee.

- **Establish your Program of Study.** Meet with your committee and figure out what coursework is required of you. Now is the time to officially establish whether you can waive required courses because of previous coursework. This step also requires submission of a form. We can help. This should happen the same semester as you form your Supervisory Committee. At this time your committee may indicate what material that will be tested during the Qualifying Exam (Ph.D.), or Final Exam (non-thesis Master’s, e.g., the instrumentation project presentation for the MSI).

- **Wrap up coursework, start engaging research.** This step should happen at the very latest by the third semester for a M.S. degree, or fifth semester for a Ph.D. This is part should be fun.

- **Propose a research project (M.S. only).** You must decide on a research project and then propose it to your Supervisory Committee. The proposal may take written form, or it may be an oral presentation, as in the M.S.I. program. Ph.D. students, for this step you take the qualifier instead:

- **Take the Qualifying Exam (Ph.D. only).** The Supervisory Committee administers this exam; its intent is to test your preparedness for research. The committee specifies the format and content of the exam to each student beforehand, typically when the Program of Study is arranged. The committee will likely ask you to give an oral presentation related to the work that you propose to do for your thesis. During the exam, committee members may ask questions on that topic or on more general background material. You may repeat the full exam, or parts of it, only once.

- **Become a Legal Resident of the State of Utah (Ph.D., domestic non-residents only).** Tuition Benefits may favor Utah residents, as only in-state tuition is covered after a total of 84 credit-hours has been accumulated. You may be required to become a resident, and are qualified to apply after 40-60 credit-hrs; see Section 4.1.2 of Utah Code R512, Determination of Resident Status. The Graduate Coordinator or Grad School Office can help.

- **Obtain a milestone M.S. degree (Ph.D. only).** Once you have obtained sufficient number of credit hours (30 total; at least 12 in coursework, plus 6 in research), and have passed the Qualifying Exam, you can arrange to get a non-thesis Master’s in Physics as part of your trajectory toward a Ph.D. The Graduate Coordinator can help with the administrative aspects of this process.

- **Do your research.** This work is the heart of your degree program. Your advisor and supervisory committee oversee your work and progress. The duration should range from approximately one year (M.S.) up to four years (Ph.D.).

- **Write up your Thesis (Ph.D. and M.S., except for MSI and milestone MS).** There is no set prescription or length for writing your thesis, but there are stringent rules, and helpful suggestions, for putting the final document together:


  The only other rule is that this step will take longer than you think.
• **Formally apply for graduation.** This is a formal step newly required by the Registrar’s Office and must be done no earlier than one year prior to graduation. See Applying for Graduation: [http://www.sa.utah.edu/regist/graduation/applying.htm](http://www.sa.utah.edu/regist/graduation/applying.htm)

• **Defend Thesis/Final Project.** This final exam, wherein you give an oral presentation describing your work and respond to questions posed by your committee, is required for all of our graduate degrees. For a Ph.D. and thesis–based Master’s degree you should have a final draft of your thesis submitted to your committee members no less than two weeks prior to your defense. The thesis defense typically consists of a public lecture, with questions, followed by a closed-door examination by the Supervisory Committee. For non-thesis degrees, the format is the same, unless otherwise specified. For example in the MSI program students

• **Submit Report of the Final Exam or Certification of Completion (non-thesis option).** When the thesis or project is successfully defended, your committee should submit this form. If yours is a non-thesis degree, congratulations! You are done.

• **Obtain Final Reading Approval and submit your thesis (Ph.D. and thesis-based MS).** These are the last steps. You should follow the guidelines at Thesis Office: [http://www.gradschool.utah.edu/thesis](http://www.gradschool.utah.edu/thesis)

• **Time limit.** One last detail: You must finish all of the above steps in the period of time allotted by the Graduate School (4 calendar years for a M.S., 7 years for a Ph.D.). This is a merciful rule: Grad school might seem interminable, but it really isn’t. If you need more time, there are options (Section 2.6).

This completes your degree requirements! NOTE: As of Fall 2010, the Electronic Graduate Record File system allows you to monitor you progress with respect to the tasks listed above. Contact the Graduate Coordinator, Jackie Hadley, for more information.

### 2.4. Course Credits: University Requirements, Exemptions and Transfers

• **Minimum course requirements.** Each degree program has a minimum number of credit hours. For the M.S. degree, it is 30 credit-hrs of which at least 9-12 must be in coursework, and 6 in research credits. The Ph.D. is less stringent, perhaps to accommodate the University’s many kinds of doctoral degrees or so students can use some graduate courses for a M.S. and others for the Ph.D. Whatever the reason, the requirement for a Ph.D. is just 14 credit hours of thesis research (PHYS 7970). Note that these are Graduate School rules and that our programs have additional requirements.

• **Transfer course credits.** Often graduate students arrive after having taken course at another institution. It is often in your best interest to transfer credits, at least if you intend to get a master’s degree (although there is a limit of 6 credit-hours). The reason is that you need 30 credit hours with courses to get the degree. For the Ph.D., transferring credit is not so important, because you do not need the official credits, only proof that you have taken certain required courses.

• **Confirm equivalence of course material.** You may waive a core course requirement if you have taken a similar course elsewhere. Your Supervisory Committee and the Department’s Director of Graduate
Studies (DoGS) may want some assurance that the course you took covers similar material and at a similar level as our own required course. The preferred way to do this is for you to discuss the course you took with the faculty member who is currently teaching (or most recently taught) the equivalent course. Get that faculty member to confirm the equivalence of course material (in writing or by email—a reply to a summary you provide is ok); that confirmation will go into your graduate record.

- **If you transfer to the U with a newly hired advisor**, and you become an official student here, your advisor, the DoGS and your Supervisory Committee here will work together to minimize the impact on you regarding courses. *We do not want you to waste time by repeating unnecessary coursework.*

### 2.5. Grading Policy

The department has adopted the following grading policy: Only a class with a course number above 5000 can count for graduate credit; to get credit for this class, a Master's student must get a B-, and Ph.D. student must earn B. A more detailed summary of grades is as follows:

- **A**  Very good, expected for M.S. and Ph.D.
- **A-** Good, acceptable for M.S. and Ph.D.
- **B+** Acceptable for M.S., passable for Ph.D.
- **B** Passable at M.S. level, marginally passable at Ph.D. level
- **B-** Marginally passable for M.S., **unacceptable at Ph.D. level**
- **C**  **Unacceptable for graduate work in the Department of Physics & Astronomy**

A student who receives an unacceptable grade (e.g., below a B for a Ph.D. student) in a required core courses, or a course deemed necessary by his or her committee, is required to repeat that course. Under special circumstances (depending on the student’s class performance), and with supervisory committee approval, the student may take an equivalent final exam in lieu of retaking a required course.

This grading system affects a student’s cumulative GPA. Thus keep it in mind and do not let your cumulative GPA drop below a 3.0 (B average), otherwise you will become ineligible for tuition benefits.

**Appeals.** If you disagree with a grade, you may make an appeal to have your work reevaluated. The first step is to talk with your instructor. If you wish to take your appeal further, consult with the DoGS, Department Chair and the Graduate School, preferably in that order.

**Required Examinations.** Exams such as the Common Exam and Qualifier are degree requirements and are all pass-fail in nature. Depending on which exam, you may be allowed to repeat part, or all, of the exam once.

### 2.6. Managing Space-time: Residency, Leave of Absence, Extensions & Dematriculation

Mostly we try to encourage students to move through our degree programs at a productive rate, and do not want to see students languish or end up as “all but dissertation.” However, for whatever reason, you may have to take a break from your coursework or research. In this section we discuss how to arrange for some time away from your graduate program, if necessary. We also describe how to arrange for more time to finish your degree than is provided by the Tuition Benefits Program. To begin, here are the rules regarding time you must spend as a registered student to earn a graduate degree.
• **Residency requirements.** It is generally a good idea to be on-campus for the duration of your degree program. If this is not possible, be aware of these Graduate School rules. They differ for Master’s and doctoral degrees.
  
  o *M.S.:* You must be in-residence while taking 24 of your 30 required credit hours.
  o *Ph.D.:* You **must be in residence for two consecutive semesters (excluding Summer).**

In both cases, “in residence” refers to being at the University of Utah doing “full-time academic work,” i.e., actively taking courses or doing research, presumably on campus.

• **Leave of Absence.** Sometimes in the course of a graduate program it is necessary for a student to take time off for an extended period of time. Reasons include:
  
  o *Family Leave, pregnancy and child care.*
  o *Military service*
  o *Sickness, or illness in your family*
  o *Conflict with outside work, especially if related to academic goals*

If you need to temporarily leave graduate school for any reason, meet with your advisor. S/he, along with the Department Chair, must petition the Graduate School to obtain an official leave of absence for you. A leave is granted for a one-year interval. If you are away longer, then you must petition every year. See the website above for details.

• **Returning to the program after an absence.** If the student took an official leave of absence, or maintained the minimum continuous registration, then there is no special arrangement necessary for the student’s return. Unfortunately, if the student did have a lapse in registration without a leave, then the student must reapply to the program. If this is you, please consult the Graduate School policy for details of how (e.g.) tuition benefits are affected. We will try to make things smooth for you.

• **Staying in Graduate School part-time.** There are options for extending your tenure as a graduate student. One is to maintain the **minimum continuous registration,** typically by enrolling for 3 credit hours. While you cannot claim Tuition Benefits with less than 9 credit hours, you can maintain your status as a graduate student in good standing at a relatively small cost. Note that you may have to reapply if you attempt to remain registered for more than 7 years. See this link for more information:

  Continuing registration: [http://www.gradschool.utah.edu/catalog/registration.php](http://www.gradschool.utah.edu/catalog/registration.php)

• **If things do not work out—Dematriculation.** We hope for success for all our students, however, there are situations when graduation is not an option. One is when a student cannot pass a required exam. Predoctoral students in this situation may still attempt a M.S. degree, but Master’s students who fail to meet requirements must leave the program. Also, gross ethical or legal misconduct by a student is grounds for dismissal. Finally a student will be “dematriculated” if enrolled past the allowed time to complete a degree (4 calendar years for a M.S., 7 years for a Ph.D.), although in this case the student might reapply. (We are unsure if dematriculation is a real word. Please do not find out.)

That is it for the administrative end of our grad program. We have only to remind you that while the Department has its requirements, written herein, the **Grad School’s rules are immutable and unyielding.** It’s best to know them well: [http://www.gradschool.utah.edu](http://www.gradschool.utah.edu).
3. DEGREE PROGRAMS

Selecting your degree
In this section we outline our degree offerings, starting with the traditional physics Ph.D. and including degrees with emphasis in specialized areas. To select your doctoral program you should apply as a doctoral student in Physics, but specify the area of emphasis (if any) on your application. For the Master’s programs, you may apply directly for M.S. Instrumentation (MSI) or M.S. Computational Physics programs; the M.S. Physics degree is also offered as part of the Ph.D. program.

