Department of Physics and Astronomy

Graduate Program Handbook

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University of Rochester

https://www.pas.rochester.edu/graduate/

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Contents

Overview

Our department offers Doctor of Philosophy (Ph.D.) degrees in both Physics and Physics & Astronomy. Students begin the program by completing at least eight 4-credit graduate courses in the department, maintaining a **minimum GPA of 3.0** with **no more than two courses with grades at or below B-**.

Following completion of coursework during the first two years of the Ph.D., students carry out three or more years of dissertation research. Ph.D. students in the department may work with a research advisor with a primary or a secondary appointment in Physics and Astronomy. Faculty from other departments with a joint appointment in PAS count as departmental advisors. While students may also identify thesis advisors who are neither primarily nor jointly appointed in PAS, it is then necessary to identify a co-advisor in PAS who can ensure the student is fulfilling the program's demands. Such arrangements are subject to approval by the Graduate Affairs Committee.

Students typically take an oral Qualifying Exam in Year 3 of the program, perform research and publish papers during Years 3, 4, 5, and beyond, and write and defend their dissertations during Year 5 or later.

The Ph.D. is awarded in recognition of contributions to original research of appropriate scope and depth. Satisfactory research contributions can vary significantly by subfield, with some students publishing one to two papers in large scientific collaborations during their careers, and others publishing one or more papers per year during the Ph.D.

The Ph.D. dissertation is a compilation of your original work, written to strict standards and guidelines, and defended during an oral examination in front of a committee of expert and non-expert faculty. While you may enter the program as a novice in your chosen subfield, it is our intention that you graduate as the world's expert on the subject of your dissertation.

Department Contact Information

A complete directory of department faculty, scientists, staff, and students is available online at https://www.pas.rochester.edu/. The department's mailing address is

Department of Physics and Astronomy
University of Rochester
206 Bausch and Lomb Hall
P.O. Box 270171
Rochester, NY 14627-0171

The department main office phone number is

(585) 275-4344

Department personnel and committee assignments relevant to the graduate program are listed below.

Department Administration, 2024-2025	
Steven Manly	Department Chair
Aran Garcia-Bellido	Department Associate Chair

Administrative Staff, 2024-2025	
Linda Case	Graduate Program Coordinator
Bill Burrows	Financial Manager
Christine Confer	Office Assistant
Connie Hendricks	Senior Accountant
Connie Jones	Administrative Assistant
Jeffrey W. Jones	POA Library Section Supervisor
Carol E. Latta	Tours Director, Mees Observatory
Benjamin R. Mitchell	POA Librarian
Jenni Oliver	Grant & Data Manager
Pamela Schenk	Office Manager
Laura Scuderi	Administrator
Lysa Wade	Undergraduate Program Coordinator

Technical Staff, 2024-2025	
Myron Culver	Senior Lab Engineer, Building Manager
Tanner Degenkolb	Senior Analyst/Programmer
Tony DiMino	Lab Technician
Kurt Holmes	Superintendant, Mees Observatory
Sergey Korjenevski	Research Engineer
Baowei Liu	Computational Scientist, Astron. & Astrophys.
Joseph Madathil	Senior Lab Engineer

Brian L. McIntyre	Technical Mgr., URNANO
Craig McMurtry	Senior Research Engineer
Jim Saporito	Lab Engineer

Graduate Affairs Committee, 2024-2025	
Segev BenZvi	Chair, Director of Graduate Studies
Alice Quillen	2024 Cohort Advisor
John Nichol	2024 Cohort Advisor
Pierre Gourdain	2023 Cohort Advisor
Aran Garcia-Bellido	2023 Cohort Advisor
Steve Teitel	2022 Cohort Advisor
Chaitanya Murthy	
Gabrial Landi	

Graduate Admissions, 2024-2025	
Machiel Blok	Co-Chair; Faculty, PAS
Chris Marshall	Co-Chair; Faculty, PAS
Gabriel Landi	Faculty, PAS
Gourab Ghoshal	Faculty, PAS
John Nichol	Faculty, PAS
Petros Tzeferacos	Faculty, PAS
Antonino Di Piazza	Faculty, PAS
Dominique Segura-Cox	Faculty, PAS
Chaitanya Murthy	Faculty, PAS

PASSAGE: Physics and Astronomical Sciences Student Association for Graduate Engagement

PASSAGE is a student-led organization whose purpose is to promote fellowship and interdepartmental community, facilitate mentorship between physics and astronomy graduate students, and provide opportunities for outreach to the greater Rochester community.

Further information is available at https://www.pas.rochester.edu/~passage/.

PASSAGE Leadership, 2024-2025	
Nitya Ravi	President
Mary McMullan	VP of Outreach
Jessica Jenick	VP of Mentorship
Joel Elias	VP of Fellowship
Trevor Ollis	Secretary
Bobbie Markwick	Treasurer
Abhaya Hegde	Webmaster

Path to the Ph.D.

The path to your Ph.D. proceeds in several stages, starting with coursework and including a teaching component that is part of your professional training.

During your first year, you will talk to potential advisors and set up a research assistantship for the summer after your first year of coursework. At the end of the summer of Year 1, you will be evaluated in a Preliminary Assessment to determine your satisfactory completion of basic coursework, teaching requirements, and successful summer research performance.

All students are required to find a summer research position before the end of the spring semester of Year 1. Note that accepting a summer research appointment does not commit you to continue with the group after Year 1.

You then choose a research field and an advisor and after one year as a research assistant, you complete a Qualifying Exam to demonstrate your readiness to perform independent research. During the second half of your Ph.D., you will perform research and publish results, write up your research in a dissertation, and defend the dissertation in a public talk and a closed oral examination with a Dissertation Committee.

Thesis Advisors

Ph.D. students in the department may pick a research advisor with a primary or a joint appointment in Physics and Astronomy. A list of Physics & Astronomy advisors, including faculty with primary or joint appointments in PAS, is provided on page 35.

Faculty from other departments with a joint appointment in PAS count as a departmental advisor.

Students may also identify thesis advisors who are neither primarily nor jointly appointed in PAS. In this case, it is necessary to identify a **co-advisor in PAS** who can ensure the student is fulfilling the program's demands, subject to approval by the Graduate Affairs Committee and the Graduate Program Coordinator.

Milestones for the Ph.D. program are summarized below. A reasonable expectation for the time commitment needed to complete the Ph.D. is six years, with the first 1.5 years spent in coursework, 3.5 years spent in research, and 1 additional year to complete the research and dissertation.

Expected time in the Ph.D. program: Six years. Individual time-to-degree will vary.

Milestones: Year 1

The Year 1 milestones include:

- Completion of the four core courses.
- Completion of two specialized elective courses.
- Attendance at weekly research seminars and department colloquia.
- Two semesters of teaching as a Teaching Assistant (TA).
- Identification of a research advisor and completion of three months of independent summer research.
- Completion of your **Preliminary Assessment** through satisfactory performance in coursework and independent research.

Note: The deadline to inform the Graduate Program Coordinator of your summer research position is **April 15.**

Milestones: Year 2

The Year 2 milestones include:

- Completion of two additional specialized advanced courses.
- Conferral of the M.A. in Physics.
- Attendance at weekly research seminars and department colloquia.
- Continuation of independent research.

Milestones: Year 3

The Year 3 milestones include:

- Presentation of a written 10-page research brief, typically based on your first full year of research, followed by a successful oral defense of the work (**Qualifying Exam**).
- Continuation of independent research.
- Presentation of a **research progress report** to your Qualifying Exam Committee and the Graduate Program Coordinator.

Note: The Qualifying Brief may also focus on a literature review or other topic if this is more appropriate to your circumstances.

Members of your Qualifying Exam Committee will likely stay on as part of your Dissertation Advisory Committee.

Milestones: Years 4, 5, and Beyond

The milestones for Year 4 and after include:

- Continuation of independent research, with publications of papers and conference proceedings.
- Annual presentation of a **research progress report** to your Dissertation Advisory Committee and the Graduate Program Coordinator.
- Completion of independent research for your thesis/dissertation.
- Completion of the written dissertation.

- Successful **defense of the dissertation** in a one-hour public presentation and a closed private defense with your Dissertation Committee.
- Revision of your thesis and final submission.

Coursework

Graduate Course Requirements

Student must complete at least eight advanced 4 credit-hour courses (numbered PHYS 400-589) in the department. The courses cannot be research or reading courses, and at least two of the eight must be considered an advanced sequence. Specialty courses are two-term advanced level sequences in specific fields of modern physics numbered PHYS 4(5)x1 and 4(5)x2, and several independent one-term courses and two-term course sequences in astrophysics numbered ASTR 4(5)x1 and 4(5)x2.

Core Courses

The program contains four required **core courses**:

Core courses are offered every year. PHYS 407 and 415 are offered in the fall and 403 and 418 in the spring.

1. PHYS 407: *Quantum Mechanics I*
2. PHYS 415: *Electromagnetic Theory I*
3. PHYS 403: *Modern Statistics and the Exploration of Large Data Sets*
4. PHYS 418: *Statistical Mechanics I*

At the end of their first year, students are required to complete a **Preliminary Assessment** based on performance in the four required core courses. The assessment is described elsewhere in this handbook, but in brief, students must display satisfactory performance in the core courses (to a standard deemed passable by the individual faculty teaching those courses) and in their summer research after the first year of study.

Placing Out of Core Courses

The Department will accept up to 14 graduate transfer credits from other programs. Graduate courses applied to an undergraduate degree program may not be transferred. Transfer students or new Ph.D. students who have taken graduate-level courses equivalent to the

Example: Students who have taken graduate-level E&M using Jackson's textbook.

core courses may be excused from taking them in the department if they can pass a short placement exam. The exam typically consists of a selection of problems from recent offerings of the core courses and/or final exams, and may include an oral component supervised by the most recent course instructor.

Students who wish to place out of a course by taking the exam must contact the Graduate Program Coordinator during their first week in the program. The decision to offer the exam will be made by the Graduate Affairs Committee, in consultation with members of the Preliminary Assessment Committee and the most recent instructor(s) of the relevant core course(s).

Specialty Courses and Advanced Sequences

Students normally complete the sequence in their chosen **specialty sequence** within the first two to four years of their graduate studies. An example course sequence suitable for specialization in theoretical quantum optics is shown in Table 3. The specialty and advanced courses are PHYS 434: *Quantum & Nano-Optics Lab* and PHYS 408: *Quantum Mechanics II* taken in Year 1, and PHYS 531 and 532 (*Quantum Optics I and II*) in Year 2.

Advanced sequences may be offered yearly or during alternating years, depending on demand.

	Fall	*Spring*
Year 1	**PHYS 407**: Quantum Mechanics I	**PHYS 403**: Probability & Data Analysis
	PHYS 415: Electricity & Magnetism I	**PHYS 418**: Statistical Mechanics
	PHYS 597: Research Seminar	**PHYS 597**: Research Seminar
	PHYS 434: Quantum Mechanics Lab	**PHYS 408**: Quantum Mechanics II
Year 2	**PHYS 531**: Quantum Optics I	**PHYS 532**: Quantum Optics II
	Elective	Elective
	PHYS 595: Ph.D. Research	**PHYS 595**: Ph.D. Research

Table 3: Physics sequence.

An example sequence appropriate for specialization in astronomy and astrophysics is shown in Table 4, with ASTR 461 and 462 (*The Physics of Astrophysics I and II*) taken in Year 1 and *Cosmology* (ASTR 554) and *High-Energy Astrophysics* (ASTR 564) completing the advanced sequence in Year 2.

Depending on your specialty, it may be preferable or necessary to complete the advanced sequence with 400-level PHYS and ASTR courses; for example, if 500-level courses are not available for a particular specialty, or are not being taught in a given year. In such cases, contact the Graduate Program Coordinator to ensure that your proposed coursework fulfills the advanced sequence requirement.

