

GRADUATE CATALOG SUPPLEMENT 2009-2010

Graduate Study and Research In Optics

The Institute of Optics
University of Rochester
Rochester, New York 14627
(585)275-4722

CONTENTS

Registration Procedure	2
Committee Assignments	3
Administration of The Institute of Optics	4
Graduate Calendar	5
Faculty of The Institute of Optics	10
Thesis Advisors	21
Graduate Course Descriptions	22
Requirements for the M.S. Degree in Optics	34
M.S. Thesis	35
M.S. Course Work	36
M.S. Examination	36
MS with Certified Specialty	37
Specialty Areas	38
MS Essay	39
BS/MS Program	39
M.S. Part-Time Program	40
M.S. Cooperative Program	40
Requirements for the Ph.D. Degree in Optics	41
A Guide to the Ph.D. Preliminary Examination	46
Miscellaneous Regulations	
Time Limitations on Incompletes	47
Petitions for Exemptions from the Rules	47
A Guide to the Preparation of Ph.D. Thesis Proposals	52
Form of Thesis Proposals	54
M.S.. Thesis Titles	56
Ph.D. Thesis Titles	60
Graduate Students	64

REGISTRATION PROCEDURE

All matriculated students must register on-line by going to the registrar's website, <http://www.rochester.edu/registrar/registration.html>. They must maintain continuous enrollment until their degree is awarded. Below are some different options for registering once you have met your 90 credit hours. :

Registration of 899/999 and 895/995 courses:

When a student has completed course and credit requirements for a degree, the student may register for either 899/999 (Masters Thesis/Doctoral Dissertation) or 895/995 (Continuation of Masters/Doctoral Enrollment).

Registration of 899/999 along with other courses:

Once a student is close to completion of coursework, 899 and 999 can be used to maintain full time status. For example, if a student only needs five more credit hours towards the degree, the student should register for classes or research credit of five hours and 899 or 999 as well.

If a student is registering for a reading course, an **Approval of Graduate Reading/Independent Study Courses Form** must be submitted to the graduate coordinator.

THE INSTITUTE OF OPTICS COMMITTEE ASSIGNMENTS 2009-2010

GRADUATE COMMITTEE

M. Alonso, Chairman
G. Agrawal
J. Fienup
N. George

GRADUATE ADMISSIONS

R. Boyd, Chairman
L. Novotny
K. Teegarden
C. Guo

Graduate Student Representatives (2008-2009)

Adam Heiniger, Jr. Grad Rep; **Joseph Vornehm**, Sr. Grad Rep

UNDERGRADUATE COMMITTEE

T. Brown, Chairman
A. Berger
J. Zavislan

Master's Co-Op Advisor
Colloquium Chairman
Biomedical Engineering Advisor
Part-Time MS Advisor:
SEAS Administrative Committee:
SEAS Computing Committee:
SEAS Graduate Committee:
Committee on Educational Policy:
Library Representative:
University Council On Graduate Studies:
OSA Advisor:
Committee of Optics Networking:

C. Guo
C. Stroud
A. Berger
G. Wicks
T. Brown
J. Zavislan
M. Alonso
T. Brown
R. Boyd
M. Alonso
J. Zavislan
J. Zavislan

ADMINISTRATIVE STAFF

Marie Banach -- Administrative Assistant

Elizabeth Benedict -- Administrative Assistant
(Undergraduate Studies)

Lissa Cotter -- Administrative Assistant
(Graduate Studies)

Lori Russell -- Administrator/Assistant Director
(Director's Office)

Gina Kern -- Administrative Assistant
(Director's Office)

Barbara Schirmer -- Administrator

Maria Schnitzler - Administrative Assistant
(Graduate Admissions)

Gayle Thompson – Special Events Coordinator and Secretary

Noelene Votens - Secretary/Bookkeeper

TECHNICAL STAFF

Michael Koch - Molecular Beam Epitaxy

Brian McIntyre -- Scanning Electron Microscopy Facility

Per Sven Adamson -- Undergraduate Teaching Laboratories

GRADUATE CALENDAR FOR THE COLLEGE
(Student Edition)

2009-2010

FALL 2009

(Statements in italics indicate Ph.D. specific information.)

- Fri. Aug. 14 Last day to submit Master's Programs of Study for October 2009 degree candidates.
- Wed. Aug. 26 MA/MS students receiving terminal degrees in October must be degree complete by this date. Plan A Master's students must submit 2 final unbound corrected thesis copies in the Graduate Studies Office.
- Last day to submit 2 corrected copies of Ph.D. dissertation for Oct. 2009 degree in Dean Jacobs' Office.*
- NOTE: If this deadline is not met, student must register and pay the appropriate fee for the fall semester at X time status.
- Thurs. Aug. 27 Orientation for new graduate students: 1:00 pm Hoyt Auditorium
- Fri. Aug. 28 TA Training Session for all new graduate students who will TA during their graduate program. 9:00 am Interfaith Chapel, Lower Level
- Tues. Sept. 1 First day of classes - fall semester
- Wed. Sept. 2 -
Fri. Sept. 11 *No Ph.D. defenses may be held during the first two weeks of the fall semester.*
- Mon. Sept. 7 Labor Day. University is closed. This day cannot be counted as a working day in meeting deadlines
- Mon. Sept. 14 *First day to hold Ph.D. defense in the fall semester. (Thesis and paperwork having been submitted to the Graduate Studies Office by Aug. 12, 2009.)*
- Tues. Sept. 15 Deadline for fall Registration. **(\$150** late fee after this date).

Fri. Sept. 25 Last day for Plan A or B final examinations - oral, written, essay for October degree conferral. (Aug. 26, 2009 deadline for students not registering for fall.)

Mon. Oct. 5 Non-terminal Plan A students must submit 2 final unbound corrected copies in the Graduate Studies Office.

All documents (exam reports, grade changes, etc.) must be submitted to the Graduate Studies Office by this date (Program of Study deadline was Aug. 14, 2009) to remain on October conferral list.

Fri. Oct. 9 Board of Trustees Meeting – degrees conferred

Tues. Oct. 13 Drop/Add/Audit Deadline for fall 2009. Withdrawal permitted only if time status is not affected.

Last day to submit Master's Programs of Study for March 2010-degree candidates.

Last day to petition GSO for waiver of audit fees (after this date the petition must be accompanied by a 506 form)

Wed. Nov. 11 *Last day to submit Ph.D. dissertation and paperwork to Graduate Studies Office for the fall semester. NOTE: If this deadline is not met, then the defense may not be held until the spring semester*

Thurs. Nov. 26 – Thanksgiving Holiday. University is closed. These two days cannot be counted as working days in meeting deadlines.

Fri. Nov. 27

Wed. Dec. 23 - Fri. Jan. 1 *Due to recess and holidays, no Ph.D. defenses may be held during this time period.*

Fri. Dec. 25 The University is closed. This day cannot be counted as a working day in meeting deadlines.

Fri. Jan. 1 The University is closed. This day cannot be counted as a working day in meeting deadlines.

Mon. Jan. 4- Fri. Jan. 8 *Ph.D. defenses may be held during this time period only if the dissertation was accepted in the Graduate Studies Office by the Nov. 11 deadline.*

Mon. Jan. 11 Identify possible Ph.D. candidates for May degree – students with even a remote possibility of completing the PhD for the May conferral should identify themselves to their department

representative. (This is to assure you receive Commencement mailings.)