Degrees offered by the Department of Physics and Astronomy
- Ph.D. Physics (including Physics Education specialization)
- Ph.D. Physics with Medical Physics Emphasis (Medical Physics Doctoral Program)
- Ph.D. Chemical Physics (Interdisciplinary, with Department of Chemistry)
- M.S. Physics
- M.S. Physics with Instrumentation Emphasis (MSI Program)
- M.S. Physics with Computational Physics Emphasis (Master’s in Computational Physics)

Related Degrees
- M.S. Computational Engineering and Science (CES). An interdisciplinary degree that allows students to incorporate advanced simulation techniques into their research. May be done as part of a Ph.D. degree. For more information, please check out MS CES Program: [http://www.ces.utah.edu](http://www.ces.utah.edu)
- Professional Master of Science and Technology (PMST). A professional, non-thesis, interdisciplinary program that fuses graduate studies in science and mathematics with skills from other professional domains, such as business, communication, and management. PMST Program: [http://web.utah.edu/pmst](http://web.utah.edu/pmst)

In what follows you will find specific degree requirements, but note that these requirements have built-in flexibility so that you can make the most out of your graduate studies.
PHYSICS DOCTORAL PROGRAM

3.1. Ph.D. in Physics

Overview

The Ph.D. in physics is for those students who wish to study physics, biophysics, nanoscience and astronomy. It is our premier degree offering.

A Ph.D. is different from other advanced degrees because to earn one, you must do original academic work. As in a Master’s program, coursework is excellent and rewarding, but the Ph.D. is about research. Thus, it is never too early to find an advisor to direct your research. Once you pass an initial proficiency benchmark, the Common Exam, you can establish a Supervisory Committee, which oversees your doctoral work with your advisor as its chair. As you get a little experience doing research, your Supervisory Committee will give you a Qualifying Exam to see if you are ready to take on your thesis project. It is this project that may define your professional career.

Along the way to your Ph.D., you may wish to earn a “milestone” Master’s degree, since it will not interfere with your progress toward a doctoral degree. Meanwhile, here is what you will have to do for a Ph.D. in Physics. Also see the General Administrative Requirements section for additional details.

Required Degree Elements

• Common Exam (or Physics GRE equivalent)
• Form Supervisory Committee
  • Core Courses:
    o PHYS 7110 Classical Mechanics/E&M I (4 credit hours)
    o PHYS 7120 E&M II (4)
    o PHYS 7220 Quantum Theory I (4)
    o PHYS 7230 Quantum Theory II (4)
    o PHYS 7310 Statistical Mechanics (3)
    o PHYS 7740 Math Methods I (4)

• Graduate Laboratory Course: PHYS 6719 or equivalent (3 credit hours)
• PHYS 7800 (2 credit hours) or PHYS 7810 (1-2 credit-hours) Colloquium Course (first 6 semesters or 4 semesters + 2 seminars programs)
• Breadth Requirement: graduate physics course outside area of specialization (3+ credit hours)
• Electives: Any graduate courses needed for specialization
• Extra Preparatory Courses (optional)
• Program of Study Approval
• Qualifying Exam
• Milestone Master’s degree (recommended)
• Thesis Research (14-credit hours minimum)
• Thesis Defense

Note: To pass a course for credit toward a Ph.D. in Physics requires a grade of B or better. In addition, to receive graduate credit, the course number must be 5000 or above.
Description of Required Elements

• **The Common Exam.** This written test, based on advanced undergraduate physics material, is designed to determine if a student’s background knowledge of physics is sufficient to proceed into the Ph.D. program. The exam is administered just before the start of each Fall semester; you should take it just before your first-year classes. A passing score is typically around 50% or above. If you do not pass, you may retake the exam at the beginning of your second year. Note: you can satisfy this requirement (equivalent to passing the Exam) by attaining a GRE Physics Subject Test score at or above a value set by the Department (around the 50th percentile) at any time until the end of the calendar year following your second attempt at the Common Exam. Please see: Common Exam: [www.physics.utah.edu/index.php/graduate-program/common-exam-a-gre](http://www.physics.utah.edu/index.php/graduate-program/common-exam-a-gre)

• **Supervisory Committee.** Once you pass the Common Exam, you should form your Supervisory Committee as soon as you have ascertained an area of interest for your thesis research. Your thesis advisor is typically the chair. Five faculty members must be on the committee; the majority—including the chair—must be regular faculty in the Department. One faculty member must be from another department or university. One of the Department faculty members must be in an area of specialization that is unrelated to your own field, for example a theorist if you are an experimentalist.

• **Core courses.** All students are required to take our core courses (or their equivalent elsewhere—see below on waiving a course requirement) Note: until the U approves Ph.D. emphases in astrophysics and biophysics, the supervisory committees will set the core curriculum for students in those fields.

• **Graduate Laboratory Course (PHYS 6719).** The purpose of this course is to help you to interpret experimental and observational data, to understand the quantitative implications of various sources of error and uncertainty, and to compare data with theoretical or computational models. With the approval of your advisor and supervisory committee you may substitute another class for PHYS 6719 (e.g., PHYS 6770 or ASTR 5015; see Appendix B for substitute course criteria).

• **Colloquium Course.** This requirement means you must attend the Department Colloquium during your first two years. In your third year you may attend either the Colloquium or one of the more specialized Graduate Seminars. Sign up for PHYS 7810 for 1 credit hour (Colloquium) or 1-2 credit hours (Grad Seminar). Take PHYS 7800 for 2 credit hours (Colloquium). Your grade is attendance-based. If you are taking too many other classes to sign up for these courses, you must still go to the Colloquium/Seminars, and your attendance will still be recorded.

• **Electives.** You may take elective (non-core) courses to satisfy your own curiosity, or because they may be needed for your thesis research. In the latter case, your supervisory committee can actually elect to require specific courses for your program of study. Please talk with your thesis advisor!

• **Breadth requirement.** Your breadth course must be in a physics subject area that is unrelated to your specialization. It cannot be otherwise required. To find a breadth course, try categorizing your specialty and our course offerings into Experiment, Theory and Computation. If you fall into one area, choose a course from another. Example: a condensed matter experimentalist might take General Relativity or Computers in Physics. Or cross disciplines: that same experimentalist could take an astronomy course or particle & nuclear physics. Avoid neighboring disciplines (e.g., condensed matter and optics) and courses that look “broad” but really are needed as part of a student’s specialization.
• **Extra preparatory courses.** If your undergraduate training in physics is not as strong as you would like, you should consider prep courses like PHYS 5010/5020 (see table below). To help with computer literacy (expected of all physics grad students), try PHYS 6720 (Intro to Computing in Physics; this course may also satisfy your breadth requirement).

• **Course requirement waivers.** If you have taken a required course at another institution, then request that the requirement be waived. Contact the instructor who teaches that course here, and compare what you’ve had with what we offer. If the comparison is favorable, ask for a brief statement saying that you have studied similar material (e.g., equivalent text book), and send it to the DoGS for approval. Alternatively, a student may satisfy a course requirement by taking that course’s final exam and passing with a B or better. The student need not register for the course.

• **Program of Study.** The final list of core + elective courses that you must take is determined by your Supervisory Committee. Typically you meet with your Committee as soon as it is officially formed to decide on the Program of Study. This is a contract to establish what courses you need for your Ph.D.

• **Qualifying exam.** This exam serves to establish that you are ready to take on your doctoral research project. You can take it as soon as you have passed the Common Exam and have established a Supervisory Committee. Often, students take the qualifier after initiating potential thesis research. The Committee informs you of the format of the exam and the material to be tested, normally at the same time that your Program of Study is approved. A typical qualifier will start with a 20-40 min presentation on a possible research topic, followed by questions from the Committee.

• **Research credits.** We require a minimum of 14 credit-hours of in-residence research for graduation.

• **Thesis defense.** In the tradition of the doctoral degree, you must defend your thesis. Here we describe three parts of this process. First you must give a final draft of your thesis to your committee members no later than **two weeks prior** to the date of your defense. In the second part you give a public talk (well under 1 hour is good) followed by a closed-door oral exam on your work, given by i your Committee. Your final step is to modify your thesis following the results of the defense and submit it in accordance with University policy (see the Graduate School’s Thesis Office website).

**Course Curriculum**

The following table shows three sample curricula, or tracks. The first, Track A, is for a well-prepared student (e.g., high Physics GRE or Common Exam score); Track B is for is for a student who is prepared but needs a lower workload (for example, if a course for TA training is also required). Track C provides additional preparation. Consult with your graduate advisor to determine which track is right for you.

NOTE: **These tracks are guidelines only.** The goal is to get through your core courses quickly and on to research. Avoid repeating courses you have taken elsewhere, especially if you entered with a M.S. degree. Your advisor can help customize your curriculum.

PITFALLS: Watch the maximum allowed credit-hours: 12 for TA, 11 for RA. In all cases colloquium attendance is monitored and required, even if your schedule does not permit registering for the PHYS 7800/7810 Colloquium course. If you find yourself struggling as the semester proceeds, then ask your instructors, advisor or the DoGS for help!
**Physics Ph.D. Course Curriculum**

<table>
<thead>
<tr>
<th>Track A*</th>
<th><strong>Fall Semester</strong></th>
<th><strong>Spring Semester</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
<td>PHYS 7110, Class. Mech./E&amp;M I ** (4)</td>
<td>PHYS 6719, Grad Lab (3)</td>
</tr>
<tr>
<td></td>
<td>PHYS 7220, Quantum Theory I (4)</td>
<td>PHYS 7120, E&amp;M II (4)</td>
</tr>
<tr>
<td></td>
<td>PHYS 7740, Math Methods I (4)</td>
<td>PHYS 7230, Quantum Theory II (4)</td>
</tr>
<tr>
<td></td>
<td>(Colloquium attendance required)</td>
<td>PHYS 7810, Colloquium (1)</td>
</tr>
<tr>
<td>Year 2</td>
<td>PHYS 7310, Stat. Mech. (3)</td>
<td>PHYS 7800, Colloquium (2)</td>
</tr>
<tr>
<td></td>
<td>PHYS 7800, Colloquium (2)</td>
<td>*** (7-10)</td>
</tr>
<tr>
<td></td>
<td>*** (4-7)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Track B</th>
<th><strong>Fall Semester</strong></th>
<th><strong>Spring Semester</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
<td>PHYS 7110, Class. Mech./E&amp;M I (4)</td>
<td>PHYS 6719, Grad Lab (3)</td>
</tr>
<tr>
<td></td>
<td>PHYS 7740, Math Methods I (4)</td>
<td>PHYS 7120, E&amp;M II (4)</td>
</tr>
<tr>
<td></td>
<td>PHYS 7800, Colloquium (2)</td>
<td>PHYS 7800, Colloquium (2)</td>
</tr>
<tr>
<td>Year 2</td>
<td>PHYS 7220, Quantum Theory I (4)</td>
<td>PHYS 7230, Quantum Theory II (4)</td>
</tr>
<tr>
<td></td>
<td>PHYS 7310, Stat. Mech. (3)</td>
<td>PHYS 7800, Colloquium (2)</td>
</tr>
<tr>
<td></td>
<td>PHYS 7800, Colloquium (2)</td>
<td>*** (3-6)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Track C</th>
<th><strong>Fall Semester</strong></th>
<th><strong>Spring Semester</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
<td>PHYS 5010, Class. Mech./QM (3)</td>
<td>PHYS 5020, E&amp;M/Stat. Mech. (3)</td>
</tr>
<tr>
<td></td>
<td>PHYS 7740, Math Methods I (4)</td>
<td>PHYS 6719, Grad Lab (3)</td>
</tr>
<tr>
<td></td>
<td>PHYS 7800, Colloquium (2)</td>
<td>PHYS 7810, Colloquium (1)</td>
</tr>
<tr>
<td></td>
<td>*** (2-5)</td>
<td></td>
</tr>
<tr>
<td>Year 2</td>
<td>PHYS 7110, Class. Mech./E&amp;M I (4)</td>
<td>PHYS 7120, E&amp;M II (4)</td>
</tr>
<tr>
<td></td>
<td>PHYS 7220, Quantum Theory I (3)</td>
<td>PHYS 7230, Quantum Theory II (4)</td>
</tr>
<tr>
<td></td>
<td>PHYS 7800, Colloquium (2)</td>
<td>PHYS 7800, Colloquium (2)</td>
</tr>
<tr>
<td>Year 3</td>
<td>PHYS 7310, Stat. Mech. (3)</td>
<td>PHYS 7800, Colloquium (2)</td>
</tr>
<tr>
<td></td>
<td>PHYS 7800, Colloquium (2)</td>
<td>*** (7-10)</td>
</tr>
<tr>
<td></td>
<td>*** (4-7)</td>
<td></td>
</tr>
</tbody>
</table>

*Curriculum tracks distinguish plans for students entering with varying levels of preparedness. Track A may be for a student entering with a Master’s degree or a high Physics GRE score; Track C may be for a student who does not pass the Common Exam. **Note: Students taking English credits** in the Fall of first year cannot do Track A. Track B is an option, or consider doing Track A except with Math Methods I in the Fall of second year.