	Fall	*Spring*
Year 1	**PHYS 407**: Quantum Mechanics I	**PHYS 403**: Probability & Data Analysis
	PHYS 415: Electricity & Magnetism I	**PHYS 418**: Statistical Mechanics
	PHYS 597: Research Seminar	**PHYS 597**: Research Seminar
	ASTR 461: Physics of Astrophysics I	**ASTR 462**: Physics of Astrophysics II
Year 2	**ASTR 554**: Cosmology	**ASTR 564**: High-Energy Astrophysics
	Elective	Elective
	PHYS 595: Ph.D. Research	**PHYS 595**: Ph.D. Research

Table 4: Astronomy sequence.

Supplementary Courses for Post-Baccalaureate Students

The department will admit promising students with atypical educational and research backgrounds into the Ph.D. program. This might include promising students who switched to physics or astronomy late in their undergraduate careers, or students who have applied to the program through the American Physical Society (APS) Bridge Program.

For such individuals, the recommended **baseline Year-1 course requirements** include a mixture of upper-level undergraduate and first-year graduate courses in physics (Table 5).

Fall	*Spring*
PHYS 217: Electricity & Magnetism I	**PHYS 218**: Electricity & Magnetism II
PHYS 235: Classical Mechanics	**PHYS 237**: Quantum Mechanics
PHYS 401 (Math Methods) or PAS Elective	**PHYS 403** (Data Analysis) or PAS Elective, e.g., **PHYS 227** (Statistical Mechanics)

Table 5: Postbaccalaureate baseline coursework.

The baseline supplementary program can be customized for students who demonstrate satisfactory proficiency in some or all of the undergraduate classical mechanics, quantum mechanics, and E&M courses. To place out of the undergraduate courses, post-baccalaureate and APS Bridge students may take an exam drawn from a recent comprehensive final exam offered in the advanced undergraduate courses. The decision to offer the exam will be made by the Graduate Affairs Committee, in consultation with members of the Preliminary Assessment Committee and the most recent instructor(s) of the relevant course(s).

Students taking supplementary upper-level undergraduate courses will perform as **Teaching Assistants** during Year 1. As described in the following chapter on teaching, TA work fulfills a requirement from AS&E. It is also a crucial part of every student's professional development and enhances their understanding of the subject.

Auditing Courses

Under limited circumstances, you may find it beneficial to participate in coursework outside your official program of study. You are allowed to audit a course with the permission of the faculty instructor.

A detailed description of the graduate course audit policy is provided in the Graduate Handbook maintained by UR GEPA.

Auditing of courses is permitted for all AS&E students with full-time and part-time status. However, due to teh instructional and administrative burden associated with students auditing a course, it carries a fee not covered by your graduate tuition waiver. Under special circumstances, an Audit Fee Waiver Request may be submitted to the Dean of Graduate Education and Postdoctoral Affairs.

General Registration Information

Nine (9) credits is considered full-time for graduate students in AS&E. Students should not register for more than 9 credits unless they are taking 3 courses (meaning no research credits).

Students doing full-time research should register for a PHYS 595 under their advisor's name. When students begin preparing their dissertations, they will register for PHYS 999 (see details below). If you are a full-time researcher but you are not registered for a PHYS 595 or a PHYS 999 course, please contact the Graduate Program Coordinator.

Graduate students register for courses using URStudent.

Please send questions about upper-level sequence requirements or exceptions due to course availability to the Graduate Coordinator. Instructions for registering in URStudent are available at

`https://www.rochester.edu/urstudent/project/student/graduate-registration/`

Year 1 Students

First-year students will enroll in the four core courses:

1. PHYS 407: *Quantum Mechanics I*
2. PHYS 415: *Electromagnetic Theory I*
3. PHYS 403: *Modern Statistics and the Exploration of Large Data Sets*
4. PHYS 418: *Statistical Mechanics I*

All first-year students register for PHYS 597 - *Graduate Research Seminar*. In addition, teaching assistants must register for PHYS 498 (Fall) or PHYS 499 (Spring) to denote their TA role.

Beyond the core courses and PHYS 597, first-year students enroll in two elective courses. You will choose the electives after meeting with your assigned cohort advisor.

Year 2 Students

Second-year students should register for their final two courses during their second year of study. (Note: you are allowed to take additional courses in later years if desired.) These courses should be chosen based on recommendations from your research advisor. Ideally, these courses will satisfy the upper-level sequence requirement.

Additionally, students should register for PHYS 595 Research credits to ensure that they are registered for a total of 9 credits to be full-time. Be sure to register for the PHYS 595 section with your advisor as instructor.

I.e. if you register for a 4-credit course, you will register for 5 credits of PHYS 595 for a total registration of 9 credits.

In Absentia Students

If you are conducting your research in a location other than Rochester, you must be approved for study In Absentia. You are not able to register for In Absentia online. You should work with the Graduate Coordinator to complete the application and the manual drop/add form required.

Further details are provided on page 32 of this Handbook.

International In Absentia students require an additional no-credit registration in EDAB 001 (Education Abroad) under the country of their mailing address. This will be done on the drop/add form in consultation with the Graduate Coordinator.

Year 3 and 4 Students

If all coursework is complete (8 courses, including the upper-level sequence requirement), then third-year students should register for 9 credits of PHYS 595 research credits with their advisor as the instructor.

You may continue to register for coursework if you so choose and if your research responsibilities allow, until you reach 90 credits. If you register for courses, you need to adjust your PHYS 595 research credits so that you are not registered for more than 9 credits total per semester. No more than 14 credist outside of PHYS or ASTR courses may count toward your overall program credits.

If in any semester before your fifth year, you will reach 90 credits with a PHYS 595 registration of less than 9 credits, you must also register for PHYS 997 for that semester.

Students in Year 5 and Beyond

Once you have reached 90 credits, you must register for the PHYS 999 dissertation course with your advisor as the instructor. PHYS 999 carries no credits but will provide full-time status.

If in any semester during your fifth year or beyond you will reach 90 credits with a PHYS 595 registration of less than 9 credits, you must also register for PHYS 999 for that semester.

Teaching

Teaching During the Academic Year

Teaching is an important part of professional development during the Ph.D. program. Students are required to serve at least one year as a Teaching Assistant (TA), usually performed during Year 1. The basic duties of a TA include:

- Running workshop, recitation, or laboratory sessions.
- Offering office hours for consultation with students.
- Grading homework and examinations.

Faculty teaching supervisors may also ask TAs to assist in curriculum development. First-time TAs must also participate in the TA training program.

Both teaching and research assistants are expected to be present for duties during the entire period of their appointment, even when classes are not in session. Students who are registered for 12 credit-hours of non-research courses are expected to work an average of 16 hours a week on their teaching or research responsibilities.

TA time commitment during the academic year: **16 hours per week**.

Whether in TA or RA appointments, students are entitled to vacation time, typically taking four weeks per calendar year (including holidays). Vacations should be discussed with the research and/or TA supervisor.

Teaching During the Summer

It is expected that at most a handful of graduate students in PAS will TA during the summer. The department offers introductory undergraduate courses such as PHYS 113/114 and PHYS 121/122 in two sessions (Session A and B) during June-July and July-August every summer. Each session lasts six weeks.

More senior Ph.D. students may teach during the summer session to participate in the department's **Certificate of College Teaching in Physics and Astronomy**. Under limited circumstances, such as the

The Teaching Certification is not open to first-year Ph.D. students.

inability to find a funded RA position in a research group, graduate students may also request to teach during Sessions A or B.

Unlike the TA position during the academic year, teaching during summer Sessions A and B is a full-time position where the student shoulders all responsibility for the course.

TA time commitment during summer: **40 hours per week**.

Certificate in College Teaching in Physics and Astronomy

The Department offers a special program for graduate students designed to give them experience in teaching at the college level. This program is intended for students who wish to develop their teaching skills as a part of their professional growth and who are committed to improving the learning experience of our undergraduate students.

Up to six students are selected for the program each year. The centerpiece of the program is the student teaching on his/her own during the University's summer session.

Students successfully completing the program are awarded a Certificate of College Teaching in Physics and Astronomy, to be presented during the graduation ceremony in May.

The requirements for the certificate are:

1. Service as a TA for at least two semesters, with above-average performance, as determined by feedback from the course instructors and information from mid-semester TA evaluations.

2. Preparation of a teaching portfolio during the teaching of a summer course, or during a preceding semester. The teaching portfolio should be prepared under the mentorship of a faculty member. The teaching portfolio should include:

   - A complete syllabus for the summer course stating what will be covered during each lecture. The course schedule should include the schedule of labs.
   - A complete set of homework assignments and solutions.
   - A complete set of exams that will be given during the course.
   - A course information sheet listing course policies, grading scheme, office hours etc.
   - Copies of undergraduate student comments and evaluations from the two semesters the graduate student served as a TA.

Since the summer course covers a whole semester in a 6 week period, this should be done by consultation with instructors who have taught courses in previous summers.

3. During the summer course, evaluations of the instructor and of the course will be obtained by:

   - Standard mid-semester TA evaluations will be used for the course instructors at the end of the summer semester.

- The Small Group Instructional Diagnostic procedure will be used in the middle of the semester. One or two instructors of the summer courses will rotate through the courses and evaluate each other's courses.

4. After completing the summer course, each graduate instructor will be asked to prepare a one-hour presentation on a topic related to the teaching of physics for PHYS 597: *Graduate Research and Teaching Seminar*.

The teaching topic must be approved by the TA training committee.

Preliminary Assessment and Qualifying Examinations

The Preliminary Assessment

The **Preliminary Assessment** is based on the performance in the four required core courses (PHYS 403, 407, 415, and 418). The Preliminary Assessment is completed by the Preliminary Assessment Committee. Nominally, the minimum passing requirements are a **cumulative GPA of 3.0** with **no more than two B- grades**. Note that this exceeds the AS&E minimum grade for passing a graduate course, which is a C. By AS&E policy, a student who receives a C in one or more courses will be automatically placed on academic probation.

First-year students also enroll in two elective courses; see your assigned cohort advisor for elective suggestions.

The AS&E Academic Probation Policy can be found in the UR GEPA Graduate Handbook.

To continue in the Ph.D. program one must pass the assessment at the Ph.D. level. The committee can decide to pass a student, or it can require that the student repeat poorly performed parts of the assessment. If a student shows specific weaknesses, the committee may choose to pass the student contingent on remedying the deficiency with additional coursework.

Student are allowed two attempts to pass the Preliminary Assessment.

Advanced transfer students who have passed similar assessments at another graduate school may be excused from taking it in the department. This decision will be made by the Graduate Affairs Committee, in consultation with members of the Preliminary Assessment Committee, and the Department Chair.

Master of Arts in Physics

While we do not offer a stand-alone Master's degree program, students typically earn the Master of Arts in Physics after their second year of study. The M.A. requires that the Preliminary Assessment has been successfully completed and the eight-course requirement has been met (32 credits). No research or reading credits are permitted to count toward the Master's degree. Those students wishing to change their degree program from Physics to Physics and Astronomy may do so after the Masters degree has been conferred.

The Qualifying Exam

Students must pass the **Qualifying Examination** to continue for the doctoral degree. The exam is taken once the student has chosen a thesis advisor and an area of research, and is usually scheduled within two years of passing the Preliminary Assessment. AS&E rules state that the exam must be taken **before the end of Year 4** of your Ph.D. Once you have passed the Qualifying Exam, you will be considered advanced to candidacy.

The purpose of the Qualifying Exam is to demonstrate that you are ready to proceed with independent research, but the Qualifying Exam in PAS is not considered a thesis proposal. While the subject of your thesis will likely resemble your qualifying brief, there is no penalty if your final dissertation deviates substantially from the brief. Whether or not the brief from your Qualifying Exam become part of your dissertation is up to you and your advisor, in consultation with your Dissertation Advisory Committee.

The exam will rigorously test the depth and breadth of your knowledge about the topic in your brief, as well as any and all physics relevant to the topic. The exam committee will assess both your **technical development** and your understanding of the **broader context** of the topic in your brief. Effective preparation for the exam includes:

Expect to budget a minimum of 6 weeks to prepare for the Qualifying Exam.

