Revised 8/10/2023

OPTICS GRADUATE HANDBOOK 2023-2024

Graduate Study and Research in Optics
The Institute of Optics
Hajim School of Engineering & Applied Sciences
University of Rochester

CONTENTS

POINTS OF CONTACT

Use the UR Directory *to look up current email contacts & office phone numbers for points of contact*: https://onlinedirectory.ur.rochester.edu/FacultyStaffDirectory.aspx

Melissa Sturge-Apple, Vice Provost and University Dean of Graduate Studies

http://www.rochester.edu/gradstudies/

AS&E Graduate Education & Postdoctoral Affairs (GEPA)
Personnel:

A. Nick Vamivakas, Dean of Graduate Education & Postdoctoral Affairs
Kris Lantzky-Eaton, Director of Graduate Education & Postdoctoral Affairs
Jon Herington, Assistant Director of Academic Operations
Katie Ferruzza, Assistant Director of Student Support Services
Aisling Sive, Graduate Admissions Counselor
Donna M. Derks, Academic Records Manager
Kym Gering, Graduate Financial Accounting Specialist

Contact Details for GEPA Personnel:
https://www.rochester.edu/college/gradstudies/about/contact.html

THE INSTITUTE OF OPTICS COMMITTEE ASSIGNMENTS 2021-2022

GRADUATE COMMITTEE
G. Wicks (PhD Co-chair)
J. Kruschwitz (MS Co-chair)
J. Cardenas
P. Postigo
L. Waxer

GRADUATE ADMISSIONS
A.N. Vamivakas, Chair
J. Bromage
C. Guo
J. Nelson
W. Renninger

Ankur Desai, Senior PhD Representative – *adesai15@ur.rochester.edu*
Daniel Gitlin, Junior PhD Representative – dgit@lle.rochester.edu
Anis Idrizovic, Junior PhD Representative – aidrizov@ur.rochester.edu
Xiaoyu Ma, MS Representative – xma28@ur.rochester.edu

UNDERGRADUATE COMMITTEE
A. Berger and J. Bentley, co-chairs
J. Zavislan
G. Wicks
E. Herger

Additional Assignments
Gary Wicks Ombudsperson

Kai Davies	Master's Co-Op Committee Chair
Govind Agrawal	Colloquium Chair
Andrew Berger	Biomedical Engineering Advisor
Gary Wicks	Part-Time M.S. Advisor
Thomas Brown	HSEAS Administrative Committee
James Zavislan	HSEAS Computing Committee
James Fienup	HSEAS Graduate Committee
James Fienup	University Council on Graduate Studies
Thomas Brown	Committee on Educational Policy
Robert Boyd	Library Representative
James Zavislan	Undergraduate Optica Advisor
Jannick Rolland	Graduate Student SPIE Advisor
James Zavislan	Committee of Optics Networking

DIRECTOR OF THE INSTITUTE

Thomas G. Brown

ADMINISTRATIVE STAFF

Kai Davies – Graduate Program Coordinator
Lori Russell – Administrator of the Institute
Meir Brea – Department Accountant
Tal Haring – Strategic Analyst to the Director
Dustin Newman – Undergraduate Program Manager
TBA – Department Financial Analyst

TECHNICAL STAFF

Michael Koch - Molecular Beam Epitaxy
Mike Pomerantz – Technical Associate
Edward Herger – Senior Laboratory Engineer for the Teaching Labs

ADDRESS DETAILS FOR THE INSTITUTE OF OPTICS

The Institute of Optics mailing address is:
Box 270186
275 Hutchison Road
Rochester, NY 14627-0186

Students can receive mail to their mailbox located on the 1st floor of Wilmot or to the mail room/printer room in Wilmot 121 addressed to their name using The Institute of Optics mailing address listed above.

For in-person deliveries and transportation pick-up/drop-off directions, use the following address:
480 Intercampus Drive
Rochester, NY 14620

480 Intercampus Drive is the address for the Goergen Hall Loading Dock, accessible via a door in the south-east corner of Wilmot or through the double doors next to the elevators in Goergen Hall. Mapping apps and car GPS often lead visitors to the Simon School when 275 Hutchison Road is used.

Students can send mail via Intercampus mail to locations on UR Campuses using Intercampus Mailing Folder and blue UR Mail bags located next to the mail/printer room in Wilmot 121.

IMPORTANT NOTICE ON POLICY

This Optics Graduate Handbook compiles rules, policies, and information for graduate students within the Institute of Optics.

Optics MS & PhD students are also subject to the rules and policies set forth by the University of Rochester, the College of Arts, Sciences & Engineering, and the Hajim School of Applied Sciences & Engineering.

Most of the rules and regulations that govern graduate students at the University of Rochester can be found in the Graduate Bulletin & in the AS&E GEPA Graduate Handbook. All Optics graduate students should access & carefully review these documents here:

Graduate Bulletin: http://www.rochester.edu/GradBulletin

AS&E GEPA Handbook: https://www.rochester.edu/college/gradstudies/graduate-handbook//index.html

USEFUL WEB & CAMPUS RESOURCES

Optics Graduate Student Resource Folder:
https://rochester.box.com/s/jiweywzxspggp1y5klk5y5oxjxtg0mve

Institute of Optics Website: http://www.hajim.rochester.edu/optics/
Optics Directory: http://www.hajim.rochester.edu/optics/people/index.html
Optics Graduate page:
http://www.hajim.rochester.edu/optics/graduate/index.html
Industrial Associates: http://www.hajim.rochester.edu/optics/ia-program/index.html
Course Descriptions:
http://www.hajim.rochester.edu/optics/graduate/courses.html
The Institute of Optics is located at 480 Intercampus Drive, Rochester NY 1427

Graduate Education Office: http://rochester.edu/gradstudies/
Located in 206 Lattimore Hall

UR Course Directory/Course Schedules (CDCS): https://cdcs.ur.rochester.edu/
Be sure to select the term in order to view courses, then refine with other fields.

Online Registration through UR Student: https://www.rochester.edu/urstudent/
Instructions & Reference Materials for Online Registration & UR Student:
https://tech.rochester.edu/urstudent/

Online Bill Payment (UR ePAY):
https://www.rochester.edu/adminfinance/bursar/epay.htm

Office of the Bursar: https://www.rochester.edu/adminfinance/bursar/
Located at 330 Meliora Hall; (585) 275-3931

Barnes Computing Center: http://www.sas.rochester.edu/pas/resources/bcc/index.html
Poster Printing Info:
http://www.sas.rochester.edu/pas/resources/bcc/posters.html
Located on the 4th floor of the Bausch & Lomb building

International Services Office: https://iso.rochester.edu/index.html
Located in College Town (40 Celebration Drive)
questions@iso.rochester.edu ; (585) 275-2866

University Health Services: http://www.rochester.edu/uhs/
Located in the University Health Services building next to Susan B. Anthony Hall

Public Safety: http://www.publicsafety.rochester.edu/
Emergeny Contact: #413 or 5-3333 on any UR network phone; (585) 275-3333 otherwise

Housing Resources for Graduate Students: https://www.rochester.edu/reslife/graduate/

Department of Parking & Transportation: http://www.rochester.edu/parking/
Shuttle Info: http://www.rochester.edu/parking/shuttles/
Located in College Town (70 Goler Building)
(585) 275-4524

River Campus Libraries: https://www.library.rochester.edu/
Carlson Library: http://www.library.rochester.edu/carlson/home
Reserving study rooms in Carlson Library:
http://libcal.lib.rochester.edu/booking/carlson
Located in the Computer Science Building (CSB)

Physics-Optics-Astronomy (POA) Library:
http://www.library.rochester.edu/poalibrary/home
Located on the 4th floor of the Bausch & Lomb building

GRADUATE ACADEMIC CALENDAR

FALL SEMESTER 2023

August 30, 2023 (Wednesday)	First day of class
September 13, 2023 (Wednesday)	End of open registration, students must be registered by this date or incur a late registration fee
September 27, 2023 (Wednesday)	End of Add/Drop Period. Deadline for full matriculation Rochester for incoming students
October 16-17, 2023 (Monday - Tuesday)	Fall term break
November 15, 2023 (Friday)	Last day to withdraw from a course
November 23, 2023 (Wednesday)	Thanksgiving recess (11/23 – 11/26) begins at noon.
December 13th, 2023 (Wednesday)	Last day of classes.
December 14, 2023 (Thursday)	Reading Period (12/14-12/16) begins.
December 17-22, 2023	Final examinations
December 23, 2023 (Friday)	Winter recess begins at end of examinations.
December 22-31, 2023	Start of PhD Defense Blackout Period (December 22 – 31st) – no PhD defenses can be scheduled during blackout period

SPRING SEMESTER 2024

January 17, 2024 (Wednesday)	First day of classes.
January 31, 2024 (Wednesday)	End of open registration, students must be registered by this date or incur a late registration fee
February 14, 2024 (Wednesday)	End of Add/Drop registration period, last day to drop or add a course
February 15, 2024 (Thursday)	Program of Study Form & Intent to Graduate Form Deadline for May 2024 Degree Conferral (MS & PhD)
March 9, 2024 (Wednesday)	Spring Break begins (March 9th – 17th)
April 10, 2024 (Friday)	Last day to withdraw from a course
April 15, 2024 (Monday)	Advisor selection deadline for 1st year PhD & MS students
April 30, 2024 (Wednesday)	Last day of classes for Spring 2023.
May 1, 2024 (Thursday)	Reading period (May 1st – 4th) begins
May 5 – 11, 2024	Final Examinations
May 17-19, 2024	Commencement Weekend, Optics Graduate ceremony anticipated on May 18th, 2024 (Saturday)

**For a more detailed calendar, please visit:
https://www.rochester.edu/registrar/academiccalendar.html or
http://www.rochester.edu/college/gradstudies/events/index.html

Thesis Advisors:

The faculty members listed below are approved thesis advisors for degrees in Optics. PhD students supported by professors with primary faculty appointments in The Institute generally receive stipends that are set by the faculty of The Institute. Students receiving graduate fellowships may, in some cases, receive a higher stipend. The stipends of students doing thesis research for professors with primary appointments in other departments or units may be set by others. In particular, students working for faculty with primary appointments in the Laboratory for Laser Energetics (LLE) might receive LLE-set stipends that may be slightly lower than Optics stipends.

Professor	**Department of Primary Appointment**
Govind Agrawal	The Institute of Optics
Miguel Alonso	The Institute of Optics
Julie Bentley	The Institute of Optics
Andrew Berger	The Institute of Optics
Nicholas Bigelow	Physics
Robert Boyd	The Institute of Optics
Jake Bromage	Laboratory for Laser Energetics
Tom Brown	The Institute of Optics
Jaime Cárdenas	The Institute of Optics
Scott Carney	The Institute of Optics
Michele Cotrufo	The Institute of Optics
Joseph Eberly	Physics
James Fienup	The Institute of Optics
Michael Giacomelli	Biomedical Engineering
Chunlei Guo	The Institute of Optics
Jennifer Hunter	Ophthalmology (URMC)
Frank Huo	Chemistry
Krystel Huxlin	Ophthalmology (URMC)
Wayne Knox	The Institute of Optics
Todd Krauss	Chemistry
Brian Kruschwitz	Laboratory for Laser Energetics
Jennifer Kruschwitz	The Institute of Optics
Qiang Lin	Electrical & Computer Engineering
John Marciante	The Institute of Optics
Susana Marcos	The Institute of Optics
Ben Miller	Dermatology (URMC)
Duncan Moore	The Institute of Optics
Kevin Parker	Electrical & Computer Engineering
Pablo Postigo	The Institute of Optics
Will Renninger	The Institute of Optics
Jannick Rolland	The Institute of Optics
Gregory Schmidt	The Institute of Optics

Nick Vamivakas	The Institute of Optics
Gary Wicks	The Institute of Optics
David Williams	The Institute of Optics
Jim Zavislan	The Institute of Optics
Xi-Cheng Zhang	The Institute of Optics
Jon Zuegel	Laboratory for Laser Energetics

For more information about the research of the different faculty members, visit:
http://hajim.rochester.edu/optics/people/faculty/index.html

REQUIREMENTS FOR THE M.S. DEGREE IN OPTICS

Overview

The Master of Science Degree Program is designed to provide a student who has a strong undergraduate preparation in physics, electrical engineering or optics with the knowledge and skills to contribute to state-of-the-art optics research and development. A number of options are available within the general degree requirements to satisfy the needs of students with a variety of goals in mind.

- Students wishing to acquire basic training in optics to enter an industrial or governmental laboratory position can obtain that training in as little as nine months. This is attractive for engineers working in industry who desire the benefits derived from advanced study in optics. Employers are often willing to grant a leave of absence for this relatively short period of time.
- It is also possible to obtain the M.S. degree through part-time study, an option of particular interest to those working in the Rochester area.
- Students who would like to combine formal education with practical industrial experience may find the M.S. Co-op program of interest.
- Students who are about to complete a B.S. in Optics at the University of Rochester might wish to begin advanced study early by entering the BS/MS Program.

Students who wish advanced and specialized training in some particular area of optics can elect the Plan A thesis option or the Plan B (non-thesis) option with a Certified Specialty.

- The Plan A option generally requires 18 - 24 months to complete, but it allows the student to develop a high level of expertise in a specialized field.
- The Plan B option with a Certified Specialty allows for coursework to be more concentrated in a particular area than the standard, more general Plan B option.

Each of these options provide a solid preparation both for students wishing to continue on to doctoral studies in optics, physics or ECE and for students with career goals in optical engineering or entrepreneurship.

General Requirements

A minimum of 30 semester hours of credit is required for the M.S. degree in Optics. A minimum grade point average (GPA) of 3.0 is required in courses taken at the University of Rochester that are counted toward the MS degree. The GPA calculation will not ordinarily include reading courses and research credits. If the GPA requirement is initially not met, a course with a “C” or a “B-“ grade can be re-taken (with the old grade being replaced by the new grade in the GPA computation) or a new course can be taken.

The first ten credits can be transferred at no charge. However, after ten credit hours are transferred, tuition must be paid for each additional transferred credit. All transfer credits must be approved by the Optics Graduate Committee and by the Dean for Graduate Studies in The College.

Advisement:

Each incoming student is assigned an initial advisor to ensure that students have faculty advisement throughout their program. However, the initial advisor serves only from the start of the fall semester until April 15th.

Initial advisor matches are emailed to incoming students in early August, along with guidance on course registration and selection.

By April 15th of the their first year, MS students are required to seek out and secure a faculty advisor to serve as their advisor to the rest of their MS program. MS Thesis track/Plan A students will secure a research advisor who supervises the student's thesis research. MS Essay track/Plan B students will secure a program advisor that advises their MS coursework, gives advisor approvals for paperwork, and will serve as the first reader for their MS essay.

Students are responsible for reaching out to faculty and initiating the discussion about advisement. Once a advisor is secured, the student must inform the Graduate Coordinator by email by April 15th of their first year. The initial advisor is only a student's advisor until April 15th and cannot assumed to be a research or program advisor without direct confirmation from the advisor in question.

Plan A: Thesis Route

There is a required set of courses for the Plan A route (Consult page 10—Plan B—regarding substitution of Optics 461 for 463, 441 for 443, and 425 for 423.)

- Optics 443 – Fundamentals of Modern Optical Systems;
- Optics 463 - Wave Optics and Imaging;
- Optics 423 – Detection of Optical Radiation;
- Optics 456 - Optics Laboratory

Plan A Masters degree also requires:

- Any one additional 400- or 500-level Optics course;
- Thesis research (6 - 12 semester hours) and written M.S. Thesis;
- Successful Final Defense of the M.S. Thesis.

This plan contains a fair amount of flexibility, as the thesis research may be counted for a minimum of six and a maximum of twelve credits. A recommended program of study is to take six courses and seven hours of thesis research, which sums to the required 30 semester hours. Each student should work closely with his/her thesis advisor to decide how best to decide among the possibilities. MS thesis work typically requires an additional 6 to 12 months of additional research time, but often has the benefit of having financial support during that time if the thesis work is being done in support of a funded project.

The thesis route is available to all M.S. students, but some comments should be made about special cases. Students in the Institute's BS Program may be able to begin research in their senior year for the Bachelor's Senior Thesis and build on that research at the graduate level.

With early planning, they may be able to take graduate courses in the senior year as well.

It is possible for a part-time student to carry out the research in an industrial setting. However, the work must be public and publishable in the open literature and an Optics professor must supervise the research in a direct fashion in order to use that research for an MS thesis. To successfully arrange such a project, the student must get approval of detailed plans for the project both by the prospective faculty thesis advisor and by the company management. These same general remarks apply to students in the M.S. Co-op Program who wish to carry out thesis research during the industrial portion of the program.

Thesis

The thesis must show evidence of independent work based in part upon original material. It must demonstrate that the candidate possesses the ability to plan study over a prolonged period and to present the results of such a study in an orderly fashion. The thesis should also display the student's thorough acquaintance with the literature of a limited field.

Students completing a MS thesis must secure a research adviser. The adviser should be selected and approached by the student at the beginning of their second semester—preferably toward the end of the first semester.

The Examination Appointment Form must be filled out and filed. The thesis must be registered with the Dean for Graduate Education and copies given to the members of the Examining Committee at least two weeks prior to the Oral Examination (Final Defense of the thesis). Always consult the Graduate Academic Calendar to be sure of deadlines and watch for email notices from AS&E GEPA. If the thesis is accepted by the student's Examining Committee, two permanent copies (hardcopies, one bound & one unbound) must be presented to the Office of the Dean for Graduate Studies and one electronic or hard copy given to the Institute of Optics Graduate Program Coordinator.

Final Oral Examination

Each candidate for a Plan A M.S. degree in Optics must pass a final oral examination and thesis defense before a committee of at least three members of the faculty appointed by the Dean for Graduate Studies. One member will be from a department other than that in which the student has done the major portion of the work. No candidate may appear for the final examination until permission is received from the faculty advisor. The examination will not be held until at least two weeks have elapsed after <u>registration</u> of the completed thesis. A student who fails the final oral examination may require re-examination not less than four months later. No student will be allowed to take the examination a third time without a recommendation from the department and the approval of the Optics Graduate Committee.

GUIDANCE ON THE MS DEFENSE PROCESS:

Step-by-step instructions for the MS Defense is available via the [Graduate Student Resources – The Institute of Optics] folder in Box. This is the most comprehensive guide for the MS defense available. Please use this as your primary resource.

Plan B: Non-thesis Route

There are two versions of Plan B. The standard version provides a general coverage of the important areas in optics. The version with a Certified Specialty allows for more concentrated study in a particular area.

Standard Plan B

There is a required set of courses for the Standard version of Plan B:

- Optics 443 – Fundamentals of Modern Optical Systems
- Optics 463 - Wave Optics and Imaging;
- Optics 423 – Detection of Optical Radiation;
- Optics 456 - Optics Laboratory

  Upon approval by a student's advisor, an MS student may substitute OPT 441 for OPT 443, OPT 425 for OPT 423, and/or OPT 461 for OPT 463, which could be advisable if the student has a definite plan to apply for a PhD program to begin immediately after the MS. (OPT 423, OPT 443, and 463 are designed to better prepare a student for an immediate job.)

  For any course that has OPT 425 , OPT 461, or OPT 441 as a prerequisite, then OPT 423, OPT 463, and OPT 443 respectively serve to satisfy that prerequisite.

In addition to these core requirements, the following are required for this plan:

- One additional course in Physical Optics;
  - examples: Optics 422 Color tech S, 446 coatings F, 447 adv coatings S, 450 polarization S (not in 22), 452 Med theory & imaging (Parker), 462, 468, 535, 561 advanced Fourier, 564
- One additional course in Geometrical Optics;
  - examples: Optics 432, 433, 442, 444 lens design, 449
- One additional course in Quantum Optics;
  - examples: Optics 412 quantum opt, 421, 428, 453, 464, 465, 467
- One additional course to reach a total of 30 semester hours;
- A research essay written under supervision of a faculty member on a selected topic. The final version of this essay should have signed approval of the faculty member supervising the essay, and signed approval by a second reader. Students should always consult the Graduate Academic Calendar to be sure of deadlines.