**The courses listed are required/recommended for Ph.D. candidates. Credit hours for each course are shown in parentheses. For Colloquium/Seminar credits, sign up for PHYS 7800; for 1 credit hour (or 1-2 credit hours of Grad Seminar) register for PHYS 7810.

***In their program of study, students may take Special Reading courses, Research credits, Electives, or a course to satisfy the Breadth Requirement. Note: a total of 9-12 credit hours in a semester is required for Tuition Benefits eligibility for TA’s, 9-11 credit-hours for RA’s.
Summary of Administrative items

Here is a list, in chronological order, of the administrative benchmarks you must reach on your way to your degree:

- Common Exam (before first semester, and second semester if necessary)
- Advising sessions (start of each semester)
- Form Supervisory Committee (after passing Common Exam).
- Program of Study
- Qualifying Exam
- Milestone Master (optional)
- Apply for Graduation
- Thesis Defense
- Final Reading/Submit defended thesis to Thesis Office for Format Approval

Details on how to accomplish some of these tasks are listed in the General Administrative Requirements section of this handbook. Note that the maximum time to complete the degree, including semesters with the minimum Continuing Registration (PHYS 7990), is 7 calendar years from time of matriculation.
PHYSICS EDUCATION

3.1.1. Ph.D. in Physics: Physics Education Specialization

Overview
The Department of Physics & Astronomy is involved in research and development activities in Physics Education. A Ph.D. candidate interested in the teaching of physics and in the research underpinnings of that teaching may wish to undertake a thesis topic in physics education leading toward a Ph.D. in Physics.

A number of faculty members in Physics & Astronomy are willing to assume responsibility for supervising thesis research in this area. The DoGS or the Department Chair will know who among the faculty currently is involved in innovative educational projects or research within the University.

Degree Requirements
The degree conferred in this program is a Ph.D. in Physics, and has all the formal requirements described above. The main difference is a fundamental shift in focus of the Ph.D. research project to explore teaching and learning in physics. The Program of Study of a Physics Education student therefore may be modified accordingly, as deemed necessary by the Supervisory Committee.

Course Curriculum
A student in Physics Education should take the Physics Ph.D. core courses, but may take electives that come from other Departments, such as Education and Philosophy.

Summary of Administrative items
The administrative issues for this degree are the unchanged from the description above. However, you should be aware that your research project, if it involves students, would require Institutional Review Board approval. Usually anticipate no difficulties for a reasonably well-designed project, just know that it may have to happen. See

  Institutional Review Board: http://www.research.utah.edu/irb/

Resources
Physics Education Research (PER) has become a mature physics specialization, applying methods of traditional physics analysis to problems in educating others about our subject. You can find more information here:

  PER Central: http://www.compadre.org/per/wiki
  UColorado’s PER site: http://www.colorado.edu/physics/EducationIssues
MEDICAL PHYSICS

3.2. PH.D. IN PHYSICS WITH MEDICAL PHYSICS EMPHASIS

Overview

Medical Physics is the application of physics as applied to medical imaging and radiation therapy. We offer a Ph.D. in Physics with Medical Emphasis, which is distinct from the Ph.D. programs described above. The UofU has an excellent medical program, and our graduate students have often branched into medicine through this degree offering, doing cutting-edge work in radiology, for example. This degree program will often involve working with a faculty member outside of Physics and Astronomy, such as the Department of Radiology’s Advanced Imaging division (UCAIR), or the Scientific Computing and Imaging Institute (SCI). A list of possible research advisors includes

- Werner Gellerman (Physics & Astronomy; Raman spectroscopy in clinical ophthalmology).
- Brian Saam (Physics & Astronomy; MRI of lung with hyperpolarized noble gases).
- Dennis Parker (Radiology; MRI, MR angiography).
- Eun-Kee (E.K.) Jeong (Radiology, MR Physics, x-nuclei MR Imaging and Spectroscopy).
- Ed DiBella (Radiology; Dynamic MRI with cardiac applications, PET).
- Don Kadrmas (Radiology; PET physics, molecular imaging).
- Daniel Kim (Radiology)
- Chris Johnson (Scientific Computing and Imaging; parallel MRI).

For more information, please check out the following links.

Medical Physics Overview: [http://www.physics.utah.edu/research/medical.html](http://www.physics.utah.edu/research/medical.html)
Utah Center for Advanced Imaging Research: [http://www.ucair.med.utah.edu](http://www.ucair.med.utah.edu)

Required Degree Elements

- Common Exam (or Physics GRE equivalent)
- Core Courses:
  - PHYS 6719 Graduate Lab (or equivalent) (3 credit-hours)
  - PHYS 7110 Classical Mechanics/E&M I (4)
  - PHYS 7220 Quantum Theory I (4)
  - PHYS 7740 Math Methods I (4)
- PLUS two of the following courses:
  - PHYS 7120 E&M II (4)
  - PHYS 7230 Quantum Theory II (4)
  - PHYS 7310 Statistical Mechanics (3)
  - PHYS 7750 Math Methods II (4)
- PHYS 7800 (2 credit-hours) or PHYS 7810 (1-2 credit-hours) Colloquium Course (as in Physics Ph.D.)
- Breadth Requirement: graduate-level physics course outside area of specialization (3 credit-hours)
- Electives: Any graduate courses needed for specialization.
- Program of Study Approval
- Qualifying Exam
- Milestone Master’s (M.S. in Physics; recommended)
- Thesis Research (14-credit hours)
- Thesis Defense
Description of Required Elements

The requirements for the Medical Physics program are similar to those of the standard Physics Ph.D., except for the specific required courses and electives as listed above. Here are details:

• The Common Exam. All entering Medical Physics students need to take the Common Exam as the Physics predoctoral students. Please see:

  Common Exam: http://www.physics.utah.edu/commonexam/cepolicy.html

• Supervisory Committee. Your thesis advisor may be from another department, and cannot technically serve as the chair of your Supervisory Committee without an exception from the Graduate School. There is no problem, since you only need to find a regular faculty member in the Department (preferably one in a field related to your research) to serve as chair. Otherwise the usual rules apply: A majority of the five members must be regular Physics and Astronomy faculty; one member of the committee must be from another department or university. We encourage you to have two outside members if your advisor is not regular faculty in the Department. One of the Department faculty members must be in an area of specialization that is unrelated to your own field.

• Core courses. As with the standard physics degree you have to take core courses. However, the list is slightly shorter to accommodate a more extensive set of electives, from which you get to choose two courses. Your research advisor and Supervisory Committee will help. Note that PHYS 6719, the Graduate Lab course, is a requirement, however, you may take an alternative lab course that satisfies specific criteria (e.g., PHYS 6770; see Appendix B). Again, please consult with your advisor for guidance.

• Colloquium credits. The requirement can be satisfied the same as in the Physics Ph.D., but students may get credit for PHYS 7800/7810 while attending more specialized seminars, like UCAIR’s RECON series. Just make arrangements with your advisor and our Graduate Coordinator, Jackie Hadley.

• Elective and breadth courses. Electives will not only help you in your area of specialization, at least one is required to give you some breadth. For this degree, each specialization (e.g., radiology) will have its own list of core course that you will take as “electives.” Your research advisor will guide you.

Examples:

- PHYS 6950: Special Topic, Physics of Magnetic Resonance Imaging, (2-3 credit hours)
- PHYSL 5200 (Physiology) Principles of Physiology (5)
- PHYSL 6050 (Physiology) General Physiology (2)
- BIOEN 5401 (Bioengineering) Medical Imaging Systems (3)
- RDLGY 7310 (Radiology) Advanced Topics in Magnetic Resonance Imaging (3)
- RDLGY 7320 (Radiology) 3D Reconstruction Techniques in Medical Imaging (3)

• Program of Study. The final list of courses that you must take is determined by your thesis Supervisory Committee. With the possibility of needing more “electives” to learn the fundamentals of your discipline, you should convene your Committee as soon as possible.

Summary of Administrative items

The list of academic and administrative benchmarks is the same as for the standard Physics Ph.D.
CHEMICAL PHYSICS

3.3. INTERDISCIPLINARY PH.D. IN CHEMICAL PHYSICS

Overview

Chemical physics concerns chemical processes from the perspective of atomic, molecular or condensed matter physics. The Ph.D. program in chemical physics is an interdisciplinary graduate curriculum permitting maximum flexibility to well-qualified graduate students. The Program of Study for the doctoral degree is administered by the Chemical Physics Executive Committee for the Departments of Chemistry and Physics & Astronomy. Course requirements are tailored to meet the need and interests of students on an individual basis in consultation with their Supervisory Committees. To enter this program you must first gain admission to the Physics (or Chemistry) Ph.D. program.

Faculty members available to supervise thesis research in this program include:

Physics & Astronomy:
Christoph Boehme (condensed matter, spintronics)
Carleton DeTar (computational physics)
Jordan Gerton (nanostructures)
Frank Harris (chemical physics)
Brian Saam (atomic physics, hyperpolarized gases)
Orest Symko (quasiperiodic crystals)
Valy Vardeny (organic semiconductors)

Chemistry:
Scott Anderson (reaction dynamics, nanoclusters)
Peter Armentrout (chemistry of surfaces, ions, organometallic complexes)
Michael Bartl (micro- and nanophotonics)
David Grant (NMR)
Valeria Molinero (membrane transport, computational chemistry)
Michael Morse (metallic and semiconductor systems)
Jennifer Schumaker-Parry (plasmonic structures and nanoparticles)
Thanh Truong (combustion chemistry, solvation, and zeolite catalysts)
Charles Wight (computational chemistry, rocket propellants & explosives)

Degree Requirements

The degree requirements are determined on a case-by-case basis by the Chemical Physics Executive Committee and the student’s Supervisory Committee. As a guideline, if your home department is Physics & Astronomy, you will follow our Ph.D. program’s exam schedule. Only the courses differ from the “standard” Ph.D. in Physics: The curriculum will be customized for each student. It presumably is some combination the standard Physics Ph.D. track and Chemistry’s divisional tract in Physical Chemistry.