Tues. Jan. 12 MA/MS students receiving terminal degrees in March must be degree complete by this date. Plan A students must submit 2 final corrected thesis copies in Graduate Studies Office.

Last day to submit 2 corrected copies of Ph.D. dissertation for March 2010 degree in Dean Jacobs' Office. NOTE: If this deadline is not met, student must register and pay the appropriate fee for the spring semester at X time status.

SPRING 2010

Mon. Jan 11 - *No Ph.D. defenses may be held during the first two weeks of the spring*

Fri. Jan. 2*semester.*

Wed. Jan. 13 First day of classes spring semester.

Mon. Jan. 25 *First day to hold Ph.D. defense in the spring semester.*

Wed. Jan. 27 Deadline for spring Registration. (**\$150** late fee after this date).

Last day to submit Master's Programs of Study for May 2010 degree candidates.

Fri. Feb. 5 Last day for non-terminal Plan A or B final examinations - oral, written, essay, for March 2010 degree (Jan. 12, 2010 deadline for students terminating in the fall semester).

Mon. Feb. 15 Non-terminal Plan A students must submit 2 final unbound corrected thesis copies in Dean's Office to remain on the March 2010 conferral list.

All documents (exam reports, grade changes, etc.) must be submitted by this date (Program of Study deadline was October 13, 2009) to remain on March conferral list.

Wed. Feb. 24 Drop/Add/Audit Deadline for spring 2010. Withdrawal permitted only if time status is not affected.

Last day to petition GSO for waiver of audit fees (after this date the petition must be accompanied by a 506 form)

Fri. Mar. 12	Board of Trustees Meeting – degrees conferred.
Mon. Mar. 15	<i>Last day to submit Ph.D. dissertation and paperwork to Graduate Studies Office for the spring semester. NOTE: If this deadline is not met, then the defense may not be held until the summer.</i>
Wed. Apr. 21	<i>Last day to hold Ph.D. defense during the spring semester.</i> Last day for Plan A or B final examinations - oral, written, essay for May 2010 degree.
Thurs. Apr. 22 - Fri. May 21	<i>Due to end-of-semester deadlines, commencements, and recess, Ph.D. defenses may not be held during this time period.</i>
Mon. Apr. 26	Master's Plan A students must submit 2 final unbound corrected thesis copies in Dean's Office.
Mon. Apr. 26	All documents (exam reports, grade changes, etc.) must be submitted by this date (Program of Study deadline was Jan. 27, 2010.) <i>Last day to submit 2 corrected copies of Ph.D. dissertation for May 2010 degree in Dean Jacobs' Office.</i>
Sat. May 15 - Sun. May 16	University Commencement Ceremonies – Degrees conferred

SUMMER 2010

University policy for Ph.D. defenses for Summer 2010

The final oral examination for the degree Doctor of Philosophy during summer 2010 cannot be held until at least **25 full working days** have elapsed after the dissertation has been registered in the Office of Graduate Studies, 218 Lattimore. This policy supersedes the published 15 full working day rule ("Regulations and University Policies Concerning Graduate Studies", *Final Oral Examination*) for summer 2010.

Wed. May 26	First day to hold Ph.D. defense for summer 2010.
-------------	--

- Mon. May 31 Memorial Day. The University is closed. This day cannot be counted as a working day in meeting deadlines.
- Tues. Jun. 15 Registration deadline for summer term.
- Wed. Jun. 23 Last day to register Ph.D. dissertation in the Graduate Studies Office Office for summer 2010.
- NOTE:** If this deadline is not met, then the defense may not be held until the fall semester.
- Mon. July 5 4th of July holiday celebrated. The University is closed. This day cannot be counted as a working day in meeting deadlines.
- Wed. Aug. 18 Last day to hold Ph.D. defense for summer 2010.
Last day to hold a masters defense for summer 2010
- Thurs. Aug. 19-
Fri. Sept. 10 No defenses may be held during this time period.
- Wed. Aug. 25 Last day to submit corrected copies of the Ph.D. or masters dissertation (two unbound copies) for Oct. 2010 degree. **NOTE:** If this deadline is not met, student must register and pay the appropriate fees for the fall semester at X time status.

THE INSTITUTE OF OPTICS FACULTY

Govind P. Agrawal

Office: G 515

Phone: 5-4846

Govind P. Agrawal received the M.S. and Ph.D. degrees from the Indian Institute of Technology, New Delhi in 1971, and 1974, respectively. After holding positions at the Ecole Polytechnique, France, City University of New York, N.Y., and AT&T Bell Laboratories, Murray Hill, N.J., he joined the University of Rochester in January 1989. Dr. Agrawal is a Professor of Optics at The Institute of Optics. He is a Fellow of both IEEE and the Optical Society of America.

Dr. Agrawal's research interests focus on the fields of quantum electronics, nonlinear optics, and laser physics. He has made important contributions to the fields of semiconductor lasers, nonlinear fiber optics and optical communications. He has authored three well-known books entitled Semiconductor Lasers (1993), Nonlinear Fiber Optics (2001) and, Fiber-optic Communication Systems (2002). Professor Agrawal's research is in the field of optical communication systems. Current research projects include dispersion-managed solitons, Raman amplification, polarization-mode dispersion, optical switching, and mode-locked fiber lasers.

Miguel A. Alonso

Office: W303

Phone: 5-7227

Miguel A. Alonso received the degree of Engineer in physics in 1990 from the Universidad Autónoma Metropolitana in Mexico City and received the Ph.D. degree in optics in 1996 from The Institute of Optics, University of Rochester. In 2003, he joined the faculty of The Institute of Optics. He was Associate Editor for Optics Express from 2002 to 2007, and is now Deputy Editor for this journal.

Professor Alonso's general research interest is in finding better ways to model the propagation of waves. In particular, he is interested in the connection between rays and waves, and how to build accurate estimates of wave fields propagating through arbitrary systems, based on ray information alone. Another aspect of his work relates to the theory of partial coherence, and the description of partially coherent wave fields in radiometric terms. Finally, he is also interested in generalizations of mathematical tools and concepts relevant to wave propagation, like integral transforms, phase space representations, and uncertainty relations.

Andrew Berger

Office: G 405

Phone: 3-4724

Andrew Berger hails from the physics departments of Yale University (BS 1991) and MIT (PhD 1998). At MIT, as part of the Laser Biomedical Research Center at the G.R. Harrison Spectroscopy Laboratory, his thesis research used Raman spectroscopy to measure the level of glucose, proteins, cholesterol, and other chemicals in serum and blood samples. After graduating, he spent two years at the Beckman Laser Institute and Medical Clinic at the University of California, Irvine, developing near-infrared, noninvasive, diode laser-based systems that measured hemoglobin, fat, and water content in the breast tissue of female volunteers and cancer patients. In July 2000, he joined the Institute of Optics as an Assistant Professor (keeping intact his streak of pursuing optics only at Institutes).

Professor Berger's research is in the field of biomedical optics, specifically spectroscopic methods of diagnosis. Most immediately, he is interested in applying near-infrared Raman spectroscopy to clinical situations where existing methods of tissue or blood analysis are slow or inconvenient for the patient. Current projects involve analysis of urine, skin, and oral bacteria samples, both in bulk and under a Raman-equipped microscope. In addition, Prof. Berger's group is launching a project whose goal is near-infrared analysis of blood supply and oxygenation to the brain.