NOTE: The examples above do not constitute comprehensive or complete lists of courses that fill Physical, Geometrical, & Quantum requirements. Core required courses cannot be used to simultaneously satisfy the core requirements **and** ***additional course requirements in the areas of Physical Optics, Geometrical Optics and Quantum Optics. See the course listing to identify additional courses that satisfy the area requirements or the Course List by Area Requirement in the appendices.***

The complete list of additional courses that can be used to satisfy the requirements above varies as new courses are introduced and old courses are modified or discontinued. Students should consult with their faculty advisors about which courses can be used for these categories during their period of study. The elective course (fourth item above) is normally a 400- level Optics course. A 400- or 500-level course in another departments (such as Physics, Electrical & Computer Engineering, or Mathematics) may be substituted if the course is relevant to the student's program of study as confirmed by the permission of the faculty advisor.

Plan B Specialty Courses

Plan B students may have an interest in a particular area of optics. Courses have been divided up into areas of interest and faculty that perform research in such areas, for students that wish to take more courses that are aligned with their interests. Like the standard, more general version of Plan B, at least 30 hours of coursework and the completion of research essay are required. Students that are pursuing courses aligned with their interests are not required to fulfill a second course in physical and geometrical optics. The special interest disciplines are summarized in the Table and courses available are listed in the Appendix. Specialty areas are only for the benefit of the student and will not show up on their degree upon graduation. Students interested pursuing specialty courses should meet with their advisor to go over course selection, and indicate these courses on their Program of Study.

Optics MS Specialty Areas

Specialty Area	**Specialty Institute Faculty**
Optical Communications	Agrawal, Brown, Cardenas, Knox
Nonlinear Optics	Agrawal, Boyd, Cardenas, Guo, Renninger, Zhang
Optical Materials	Cardenas, Postigo, Wicks
Laser Engineering	Guo, Eberly, Renninger, Zhang
Biomedical Optics	Berger, Cardenas, Foster, Knox, Renninger, Rolland, Williams, Zavislan
Image Science	Fienup, Rolland
Optical Design, Fabrication and Testing	Bentley, J. Kruschwitz, Moore, Rolland, Zavislan,
Nano- and Integrated Photonics	Cardenas, Lin, Krauss, Postigo, Vamivakas, Wicks

All must take:

- OPT 443 or 441 (Foundations of Modern Optical Systems or Geometrical Optics);
- OPT 463 or 461 (Wave Optics and Imaging or Fourier Optics)
- OPT 423 or 425 (Detection of Optical Radiation or Radiation and Detectors)
- A quantum optics course such as OPT 465 (Lasers)
- OPT 456 Lab – Except for part-time, in-person students

NOTE: All special interest (Specialty) areas available are listed in the Appendix.

Considerations for part time MS and BS/MS Students

Under some circumstances students will complete all or part of their MS program while in full time employment that includes technical responsibilities in optical science and technology. In such cases where the student has already accumulated considerable lab experience while employed, the optics 456 laboratory requirement may be waived provided the student provides, to the graduate advisory committee, suitable proof of laboratory experience. This consideration may be extended to either Plan A, Plan B, or MS Co-Op students. However, waiver of the laboratory requirement does not reduce the total number of credits required for completion. Another course must be substituted for Optics 456 in order to reach at least 30 credits for the MS program.

Please NOTE: The Optics Laboratory course has a wide scope that is rarely fulfilled by typical lab work. Students requesting a waiver of the Optics Laboratory requirement must reach out to the Graduate Coordinator for the Waiver Request form. Part-time students have the option of taking the HOME version of the Optics Laboratory course (see the HOME guidance section for more details).

Students in the BS/MS Program frequently take 400-level Optics courses during their senior year. If the courses are used to satisfy the total credit requirement for the undergraduate degree, they may not be counted in the total credit requirements for the MS degree. However, 400 level courses taken as an undergraduate will count toward both core and specialty requirements. Students admitted to the BS/MS Program should work closely with their faculty advisors to develop an appropriate academic program.

The Master's Essay (Plan B)

The MS essay consists of a brief but comprehensive overview, including an appropriate bibliography, of the state of the art of a given area in optical science and/or technology. This essay must be supervised by a member of the Optics faculty, which can include professors with a joint or adjunct appointment in Optics.

Its main body should have a length of 10 to 15 pages (1.5 spacing), including figures and bibliography. The cover page should include the title, name of the student, submission date, as well as signatures of the faculty supervisor and a second faculty member who have read and approved the essay, as shown in the included cover page template. The student is expected to spend approximately 40 hours in the preparation of this document.

The student is responsible for securing two faculty readers of the MS Essay, the Essay Advisor and another professor who has agreed to be the second reader. The Essay Advisor is responsible for the detailed quality of the essay. The second reader is to provide a pass/fail sanity check. If the Essay Advisor is a joint or adjunct member of the Optics faculty, the second reader must be a full-time Optics faculty member. The Essay Advisor is not required to be the same as the initial advisor assigned to incoming students.

The end of the semester and academic year makes extra demands on everyone's time. **Students must follow the timeline below to graduate on time.** Deadlines & timelines for December or Summer conferrals are distributed by the graduate coordinator via the OptStudents mailing list (which distributes emails to their graduate student email accounts). Any emailed timelines/deadlines supersede the timeline below.

GUIDANCE ON THE MS ESSAY PROCESS:

Step-by-step instructions for the MS essay is available via the Graduate Student Resources – The Institute of Optics folder in Box. This is the most comprehensive guide for the MS essay available. Please use this as your primary resource.

The timeline and submission of documents for the MS essay is now managed through Blackboard. Please alert the Graduate Coordinator when you are planning to complete the MS essay in order to be added to the MS Essay Blackboard.

SCHEDULE FOR DECEMBER GRADUATION:

September 15:

- Consider topic for MS Essay, as well as faculty to be the Essay Advisor & second reader.

October 15:

- The student must provide a signed Program of Study form and an Intent to Graduate Form to the Graduate Coordinator
- The student must submit a title, abstract, and list of references for the desired topic to the Essay Advisor and to the Graduate Coordinator, identifying the Essay Advisor.

November 15:

- The student must submit a finished first draft to the Essay Advisor who will suggest necessary changes. Concurrently submit a copy to the Graduate Coordinator. The student must identify the second reader.
- Begin corrections as soon as possible. After a first round of changes, send the second draft to the second reader as well as the Essay Advisor for further comments.

December 8:

- The final version of the essay, endorsed by the Essay Advisor and the second faculty reader, must be submitted to the Graduate Coordinator.
  - This final submission should include the "Examination Report Form" signed by the readers. Return this with the final essay to the Graduate Coordinator.

The student is strongly encouraged to begin work on this essay at the very beginning of Fall semester or sooner.

SCHEDULE FOR MAY GRADUATION:

End of Fall Semester:

- Master's Program of Study Form has been submitted to GSO.
- Consider topic for MS Essay.

March 16:

- The student must provide a signed Program of Study form and an Intent to Graduate Form to the Graduate Coordinator
- The student must submit a title, abstract, and list of references for the desired topic to the Essay Advisor and to the Graduate Coordinator, identifying the Essay Advisor.

April 4:

- The student must submit a finished first draft to the Essay Advisor who will suggest necessary changes. Concurrently submit a copy to the Graduate Coordinator. The student must identify the second reader.

- Begin corrections as soon as possible. After a first round of changes, send the second draft to the second reader as well as the Essay Advisor for further comments.

April 28:

- The final version of the essay, endorsed by the Essay Advisor and the second faculty reader, must be submitted to the Graduate Coordinator.
    - This final submission should include the "Examination Report Form" signed by the readers. Return this with the final essay to the Graduate Coordinator.

The student is strongly encouraged to begin work on this essay before the start of the second (final) semester.

Please NOTE: The conferral deadlines are updated and released by GEPA partway into Fall & Spring semesters and the dates above are subject to change in order to comply with the updated GEPA deadlines. Emails with updated guidance will be sent through OPTSTUDENTS@lists.rochester.edu once updated guidance is received.

MS ESSAY GUIDE:

The MS Essay must be formatted according to the guidelines listed below. Please take particular care to have the proper formatting of the cover page.

Cover Page format:

Thesis Title Typed in Upper and Lower Case Letters (not all caps or all lower case)
by
Your Name (no degree credentials)

Master's Essay
Submitted in Partial Fulfillment of the
Requirements for the Degree
Master of Science
Supervised by Professor (Your advisor's first and last name --- no credentials; may include middle name or initial as appropriate)

The Institute of Optics (This is the name of our department)
Arts, Science, & Engineering
Edmund A. Hajim School of Engineering and Applied Sciences

University of Rochester
Rochester, New York
(year of submission)

Determination: _______ PASS
_______ FAIL

____
Professor (Advisor/First reader first and last name), First Reader Date

____
Professor (Second reader first and last name), Secondary Reader Date

Labelling Guide for Essay Sections:

ABSTRACT (no section number)

1 INTRODUCTION

2 BACKGROUND

3, etc SECTION TITLE (additional sections as appropriate, labelled in capital letters)
3.1 Subsection Title (subsections should be labelled Section #. Subsection # followed by the subsection title in upper and lower case --- not all caps)

CONCLUSION

References (no section number, in capital and lower case, not in all caps like section titles)

Formatting Guide:

- 11 pt font or larger for the body of the essay
- 9 pt font or larger for figure descriptions
- Margins must be at least 1”
- Figures must be labelled
- References must be numbered and listed in the same style (use only one citation format)
- Check references, and figure and section labelling for consistency
- Include page numbers in the bottom right hand corner of the page
  - Do NOT include a page number on the cover page
- There is no page limit or minimum length requirement
  - Typically, Master’s essays are 10-15 pages in length, including cover and references

Guidance for HOME (Hybrid Optics Master's Education)

The HOME program confers an Optics MS degree that is identical to the traditional in-person MS degree. All degree requirements, including course requirements and the final requirement (MS Essay). Nearly all HOME students will complete the MS Essay instead of the MS Thesis, unless they switch to the in-person version or there is a joint research project between an Optics advisor and the student's employer. Please connect with the Graduate Coordinator to discuss if the MS thesis is an option for you as a HOME student.

HOME Lab Requirement:

HOME students have several options for completing the Optics Laboratory requirement. The options available for HOME students (454 & 401, 402, 403) are only 3 credits total, instead of 4 credits. The HOME options fulfill the program requirement, but students must still complete at least 30 credits to satisfy the requirements of the MS degree.

Course	**Offered**	**In-person Duration**	**Credits**	**Notes**
OPT 401 First HOME Lab	At beginning of Fall & Spring semesters, OR during summer session	A long weekend (for Fall & Spring offerings), OR a one-week (for summer offering)	1	401 must be taken before OPT 402 or OPT 403
OPT 402 Second HOME Lab	At beginning of Fall & Spring semesters, OR during summer session	A long weekend (for Fall & Spring offerings), OR a one-week (for summer offering)	1	Prerequisite: OPT 401 403 can be taken before 402
OPT 403 Third HOME Lab	At beginning of Fall & Spring semesters, OR during summer session	A long weekend (for Fall & Spring offerings), OR a one-week (for summer offering)	1	Prerequisite: OPT 401 403 can be taken before 402
OPT 454 HOME Lab	During Summer session	3-week duration	3	
Optics Lab Short Course Series	*During Summer Session*	*3-week duration*	***0***	*Students who complete the Summer Short Course on Optics Laboratory skills may petition to have their Optics Laboratory requirement waived. However, they must still complete at least 30 credits for their degree.*
OPT 456 Optics Laboratory	Fall & Spring semesters	Full semester	4	This is the in-person, traditional offering of Optics Lab

OPT 456 Optics Laboratory is an in-person course offered each Fall and Spring. It is poorly suited to remote students as it requires in-person attendance throughout the semester. HOME students may elect to take this version but are advised that it requires in-person attendance for a full semester.

Course Loads & In Absentia Status

HOME students are encouraged to take 1 course (4 credits) during their first semester, especially if they are working full-time. The vast majority of HOME students take 1 course per semester in order to avoid overloading their schedule. Students working full-time should take no more than 2 courses per semester.

HOME students are not barred from taking a full-time course load (9 credits or more/typically 3 courses or 12 credits). However, HOME students with a full-time course load incur in-person student fees (mandatory health fee, student activity fee) and fall under the health insurance requirement unless they also complete an in absentia approval process. Please contact the Graduate Coordinator before the end of Add/Drop registration to set up your in absentia status.

Course Selection & Registration:

The University of Rochester only offers remote courses for the HOME program, the Warner School of Education, and the Simon School of Business. As a result, the UR Student system used for registration **does not accurately reflect the delivery method of HOME-friendly courses.** All courses in UR student are listed as in-person if there is an in-person room booked even if it is truly a hybrid course.

To identify which courses are suited to the HOME program, please view our HOME course guide: http://www.hajim.rochester.edu/optics/graduate/home-courses.html

To plan for future semesters, please see the typical course offering schedule on this page under “Curriculum”: https://www.hajim.rochester.edu/optics/graduate/ms-home.html

Changing MS Track:

MS Students may change from in-person to HOME (or the reverse) at will on a semesterly basis by alerting the Graduate Coordinator via email. The changes to your student status (in absentia or in-person) are reflected through registration for full-time students, so be sure to alert the Graduate Coordinator before the end of Add/Drop to avoid complications.

In UR Student, HOME students are listed in OPO, while in-person students are listed in OPT. If you notice that you are improperly listed, please alert the Graduate Coordinator. OPO vs OPT can affect what fees you receive and has additional administrative effects for the department.

M.S. Cooperative Program

The curriculum and requirements for this program are the same as those for our regular program. The program consists of three blocks: 1) a four-month, full-time (16 credits) Fall semester at the University of Rochester; 2) a twelve-month "work block" in industry or at a government lab, and 3) a second four-month semester, a full-time (16 credits) Spring semester, at the University of Rochester to complete the Masters program.

In order for the student to participate in the work block, they must satisfactorily complete the Fall semester academic block. Failure to do so will result in termination from the program. Students will, of course, have to fulfill the normal conditions of employment at the various corporations (these conditions may include, for example, passing a health examination, signing nondisclosure agreements, etc.). During the work block, the student will be paid wages comparable to those of other employees with similar educational backgrounds and experience.

Interviews for the work block are held on campus during the Fall semester, usually in October or November. Students are admitted to the M.S. Co-Op at the discretion of the Graduate Admissions Committee and only after the student has been placed with a company.

During the time the student is employed in industry, they will be registered for the Co-op program (OPT 894, which carries zero credits) and will have all of the normal rights and privileges of a matriculated student, even though he or she is not in residence during that period. For both the Spring semester of the first year and the Fall semester of the second year, the student will need to pay the OPT 894 course fee (currently $1,035) as well as the mandatory health fee and health insurance (although this might be able to be waived) and any appropriate student fees. During the summer after the first year, the Spring registration carries through, so the student would remain full-time but not need to register for anything.

Filing of M.S. Program of Study Form

Each student must submit a proposed masters degree program for approval by the department and by the Dean for Graduate Studies. The student should list the courses they have taken, and intend to take, to fulfill the requirements for the M.S. degree. These are submitted on an official form after consultation with the student's advisor. It is the student's responsibility to see that this form is filed <u>by the end of the first semester to be kept on file as a plan for future semesters</u> A final Program of Study with all courses accurately listed must be submitted before or early in the final semester of the MS program for filing with GEPA.
Alterations in the program can be made almost any time. This form must be approved and on file before a student may begin work on the MS Thesis or Essay as it is required for MS program completion. The purpose of this form is to allow the Graduate Coordinator and GEPA Registrar to monitor each student’s compliance with the plan of courses which satisfy the M.S. requirements. If plans are changed or modified, the Graduate Coordinator must also be duly notified.

Forms are available on line:
http://www.rochester.edu/college/gradstudies/current/policies/.

REQUIREMENTS FOR THE PH.D. IN OPTICS

I. Overview

The Official Bulletin of Graduate Studies describes the general requirements for a Ph.D. as: "The degree of Doctor of Philosophy is awarded primarily for completion of scholarly work, research, or outstanding creative work satisfactorily described in a dissertation. It is assumed that recipients of this degree are well versed in the subject matter and research techniques of a specific discipline and have demonstrated breadth of interest and originality of outlook that indicate promise of success in future research and teaching."

It is expected that a student completing this program in Optics will be ready to assume a role as an independent researcher in a university, industrial, or government laboratory. Most of the time in the program is devoted to learning specialized research skills and carrying out thesis research. However, it is also important that the student master the subject matter and develop a breadth of interest in the whole field of optics. To this end, a set of required core courses, a number of elective courses and a Preliminary Examination are included in the program.

The outline below illustrates a student's progress in the Ph.D. program. Details are given in subsequent sections.

First Year
Full time coursework and study
Attend Optics Colloquia
Choose Thesis Advisor by 4/15
Summer Research
Preliminary Examination

Second Year
Advanced specialized coursework
Attend Optics Colloquia
Teaching Assistantship
Research
File Program of Study Form

Third Year
Thesis Proposal
Oral Qualifying Examination
Elective Courses
Research

Fourth Year and Beyond
Research
Elective Courses (as needed)
Thesis submission
Oral Thesis Defense

II. Entering Orientation

The students meet with the Director and the Graduate Committee Chair during an orientation meeting. They work with a Faculty Advisor assigned to them to plan course schedules for the first year. Students who have taken graduate courses prior to their enrollment in the Ph.D. program may take courses other than the ones on the standard program. The initial Faculty Advisor is replaced by the thesis Advisor at the end of the first year. Students are responsible for seeking and confirming their thesis Advisor.

III. First Year of Graduate Study

First-year financial support is usually in the form of a fellowship allowing the student to devote full time to course work. The full load is 17 hours of credit per semester. The purpose of this year's work is to provide a broad background in optical physics and engineering. The following is recommended to provide a broad survey of optics.

Fall	Spring
OPT 411 Mathematical Methods for	Opt. OPT 442 Instrumental Optics
OPT 425 Radiation & Detectors	OPT 462 Electromagnetic Waves
OPT 441 Geometrical Optics	OPT 412 Quantum Mechanics for Optics
OPT 461 Fourier Optics	(1) Elective Course
OPT 596 Optics Colloquium	OPT 596 Optics Colloquium

With the exception of the elective, these courses are core courses and are normally required for a Ph.D. They can be waived by petition to the Graduate Committee in those cases where they seem inappropriate for a student with an unusual background or interests.

Students should consult the schedule of courses to determine what courses are available. The elective could be a course which covers some of the material included in the preliminary examination. Students that are interested in engaging in research early on can substitute this course by research credits under the supervision of a faculty member.

A final, very important part of the first year program is getting acquainted with the faculty, advanced students, and research in The Institute. Students should make a point of meeting and getting acquainted with every faculty member. They are welcome to stop in and see what is going on in the laboratories. They are strongly encouraged to attend as many "What's Up in Optics" presentations as possible.

Starting Fall 2019, all 1st & 2nd year PhD students are required to take 4 credits of OPT 596 Optics Colloquium (taken as 4 individual 1-credit courses in the first 4 semesters of their PhD program. OPT 596 has a Satisfactory/Not satisfactory grading scale. To receive a Satisfactory grade (and "pass" the course) students must attend 75% or more of the colloquia in that semester. Note: students who began their PhD program prior to Fall 2019 are exempt from the Colloquium requirement, but can opt into the Colloquium requirement by emailing the Graduate Program Coordinator and completing 4 credtis of OPT 596 (taken 1 credit per semester).

Normally, the first summer is spent working with a faculty member on a research project both before and during the process of preparing for the preliminary exam. Students should talk with faculty members whose research areas are of interest and select a thesis advisor. The arrangements should be made by **April 15th.**

The Department requires that, before the end of the summer, students prepare the Program of Study form, have it signed by their advisor and returned to the Graduate Coordinator.