Summary of Administrative items.

The administrative requirements for this degree are similar to those of the Physics Ph.D., except that both the Chemical Physics Executive Committee and the Supervisory Committee must approve the Program of Study. Please contact the Graduate Coordinator for more information. Profes. DeTar and Morse have served most recently on the Executive Committee and can provide the best guidance.
MASTER'S DEGREE IN PHYSICS

3.4. M.S. IN PHYSICS

Overview
The Master’s Degree in Physics is demonstrates that a student has a solid foundation in graduate physics and has the ability to do research, although the student does not need to complete an extensive original research project as for the Ph.D. The Master’s is often conferred to students to acknowledge the completion (or near completion) of all but the doctoral research project, hence the name “milestone” Master’s. The degree is also an option for a student who decides to leave the Ph.D. program or who does not pass a Ph.D. requirement such as the Common Exam or Qualifier.

There are two types of M.S. degrees: thesis and non-thesis. The milestone Master’s is non-thesis degree for students seeking a Ph.D. If you are not going on to get a Ph.D., you are strongly encouraged to work toward a Master’s with a thesis.

Required Degree Elements

• Form Supervisory Committee
• Graduate-level non-research courses (12 credit-hours)
• Research courses (e.g. PHYS 6970; 6 credit-hours)
• Graduate-level courses (12 credit-hours)
• Program of Study Approval
• Thesis Defense or Final Examination (non-thesis option)

Note: To pass a course for credit toward a Master’s in Physics requires a grade of B- or better. In addition, to receive graduate credit, the course number must be 5000 or above.

Description of Required Elements

• Supervisory Committee. The committee consists of three faculty members. Two—including the chair—must be regular faculty in the Department. One and only one member must specialize in an area that is unrelated to your own field, for example, a theorist if your specialization is experimental.

• Courses. A necessary condition for getting a Master’s is the successful completion of 30 credit-hours of coursework. Unlike the Ph.D., there are no specific required courses, but the final Program of Study must reflect adequate training in Physics, as determined by the Supervisory Committee.

• Research Project, Thesis or Report. Your research project will be selected and agreed upon by you and your Supervisory Committee. In the case of a thesis-based Master’s degree, you must write up your results according to University guidelines (according to Grad School’s Thesis Office specifications; see Section 2.1). If you seek a non-thesis (milestone) M.S. as you progress toward your Ph.D., you may have some of the credits-hours from your doctoral research count for the master’s degree.

• Thesis Defense/Final Examination (non-thesis option). You will take an oral exam that begins with a short public presentation followed by a closed-door examination by the Supervisory Committee on your thesis work or research project. For the milestone Master’s, this requirement is typically satisfied during the same time and meeting at which you take your Ph.D. Qualifying Exam.
Course Curriculum

The curriculum depends on the student’s circumstances and the decisions of the Supervisory Committee. We anticipate that a Master’s student will have most of the core courses completed (certainly for a milestone degree); with 6 additional-credit hours of graduate research, the course requirements are satisfied. If a student wishes to graduate with a Physics M.S. without continuing on to a Ph.D., then s/he may do so with a reasonable schedule within two years. For example:

<table>
<thead>
<tr>
<th>M.S. Curriculum</th>
<th>Fall Semester</th>
<th>Spring Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PHYS 7740, Math Methods I</td>
<td>PHYS 6719, Grad Lab</td>
</tr>
<tr>
<td>Year 2</td>
<td>PHYS 6970, M.S. Thesis Research (elective)</td>
<td>PHYS 6970, M.S. Thesis Research (elective)</td>
</tr>
</tbody>
</table>

The Supervisory Committee must approve the electives. The implied two-year time frame is recommended, because of the Tuition Benefit limitations for a M.S. degree (please consult with the Graduate Coordinator about benefits).

• Milestone M.S. versus Ph.D. course credits. In general that whatever course credits you use to satisfy the M.S. Physics degree cannot be used for any other graduate degree, M.S., Ph.D. or otherwise, here at the U. Even so, flexibility in degree requirements makes it straightforward to obtain both a M.S. and a Ph.D. without adding courses to the Ph.D. track.

Summary of Administrative items

Here is a list, in chronological order, of the administrative benchmarks you must reach on your way to your degree:

• Advising sessions (start of each semester)
• Form Supervisory Committee
• Program of Study
• Apply for Graduation
• Final Examination or Thesis Defense
• Submit defended thesis to Thesis Office for format approval (if applicable)

The maximum time allowed to complete a M.S. Physics degree is 4 calendar years from the date of matriculation.
THE MSI PROGRAM

3.5. PHYSICS M.S. WITH INSTRUMENTATION EMPHASIS

Overview

This program is designed to qualify those with training in various scientific and engineering fields to understand, work with and develop modern numerical methods, electronics, measurement system characterization, computer data acquisition/control, and the physical principles of the operation of various measurement transducers and sensors. The degree candidate is required to take part in an instrumentation project, which can be in a wide variety of research and industrial test areas. In many cases the project will occur in disciplines other than physics and can be performed in an industrial setting with appropriate departmental supervision. Projects related to a student’s profession are encouraged; indeed, as MSI students do not typically receive financial support from the Department, many pursue this degree while working full time in industry. Note that projects involving proprietary and/or confidential research can be accommodated. While this is a non-thesis Master’s degree, the successful project is fully documented and results in a detailed written report of the project.

Required Degree Elements:

• Form Supervisory Committee
• Required Core Courses:
  o PHYS 6610 Electronics for Scientific Instrumentation\(^1\) (4 credit-hours)
  o PHYS 6620 Data Acquisition for Scientific Instrumentation\(^1\) (4)
  o PHYS 6750 Applied Modern Optics I & II (4)
  o PHYS 6770 Optical Measurement Techniques & Instrumentation (4)
  o PHYS 6730 Computational Physics (4)
• Instrumentation Project Proposal
• Program of Study Approval
• Elective Courses
  o PHYS 5719 Fundamental Laboratory Techniques (2-3)
  o PHYS 5739 Microscopy (3-4)
  o PHYS 6771 Ionizing Radiation\(^2\) (2)
  o Machine Shop\(^3\) (non-credit, 20 [real-time] hours)
• Research credits:
  o PHYS 6859 Instrumentation Project (6-10)
• Final Presentation and Written Report

• Optional Preparatory Courses:
  o PHYS 5010 Theoretical Mechanics & Quantum Mechanics\(^4\) (3)
  o PHYS 5020 Theoretical E&M and Statistical Mechanics\(^4\) (3)
  o PHYS 6720 Introduction to Computing in Physics\(^5\) (4)

\(^1\)PHYS 6610 and 6620 are usually called Electronics I and Electronics II.

\(^2\)PHYS 6771 is recommended but offered less frequently than the other courses.

\(^3\)Machine shop is a non-credit, four-week training class offered by the Department.

\(^4\)PHYS 5010/5020 are recommended (not required) for a broad Physics background.

\(^5\)PHYS 6720 is recommended for experience with C++ and UNIX to prepare for PHYS 6730.
Description of Required Elements

Many elements of the MSI degree are the same as in the M.S. Physics program, such as the formation of the Supervisory Committee and Program of Study approval. There are differences, as we now describe.

• **Courses.** A total of 30 semester hours of credit are required to complete the program. Six to ten credit-hours will be related to the instrumentation project. Select courses above the 5000 level in physics, chemistry, mathematics, computer science, and engineering may be substituted for the instrumentation courses above with prior approval from a student's Supervisory Committee. These courses should be in fields relevant to the Instrumentation Project, although some may be preparatory in nature, if deemed necessary by the Supervisory Committee.

• **Instrumentation Project Proposal.** Before you begin your instrumentation projects, you must give an oral presentation to your Supervisory Committee describing your proposed project. Expect that your committee will ask you questions during and after your presentation.

• **Final presentation and Written Report.** A final formal oral presentation to the Supervisory committee of the project, and a detailed project write-up are required for completion of the degree. A copy of the Project write-up must be placed in the Physics & Astronomy Library; there you can find examples of successfully completed MSI projects to serve as format and style guides for your own work.

Course Curriculum

The curriculum depends on the student’s preparation, the nature of the instrumentation project. Here is a possible schedule for a student who does not need to take optional preparatory courses:

<table>
<thead>
<tr>
<th>M.S.I. Curriculum</th>
<th>Fall Semester</th>
<th>Spring Semester</th>
</tr>
</thead>
</table>
| Year 1            | PHYS 6610 Electronics I  
PHYS 6750 Modern Optics I & II | PHYS 6620 Electronics II  
PHYS 6730 Computational Physics |
| Year 2            | PHYS 5719 Lab Techniques  
PHYS 6771 Ionizing Radiation | PHYS 6770 Optical Measurements  
PHYS 6859 Instrumentation Project |

Subsequent semesters, if necessary, would consist of PHYS 6859 Instrumentation Project research credits.

Summary of Administrative items

• Advising sessions (start of each semester)
• Form Supervisory Committee
• Program of Study
• Instrumentation Project Proposal
• Apply for Graduation
• Final Presentation/Submit Report to Department
MASTER’S IN COMPUTATIONAL PHYSICS

3.6. PHYSICS M.S. WITH COMPUTATIONAL PHYSICS EMPHASIS

Overview
The Department of Physics & Astronomy offers a Computational Physics option under its regular M.S. program in cooperation with the Departments of Mathematics and Computer Science. This program is intended to equip students in science and engineering disciplines with modern computational skills for use in solving problems in the physical sciences. Degree requirements include classes in numerical analysis using networked Unix workstations in an X-window environment, physics core and specialty courses, and a computational physics project. The project may be developed in cooperation with a student's employer or in conjunction with a University research group. A detailed project report is required. Electives include scientific visualization, architectures and algorithms, minicomputer interfacing with experimental apparatus, and case studies in computational engineering and science.

Faculty members of Physics & Astronomy available to supervise thesis research in this program include:

Adam Bolton (astronomy; data mining, statistical analysis)
Ben Bromley (astrophysics; planet formation and galactic dynamics simulations)
Carleton DeTar (high-energy theory; lattice quantum chromodynamics [QCD])

This program is open to any student admitted to graduate studies in Physics & Astronomy.

Required Degree Elements

• Form Supervisory Committee
• Core Courses
  o PHYS 5010 Theoretical Mechanics & Quantum Mechanics (3 credit-hours)
  o PHYS 5020 Theoretical E&M and Statistical Mechanics (3)
  o PHYS 6720 Introduction to Computing in Physics (4)
  o PHYS 6730 Computational Physics (4)
• Specialization Course (minimum 3 credit-hours, 5000+ level)
• Computer Science Electives (minimum 6 credit-hours)
  o PHYS 6620 Data Acquisition for Scientific Instrumentation (4)
  o MATH 5660 Parallel Numerical Methods (3)
  o MATH 5740 Mathematical Modeling (3)
  o MATH 6790 Case Studies, Computational Engineering & Sciences (3)
  o MATH 6795 Seminar, Computational Engineering & Sciences (3)
  o CS 5010 Software Practice I (3)
  o CS 5020 Software Practice II (3)
  o CS 5630 Scientific Visualization (3)
  o CS 6210 Advanced Scientific Computing I (3)
• Program of Study Approval/Review of Proposed Project
• Research credits (PHYS 6970 Master’s Research, 6-10 credit-hours)
• Final Presentation and Written Report

Note: MATH 6795 is cross-listed with CS 6938
**Description of Required Elements**

Many elements of the MSI degree are the same as in the M.S. Physics program, such as the formation of the Supervisory Committee and Program of Study approval. There are differences, as we now describe.