Nicholas H. Bigelow

Office: B&L 312

Phone: 5-2309

Prof. Bigelow's research interests are in the areas of Quantum Optics and Quantum Physics. His recent work has focussed on the creation and study of ultra-cold quantum gasses, the manipulation and control of atomic motion using light pressure forces, the laser cooling and trapping of atoms and molecules, Bose-Einstein Condensation and the basic quantum nature of the basic atom-photon interaction.

Prof. Bigelow's current experimental research activities center around the creation and manipulation of ultracold atomic vapors which are mixtures of atoms of distinct atomic species. Current projects include the realization of a two-species Bose-Einstein condensate, the application of quantum control and ultra-fast spectroscopy to the creation and manipulation of ultracold molecules, including heteronuclear molecular species and in the cooperative behavior of ultracold molecular vapors. Experiments are also underway on quantum noise in atomic measurement. Professor Bigelow's group is also engaged in theoretical research and current projects include the investigation of Bose-Einstein condensation of atomic vapors with internal degrees of freedom such as spinor condensate, multi-component Bose-Einstein condensates, atom lasers, atom-atom interactions and cold collisions, and self-organization of dense, ultracold polar molecular vapors. More details about the activities of Prof. Bigelow's research group can be found [here](#).

Professor Bigelow is a member of the Rochester Quantum Information Center and the University of Rochester's Materials Science Program and is a cohort of the Rochester Theory Center for Optical Science and Engineering.

Robert W. Boyd

Office: W 308

Phone: 5-2329

Robert W. Boyd received the B.S. degree in physics in 1969 from the Massachusetts Institute of Technology and received the Ph.D. degree in physics in 1977 from the University of California at Berkeley. His thesis work involved the use of nonlinear optical techniques for infrared detection for astronomy.

In 1977, he joined the faculty of The Institute of Optics as Assistant Professor, and since 1987 has held the position of Professor of Optics. He is author of Radiometry and the Detection of Optical Radiation (1983), Nonlinear Optics (1992), is co-editor of Optical Instabilities (1986), and has published approximately 120 research papers and three U.S. patents. His research interests include the study of nonlinear optical interactions and the use of phase conjugation techniques in the development of laser systems. Professor Boyd is a Fellow of the Optical Society of America.

Thomas G. Brown

Office: G 516

Phone: 5-7816

Thomas G. Brown received the A.B. degree in physics from Gordon College in 1979. He received the Ph.D. degree (1987) from The Institute of Optics, University of Rochester. In 1987 he joined the faculty at The Institute of Optics as Assistant Professor. Dr. Brown's primary research interests are in the areas of Guided Wave Optics, Optical Properties of Semiconductors, and Optical Communications. Particular areas of research include: 1) optical interactions in indirect gap semiconductors; 2) silicon based optoelectronics with emphasis on nonlinear optical processes in silicon-on-insulator waveguide structures; 3) Intrinsically-stable semiconductor lasers with emphasis on gain-coupled distributed feedback laser structures.

Joseph H. Eberly

Office: B&L 321

Phone: 5-4576

Joseph H. Eberly earned his Ph.D. in physics at Stanford University in 1962, and in 1979 joined The Institute of Optics faculty. A member of the UR physics faculty since 1967, he is currently Professor of Physics and of Optics.

Professor Eberly's research interests focus on theoretical quantum optics, including the interaction of quantized light fields with idealized atoms in high-Q cavities and the computer modeling of one-electron and two-electron stabilization and localization in atoms subjected to very intense and very short laser pulses.

The prediction of spontaneous collapse and revival effects in the wave function of a single atom in a cavity was made by Professor Eberly and his research group. These and related quantum micromaser phenomena are the subjects of theoretical and experimental study in Rochester and elsewhere.

Philippe M. Fauchet

Office: Computer Studies 514

Phone: 5-1487

Philippe M. Fauchet received a Ph.D. in Applied Physics from Stanford University in 1984, an M.S. in Engineering from Brown University in 1980 and his Electrical Engineer's degree from Faculte Polytechnique de Mons, Belgium in 1978. He joined the Electrical Engineering faculty at the University of Rochester as an Associate Professor in 1990 and was promoted to the rank of Professor in 1993. In 1994 he accepted a joint appointment on the faculty of The Institute.

Previously, he was on the faculty of Princeton and Stanford Universities. Dr. Fauchet has published in the fields of ultrafast laser spectroscopy of semiconductors, picosecond optoelectronics, ultrashort pulse laser physics and technology, optical diagnostics of semiconductor materials and devices, laser-materials interactions, and Raman spectroscopy.

James R. Fienup

Office: W 410

Phone: 5-8009

James R. Fienup has an A.B. in physics and mathematics from Holy Cross College (Worcester, MA), and M.S. and Ph.D. (1975) degrees in Applied Physics from Stanford University. Until 2002, he was a Senior Scientist at the Environmental Research Institute of Michigain and Veridian Systems, at which time he joined the faculty at The Institute of Optics as the Robert E. Hopkins Professor of Optics. He is a Fellow of both the Optical Society of America and of the SPIE, and chairs the Graduate Committee.

Professor Fienup's research interests center around imaging science. His work includes unconventional imaging, phase retrieval, wavefront sensing, image reconstruction and restoration, and image quality assessment. These techniques are applied to passive and active optical imaging systems, synthetic-aperture radar, and biomedical imaging modalities.

Thomas H. Foster

Office: 3-5333 Med. Ctr.

Phone: 5-1347

Thomas H. Foster received the B.S. degree in physics from Stevens Institute of Technology in 1983. He then joined the General Electric Corporate Research and Development Center in Schenectady, NY as a staff biophysicist. There he worked on the development of medical applications of nuclear magnetic resonance imaging and spectroscopy. In 1985 he began graduate work at the University of Rochester and completed the M.A. (1988) and the Ph.D. (1990) degrees in physics. He was then appointed to the Radiology faculty in the School of Medicine and Dentistry at Rochester, where he is currently Associate Professor. Joint appointments in Physics and Astronomy and in the Institute of Optics were made in 1992 and 1999, respectively.

Professor Foster's research students investigate various problems in the field of medical optics. They are particularly interested in physical aspects of photodynamic therapy of cancer and in the use of optical spectroscopic probes that may be useful in monitoring the

Thomas H. Foster (cont'd)

Underlying photochemical processes and the tumor response to therapy. This work often involves the adaptation of spectroscopic techniques to highly scattering systems.

Nicholas George

Office: W 207

Phone: 5-2417

Nicholas George received the B.S. degree with highest honors from the University of California at Berkeley, the M.S. degree in electrical engineering from the University of Maryland, and the Ph.D. degree in physics and electrical engineering from the California Institute of Technology (1959). Prior positions include Section Chief, National Bureau of Standards; professor of applied physics and electrical engineering, California Institute of Technology. Dr. George is a Professor of optics at The Institute of Optics and he also serves as Associate Dean for Research in the School of Engineering and Applied Science. He was Director of The Institute for more than four years.

Professor George's central research interest is in the field of opto-electronic systems. Research areas of interest are (1) Image Understanding, (2) Automatic Pattern Recognition, (3) Speckle and Statistical Optics, and (4) Holography.