- Writing of the brief in consultation with your advisor and mentors, with multiple rounds of editing and refinement.
- Development of your oral presentation in consultation with your advisor and mentors.
- A deep dive into the literature on your topic.

Preparing for the Qualifying Exam

To take the Qualifying Exam, each student must find a faculty sponsor. The sponsor is usually the student's thesis advisor but is not required to be. As soon as possible, but ideally, no later than one year after obtaining a Ph.D. advisor, students should form a Dissertation Advisory Committee (DAC), which will serve as the Qualifying Exam Committee, and set a date or a range of dates for the Qualifying Exam.

Students are expected to finish their Qualifying Exam during Year 3 in the Ph.D. program, or no later than one year after obtaining an advisor if they did not begin full-time research in Year 2.

After the DAC is formed, students must **submit a short, informal written statement to the graduate coordinator** summarizing their work in the previous term after every semester. The coordinator then disseminates the statements to the advisor and members of the DAC.

Structure of the Qualifying Exam

The sponsor and student will agree on a research or review topic in which the student will prepare an **oral presentation**, no more than **25 minutes in length**, and an accompanying **written brief** of no more than **10 journal-style pages**. The presentation and brief may demonstrate progress toward original research and/or knowledge of the subfield of specialization. The Qualifying Exam is closed, to be attended only by the student and their committee.

If a student has published, submitted, or drafted a paper for a research journal based on this research, that document or a subset of it can be used as the exam brief, provided that the advisor deems the document to be reasonably accessible to the broader audience of the Qualifying Exam committee.

The chosen topic and copies of the brief must be distributed to the Qualifying Examination Committee members at least two weeks prior to the exam.

The committee for the Qualifying Examination will consist of at least four faculty members, including:

1. The student's thesis advisor or sponsor. The advisor fills only that role on the committee.
2. A faculty member in the same research area.
3. One theorist for a student working in experimental physics, or one experimentalist for a student working in theoretical physics.
4. One faculty member outside of the research area.

At least two faculty members on the committee must have primary appointments in physics and astronomy. One of the members may be from outside of the department, if appropriate.

Scheduling the Qualifying Exam

Each student should schedule the Qualifying Exam, in consultation with the exam committee members and the Graduate Program Coordinator, and make all final arrangements **at least two weeks before the exam**. The graduate student reaches directly out to the committee members after being given permission to proceed from their advisor to arrange for the exact date and time of the Qualifying Exam.

The student must email the Graduate Program Coordinator **at least three weeks before the exam** is to be held with the date, time and list of committee members, and the Graduate Program Coordinator will arrange for appropriate space for the exam.

It is due to the GEPA approval process that we require two weeks of advance notice. The other main reason for two weeks' notice is that the brief must be written and sent to the committee with at least two weeks' notice so that your faculty committee is given sufficient time to review the brief and prepare for the exam.

The student then completes the exam appointment form, obtaining approval from the your advisor, and submits the form to the Graduate Program Coordinator. The Graduate Program Coordinator will then submit the form to the Director of Graduate Studies, and finally, submit the form to the AS&E GEPA office for recording. The final approved form must be recorded at least two weeks before the exam.

What to Expect During and After the Qualifying Exam

At the start of the exam, the committee members may ask the student to step out of the room while they briefly review the student's academic progress toward the degree. The advisor conveys any necessary annotations, and the committee organizes its questioning procedure. The student will then be called in for their presentation. Following the presentation, the committee members will ask questions for 10 to 15 minutes per person. Although the questions typically focus on the subject of the student's brief, in principle any question on relevant physics is considered reasonable.

After the examination, the Exam Committee files a written report. Typically, the members of the Qualifying Examination Committee will continue to serve as a Dissertation Advisory Committee for the student and meet about once a year. These regular meetings may be waived only by permission of the chair of the Graduate Affairs Committee.

The Dissertation Advisory Committee can be called into special session at any time by any of the following parties: the student, the thesis advisor (and/or internal advisor), or the Graduate Affairs Committee.

Qualifying Exam Checklist

At least 3 months before the Qualifying Exam:

- ☐ Choose your exam sponsor, usually your research advisor.

Note: the exam sponsor is not required to be your research advisor.

- ☐ Decide on the research topic for the exam with the guidance of your sponsor/advisor.
- ☐ Create your Qualifying Exam Committee. Comments:
  - The committee will become your Dissertation Advisory Committee through your defense, and will likely comprise the majority of your Defense Committee.
  - The committee must include four faculty members:
    1. Your advisor or sponsor.
    2. A faculty member in the same research area.
    3. A theorist (for students working in experimental physics) or an experimentalist (for students working in theoretical physics).
    4. A faculty member outside your research area.

Note that at least two committee members must have primary appointments in PAS. One committee member may be from outside the department, if appropriate.

At least 6 weeks before the Qualifying Exam:

- ☐ Set a date and time that is mutually agreed upon by all committee members.

Warning: this is often a time-consuming step; do not postpone it!

- ☐ Contact the Graduate Program Coordinator (GPC) to book an appropriate space for the exam.
- ☐ Create a Zoom booking for the exam if needed.

At least 4 weeks prior to the Qualifying Exam:

- ☐ In consultation with your advisor/sponsor, prepare a written brief of no more than 10 journal-style pages. Comments:
  - A published, submitted, or drafted paper (or subset) may be used as the exam brief if the advisor assesses it is appropriate for the broader audience in the Qualifying Exam Committee.
  - If desired, make an appointment at the U of R Writing Center for help in preparing your draft.

Three weeks prior to the Qualifying Exam:

- ☐ Fill out a Qualifying Exam Appointment Form.

To obtain the form, contact the PAS Graduate Program Coordinator.

- ☐ Have your advisor/sponsor sign the form.

☐ Return the Qualifying Exam Appointment Form to the Graduate Program Coordinator, who will submit it to the Director of Graduate Studies for approval.

The form must be submitted to the Registrar 2 weeks before the exam, so we build in a week of lead time.

Two weeks prior to the Qualifying Exam

☐ Submit your 10-page brief to the Qualifying Exam Committee and PAS Graduate Program Coordinator.

☐ Prepare an oral presentation of no more than 25 minutes in length.

On the exam date:
Pick up and bring the following papers from the Graduate Program Coordinator and bring them to the exam:

☐ A copy of your unofficial transcript.

☐ A copy of the Qualifying Exam Report. Comments:

- All committee members must sign the form after the exam, indicating approval (Pass or Fail).
- Remote committee members must email the Graduate Program Coordinator indicating Pass (or Fail) in lieu of a signature.

Post-exam:

☐ A faculty member must return the signed Qualifying Exam Report Form to the Graduate Program Coordinator for submission to the Registrar.

Ph.D. Research

Step 1: Starting Your Research Program

As soon as possible, graduate students should become familiar with the research programs available in the department, choose a field of specialization, and ask a faculty member to serve as thesis advisor and principal Ph.D. supervisor. It is each student's own responsibility to find a thesis advisor.

Usually, one's advisor will provide financial support in the form of a research assistant (RA) position through an appropriate research grant. There is no formal assignment process for joining a research group. Once a student has an understanding with a research advisor to join the group, they must notify the **Graduate Program Coordinator**, who will arrange for the student to be paid from the appropriate grant.

The graduate coordinator will set up payment of the student's salary, benefits, and tuition from the appropriate account(s) obtained from form 506.

As stated previously, it is possible to pursue your thesis in a research group outside the department. If you choose to work with a thesis advisor who does not hold a full-time appointment at the University or a joint appointment in this department, you must also find a member of our department faculty who is willing to act as the internal advisor for your thesis. The Graduate Program Coordinator must be apprised of your proposed arrangement and will submit hte proposal to the Graduate Affairs Committee for approval.

Step 2: Conducting Research

The Ph.D. allows you progressively more independence as you move through the program. A vital part of your Ph.D. is obtaining the tailored mentoring required to become an independent and productive researcher. Mentorship includes learning new concepts and skills, being exposed to resources and professional opportunities, asking for and receiving advice, obtaining regular feedback (including papers, proposals, and talks) and developing the "soft skills" required to succeed in future work.

Be aware that progress in research can proceed in fits and starts.

The Ph.D. is a marathon, not a sprint.

It is not uncommon for students to go long stretches with no publications, and then to produce a burst of papers near the end of their Ph.D. as their research program coheres.

As you progress through the Ph.D., you will take on some of the support and mentoring responsibilities that were given to you early in the program. Working well with others and learning how to thoughtfully review their work (including the work of your advisor) is a key part of your training.

Your responsibilities in Ph.D. research include clear communications about timelines, your level of effort, research expectations, and the amount of work and vacation time during the year. You are expected to meet deadlines, make safe and ethical use of resources, abide by professional standards, and abide by safety standards. A critical part of research conduct is maintaining good records of your work to allow for replication of results.

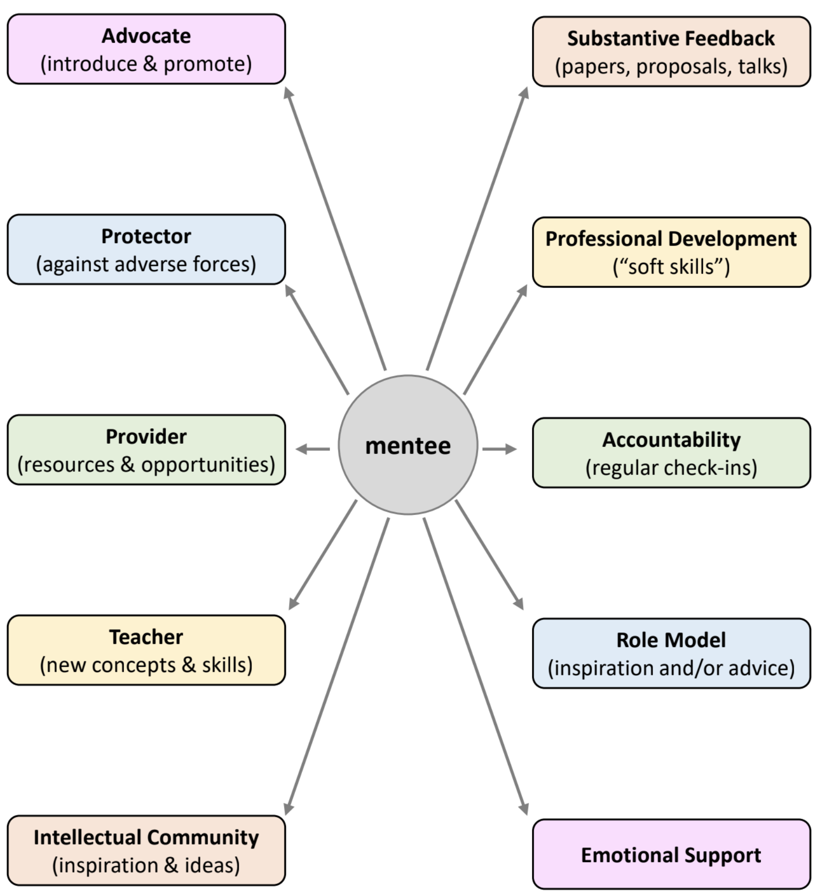

Figure 1: Graduate mentorship map, from Jennifer Hoffman, Department of Physics, Harvard University.

A successful Ph.D. requires that you **draw upon a number of resources beyond your advisor** (see Fig. 1). Your mentors may include your peers, more advanced Ph.D. students in your research group, postdoctoral researchers, scientific and technical staff at your institution, and collaborators external to the University.

You must also **embed yourself in the intellectual community of your subfield**. Attend journal clubs and seminars, keep up-to-date with the literature, and when you are ready, attend professional workshops and conferences.

Seminars and colloquia are listed in the PAS Calendar.

Finally, be aware of the networks designed to **protect you from adverse forces** and provide **emotional support** as you progress through the program. In the department, support networks include peer and cohort faculty advisors, peer groups such as PASSAGE, the Graduate Program Coordinator, the Director of Graduate Studies, and the Department Chair. University support includes the CARE Network, as well as AS&E Ombudspeople and the Title IX Office.