- **Courses.** A total of 30 semester hours of credit are required to complete the program. Six to ten credit-hours will be related to the computational project. Well-prepared students may exchange PHYS 5010/5020 with electives or other courses as approved by their Supervisory Committee.

- **Computational Physics Project.** At the present time there is no formal project proposal that needs to be approved. However, we recommend that your Supervisory Committee review your proposed work before you begin your project.

- **Final presentation and Written Report.** A detailed project write-up is required for completion of the degree, and a final formal oral presentation to the Supervisory committee of the project may be required as well, at the Committee’s discretion.

**Course Curriculum**

The curriculum depends on the student’s preparation, the nature of the instrumentation project. Here is a possible schedule for a student who does not need to take optional preparatory courses:

<table>
<thead>
<tr>
<th>Computational Physics M.S. Course Curriculum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M.S. Comp. Phys.</strong></td>
</tr>
<tr>
<td>Year 1</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Year 2</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Subsequent semesters, if necessary, would consist of PHYS 6970 Computational Physics Project Research credits (PHYS 6790).

**Summary of Administrative items**

- Advising sessions (start of each semester)
- Form Supervisory Committee
- Program of Study
- Apply for Graduation
- Final Presentation/Submit Project Report
4. ASSISTANTSHIPS AND FELLOWSHIPS

4.1. TEACHING ASSISTANTSHIPS, TEACHING FELLOWSHIPS, & RESEARCH ASSISTANTSHIPS

The Physics & Astronomy Department has a number of assistantships and fellowships available to graduate students. Awards will be made generally to graduate students in good standing who are making substantial progress toward their degrees. Eligibility for these awards is usually the same as eligibility for Tuition Benefits (Section 2.2). For example, you must maintain a cumulative GPA of at least 3.0, and that you register for 9-12 credit-hours of graduate-level courses (5000 or higher). Furthermore, if you are an international student seeking a teaching assistantship (ITA), then you will need to demonstrate spoken-English proficiency (e.g., TOEFL), as defined by the Grad School; see


The Department tries to support students financially as best it can through assistantships and fellowships. Typically Ph.D. students start off as teaching assistants (TA’s), and after they start in on their research projects, they become research assistants (RA’s), with funding arranged by their research advisor. In cases where advisors do not have grant support, students may continue to serve as TA’s if TA slots are available. Please bear in mind that there are also external sources of funding for graduate students, which sometimes come with extra resources for travel, as well as prestige.

In this section you will find a description of the Department’s assistantships and fellowships; Section 5 contains information on external funding sources. (Note: Here we often refer to students who need to demonstrate English proficiency. Recent Grad School admission requirements make these cases increasingly rare.)

**Teaching Assistantships**

These assistantships are awarded to students in good standing (i.e., eligible for Tuition Benefits) usually for a maximum of two years for Ph.D. candidates, and one year for Master’s degree candidates. To maintain support after this time limit, each semester the teaching assistant (TA) must have the chair of his or her Supervisory Committee write a letter to the Director of Graduate Studies requesting support, enumerating progress toward the degree during the previous semester.
The Department and University currently offer several types of teaching assistantships, varying by degree of experience of the TA and nature of the teaching assignment:

- **Level I TA or Graduate Assistant (GA).** This position offers a baseline in salary and level of responsibility; A TA at this level may cover grading, but not lab or discussion sections. The GA designation is typically used for students who have not yet demonstrated English proficiency.

- **Level-II TA.** Students who perform well in teaching, demonstrate English proficiency (in cases of International TA’s), and have good academic standing in their graduate programs are encouraged to apply for a (Level-II) TA position. Responsibilities of a Level-II TA may include overseeing lab or discussion sections or serving as a Class Marshall (see below). Salary for this position will exceed that of the Level-I TA by approximately 18%. To receive a Level-II TA position you must apply, usually as part of your Graduate Admission application. Awards may be made throughout the academic year, although they are subject to revocation upon poor teaching or academic performance.

- **University TA (UTA).** Alternatively a more experienced TA may apply for a competitive University Teaching Assistantship through the Graduate School. For more information, see UTA application: [http://www.gradschool.utah.edu/tbp/finassist.php - uta](http://www.gradschool.utah.edu/tbp/finassist.php - uta)

**Teaching Fellowships**

Graduate students may apply for a selective Teaching Fellowship (TF), if they have passed the Common Examination, established a supervisory committee, demonstrated good teaching skills, and shown progress toward the degree. Applications are made with the help of the research advisor. The Teaching Fellowships may be renewed for a second year. Students receiving the stipend will be expected to perform teaching duties as with the teaching assistantship.

**Research Assistantships**

Faculty members often provide funding to students, usually (but not always) their advisees, to work on a research project. The arrangements for awarding and renewing a research assistantship (RA) are made directly with the professor who has the funding. Assistantships are typically given only to those students who have passed the Common Examination and have established a supervisory committee. The length of the research assistantship is an agreement between the student and the faculty member with the funding. There are award research fellowships available, too, such as the University’s GRF program:

University’s Award Fellowships: [http://www.gradschool.utah.edu/tbp/finassist.php#fellowships](http://www.gradschool.utah.edu/tbp/finassist.php#fellowships)

**Summer Assistantships**

A few summer teaching assistantships (Level II TA) are available and will be given to those students who best demonstrate good teaching skills.
Evaluation Of Performance of GA’s, TA’s, and TF’s

The performance and progress of teaching fellows and teaching assistants will be reviewed annually. In addition to satisfactory performance of teaching duties, TF’s and TA’s should be making progress in their academic program, including (if applicable) English proficiency. If a student is not successful in these respects, the teaching assistantship may be terminated. If you find your assistantship to be at risk, contact your graduate advisor, who may help arrange for a continuation or reinstatement of an assistantship, conditional on improved academic or teaching performance. Be careful, though. If you fall out of Tuition Benefit Eligibility (e.g., GPA below 3.0), the Department may not be able to help, as there may be conflicts with Grad School regulations about TA support.

Occasionally the Physics & Astronomy Department may have teaching needs that will lead to the temporary waiving of the above rules. Usually this will only occur if the student has special teaching skills that are particularly needed. Also, a student’s supervisory committee may request that the Department waive these rules if some clearly special circumstances exist. Note that these waivers are rare, and never indicate a formal change in the rules.

4.2. Teaching Assistant Responsibilities

This section is intended to outline departmental procedures regarding Teaching and Graduate Assistants. It covers assignment procedures, job disciplines.

Teaching Assignments & Loads

A standard TA or GA load is 20 hours per week. TA’s and GA’s are typically awarded for two semesters and the load is maintained for two semesters. Enrollment contingencies may make it necessary to trade overloads in one semester for light loads in another. In other words, the standard TA/GA load is actually no more than 20 hours per week averaged over two semesters.

Some jobs are common enough to have pre-assigned hourly workloads, whereas some must be evaluated as they arise. The following is a table of typical pre-assigned workload values:

<table>
<thead>
<tr>
<th>Job (Fall/Spring)</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Discussion Sections 2010 or 2110 Series</td>
<td>20</td>
</tr>
<tr>
<td>2 Discussion Sections 2210 Series</td>
<td>20</td>
</tr>
<tr>
<td>1 Lab Section 2019, 2029 Series</td>
<td>7 (10 first semester teaching lab)</td>
</tr>
</tbody>
</table>

The above unit values are for Fall and Spring semesters. In the Summer semester, the typical values are:

<table>
<thead>
<tr>
<th>Job (Summer)</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Discussion Section 2010 or 2110 Series</td>
<td>10 (dependent on course level and enrollment)</td>
</tr>
<tr>
<td>Grading</td>
<td>(dependent on course level and enrollment)</td>
</tr>
</tbody>
</table>

The workload value for the other jobs is determined case by case. For example, a grader is assigned to any instructor of a class other than a discussion section whose enrollment warrants assistance, but the
actual assignment may vary depending on whether the class is introductory (e.g., PHYS 1010) or advanced (such as PHYS 6720). Where possible, the workload is estimated with help from experienced TA’s who have previously read for a particular course. Note that the assignment is made on the basis of how long it should take, not how long it actually does take.

A few exceptional TA’s may be selected as course marshal for large courses (e.g., PHYS 2010). The marshal typically has reduced grading or discussion section workload, but has additional responsibility in terms of organizing the discussion section schedules of other TA’s for the course, arranging help sessions, and coordinating grading of homework and exams.

**Example Job Descriptions**

For the more common TA and grading assignments, we can list specific duties and necessary job qualifications.

**Instructors of Discussion Sections (2010, 2020, 2110, 2120, 2210, 2220)**

*The Job:* The Instructor meets with the discussion section twice weekly to provide help with assigned problems and with questions that arise concerning the course. He or she grades exams and helps proctor them. Attendance at lecture is required. Personal involvement with students (dating, tutoring for pay, etc.) in one’s discussion section is forbidden. Each instructor should schedule approximately three hours per week for consultation with students.

*Qualifications:* The Instructor must be able to speak English well, must have passed the SPEAK test, must be conscientious about preparing for class, must be reliable in attendance, and must be willing to help students on an individual basis where necessary. It is highly recommended that the TA attend the lecture (at least the first time through the course).

*Criteria for Assignment and Retention:* Student ratings on university or departmental evaluations and recommendation of the instructor in charge of the course form the basis for assignments and retention.

**Lab Instructors (2015, 2025, 2215, 2225)**

*The Job:* The class meets once a week, for a three-hour period of investigation in the laboratory. The instructor's responsibilities in the laboratory are (a) to motivate the students towards independent thinking in applying physical principles to experimental problems; (b) to teach experimental techniques; (c) to instruct the students in the care and use of equipment; and (d) to solve simple malfunction problems with the equipment. The instructor is required to attend scheduled meetings of laboratory instructors and must become familiar with the equipment and the experimental procedures prior to the laboratory class. **The instructor is to remain in the laboratory during the time the students are performing the experiments.** In case an instructor is unable to attend class, he or she is expected to find an approved substitute. The instructor grades the students’ homework and lab reports and must keep a record of these grades.

*Qualifications:* The instructor must be able to communicate effectively, must be conscientious in helping the students in both an individual and a group basis, and must have some prior knowledge of experimental equipment, experimental techniques and safety lab.
**Criteria for Assignment and Retention:** Student ratings on University and departmental evaluations and an appraisal by the laboratory supervisor concerning attitude, accomplishments, and ability form the basis for assignments and retention.

**Graders**

**The Job:** Graders are assigned to a lecturer (professor in charge of a course) to grade homework, quizzes, and/or exam. At the request of the lecturer, a grader answers student's questions about problems.