Chunlei Guo

Office: W 419

Phone: 5-2134

Chunlei Guo received the B.S. degree in physics from Changchun Institute of Optics and Fine Mechanics in China in 1994, and Ph.D. in physics from University of Connecticut in 1999. His Ph.D. research was on studying nonperturbative behaviors of diatomic molecules in strong laser fields using femtosecond laser techniques.

Subsequently, he performed his postdoctoral research in studying ultrafast dynamic processes in solid materials under high-intensity radiation at Los Alamos National Laboratory. In 2001, he left New Mexico for New York, joining the Institute of Optics as an Assistant Professor.

Professor Guo's general research interest is in high-intensity femtosecond laser interactions with matter, including gas, solid (including biomaterials), and plasma phases. Some examples include, in gas phase, understanding multielectron effects of atoms and molecules in a variety of strong field phenomena; in solid materials, studying electronic and optical processes in the highly nonequilibrium regime; in various matter, exploring novel processes of generating nonlinear optical radiation.

Stephen D. Jacobs

Office: LLE 1429

Phone: 5-4837

Stephen D. Jacobs received his B.S. in Optics (with high distinction) in 1970, and his Ph.D. in Optics in 1976, both from the University of Rochester. He has worked at the Laboratory for Laser Energetics (LLE) his entire career, becoming a Senior Scientist in 1982. He manages the Department of Optical Technology within the Engineering Division. This department consists of over 35 scientists, engineers and technicians doing

Stephen D. Jacobs (cont'd)

basic materials research, advanced development, process development and optics manufacturing. Areas of responsibility in support of the OMEGA and OMEGA EP laser systems include precision optics from the IR through the UV, high power dielectric/sol-gel coatings, laser induced damage, and liquid crystal optics.

Dr. Jacobs holds joint appointments as a Professor of Optics (The Institute of Optics), Professor of Chemical Engineering (Department of Chemical Engineering), and Professor of Materials Science (Materials Science Program). He teaches two graduate courses: Optical Fabrication and Testing (Optics 443, Spring-even years), and Liquid Crystal Optics (ChE 447, Spring, odd years). He supervises Ph.D thesis research in all three disciplines. He is a Fellow of the SPIE.

Dr. Jacobs conducts research in two areas. His work on novel optical finishing processes is currently centered on mechanisms of material removal for Magnetorheological Finishing (MRF). His group and an international group of collaborators invented MRF in the mid '90's, and the technology was successfully spun off in the form of a local company, QED Technologies, Inc., in 1997. Dr. Jacobs' work in the field of liquid crystals spans three decades. OMEGA is the only high peak power laser system in the world to use large aperture lc polarizers and wave plates. It contains 300 devices in apertures to 200 mm. Currently his lc group is conducting research on polymer cholesteric liquid crystal flakes for active e-o applications such as electronic paper.

Todd D. Krauss

Hutchison 465

Phone: 5-5093

Todd Krauss was born on October 27, 1969 and grew up in New York City. He received his B.S., M.S., and Ph.D. all from Cornell University, the latter under the advisement of Frank Wise. Upon graduating in 1998, he moved to Columbia University, serving as a postdoctoral fellow under Louis Brus until 2000, when he joined the Chemistry faculty at the University of Rochester as an Assistant Professor of Chemistry. In 2006 he was promoted to the rank of Associate Professor of Chemistry and in 2008 he received a joint appointment with Optics. Krauss's research interests involve fundamental studies of materials at the nanometer scale, down to the single molecule level, with a specific emphasis on single walled carbon nanotubes and semiconductor quantum dots. Additionally, he is pursuing applications for these nanometer scale materials in the general areas of novel biological sensors and nanophotonics. Over the next several years, the Krauss group will continue initial studies of the linear and ultrafast nonlinear properties of single-walled carbon nanotubes (SWNTs), and further explore the relationship between charge and fluorescence of single CdSe quantum dots (QDs) and single quantum rods (QRs). Krauss and his group will also pursue studies of two-color, single spot surface immobilized molecular beacon biosensors, in addition to initiating several new directions of research, including studies of photoinduced charge transport in quantum dot-carbon nanotube heterostructures with applications toward renewable energy, quantum-dot based solid state lighting devices (for reduced energy consumption),

Todd D. Krauss (cont)

and single-protein folding studies of cytochrome *c*. The author of more than 50 publications in peer reviewed journals, Krauss also lectures locally and nationally on

nanometer scale materials for biotechnology. At the University of Rochester he teaches both at the undergraduate and graduate levels and has graduated five PhD Students since 2000. The recipient of numerous honors and fellowships, Krauss has most recently received the Camille Dreyfus Teacher-Scholar Award (2005), the Alfred P. Sloan

Research Fellowship (2004), the James D. Watson Investigator Award (2002), the Army Young Investigator Award (2002), and the Research Innovation Award (2001).

John Marciante

Office LLE

Phone:

John R. Marciante received the B.S. degree in Engineering Physics from the University of Illinois at Urbana-Champaign in 1991 and the M.S. and Ph.D. degrees, both in Optics, from the University of Rochester, in 1992 and 1997, respectively. In 1991, he joined the USAF Phillips Laboratory in New Mexico (later to become the Air Force Research Laboratory) as a Research Physicist. In 2001, he returned to Rochester to join Corning Rochester Photonics Corporation as a Senior Research Scientist and the Institute of Optics as an Adjunct Professor. Since 2003, he has been a Research Scientist at the University of Rochester's Laboratory for Laser Energetics, and he holds a joint appointment as Associate Professor of Optics at the Institute of Optics. He has also held positions as Adjunct Professor at the University of New Mexico and Chairman for the IEEE/LEOS Albuquerque Chapter. He is currently a Topical Editor for the Journal of the Optical Society of America B.

Professor Marciante's general research interests center around optical waveguides, including active, passive, and nonlinear devices. The tight confinement of light allows for increased material interactions, which is beneficial for waveguides with gain or nonlinear properties, and can also lead to designable spatial and dispersive properties. In particular, he is interested in the generation of high power/energy spatially coherent sources and the ability to dynamically manipulate the temporal and spectral aspects of optical pulses. Current research activities include large-mode area fibers, single-frequency fiber lasers, pulse-stacking waveguide circuits, and multi-section DBR lasers.

Duncan T. Moore

Office: G 410

Phone: 5-5248

Duncan T. Moore received the B.A. degree in physics from the University of Maine at Orono. He received the Masters (1970) and Ph.D. (1974) degrees from The Institute of Optics, University of Rochester. His theses were on the topic of gradient-index optics. In 1974, he joined the faculty of The Institute of Optics, University of Rochester, where he is now Professor of Optics. He was Director of The Institute of Optics from 1987 to 1993. Professor Moore became Dean of Engineering and Applied Sciences in January 1995. During 1983, he spent a sabbatical year working for Nippon Schlumberger K.K. as

Duncan T. Moore (cont'd)

Acting Manager of Optics in their Tokyo facility. His areas of research are predominantly in the areas of gradient-index optics, computer-aided manufacturing of optical lenses, optical engineering, and optical testing. Professor Moore's research group developed the first gradient-index materials by a sol-gel process. This process - of making glass at room temperature - allows for gradients to be diffused over very large distances in open structures. This will lead to the development of new optical materials and significant reductions in the number of lens elements required in sophisticated lens systems.