IV. <u>Credit and GPA Requirements</u>

90 credit hours are required for the Ph.D. program. There is some flexibility in how the credit hours are allotted (research credits vs. course credits); however, each student must meet the following minimum requirements:

- 48 credit hours of course work in Optics or other subjects that have relevance to Optics.
    - At least 8 hours of the course work required for the Ph.D. must be in advanced courses, which include any 500-level course and any 400-level course that has another 400-level course as a prerequisite, and all courses marked as Advanced Courses in the Handbook course listing (see pages 31 – 43) .
        - These may be in Optics or in other subjects that have relevance to optics.
        - The Optics courses that satisfy this requirement are identified by an asterisk next to their title in the “Graduate Course Description” section of this handbook.
        - Reading courses (Optics 591), research credit (Optics 595), the Optics Colloquium (OPT 596), and the seven required 400-level courses do not fulfill this advanced course requirement.
- 30 credit hours of research (OPT 595 PhD Research in Optics)
- 4 credit hours of Optics Colloquium (OPT 596) taken in the first 4 semesters of the PhD program
- The remaining minimum of 8 credits can be Optics coursework, research credits, reading courses (OPT 591), internships (OPT 594), or other relevant course credits.

If a student has a M.S. degree prior to enrollment in the Ph.D. Program, she/he can transfer up to thirty credit hours of the M.S. degree toward the 48 hours of course work required for the Ph.D. once it is approved by the Dean for Graduate Studies.

A minimum grade point average (GPA) of 3.0 in courses taken at the University of Rochester counted toward the Ph.D. degree is required for graduation. Additionally, students taking the Ph.D. preliminary exam are expected to have a GPA of 3.0 or higher for the graduate courses taken at the University of Rochester. Students whose GPA is lower than 3.0 who wish to take the preliminary exam must write a petition to the Graduate Committee Chair.

V. Ph.D. Preliminary Examination

The examination consists of three segments and during the summer, typically before the start of the third semester of graduate study. Each of the three-hour segments of the examination is taken on a separate day. Further details are given later in the Guide to the Ph.D. Preliminary Examination.

Faculty grade their respective exam questions. Thereafter, the scores are presented to a faculty review board. Passing the preliminary exam is dependent not only on proficiency shown on the test, but also on the student's entire body of work including past course work, past and current research activity within The Institute, and recommendation from his/her advisor and other faculty.

Students are placed in three categories: "pass", "conditional pass/pass with remediation", or "fail", and receive notification of their status via letter from the graduate committee chair. Students who fail are allowed to take the test a second time the following year.

"Conditional pass" means that the student’s performance in one or more parts of the exam requires some mandatory remedial action, specified in the notification letter. Such remedial action could consist of taking a related course, writing an essay on the topic, or taking an oral exam on the topic(s), as determined by the faculty grader of the question.

Prelim Readiness Assessment:
In order to take the Prelim exam, students must have at least a 3.0 GPA, complete all core courses (411, 412, 425, 441, 442, 461, & 462), and have secured a research advisor. Students who do not meet these requirements must request permission from the Graduate Advisory Committee to take the prelim exam no later than May 15th.

To confirm that these requirements have been met, students must submit a Prelim Readiness Assessment form to the graduate coordinator by May 1st. The Prelim Readiness Assessment form is included at the end of this Handbook and in the Graduate Student Resource Folder here: https://rochester.box.com/s/jiweywzxspggp1y5klk5y5oxjxtg0mve

VI. Second Year of Graduate Study

During this year, the student takes courses in advanced subjects and concentrates in some area of specialty in preparation for Ph.D. research. Note that to be considered a full-time graduate student, the College requires a minimum of 12 credit hours per semester, or 9 hours for a Teaching Assistant (TA) or Research Assistant.

During the second year, students usually fulfill their TA requirement, which is two semesters of service. This service is required whether or not the student has received financial support from the University. It is the intent of the Optics faculty that this teaching should be more than merely grading papers for a course and should include some sessions in the classroom.

The student will also complete 2 additional credits of Optics Colloquium to complete the requirement (4 total credits, OPT 596).

During this year, the student should become familiar with some of the research in their area and should discuss possible thesis research topics with his/her thesis advisor. This discussion leads to the preparation of a research proposal, which is discussed later in this section.

VII. Thesis Proposal and Oral Qualifying Examination

According to University regulations, the oral examination is the official Ph.D. Qualifying Examination. However, the written Preliminary Examination must be passed to become eligible to take the oral examination. The Qualifying Examination should be taken <u>no later than 21 months after the student successfully passes the Preliminary Examination</u>.
The procedure is as follows:

1. The student finds a prospective thesis advisor and selects a topic for Ph.D. research.
2. The student prepares a written document which describes the proposed research. This Thesis Proposal shall be no longer than 12 pages in length, not counting additional page(s) for references. It includes a brief literature survey and should convince the reader that the candidate is aware of the problems he or she is attempting to solve and has some inkling of how to solve them (the section "A Guide to the Preparation of Ph.D. Thesis Proposals" provides more details.). The thesis proposal will be circulated (in electronic form) to all the Optics faculty members by the Graduate Coordinator. Provide an electronic copy to Graduate Coordinator at least two weeks before the examination.
3. The student prepares a 25-30 minute presentation for the oral examination. The committee members can ask questions during and following this presentation. The question session can take up to one and a half hours.

The thesis advisor and committee members sign the Examination Report Form (checking PhD Qualifier) and indicate whether the candidate failed or passed. A copy is kept on file by the Graduate Coordinator and the original is submitted to the Graduate Studies Office.

Note: The thesis proposal should not be delayed past 21 months after passing the Preliminary exam. The student is not obligated to complete their final thesis on the exact topic of their thesis proposal.
The thesis proposal/qualifying exam is a valuable exercise in research/thesis planning & writing, and it triggers the creation of the student's Thesis Advisory Committee, which is also a crucial resource for the student.

GUIDANCE ON THE PhD QUALIFYING EXAM PROCESS:

Step-by-step instructions for the PhD Qualifying eam is available via the Graduate Student Resources – The Institute of Optics folder in Box. This is the most comprehensive guide for the qualifying exam available. Please use this as your primary resource.

VIII. Filing of Ph.D. Program of Study Form

The student should list the courses he or she has taken or intends to take to fulfill the requirements for the Ph.D. These are submitted on an official form after consultation with the thesis advisor. It is the student's responsibility to see that this form is filed by the end of the first year of graduate study. Alterations in the program can be made at a later time. Forms are available on line:
http://www.rochester.edu/college/gradstudies/current/policies/. The purpose of this form is to allow the Registrar to monitor each student's compliance with the plan of courses which satisfy the Ph.D. requirements. If plans are changed or modified, the Registrar must also be duly notified.

IX. Annual Progress Reports

Starting in the Spring semester of the second year of graduate studies at The Institute of Optics, each Ph.D. student must write a brief report describing the activities carried out during the last twelve months (including research, publications, conference attendance and presentations, courses taken, TA and other service, academic visits, etc.). The report should also include a list of objectives for the following twelve months, as well as for the rest of the Ph.D. studies. The student must use the form entitled "Ph.D. Student Annual Progress Report" included later in this handbook. This form must be completed, and sent by email to the Academic Advisor, all Thesis Advisory Committee members (in the case of students who have passed their qualifier exam), the Graduate Coordinator and the Graduate Committee Chair, by May 29. The completion of this requirement is mandatory; students will be allowed to register the following Fall semester only if they have submitted their Annual Progress Report.
See Appendix for Annual Progress Report form.

Note: The Graduate Education Office sets the exact requirements for the Annual Progress Report & may change the format, content, or method of administering the Annual Progress Report.

X. <u>Thesis Advisory Committee</u>

The regulations of the School of Engineering and Applied Science require that a Thesis Advisory Committee be appointed for each student, and that it meet periodically to review the student's research. This committee is formed at the time of the oral qualifying examination and is sometimes referred to as a defense committee.

The program of research undertaken by the student will be reviewed by the committee. It is recommended that the committee will will meet with the candidate not less than once each academic year. The committee will report to the Dean that it has met and reviewed the progress of the candidate. A copy of this report will be placed in the student's file. It is the student's responsibility to see that the Advisory Committee meets. The purpose of this committee is to provide guidance and advice and to see that the program is leading toward a thesis.

In Optics, typically members the Oral Qualifying Exam Committee, the PhD Thesis Advisory Committee, and the Final Oral (thesis defense) Examining Committee are the same people, but they need not be. Following the rules of the college, the minimum membership of these committees are three faculty: two with primary appointments in Optics and one with a primary appointment outside of Optics (which may include those with secondary appointments in Optics, such as N. Bigelow, J. Eberly, T. Foster, T. Krauss, F. Huo, and Q. Lin).

Note: If the advisor does not have a primary appointment in Optics, then he/she becomes a third “inside reader” and cannot count as the outside member. The dean of graduate studies may be petitioned to approve as a committee member someone other than a full-time faculty member (e.g., a senior research associate or an adjunct faculty member) to serve on the committee as an outside member using a Petition for Non-Standard Committee Member form (available here: http://www.rochester.edu/college/gradstudies/current/policies/.)

XI. Requirements for Formal Progress Review

1. A thesis advisory committee must be in place before the end of the third year of study.

2. Any student who has not passed his or her oral qualifying exam by the middle of year four must meet with each member of the thesis advisory committee each semester and file a report of that meeting with the Graduate Coordinator.

3. Every student must take and pass the oral qualifying exam (thesis proposal) before the end of the fifth year of study.

4. Any student who has not completed degree requirements before the end of year six must prepare, in consultation with his or her advisor, a schedule, including intermediate goals, for completing the degree. This schedule will be reviewed with each member of the thesis advisory committee either individually or collectively each semester until the degree is completed.

5. Any student undertaking thesis research supervised by a professor without primary appointment in Optics must have a thesis advisory committee in place by the end of the second academic year, or by the end of the semester after joining such a research group if that occurs after the end of the second academic year.

Failure to fulfill these requirements can prevent a student from registering. Failure to maintain registration will lead to dematriculation.

XII. Preparation of the Ph.D. Thesis and the Final Oral Examination

The cost of typing, illustrating, reproducing, and binding a thesis is borne by the student. Details on the format of the thesis, etc., are given in a document called "The Preparation of Doctoral Theses", available on-line at http://www.rochester.edu/Theses/.

Once the student is ready to defend, he/she should speak with the Graduate Coordinator about the necessary steps required to register for the thesis defense. The University's Official Bulletin of Graduate Studies gives details on the selection of the Final Oral Examination Committee, the scheduling of the examination, and so on. Each student is required to provide one bound copy of the finished thesis to the Graduate Coordinator for the departmental archives. The Final Oral Examination consists of two parts: 1) a one-hour public presentation (50 minutes of talk plus 10 minutes for questions by the audience), and b) a closed-door oral examination by the Committee.

The student must refer to the PhD Defense Instructions for Students and Faculty, available in the Graduate Student Resources – The Institute of Optics folder in Box.This should be your primary resource as it is specifically written for Optics PhD student and faculty.

The AS&E Graduate Education (AS&E GEPA) office also provides resources on preparing for the PhD defense. The AS&E GEPA guide, "Preparing for a PhD Defense" is available here: http://www.rochester.edu/college/gradstudies/phd-defense/index.html.

The thesis must strictly adhere to the Thesis manual provided by AS&E GEPA, available here: http://www.rochester.edu/theses/ThesesManual.pdf

Scheduling for a final defense should begin 3 months in advance and take into accound AS&E GEPA deadlines for degree conferral and the University of Rochester academic calendar. The should should refer to the PhD Date Calculator to set a timeline for their defense: http://www.rochester.edu/college/gradstudies/phd-defense/datecalculator/index.html

XIII. Duration of Program

Time for completion of the Ph.D. degree varies in the range of 4 to 7 years. Students entering a Ph.D. program with a Bachelor's degree are expected to complete the Ph.D. degree within six years. Those entering a Ph.D. program with a Master's degree are expected to complete the Ph.D. degree within five years. Students who have not graduated by the end of their sixth year in the program must meet with the Optics Graduate Committee and the Director of The Institute of Optics to discuss their progress and/or complete a Time to Degree Completion Petition.

XIV. Other Topics

This document is a supplement to the Official Bulletin for Graduate Studies. Details of university-wide regulations are found in the Bulletin and are not always included here. Make sure you are aware of all the regulations mentioned in the Official Bulletin for Graduate Studies.

A. Foreign Language Requirement

There is no foreign language requirement for the Ph.D. in Optics.

B. Compatibility of the M.S. and Ph.D. Degree Requirements

The Masters Degree in Optics is a valued degree in its own right, and is not a consolation prize for students who do not meet the standards for the Ph.D. The Masters degree is not automatically granted to anyone satisfying the Ph.D. requirements. It is possible, however, to satisfy the M.S. requirements while working for the Ph.D. by satisfying the appropriate course requirements, filing an approved M.S. program form, and completing the Master's Essay. Another option for Ph.D. students who have fulfilled the M.S. course requirements is to submit a published paper or to complete their Ph.D. Qualifying Exam and substitute their Ph.D. proposal for the essay. In both cases, the paper or proposal must have a cover page that follows the MS Essay template.
This option allows the student to receive both degrees without delaying the Ph.D. (thirty graduate hours from an approved M.S. degree can be counted towards the ninety hours required for the Ph.D. degree in Optics). It is also possible for the Ph.D. student to do a Masters Thesis. This is not generally recommended because writing two theses seriously delays the completion of the Ph.D.A Ph.D. student can submit their Ph.D. thesis proposal or published paper to fulfill the Master's Essay requirement with research advisor approval and including a correctly formatted cover page.

Ph.D. students who wish to receive an M.S. degree can petition that the OPT 456 requirement be waived if they have performed extensive, diverse experimental work equivalent to OPT 456. The faculty or staff teaching OPT 456 must sign the petition and certify that the student's experimental experience is adequate. Students are advised that they will need to clearly demonstrate that they have covered the areas of work covered by OPT 456, which is rarely fulfilled by standard laboratory research experience.

C. Time Limitation on Incompletes

If a student needs to take an Incomplete for a course(s) due to unforeseen circumstances, the student must first contact the Graduate Coordinator. In order to receive an Incomplete, a student along with the professor(s) must write up a "Memo of Intent" (MOI) which states the timeline for completing the work. This memo needs to be signed by both the student and the professor (s) and filed with the Department and the Office of Graduate Studies.

The following is departmental policy on incompletes for Optics graduate students. An Incomplete (I) grade in an Optics course must be made up within four weeks after the start of the following semester unless otherwise stated in the MOI. At the end of this time, the Registrar's Office will be instructed to change the I to an E, unless another grade has been assigned. This means that students should:

a) (preferably) complete, within four weeks after the start of the new semester, all work required to change the I to a passing grade;
OR
b) complete enough work to justify a request for a time extension. Extensions will be granted solely at the discretion of the instructor, and are not automatic. Please note that positive action on both the student's part and the instructor's is required to prevent the I from becoming an E. It would be wise for students to check that required paperwork has been carried out.

D. Internships

Optics graduate students can take internships appropriate to their program of student with advisor approval.

Internship positions must be reported to the graduate coordinator at least **3 WEEKS** before the start date of the internship or as soon as the offer is received if 3 weeks lead time is not possible. Internships must be registered with GEPA, using the Research Internship Approval form, available form the Graduate Coordinator.

Internship should be timed according to the University of Rochester academic calendar. Students taking internships are registered for 1 credit of OPT 494 (MS Internship in Optics) or OPT 594 PhD Internship in Optics for each semester in which the internship takes place. Internships that start shortly before the end of a semester or end shortly after the beginning of a semester will still require registration for the internship credit for the partial semester(s). Tuition discounts are not applied if the student has already completed their program credits (30 for MS/90 for PhD).

Students studying on a F-1 Student visa must also complete a CPT form for the International Services Office (ISO) in order to document the work approval on the I-20. Failure to complete this paperwork risks terminating the F-1 visa or requiring repayment of internship pay received prior to approval.

Students interested in an internship must apply to internship/employment opportunies and receive an offer of employment. Students are encouraged to participate in the Industrial Associates' Symposium in Fall & Spring to connect with internship employers.

Internships should be paid with competitive wages. The Institute of Optics does not advise students to take unpaid internships and students should take caution with any internships that are unpaid, paid in-kind (i.e. unpaid but with room & board provided), or require a training fee.

E. In Absentia – Program Conducted Away from Campus

Students that are continuing their program outside of the University of Rochester campuses must alert the graduate coordinator. The graduate coordinator will instruct you in the completion of In Absentia paperwork as needed. HOME students are assumed to be In Absentia unless completing OPT 454 and do not need to notify the graduate coordinator.

In Absentia paperwork is used to document off-campus student activity in GEPA. It is also crucial for charging (and waiving) students fees correctly, and maintaining documentation for the ISO. In Absentia registration is completed at the time of In Absentia approval form submission. Please contact the graduate coordinator for the In Absentia approval form and further instructions.

Students in absentia for more than one year must re-submit a new In Absentia approval form at the beginning of each Fall semester to cover the new academic year.

F. Petitions for Exceptions to Policies & Procedures

No set of rules can be expected to handle properly every situation. Any student who feels that their educational needs would be better served if an exception were made to the regulations given in this handbook should first discuss the matter with a faculty advisor, the Graduate Program Coordinator, and with the Chair of the Graduate Committee. This is usually followed by a written petition for a formal waiver of the requirement. The petition should be in the form of a letter addressed to the Chair of the Graduate Committee stating the desired exception and providing appropriate supporting information. In the case of requests for waiver of a particular course requirement, a supporting letter from the instructor in the course is helpful.

It is important to understand that the Institute of Optics graduate committee and faculty have the authority to adjust, when appropriate, departmental program requirements, but does not have the authority to waive University-level regulations. Thus, any special circumstances requiring a waiver of College or University rules requires a petition to the University Dean of Graduate Studies.

REGISTRATION GUIDANCE

Full-time Status:
Full-time status is achieve through course loads or placeholder registrations.
Starting 2022-2023, 9 credits is the minimum for full-time status.

Students do not need to register for Summer semesters unless they are taking the HOME Optics Laboratory course (OPT 454), are visiting students through Global Visitor Program, graduating during August, or enrolling for the first time in Summer.

Changing Status:
MS students (in-person and HOME) can be full-time or part-time, and can change between full-time and part-time status on a semesterly basis by notifying the graduate program coordinator.
It is important to properly report full-time or part-time status changes to avoid issues with student fees, tuition discounts, and visa statuses.

NOTE: PhD students must maintain a full-time student status in order to receive their 100% tuition discount. Students who wish to move to a part-time status should contact their advisor and the graduate coordinator.

NOTE: Students with F-1 student visas must maintain full-time student status to maintain their visa eligibility.

Placeholder Registrations:
Placeholder registrations establish full-time status without any credits and appear in UR Student as having 0 credits. Students who fall below 12 credits (no TA duties) or 9 credits (with TA duties) should add a placeholder to their registered courses.

Students who have completed their course requirements will register for one of the following placeholders **in the section with their advisor listed as the instructor**;

MS Placeholder Registrations:

MS students may register for OPT 897 MS Dissertation **only one time** during their MS program. OPT 897 ensure full-time student status and does not incur a continuing enrollment fee.
MS students should register for OPT 899 MS Dissertation if they have already registered for OPT 897 before. OPT 899 incurs a continuing enrollment fee of $1,070.

NOTE: the course title for OPT 897 and OPT 899 is MS DISSERTATION, however, MS students do not complete dissertations. The course title is set by GEPA and cannot be adjusted. While there is a fine distinction between a thesis and a dissertation, this can cause confusion.

PhD Placeholder Registrations:

PhD students in their 3 year or earlier should register for OPT 997 PhD Dissertation.
PhD students in their 4th year or later should register for OPT 999 PhD Dissertation.

Other Placeholder Registrations:
Other placeholders will be registered directly with GEPA by the graduate coordinator as registration is not open to students. This includes registrations for in absentia placeholders, leaves of absence, internships, co-ops, visiting students, and summer degree conferrals.

Tuition Discounts & Credits for Program of Study:

The Dean's office provides the tuition discount noted in the offer/admissions letter. This coverage is for the required credit minimum only, which is 30 credits (for MS students) or 90 credits (for PhD students). Tuition discounts for credits over the required credit minimum must be requested from GEPA. Students requesting additional tuition coverage should send a detailed explanation of how the additional credits benefit/are necessary for their program to the graduate coordinator. The graduate coordinator will use that detailed explanation to request additional tuition discount.

As most courses are 4 credits, tuition discounts up to 32 credits (for MS students) is common and does not require special permission.