Step 3: Preparing the Dissertation

All Ph.D. students are required to prepare a written dissertation and defend it during an oral examination. The dissertation must conform to the format specified by the AS&E document *Preparing Your Thesis: A Manual for Graduate Students*:

`http://www.sas.rochester.edu/eng/assets/pdf/ThesesManual%202014.pdf`

The rules for the Ph.D. defense are given in the *Official Bulletin on Graduate Studies* (current version: 2018-2022):

`https://www.rochester.edu/graduate-education/wp-content/uploads/2022/08/University-of-Rochester-Graduate-Bulletin-2018-2022.pdf`

Since the *Bulletin* is quite long, the Dean of Graduate Studies has also provided a very helpful *Guide for Graduate Students Preparing for Ph.D. Defense*:

`http://www.rochester.edu/college/gradstudies/academics/phd-defense.html`

When your dissertation is complete and approved by all members of your Thesis Defense Committee, it may be registered with the Dean of Graduate Studies through the Graduate Program Coordinator. Your dissertation defense must be officially scheduled **no later than 15 business days** before the agreed-upon date of the defense.

Step 4: The Ph.D. Defense

The purpose of the thesis defense is to demonstrate the significance of the dissertation and the adequacy of the arguments presented in support of the thesis. The examination is carried out by a Thesis Defense Committee consisting of your thesis advisor, at least two other full-time faculty members in PAS, and at least one faculty member from another department. A separate defense chair, also from another department, oversees and manages the exam. The defense chair can, but is not expected to, participate in the questioning. The student and thesis advisor suggest committee members and choose a committee chair. The student and the Graduate Program Coordinator then register the defense.

Please notify the graduate office (grad@pas.rochester.edu) of your intention to complete a thesis and set a defense date.

Typically, the members of the committee also served on the student's Qualifying Exam and Dissertation Advisory Committee.

In advance of the registration of a thesis, students and advisors should plan on **at least 10 additional working days** for each committee member to review the thesis document and sign off on the work. Students can send copies of their thesis to the committee electronically, as long as they provide bound paper copies to those who request them.

The final pre-defense thesis must be submitted to the Sharepoint system at least **25 business days** before the defense date. It is good practice to plan on submitting your thesis a minimum of 6 weeks prior to the defense.

Structure of the Ph.D. Defense

Each defense consists of a public one-hour lecture by the candidate, followed by a closed-session oral examination of the candidate's thesis. The examination includes the subject matter of the dissertation and developments in the specialty area in which the dissertation is written. After questioning, the candidate is briefly excused from the room while the Thesis Defense Committee votes on the results. The vote to pass the defense must be unanimous.

After your defense, the University Deans' Office will send you an email with instructions for electronic submission of the final corrected dissertation and abstract to ProQuest, along with additional instructions for degree completion.

Note that the University has five Ph.D. degree cycle deadlines per year. Each cycle has a final deadline to submit the final version of the thesis to ProQuest. **There are no exceptions to the deadlines.** If a deadline is missed, your name cannot be approved by the Council on Graduate Education and presented to the Board of Trustees until the subsequent degree conferral date.

Dissertation Checklist

Six months prior to the expected defense date:

☐ Consult with your Research Advisor and confirm that your thesis will be ready in the allotted time.

☐ Form your final Dissertation Defense Committee and submit the **list of committee members** to the Graduate Program Coordinator (GPC) and Director of Graduate Studies (DGS), together with the **anticipated semester of completion**. The committee must include:

- Your advisor.
- Two PAS faculty members (at least one must be outside your subfield).
- One faculty member with a primary appointment outside PAS.
- A committee chair.

The chair must be outside your subfield and have a primary appointment outside of PAS. They may have a secondary appointment in PAS.

☐ Begin preparing your 1-hour public lecture presentation.

Four months prior to the expected defense date:

☐ Contact your Dissertation Committee and confirm that all members will be available for your proposed defense date and time. Comments:

Include the GPC and your advisor on all communications.

- Plan on a two-hour window: one hour for the presentation and one for the closed exam.
- Avoid university holidays and other blackout dates. See the Graduate Academic Calendar for specific dates and deadlines for your defense timeframe.
- Remote defenses are permitted, but if there is an in-person component to the defense it must occur on University of Rochester property.
- A hybrid defense is permitted provided that the student, advisor, and committee chair all participate in person in the same university space. Other committee members may join remotely.
- The GPC will find you an appropriate space, with the exception of those planning to use the LLE Coliseum.

☐ Create an ORCID number if you do not already have one. This will be needed to create your dissertation record in Sharepoint, the system that tracks the approval process leading up to the defense.

☐ Once you have your defense date, time, and location, fill out the Defense Application and return it to the Graduate Program Coordinator. The Graduate Program Coordinator will create your record in Sharepoint. A six-week window is required between submission of the pre-defense thesis to the committee and the defense date.

Six weeks prior to the expected defense date:

- ☐ Submit your final pre-defense thesis to your dissertation committee by email using an email attachment. Include a reminder of the date and time of your thesis in the email.
- ☐ Send an email to the Graduate Program Coordinator with your dissertation (or copy them on the previous email). They will help you manage the thesis upload to Sharepoint and start the approval timeline.

Please note that no changes can be made to the dissertation once it has been sent to the committee.

The day of the defense: Make sure one of the following steps is completed. Either:

- ☐ Print the Defense Report Form and have all committee members sign the form after your defense.
- ☐ Return the form to the Graduate Program Coordinator.

or:

- ☐ Ask the Dissertation Committee Chair to email the University Graduate Education Administrator, with all committee members in CC, to report the results of the defense.

This option would be appropriate for a remote defense.

Post-defense:

- ☐ Follow all post-defense instructions sent by the Sharepoint system.
- ☐ Please email the Graduate Program Coordinator to inform them of your post-graduation plans for our alumni pages.

Sharepoint will include instructions on uploading your final revised thesis to ProQuest and completing the University exit survey.

Research Outside the University

During your Ph.D., you may find it beneficial (or necessary) to conduct research for a period of time at another university or research organization, such as a national lab. In limited cases, some students may pursue paid off-campus employment in a practical internship. Here we detail the department and university policies for off-campus work.

Study in Absentia

Students working for one or more semesters in a research environment at another university, or at a facility such as Fermilab, CERN, LLNL, etc., will need to submit a request for study in absentia prior to beginning the research. To apply for in absentia status, students must fill out a Request for In Absentia Form.

https://www.rochester.edu/asei/get_file.php?id=489

If you are approved for in absentia status, you will need to register for one of two courses:

1. PHYS 595(A/B), if you have accumulated less than 90 credit hours.
2. PHYS 999(A/B), if you have accumulated over 90 credit hours.

A=in absentia status inside the U.S., B=in absentia status outside the U.S.

Graduate Practical Research Internship

While the Ph.D. is an academic and not a professional degree, in limited cases students may wish to pursue an internship outside the university to obtain practical training. Since practical training internships do not contribute to Ph.D. research, and an internship may disrupt the research activities of your advisor and group, the decision to pursue and accept an internship must be made in careful consultation with your Research Advisor.

Due to the interruption to your Ph.D. research, **the department strongly recommends that students do not pursue internships until the final year of their Ph.D.**, and ideally after they begin drafting their written dissertations. We outline the process for pursuing an internship below. International students with an F-1 visa must complete an additional Curricular Practical Training (CPT) form.

Internship Process (All Students)

You may use the following checklist to set up a research internship.

- ☐ Discuss the possibility of an internship with your Research Advisor. Be sure they approve of your time away from your regular research.
- ☐ Network to find an available internship that is relevant to your research and career interests.
- ☐ When you secure an internship, ensure that the start and end dates align with the university's academic calendar. Internships cannot begin and end during the middle of a semester.
- ☐ Once you receive an internship offer, send a copy of the offer to the PAS Graduate Program Coordinator along with a filled Approval of Graduate Practical Research Internship form, signed by your advisor.
- ☐ The Graduate Coordinator will get the approval of the Director of Graduate Studies and send the Approval Form to the Registrar.
- ☐ If you are an international student on an F-1 visa, prepare and submit the Curricular Practical Training (CPT) form.

PAS recommends you and your advisor create a written plan outlining mutual expectations during and after the internship.

The offer letter and approval form must be sent to the Program Coordinator a minimum of **two weeks** prior to the start of the internship.

CPT requests must go to ISO a minimum of **one week** prior to the start of the internship.

After you have submitted all the forms, the Graduate Coordinator will:

- Set up a PHYS 594 internship course with your advisor as the instructor.
- Complete a drop/add form for you to enroll in PHYS 594.
- Sign your CPT form (if you are an international student).
- Report the dates when you will be directly paid by your internship and pause your UR payroll.

F-1 Curricular Practical Training (International Students)

International students taking a practical research internship must complete the F-1 Curricular Practical Training (CPT) form a minimum of one week prior to beginning the internship. **Do not begin any off-campus employment without completing this form**, or you will endanger your F-1 status. The steps are:

Details are available on the ISO website.

1. Complete a Detailed Offer Letter, on employer letterhead, including all of the following information:
   - Official Employer Name, to be listed in SEVIS.
   - Employer's address (street address, including U.S. ZIP code).
   - Address of employment, if different from Employer's address.
   - Start date/End date, and expected number of hours per week.
   - Job title and description of duties.

2. Provide Evidence of Academic Objective, as appropriate.

   For most students at UR, internship course registration is required to participate in off-campus employment opportunities. Please talk to your department/school first about the appropriate course registration for your CPT and submit your registration, because it needs to be complete before ISO can process your request. For undergraduate students in the College, please meet with a career advisor at the Gwen M. Greene Center.

   Example: PHYS 594, set up by the PAS Graduate Coordinator.

   All CPTs require one of the following:

   - Course credit (PHYS 594).
   - Co-op program: registration or copy of the University catalog with co-op details.
   - Degree requirement: copy of the University catalog with degree requirements.

3. Submit ISO's Request for Curricular Practical Training (CPT) e-form in URcompass. Your academic department will have to review your submission, so you will be prompted to provide the contact information for your correct academic contact in the form.

   Ask your advisor or the Graduate Coordinator for the correct academic contact.

After your CPT has been authorized in SEVIS, the new I-20 listing the CPT authorization on page 2 will be emailed to you. You must print this I-20 and sign/date it in ink. Do not start work until you have received this I-20 and have verified the authorization details on page 2!

Appendix: Thesis Advisors

Thesis Advisors

Ph.D. students in the department may pick a research advisor with a primary or a joint appointment in Physics and Astronomy. The list below includes faculty with primary or joint appointments in PAS. Joint-appointed faculty are indicated in gray.

Faculty from other departments with a joint appointment in PAS count as a departmental advisor.

Students may also identify thesis advisors who are neither primarily nor jointly appointed in PAS. In this case, it is necessary to identify a **co-advisor in PAS** who can ensure the student is fulfilling the program's demands, subject to approval by the Graduate Affairs Committee and the Graduate Program Coordinator.