Lukas Novotny

Office: A 101

Phone: 5-5767

Lukas Novotny studied Electrical Engineering and received his Ph.D. at the Swiss Federal Institute of Technology (ETH) in Zurich, Switzerland (1996). His doctoral research was in close collaboration with the IBM Research Laboratory in Switzerland and dealt with theoretical questions in near-field optics. He received his doctoral degree in 1986 at the ETH. After spending three years at the Pacific Northwest National Laboratory, WA, working on new schemes of near-field optical microscopy applied to the study of biological membranes, he joined in 1999 the faculty of the Institute of Optics as an Assistant Professor.

Professor Novotny's general research interest is focused on optics on the nanometer scale. He is interested in exploring ways to surpass the diffraction limit of classical optics and in studying the interaction of nanometric systems such as quantum dots or biological proteins with the optical near-field. Of special interest is the combination of near-field optics and nonlinear spectroscopy. Currently, he is working on a scheme which relies on the enhanced electric field close to a sharply pointed metal tip under laser illumination. This field is sufficiently strong to excite local nonlinear responses of a responses material in close proximity. Using this approach, optical resolutions on the order of 20nm have been demonstrated recently.

Jannick Rolland

Office: G 505

Phone: 3-4040

Jannick Rolland received a Diploma from the *Institut D'Optique* in 1984, and MS and Ph.D. (1990) degrees in Optical Science from the University of Arizona. Prior positions include Lens Designer for REOSC Corp. (France) and Perkin Elmer, head of the Vision Research Group for Medical Displays at the University of North Carolina at Chapel Hill (1992-1996), and Professor of Optics at the University of Central Florida (1996-2008). In 2009, she joined the Institute of Optics at the University of Rochester as Professor of Optics and Biomedical Engineering and Associate Director of the R.E. Hopkins Center for Optical Design and Engineering. Professor Rolland served on the editorial board of the *Journal Presence* (MIT Press) (1996-2006), and as Associate Editor of *Optical Engineering* (1999-2004). She is a Fellow of the Optical Society of America and SPIE, a senior member of IEEE, and a member of SID.

Jannick Rolland (cont'd)

Professor Rolland's central research interests are in the fields of optical instrumentation and system engineering. Research areas of interest are (1) Optical System Design for Imaging and Non-imaging Optics (2) Physics-based modeling, and (3) Image Quality Assessment. These areas have been applied to Eyewear Displays for Augmented Reality, Optical Coherence Imaging, Biomedical and Medical Modeling and Simulation, Alignment of Optical Systems, and 3D Velocimetry.

Wolf D. Seka

Office: LLE: 205

Phone: 5-3815

Wolf D. Seka is a senior scientist at the Laboratory of Laser Energetics and holds a joint appointment as Associate Professor at The Institute of Optics. He completed his undergraduate studies in physics at the University of Graz, Austria, and received a Ph.D. in physics from the University of Texas at Austin in 1965.

Professor Seka has worked in the areas of visible and x-ray spectroscopy, plasma physics, and laser physics at various institutions in several countries. He joined LLE in 1976 where he has contributed significantly to the design and testing of the OMEGA laser system and its conversion to a 2.5kJ third-harmonic laser facility. He has extensively used the LLE laser systems to investigate nonlinear laser plasma interaction processes such as stimulated Raman and Brillouini scattering.

Carlos R. Stroud, Jr.

Office: W 312

Phone: 5-2589

Carlos R. Stroud, Jr. has an A.B. degree in physics and mathematics from Centre College, and a Ph.D. degree (1969) in physics from Washington University. Currently Professor of Optics, and Professor of Physics and Astronomy. He has been a member of the faculty since 1969. He is a Fellow of the Optical Society of America as well as the American Physical Society.

Professor Stroud's research interests span most of experimental and theoretical quantum optics. Among his research accomplishments are the first use of continuous-wave dye lasers to do ultra-high resolution atomic spectroscopy, the observation of the modification of the spectrum of spontaneous emission by a resonant laser beam, and the development of alternatives to quantum electrodynamics for describing the interaction of radiation and matter.

His current research is concentrated in two general areas: the study of the dynamics and instabilities of laser systems, and the use of coherent Rydberg atoms.

Kenneth J. Teegarden Office: W 519 Phone: 5-7708

Kenneth J. Teegarden received the Ph.D. degree in physics from the University of Illinois in 1954. He joined the faculty of the University of Rochester in 1954 and is now Professor of Optics. He was Director of The Institute of Optics from 1981 to 1987.

Professor Teegarden and his group are concerned with the development of new optical materials. The work ranges from basic solid state studies of the electronic structure of insulators to investigations on materials for use as electro-optical devices.

Gary W. Wicks Office: W 109A Phone: 5-4867

Gary W. Wicks received four degrees, B.S. with distinction (1977), M.Eng. (1978), M.S. (1979) and Ph.D. (1981), from the Applied and Engineering Physics Department of Cornell University. He remained at Cornell until 1987 as a research associate, and later as a senior research associate, in the Electrical Engineering Department. In 1987 he joined The Institute of Optics faculty as an Associate Professor.

Professor Wicks' research interests center around III-V semiconductors - epitaxial growth, optical properties and optical devices. Examples of his research include molecular beam epitaxial growth of reduced dimensional structures such as quantum wells, quantum wires and superlattices; studies of III-V heterostructure interfaces with Raman and photoluminescence spectroscopies; and quantum well lasers and optical modulators. Currently he is a Professor in Optics at The Institute.

David R. Williams Office: Cntr. Visual Sci. Phone: 5-8672

David R. Williams received his B.S. degree in Psychology (1975) from Denison University, his M.S. (1976) and Ph.D. (1979) in Psychology from the University of California-San Diego. He is currently Professor of Psychology and Optics.

Dr. Williams' research interests are in the area of sensitivity and resolution of the human visual system to patterns that are modulated in wavelength, space and time.

Emil Wolf Office: B&L 307A Phone: 5-4397

Emil Wolf received a Ph.D. degree from Bristol in 1948 and a D.Sc. degree from Edinburgh in 1955. Professor Wolf is an internationally known scientist in optics. He is the recipient of numerous awards for his scientific contributions and is an honorary member of the Optical Society of America, of which he was the President in 1978. Professor Wolf is co-author, with Max Born, of Principles of Optics, first published in 1959 and now a widely read standard text in the field, and is also the editor of Progress in Optics. He is presently Professor of Physics and Professor of Optics and was recently named Wilson Professor of Optical Physics.

Emil Wolf (cont'd)

Professor Wolf's main research is in the following areas: coherence properties of optical fields, spectroscopy of partially coherent radiation, diffraction, direct and inverse scattering, and the theory of phase-conjugated waves.

Geunyoung Yoon

Office: Meliora 262

Phone: 3-4998

Professor Yoon received his BS in Physics (1990) from SungKyunKwan University, South Korea and his MS (1995) and PhD (1998) in the field of Laser Optics both from Osaka University, Japan.

Prof. Yoon studied laser optics for a high-power laser system for fusion while in Japan, where he also worked on the shaping of optical surfaces with an excimer laser. Since then, he has accumulated three and half years of research experience in visual optics at the University of Rochester. His main interest at the University has been to evaluate the potential visual benefit of correcting higher order aberrations in the eye with adaptive optics. The results of this work are directly relevant to customized refractive surgery, contact lenses, and intraocular lenses.

James M. Zavislan

Office: G416

Phone: 5-9819

James M. Zavislan attended the University of Rochester, the Institute of Optics and received a B.S. with honors (1981) and a Ph.D. (1988). He worked as a Research Staff member at Almaden Research Center, IBM Research Division from 1987-1992.