**Qualifications:** Language fluency is less important in this job. The grader should have completed the next higher level course sequence (than the course being graded) with at least a B+ grade.

**Criteria for Assignment and Retention:** The recommendation of the lecturer provides the basis for assignments and retention.

The above job descriptions apply to Fall and Spring semesters. In Summer Semester, some of the discussion sections meet on a different schedule; thus the teaching loads are different. Information about loads is available at the time TA applications for Summer Semester are received.

**Performance assessments**

For the above assignments and others not listed, your performance will be evaluated. Personal observation by the instructor or other members of the Department, as well as comments from individual students, will be factors in assessing how well you are doing. If students fill out course evaluations for you, you may find them in the Physics & Astronomy Main Office (they are not publicly available).

If you or someone else determines that your TA or grading performance needs to improve, please make this an opportunity to go get help. Center for Teaching & Learning Excellence is a great place to start.

CTLE:  [http://www.ctle.utah.edu](http://www.ctle.utah.edu)

(We all benefit from tuning up our teaching effectiveness, so please check out the site, no matter what!)

If students cannot or refuse to work on improving teaching skills, the Department may be unable to provide GA or TA support. Also, if a student is negligent in any way, for example failing to show up for an assignment/discussion section, then at very least a verbal or oral reprimand will be issued. More severe cases may require more severe action, including termination or non-renewal of assistantship. Such cases will be considered by the Department Policy Board, which will then take appropriate action.

**4.3. TA ASSIGNMENT PROCEDURES & CONSIDERATIONS**

Teaching assignments in the Physics & Astronomy Department typically fall into four main categories:

1. Discussion sections for large courses (2010, 2010, 2110, 2120, 2210 and 2220)
2. Upper level lab assistants (3410, 3610 and 3719)
3. Elementary lab assistants (1890, 2015, 2025, 2215 and 2222)
4. Grading for undergraduate courses
These assignments are listed in the order of communication skills required to fill the assignment. Discussion TA’s need the highest communication skill set since they have four hours of student contact each week. They need to be able to speak clearly, understand questions students ask, and explain physics problems with clarity and accuracy. TA’s for upper level lab courses require the same communication skills and need a deeper understanding of the course material. Elementary lab TA’s need a high level of communication skills, but typically meet students on a one-on-one basis. The ten-minute introduction requires good communication skills. Grading requires the least communication skills unless the instructor requires the TA to conduct a discussion section for the course.

There are many factors that go into making a TA assignment. Some of the most important issues are listed in approximately the order of importance:

- A list of possible TA’s is shown to the faculty members who will teach the large lecture courses, and the instructors are asked to give approval of the TA’s who are planned for the course. Faculty input is taken very seriously, and every attempt is made to make certain that faculty are happy with the list of TA’s. This is especially true when the marshal is being selected. (Most of the time the faculty member will request a specific marshal).
- The prospective discussion TA list is reviewed with staff members who have worked with the individual TA’s in prior semesters. This input is weighed and considered. Student evaluations of TA’s are reviewed to make certain all is in order.
- Many faculty have requests for specific graders, lab assistants, discussion leaders and marshals. These requests are factored in and granted when possible.
- New TA’s are surveyed during the orientation and asked to list the assignments they would prefer. These requests are granted when possible.
- Discussion assignments for the large lecture courses are made first, lab assistant assignments second, and finally grading assignments.
- There are always one or two special need assignments that require special considerations (3730 TA, one time course offering TA, etc.)
- Always at the last minute a TA will have an assignment and then finds an RA. This requires a reshuffling of assignments - sometimes requiring extensive reassignments.
- TA performance will be considered in making TA assignments. Typically outstanding performance will most likely result in that TA becoming marshal in the near future. Bad performance should lead to dismissal but to this point in time has resulted in a reassignment of duties for future semesters.
- We will send out a notice to TAs for spring semester and fall semester to have respond and request the assignment they desire for that semester. These requests obviously cannot be guaranteed, however whenever possible they will be honored.

The goal we strive for with TA assignments are, in order of importance:

- The assignments are fair. Each TA should be given an assignment that requires approximately 20/week. This is spelled out on the final TA Assignment list, and the faculty know exactly how many hours each TA has been assigned.
- The assignments will provide the best instruction for the students. The students deserve the best TA’s we can provide in each position.
- Faculty are happy with the TA’s who have been assigned to them.
- TA ability a skill set is matched to the TA assignment.
- TA’s feel they have been treated fairly.
In order to achieve these goals there has always been fine tuning in the assignments after the first list is distributed. A sheet listing the assignments is sent to all TAs with a note telling them to contact the person making the assignments if there is a problem. Faculty or TA In marshals often give input that additional help is needed or that a certain TA needs to be shifted to another assignment, etc.

4.4. Summary Items for TA’s

We close this section with a final summarizing list relevant to Teaching assistantships:

- Level I TA’s are not given responsibility in the labs or discussions. These students have not passed the Versant Spoken Language Test requirements imposed by the University of Utah.
- Level II TA’s are given any assignment since they have passed the Versant Spoken Language Test. They are paid at a higher rate. These are the only students considered for a summer TA since the summer assignments are so scarce and limited.
- A full TA for 20 hours/week is normally one of the following
  - 2 discussion sections
  - 3 labs (2 the first time teaching labs)
  - Grading 1 or 2 courses depending on enrollment & how the instructor uses the grader.
  - Miscellaneous (rare) special assignments.
- The minimum requirement for graduate students to get a TA after being one for two or more years is a letter from the chair of his/her Supervisory Committee to the DoGS or Department Chair. The letter must certify that the student is making satisfactory progress toward the degree, explain why there is no funding for RA, support and provide the expected date of graduation.
5. GRADUATE STUDENT RESOURCES

Here we cover some academic and non-academic issues that may be of broad concern as your graduate career progresses, such as how to look out for your overall well-being, among many other things.

5.1. INTERNATIONAL STUDENT INFORMATION

If you are an international student, you may have a whole level of bureaucracy (ICE) to do deal with that has little to do with your degree, and everything to do with your ability to attain it. The International Center provides resources here at the University to help with a variety of issues, especially with regard to your visa. The Center’s website is

   International Center: http://ic.utah.edu

**Visa Issues.** Unfortunately, visa troubles sometimes occur and when they do they are painful. So please be careful with arranging for a Leave of Absence, or Continuous Minimum Registration. Also, if for any reason you need to go abroad in the middle of a semester while you are on a TA or RA, make arrangements in case you are prevented from re-entering the country. You may lose Tuition Benefits and get charged for tuition, among other things. Just plan ahead. Here is a place to start:

   IC’s F-1 Visa Status: http://www.ic.utah.edu/students/current/maintainingStatus.htm

**English proficiency.** Finally, international students who are not native English speakers must be cleared by the International Teaching Assistant (ITA) program in order to be given a TA.

   International TA Program: http://www.gradschool.utah.edu/ita

If English fluency is a problem for students, then they will be encouraged to get some assistance, through ESL classes, for example. The International Center can help.
5.2. DISABILITY SERVICES: MAKING THE PROGRAM WORK FOR YOU

The University provides accommodations to enhance your educational development if you are a student with disabilities. The range of services is broad, and the Center for Disability Services has compiled an excellent list of resources, available through this link:

Center for Disability Services:  http://disability.utah.edu

5.3. MAINTAINING YOUR WELL-BEING: HEALTH AND COUNSELING RESOURCES

Graduate school is notoriously stressful. Here are some ideas and resources available to you so that your grad school experience is broadly rewarding.

• **Be part of the Community.** Life as a grad student is more than coursework and research, but making it fulfilling may seem difficult, especially if you do not have family here. Fortunately there are many opportunities to meet people and to enjoy varied activities in Salt Lake City. To start, try the Physics and Astronomy Graduate Student Advisory Committee. They may provide excellent ideas. (You might become an active member!):

  Graduate Student Advisory Committee:  http://www.physics.utah.edu/~gsac

• **Health issues.** For most of us, access to health care requires health insurance. Fortunately you can get subsidized health insurance through a program administered by the Graduate School. Another important resource is the Student Health Center, where you can receive a variety of services including vaccines, diagnostic testing/screening, and counseling.

• **Stress management and counseling.** If you need help with stress, anxiety, depression or mood swings, or if you and your partner could benefit from talking together with a counselor, then call or visit the Counseling Center. The services are comprehensive, excellent and extremely inexpensive. **HIGHLY RECOMMENDED for all University students and employees.**

• **Substance Abuse.** There are many resources available to help with addiction and alcoholism. The Student Wellness Center provides some on-line links, and both the Student Health Center and Counseling Center can help more directly.

• **Use all available resources.** On-campus providers can guide you to more comprehensive treatment and recovery services off-campus.

• **Links to campus health and wellness resources:**

  Counseling Center:  http://www.sa.utah.edu/counsel/
  Subsidized Student Insurance:  http://www.gradschool.utah.edu/tbp/insurance.php
  Student Health Center:  http://www.studenthealth.utah.edu/
  Student Wellness Center:  http://www.wellness.utah.edu
5.4. GETTING ALONG: PROFESSIONAL CONDUCT AND CONFLICT RESOLUTION

The atmosphere in the Department of Physics and Astronomy is generally professional, yet very friendly and supportive. Students in our graduate program tend to have a positive “we’re in this together” attitude toward meeting the challenges of coursework, research, and being a TA. Like the faculty students are required to maintain high ethical standards and to treat others with respect. In this section we discuss these issues, as well as what happens when conflict arises, perhaps because of a failure to show respect.

- **Student Rights and Responsibilities.** The University has outlined its policy regarding your conduct as a graduate student:

  Student code: [http://www.regulations.utah.edu/academics/6-400.html](http://www.regulations.utah.edu/academics/6-400.html)

  The bottom line is that we are in a place of learning and we shall help, not impede, our own or others’ pursuit of knowledge (do not plagiarize, cheat or interfere with other’s studies). If you do your part we will try our best to support your effort. If you do not, you may be required to leave our University.

- **Conflict resolution.** We hope that your stay in the Department of Physics and Astronomy is free of conflict. However, in case you are in a situation where a conflict or dispute has arisen, we want to provide you with options.

  - **Physical threat.** First and foremost, be safe. If there is any physical threat to you, try to move yourself out of the situation and **contact 911 or Campus Police (1-5801).**

  - **Sexual Harassment.** In cases of sexual harassment, we ask that you contact the OEO (Office of Equal Opportunity; 801-581-8365), even If you are in doubt. We can help you contact OEO if that would help.

  - **Conflict between students or a student and a faculty member.** If a conflict arises, perhaps because of unprofessional behavior it may help to talk with the person with whom you are in conflict if there is no question about personal safety. Otherwise talk with your advisor, the DoGS, the Department Chair or the Dean of Students. When appropriate s/he will bring the parties together and attempt to reach a resolution. Note that a conflict between student and faculty can involve research ethics, such as failure of an advisor to give proper credit for a student’s research.