Professor	Research Area	Primary Appointment
Govind P. Agriwal	Theoretical Optics	Institute of Optics
Segev Y. BenZvi	Particle astrophysics, cosmology	Physics & Astronomy
Riccardo Betti	High-energy density physics	Laboratory for Laser Energetics
Nicholas P. Bigelow	Experimental quantum physics	Physics & Astronomy
Eric G. Blackman	Theoretical astrophysics	Physics & Astronomy
Machiel Block	Experimental quantum information	Physics & Astronomy
Mark F. Bocko	Experimental condensed matter	Electrical & Computer Engineering
Arie Bodek	Experimental high-energy physics	Physics & Astronomy
Robert W. Boyd	Experimental optics	Institute of Optics
Jaime Cardenas	Nanoscale photonics	Institute of Optics
Gilbert Collins	High-energy density physics	Mechanical Engineering
Regina Demina	High-energy physics, cosmology	Physics & Astronomy
Hanan Dery	Theoretical condensed matter	Electrical & Computer Engineering
Antonino Di Piazza	Quantum electrodynamics	Physics & Astronomy
Joseph Eberly	Theoretical quantum optics	Physics & Astronomy
William Forrest	Experimental astrophysics	Physics & Astronomy
Ignacio Franco	Theoretical condensed matter	Chemistry
Adam Frank	Computational astrophysics	Physics & Astronomy
Dustin Froula	High-energy density physics	Laboratory for Laser Energetics
Aran Garcia-Bellido	Experimental high-energy physics	Physics & Astronomy
Gourab Ghoshal	Theoretical condensed matter	Physics & Astronomy

Pierre Gourdain	Experimental plasma physics	Physics & Astronomy
Chunlei Guo	Experimental condensed matter	Institute of Optics
Ralf Haefner	Computational neuroscience	Brain & Cognitive Sciences
Suxing Hu	Theoretical plasma physics	Laboratory for Laser Energetics
Andrew N. Jordan	Theoretical condensed matter	Physics & Astronomy
Gabriel Landi	Theoretical quantum information	Physics & Astronomy
Steven L. Manly	Experimental high-energy physics	Physics & Astronomy
Christopher Marshall	Experimental high-energy physics	Physics & Astronomy
Kevin McFarland	Experimental high-energy physics	Physics & Astronomy
Lee Murray	Climate science	Earth & Environ. Sciences
Chaitanya Murthy	Theoretical condensed matter	Physics & Astronomy
Miki Nakajima	Planetary dynamics	Earth & Environ. Sciences
John M. Nichol	Experimental quantum information	Physics & Astronomy
Alice Quillen	Theoretical astrophysics	Physics & Astronomy
Chuang Ren	Theoretical plasma physics	Mechanical Engineering
William Renninger	Theoretical quantum optics	Institute of Optics
Hans Rinderknecht	Experimental plasma physics	Laboratory for Laser Energetics
Lewis Rothberg	Experimental condensed matter	Chemistry
Ryan Rygg	Experimental plasma physics	Laboratory for Laser Energetics
Wolf-Udo Schröder	Experimental nuclear physics	Chemistry
Adam Sefkow	Computational plasma physics	Mechanical Engineering
Dominique Segura-Cox	Observational astronomy	Physics & Astronomy
Roman Sobelewski	Experimental condensed matter	Electrical & Computer Engineering
Rick Spielman	Experimental plasma physics	Laboratory for Laser Energetics
Carlos Stroud	Theoretical optics	Institute of Optics
John A. Tarduno	Planetary dynamics	Earth & Environ. Sciences
Stephen L. Teitel	Theoretical condensed matter	Physics & Astronomy
Petros Tzeferacos	Computational astrophysics	Physics & Astronomy
Nickolas Vamivakas	Theoretical quantum optics	Institute of Optics
Dan M. Watson	Observational astronomy	Physics & Astronomy
Frank L. H. Wolfs	Experimental high-energy physics	Physics & Astronomy
Stephen Wu	Experimental condensed matter	Electrical & Computer Engineering
Xi-Chang Zhang	Experimental optics	Institute of Optics
Jianhui Zhong	Experimental biophysics	URMC Imaging

Appendix: Graduate Course Catalog

Physics Graduate Courses

The list of graduate courses offered in physics is given below. Courses not offered in the coming academic year are colored gray.

PHYS 401 *OPT 411*	Fall 2024	Mathematical Methods of Optics & Physics	Mathematical techniques such as contour integration, transform theory, Fourier transforms, asymptotic expansions, and Green's functions applied to differential, difference, and integral equations.
PHYS 403	Spr 2025	Modern Statistics & the Exploration of Large Data Sets	Fundamentals of probability with applications in practical data analysis, including parameter estimation, hypothesis testing, regression, simulation, and advanced error analysis (statistical and systematic). Uses of machine learning in inference.
PHYS 405	—	Geometrical Methods of Physics	Topological spaces. Manifolds. Vectors and Tensors. Lie groups. Riemannian Manifolds. Applications.
PHYS 406	—	Symmetries in Physics	Finite groups. Compact and non-compact Lie groups and Lie algebras. Group representation theory.
PHYS 407	Fall 2024	Quantum Mechanics I	Physical basis of quantum mechanics. The Schrödinger equation and matrix formulation of quantum mechanics. Angular momentum and spin. Stationary-state and time-dependent perturbation theory.
PHYS 408	Spr 2025	Quantum Mechanics II	Symmetries including parity, lattice translations, and time reversal. Scattering theory with applications. Elementary QED, multipole and plane-wave expansions, properties of the photon. The Dirac equation and elementary mass renormalization.

PHYS 411	—	Advanced Mechanics	Lagrangian and Hamiltonian dynamics, canonical transformations, Hamilton-Jacobi equations, chaotic dynamics, periodic orbits, stable and unstable orbits, Julia and Fatou sets, convergence of Newton's Iteration, KAM theory.
PHYS 413	—	Gravitation	Metric theory of gravity. Principle of equivalence. Principle of general covariance. Einstein field equations and solutions. Weak field approximation. Applications: black holes; relativistic star models; cosmological models; early stages of the evolution of the universe; gravitational waves.
PHYS 415	Fall 2024	Electromagnetic Theory I	An advanced treatment of electromagnetic phenomena. Electromagnetic wave propagation, radiation, and waveguides and resonant cavities, diffraction, electrodynamic potentials, multipole expansions, and covariant electrodynamics.
PHYS 418 *MSC 418*	Spr 2025	Statistical Mechanics I	Review of thermodynamics; general principles of statistical mechanics; micro-canonical, canonical, and grand canonical ensembles; ideal quantum gases; applications to magnetic phenomena, heat capacities, black-body radiation; introduction to phase transitions.
PHYS 434 *OPT 453*	Fall 2024	Advanced Quantum and Nano-Optics Lab	Quantum entanglement and Bells inequalities, single-photon interference, single-emitter confocal fluorescence microscopy and spectroscopy, photonic bandgap materials, Hanbury Brown and Twiss interferometer/photon antibunching. Applications in photonic based quantum computing and quantum cryptography.
PHYS 435 *ME 465* *OPT 465* *TEO 465*	Spr 2025	Principles of Lasers	Two-level atomic systems, optical gain, homogenous and inhomogenous broadening, laser resonators and their modes, Gaussian beams, cavity design, pumping schemes, rate equations, Q switching, mode-locking, various gas, liquid, and solid-state lasers.

PHYS 437 *OPT 467* *TEO 467*	Fall 2024	Nonlinear Optics	Nonlinear interaction of light with matter. Optical nonlinearity, second-harmonic and sum and difference-frequency generation, photonics and optical logic, optical self-action effects including self-focusing and optical soliton formatin, optical phase conjugation, stimulated Brillouin and stimulated Raman scattering, and selection criteria of nonlinear optical materials.
PHYS 440	Fall 2024	Foundational Theories of Particle and Nuclear Physics	The course introduces the Standard Model of particle physics. Topics include: development of relativistic quantum mechanics of particles and fields; Lagrangian formulation of the theory of electroweak interactions; the Higgs mechanism of electroweak symmetry breaking; Quantum Chromodynamics; and neutrino oscillations.
PHYS 445 *CHEM 444*	Spr 2025	Advanced Nuclear Science Education Lab (ANSEL)	Lab course that develops a sophisticated understanding of our terrestrial radiation environment and of some of the important applications of nuclear science and technology. Use of radiation detectors, monitors, and electronics; assessment of radiation threats and prospects of their abatement.
PHYS 451	—	Physics of Astrophysics I	See ASTR 461.
PHYS 452	Spr 2025	Physics of Astrophysics II	See ASTR 462.
PHYS 453 *ME 537*	Fall 2024	Intro to High Energy Density Physics	A survey of the field of high-energy-density science (HEDS), from ultra-dense matter to the radiation-dominated regime. Experimental and computational methods for the production, manipulation, and diagnosis of HED matter; thermodynamic equations-of-state; dynamic transitions between equilibrium phases; and radiative and other transport properties.
PHYS 454 *ME 434* TME 434	Fall 2024	Intro to Plasma Physics I	Orbit theory, adiabatic invariants, collective effects, two-fluid and MHD equations, waves in plasma, transport across magnetic fields and in velocity space.

PHYS 455 *ME 435* *TME 435*	Spr 2025	Intro to Plasma Physics II	Introduction to kinetic theory and the moment equations. Vlasov equation, Landau damping. Waves in unmagnetized and magnetized plasmas. Collisional processes, Fokker-Planck equation. Two-stream instability, micro-instabilities. Nonlinear effects.
PHYS 456 *ME 436* *TME 436*	—	Compressible Flow	Kinematics, equations of motion; thermodynamics of gases; linear acoustics; Bernoulli equation; potential flow; steady one-dimensional flow; shock waves, normal and oblique shocks; unsteady one-dimensional flow, characteristics. Applications in engineering and astrophysics.
PHYS 457 *ME 437* *TME 437*	Fall 2024	Incompressible Flow	Fluid motions which are gentle enough that the density of the fluid changes little to none. Conservation equations. Bernoulli's equation, the Navier-Stokes equations. Inviscid flows; vorticity; potential flows; stream functions; complex potentials. Viscosity and Reynolds number; some exact solutions with viscosity; boundary layers; low Reynolds number flows. Waves.
PHYS 458	—	Geometric Methods in Fluids	Riemannian geometry applied to fluid mechanics. Euler and Navier-Stokes equations in various geometries. Geodesic equations in the infinite-dimensional group of volume-preserving diffeomorphisms. Instabilities of fluids in terms of the sectional curvature of this space. Flow along the principal directions of this metric and "force-free" flows. Application to self-gravitating fluids in astrophysics, relativistic fluids in nuclear physics, fluids near a critical point, and quantum fluids such as Bose condensates.
PHYS 459 *ME 439*	—	Turbulence	Introduction to turbulence theory and modeling, stressing intuitive understanding, mathematical analysis techniques, and numerical methodologies. Applications include aeronautics, fusion sciences, geophysics, and astrophysics.

PHYS 464	—	Biological Physics	Physical and quantitative data from light microscopy images and methods of fluorescence imaging (Confocal, TIRF, Lightsheet, SIM, STORM, PALM, STED, FRET). Introduction to image analysis: segmentation and particle tracking, and use of these processes to extract physical data (e.g. microrheology and traction force microscopy). Quantitative analyses of real-world data sets.
PHYS 467 *BME 453* *ECE 453* *TEB 453*	—	Ultrasound Imaging	Introduction to the principles and implementation of diagnostic ultrasound imaging. Topics include linear wave propagation and reflection, fields from pistons and arrays, beamfoaming, B-mode image formation, Doppler, and elastography.
PHYS 492	Summer 2024	Certificate of Teaching of College Physics or Physics and Astronomy	After serving as a lead Teaching Assistant (TA), the student teaches a course during the University's summer session. Students successfully completing the Graduate Teaching program are awarded a Certificate of College Teaching in Physics and Astronomy to be presented during the graduation ceremony in May. Please visit the department website for more information.
PHYS 498	Fall 2024	Supervised Teaching Assistantship I	Laboratory or Recitation Teaching Assistant (TA) for teaching two laboratories or up to four recitations for introductory undergraduate courses ASTR 111, PHYS 113, PHYS 122, PHYS 141, or PHYS 142; or, teaching one or more recitation(s) in ASTR 111, PHYS 113, PHYS 122, PHYS 141, PHYS 142, or a 200-level undergraduate course. Required attendance in weekly teaching seminars (PHYS 597), feedback to other leaders, and a constructive evaluation process. The course is non-credit and may be taken more than once.
PHYS 499	Spr 2025	Supervised Teaching Assistantship II	Continuation of PHYS 498.