Tuition discounts for additional internship credits in particular are not commonly covered. Students are cautioned to plan ahead to ensure that any internship credits (1 credit per semester of internship) fall within the program credit minimum.

GRADUATE COURSE DESCRIPTIONS

Unless otherwise noted, all courses carry 4 hours of credit. **An asterisk (*)** after the course name indicates that this course satisfies the advanced course requirement.

OPT 407 – Scanning Electron Microscopy Practicum

Overview of techniques for using the SEM (Scanning Electron Microscope) and Scanning Probe (AFM, STM) and analyzing data. Students perform independent lab projects commensurate with their graduate research.
Last offered: Spring 2023

OPT 410 – Introduction to Augmented and Virtual Reality

This course provides a broad introduction to augmented and virtual reality (AR/VR) systems. The course involves lectures covering an overview of all aspects of the AR/VR domain, as well as individual work performed by each student aimed at providing more intensive training on various aspects of AR/VR. Topics covered in the lectures include history, conceptual origins, and design/evaluation principles of AR/VR technologies; overview of visual/auditory/haptic AR/VR interfaces and applications; visual perception; optics/platforms/sensors/displays; auditory perception and spatial audio; silicon hardware architecture and materials; graphics and computation; interfaces and user experience design; data processing and machine intelligence for AR/VR; introduction to AR/VR programming tools; societal implications and ethical aspects. At the end of the course, students will have gained familiarity with the techniques, languages, and cultures of fields integral to the convergent research theme of AR/VR.
There is a follow-up course to OPT 410 listed under OPT 438 Selected Topics in AR/VR (as OPT 411 has already been assigned to an unrelated course).
Last offered: Fall 2022

OPT 411 – Mathematical Methods for Optics & Physics

Advanced techniques utilizing vector calculus, series expansions, contour integration, integral transforms (Fourier, Laplace and Hilbert) asymptotic estimates, and second order differential equations.
Prerequisites: ME 201, 202 and permission of instructor
Offered each Fall semester

OPT 412 – Quantum Mechanics for Optics

This course covers the topics in modern quantum theory which are relevant to atomic physics, radiation theory, and quantum optics. The theory is developed in terms of Hilbert space operators. The quantum mechanics of simple systems, including the harmonic

oscillator, spin, and the one-electron atoms, are reviewed. Finally, methods of calculation useful in modern quantum optics are discussed. These include manipulation of coherent states, the Bloch spere representation, and conventional perturbation theory.
References: Cohen-Tannoudji, Diu and Laloe, Merzbacher, Schiff, Dirac.
Prerequisite: One course in undergraduate wave mechanics or permission of instructor.
Offered each Spring semester

OPT 413 – Introduction to Random Processes

Random signals and noise in linear systems. Selected topics in probability theory, random variables, random vectors, random sequences (random walk, Martingales, ARMA model, Markov chains), random processes (Poisson process, Gaussian process, Wiener process, Markov process), stationary and cyclostatioany processes, random process inputs to linear systems, ergodicity, filtering, linear estimation, bandlimited and bandpass processes.
Last offered: Fall 2022

OPT 414 – Detection Estimation Theory *

Cross-listed with ECE 441. Loss and utility; Bayesian inference; risk functions, randomized decisions, admissible decisions; empirical Bayes for unknown prior; Neyman-Pearson hypothesis testing, receiver operating characteristic; sufficient and minimal sufficient statistics and Rao-Blackwellization; unbiased estimation; minimum variance unbiased estimation and Cramer-Rao inequality, maximum likelihood estimation; nonparametric estimation of cdfs.
Prerequisite: ECE440 or equivalent, or permission of instructor.
Last offered: Fall 2022

OPT 421 – Optical Properties of Materials

Optical properties of materials, primarily via interaction of light with materials' electrons and phonons. Excitons, plasmons, polaritons. Optical processes: reflection, refraction, absorption, scattering, Raman scattering (spontaneous and stimulated), light emission (spontaneous and stimulated). Kramers-Kronig relations. Electrooptic effects and optical nonlinearities in solids. Plasmonics. Emphasizes semiconductors; metals and insulators, and gases also discussed.
This course consitutes one of the topics covered in the PhD Preliminary Examination.
This course fulfills the Quantum Optics course requirement for MS Plan B students.
Prerequisites: Undergraduate Quantum Mechanics
Last offered: Spring 2023

OPT 422 – Color Technology

Color Technology is more than just pigments, dyes, paints, and textiles. Everywhere in modern technology (smart phones, tablets, displays, lighting, cinema, printers, etc.) is the

need for a basic understanding of how we measure, identify, communicate, specify, and render color from one device to another. This course addresses color order systems, color spaces, color measurement, color difference, additive and subtractive color, and rendering of color images. The student will learn about color matching, lighting conditions, metamerism, and color constancy. At the semester's end, each student will have compiled a Color Toolbox with useful functions to derive different necessary color values within MatLab.
Prerequisites: Linear Algebra, MatLab
Last offered: Spring 2023

OPT 423 – Detection of Optical Radiation

The course covers modeling of optical radiation, human perception of light, emission of thermal radiation, statistics of light and detectors, basic parameters of photodetectors, and different types of detectors.
References: Robert W. Boyd, Radiometry and the Detection of Optical Radiation, Wiley, 1983, ISBN 0-471-86188-X; William L. Wolfe, Introduction to Radiometry, SPIE, 1998, ISBN 0-8194-2758-6; Bahaa E. A. Saleh and Malvin C. Teich, Fundamentals of Photonics, Wiley, 2007, ISBN 978-0471358329
Offered each Spring semester.
This course is designed and offered as a remote-friendly, hybrid course and is appropriate for in-person and HOME students.

ARCHIVED COURSE – OPT 424 – Fundamentals of Lasers (for external students)

Fundamentals and applications of lasers and laser systems, including optical amplification, cavity design, beam propagation and modulation. Emphasis is placed on developing the basic principles needed to design new systems, as well as an understanding of the operation of those currently in use.
Prerequisites: Permission of instructor. Not available for Optics and Physics graduate students.
Last offered: Fall 2012

OPT 425 – Radiation and Detectors

The course covers the following topics: emission of thermal radiation, modeling of optical propagation (radiometry), quantifying the human perception of brightness (photometry) and of color (colorimetry), fundamentals of noise in detection systems, parameters for specifying the performance of optical detectors, and a survey of several specific types of lasers. References: Boyd, Radiometry and the Detection of Optical Radiation; Kingston, Detection of Optical and Infrared Radiation.
Offered each Fall semester.

ARCHIVED COURSE - OPT 427 – Optical Liquid Crystals

This course will introduce the materials, terminology, effects, and devices used in the field of liquid crystal optics. Basic structures in nematic and cholesteric liquid crystals will be discussed and related to optical phenomena like transmittance, absorption, scattering, birefringence and selective reflection (the effect seen in scarab beetles and utilized to protect the OMEGA laser at LLE from blowing itself up). Two keys for device applications are LC chemical composition and molecular alignment, and these will be covered in order to understand the manufacture and operation of passive devices like wave plates and selective reflection polarizers. The basic electro-optics for active devices like EO switches and LC displays will also be covered. Other applications to be explored include mood rings, polarizing pigments for document security, smart windows, and car paint.
Last offered: Fall 2020

OPT 428 – Optical Communication Systems

The course is designed to give the student a basic understanding of modern optical communication systems while making him/her aware of the recent technological advances. The following topics will be covered: analog and digital signals, multiplexing techniques, modulation formats, dispersive and nonlinear effects in optical fibers, light-emitting diodes and semiconductor lasers, receiver design, noise and signal-to-noise ratio, bit error rate, optical amplifiers, dispersion management, multichannel systems, soliton systems, coherent lightwave systems.
Course Textbook: G. P. Agrawal, Fiber-Optic Communication Systems, 3rd ed. (Wiley, New York, 2002); Reference books: Ramaswami and Sivarajan, Optical Networks, (Moragn, 2002); G. Keiser, Optical Fiber Communications, (McGraw-Hill, 2000).
This course fulfills the Quantum Optics course requirement for MS Plan B students.
Last offered: Fall 2022

OPT 429 – Chemical Bonds: Molecules and Materials

An introduction to the electronic structure of extended materials systems from both a chemical bonding and a condensed matter physics perspective. The course will discuss materials of all length scales from individual molecules to macroscopic three-dimensional crystals, but will focus on zero, one, and two dimensional inorganic materials at the nanometer scale. Specific topics include semiconductor nanocrystals, quantum wires, carbon nanotubes, and conjugated polymers.
Last offered: Spring 2023

OPT 432 – Opto-Mechanical Design

The mechanical design and analysis of optical components and systems will be studied. Topics will include kinematic mounting of optical elements, the analysis of adhesive bonds,

and the influence of environmental effects such as gravity, temperature, and vibration on the performance of optical systems. Additional topic include analysis of adaptive optics, the design of lightweight mirrors, thermo-optics and stress-optics (stress birefringence) effects. Emphasis will be placed on integrated analysis whish includes the data transfer between optical design codes and mechanical FEA codes. A term project is required.
This course fulfills the Geometrical Optics course requirement for MS Plan B students.
Last Offered: Spring 2023

OPT 433 – Optical Fabrication and Testing Technology

This laboratory and lecture course is designed to give a firsthand working knowledge of optical glasses, their properties, and the methods for fabricating and characterizing high quality glass surfaces and components. Lectures will emphasize the physical and optical properties of glass, methods for manufacturing glasses, the component finishing process (grinding and polishing), cleaning, finished element specification, chemical durability and optical quality evaluation methods. New glasses and their applications in laser systems and nonlinear optics will be described.

The laboratory is designed to expose the student to several varieties of optical glasses, the methods for cold working glass blanks, and the fabrication and testing of selected optical elements. Hands-on activity with grinding and polishing equipment will be required to complete one of a variety of projects. In addition to using standard test fixtures and reference standards, to evaluate their work as it progresses, each student will learn the fundamentals of interferometric testing and data interpretation, and methods for evaluating surface smoothness via noncontact, optical profilometry. An introduction, by demonstration, to continuous polishing and optical contacting techniques will be provided during the laboratory portion of the course. (continued next page)

Enrollment: 12 students maximum (priority to graduate Optics students).
Text: Instructor’s notes, 450 pages provided to students in a 3-ring binder at cost.
Last Offered: Spring 2022

OPT 438 – Selected Topics in Augmented and Virtual Reality *

This is the second course offered as part of the PhD training program on augmented and virtual reality. It builds on the first course, Introduction to Augmented and Virtual Reality (AR/VR). The goal of the course is to provide exposure to problems in the AR/VR domain addressed by various disciplines. The course consists of three one-month long modules in a semester. Modules engage students in particular aspects of AR/VR or hands-on experience on AR/VR. Modules to be offered in various years include: fundamentals of optics for AR/VR; AR/VR in the silicon; foundations of visual perception in the context of AR/VR; computer audition and acoustic rendering; measuring the human brain; deep learning and visual recognition for AR/VR; brain-computer interfacing in a virtual environment; 3D interfaces and interaction; AR/VR for collaborative education & professional training.

Pre-requisites: ECE 410 or OPT 410 or BME 410 or NSCI 415 or CSC 413 or CVSC 534
Last Offered: Spring 2023

OPT 440 – Freeform Optics *

Freeform optics is an emerging technology that a broad industry community anticipates will permeate optical systems of the future. This course will define and reveal the history of freeform optics. After an overview on freeform optics that will span design, fabrication and optical testing, the course will then review the theory of optical aberrations for rotationally symmetric system with an emphasis on the field dependence of the aberrations, before introducing Nodal Aberration Theory that was developed in the 1980s for systems that depart from rotational symmetry. Design concepts will then be presented, including the aberrations of freeform optics. Examples of freeform optics designs will be presented. The sensitivity of freeform optics systems to misalignment and form errors will then be discussed. Guest lectures on the mathematics of freeform optics for manufacture, and optical fabrication and testing will be included as possible. The class is intended to be accessible to graduate students in Optics. The course will allow graduate students to learn about freeform optics and also to advance their skills in optical system design. The format of the course will include meeting once a week and will include lectures interspersed with hands-on exercises throughout the semester and the writing of a report on each workshop problem. The reading material for the class will consist of review articles and papers from the primary scientific literature. Each student will be expected to report on the methods and conclusions of at least one paper from the primary literature as well as lead a discussion of that paper with the class or report on an independent project.
Pre-requisites: OPT 444 Lens Design and OPT 544 Advanced Lens Design. This course is aimed at graduate students who completed OPT444, and OPT544 is required but may be taken in parallel with OPT440.
This course fulfills the Geometrical Optics course requirement for MS Plan B students.
Next Offered: Fall 2024

OPT 441 – Geometrical Optics

This course is designed to give the student a basic working knowledge of image-forming optical systems. The course is oriented toward problem solving. Material covered includes: image formation, raytracing and first-order properties of systems; magnification, F/number, and numerical aperture; stops and pupils, telecentricity vignetting; telescopes, microscopes, magnifiers, and projection systems; the Delano diagram; the eye and visual systems, field lenses; optical glasses, the chromatic aberrations, and their correction; derivation of the monochromatic wavefront aberrations and study of their effects upon the image; third order properties of systems of thin lenses; effects of stop position and lens bending; aplanatic, image centered, and pupil centered surfaces; and field flatteners.
References: Smith, Modern Optical Engineering, McGraw-Hill; Lecture notes. This course consitutes one of the topics covered in the PhD Preliminary Examination.
Offered each Fall

OPT 442 – Instrumental Optics

This course provides an in-depth understanding of the principles and practices of optical instrumentation: Optical metrology, including wavefront and surface metrology, interferometric instruments and interferogram analysis, coherence and coherence based instruments, phase measurement and phase-shifting interferometry; Spectroscopic instrumentation, including the Fourier Transform Spectrometer, the Fabry-Perot interferometer, and the grating monochromator; Image plane characterization (star test, Ronchi test, and modulation transfer function); The influence of illumination and partial coherence on image forming systems, including microscopes, systems for projection lithography, and displays.
Prerequisites: OPT 441.
This course fulfills the Geometrical Optics course requirement for MS Plan B students.
Offered each Spring

OPT 443 – Fundamentals of Modern Optical Systems

This course covers fundamental ray optics that are necessary to understand today's simple to advanced optical systems. Included will be paraxial optics, first-order optical system design, illumination, optical glasses, chromatic effects, and an introduction to aberrations.
References: Hecht, Optics (4th edition); Smith, Modern Optical Engineering; Lecture notes.
Offered each Fall
This course is designed and offered as a remote-friendly, hybrid course and is appropriate for in-person and HOME students.

OPT 444 – Lens Design

A review of geometrical optics and 3rd order aberration theory. Specification documents. Image assessment: ray intercept plots, wavefront analysis, spot diagrams, MTFs, and point spread functions. Optimization theory, damped least squares, global optimization, merit functions, variables and constraints. Glass, plastic, UV and IR materials. Aspheres, GRINs, and diffractive optics. Secondary spectrum, spherochromatism, higher order aberrations. Induced aberrations. Splitting and compounding lens elements. Aplanats and anastigmats. Refractive design forms: landscape lens, achromatic doublet, Cooke triplet, Double Gauss, Petzval lens, wide angle, telephoto, and eyepieces. Reflective design forms: parabola, Cassegrain, Schmidt, Ritchey Cretian, Gregorian, three mirror anastigmat, and reflective triplet. Computer aided lens design exercises using CodeV - includes a 4-6 week individual lens design project.
Prerequisites: Permission of Instructor. This course fulfills the Geometrical Optics course requirement for MS Plan B students.
Last Offered: Spring 2023

OPT 445 – Precision Instrumental Design

This course focuses teaching the multidisciplinary aspects of designing complex, precise systems. In these systems, aspects from mechanics, optics, electronics, design for manufacturing/assembly, and metrology/qualification must all be considered to design, build, and demonstrate a successful precision system. The goal of this class is to develop a fundamental understanding of multidisciplinary design for designing the next generation of advanced instrumentation.
Last Offered: Fall 2022

OPT 446 – Optical Interference Coating Technology

This course addresses the design. manufacture and quality control of optic interference coatings. Topics covered include: reflection and transmission at interfaces: the vector diagram; the Smith Chart; properties of periodic media; design of high reflectors. bandpass filters and edge filter; use of computer programs for design analysis; production techniques; thickness monitoring; thickness uniformity calculations.
This course fulfills the Physical Optics course requirement for MS Plan B students.
Last Offer: Fall 2022

OPT 447 – Advanced Optical Coating Design *

This course will cover such topics as the effects of dispersion, scatter, and inhomogeneity in multilayer interference coating designs. Attention will be given toward manufacturability of designs and meeting common optical specifications. Design assignments will address fields including, but not limited to Ophthalmic, Lighting, Display, Anti-counterfeiting, Laser, and Infrared applications. Each student will be given access to current market design, optical characterization, and post-process analysis software.
Prerequisites: Linear Algebra, OPT 446 or OPT 462, or permission from Instructor
This course fulfills the Physical Optics course requirement for MS Plan B students.
Last Offered: Spring 2023

OPT 448 – Vision and the Eye

This course will reveal the intricate optical and neural machinery inside the eye that allows us to see. It will describe the physical and biological processes that set the limits on our perception of patterns of light that vary in luminance and color across space and time, we will compare the human eye with the acute eyes of predatory birds and the compound eyes of insects. The course will also describe exciting new optical technologies for correcting vision and for imaging the inside of the eye with unprecedented resolution, and how these technologies can help us understand and even cure diseases of the eye. The class is intended to be accessible to advanced undergraduate students, especially those majoring in Optics, Biomedical Engineering, or Brain and Cognitive Science, but is recommended for

anyone with a curiosity about vision or an interest in biomedical applications of optics. The course will also serve as an introduction to the study of vision for graduate students.
Last Offered: Spring 2023

OPT 449 – Introduction to Illumination

This course describes the design, construction, and operation of optical instrumentation used in modern vision research. We discuss various techniques for delivering stimuli to the retina including Maxwellian view optics and CRT displays. Methods of calibrating these systems are described in the context of a practical treatment of radiometry, photometry, and colorimetry. The course also covers optical techniques for monitoring the retina such as optical coherence tomography, monitoring eye position such as Purkinje eye tracking, and monitoring the brain such as with infrared reflectance imaging.
Last Offered: Fall 2022

OPT 450 – Polarization *

This course covers the fundamentals necessary to understand the behavior of fully and partially polarized light, and the significant range of applications and optical systems in which polarization is important. Topics include foundational electromagnetic theories of propagation and scattering, polarized plane waves, polarization eigenstates, Jones and Mueller Calculii, ellipsometry, polarization in multilayers and gratings, principles of polarization ray tracing, polarization effects in focusing and imaging, polarization metrology, and topics in polarization coherence.
Prerequisites: OPT 441 or 443 and 461 or 463 or permission of the instructor.
This course fulfills the Physical Optics course requirement for MS Plan B students.
Last Offered: Spring 2022 (offered alternating Spring semesters)

OPT 452 (ECE 452) – Medical Imaging – Theory and Implementation

Physics and implementation of X-ray, ultrasonic, and MR imaging systems. Special attention is given to the Fourier transform relations and reconstruction algorithms of x-ray and ultrasonic-computer tomography, and MRI.
This course fulfills the Physical Optics course requirement for MS Plan B students.
Last Offered: Fall 2021

OPT 453 – Quantum and Nano Optics Laboratory

This laboratory course (3 hours per week) exposes students to cutting-edge photon counting instrumentation and methods with applications ranging from quantum information to nanotechnology,biotechnology and medicine. Major topics include quantum entanglement and Bell's inequalities, single-photon interference, single-emitter confocal fluorescence microscopy and spectroscopy, photonic bandgap materials, Hanbury Brown and Twiss interferometer, and photon antibunching. Each lab also includes lecture and

discussions of lab materials.This course fulfills the Quantum Optics course requirement for MS Plan B students.
Last Offered: Fall 2022

OPT 454 – Optics Laboratory for HOME Students

This is an accelerated version of OPT 456 Optics Laboratory intended for students taking the Hybrid Optics Master's Education (HOME) program.
3 CREDIT COURSE
Offered Summer Session I

OPT 456 – Optics Laboratory

This is an intensive laboratory course. The laboratory experiments are likely to include the following:

1. Transverse and axial mode structure of a gas laser.
2. Detector calibration using a blackbody.
3. Production of a white light viewable transmission hologram.
4. Acousto-optic modulation.
5. Twyman-Green interferometry.
6. Optical Fibers Laser.
7. The Pockels cell as an optical modulator.
8. Optical beats (heterodyning) and CATV.
9. The YAG laser and second harmonic generation.
10. Fourier optics and optical filtering.
11. Lens Evaluation.
12. Modulation Transfer Function.
13. Applications and properties of pulsed dye laser.
14. Holographic optical elements.
15. Properties of Gaussian beams.