- **Conflict resolution options**

<table>
<thead>
<tr>
<th>Safety threat</th>
<th>911 / Police / Campus Security</th>
<th>801-581-5801</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sexual Harassment</td>
<td>OEO/Office of Equal Opportunity</td>
<td>801-581-8365</td>
</tr>
<tr>
<td>Informal dispute</td>
<td>Discussion between parties</td>
<td></td>
</tr>
<tr>
<td>Mediated resolution</td>
<td>Meet with Chair or DoGS</td>
<td></td>
</tr>
<tr>
<td>University assistance?</td>
<td>Dean of Students Office</td>
<td>801-581-8061</td>
</tr>
</tbody>
</table>
5.5. BEYOND CLASSES: OTHER EDUCATIONAL OPPORTUNITIES

You will start off taking courses, but it is important to explore other education possibilities as well. One practical reason is that the tuition benefits program is generous, but it does limit your time here., it is best to find a research project quickly. You will want to get as much information as you can about your options. Take part in the Graduate Student Symposium, the Condensed Matter Seminars, the BOWTIE seminar (astronomy/astrophysics), and especially the Department Colloquium to learn about your research possibilities. (Note: You may be required to attend the Colloquium.) Talk with other graduate students. Do not limit yourself to the Department; there are research groups in Scientific Computing Institute and the Department of Radiology, for example, in which our students have worked.

Another possibility is to attend conferences. Often you will participate in professional meetings with your advisor, but do not wait for an invitation. Often meeting organizers can provide some travel money for graduate students. If you are well into your research, definitely present a poster or (better) give a talk. Just for example, some good local meetings include:

- APS Four-Corners Section Meeting: [http://www.aps.org/units/4cs](http://www.aps.org/units/4cs)

5.6. ON-LINE RESOURCES FOR GRADUATE STUDY AND BEYOND

HOW TO GET FUNDING, WRITE A THESIS, AND MORE

This section lists some websites that may contain useful information for you. However, first you must get on-line. As a graduate student, you will be given an account on our Department’s computer system. We have terminals available for use in all of our campus buildings (INSCC, JFB, SP). To apply for an account, ask at the Physics & Astronomy front desk.

The sites provided here are the “tip of the iceberg” of on-line resources for grad students. We will try to give just some basics. Try the Department website for more, especially those sites related to fellowships. You should apply, even if your advisor has funding for your research, since many fellowships carry prestige.

**Graduate School and University sites that you should know about**

- Grad School Home: [http://www.gradschool.utah.edu](http://www.gradschool.utah.edu)
- Graduate Catalog (requirements): [http://www.gradschool.utah.edu/catalog](http://www.gradschool.utah.edu/catalog)
- International TA program: [http://www.gradschool.utah.edu/ita](http://www.gradschool.utah.edu/ita)
- International Center: [http://ic.utah.edu](http://ic.utah.edu)
- Marriott Library: [http://www.lib.utah.edu](http://www.lib.utah.edu)
- Student Resources: [http://www.gradschool.utah.edu/students](http://www.gradschool.utah.edu/students)
- Tuition Benefits Program/Insurance: [http://www.gradschool.utah.edu/tbp](http://www.gradschool.utah.edu/tbp)

**Your Rights and Responsibilities**

- Student Code: [http://www.regulations.utah.edu/academics/6-400.html](http://www.regulations.utah.edu/academics/6-400.html)
Funding opportunities for grad school (There are more! Ask your advisor...)

- University of Utah Fellowships:  http://www.gradschool.utah.edu/tbp/finassist.php?fellowships
- NASA GSRP Fellowships:  http://fellowships.hq.nasa.gov/gsrp/nav/
- PhDs.org’s fellowship list:  http://jobs.phds.org/physics-jobs/graduate

How to write a thesis


Dissertation Bootcamp was started in 2010 and the demand is extraordinarily high. Check it out, and sign up, if it seems helpful. Also, let the DoGS know what you think!

Teaching resources

- TA Resource Center:  http://web.utah.edu/taresources
- Center for Teaching & Learning Excellence:  http://www.ctle.utah.edu

(The CTLE really is excellent.)

Computing resources

- Utah Center for High Performance Computing:  http://www.chpc.utah.edu

Professional Organizations

- American Institute of Physics:  http://www.aip.org
- American Physical Society:  http://aps.org

Find a job in Physics and Astronomy

- AAS’s Job Register for astro-ph:  http://members.aas.org/JobReg/JobRegister.cfm
- The APS’s physics careers page:  http://aps.org/careers/employment/index.cfm
- PhDs.org’s jobs resources:  http://jobs.phds.org/physics-jobs

Almost every astronomy or astrophysics faculty member got a position here in Utah through the AAS Job Register. Almost every physics faculty member found his/her position here through APS’s Physics Today.
5.7. **Off-line resources: things to do for fun.**

Salt Lake City, Utah, and the University of Utah in particular offer many opportunities for enjoying breaks from your studies. Word-of-mouth is a good way to find fun things to do. The University always has interesting events as well:

U of U events calendar: [http://www.events.utah.edu/](http://www.events.utah.edu/)

Meanwhile, for your amusement only, here is a to-do list while you are in Salt Lake City. (The Department’s virtual legal squad has not approved of all of these items. They do not constitute an endorsement of any kind. This list is NOT an implicit recommendation that you should ever be away from your lab bench or computer workstation.)

- Look at stars from the South Physics Observatory
- Go to a play at the Pioneer Theatre
- Volunteer as a science fair judge ([http://www.slvsef.org](http://www.slvsef.org))
- Swim in the Great Salt Lake. Or at least smell it.
- See a concert at Kingsbury Hall
- BORSCH (Bike, Overnight [camp], Run, Ski, Climb, Hike); we are less than a half-day’s drive from Grand Canyon, Yellowstone, Bryce, Zion, Canyonlands, Arches, Capitol Reef...
- Check out the Sundance Film Festival
- Take a Gallery Stroll downtown (third Friday of each month, 6pm)
- Do something cool and have the DoGS add it to this list!
6. SUPPLEMENTAL DEPARTMENT INFORMATION

6.1. GRADUATE COURSES IN PHYSICS AND ASTRONOMY

**PHYSICS**

5010 Theoretical Classical Mechanics and Quantum Mechanics
5015 Observational Methods and Data Analysis
5020 Theoretical Electricity & Magnetism and Statistical Physics
5070 Physics Teaching Methods
5110 Introduction to Nuclear & Particle Physics
5150 Energy & sustainability-A Global Perspective
5410 Physics Core of Modern Technology and Life Science
5450 Introduction to Quantum Mechanics
5510 Solid-State Physics I
5520 Solid-State Physics II
5530 Introduction to Disordered Solids
5719 Fundamental Lab Techniques
5739 Scanning Electron Microscopy
5810 Nanoscience: Where Biology, Chemistry and Physics Intersect
6071 Science Teaching Methods
6072 Science Teaching Methods
6073 Science Teaching Methods
6074 Science Teaching Methods
6110 Theoretical Mechanics
6210 Optics in Biology
6510 Physics of Semiconductors I
6520 Physics of Semiconductors II
6610 Electronics for Scientific Instrumentation
6620 Data Acquisition for Sci. Instrumentation
6710 Technical Comm. & Scientific Judgment
6719 Graduate Laboratory
6720 Introduction to Computing in Physics
6730 Computational Physics 2
6740 Computational Physics II
6750 Applied Modern Optics I & II
6751 Modern Optics I
6760 Physical Measurement & Sensor Systems
6770 Optical Measurement & Instrumentation
6771 Ionizing Radiation
6775 Optical Measurement Techniques and Instrumentation Laboratory
6800 Physics Colloquium
6810 Graduate Seminar: Master's
6849 Physics Masters Project
6859 Instrumentation Project
6910 Advanced Applied Electricity & Magnetism
6920 Advanced Applied Modern Physics
6950 Special Reading Topics: Master's
6970 Thesis Research: Master's
6980 Faculty Consultation
7110 Electrodynamics I
7120 Electrodynamics II
7220 Quantum Theory I
7230 Quantum Theory II
7310 Statistical Mechanics
7510 Advanced Solid-State Physics I
7520 Advanced Solid-State Physics II
7530 Principles of Nuclear Magnetic Resonance
7550 Physical Applications of Group Theory
7640 Quantum Field Theory I
7650 Quantum Field Theory II
7720 General Rel. & Relativistic Astrophysics
7730 Computational and Statistical Methods
7740 Mathematical Methods of Physics I
7750 Mathematical Methods of Physics II
7800 Physics Colloquium
7810 Graduate Seminar for Ph.D. Students
7910 Special Reading Topics: Ph.D.
7970 Thesis Research: Ph.D.
7980 Faculty Consultation
7990 Continuing Registration: Ph.D.

**ASTRONOMY**

5015 Observational Methods and Data Analysis
5570 Galactic Astronomy & Stellar Populations
5580 Extragalactic Astronomy and Cosmology
5590 Stellar Astrophysics and Compact Objects
6410 Intro to Research in Astron. & Astrophysi.
7730 Computational and Statistical Methods
6.2. Faculty Research

Ailion, David - Atomic Physics, NMR.
Bergman, Douglas - Cosmic rays.
Boehme, Christoph (Assoc. Chair) – Condensed matter, spectroscopy and spintronics
Bolton, Adam – Astronomy, observational cosmology and galaxy evolution
Bromley, Ben – Computational astrophysics, planet formation, galactic dynamics
Dawson, Kyle – Astronomy, observational cosmology, instrumentation
DeTar, Carleton – High-energy theory, computational physics, lattice QCD
Deemyad, Shanti – Condensed matter (experiment), high pressure phenomena
Efros, Alexei – Condensed matter (theory), disordered systems, left-handed materials
Gerton, Jordan – Nanoscience, Biophysics, near-field optical microscopy
Gondolo, Paolo – Theoretical astrophysics, dark matter, dark stars, cosmology
Harris, Frank – Chemical physics, atomic physics
Ivans, Inese – Astronomy, Galactic archaeology and stellar populations
Jui, Charlie – Cosmic rays
Kieda, David (Chair) – High-energy astrophysics, γ-ray astronomy, AGN variability
LeBohec, Stephan - High-energy astrophysics, γ-ray astronomy, optical intensity interferometry
Mishchenko, Eugene – Condensed matter (theory), 2-d spin polarized transport, graphene
Raikh, Mikhail – Condensed matter (theory), disordered systems, quantum Hall effect
Rogachev, Andrey – Condensed matter (exp’t), electron transport, superconductivity
Saam, Brian (Associate Dean, Science) – Atomic physics, biophysics, MRI, hyperpolarized Xe
Saffarian, Saveez – Biophysics, enveloped virus budding
Sandick, Pearl – High-energy theory, LHC phenomenology, dark matter
Seth, Anil – Astronomy, star clusters, galactic nuclei and black holes
Sokolsky, Pierre (Dean, Science) – Cosmic rays
Springer, Wayne – Astroparticle physics, cosmic ray, (W. E. Observatory Director)
Starykh, Oleg – Condensed matter (theory), strongly correlated systems, frustrated magnetism
Symko, Orest – Condensed matter (experiment), superconductivity, thermoacoustics
Thomson, Gordon (Keuffel Chair) – Cosmic rays
Vardeny, Valy – Experimental physics, organic semiconductors, random lasers
Vershinin, Michael – Biophysics, nanoscience, optical trapping, emergent complexity
Williams, Clayton – Applied physics, atomic force and scanning tunneling microscopy,
Wu, Yong-Shi – High-energy theory, condensed matter physics, string theory
Zheng, Zheng – Theoretical astrophysics, cosmology, galaxy evolution and clustering

(http://www.physics.utah.edu/people/faculty.html)
Appendix A. Graduate Advising Checklist (Ph.D. Physics)

Purpose: To provide a guide for an advising session between a grad student and the assigned Graduate Advisor or the student’s Supervisory Committee Chair (usually the thesis advisor). Students in Chemical Physics, Medical Physics, Astronomy, Biophysics or Master’s programs should meet with an advisor related to their program. Students who have begun thesis research should meet with their Supervisory Committee Chair. This checklist is informal; Jackie has the official version, which you and your advisor must complete for you to receive Tuition Benefits.