In 1992 he helped found Lucid, Inc. and served as Senior Vice-President for Technology and Chief Technology Officer. He joined the Institute of Optics as a part-time Adjunct Assistant Professor in 2001. In 2002, he joined the faculty full time as an Associate Professor. Professor Zavislan's research interests are in optical engineering, specifically-biomedical imaging systems, optical system analysis and optical metrology.

Thesis Advisors

The faculty members listed below are approved thesis advisors for degrees in optics. Students doing thesis research for professors with primary faculty appointments in The Institute receive stipends that are set by the faculty of The Institute. 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
G. Agrawal	The Institute of Optics
M. Alonso	The Institute of Optics
A. Berger	The Institute of Optics
N. Bigelow	Physics
R. Boyd	The Institute of Optics
T. Brown	The Institute of Optics
J. Eberly	Physics
P. Fauchet	Electrical Engineering
J. Fienup	The Institute of Optics
T. Foster	Radiology
N. George	The Institute of Optics
P. Givens	The Institute of Optics
C. Guo	The Institute of Optics
S. Jacobs	Laboratory for Laser Energetics
T. Krauss	Chemistry
J. Marciante	Laboratory for Laser Energetics
D. Moore	The Institute of Optics
L. Novotny	The Institute of Optics
J. Rolland	The Institute of Optics
W. Seka	Laboratory for Laser Energetics
C. Stroud	The Institute of Optics
K. Teegarden	The Institute of Optics
I. Walmsley	Adjunct
G. Wicks	The Institute of Optics
D. Williams	The Institute of Optics
E. Wolf	Physics
G. Yoon	Dept of Ophthalmology M&D
J. Zavislan	The Institute of Optics

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 256 (Credit: 3) -- 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.

Prerequisites: OPT 242 and OPT 261.

OPT 411 -- MATHEMATICAL METHODS FOR OPTICS

Study of mathematical techniques such as vector calculus, series expansions, contour integration, integral transforms (Fourier, Laplace and Hilbert), asymptotic estimates, and second order differential equations.

Prerequisites: ME 201, 202 or equivalent, and permission of the instructor.

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. Also, methods of calculation useful in modern quantum optics are discussed. These include manipulation of coherent states, the Bloch sphere representation, and conventional perturbation theory.

Prerequisite: One course in undergraduate wave mechanics or permission of instructor.

References: Cohen-Tannoudji, Diu and Laloe, Merzbacher, Schiff, Dirac.

OPT 421 -- OPTICAL PROPERTIES OF SEMICONDUCTORS

The course concerns the aspects of the solid state physics of materials, which influence their optical properties. Semiconductors are emphasized, but metals and insulators are treated also. The physics of optical absorption, emission, reflection, modulation, and scattering of light is covered. Optical properties of electrons, phonons, plasmons, and polaritons are detailed. The optical properties of reduced dimensionality structures such as quantum wells are contrasted with those of bulk semiconductors.

Prerequisites: undergraduate Quantum Mechanics

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.

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 detectors.

References: Boyd, Radiometry and the Detection of Optical Radiation; Kingston, Detection of Optical and Infrared Radiation.

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).

OPT 441 -- GEOMETRICAL AND INSTRUMENTAL OPTICS I

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.

OPT 442 -- GEOMETRICAL AND INSTRUMENTAL OPTICS II

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.

OPT 443 -- 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.

Enrollment: 12 students maximum (priority to graduate Optics students).

Text: Instructor's notes, 450 pages provided to students in a 3-ring binder cost.

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 Cretien, 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

OPT 446 -- OPTICAL INTERFERENCE COATING TECHNOLOGY

This course addresses the design, manufacture and quality control of optical 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.

OPT 447 – ADVANCED OPTICAL INTERFERENCE COATINGS*

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, Infrared applications, Lasers, and Telecommunications. Each student will be given access to current market design, optical characterization, and post-process analysis software.

Prerequisite: OPT 246/446 or special permission from Instructor.

OPT 448 -- PRINCIPLES OF EYE DESIGN

The course explores the design of the human eye, revealing the optical and neural factors that limit color and spatial vision. The design of eyes (such as those of predatory birds and the compound eyes of insects) that evolved to operate in environments different from that of the human eye will also be examined. The course begins with a treatment of the information losses associated with the eye's optics, the photoreceptor mosaic, and the ganglion cell array that transmits visual information to the brain. The course ends with a discussion of image processing by the visual cortex of the brain.

OPT 449 (CVS 541) -- INSTRUMENTATION AND METHODS FOR VISION RESEARCH

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.

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 Calculi, 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: Optics 441 and 461 or permission of the instructor.

OPT 452 MEDIAL IMAGING --THEORY AND IMPLEMENTATION

(Same as ECE 452)

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.

OPT 461 -- 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.

Prerequisites: Undergraduate electromagnetic theory, advanced calculus, linear algebra.
Text: Goodman, Introduction of Fourier Optics; Class Notes; References: Born and Wolf, Principles of Optics; Gaskill, Linear Systems, Fourier Transforms and Optics; Siegman, Lasers.

OPT 462 -- 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.

Prerequisites: Undergraduate electromagnetic theory, advanced calculus, vector analysis.
References: Jackson, Classical Electrodynamics; Born and Wolf, Principles of Optics.

OPT 463 -- NANO-OPTICS*

Nano-optics is an emerging new field of study motivated by the rapid advance of nanoscience and technology. The course addresses the key issues of optics on the nano-meter scale. Among the topics are theory of strongly focused light, confocal and near-field optical microscopy, atomic decay rates in inhomogeneous environments, single molecule spectroscopy, and optical forces.

Prerequisites: Students must have completed Opt 461 (Physical 1) and 412 (Quantum).

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 inhomogenous broadening, laser resonators and their modes, Gaussian beams, cavity design, pumping schemes, rate equations, Q switching, mode-locking, various gas, liquid, and solid-state lasers.

Prerequisites: undergraduate electromagnetic theory and quantum mechanics.

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.

Prerequisites: Students must have completed either Optics 461 or 462.

References: Robert W. Boyd, Nonlinear Optics, Second Edition.

OPT 468 -- WAVEGUIDE OPTOELECTRONIC DEVICES

This course covers the propagation and interactions in optical waveguides. Topics to be covered include: the Goos-Haenchen effect; modes of the planar waveguide; coupled-mode theory; modes of the optical fiber; pulse broadening in optical fibers; coupling between guided-wave structures; waveguide devices such as semiconductor lasers, fiber lasers and amplifiers, passive components and electro-optics devices.

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 (most recently in 2008) and is intended to alternate with and be complementary to Biomedical Microscopy (BME 270/470, first taught in Fall 2007), 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).

OPT 481 -- TECHNICAL ENTREPRENEURSHIP

Course Objective: The 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 consist of lectures, evaluation of a current business situation, and presentations by guest speakers. Each speaker has started a business or been intimately involved in an entrepreneurial venture. The primary requirement for the course is the development of a business plan for a start-up that integrates the various organizational functions of a company. Furthermore, two (one for engineers) case studies must be prepared for credit. The first case examines a new venture in real time. The second involves an evaluation of a proposed new venture and the development of its marketing program.

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.

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.

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).

Prerequisites: OPT 461, OPT428 recommended (but not required).