Offered Each Fall & Spring Semester

OPT 461 – Fourier Optics (formerly PHYSICAL OPTICS I)

The principles of physical optics including diffraction and propagation based on Fourier transform theory; integral formulation of electromagnetic propagation; diffraction from apertures and scattering objects; applications to optics of Fourier transform theory, sampling expansions, impulse response, propagation through optical systems, imaging and transforming, optical transfer function, optical filtering; and selected topics of current research interest.
Text: Goodman, Introduction of Fourier Optics; Class Notes.
Prerequisites: Undergraduate electromagnetic theory, advanced calculus, linear algebra.
Offered each Fall semester

OPT 462 – Electromagnetic Waves (formerly PHYSICAL OPTICS II)

This course covers topics in electromagnetic theory that serve as a foundation for classical descriptions of many optical phenomena. A partial list of topics includes: review of Maxwell's equations, boundary conditions, and wave equations; polarization of light; crystal optics; vector, scalar, and Hertz potentials; radiation from accelerated charges; electric and magnetic dipole radiation; Lorentz atom description of the interaction of light with matter; scattering; optical waveguides.
References: Jackson, Classical Electrodynamics; Born and Wolf, Principles of Optics.
Prerequisites: Undergraduate electromagnetic theory, advanced calculus, vector analysis.
This course fulfills the Physical Optics course requirement for MS Plan B students.
Offered each Spring semester

OPT 463 – Wave Optics and Imaging

This course provides the practicing optical engineer with the basic concepts of interference, diffraction, and imaging. Each topic will be reinforced with real-world examples. The interference section will include interferometry, Fabry-Perot etalons, and multilayer thin films. The diffraction and imaging sections will include, but are not limited to, diffractive optics, Fourier series, continuous and discrete Fourier transforms, convolution theory, and Linear Systems.
References: Hecht, Optics (4^{th} edition); Gaskill, Linear Systems, Fourier Transforms, and Optics; Lecture notes.
Prerequisites: Advanced Calculus, Linear Algebra
Offered each Fall semester
This course is designed and offered as a remote-friendly, hybrid course and is appropriate for in-person and HOME students.

OPT 464 – Physics and Applications of Nanophotonic and Nanomechanical Devices *

Various types of typical nanophotonic structures and nanomechanical structures, fundamental optical and mechanical properties: micro/nano-resonators, photonic crystals, plasmonic structures, metamaterials, nano-optomechanical structures. Cavity nonlinearoptics, cavity quantum optics, and cavity optomechanics. Fundamental physics and applications, state-of-art devices and current research trends. This class is designed primarily for graduate students. It may be suitable for senior undergraduates if they have required basic knowledge.Prerequisites: Base knowledge of the following subjects is required for this course: Electromagnetic waves (ECE230 or OPT262 or OPT462); Waveguides and optoelectronics (ECE235/435 or OPT226 or OPT468); Quantum mechanics (OPT223 or OPT412 or PHY237 or PHY407).
This course fulfills the Quantum Optics course requirement for MS Plan B students.
Last Offered: Fall 2022

OPT 465 – Principles of Lasers

This course provides an up-to-date knowledge of modern laser systems. Topics covered include quantum mechanical treatments to two-level atomic systems, optical gain, homogenous and inhomogeneous 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.
Prerequisites: undergraduate electromagnetic theory and quantum mechanics.
This course constitutes one of the topics covered in the PhD Preliminary Examination.
This course fulfills the Quantum Optics course requirement for MS Plan B students.
Last Offered: Spring 2023

OPT 466 – Ultrafast Optics and Laser-Matter Interactions

The course starts with an introduction of fundamentals on ultrashort pulse generation, propagation, dispersion, manipulation, and measurements. Subsequently, a range of ultrafast optical phenomena and applications will be discussed, spanning spectroscopy, imaging, and ultrafast nonlinear optics. Finally, a dedicated focus will be directed towards introducing pulsed laser interacting with matter in a various states, such as solids, gases, and plasmas.
Note: As of Fall 2023, OPT 466 is a 4 credit course, although it was previously offered as 2 credit course.
This course fulfills the Quantum Optics course requirement for MS Plan B students.
Last Offered: Fall 2022

OPT 467 – Nonlinear Optics *

Fundamentals and applications of optical systems based on the nonlinear interaction of light with matter. Topics to be treated include mechanisms of optical nonlinearity, second-harmonic and sum- and difference-frequency generation, photonics and optical logic, optical self-action effects including self-focusing and optical soliton formation, optical phase conjugation, stimulated Brillouin and stimulated Raman scattering, and selection criteria of nonlinear optical materials.
References: Robert W. Boyd, Nonlinear Optics, Second Edition.
Prerequisites: Students must have completed either OPT 461 or 463 or 462.
This course fulfills the Quantum Optics course requirement for MS Plan B students.
Last Offered: Fall 2022

OPT 468 – Waveguides & Optoelectronic Devices

The course will cover the behavior of light in integrated waveguide devices. The course will feature in-class demonstrations, integrated photonic device design, and device testing in a laboratory setting. We will review Maxwell's Equations and cover topics such as optical modes, planar waveguides, optical fibers, rectangular waveguides, coupled-mode theory,

mode coupling, resonators, modulators, and numerical methods for integrated photonic device design. During this class you will learn the fundamentals of integrated photonics, design an integrated photonic device, and test and analyze its performance.
This course constitutes one of the topics covered in the PhD Preliminary Examination.
This course fulfills the Physical Optics course requirement for MS Plan B students.
Last Offered: Fall 2022

OPT 473 – Laser Engineering

This course provides an introduction to the fundamentals of lasers, laser performance, and applications. Topics include the physics of laser operation, laser cavities, laser types and applications, performance metrics, polarization optics in lasers, and laser amplifiers.
This course fulfills the Quantum Optics course requirement for MS Plan B students.
First Offering: Fall 2023
This course is designed and offered as a remote-friendly, hybrid course and is appropriate for in-person and HOME students.

ARCHIVED COURSE - OPT 476 – Biomedical Optics

Biomedical optics is the study of how light is used to study biological systems, to obtain medical information, and to perform clinical procedures. Major topics in this course include biomedical spectroscopy (absorption, fluorescence, Raman, and elastic scattering), propagation of photons in highly scattering media (such as tissue), and techniques for high-resolution imaging in biological media: confocal imaging, multiphoton imaging, and optical coherence tomography.

Students taking this course come from a variety of backgrounds. As such, the course is intended to be flexible in giving students depth in a few self-selected areas. In addition to the broader problem sets, there are two team-based reviews (oral and written) of recent journal articles, chosen by the team. The final project consists of a longer review paper, written individually, and a corresponding oral examination on that topic. This course is offered every second Fall (even years) and is intended to alternate with and be complementary to Biomedical Microscopy (BME 270/470, offered on the Fall semester in odd years), forming a two-semester Fall sequence that can start with either course.

Prerequisites: basic knowledge of quantum mechanics, statistical mechanics, linear algebra, differential equations, and vector calculus. Open to graduate students and upper-level undergraduates (who usually enroll in OPT 276, with fewer homework problems).
Last Offered: Spring 2019

OPT 477 – Singular Optics

Singular Optics deals with the fine structure of optical wave fields. It is concerned with objects such as phase singularities of scalar fields, and singular behavior of the Poynting

vector, the polarization ellipse and correlation function. We will discuss how these different field features can evolve into each other through topological reactions. This course follows the book Singular Optics by Gbur.
Last Offered: Fall 2022

OPT 479 – TeraHertz Technology and Applications

The course introduces the historical and technological context of THz science and technology, including major previous developments, recently advances, future prospects, and its relationship with other disciplines, such as photonics and electronics. Applications will be highlighted. The course includes THz wave generation, detection, spectroscope, imaging, interaction with matter, and instrumentation.
2 CREDIT COURSE
Last Offered: Fall 2022

OPT 481 – Technical Entrepreneurship / General Management of New Ventures

This course provides an opportunity to examine the management practices associated with innovation and new business development. The analysis of entrepreneurship is evaluated from the perspective of start-up ventures and established companies. There is an appraisal of the similarities and differences in the skills and the functions required to develop successful projects in both types of situations. A range of management issues is discussed, including organizational development, analysis of market opportunities, financial planning and control, capitalization, sources of funds, the due-diligence process, and valuing the venture.
Course Approach: To expose students to various facets of new venture management and entrepreneurship, classes will consist of lectures, evaluation of current business situation, and presentations by guest speakers. Furthermore, two (one for engineers) case studies must be prepared for the credit.
Last Offered: Spring 2023

OPT 482 – System Integrations and Product Development *

In this class, we will explore the ISO 9000 product development process and illustrate how to use this process to develop both products and research systems that meet necessary specifications. The class will use systems such as video projectors, CD-ROM drives, bar-code scanners and scanning laser microscopes as examples to illustrate the various concepts.
Prerequisites: OPT 425, 441 or 443, and 461 or 463, or permission of the instructor.
Last Offered: Spring 2023

OPT 483 - Computational Imaging

Computational Imaging is a graduate-level introduction to optical systems as an integral part of the sense-process-decide-act cycle. This cycle is central to the operation of any goal-directed system, biological or engineered. Students will gain a basic understanding of the

mechanisms by which information about a scene is encoded on an electro-magnetic wave. Furthermore, the students will learn to analyze the information extraction process realized via the chain of front-end optics, transduction, and post-processing. The objective of the course is to understand how optics, photon-to-electron transduction, and post-detection processing can be jointly designed to enable sensors with unique optical capabilities.
Last Offered: Spring 2021
This course is designed and offered as a remote course and is appropriate for in-person and HOME students.

OPT 484 – Petawatt Lasers

Since the first demonstration of chirped pulse amplification, researchers worldwide have worked to generate and focus lasers to higher and higher intensities. In 1999, the first petawatt (10^{15} W) laser was demonstrated, and since that time the race has been on to build lasers that deliver higher powers, higher focused intensities, and higher repetition rates, opening entire new areas of physics to investigation in the laboratory. This course will take an engineering approach to how one builds a petawatt laser. Topics covered include an introduction to laser fundamentals, chirped pulse amplification, large-aperture laser amplifiers, pulse shape characterization, and wavefront considerations and correction. The course will culminate with the formation of a design team to develop a conceptual design for a petawatt laser.
Last Offered: Spring 2022
This course is designed and offered as a remote course and is appropriate for in-person and HOME students.

OPT 485 – Proposal Writing in Vision Science and Optics

This course will introduce students in Optics and Vision Science to best practices for writing successful grant proposals, an essential skill for anyone considering an academic research career. Students will develop a complete proposal ready for submission by the end of the semester. Acceptable kinds of proposals include, but are not necessarily limited to, NSF Graduate Research Fellowships, NIH National Research Service Award Fellowships, and PhD thesis proposals.

The course will begin with lectures on the funding process including a survey of the funding sources available. There will be an emphasis on graduate fellowships, the winning of which is not only budget relieving for the laboratory, but even more importantly is an impressive early addition to a curriculum vita. NIH, NSF, DoD, as well as corporate and foundation funding for research projects will also be described. Students will then be expected to develop a concept for their own proposal. These initial concepts will be conveyed via oral presentations in class as well as a written summary that will be critically evaluated by peers.

Peer evaluation of each student's written ideas by the rest of the class, which parallels the peer review process that is fundamental to most external funding sources, will be used extensively as a vehicle for developing critical thinking skills. Subsequent sessions will focus in turn on written descriptions by each student of the scientific significance of the concept in the context of the existing literature, the innovativeness of the proposal in terms of the novelty of the technology required to execute the research, as well as the soundness of the methodological approach.

While the focus of the class will be on proposal writing, lectures and discussion will also address more broadly the components required for a successful academic career, including scientific ethics, strategies for securing a job after graduate school, and successful promotion through the ranks as a faculty member.
Last offered: Fall 2021

OPT 492 – Special Topics in Optics

The topics covered by 492 change from semester to semester. Previous OPT 492 offerings are listed below. Some of these courses have been spun-off into regularly offered courses outside of the OPT 492 course definition.
Last Offered: Spring 2019

OPT 492 – THz Technology and Ultrafast Phenomena *

This course has two parts: THz technology and ultrafast phenomena.
[1] THz technology covers the basic concepts of generation, propagation and detection of THz waves. It provides the fundamentals of free-space THz optoelectronics for sensing, imaging and spectroscopy applications. A THz optoelectronic system, with diffraction-limited spatial resolution, femtosecond temporal resolution, DC-THz spectral bandwidth, and mV/cm field sensitivity, will be central to the course. Examples of nondestructive testing, environmental sensing, homeland security, and biomedical applications will be highlighted.
[2] Ultrafast Phenomena covers the methods for short optical pulse and phenomena measurements, short laser pulse generation, amplification, detection, and characterization, as well as attosecond science and high harmonics generation.
Prerequisites: OPT 462, 465, or permission of the instructor.

OPT 492 – Research Techniques and Topics in Nonlinear Fiber Optics

This course will cover topics in nonlinear optics and optical fibers including group-velocity dispersion, self-phase modulation, modulation instability, optical solitons, Raman and Brillouin scattering and parametric processes. With this material, this course will examine graduate research techniques for contextualizing research, writing journal reviews, writing journal articles and licensing new technology. Special Topics in Optics - High level courses on special topics within the field of optics. Offered topics change each semester.

ARCHIVED COURSE - OPT 493 – Essay

Students should not register for OPT 493 unless specifically instructed to do so by the graduate coordinator or the Graduate Education & Postdoctoral Administration (GEPA) office. MS students that have completed 30 credits and are completing the MS essay should register for OPT 897 or OPT 899 MS Dissertation with their advisor listed as the instructor.

OPT 495 – MS Research in Optics

MS thesis students conducting research must complete at least 6 credits and no more than 12 credits of OPT 495. Research credits correspond to effort in the lab and research advisors assign pass or fail grades based on research performance.
Students should not register for OPT 495 until they have confirmed their research advisor and the research plan. Failure to confirm your plan to conduct research with your research advisor prior to registration will likely result in a Fail grade.
Students must register in the section with their research advisor listed as the instructor. If your advisor is not listed, contact the Graduate Coordinator.
VARIABLE CREDITS (1 – 12)

ARCHIVED COURSE - OPT 511 – Advanced Mathematical Methods *

This course focuses on advanced numerical and analytical techniques that are likely to be useful for PhD-level Optics students. It will begin with a review of numerical errors and then develop simple algorithms for solving nonlinear algebraic and differential equations. The later half of the course will cover several analytical techniques useful for solving ordinary and partial differential equations encountered in various areas of optics and photonics. Students will be given weekly homework problems based on the material covered each week.
Course Textbook: S. Chapra, *Applied Numerical Methods with MATLAB*, 3rd edition (McGraw-Hill, 2011).
Prerequisites: OPT 411 and some knowledge of MATLAB.
Last Offered: Fall 2020

OPT 516 – Inverse Problems in Optics *

This is a course in physical optics, the solution of linear inverse problems, and computed imaging. Topics include forward problems in diffraction, asymptotics, ray propagation, x-ray projections, scattering, sources, optical coherence tomography, and near-field optics. The associated inverse problems are solved. That is, back-propagation, back-projection, Radon transforms (x-ray CT), inverse scattering, source localization, interferometric synthetic

aperture microscopy, and near-field tomography are covered. Special topics will be included, time permitting.
This course satisfies the Physical optics requirement for MS Plan B students.
Last Offered: Fall 2020

*ARCHIVED COURSE – OPT 521 – Optical Interactions in Solids **

The course consists of a sequence of lectures on topics in solid state physics which are necessary to understand the operation of optoelectronic devices. To balance the course between theoretical and experimental topics, each lecture commences with a fifteen minute overview of a specific experimental technique, or device which is related to the optical properties of solids. Lectures cover the following topics: optical constants of solids, electronic states, the role of lattice vibrations, a detailed look at optical transitions, and building devices.
Last offered: Fall 1988
No longer offered. Contact Graduate Coordinator if interested in course.

*ARCHIVED COURSE – OPT 528 – Advanced Topics In Telecommunications **

The course is designed to provide the student with understanding of the recent advances in the field of lightwave technology. The following topics are covered: Dispersive and nonlinear effects in optical fibers; linear and nonlinear properties of fiber Bragg gratings, linear and nonlinear properties of fiber couplers, fiber interferometers: including Fabry-Perot resonators, nonlinear fiber-loop mirrors, Mach-Zehnder interferometers, different kinds of fiber amplifiers and lasers, pulse-compression techniques, design of modern fiber-optic communication systems, optical solitons and their applications.
Prerequisites: OPT 461 or 463, OPT 428 recommended (but not required).
Course Textbook: G. P. Agrawal, Applications of Nonlinear Fiber Optics
(Academic Press, San Diego, 2001); Supplementary Reading: G. P. Agrawal, Nonlinear Fiber Optics, 3rd ed. (Academic Press, San Diego, 2001).
No longer offered. Contact Graduate Coordinator if interested in course.

OPT 535 – Modern Coherence Theory *

Theory of random process, stationarity ergodicity, the auto-correlation function and the cross-correlation function of random process. Spectrum of a stationary random process and the Wiener--Khintchine theorem, Second-order coherence theory in the space-time domain, the mutual coherence function, the degree of coherence. Second-order coherence theory in the space-frequency domain, the cross spectral density, mode representation, propagation problems, Inverse radiation problems, effects of source correlations and scattering of partially coherent light from deterministic and from random media. Phase space representations. Quantum theory of coherence.
Pre-requisite: OPT 461 or 463, OPT 425, OPT 442, or permission by instructor

This course fulfills the Physical Optics course requirement for MS Plan B students.
Last Offered: Fall 2021

OPT 544 – Advanced Lens Design *

Complex zoom lenses and multi-mirror reflective systems are discussed detail starting with first principles. Other topics include materials for other wavelength bands, tolerancing, sensitivity analysis, monte carlo analysis, ghost and stray light analysis. Students required to complete two complex group design projects.Pre-requisite: OPT 444.
This course fulfills the Geometrical Optics course requirement for MS Plan B students.
Last Offered: Fall 2023

OPT 551 (PHY 531) – **Intro 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.
Prerequisites: OPT 412 or PHY 407/408 or permission of the instructor.
This course fulfills the Quantum Optics course requirement for MS Plan B students.
Last Offered: Fall 2022

OPT 552 – Quantum Optics I: Quantum Optics of EM Field *

This course is a continuation of Quantum Electronics I in which the basic theory developed in the first semester is applied to atomic and molecular systems. The topics covered include resonance fluorescence, superfluorescence, saturation spectroscopy, stimulated Raman scattering, multiphoton ionization, and other spectroscopic techniques of current interest.
Prerequisites: OPT 551 or permission of the instructor.
References: Allen and Eberly, Optical Resonance and Two-Level Atoms; Loudon, The Quantum Theory of Light; Current literature.
This course fulfills the **Quantum** Optics course requirement for MS Plan B students.
Last Offered: Spring 2023

ARCHIVED COURSE - OPT 553 (PHY 532) – Quantum Optics II: Atom-Field Interactions *

Topics covered include the resonant interaction of atoms and quantized fields including spontaneous emission, the Lamb shift, resonance fluorescence, the quantum regression and fluctuations-dissipation theorems, quantum states of the field including squeezed states, Schrodinger cat states and bi-photons, entanglement in atom-field interactions, multiphoton ionization and other strong field effects, and wave packet physics.

Prerequisite: OPT 551/PAS 531 or permission of instructor.
Last offered: Spring 1996
No longer offered. Contact the Graduate Coordinator if interested in course.