PHYS 501 *OPT 511* *TEO 511*	—	Advanced Mathematical Methods in Optics	Advanced numerical and analytical techniques for Ph.D.-level Optics students. Review of numerical errors and simple algorithms for solving nonlinear algebraic and differential equations. Analytical techniques useful for solving ordinary and partial differential equations encountered in various areas of optics and photonics.
PHYS 511	—	Field Theory	Path integral formulation of quantum mechanics, free harmonic oscillator, fermionic oscillator, instantons, free scalar field, Green's functions, generating functional statistical mechanics as Euclidean field theory, partition function as a path integral, free Bose gas, interacting quanta, Green's functions and scattering amplitudes at tree level, symmetry, Ward identities, symmetry breaking and Goldstone theorem, effective action at one loop, 1D and 2D Ising model, duality, high and low temperature expansions, transfer matrix, scaling of coupling with lattice size.
PHYS 512	—	Renormalization	Non-Abelian gauge theories (QCD), Path integral quantization of gauge theories, BRST invariance, Ward identities, Ghost free gauges, Symmetry breaking and Higgs mechanism, Standard model, Regularization, Renormalization theory, Anomalous Ward identities, Schwinger model, Renormalization group equation and solutions, Callan-Symanzik equation.
PHYS 516	—	Electromagnetic Theory II	A continuation of PHYS 415 covering special relativity, radiation from moving charges, radiation damping, scattering and electrodynamics in material media.
PHYS 519	—	Statistical Mechanics II	A continuation of PHYS 418, involving the theory of imperfect gases, phase transition, and Brownian motion.

PHYS 521 *MSC 550*	Fall 2024	Condensed Matter I	Fundamentals of solid state physics and description of why solids behave differently than individual atoms. Free-electron model of solids, crystal structure, x-ray diffraction, Bloch's Theorem, band structure, the tight-binding model, crystal vibrations, phonons, magnetism, and superconductivity.
PHYS 522 *MSC 551*	Spr 2025	Condensed Matter II	Electron-phonon interaction, transport, magnetism, and topics of current interest such as superconductivity or localization, to be determined by the instructor.
PHYS 525	Fall 2024	Data Science II: Complexity	Investigation of the qualitative and quantitative changes to the behaviors of systems as the number of interacting degrees of freedom (or agents) in a given system increases. Fractals, non-linearity and chaos, adaptation and evolution, critical and tipping points, pattern formation, network modeling, feedback loops, emergence and unpredictability. (Prerequisites: basic knowledge of differential equations, linear algebra, and probability.)
PHYS 526 *ECE 520* *MSC 520* *TEE 520*	—	Spin-Based Electronics	Introduction to the basic physics of magnetism and of quantum mechanical spin. Spin transport with emphasis on spin-diffusion in semiconductors. Student and lecturer presentations of selected spintronics topics which may include: spin transistors, magnetic random access memories, spin-based logic paradigms, spin-based lasers and light emitting diodes, magnetic semiconductors, spin-torque devices for memory applications and the spin Hall effect.
PHYS 527 *BCSC 547* *CSC 441*	Fall 2024	Introduction to Computational Neuroscience	Models of individual neurons and networks of neurons and behavior. Classic signal processing and probabilistic perspective on how neurons support the brain's computations. The sensory system and perceptual decision-making.

PHYS 531 *OPT 551*	Fall 2024	Introduction to Quantum Optics	Classical and quantum mechanical theories of the interaction of light with atoms and molecules, with emphasis on near resonance effects, including coherent nonlinear atomic response theory, relaxation and saturation, laser theory, optical pulse propagation, dressed atom-radiation states, and multi-photon processes.
PHYS 532 *OPT 552*	Spr 2025	Quantum Optics of the Electromagnetic Field	Properties of the free quantized electromagnetic field, quantum theory of coherence, squeezed states, theory of photoelectric detection, correlation measurements, atomic resonance fluorescence, cooperative effects, quantum effects in nonlinear optics. (Prerequisite: PHYS 531.)
PHYS 533 *OPT 553*	—	Quantum Optics of the Atom-Field Interaction	Selected topics of interest in quantum optics.
PHYS 552 *ME 532*	Spr 2025	Magnetohydrodynamics	Introduction to magnetohydrodynamics (MHD) with applications in engineering and high-energy density physics. Governing Equations. Electromagnetic induction; magnetic Reynolds number; frozen-in magnetic fields and magnetic flux tubes. Hydromagnetic equilibria; force-free fields. Alfvén waves, magneto-acoustic waves. Discontinuities, magnetosonic shock waves. Viscous flows: Hartmann boundary layers. Stability of MHD flows. Numerical MHD, introduction to magnetized HEDP experiments. MHD in plasma physics, extended MHD.
PHYS 553 *ME 535*	Spr 2025	Laser Plasma Interactions	Breakeven conditions for inertial confinement fusion. The coronal plasma. Inverse bremsstrahlung absorption. Resonance absorption. Parametric instabilities. Nonlinear plasma waves. Zakharov equations and collapse.
PHYS 554	Spr 2025	Cosmology	See ASTR 554.

PHYS 556	—	Hydrodynamic Instabilities in Fluids and HEDP	Hydrodynamic equations of motion, linear stability analysis, the classical Rayleigh-Taylor instability, the ablative Rayleigh-Taylor instability, the effects of finite density gradients, the Kelvin-Helmholtz instability, the Richtmyer-Meshkov instability, the Rayleigh-Benard instability. The effects of magnetic fields. Nonlinear evolution. Numerical simulations.
PHYS 558 *ME 533*	—	Introduction to Inertial Confinement Fusion	Fusion energy. Lawson criterion for thermonuclear ignition. Fundamentals of implosion hydrodynamics, temperature and density in spherical implosions. Laser light absorption. Implosion stability. Thermonuclear energy gain.
PHYS 564	—	High Energy Astrophysics	See ASTR 564.
PHYS 573	—	Physics & Finance	Introduction to econophysics and the application of statistical physics models to financial markets. Parallels between physical and financial phenomena will be emphasized. Random walks and Brownian motion, introduction to financial markets and efficient market theory, asset pricing and the Black-Scholes equation for pricing options, non-Gaussian Levy processes and the applicability of power law distributions and scaling to finance.
PHYS 581	—	Particle Physics I	Hadrons and symmetries. Quark and lepton mixing phenomenology and experiments. Theories of neutrino mass. Nuclear masses and stability. Nuclear models and applications. Connections between cosmology and particle physics. Direct and indirect detection of dark matter. Passage of particles through matter, detectors, and experimental methods.
PHYS 582	Fall 2024	Particle Physics II	Generators and simulations of particle and nuclear physics experiments. Higher order processes, renormalization, and precision measurements. Beyond the Standard Model physics topics. Phenomena of perturbative Quantum Chromodynamics. Accelerator physics. Current topics, as time permits.

PHYS 591	Fall 2024, Spr 2025	Ph.D. Readings in Physics	Special study or work, arranged individually.
PHYS 595	Fall 2024, Spr 2025	Ph.D. Research	Research assistantship for the Ph.D. Taken every semester during Ph.D. research.
PHYS 597	Fall 2024, Spr 2025	Research Seminar	Noncredit course given once per week, required of all first-year graduate students. Lectures and discussions on various aspects of being an effective teaching assistant; presentations from faculty on their current area of research interest.
PHYS 598	Fall 2024	Teaching Workshop Leader Pedagogy	This course is designed for a student to be a Workshop Leader Teaching Assistant (TA). Support and training in group dynamics, learning theory, and science pedagogy for students facilitating collaborative learning groups for science and social science courses. The TA teaches three to four workshops in one of the fall semester introductory physics courses, attends PHYS 597 (Fall), and gives feedback to other leaders. This course is non-credit and may be taken more than once.
PHYS 599	Spr 2025	Pedagogy and Group Leadership	This course is designed as a follow-up course for an experienced lead Workshop Leader Teaching Assistant (TA). Participants attend weekly Workshop Leader Training meetings, foster ongoing communication among faculty members and study group leaders, and provide an environment for review of study group-related issues. Students spend the semester teaching three to four workshops for the spring semester introductory physics courses.
PHYS 999	Fall 2024, Spr 2025	Doctoral Dissertation	Completion of the Ph.D.

Astronomy Graduate Courses

The list of graduate courses offered in Astronomy is given below.
Courses not offered in the coming academic year are colored gray.

ASTR 444	Spr 2025	Observational Astronomy	Introduction to astronomical instrumentation, observations, and image processing. Students carry out challenging observing projects using the 24″ Cassegrain telescope and its research-grade instrument suite at the C.E.K. Mees Observatory, reduce and analyze the data, and write up the results.
ASTR 453	—	Stellar Structure and Atmospheres	A first course on stellar structure and stellar atmospheres. Topics covered include hydrostatic equilibrium, the virial theorem, energy generation and transport, stellar evolution, stellar modeling, basic radiative transfer, radiative equilibrium, line-broadening mechanisms, and spectral line formation.
ASTR 461 *PHYS 451*	—	Physics of Astrophysics I	The physics of radiation production by ionized and atomic matter, the transfer of radiation through matter, and what we measure from astrophysical objects. Concepts are developed from first principles and many applications in astrophysics are studied.
ASTR 462 *PHYS 452*	Spr 2025	Physics of Astrophysics II	Hydrodynamic and plasma processes relevant to astrophysics, developed from first principles. Fundamentals of fluid dynamics and magnetohydrodynamics. Instabilities, turbulence, supersonic and subsonic flow. Accretion physics, shocks, dynamos, particle accelerations in plasmas, dynamics of magnetic fields.
ASTR 465	Fall 2024	Galactic Structure	Star, gas, and dust distribution in the Milky Way. Structure studies and classification of other galaxies. Clusters of galaxies, redshifts, Seyfert galaxies, peculiar galaxies, quasars.
ASTR 551	—	The Interstellar Medium	The Galactic interstellar medium, the processes of star formation, and the interaction of stars with their birthplaces. Phenomenology and modeling of observations. Students will complete a term project in which they will learn to use standard software packages to model sets of observations of interstellar gaseous objects.

ASTR 554 *PHYS 554*	Spr 2025	Cosmology	Introduction to the universe, introduction to general relativity, cosmological models and the Fridemann-Walker universe, thermodynamics of the early universe, particle physics of the early universe, and the formation of large-scale structure.
ASTR 564 *PHYS 564*	—	High Energy Astrophysics	Survey of current research in high energy astrophysics. X-ray and γ ray astrophysics, supernovae and planetary nebulae, binary accretors, compact objects, plasma astrophysics, magnetic field-particle interactions, cosmic rays, astrophysical jets, active galactic nuclei.
ASTR 565	—	Formation of Stars & Planetary Systems	Survey of theory and multi-wavelength observations related to the formation of early evolution of stars and planets. Interstellar medium, dust, molecular clouds, protostars, T Tauri stars, circumstellar disks, pre-main sequence stellar evolution, extrasolar planets and substellar objects, constraints on the protostellar nebular from meteorites and the planets.
ASTR 570	—	Solar System Dynamics	Dynamics of bodies in the solar system and exo-solar systems. Two-body problem. Orbital elements. f and g functions. Universal variables for hyperbolic and eccentric orbits. Hamiltonian formulation. Canonical transformations. Symplectic integrators. Hyperbolic orbits, Impulse approximations. Dynamical friction. Gravitational stirring. Three body problem. Jacobi integral. Tisser and relation. Disturbing function. Low-eccentricity expansions. Secular perturbations, mean-motion resonances, resonant trapping, dust dynamics, Yarkosky effect. Collision cascades. Debris disks. Planetesimal size distributions. Spiral density waves, torque formulas, gap opening, planet migration, stability of N-body systems. Resonance overlap, Chaos. Tidal evolution. Planet and planetesimal formation, disk clearing, Nice model.

ASTR 591	Fall 2024, Spr 2025	Ph.D. Readings in Astrophysics	Special study or work, arranged individually.
ASTR 595	Fall 2024, Spr 2025	Ph.D. Research	Research assistantship for the Ph.D. Taken every semester during Ph.D. research.
ASTR 999	Fall 2024, Spr 2025	Doctoral Dissertation	Completion of the Ph.D.

Appendix: Advisor-Advisee Agreements

The advisor-advisee relationship is often crucial to your development as an independent researcher. While you are learning to develop your own research, you are also responsible for helping to carry out the broader research program of your advisor, research group, and collaboration. It is your job to stay current on research in your subfield, to show up on a regular schedule prepared to work, and to learn how to prepare and carry out independent projects. Ph.D. research is very often not a "9-to-5" job and it is important to come to an understanding with your advisor on mutual expectations.