OPT 544 – ADVANCED LENS DESIGN*

This course starts with a review of refractive optical design forms. The design of complex zoom lenses and multi-mirror reflective systems is discussed in detail starting with first principles. Other topics covered include: optical design and materials for the ultraviolet and infrared wavelength bands, plastic optical systems, opto-mechanical design, tolerancing, sensitivity analysis, monte carlo analysis, environmental analysis, advanced optimization techniques such as user-defined and global optimization, ghost and stray light analysis, and illumination design. Students will be required to complete two complex group design projects.

Pre-requisite: Optics 444 Introduction to Lens Design

OPT 551 (PHY 531) -- INTRO TO QUANTUM OPTICS*

An introduction to quantum and semiclassical radiation theory with special emphasis on resonant and near-resonant interactions between atoms and optical fields. Topics covered include field quantization, Weisskopf-Wigner and Jaynes-Cummings models, the optical

Bloch equations, resonant pulse propagation, homogeneous and inhomogeneous broadening, adiabatic and non-adiabatic transitions, and dressed states.

Prerequisite: OPT 412 or PHY 407/408 or permission of instructor.

OPT 552 -- QUANTUM OPTICS I*

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.

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.

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.

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; phase-error correction for synthetic-aperture radar and medical ultrasound, Lyot coronagraphy, Fourier telescopes, Fourier-transform imaging spectroscopy, structured-illumination superresolution, optical coherence tomography, and extended-depth-of-field imaging. 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, multiframe blind deconvolution, de-aliasing, side-lobe reduction, and phase-error correction algorithms.

A term paper, exploring one of these topics in depth, including computer simulations and implementing the image formation or restoration algorithms, is required.

Prerequisites: OPT 461 (Physical Optics I -- Fourier Optics)

OPT 563 -- STATISTICAL OPTICS*

Topics to be covered include: Elements of Applied Probability Theory: Probability theory, random variables, density and distribution functions, moments of a random variable, characteristic and moment generating functions, and the central-limit theorem. Introduction to Stochastic Processes: Stationarity and ergodicity, correlation functions, power or Wiener spectrum, Gaussian processes, Poisson point processes, compound Poisson point processes. Coherence Properties of Optical Fields: Temporal coherence, spatial coherence, propagation of the mutual coherence function, Van Cittert-Zernike theorem, effects of partial coherence on imaging systems. Laser Speckle and its Applications: Speckle statistics, addition of speckle patterns, integrated speckle, speckle statistics in the far field and in the image plane, space-time correlation functions, speckle velocimetry, and speckle interferometry. Photoelectric Detection of Light: Semiclassical model for photoelectric detection, effects of stochastic fluctuations of the classical intensity, interferometry at low light levels, and pattern recognition using photon-limited images.

Prerequisites: OPT 461 and OPT 462; students are encouraged to take PHY 404 concurrently.

OPT 564 -- THEORY OF OPTOELECTRONIC SYSTEMS*

With a definite systems orientation, we will study topics in diffraction theory, coherence, signal processing, detection theory, digital image processing, spatial and frequency domain filtering, and statistical optics as they apply to systems for imaging, digital cameras and remote sensing. Regular problem sets will be assigned together with request-for-proposal (RFP) topics so that the advanced graduate student will obtain experience in the technical aspects of preparing systems proposals. Students will prepare a final oral presentation (no other final examinations) to brief the class on a topic related to the course material. The course is a continuation of OPT 461-462.

Prerequisites: OPT 461 is a prerequisite for this course.

Texts: Selected chapters in: 1) Applications of Optical Fourier Transforms by Henry Stark; 2) Image Recovery by Henry Stark; 3) Image Science by J. C. Dainty and R. Shaw; 4) Digital Halftoning by R. Ulichney, as well as selected papers in the literature.

OPT 592 -- MODERN COHERENCE THEORY*

Theory of random process, stationarity, ergodicity, the auto-correlation function and the cross-correlation function of random processes. 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.

Prerequisites: OPT 461 is a prerequisite for this course.

REQUIREMENTS FOR THE M.S. DEGREE IN OPTICS

Overview

The Master of Science Degree Program is designed to provide the 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 the engineer working in industry who desires the benefits derived from advanced study in optics. An employer is 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. The student who would like to combine formal education with practical industrial experience may find the M.S. Co-op program of interest. The student who is 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. The student who wishes 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. All of these options provide a solid preparation for the student who wishes to continue advanced study to obtain a doctorate in optics, electrical engineering, or physics.

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 in courses counted toward the M.S. degree is required. If the GPA requirement is initially not met, a course 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. Normally, no more than ten hours of course work taken at another university can be accepted as transfer credit. All transfer credits must be approved by the Optics Graduate Committee and by the Associate Dean for Graduate Studies in The College.

Plan A: Thesis Route

There is a required set of courses for the Plan A route: Optics 441 - Geometrical and Instrumental Optics I; Optics 461 - Physical Optics I; Optics 425 - Radiation and Detectors; and Optics 256 - Optics Laboratory (a 3 semester hour course when taken for graduate credit).

In addition to the core requirements discussed above, the following are additional requirements for the Plan A M.S. degree:

1. Any one additional 400- or 500-level Optics course;
2. Thesis research (6 - 12 semester hours) and written M.S. Thesis;
3. 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 ten semester hours of credit. 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.

The thesis route is available to all students, but some comments should be made about special cases. Students in the BS/MS Program are in an especially good situation to take advantage of the Plan A route because of their early admission to graduate school. It is possible, with proper planning, to take graduate courses and begin the thesis research during the senior year. It is also 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. Furthermore, an Optics professor must supervise the research in a direct fashion. 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.

The Examination Appointment Form must be filled out and filed. The thesis must be registered with the Associate Dean for Graduate Studies and copies given to the members of the Examining Committee at least two weeks prior to the Oral Examination (Final Defense of the thesis). This Final Examination must be held prior to the date stated in the Graduate Studies Calendar (see page i of this Supplement). If the thesis is accepted by the student's Examining Committee, two permanent copies must be presented to the Office of the Associate Dean for Graduate Studies for deposit in the University Library and two copies given to the Administrator for Graduate Studies in The Institute of Optics.

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 Associate 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 given until at least two weeks have elapsed after registration 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 Committee on Graduate Studies.

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 441 - Geometrical and Instrumental Optics; Optics 461 - Physical Optics I; Optics 425 - Radiation and Detectors; and Optics 256 - Optics Laboratory (a 3 semester hour course when taken for graduate credit).

In addition to the core requirements listed in Section II above, the following are required for this plan:

1. One additional course in Physical Optics;
(examples: Optics 446, 452, 462, 463, 468, 561, 564)
2. One additional course in Geometrical Optics;
(examples: Optics 442, 443, 444)
3. One additional course in Quantum Optics;
(examples: Optics 412, 421, 428, 465, 467)
4. One additional course to reach a total of 30 semester hours;
5. A research essay written under supervision of a faculty member on a selected topic. This essay should be submitted to the Graduate Program secretary by April 16 after approval of the faculty member supervising the essay, and an approval by a second reader.

The complete list of courses that can be used to satisfy the requirements in categories 1, 2, and 3, above, varies as new courses are introduced and old courses 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 (item 4, above) is normally a 400- level optics course. A course in another department such as Physics, Electrical Engineering, or Mathematics may be substituted, however, with the permission of the Faculty Advisor.