*ARCHIVED COURSE – OPT 554 – Advanced Topics in Quantum Optics **

Several professors from the Institute of Optics and the Department of Physics and Astronomy (Alonso, Bigelow, Boyd, Eberly, Howell and Stroud) deliver a two-double lecture sequence as an overview of their current research interests in Quantum Optics. Both experimental and theoretical topics will be discussed. In addition, students will carry out 6-hour laboratory experiments on generation and characterization of single and entangled photons (Lukishova). Grades [S (satisfactory) or E (failure)] will be based on the evaluation of a homework problem set for each section of the course.
Prerequisite: OPT 412 or PHY 407/408 or permission of instructor.
This course fulfills the **Quantum** Optics course requirement for MS Plan B students.
No longer offered. Contact the Graduate Coordinator if interested in course.

OPT 561 – Advanced Imaging *

This course covers advanced topics in imaging, concentrating on computed imaging, Fourier-transform-based imaging, and unconventional imaging, with emphasis on imaging through aberrating media (particularly atmospheric turbulence), in mathematical depth. Topics are selected from the following: stellar (speckle, Michelson, and intensity) interferometry, wavefront sensing for adaptive optics, phase diversity; pupil-plane lensless laser imaging including 2-D and 3-D digital holography, imaging correlography, and X-ray diffraction imaging; Lyot coronography, synthetic-aperture radar, Fourier telescopy, Fourier-transform imaging spectroscopy, structured-illumination superresolution, optical coherence tomography, extended-depth-of-field imaging, and synthetic-aperture radar. Additional topics suggested by the students are also considered. The course also explores image reconstruction and restoration algorithms associated with these imaging modalities, including phase retrieval, Wiener-Helstrom and maximum likelihood deconvolution, multi-frame blind deconvolution, de-aliasing, side-lobe elimination, and phase-error correction algorithms.
A project plus term paper, exploring an advanced imaging topic in depth, including computer simulations (or laboratory experiments) and implementing the image formation or restoration algorithms, are required.
Prerequisites: OPT 461 (Fourier Optics) or 463.
This course fulfills the Physical Optics course requirement for MS Plan B students.
Last Offered: Spring 2022

OPT 591 – Reading Course in Optics

Reading courses can be organized in consultation with a faculty member to cover topics not offered in existing formal courses. A typical format for a 4 credit hour reading course is the following: the supervising faculty member assigns reading material on the topic in question to the student(s), who then meet once or twice per week with the professor and give oral presentations and discuss the materials. No more than 8 credit hours of reading courses can be used towards the 60 credits of courses required for the Ph.D. degree. Reading courses cannot be used to satisfy the advanced course requirement.
Prerequisites: permission of instructor and of Graduate Dean required; special application required; available each Fall, Spring, and Summer semester.

OPT 595 – PhD Research in Optics

PhD students must complete 30 credits of OPT 595. Research credits correspond to effort in the lab and research advisors assign pass or fail grades based on research performance. A PhD student working in the lab and taking no courses should register for 9-12 credits of OPT 595. Students must register in the section with their research advisor listed as the instructor. If your advisor is not listed, contact the Graduate Coordinator.
VARIABLE CREDITS (1 – 12)

OPT 596 – Optics Colloquium

The Institute of Optics Colloquium series presents invited speakers in Optics from outside of the University of Rochester to the UR Optics community.
PhD students who began their program in 2019 or later are required to complete 4 credits of OPT 596 as part of their program. It is recommended that PhD students complete their 4 credits of OPT 596 in the first 4 semesters of their program. Grades for OPT 596 are Pass/Fail. Students must attend 75% of offered Colloquia to receive a Pass grade.
Offered each Fall and Spring Semester.
1 CREDIT COURSE

OPT 897 – MS Dissertation

OPT 897 is a placeholder indicating that a MS student is still active with a full-time status. MS students that have completed their 30 credit requirement, but are still working on their MS thesis or MS essay should register for a placeholder.
OPT 897 can only be used once as it waives the continuing enrollment fee charged for placeholder registrations. If you have already used OPT 897, please register for OPT 899. Students must register in the section of OPT 897 with their advisor listed as the instructor. Please contact the graduate coordinator if your advisor is not listed.
Placeholder Registration – no credits

OPT 899 – MS Dissertation

OPT 899 is a placeholder indicating that a MS student is still active with a full-time status. MS students that have completed their 30 credit requirement, but are still working on their MS thesis or MS essay should register for a placeholder.
OPT 899 incurs the continuing enrollment fee ($1,070 per semester) charged for placeholder registrations. Students may register for OPT 897 instead of 899 ONCE.
Students must register in the section of OPT 897 with their advisor listed as the instructor. Please contact the graduate coordinator if your advisor is not listed.
Placeholder Registration – no credits

OPT 997 – PhD Dissertation

OPT 997 is a placeholder indicating that a PhD student is still active with a full-time status. PhD students that have completed their 90 credit requirement, but are still working toward their final defense should register for a placeholder.
OPT 997 is to be used by PhD student that began their program in or after 2017. If you began your PhD program in or before 2016, please register for OPT 999.
Students must register in the section of OPT 997 with their advisor listed as the instructor. Please contact the graduate coordinator if your advisor is not listed.
Placeholder Registration – no credits

OPT 999 – PhD Dissertation

OPT 999 is a placeholder indicating that a PhD student is still active with a full-time status. PhD students that have completed their 90 credit requirement, but are still working toward their final defense should register for a placeholder.
OPT 999 is to be used by PhD student that began their program in or before 2018. If you began your PhD program in or after 2017, please register for OPT 997.
Students must register in the section of OPT 999 with their advisor listed as the instructor. Please contact the graduate coordinator if your advisor is not listed.
Placeholder Registration – no credits

RECENT M.S. THESIS TITLES

2015

Design and Illumination for a Czerny-Turner Spectrometer

On the Measurement of Quantum Entanglement of Photons from a Silicon Microdisk

2016

Estimating Organelle Size Distributions in Single Cell via Angular Scattering: Quantifying Sources of Uncertainty

A Study of Homogeneous and Spherical Gradient-Index Ball Lenses

2017

Effect of Raman Scattering on Soliton Interaction in Optical Fibers

Forward-Adjoint Monte-Carlo Photon Migration Simulation for Spatially Offset Raman Spectroscopy

Broadband High NA Objective Minimizing Total Group Delay Dispersions: A Design Study

Towards Quantitative Phase Imaging Using a Limited-Range Phase Shifter

A Study of Homogeneous and Spherical Gradient-Index Ball Lenses

Coherent Control of a Single Nitrogen-Vacancy Center Spin in an Optically Levitated Nano

Beam Quality Measurement in High Powered Femtosecond Pulsed Lasers

2018

Application of Othonormal Polynomial Bases and their Fourier Transform in Optics

Myopia Development: Optical Characterization of Eye Across the Visual Field

Kerr Frequency Comb Generation in a High-Q Lithium Niobate Micro-Resonator

Classical and Quantum Ghost Imaging

Review of the Atom-Light Interactions

A Review of Eye Tracking Technology and Its Application in Virtual Reality Systems

The Use of Adaptive Optics in Free Space Optical Communication

A Review of the Vergence-Accommodation Conflict in Virtual Reality

2019

Investigation of different liquid properties on emitting terahertz wave under ultrashort optical excitation

Multiband and Broadband Metal-Insulator-Metal Plasmonic Metamaterial Absorbers in the Infrared created by Femtosecond Laser Processing

Ghost Imaging in the Quantum and Classical Realm and its Applications

Characterizing Mid-spatial Frequencies and their effect on Optical Systems

Vision Correction and Improved Accommodation with Intraocular Lenses

Thin-Film Coatings: Rugate Coating Construction and Optimization

Photonic Biosensor Technology and Applications

Properties and Preparation of Anodic Aluminum Oxide with High Emissivity in Infrared Atmospheric Window

Augmented Reality and Its Applications in Surgical Environment

A Review of Material Systems and Development of Single Proton Emitters

2020

Femtosecond Laser-processed Broadband Optical Absorbers for Solar Thermal Application

Numerical calculation of Zernike polynomials and the sample selection method of NURBS spline generation

Achieving the Ultimate Energy Conversion Efficiency by Applying Novel Chirp Matching Condition in Fiber Four Wave Mixing

Autofluorescence of Optical Glass Classification and Relative Assessment

Chromaticity vector path and its application on color rendering of LED white lights

2022

Optical solitons in nonlinear dispersive media

2023

Phase shaping in femtosecond laser micromachining of ophthalmic materials with a liquid crystal on silicon spatial light modulator

Measurement of gradient-index materials with transmission deflectometry

Free space cavity development for high energy Kerr soliton generation

Tapered Fiber Fabrication for Brillouin Devices

RECENT M.S. ESSAY TITLES

2021

An Overview of the Evolution and Operation of Fiber Optic Data Communication Detectors

Different Techniques Used for Multispectral Imaging

Methods of Developing Spatial Periodicity in Beams Against Optical Filamentation

Polarization Techniques for Wafer Metrology

Recent Advances in the Heterogenous Integration of III-V Semiconductor Lasers With Silicon
Photonics

Designing augmented and virtual reality optical systems for perceptual realism

An Overview of the Evolution and Operation of Fiber Optic Data Communication Detectors

Optical Waveguides and Gratings in Modern Near Eye Displays
Material Surface Processing Using Laser Ablation

Analysis of Demosaicking Algorithms for Bayer Color Arrays

Optical Nanoscopy Using Structured Illumination

Curved Optical Sensors: Advantages, Applications, and Production Methods

2022

Converting a Digital Camera to a Spectrophotometer

Freeform Telescopes with Accessible Entrance Pupils

Review of EUV High Reflectivity Coating Designs

Freeform Gradient Index Prescribed Illuminators

Correction of Detrimental Polarization Effects in Roofed Prisms

Comparison of MRF (Magneto-rheological Finishing) and IBF (Ion Beam Figuring)

Fiber optics fused coupler: Theory, manufacturing and applications

2023

Optical Techniques for Non-contact Fluid Concentration Measurements

Impact of Compressor Grating Misalignment on Ultra-intense CPA Lasers

Tapered Fiber Fabrication for Brillouin Devices

Design of All-reflective Freeform Imaging Optical Systems

RECENT PhD THESIS TITLES

2018

Novel Concepts for Enhancing Nonlinear Phenomena in Optical Fibers

Description and Applications of Space-variant Polarization States and Elements

Nonlinear Optical Phenomena in Multimode Fibers

Mid-Wave and Long-Wave Infrared Gradient-Index Optics: Metrology, Design and Athermalization

Spatio-Spectral Interferometric Imaging and the Wide-field Imaging Interferometry Testbed

Advances in Deterministic Femtosecond Laser Writing of Vision Correction Devices in Ophthalmic Hydrogels

2019

Nonlinear Nanophotonics in Lithium Niobate

Two-Photon Excited Fluorescence Adaptive Optics Ophthalmoscopy of Retinal Function

Geometrical representations of structured light: From paraxial to electromagnetic

Expanding the Capture Range of Image-Based Wavefront Sensing Problems

Gabor-domain optical coherence microscopy combined with fluorescence microscopy

Design Methods for Two Regimes of Unobscured Reflective Optical Systems

Optomechanics with Optically Levitated Nanoparticles

2020

Optical design of translational broadband reflective adaptive optics ophthalmoscopes

Mid-Wave Infrared Resonant Cavity Detector

Mathematical Tools for Understanding the Effects of Mid-spatial Frequency Structures on Freeform Surfaces

Imaging Translucent Retinal Neurons and Vascular Cells by Optimizing Phase Contrast in the Living Mouse Eye

Phase-Sensitive Angular Light-Scattering Microscopy of Single Cells

Software and Hardware Enabling the Next-Generation Near-Eye Displays

Advances in Optical Surface Metrology by Phase and Prescription Retrieval

Enhancement of Near-Infrared Femtosecond Photomodification with Biocompatible Dopants: Experimental Study in Hydrogel and Cornea

Planar Light Guide Solar Concentrators for Building Integrated Photovoltaics

Orthogonal polynomials and mathematical surface descriptions in freeform optical design

2021

Cascade optical coherence tomography (C-OCT) for the surface form metrology of freeform optical components

Orthogonal polynomials and mathematical surface descriptions in freeform optical design

Planar Light Guide Solar Concentrators for Building Integrated Photovoltaics

Optical communication with structured photons propagating through aberrating media

Imaging Single-Cell Dynamics in the Living Eye, from Milliseconds to Months

Tailoring ultrashort pulses for surface structuring and characterizing ultrashort pulses

Structured photons enabled secure quantum communication and spatio-temporal characterization of terahertz pulses

Iterative Phase Estimation Algorithms in Interferometric Systems

Four Novel Fiber Types for Advancing High-Power Fiber Lasers and Amplifiers
Advanced coronagraphic modeling and wavefront control

2022

Divided Pulse Nonlinear Compression: A Scalable Technique to Overcome High Power Nonlinear Compression Limitations

Freeform Gradient-index Optics with Applications in Rotationally Variant Systems

Femtosecond laser-induced refractive index changes in ophthalmic materials: multiparameter optimization and modeling

Theory and Design of Freeform Gradient Index Optics and Applications in Progressive Addition Lenses

Structured Light, polarization and birefringence

Generation and Measurement of Complex Fields Using Stress-Engineered Optics

Spin-active optical emitters in two-dimensional materials

Integrated Photonic Devices with Inverse Weak Value Amplification for Precision Metrology

Explorations in Optical Spatial Coherence

Nonlinear Optical Phenomena in Graded-Index Multimode Fibers

2023

Suppression of the Conjugate Signal for Broad-band Computed Imaging via Synthetic Phase Modulation

On-chip 2D material Microring Laser Operating At Room Temperature
Functional Imaging and Classification of Retinal Ganglion Cells in the Living Primate Eye

Multiverse of Light-matter Interaction: Semiconducting Microcavitie

Quantum Photonic Devices for Use at Telecommunications Wavelengths

Wide-field Wavefront Control for Virtual Reality and Peripheral Vision

Reverberant Elastography and Speckle Analysis for Brain Characterization

Towards On-Chip Optical Quantum Simulation

Local Measurement of Terahertz Field-Induced Second Harmonic Generation in Plasma Filaments and Single-Shot Detection of THz using Third-Order Nonlinearities

Wavefront sensing and 3D image reconstruction in deep turbulence

Angularly-resolved light scattering for sizing organelle distributions in single cells

Characterizing and Identifying the Fluorescence Lifetime of the In Vivo Human RPE Cellular Mosaic

Survey of Three- and Four-Mirror Freeform Reflective Imagers Using Analytically Designed Starting Points

Non-Destructive Three-Dimensional (3-D) Recontruction for Gradient-Index Materials

Integrated silicon nitride devices for novel photonic applications

Current Optics Graduate Students:

Name	Program	Cohort	Advisor
Akinyimika, Adewale	PhD	2023	
Alappat, Nicholas	PhD	2022	J. Fienup
Ambastha, Abhinandan	MS	2020	C. Guo
Amin, Mitesh	PhD	2019	T. Krauss
Barman Ray, Arnab	PhD	2018	N. Vamivakas
Belzer, Matthew	PhD	2023	
Berjon de la Parra, Javier	PhD	2020	W. Knox
Bohora, Sanket	PhD	2022	Q. Lin
Brone, Jerome	HOME	2021	
Bu, Yifan	PhD	2022	G. Schmidt
Cai, Lingyi	MS	2022	
Cai, Christie Yongyi	PhD	2019	D. Williams
Campos Okumiya, Karina	MS	2023	
Chen, Yuelin	PhD	2023	W. Renninger
Choudhary, Saumya	PhD	2015	R. Boyd
Cong, Cong	PhD	2018	C. Guo
Cortes Herrera, Luis	PhD	2018	G. Agrawal
De Aguiar, Anthony	HOME	2022	
Desai, Ankur	PhD	2019	D. Moore
Donaldson, Henry David	HOME	2023	
Dowdell, Demetrious	PhD	2020	T. Brown
Eller, Joshua	HOME	2021	
Elmadny, Yossif	PhD	2022	J. Cardenas
Everly, Christopher	PhD	2021	P. Postigo
Fan, Yiwen	PhD	2020	J. Rolland
Feng, Yi-Ting	PhD	2020	T. Brown & M. Alonso
Ferguson, Matt	PhD	2021	J. Rolland
Fiedler, Mark	HOME	2023	
Fu, Steven	PhD	2019	X-C Zhang
Gao, Haibo	PhD	2022	G. Schmidt & J. Bentley
Gebhart, Katelynn	HOME	2023	
Georgiadis, Antony	MS	2023	
Gitlin, Daniel	PhD	2022	J. Pigeon & D. Froula
Gong, Zhengyang	MS	2022	
Goodsell, Jeremy	PhD	2017	J. Rolland
Graf, Austin	PhD	2016	Q. Lin
Grcevic, Thomas	HOME	2021	
Griffo, Joseph	HOME	2022	
Guo, Zhenhua	PhD	2021	W. Renninger

Gupta, Shravan	PhD	2019	S. Carney
Guzi, Daniel	MS	2023	
Guzman-Thompson, Angelica	PhD	2021	W. Knox
Hancock, Benjamin	PhD	2022	T. Krauss
Hassard, Brian	PhD	2023	initial
He, Xiaotong	PhD	2018	J. Cardenas
Hewafonsekage, Jevon	HOME	2022	
Hewson, Connor	PhD	2023	
Holcomb, Robert	PhD	2019	J. Bromage
Hordin, Nicholas	HOME	2023	
Hosseini, Mohammad	PhD	2022	A. Berger
Howard, Tyler	PhD	2019	T. Brown
HU, Qili	PhD	2021	Q. Lin
Huang, Grayce Xiaojing	PhD	2019	J. Bentley & A. Dubra
Huang, Yifei	MS	2023	
Huh, Jin	PhD	2019	J. Schallek
Idrizovic, Anis	PhD	2022	M. Rucci & J. Rolland
Iqbal, Saleem	PhD	2018	R. Boyd
Irani, Shler	MS	2022	
Islam, Rushnan	PhD	2019	W. Knox
Iyer, Arjun	PhD	2017	W. Renninger
James, Evan	PhD	2020	G. Schmidt
Javid, Usman	PhD	2016	Q. Lin
Jia, Wuao	PhD	2021	J. Hunter
Johnson, Robert Revere	PhD	2021	N. Vamivakas
Kalinadhabhotla, Pranav	MS	2023	
Karpishin, Thomas	MS	2023	
Kim, Woo	PhD	2019	J. Rolland
King, Melanie	PhD	2018	S. Carney
Kolawole, Michael	HOME	2023	
Kowalski, Laura	PhD	2022	A. Pickel
Kumar, Sushant	PhD	2019	J. Cardenas
Lai, Jonathan Tianshu	MS	2023	
Laurin, Erik	HOME	2021	
Le, Martin	MS	2021	
Lee, Blake	HOME	2021	
Leonard, Isabelle	HOME	2023	
Lev, Ann	HOME	2023	

Li, Zeshu	MS	2023	
Liao, Haolin	PhD	2023	W. Knox
Liguori, Thomas	HOME	2021	
Limo, Michael	MS	2023	
Lippman, Davide	PhD	2018	D. Moore
Liu, Yihan	PhD	2020	B. Kruschwitz
Liu, Chang	MS	2023	
Liu, Prosper	MS	2022	
Liu, Soh Hang	MS	2023	
Liu, Yuxuan	PhD	2017	J. Rolland
Lopez-Rios, Raymond Fabricio	PhD	2020	Q. Lin
Ma, Mingjiang	MS	2021	C. Guo
Ma, Xiaoyu	MS	2022	initial
Mahoney, John	PhD	2022	J. Palastro
Manjula Narayanan, Renuka	PhD	2021	J. Rolland
Manning, Zachary	PhD	2019	W. Knox
Marion, John	MS	2021	
Marra, Louis	MS	2021	Q. Lin
McClure, Mathew	PhD	2022	T. Brown
Mishra, Nabendu	PhD	2022	N. Vamivakas
Moglianesi, Andrew	MS	2023	
Moon, Benjamin	PhD	2018	J. Rolland
Moran, Omar	MS	2023	
Morshed, Ovishek	PhD	2018	T. Krauss
Mugeni, Lyse	PhD	2021	G. Schmidt
Muhammad, Abdullah	HOME	2022	
Murphy, Peter	PhD	2019	D. Williams
Nauriyal, Arunima	PhD	2023	J. Cardenas
O'Connor, Samuel	MS	2023	
Paz, Angel	PhD	2023	
Percevault, Garrett	MS	2023	
Petterson, Ganesh	PhD	2023	
Poynton, Sean	HOME	2021	
Rauber, Griffin	MS	2023	
Roccabruna, Jacob	MS	2022	
Rodriguez Lopez, Omar	MS	2023	
Rodriguez, Chelsea	MS	2023	
Rodriquez, Micheal	PhD	2017	J. Marciante
Rojas Mena, Carlos Eduardo	HOME	2023	
Romer, Nikolas	PhD	2021	J. Rolland
Sacks, Jacob	PhD	2022	J. Bentley