Below we include three examples of written advisor-advisee policies. The first document is an **Advisor Framework Agreement** developed by the Graduate Education and Postdoctoral Affairs Office (UR-GEPA). We recommend that students and advisors use this form to plan the goals and milestones of the Ph.D. After signing the form, it can be sent to the PAS Graduate Program Coordinator and/or emailed to ASEGEPA@rochester.edu to be placed into the student's file.

A downloadable PDF of the framework is available at the UR-GEPA website.

A second document, **Mutual expectations for advisors and advisees**, is akin to a contract that lays out the terms and conditions of the relationship between an advisor and an advisee. It enumerates the expectations students should have of their advisors, and vice-versa. Like a contract, there is room at the end for a student and advisor to sign the agreement.

A copyable version of this advisor-advisee contract is available here.

A third document is more akin to a statement of policies in a research group, written by the principal investigator of an experimental physics group outside the University of Rochester. It enumerates rights and expectations as well as boundary conditions such as what might be an appropriate amount of vacation time, what are reasonable expectations for travel to conferences given budget constraints, and when to seek guidance from peers and other mentors beyond the principal investigator. Importantly, the document includes links to useful resources such as a Graduate Mentorship Map.

A copyable version of this research group's policies is available here.

Example 1: GEPA Advisor Framework Agreement

ADVISOR FRAMEWORK AGREEMENT: STEM AND QUANTITATIVE SOCIAL SCIENCES

This agreement should be first completed any time a student begins working with a new advisor/mentor/PI. This is a living document and should be returned to and revised yearly.

Use these questions to begin a conversation about shared expectations regarding what the advising relationship will be like. This framework is designed to cover work expectations for the student's research responsibilities, rather than teaching responsibilities. If a question is not applicable (either currently or in general), write "N/A."

Student: ___________________________________ Advisor: ___________________________________

Program and Degree: ____

I. WORK AND COMMUNICATION EXPECTATIONS

1. Outside of coursework, how many hours per week should the student expect to spend working on Ph.D. research? Is summer work expected or required based on the stipend/fellowship support?

2. What are the standard working hours the student is expected to keep? Is remote work an option for any of the student's research responsibilities?

3. Discuss expectations regarding vacations and time away from campus. What is the timeframe for notification regarding anticipated absences?

4. What is the best method/technology to get in touch with each other? What is the appropriate timeframe to expect a response, including when either the faculty member or graduate student is working remotely?

5. Will there be any lab administrative tasks expected of the student as part of their research responsibilities (e.g., ordering supplies, organizing group meetings, etc.)?

II. MENTORSHIP EXPECTATIONS

1. How often will we meet? How is the agenda set? How long will the meeting be?

2. How are next steps and action items identified after a meeting?

ADVISOR FRAMEWORK AGREEMENT: STEM AND QUANTITATIVE SOCIAL SCIENCES

3. If there are conflicts or disagreements, how will we address those?

4. Will the student be expected or encouraged to mentor undergraduates, post-baccalaureate students, or more junior graduate students working in the lab? If yes, describe that relationship.

5. Mentorship may include academic (e.g., advising, research, substantive feedback), professional (career guidance, intellectual community), and well-being (personal and emotional) support. Which of these areas will we work together on?

6. Are there additional resources and support that would help you do your best work (needs such as physical access, workspace accommodations, work hours, language, and technology, well-being breaks, dietary needs, etc.)?

III. PROFESSIONAL AND PROGRAM GOALS

1. Identify short-term and long-term goals for the student's research.

2. Discuss any steps, resources, and training necessary to accomplish these goals.

3. Completion of Programmatic and Other Milestone Goals

Agree on target completion terms for your program's milestones. These might include completing coursework, assembling dissertation committee, completing the qualifying exam, defending the dissertation, and any other requirements set by the department. Place an X in terms designated for milestones. F = fall, S = spring, Su = Summer. Revise these as needed.

Milestone	Year 1			Year 2			Year 3			Year 4			Year 5		
	F	S	Su	F	S	Su	F	S	Su	F	S	Su	F	S	Su

ADVISOR FRAMEWORK AGREEMENT: STEM AND QUANTITATIVE SOCIAL SCIENCES

4. What professional meetings and conferences should the student consider attending and/or submitting proposals to? What funding is available to attend these meetings? What other opportunities for networking exist that the student should consider, both on and off campus?

5. Discuss the student's target defense semester and graduation dates. What steps should be taken if progress slows?

6. If applicable, when can the student seek internships and outside employment? Are there limitations on outside employment placed by the department?

7. Identify professional and career goals beyond degree completion.

IV. AUTHORSHIP AND FEEDBACK

1. What are the disciplinary, departmental, and lab norms around authorship and co-authorship? How will the student collaborate with the advisor on projects? How will authorship order be determined? How will a decision be made regarding if a project is ready for publication?

2. In what form and how often should the student expect to receive feedback regarding overall progress and other professional activities (teaching, outreach, and presentation skills)?

3. At which stages in the drafting, editing, and revising process can the student expect to receive feedback? Does the type of feedback differ depending on the stage of writing? How long is reasonable for expecting feedback on a draft?

4. Beyond the University guidelines, are there any expectations or norms as to whom should serve on the committee?

ADVISOR FRAMEWORK AGREEMENT: STEM AND QUANTITATIVE SOCIAL SCIENCES

5. How should feedback from multiple committee members be coordinated, especially if readings and reactions contradict one another?

V. DEPARTMENTAL AND CAMPUS EXPECTATIONS AND RESOURCES

1. What are expectations for the student contributing to the intellectual life of the department? Are there departmental norms surrounding attending colloquia, symposia, visiting speakers, and other campus events?

2. Identify the skills and abilities that the student will focus on developing during the coming year. These could be writing, research, mentoring, or professional skills, as well as additional training experiences such as workshops and internships.

3. Discuss the funding model and opportunities/plans for future funding. What fellowship opportunities exist, internal and external? Discuss any uncertainty in future sources of funding and contingencies.

4. What related resources exist that the student should consider accessing (examples include GEPA and UGE workshops, WSAP, the Learning Center, UHS/UCC, departmental working groups, disciplinary mentoring programs, etc.)?

5. List other areas of understanding between the student and mentor regarding their working relationship during the student's tenure.

Student signature: ____ Date: _________________

Advisor signature: ____ Date: __________________

Optional: Email the document to ASEGEPA@rochester.edu for upload to the student's file.

Example 2: Mutual Expectations for Advisors and Advisees

Credit: Dan Watson and Adam Rubinstein, University of Rochester

Mutual expectations of advisors and advisees

The relationship between advisor and advisee is central to students' experience in doctoral programs. Both partners in this relationship must contribute for it to succeed. Successful advisor-advisee relationships enhance the careers of both partners. The relationship can take on three forms: advisor-advisee; supervisor-subordinate; and mentor-mentee. In the best cases, the three forms work together. In this document, we list the key contributions from each partner to an advisor-advisee relationship that leads to mutual benefit.

The Advisor

Advising graduate students in research-based degree programs is part of the job for almost all UR faculty members. Graduate students help build their faculty advisor's record and reputation by contributing to their advisor's research program. This situation carries an inherent tension for the faculty member, which graduate students need to recognize. Although the faculty member's success depends at least in part on the student's success, the faculty member may also be responsible to outside sponsors, whose goals may not directly match those of the student. As an educator, the advisor must always protect the student's interests as well as the sponsor's and their own in the research relationship.

The Advisee

The student's motivation is to earn a doctorate, which requires acquiring and demonstrating scientific knowledge and research competence. Participation in the research process is an essential requirement for all UR PhD students. In this part of their education, the student's duty is to put a best-faith effort into their assigned contribution to the research process. At the same time, graduate research assistants receive stipends under the terms of grants and contracts, and must help their advisor and research group meet the associated requirements. As such, graduate research assistants (RAs) have responsibilities that may not align with their research objectives or those of their advisors. This situation creates an inherent tension between the student's educational goals and their duties as an RA, which faculty advisors need to recognize.

A student expects from their advisor:

Respect

- Respect as a person, student, and professional member of a research group.
- Recognition and respect for differences in culture, ethnicity, gender, and other dimensions of diversity.
- Commitment of time, effort, and financial support; advising only as many students as resources permit.

Credit: Dan Watson and Adam Rubinstein, University of Rochester

- Ability to communicate and express concerns without the fear of retribution.
- Understanding of the student's commitments to course work and RA responsibilities.

Open and clear communications

- Mutually agreed upon expectations for frequency and format of communication.
- Clear communication about project timelines, availability, nature of funding, level of effort, research expectations, and amount of working and vacation (including out-of-town) time.
- Timely review and feedback on the student's research and academic progress.
- Notification of and appropriate resolution of issues that arise within the program, be they academic, research, financial or interpersonal in nature.

Guidance on research and degree completion

- Guidance on planning and managing research projects from conception to publication.
- Reasonable, mutually agreed upon expectations of the time frame necessary to produce results, and progress to qualifying exam, candidacy, dissertation, and defense.
- Proper training and resources to successfully complete research projects.
- Guidance on professional and ethical standards.
- Training in the responsible conduct of research.

Guidance on career

- Advice on advancing professional goals in the direction most desired by the individual student.
- Opportunities to participate in career development activities.
- Help in building professional networks.

An advisor expects from their student:

Respect

- Respect both as professor and person; recognizing the value of their time and their responsibilities within and outside the University.
- Understanding that mentoring is tailored for each individual student and adjusted for progress in the degree program.

Open and clear communications

- Mutually agreed upon expectations for frequency and format of communications.

Credit: Dan Watson and Adam Rubinstein, University of Rochester

- Clear communication about project timelines, availability, and nature of funding, level of effort, research expectations, and amount of working and vacation (including out-of-town) time.
- Regular progress reports including what the student has and has not done, including set-backs.
- Reasonable, mutually agreed upon expectations of the time frame necessary to give feedback and review results.
- Discussion of difficulties with the advisor first, before turning to other means for conflict resolution.
- Notification as soon as possible if planning to leave the program or advisor sooner than expected.

Commitment & Productivity

- Understanding of the expectations of the degree program, advisor and research team, and graduate research-assistant responsibilities.
- Learning and progress through the program, with progressively more independence as the student advances.
- Commitment and steady effort to make progress towards mutually agreed upon results and deliverables; adhering to timelines and deadlines.

Responsibility

- Safe, ethical, and efficient use of resources.
- Abiding by professional and safety standards.
- Taking feedback seriously and revising in response.
- Maintaining good records and documentation that would allow replication of results.
- When graduating or leaving the team, leaving behind the organized research materials.

Teamwork

- Working well with others; supporting and mentoring others in the team.
- Carrying a fair share of the responsibility.
- Understanding the common intellectual property principles involved in teamwork.
- Meeting deadlines.
- Thoughtfully reviewing the work of others, including the advisor.

In our work together, we agree to abide by these principles and to depart or modify them only by mutual consent.

Credit: Dan Watson and Adam Rubinstein, University of Rochester

Graduate student advisee:

Student's Name

DD Month YYYY

Faculty advisor:

Advisor's Name

DD Month YYYY

Example 3: Expectations in Our Research Group

Credit: Naoko Kurahashi Neilson, Drexel University

Expectations in Our Research Group

Culture and Collaboration

We are collaborators and a team. Often, a strong team is built from "hybrid vigor"' – the synthesis of different strengths and weaknesses, rather than cloning our own favorite qualities. In other words, I do NOT strive to make a group of similar personalities or backgrounds. Learning to work with various people is a necessary skill in any professional field. As such, all members are obligated to give their best optimistic effort to have good professional relationships with each other. You do not have to be best friends, but you are expected to work together effectively.

Communication

Ask questions

Students (or even postdocs) are not expected to know how to do everything when they arrive. Don't be embarrassed to ask. If you don't understand the goals or parameters of the task that you are supposed to be working on, ask! Even if you've asked before, but maybe didn't fully understand the answer the first time, ask again! It is much worse to waste time doing something incorrectly than it is to admit that you don't know something. Understanding of physics and experiments is layered. There are always deeper layers to understand. Keep asking questions. Stay curious!