1. Review Common Exam status. Has student passed? If not, what preparatory courses are necessary? (Recommendation: use Alternate Curriculum in the Graduate Handbook, Section 3.)

2. Review courses already completed. Have core courses been taken? Has student received a B or better (required for graduate credit) for all courses?

- PHYS 7110, Class. Mech./E&M I
- PHYS 7220, Quantum Theory I
- PHYS 7310, Stat. Mech
- PHYS 7740, Math Methods I
- PHYS 7120, E&M II
- PHYS 7230, Quantum Theory II
- PHYS 6719, Grad Lab
- PHYS 7800/7810 Colloquium/Seminar*

*Colloquium attendance is required for first 6 semesters and encouraged thereafter. If schedule permits, take PHYS 7800 for 2 credit-hours, otherwise take 7810 for 1 credit-hour. Even if neither 7800 or 7810 are taken, attendance will be monitored.

3. Determine courses for this semester. Consider long-term goals as well as degree requirements. Note that for tuition benefits eligibility, the total number of credit-hours is 9-12 (TA’s) or 9-11 (RA’s). If a student is on the astronomy track, please refer her/him to an astronomy faculty for advice.

4. Discuss long-term plans for coursework and research. If a student has not chosen a research area, identify areas of interest and (e.g.) plan to meet with faculty working in those areas.

5. Ensure student is on track with the degree requirements. This list is for Ph.D., up to thesis defense:

- Common Exam
- Core Courses
- Elective outside of specialization
- Form Supervisory Committee (by 2nd yr)
- Program of Study (w/your Committee)
- Qualifying Exam (by 3rd year)
- Milestone Master’s (recommended)*
- Apply for Graduation**

*Milestone M.S. can be conferred after Qualifier is passed.
**Application for Graduation is a University formality submitted the academic year of graduation; please see Jackie Hadley.

6. Review Tuition Benefit Program eligibility (if applicable).

- Cumulative GPA of 3.0 or above
- Within allowed number of supported semesters*
- Registered for 9-12 credit-hours (TA) or 9-11 credit-hours (RA)
- TA/RA assignment is appropriate

*4 semesters for M.S.; 8 for Ph.D. with prior M.S.; 10 for Ph.D. (no M.S.); add 2 semesters if student is/was TA for 2 years.

7. Sign Tuition Benefits Form IF eligibility requirements are met and IF there is an agreement on course selection. Otherwise, please see the Chair of the Graduate Advising Committee.

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Appendix B. Graduate Lab Course Criteria

The Department of Physics and Astronomy has a Graduate Laboratory Requirement for several of its degree programs (e.g., Ph.D. in Physics). This requirement ensures that students have experience with experimental or observational data. One course, PHYS 6719, satisfies this requirement. However, under some circumstances, a student and her/his supervisory committee may find it beneficial to take a different course (3-4 credit-hours), perhaps more directly relevant to the student’s thesis research. Such a substitution for PHYS 6719 is justified if the substitute course contains the following curriculum items:

a. Counting and statistics; statistical distributions.
b. Error analysis and propagation.
c. Noise, noise sources, and signal averaging.
d. Fitting data to models, interpreting significance of results.
e. Execution of at least two experimental or observational projects incorporating the above concepts, and some sort of write-up.
f. Oral presentation (e.g. APS meeting-style) of work done.

Two courses, PHYS 6770 and ASTR 5015, are satisfactory substitutes. However, they may be used in lieu of PHYS 6719 as a degree requirement only if approved by the student’s supervisory committee.
Appendix C. Proposed Degree Specialization/Emphasis Requirements

This section is reserved for Degree Programs that are coming soon but are NOT YET OFFICIAL!

C.1. PH.D. IN PHYSICS: ASTROPHYSICS EMPHASIS

Overview

Our faculty work on a wide range of observational and theoretical topics, including cosmology, galactic astronomy, the large-scale structure of the Universe, and the origin of planetary systems. We are an institutional partner in the Sloan Digital Sky Survey III, VERITAS (gamma-ray observatory), and the Telescope Array (cosmic rays). We observe on the Hubble Space Telescope and the SWIFT spacecraft, as well as on world-class ground-based telescopes, including Subaru, MMT, and Apache Point. We also operate a 0.8-m telescope in southern Utah designed to give students hands-on observing experience. Opportunities for research abound! Potential research advisors include:

Adam Bolton (observational cosmology and galaxy evolution)
Ben Bromley (theoretical astrophysics, origin of solar systems, galactic dynamics)
Kyle Dawson (observational cosmology, instrumentation)
Paolo Gondolo (cosmology, high-energy theory, dark matter)
Inese Ivans (observational galactic archaeology and stellar populations)
Dave Kieda (gamma-ray astronomy, active galactic nuclei)
Stephan LeBohec (gamma-ray astronomy, active galactic nuclei)
Pearl Sandick (cosmology, particle phenomenology, dark matter)
Anil Seth (observational astronomy, nuclear star clusters, galactic astronomy)
Wayne Springer (particle astrophysics)
Zheng Zheng (theoretical astrophysics, large-scale structure, galaxy evolution)

Please see: http://www.physics.utah.edu/astronomy for more information.

Required Degree Elements

• Common Exam
• Core Courses. Currently the following are offered:
  o ASTR 5570 Galactic Astronomy and Stellar Populations (3 credit-hours)
  o ASTR 5580 Extragalactic Astronomy and Cosmology (3)
  o ASTR 5590 Stellar Astrophysics and Compact Objects (3)
  o ASTR 6410 Grad Research in Astronomy & Astrophysics (3)
  o PHYS 7110 Classical Mechanics/E&M I (4)
  o ASTR 7130 Radiative Processes (4)
  o PHYS 7220 Quantum Theory I (4)
• Graduate Lab Requirement, currently satisfied by ONE of the following courses:
  o ASTR 5015 Observational Methods and Data Analysis (3)
  o PHYS 6719 Graduate Lab (4)
  o PHYS 6770 Optical Measurement Techniques (4)
  o ASTR 7730 Statistical and Computational Astrophysics (3)
• PHYS 7800 (2 credit-hours) or 7810 (1-2 credit-hours) Colloquium Course (first 6 semesters);
• Research Preparation Course: PHYS 6790 (first year, 3 credit-hours);
• Breadth Requirement: graduate-level physics course outside area of specialization (3 credit-hours)
• Electives: Any 5000-level or above course(s) needed for specialization
• Program of Study Approval
• Qualifying Exam
• Milestone Master’s (M.S. in Physics; recommended)
• Thesis Research (14-credit hours)
• Thesis Defense

Description of Required Elements:

This program leads to a Physics Ph.D., and is identical to the standard track except for the required courses and electives as listed above. These changes in the curriculum allow you to study physics in the much broader context of astrophysical systems. To emphasize, all requirements such as the Common Exam, Qualifying Exam, are identical to those listed in Section 3.1. Please refer to the information contained therein. You still may want to consider these two items:

• Supervisory Committee. When you form your Supervisory Committee, make sure that you have one faculty member who is in the Department and NOT doing astrophysics or astronomy. For example, if you are doing work in observational astronomy, find a theorist in an area other than astrophysics.

• Preparatory courses. Some students may enter the Ph.D. program with a strong interest in astronomy, yet with no formal training. The core courses will cover the most important preparatory material but cannot cover all of the fundamentals in a semester. If you do not have much of an astronomy background, or want to familiarize yourself with the nomenclature and basic concepts, there are routes by which you can prepare yourself: (1) ask the instructors of the core courses for advice on recommended reading -- what material would they consider to be Chapter Zero; (2) arrange to audit (with the instructor's permission) undergraduate classes that interest you; and (3) ask about obtaining a teaching assistantship for an undergraduate astronomy class aimed at science students -- you know the physics better than they do and you can learn the astrophysical applications together.

Four, get involved in research -- learning the background literature for a well-defined projects and presenting results at national meetings such as the American Astronomical Society (http://www.aas.org) or the American Physical Society (http://www.aps.org) is a fun, efficient, and professional way of getting up to speed.

• Required research preparation course. As early as possible consider taking PHYS 6790, supervised research (3 credits). The goal of this course is for you to get some exposure to the variety of research in the Department, and to guide you quickly toward a doctoral thesis project. You may take this course under the supervision of one or more of the Astronomy/Astrophysics faculty.

Course Curriculum: Possible Electives

• PHYS 6720  Introduction to Computers in Physics (4 credit hours)
• PHYS 7120  E&M II (4)
• PHYS 7230  Quantum Theory II (4)
• PHYS 7310  Statistical Mechanics (4)
• PHYS 7640  Quantum Field Theory (4)
• PHYS 7740  Mathematical Methods I (4)
• PHYS 7720  General Relativity & Relativistic Astrophysics (3)

Summary of Administrative items
The list of academic and administrative benchmarks is the same as in the standard Physics Ph.D. case.

**PHYSICS PH.D. WITH ASTROPHYSICS EMPHASIS***

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<th>2011/Odd</th>
<th>Fall Semester</th>
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<td><strong>Year 1</strong></td>
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<td>ASTR 5015, Obs. Methods</td>
<td>(3)</td>
<td>ASTR 5570 Galactic Astronomy</td>
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<td>PHYS 7110, Class. Mech./E&amp;M I</td>
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<td>ASTR 6410, Grad Research class</td>
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<td>PHYS 7220, Quantum Theory I</td>
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<td>ASTR 7130, Radiative Processes</td>
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<td>PHYS 7810, Colloquium</td>
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| **Year 2** | | |
| ASTR 5590, Stellar Astrophysics | (3) | ASTR 5580, Extragalactic Astron. | (3) |
| PHYS 7810, Colloquium | (1) | ASTR 7730, Stat. & Comp. Meth. | (4) |
| *** | (5-8) | PHYS 7810, Colloquium | (1) |

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| **Year 2** | | |
| ASTR 5015, Obs. Methods | (3) | ASTR 5570 Galactic Astronomy | (3) |
| PHYS 7800, Colloquium | (2) | ASTR 7130, Radiative Processes | (4) |
| *** | (3-7) | PHYS 7810, Colloquium | (1) |

*Curriculum tracks distinguish plans for students entering on odd years (Fall 2011, 2013,...) and even years (Fall 2012...).

**Courses listed explicitly with course numbers are required/recommended for the degree emphasis. Credit hours for each course are listed in the parentheses.

***In their program of study, students may take Special Reading courses, Research credits, Electives, or a course to satisfy the Breadth Requirement. Note that a total of 9-12 credit hours in a semester is required for eligibility for Tuition Benefits for TA’s, 9-11 credit-hours for RA’s.