Sanchez Soria, Natalia	PhD	2022	J. Fienup
Sanchez, Martin	PhD	2021	P. Postigo
Scheg, Lauren	HOME	2022	
Scibilia, Matthew	MS	2023	
Seitz, Kevin	HOME	2022	
Semple, Ryan	HOME	2021	J. Kruschwitz
Sentowski, Alexander	PhD	2023	
Sheikhakbari, Elaheh	PhD	2023	
Sparling, Jonathan	MS	2023	
Spiecker, David	PhD	2019	T. Brown
Staffa, Jeremy	PhD	2019	Q. Lin
Steidle, Jessic	PhD	2017	J. Rolland
Stepien, Witold	PhD	2018	J. Marciante
Stoogenke, Samuel	MS	2023	
Sukovaty, Icel	HOME	2023	
Sun, Ao	PhD	2022	N. Vamivakas
Swertfeger, Rebecca	PhD	2021	J. Bromage
Tang, Joseph	PhD	2015	J. Fienup
Tang, Luheng	PhD	2021	C. Guo
Tangari Larrategui, Martin	PhD	2016	T. Brown
Taylor, Mike	PhD	2020	Frank Huo
Teverovsky, Doran	PhD	2020	D. Williams & J. Bentley
Thietz, James	HOME	2022	
Vaden, Justin	HOME	2022	
Varley, McCain	MS	2023	
Vijayakumar, Surendar	PhD	2019	R. Boyd
Villegas Burgos, Carlos Mauricio	PhD	2017	N. Vamivakas
Viteri-Pflucker, Valeria	PhD	2022	N. Vamivakas
Wampler, Rhett	PhD	2022	J. Bromage
Wang, Yi	MS	2022	
Wei, Jiahui	PhD	2021	T. Krauss
Wei, Ran	PhD	2019	C. Guo
Wilson-Leslie, Sean	HOME	2023	
Wong, Felix	PhD	2023	
Wu, Ruei-Jr	PhD	2019	M. Rucci
Wu, Yuchen	PhD	2022	G. Schmidt
Xia, Yuning Lisa	PhD	2022	J. Bentley
Xiang, Jiewei	PhD	2019	J. Cardenas
Xiong, Isabella	PhD	2019	N. Vamivakas
Xu, Haozhen	PhD	2022	W. Renninger
Xu, Tianshu	PhD	2021	C. Guo

Xu, Wendao	PhD	2019	W. Renninger
Xu, Zhengyang	PhD	2022	J. McGregor
Yang, Ruichen	MS	2022	initial
Ye, Junran	PhD	2023	W. Knox
Yi, Xiuyuan	MS	2020	
Young, Liam	PhD	2023	
Zhang, Chi	PhD	2022	J. Rolland
Zhang, Junchi	PhD	2019	G. Agrawal
Zhang, Kai	PhD	2020	N. Vamivakas
Zhang, Kaibo	MS	2020	G. Agrawal
Zhang, Sizheng	MS	2023	
Zhang, Yueteng	MS	2023	
Zhao, Jiacheng	PhD	2022	X-C Zhang
Zhao, Tianyu	PhD	2023	
Zou, Hangyue	MS	2022	J. Rolland
Zou, Tianlun	PhD	2022	S. Marcos

Appendix I: Special Interest Courses (Specialties)

MS Students who are interested in a specialty area need to take the four required courses listed below as well as the choice of courses required for the specialty.

Core Courses

☐ 423 – Detection of Optical Radiation (Spring)..............................4 credits
☐ 443 – Foundations of Modern Optical Systems (Fall) ....4 credits
☐ 463 – Wave Optics and Imaging (Fall) ....4 credits
☐ 456 – MS Laboratory (Fall/Spring)..4 credits

Laser Engineering

Required (1 course)

☐ 473 – Laser Engineering (Fall)..4 credits

Quantum Elective (choose 1 course)

☐ 412 – Quantum Mechanics for Optics (Spring) ....4 credits
☐ 421 – Optical Properties of Materials (Spring).............................4 credits
☐ 428 – Optical Communications (Fall)..4 credits
☐ 453 – Quantum and Nano Optics Laboratory (Fall) ....4 credits
☐ 464 – Nanophotonic and Nanomechanical Devices (Fall)............4 credits
☐ 465 – Principles of Lasers (Spring)..4 credits
☐ 467 – Nonlinear Optics (Fall) ....4 credits

Other Electives (choose 2 courses)

☐ 428 – Optical Communications (Fall)..4 credits
☐ 467 – Nonlinear Optics (Fall) ....4 credits
☐ 468 – Waveguides and Optoelectronic Devices (Fall)..................4 credits
☐ 484 – Petawatt Lasers (Spring)...4 credits
☐ Other [approved by advisor] ....4 credits
☐ Other [approved by advisor] ....4 credits

Image Science

Electives (choose 3 courses)

☐ 412 – Introduction to Random Processes (Fall) ....4 credits
☐ 448 – Vision and the Eye (Spring)...4 credits
☐ 452 – Medical Imaging – Theory and Implementation (Fall) ....4 credits
☐ 483– Computational Imaging (Spring)..4 credits
☐ 561 – Advanced Imaging (Spring)...4 credits
☐ Other [approved by advisor] ....4 credits
☐ Other [approved by advisor] ....4 credits

Quantum Elective (choose 1 course)

☐ 412 – Quantum Mechanics for Optics (Spring) ....4 credits
☐ 421 – Optical Properties of Materials (Spring).............................4 credits
☐ 428 – Optical Communications (Fall)...4 credits
☐ 453 – Quantum and Nano Optics Laboratory (Fall) ....4 credits
☐ 464 – Nanophotonic and Nanomechanical Devices (Fall)............4 credits
☐ 465 – Principles of Lasers (Spring)...4 credits
☐ 467 – Nonlinear Optics (Fall) ....4 credits

__**Optical Communications**__

Required (1 course)

☐ 428 – Optical Communications (Fall)...4 credits

Quantum Elective (choose 1 course)

☐ 412 – Quantum Mechanics for Optics (Spring) ....4 credits
☐ 421 – Optical Properties of Materials (Spring).............................4 credits
☐ 453 – Quantum and Nano Optics Laboratory (Fall) ....4 credits
☐ 464 – Nanophotonic and Nanomechanical Devices (Fall)............4 credits
☐ 465 – Principles of Lasers (Spring)...4 credits
☐ 467 – Nonlinear Optics (Fall) ....4 credits

Other Electives (choose 2 courses)

☐ 421 – Optical Properties of Materials (Spring).............................4 credits
☐ 468 – Waveguides & Optoelectronic Devices (Fall) ....4 credits
☐ Other [approved by advisor] ....4 credits
☐ Other [approved by advisor] ....4 credits

__**Optical Design, Fabrication, and Testing**__

Required (choose 1 course)

☐ 433 – Optical Fabrication and Testing Technology (Spring).........4 credits
☐ 444 – Lens Design (Spring)...4 credits

Quantum Elective (choose 1 course)

☐ 412 – Quantum Mechanics for Optics (Spring) ....4 credits
☐ 421 – Optical Properties of Materials (Spring).............................4 credits
☐ 428 – Optical Communications (Fall)...4 credits
☐ 453 – Quantum and Nano Optics Laboratory (Fall) ....4 credits
☐ 464 – Nanophotonic and Nanomechanical Devices (Fall)............4 credits

☐ 465 – Principles of Lasers (Spring)..4 credits
☐ 467 – Nonlinear Optics (Fall) ....4 credits

Other Electives (choose 2 courses)
☐ 432 – Opto-Mechanical Design (Fall) ....4 credits
☐ 433 – Optical Fabrication and Testing Technology (Spring).........4 credits
☐ 440 – Freeform Optics (Fall) ....4 credits
☐ 442 – Instrumental Optics (Spring)...4 credits
☐ 444 – Lens Design (Spring)...4 credits
☐ 445 – Precision Instrument Design (Fall)......................................4 credits
☐ 448 – Vision and the Eye (Spring)...4 credits
☐ 449 – Illumination (Fall)...4 credits
☐ Other [approved by advisor] ....4 credits
☐ Other [approved by advisor] ....4 credits

<u>**Nonlinear Optics**</u>
Required (1 course)
☐ 467 – Nonlinear Optics (Fall) ....4 credits

Quantum Elective (choose 1 course)
☐ 412 – Quantum Mechanics for Optics (Spring) ....4 credits
☐ 421 – Optical Properties of Materials (Spring)............................4 credits
☐ 428 – Optical Communications (Fall)...4 credits
☐ 453 – Quantum and Nano Optics Laboratory (Fall) ....4 credits
☐ 464 – Nanophotonic and Nanomechanical Devices (Fall)............4 credits
☐ 465 – Principles of Lasers (Spring)..4 credits

Other Electives (choose 2 courses)
☐ 421 – Optical Properties of Materials (Spring).............................4 credits
☐ 465 – Principles of Lasers (Spring)..4 credits
☐ 468 – Waveguides & Optoelectronic Devices (Fall) ....4 credits
☐ 479 – Singular Optics (Fall) ....4 credits
☐ Other [approved by advisor] ....4 credits
☐ Other [approved by advisor] ....4 credits

<u>Nano and Integrated Photonics</u>

Required (1 course)

☐ 453 – Quantum and Nano Optics Laboratory (Fall) ....4 credits

Quantum Elective (choose 1 course)

☐ 412 – Quantum Mechanics for Optics (Spring) ....4 credits
☐ 421 – Optical Properties of Materials (Spring)............................4 credits
☐ 428 – Optical Communications (Fall)...4 credits
☐ 464 – Nanophotonic and Nanomechanical Devices (Fall)............4 credits
☐ 465 – Principles of Lasers (Spring)...4 credits
☐ 467 – Nonlinear Optics (Fall) ....4 credits

Other Electives (choose 2 courses)

☐ 407 – Scanning Electron Microscopy (Spring)..............................4 credits
☐ 429 – Chemical Bonds: Molecules and Materials (Spring)...........4 credits
☐ 464 – Nanophotonic and Nanomechanical Devices (Fall)............4 credits
☐ 468 – Waveguides and Optoelectronic Devices (Fall)..................4 credits
☐ Other [approved by advisor] ....4 credits
☐ Other [approved by advisor] ....4 credits

<u>Optical Materials</u>

Required (1 course)

☐ 421 – Optical Properties of Materials (Spring)............................4 credits

Quantum Elective (choose 1 course)

☐ 412 – Quantum Mechanics for Optics (Spring) ....4 credits
☐ 428 – Optical Communications (Fall)...4 credits
☐ 453 – Quantum and Nano Optics Laboratory (Fall) ....4 credits
☐ 464 – Nanophotonic and Nanomechanical Devices (Fall)............4 credits
☐ 465 – Principles of Lasers (Spring)...4 credits
☐ 467 – Nonlinear Optics (Fall) ....4 credits

Other Electives (choose 2 courses)

☐ 433 – Optical Fabrication and Testing Technology (Spring)..........4 credits
☐ 453 – Quantum and Nano Optics Laboratory (Fall) ....4 credits
☐ 468 – Waveguides and Optoelectronic Devices (Fall)..................4 credits
☐ Other [approved by advisor] ....4 credits
☐ Other [approved by advisor] ....4 credits

Appendix II: Example HOME Programs of Study

Part-time HOME Student - Plan B Essay track

Course	Offered	Requirement	Credits	Note
443 – Found. Modern Opt Sys	Each Fall	Core	4	Pre-req for Optics Laboratory
463 – Wave Opt & Imaging	Each Fall	Core	4	Pre-req for Optics Laboratory
423 – Detect. Opt. Rad.	Each Spring	Core	4	
401 – 1st HOME Opt. Lab.	Each semester & summer session	Core	1	
402 – 2nd HOME Opt. Lab.	Each semester & summer session	Core	1	
403 – 3rd HOME Opt. Lab.	Each semester & summer session	Core	1	
464 – Nanophot. & Nanomech Devices	Each Spring	Quantum Area Req.	4	
444 – Lens Design	Each Spring	Geo. Area Req.	4	
421 – Opt. Properties of Materials	Each Spring	Quantum Area Req.	4	
467 – Nonlinear Optics	Each Fall	Elective	4	Also satisfies Quantum area req.
		Total Credits	31	

Course	Offered	Requirement	Credits	Note
443 – Found. Modern Opt Sys	Each Fall	Core	4	Pre-req for Optics Laboratory
463 – Wave Opt & Imaging	Each Fall	Core	4	Pre-req for Optics Laboratory
423 – Detect. Opt. Rad.	Each Spring	Core	4	
422 – Color Tech	Each Spring	Physical Area Req.	4	
449 – Illumination	Each Fall	Geometrical Area Req.	4	
ECE 452 – Med. Imaging	Each Fall	Elective	4	Also fulfills Physical Area Req.
465 – Princ. Of Lasers	Each Spring	Quantum Area Req.	4	
454 – Opt. Lab. For HOME	Each Summer	Core	3	Equivalent to 456 Opt. Lab.
		Total Credits	31	

Courses by Area Requirement

Physical Optics:
422 – Color Technology
446 – Optical Interference Coating
447 – Advanced Optical Coatings
450 – Polarization
OPT/ECE 452 – Medical Imaging – Theory & Implementation
462 – Electromagnetic Waves
468 – Waveguides & Optoelectronic Devices
479 – Singular Optics
535 – Modern Coherence Theory
561 – Advanced Fourier Optics

Geometrical Optics:
432 – Opto-Mechanical Design
433 – Optical Fabrication and Testing Technology
440 – Freeform Optics
442 – Instrumental Optics
444 – Lens Design
449 – Introduction to Illumination
544 – Advanced Lens Design

Quantum Optics:
412 – Quantum Optics
421 – Optical Properties of Materials
428 – Optical Communication Systems
453 – Quantum and Nano Optics Laboratory
464 – Physics & Applications of Nanophotonic & Nanomech. Devices
465 – Principles of Lasers
467 – Nonlinear Optics
551 – Introduction to Quantum Optics
552 – Quantum Optics of EM Field (Quantum Optics I)

Preliminary Exam Readiness Form

Name:
Research Advisor:
Have you received a "C" or "E" grade for any courses? If so, list the courses below:

Please enter your grades for the following courses:

OPT 411 Math Methods	
OPT 412 Quantum Optics	
OPT 425 Radiation & Detectors	
OPT 441 Geometrical Optics	
OPT 442 Instrumental Optics	
OPT 461 Fourier Optics	
OPT 462 Electromagnetism	

Once you are "cleared" to take the preliminary exam, you will be added to the Prelim course on Blackboard, where you will find study guidance and any papers needed for the exam.

This form is due no later than May 1st to
Kai.Davies@rochester.edu

2023 Preliminary Examination Preparation Materials

Table of Contents:

2023 Section Guide & Instructor Assignments

Section	Course / Instructor	Written by	Day	Duration	Paper-based
Quantum & Atomic Physics	412 – Visser	Nick Vamivakas & Taco Visser	1	45 minutes	
Electromagnetism	462 – Agrawal	Govind Agrawal	1	45 minutes	
Fourier Optics	461 – Fienup	Jim Fienup	1	45 minutes	
Mathematical Methods	411 – Renninger	Will Renninger	1	45 minutes	
Lasers	465 - Postigo	Pablo Postigo	2	45 minutes	
Instrumental Optics	442 – B. Kruschwitz	Brian Kruschwitz	2	45 minutes	
Radiation & Detectors	425 –Wicks	Gary Wicks	2	45 minutes	
Geometrical Optics	441 – Buralli	Greg Schmidt	2	45 minutes	
Vision	448 – Sarah Walters	David Williams	3	30 minutes	X
Spectroscopy/Optical Properties of Materials	421 – Wicks	Andrew Berger	3	30 minutes	X
Photonics	428 – Cárdenas	Jaime Cárdenas	3	30 minutes	
System Design & Analysis		Jim Zavislan	3	90 minutes	

A GUIDE TO THE 2023 Ph.D. PRELIMINARY EXAMINATION

This is a 9-hour written examination made up of 3 segments, one of which is given on each of 3 successive days. **For the summer of 2023, it will be from June 26 through June 28th from 9am to 12pm in Goergen 109.**

The prelim is designed to be taken by students who have completed the normal first year Ph.D. course work in optics. There are two main purposes, which the examination serves. First, the preparation for the examination enables the student to gain an overview of some five years' study in physics, optical engineering, and mathematics. Students have an opportunity to review past courses, to sift out the important topics, and to distill the essential subject matter. Secondly, the examination provides the Optics faculty with a quantitative basis for deciding whether the student has the foundation of knowledge necessary to begin course work and thesis research in a specialized area. Although the performance on this examination is not the only criterion that is considered in making this judgment, it is weighted heavily.

How to prepare for your prelim:

In order to prepare for the preliminary exam, the students should:

a) Review some of the exams from recent years. Copies of these exams are distributed early in the summer by the Graduate Coordinator to the students who are taking the exam. These previous exams should be reviewed judiciously for several reasons. First, the emphasis on some of the subjects might have shifted. Another reason is that the examination questions are submitted by individual faculty. Questions which bear the hallmark of some faculty member may depend on whether they are in charge of writing the corresponding part of the exam that year or not.

b) Review the topics listed in the guide, which follows. While the faculty who prepared this guide did their best to list the likely topics for the preliminary examination, the term "guide" is used because it is not guaranteed that these and only these topics will appear on the examination.

c) Confer with faculty. Often there will be a point that was not clear in a course. During review, as these points become apparent, students should avail themselves of the opportunity to discuss such problems with the faculty.

What's new for 2023?

Very little is changed from one year ago. In 2020, we introduced a new style of question in order to provide students with additional focus for their preparation, and to remove some of the disadvantage felt by students who may not have taken a course in one or more of those subjects. It is also to allow you to dig deeply into some classic original papers in areas of optics. As researchers, there is usually not a textbook to teach you how to solve your research problems: You learn from other individuals and you learn from the literature.

The subjects for which the new questions will be used are as follows:

Vision and Spectroscopy/Optical Properties of Materials.

The papers can be found in the Graduate Student Resources Folder in Box within the Prelim Materials folder:
https://rochester.box.com/s/jiweywzxspggp1y5klk5y5oxjxtg0mve

For each of these areas, you will be provided with one to three papers. One of these papers will be provided with the exam and will be the basis of the question. You don't know which one, so you will have to be acquainted with all three. The questions may include the following: inquiries about the foundational importance of the papers; an explanation of some of the theoretical derivations (e.g. what is the significance of the last term in equation 4); an explanation of the purpose of a particular experimental component; an assessment of the certainty of the conclusions; or an explanation of certain technical terms that may be used in the paper. You are encouraged to work together to understand the papers, or to make an appointment with the faculty member responsible for the question to discuss them.

Day 1

Quantum and Atomic Physics - 45 minutes

Simple quantum mechanical systems, such as a harmonic oscillator, a spin, or a two-level atom interacting with an external electric or magnetic field. Application of either time-dependent or time independent perturbation theory or solving the time-dependent Schrodinger equation, or Heisenberg equation for the dynamics of the system. Coherent states of harmonic oscillators, electric dipole selection rules for optical transitions in atoms and molecules, as well as the vector model of addition of angular momenta.