Where to get answers

During group meetings or one-on-ones, ask questions of fellow students, postdocs, your advisor, and other people in the collaboration. Read internal wiki pages, technical notes, papers, Google, etc., etc. Be smart about this. Don't spend 5 hours on Google when I can answer it in 5 minutes. Don't spend 5 hours waiting to talk to me when you can Google the answer in 5 minutes. If you are new, your job is to ask. You should never feel bad to ask, but you should also not take it personally when others say they don't have time. This includes Slack: keep asking questions in our Slack channel, never feel bad that you ask too much, but also don't feel bad if nobody responds. If you are close to defending your Ph.D., your job includes mentoring new students effectively while still defending your time (and that will include saying "no" at times).

Take notes

When in group meetings, or any meetings, and I or other people suggest a plot to make, a number to calculate, etc., TAKE NOTES. Don't go into a meeting without a way to take notes. Did I say take notes? Yes, please always take notes.

Credit: Naoko Kurahashi Neilson, Drexel University

Annual review

You are expected to do a one-on-one advisor-advisee review with me using a worksheet (here). This is an important meeting to make sure our expectations are on the same page. It is also a good opportunity to give each other feedback to make our mentoring relationship more effective. This will usually be done every year around the start of summer.

Expectations by Position

Graduate Students on an RA

Research is a collaborative endeavor. As such, I expect students on an RA to be here and interact with the other members of the research group (e.g., serving as a mentor to more junior students). In general, this means that you are to come to campus. I also expect that your time on campus should overlap with normal working hours for the majority of the time. For example, if you want some quiet time when others are not around, then 6 am - 2 pm or 12 pm - 8 pm would be fine hours, but 6 pm - 2 am is not. At the minimum, please remember that you are paid (albeit poorly) to work 40 hr/week. That is on average 8 hr/day.

Please also keep in mind that the RA stipend that you are being paid is for a particular body of work with a fixed timescale and deliverables and is not an open-ended fellowship. Failure to make sufficient progress will require a reallocation of funding to meet the goals of the grant and a return to a TAship.

Graduate Students on a TA

Since I'm not paying you, I have less leverage to dictate the terms of your employment. But, generally speaking, if you aren't putting in 40 hours for TAing and classwork, the remainder of the time should be used for research. Generally, I'll assume that TAing takes 10 to 15 hours/week and that coursework takes about 5 to 10 hours/class/week. So, if you are taking 3 classes, you might not have any time. However, if you are only taking 1 class, you should have at least 15 hours (if not more) of research time. Consider the above as guidelines for your research time if you expect me to seek post-quals RA funding for you in my group. I am fully aware that TA and class time commitments fluctuate throughout the quarter.

Postdocs

In general, the rules for grad students on an RA apply. (Note: I'm more flexible and happy to give you more freedom of hours and where you work if at least 5 hours a day of normal working hours is spent on campus.)

Credit: Naoko Kurahashi Neilson, Drexel University

Other Policies

Travel

As soon as you have meaningful results to show, I am happy to send you to collaboration meetings, then conferences. There is no guarantee that after a certain time, you automatically go to all meetings. For example, if you have no new and substantial results between collaboration meetings, you will not go to the next meeting. I have a fixed amount of travel budget, and the goal of travel is to showcase our group's contributions to science. Travel will be allocated according to this.

Vacation/Days off

Please email me (not Slack) to notify me when you are taking days off. If it is less than a full day (i.e. you are unavailable for the afternoon), there is no need to do this. I will never say no to you taking days off, but this email serves as documentation for both of us so we are clear on how many days you have taken off, so, for example, I don't unfairly assume that ``you have been taking too many days off.'' There are no quotas for this number. However, I expect at most around 30 days a year. This includes sick days, holidays (there are 10 federal holidays a year if you want to keep to that calendar), time you take off around holidays (Thanksgiving, Christmas, New Year's, etc.), and of course vacation. If you are working remotely, please let me and the group know (Slack is fine) but this won't count towards days off.

How much guidance?

If you think that you don't get enough done because you don't get enough guidance, please reflect. I'd like to remind you that you get more guidance than an average Ph.D. student in physics (just think how many hours a senior student or postdoc has talked to you on Slack!). The whole collaboration is available to you in various resource forms (wiki, Slack, email, bootcamp w/recordings, working group guidance pages, etc.). This is also the reason we have group meetings. You see me once a week, along with all other people who can serve as local resources. Talk to each other! When you come across a problem, the first thing you should do is turn around to a fellow student (because you're already in the office) and ask if what you have looks right. In addition to group meetings and email or Slack, I'm happy to meet with everyone individually for up to 1 hr/week regularly (there will be irregular circumstances where this needs to be more). It is your job to become an independent researcher, and my job to facilitate that. I'm happy to help, but progress needs to be made when I'm not there too.

Connection tips for reaching the advisor

- You can reach me via email or Slack. If you message me in a Slack channel, please remember to @ me. If you don't get a timely answer, send it again. If your email contains several action items, I may have glanced at it and thought that one of the action

Credit: Naoko Kurahashi Neilson, Drexel University

items would take too long for the 3 minutes I had before my next commitment, so I failed to address the email at all. So separate your action items, give each a descriptive subject line and a clear deadline, and send again. I won't be irritated or offended by repeat emails.

- We have a weekly group meeting in which every group member takes turns listing their progress for the week. If you or I miss the regular group meeting, then I'd be happy to receive a quick individual weekly update via Slack or email.
- Undergraduates (especially those working just for summer) should take the initiative to email me weekly updates, as these can form the basis of my record of your accomplishments, for use in later writing a letter of recommendation.
- There may be cases with some lab members in which I request daily updates for limited periods of time, to ensure clear communication. I am never going to complain about too many updates – it is great for me to know what everybody is doing (even senior students and postdocs), and I regret that I don't have the time to ask every single day. So when in doubt, please send me an update!

Mentorship

See this graduate mentorship map from Jenny Hoffman (Harvard University).

Appendix: Policies on Separation from a Research Group or the Ph.D. Program

Lack of satisfactory progress toward the Ph.D. is of great concern to both students and advisors. For this reason, it is strongly recommended that students and advisors use Advisor-Advisee Framework Agreements to support communication and expectations for graduate work. In addition, faculty should consider developing a Research Group Code of Conduct to further positive experiences for students. Students shall also receive an annual evaluation, discussed between the advisor and the student, to assess progress in graduate work.

Process of Separation from a Research Group

When a student is identified as not making significant progress, the faculty advisor may institute the process outlined below. The goal of this process is to identify ways that the graduate student can move forward in their academic program to complete their Ph.D.

This process is related to progress in research and any concerns about academic course-related progress should refer to the Academic Probation policy in the Graduate Handbook.

1. The faculty advisor will meet with the Director of Graduate Studies (DGS) to discuss the student's progress and the reason for probation.

2. The faculty advisor will meet with the student and share their concerns and provide a written probation letter including the advisor's concerns and a performance improvement plan that provides **a minimum of one month** to make progress. The faculty advisor will provide the probation letter, the annual evaluation and the performance improvement plan to the DGS and the GEPA office. If the Advisor-Advisee Framework is available, that may be submitted as well.

The time window for improvement may be negotiated between the advisor and student in consultation with the Director of Graduate Studies.

3. At the end of the time window determined in Step 2 and stipulated in the performance improvement plan, the graduate student, faculty advisor, and DGS will meet to determine if adequate progress has been made. If the faculty advisor and DGS think

the student has not met the expectations outlined in the performance improvement plan by the end of this period, the faculty advisor and DGS have the option to continue the probation or to recommend separation from the research group or faculty advisor. If probation is to be continued, a new probation letter should be shared with the student, DGS, and the GEPA office. After the time window determined in the new probation letter, the graduate student, faculty advisor, and DGS will meet to determine if adequate progress has been made. If satisfactory progress has not been made, the student will be separated from the research group or faculty advisor.

4. A student separated from a research group or faculty advisor will have **three months of continued financial support**. The faculty advisor or program will provide the financial support. During these three months, the student should work with the Director of Graduate Studies and Graduate Program Coordinator to find a new faculty advisor. If applicable, a student who finds a new research group will no longer receive financial support from the previous faculty advisor after the date of joining the new research group. A student may be required to serve as a Teaching Assistant during these three months.

5. A student who fails to find a new research group or faculty advisor after **three months** will be withdrawn from the program.

Student Dismissal for Conduct Violations

The Dismissal for Conduct Violations policy applies to egregious research or academic conduct violations, such as repeated or severe safety violations, harassment, continued unexcused absence, or academic misconduct.

For academic honesty violations related to course work, refer to the Academic Honesty Policy.

1. The faculty advisor will meet with the student and share their concerns and provide written documentation including concerns and a performance improvement plan. The faculty should provide the annual evaluation, Advisor-Advisee Framework, code of conduct (if applicable), and the performance improvement plan to the DGS and the GEPA office.

2. The student's faculty advisor must consult with the Dean of Graduate Education and Postdoctoral Affairs, Department Chair, and DGS. If it is determined that the student has committed a violation the student may be recommended to the Office of Student Conduct for investigation.

3. The DGS and/or Graduate Program Coordinator (GPC) director will send the student a letter placing the student on probation. The letter placing a student on probation must include an explicit statement of the process to return to good standing in the program. The DGS or the GPC director will inform the Graduate Education and Postdoctoral Affairs Office in writing when the probationary period has begun. If the student does not comply with the conditions of probation, a letter signed by the DGS will be sent notifying the student of a dismissal meeting from the degree program.
4. In case of dispute, the Dean of Arts and Sciences shall have the final authority as to whether the problems are egregious enough to warrant immediate dismissal.
5. Upon dismissal the student's funding will be discontinued.

Process of Separation from the Ph.D. Program

When the department wishes to dismiss a student from the Ph.D. program, it will follow the above processes outlining a lack of satisfactory progress or conduct violations. If either process is initiated, the affected student will be notified in writing with a probation letter. Should the terms of the probation remain unmet, the department will complete the following steps to terminate the student's position in the Ph.D. program:

1. Before notifying the student, the department will provide the GEPA office with a letter outlining the reasons for separation and relevant supporting documentation, including the student's performance improvement plan, annual evaluation, and notice of separation.
2. The student will receive in writing the notice of separation and the information for appeal from the DGS or Department Chair.
3. Separation occurs at the end of a term and GEPA will complete the separation paperwork with the Registrar's Office.

The GEPA office will review letters of separation to make sure information related to degree completion and dates of separation are correct.

Appendix: University Policy on Temporary Closures

Emergency or Temporary Closings and Other Changes in Class Schedules and University Operations

The University plans to commence and conclude classes on the dates indicated in the academic calendars. But unforeseen circumstances or events may occur that require the University to temporarily close or otherwise make adjustments to its student life, residential housing, class schedules and format, method and location of instruction, educational activities, and operations because of reasons beyond the University's control. For example, such circumstances or events may include but are not limited to inclement weather, the onset of public health crises, being subject to government order(s), significant safety or security concerns, faculty illness, strikes, labor disturbances, sabotage, terrorism, war, riot, civil unrest, fire, flood, earthquake, acts of God, malfunction of University equipment (including computers), cyberattacks, unavailability of particular University facilities occasioned by damage to the premises, repairs or other causes, as well as disruption/unavailability of utilities, labor, energy, materials, transportation, electricity, security, or the internet. If any of these or other unforeseen circumstances or events outside of the University's control occur, the University will respond as necessary and appropriate, and it assumes no liability for any interruption or adjustments made to student life, residential housing, class schedules, and format, method and location of instruction, educational activities, and operations caused by these or other unforeseen circumstances or events. And the University shall not be responsible for the refund of any tuition or fees in the event of any such unforeseen circumstances or events, except as may otherwise be expressly provided in the University's Leave of Absence and Withdrawal Policy or its published tuition refund schedule (Payments and Refunds - Office of the Bursar (rochester.edu)).

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