References: OPT 412 material (notes and textbook reading)

Electromagnetism - 45 minutes

First-year graduate level material on electromagnetism, including:

- Maxwell's equations,
- Lorentz and Drude models,

- propagation of plane waves and pulses,
- polarization and crystal optics,
- reflection at an interface,
- thin films,
- dielectric mirrors,
- waveguides,
- potentials and gauge transformations,
- Green's function,
- radiation emitted by dipoles, wires, and antennas

References: OPT 462 notes and textbook

Fourier Optics - 45 minutes

Diffraction in free space, the linear system formulation for imaging systems, Fourier transform theory, optical information processing, and holography.

References: OPT 461 material.

Mathematical Methods - 45 minutes

Vector Calculus, Dirac Delta-functions, Complex Analysis, Taylor and Laurent series, Contour integrals, Residues, Singularities, Fourier & Laplace transforms, Ordinary differential equations, Green's functions.

References: OPT 411 material.

Day 2

Radiation and Detectors - 45 minutes

Radiometry; Photometry; Colorimetry; Blackbody radiation; Statistics of photons and noise; Figures of merit of detectors; Specific detector types: photomultiplier, photoconductive detector, photovoltaic detector, avalanche photodiode, bolometer, pyroelectric detector, thermopile, CCD.

References: OPT 425 material (notes and readings).

Geometrical Optics - 45 minutes

Foundations of Geometrical Optics. Fermat's principle. Implications of symmetry in axial systems (rotation invariants). Imaging properties expanded in Taylor series-definitions of first- and third-order properties. First order analysis and design of optical systems. First-order transfer and refraction. Thin lens equations. Cardinal Points. Stops and Pupils (marginal and chief rays). Primary chromatic aberrations. Afocal, visual, transverse, and longitudinal magnifications. Lagrange invariant. First order layout in simple systems--achromatic doublets, telescopes, microscopes, telephoto and reverse telephoto lenses, etc. Third order analysis and design of optical systems. Primary third-order monochromatic aberrations. Wave aberration function and transverse ray errors. Stop shift equations. Thin lens equations.

References: OPT 441 material

W.J. Smith, *Modern Optical Engineering*

Lasers - 45 minutes

You may find the following references helpful:

OPT 465 notes

Svelto, *Principles of Lasers*

Questions in Quizzes 1, 2, and 3

Instrumental Optics - 45 minutes

You may find the following references useful:

Optics 442 material

Malacara, *Optical Shop Testing*

Born and Wolf, *Principles of Optics* (Coherence Chapter, starts on page 515 of the .pdf in the Box folder).

Day 3

The third day consists of questions on courses that the majority of students taking the preliminary exam have not yet taken. The benefits of this set of questions include the following. These questions test the ability of the students to study and acquire knowledge by themselves, a skill that they will need in order to do independent research. It also gives them some familiarity with areas that they might not otherwise study, broadening their knowledge. Studying these areas also affords the students to learn a little about special topics in optics that are active areas of research at the Institute.

Vision – 30 minutes

You may find Prof. Sarah Walter's OPT 448 Vision class notes useful.

The questions for the vision portion of the exam will be based on the following two review articles, which will be provided during the exam itself:

Susana Marcos, Pablo Artal, David A. Atchison, Karen Hampson, Richard Legras, Linda Lundström, and Geunyoung Yoon, "Adaptive optics visual simulators: a review of recent optical designs and applications [Invited]," Biomed. Opt. Express 13, 6508-6532 (2022)

David R. Williams, Stephen A. Burns, Donald T. Miller, and Austin Roorda, "Evolution of adaptive optics retinal imaging [Invited]," Biomed. Opt. Express 14, 1307-1338 (2023)

Spectroscopy (a.k.a Optical Properties of Materials) – 30 minutes

Although students are of course free to read through all of the materials, the required readings are as follows:

Berger Raman chapter - sections 1 through 4, inclusive

Fluorescence chapter - from beginning to section 2.1, inclusive

Journal article (Shipp et al.) - pages 1-4 plus the conclusion section. The point of this paper is for the students to understand that Raman and fluorescence techniques are both used.

The examination will be partially about the fundamentals from the two introductory PDFs and partially about the journal article sections.

Photonics – 30 minutes

The students should use the textbook reference, Integrated Photonics by Clifford Polloch & Michal Lipson. They need to read chapters 3, 4, 10 (sections 1 through 4), and 11 (sections 1 through 3).

They should be prepared to answer conceptual and quantitative questions. Calculator is not needed.

The book is located in reserve at POA library. Electronic version included in Box & available here:

https://rochester.primo.exlibrisgroup.com/permalink/01ROCH_INST/300o2r/alma9978272151605216

System Analysis & Design – 90 minutes

Companion video link:
https://rochester.hosted.panopto.com/Panopto/Pages/Viewer.aspx?id=cfe25dc5-2c56-414b-83b2-b0040142d6c2

1) Purpose of the System Design and Analysis Question

    Include in your preliminary exam preparation activities that will assist in experimental design and implementation.

2) Format of Question

    Develop a first-order design for an existing product that uses an optical technique based on material covered in your first year-courses.

3) Strategies for Answering the Question

    i. Starting the problem:

    ii. What is the problem asking me to do?

    iii. What information does the instrument need to provide to work well? (Consider, what environment will the system be used, and who will be using the system?)

    iv. What test or tests would I need to run to determine if the system is working properly? How many tests need to be run and in what environments. It is very, very rare that a single test can prove a system is functional (This is often called the *Validation or Acceptance Test.*) Knowing how a system will be tested gives you very important guidance in designing a system. After all it is through these tests that you will know if the system is "good enough".

v. What level of accuracy and precision is needed to determine if the system is working? Consider whether the required accuracy and precision are straightforward or challenging to measure.

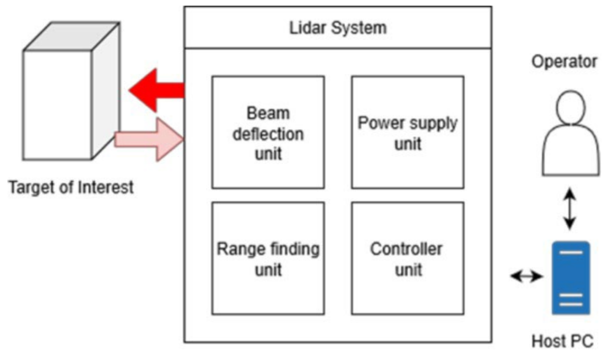
vi. What are the optical measurements or principles that can provide the information to the appropriate accuracy and precision?

vii. List as many different approaches as time allows that are consistent with the information you have considered in 3)i-v.

viii. Pick the one approach that ***you believe most likely to work in the situation presented. Write down the reasons for your decision (can be brief) and make sure you believe that this system concept has the ability to meet the validation/acceptance test.*** (This is an important step.)

b. Developing the system:

i. Build a block diagram[1] of the system. This includes all the needed subsystems or compoents to make it work. Below is a block diagram for a Lidar system[2] showing the subsystems within the overall system and the flow of information. A lidar system was one of the best solutions to the 2016 question.



4)
5) Fig.1 Lidar System Block Diagram[2]

[1] See https://www.techtarget.com/whatis/definition/block-diagram for a concise definition of a block diagram.

[2] T. Raj, et. Al, A Survey on LiDAR Scanning Mechanisms, *Electronics* **2020**, *9*(5), 741; **https://doi.org/10.3390/electronics9050741**

i. Consider the functions of each block including what information will be exchanged between blocks and ***how well each block must function for the overall system to work.*** (This a very important step in your thesis research. Often the overall system fails to work because one or more "blocks" do not meet the needed level of stability/repeatability. For example: when capturing analog data, how many "bits" does an A/D need to have to be able to distinguish relevant changes in the signal.)

ii. Repeat the process outlined in a. for each of the blocks in the block diagram. ***For the purpose of answering the preliminary exam question, concentrate your effort on the optical portions of the block diagram and any of the other system that are critical to in supporting the optical functions. For example, in an interferometer the stability of the mechanical system plays a critical role. So, the mechanical performance needs to be stated, but you would not need to develop a specific design.***

iii. Develop a first-order design for each of the optical systems in the design (note, system may include both an illumination and imaging system). Where appropriate, identify the field of view, the operating wavelength range, magnification and NAs in object and image spaces. Answer the question what does the optical system need to do to be able to provide the information needed?

iv. Consider the photon budget for the system. ***When answering the***

<u>preliminary question, set up the radiometry problem and make an estimate of how many photons are needed to obtain the needed information.</u> (In your research or in actual system design, extensive modeling or preliminary subsystem testing needs to be done to establish specification.)

v. ***<u>It is acceptable to decide that your initial approach was incorrect. If you come to this conclusion, state your reasons and outline corrective steps.</u>***

<u>When grading this question, I consider whether the approach taken by the student would be successful if they had sufficient time and resources to build and test what was proposed. More credit is NOT given when irrelevant or superfluous details are provided.</u>

6) Things to avoid

a. <u>Start to answer the questions, prior to reading over the entire problem statement</u>. Instead, read over the entire question and decide how much time you will spend on each part. Your goal is to develop the most complete answer to the entire question prior to the end of the exam. While it is understood that the preliminary exam is timed test, making a plan so that you can complete a project by a deadline is an important skill both for your research and in your career. Often you will need to make decisions on *what you do* based on *how much time you have*. Remember you cannot buy time, but you can often buy resources that save time or improve productivity. You should only buy what you need.

b. <u>Picking the first approach that comes to mind and building a system around this.</u> Instead, I strongly encourage you to go through the steps outlined in 3 a. (You will need to practice these enough so that you can recall them by memory) ***<u>Proceeding through these steps provides valuable insight and context that assists in choosing an approach that has the best chance of succeeding.</u>*** Historically, students have failed to earn points because the tried to solve the wrong problem or picked an impractical approach to acquiring the requested information. For example, in the 2016 System Design question students considered the design of an *<u>existing, commercially available</u>* mapping system used in an aerial drone that:

uses a scanned laser to measure the surface topography below the drone with horizontal resolution of 4 x 4 cm and vertical resolution of 4 cm while *moving at 1 m/s. The next page provides general specification for the system provided by the manufacturer. The image at the top of the page illustrates a "false-color" rendering of the terrain below.*

Relevant specifications.

> *Scan width of 50 m full width from a relative altitude of 25 m. Horizontal resolution of 4 cm x 4cm and vertical resolution of 4 cm.*

<u>Many students chose to use a Twyman-Green interferometer to do the optical ranging. While interferometry can measure typography, a Twyman-Green interferometer would not work in this operating environment and geometry.</u>

c. *Going into too much detail on one part of the system* just because you happen to know something about yet not enabling the performance of the entire system. Instead consider all the parts of the system and remember when designing systems, there is no benefit in providing into more detail then needed. Answer the questions based on the information requested. Again, in answering the preliminary exam question, you will be concentrating on the optical system and the subsystems needed so.

7) Preparing for the exam

   a. Review the concepts found in OPT 441, 442, 425 and 461. Consider how these concepts are used in instruments used in your research group. Consider how these are used in commercial and consumer products. The 2021 question requested students develop a system to measure airborne particulates. Diffraction pattern sensing is well suited for this type of question.

   b. Convene a group to answer the questions from a prior year's *System Design* problem, using the process outlined in this document. Evaluate each other's designs, using the criteria: Would it be possible to build a prototype that meets the validation test using the approach outlined assuming that you had sufficient time and resources?

Taking the Exam

It is recommended that you leave for the exam earlier than your typically would leave to come to campus to avoid last minute stressors. You can purchase parking permits for Intercampus Lot Zone 2 South at the parking booth on Wilson Blvd (next to Hutchinson Hall) to reduce your commute time.

The exam will begin at 9am unless all students are present early and unanimously agree to begin the exam early. The exam duration is 3 hours each day. Students with testing accommodations that grant extra time will have additional time as set by the Office of Disability Resources. If you have classroom or testing accommodations, please alert Kai Davies if you haven't already.

Note: While the Office of Disability Resources (ODR) documents and manages accommodations, the Institute of Optics will consider and potentially grant accommodations for students with expired ODR documentation or who do not have ODR documentation.

Be sure to have the following with you each day:

- Pens and/or pencils
    - You may use either. Keep in mind that you will have basic figures to draw.
    - Extra pens and pencils will be provided by the dept, along with all testing booklets & scratch paper
- Calculator
    - Not all sections will call for a calculator
    - You cannot use a calculator on the Mathematical Methods section & you must set aside your calculator when working on or viewing that section
- Drinks or Snacks
    - Please keep cleanliness and noise in mind when selecting your snacks. If you have a noisy wrapper, please open the item all at once to reduce disruption.

During the Exam

All of your personal items, including your cell phone, must be tucked away neatly and secured out of sight during the exam. The items you will use during the exam should be laid out and set aside at the start of your test. If you need to access your secured belonging, please alert the proctor first.

NOTE: The proctor may request to inspect any of your items for unauthorized notes or attempts to cheat.

The 3-hour testing period is continuous, with no planned breaks. You may raise your hand to request to use the restroom. You must leave your cellphone and any other devices in the testing room.

The proctor list is not yet set, but we anticipate having a faculty member present for the majority of the exam. They can take questions or offer clarification on questions at their discretion. Any questions asked will be answered and shared with all test takers in the interest of fairness.

Flow of the Exam

When it is time for the exam to begin, the proctor will call for all test areas to be cleared of restricted items. The exam packets will be distributed.

Do NOT open the test packet until you are instructed to begin the exam itself.

The exam packet will include 4 Blue Books labelled with each prelim section with the questions for that section tucked into the first page of the Blue Book. Scratch paper and additional blue books will be included with the packet with additional books and paper available in the exam room.

Be sure to put your name on all 4 Blue Books as the sections will be separated for grading.

A clock will be visible throughout the exam or the proctor will write the time periodically on the board. The exam is self-timed. While there are suggested testing durations for each section, each student will manage their own time spent. Students may complete the sections in whatever order best suits them.

Upon completion of the exam, put your writing utensils down immediately and reassemble your exam packets--- put your question sheets and scratch paper inside the Blue Book they correspond to. You will place the Blue Books into bins or piles labelled for each section at the front of the exam room.

Following the final day of exams on Wednesday, June 28th, we will have a Prelim Picnic in Genesee Valley Park for prelim test takers and Optics PhD students only. Please watch for emails with the exact details for the event as we get into June 2023.

Post-Exam

The sections will be sent off for grading, followed by a special faculty meeting to discuss the results of the exam. Following the special faculty meeting on the prelim, test-takers will be notified of their results via email. Instructions for students who need to complete remediation or retake the exam will be included in the letters. All test-takers will receive a letter indicating the results of their preliminary examination.

Unfortunately, the grading process and faculty meeting can take considerable time to complete. We anticipate sending notice of grades in the later part of July.

Ph.D. Student Annual Progress Report

Student's Name: ______________________________ Date:_________________________

Advisor's Name: ___________________________ Year enrolled in PhD program: __________

1) Thesis Committee members (if applicable):

2) All course requirements have been met (90 credits); (yes / no)
Program of Study form is on file or attached (yes / no)

3) Thesis proposal completed or expected month:

4) Thesis defense expected year/month:

5) In the past 12 months I have accomplished these things:
-Research, publications, conference attendance and presentations, courses taken, TA, etc.

6) My goals for the upcoming 12 months:
-Objectives you have for the coming 12 months, as well as for the rest of your PhD studies.

7) My concerns & anticipated obstacles for the upcoming 12 months:
-Areas of concern or foreseeable issues that you anticipate encountering in the coming 12 months or during the completion of your PhD program.

Comments from advisor:

Advisor Signature: ____

Note: If you are advised by faculty outside of Optics, we need your internal advisor's signature as well.

Please complete this form, **obtain your advisor's comments and signature,** and give a hard-copy or electronic copy to Kai Davies by **August 1st**. Submissions are accepted by email or using this link: https://rochester.app.box.com/f/f67f02dc95be4128b4cd4784de9586c6

A GUIDE TO THE PREPARATION OF PH.D. THESIS PROPOSALS

In order to help students conduct research that will lead to successful completion and defense of the doctoral dissertation, The Institute of Optics faculty has established a requirement that all students prepare and defend a thesis proposal in the early phases of their research. It is felt that the experience gained through the completion of this requirement will be beneficial to all students, for it will make them conduct thorough review of their field of specialization, clearly delineate the problem to be investigated, and establish goals and objectives that are appropriate in scope for a doctoral research project.

The thesis proposal and any subsequent revisions are to be submitted to The Institute faculty as a whole; all are invited to make whatever comments or suggestions they feel appropriate. In order to allow time for the faculty to make these comments, the proposal must be circulated to the entire faculty at least two weeks before the examination. The proposal must have the general approval of the student's prospective thesis advisor prior to submission to the faculty. However, the thesis advisor is not expected to vouch for all statements made in the proposal, nor to assume the student's burden of responsibility for the proposal.

It is expected that students will submit thesis proposals no later than 21 months after they demonstrate, by passing the written Preliminary Examination, their general competence at the level required for doctoral research. It is very much in the student's best interests to write the proposal as soon as possible. This will organize the research efforts so as to complete the dissertation with the least wasted time and effort.

At the time of circulation to the faculty, a copy of the proposal should be given to the Administrator for Graduate Studies who will place it in the files. The Administrator will also provide a copy of the “Examination Appointment Form for the Master's Final, Doctor of Philosophy Qualifying”. This form nominates the faculty members to serve on the examination and sets a date for it. This form must be submitted to the Dean for Graduate Studies at least two weeks before the date of the examination.

Oral Qualifying Examination

According to University regulations, the oral qualifying examination is the official Ph.D. Qualifying Examination, and the written examination must be passed for the student to become eligible to take the oral examination.

The oral qualifying Examination is subject to the following University rules. It must be taken at least six months before the final examination. A vote to pass the candidate must be approved by at least three-fourths of the designated members of the committee. The votes of all committee members will be recorded. The office of the Dean must be notified at least two weeks before a qualifying examination is to be held, and passage or failure must be reported to the Dean within one month after the examination. A second qualifying examination may be taken only upon the recommendation of the College Graduate Committee and the approval of the Dean.

In the oral qualifying examination, the student is expected to present a defense of the thesis proposal and to demonstrate competence in areas that are generally related to the proposed research. The Examining Committee, after hearing the defense, will either pass the student, allowing formal commencement of research, or fail the student, with an appropriate recommendation for future action. An exception is that when only minor deficiencies in the proposal or defense are brought out in the exam, the Examining Committee may postpone its decision to a later date, to give the student an opportunity to eliminate the deficiencies.

The procedure is as follows:

1. The student finds a prospective thesis advisor and selects a topic for Ph.D. research.

2. The student prepares a written document which describes the proposed research. The Thesis Proposal serves three purposes. It organizes the student's efforts along a path which the Faculty agree may reasonably lead to a doctoral thesis. It acquaints the Faculty as a whole with the research effort so that they may offer assistance and counsel as is appropriate. It forms the focus for the Oral Qualifying Examination.

In order to properly serve these purposes, it is essential that the proposal state as clearly and succinctly as possible the nature and scope of the project proposed. It is also essential that the proposal be prepared in a timely fashion so that it can assist and guide the research. It should not be a draft of the first half of the thesis describing completed work.

FORMAT OF THESIS PROPOSALS

Thesis proposals should be typeset (double-spaced) and made into a pdf file. Copies of recent successful thesis proposals are available from the Graduate Coordinator. The thesis proposal should contain the following parts:

1. **Title/Abstract Page**

The first page of the thesis proposal, the cover page, should give the tentative title of the thesis, the student's name, the prospective faculty advisor's name, and the date of the proposal. This should be followed by a 200-word abstract. The abstract should summarize the proposed research, rather than give a description of what is contained in the proposal.

2. **Introduction**

The introduction should give a general description of the field within which the proposed research falls. It should make use of extensive literature references, both to permit the discussion to be concise and to demonstrate that the student is familiar with the literature in the chosen field.

3. **Proposed Research**

This section is the heart of the thesis proposal, and should present, in detail, the objectives of the proposed research. The discussion should describe the particular contributions that are anticipated, and how they relate to previous work in the field. Alternative courses of action should be considered, and the chosen one justified. Anticipated problems should be described.

4. **Bibliography & References Cited**

Include a bibliography of references directly cited and source materials relied upon for this project. All citations must be formatted consistently.

Total Length

The total length of the proposal, including text, figures, appendices, etc., should not exceed 12 pages, not counting the cover page and additional page(s) for references.