There are exceptions to the above rules for the Plan B MS Program. First, part-time students are not required to take Optics 256 - Optics Laboratory. They must, however, take another course in its place. The second exception involves students in the BS/MS Program. These students frequently take 400-level Optics courses during the senior year, a fact that can have an impact on the requirements for the Plan B Program. Students admitted to the BS/MS Program should work closely with their faculty advisors to develop an appropriate academic program.

Plan B with Certified Specialty

This version of Plan B concentrates study in a particular area. Like the general version of Plan B, at least 30 hours of coursework and the completion of research essay are required. The certified specialty areas are summarized in the Table. In the specialty area of Business Administration, the research essay is replaced with a business plan and a research thesis. The courses outlined in the table are guidelines, not rigid requirements. Students interested in the Plan B option with Certified Specialty should meet with their advisor.

Optics MS Specialty Areas

Specialty Area	Physical Optics	Courses in Specialty Area Required (electives)	Overseers
Optical Communications	462	428, 425, (421, 468, 521, 528, EE 435)	Agrawal, Brown, Knox
Electro-optics/ Nonlinear Optics	462	467, 421, (EE-435, ME 451, CE 468)	Agrawal, Boyd, Guo, George
Optical Materials	462	421, 425, (443, EE 435, ME 451, ME 452, CE 486, 568)	Wicks, Fauchet, Jacobs, Novotny
Laser Engineering	461	425, 568 (428, 465, 467)	Guo, Eberly, Seka, Stroud
Medical Optics	462	476, 448, (425, BCS 526, BCS 519)	Berger, Foster, Knox, Williams, Zavislan
Image Science	461	564 and/or 561, EE 446 and/or EE 440 (463, EE 452, 563, 592)	Fienup, George, Novotny
Optical Design, Optical Fabrication and Testing	462	442, 443, (444, 544, 425)	Jacobs, Moore, Zavislan
Business Administration	462	425, 481 (Entrepreneurship); any two of ACC 401, FIN 402, STR 401, OMG 402, and MKT 402; and any one of OPT 428, 442 or 476	Moore, Zavislan

All must take:

OPT 441 (Geometrical Optics);

OPT 461 (Physical Optics I) or OPT 462 (Physical Optics II) -- the recommended one is listed in the table;

A quantum optics course such as OPT 465 (Lasers); and

OPT 256 Lab -- except for Business Administration Specialty.

The Master's Essay

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. It must be supervised by a member of the Optics faculty. 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, and submission date. A copy of the paper, endorsed by the supervising faculty member and a second faculty member, must be submitted to the Optics graduate committee secretary by April 16th for the student to graduate on time. Therefore, the student must submit the essay to the faculty advisor a few weeks before that to allow time for corrections and revisions. Upon submission, the student must pick up the examination report form, have it filled and signed by the advisor, and return it to the graduate committee secretary.

B.S.-M.S. Program in Optics

Optics Juniors contemplating graduate work should consider this five-year program. Students are accepted into the program in the spring of the junior year and can begin master's-level work during the senior year. The Bachelor of Science degree is awarded at the end of the fourth year. Work or study for credit in the summer between the fourth and fifth years can be arranged, if desired.

To apply, students must be in good academic standing and must have completed all required courses through the first semester of the junior year. Students may also compete with other M.S. candidates for financial aid in the fifth year.

FALL

Fourth (senior) Year

OPT 441 or 461
OPT 223
OPT 425
Elective (Distribution)

SPRING

OPT 442 or 462
OPT 256
Elective (Technical or Free)
Elective (Technical or Free)

Fifth Year

OPT 441 or 461
Optics Elective
Optics Elective
Optics Elective

OPT 442 or 462
Optics Elective
Optics Elective
Optics Elective

Part-time Study

The degree requirements are the same for full- and part-time study with one exception. The laboratory course, Optics 256, is not required for part-time students. It is not generally possible to offer all of the required and elective courses in evening time slots, so released time from regular working hours will be required to fulfill the degree requirements.

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 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 at the University of Rochester to complete the Masters program.

In order for the student to participate in the work block, he or she must satisfactorily complete the 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, he or she will be registered for the Co-op program 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.

Filing of M.S. Program Form

Each student must submit a proposed masters degree program for approval by the department and by the Associate Dean for Graduate Studies. The student should list the courses he or she has taken, or intends 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 by the end of the first semester. Any alterations in the program can be made at a later time. This form must be approved and on file before a student may take the M.S. Examination. Copies of this form are available from the Administrator for Graduate Studies. The purpose of this form is to notify the Registrar of the courses which must be taken to satisfy the M.S. requirements.

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.

Listed below is a typical schedule of a student in the Ph.D. program. Details are given in subsequent sections.

First Year

Full time coursework and study
Choose Advisor (by April 15th)
Summer Research
Preliminary Examination

Second Year

Advanced specialized coursework
Teaching Assistantship
Research
File Program Form

Third Year

Thesis Proposal
Oral Qualifying Examination
Elective Courses
Research

Fourth Year and Beyond

Research
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 the Graduate Secretary and a temporary Faculty Advisor assigned to them to plan the course schedule 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 temporary Advisor is replaced by the thesis Advisor at the end of the first year,

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 16 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.

<u>Fall</u>	<u>Spring</u>
Optics 411	Optics 442
Optics 425	Optics 462
Optics 441	Optics 412
Optics 461	Elective

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.

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 also welcome to stop in and see what is going on in the laboratories.

Normally, the first summer is spent working with a faculty member on a research project. 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 should fill out the Program of Study form, have it signed by their advisor and return the signed form to the graduate coordinator.

IV. Ph.D. Preliminary Examination

The examination consists of three segments and is given one or two weeks before classes start in the fall semester. It is normally taken 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. The examination includes questions on physical optics, instrumental optics, mathematical techniques, quantum mechanics, and so on. Further details are given later in the Guide to the Ph.D. Preliminary Examination, on page 48.

V. 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. The student is required to take not less than 16 hours of courses during this year. This is equivalent to two courses per semester. 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. Reading courses (Optics 591) and research credits (Optics 595) can be used for the credits beyond 8 hours.

At least 8 hours of the sixty hours of 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. These may be in Optics or in other subjects that have relevance to optics. Reading courses (Optics 591), research credit (Optics 595), and the seven courses required for all PhD students do not fulfill this requirement.

During the second year, the student should become familiar with some of the research 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.

During the second year, students usually fulfill their teaching 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.

VI. 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 no later than 21 months after the student successfully passes the Preliminary Examination.

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 is typically 15-20 pages in length. It includes a brief literature survey (none of us desires to re-invent the wheel) 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 "Form of Thesis Proposals" provides more details.). The thesis proposal should be circulated to all the faculty members at The Institute at least two weeks before the examination and a copy given to the Administrator for Graduate Studies.
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 Director of The Institute of Optics should complete Form 2, Nomination of the Examining Committee for the Ph.D. Oral Qualifying Examination.

VII. Filing of Ph.D. Program 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 second year of graduate study. Any alterations in the program can be made at a later time. Copies of this form are available from the Administrator for Graduate Studies. The purpose of this form is to notify the Registrar of the courses which must be taken to satisfy the Ph.D. requirements. This form must be submitted by the end of the second semester.

VIII. Thesis Advisory Committee

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.

The program of research undertaken by the student will be reviewed by the committee, which will meet with the candidate not less than once each academic year. The committee will report to the Associate 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 (which for this purpose includes S. Jacobs, J. Marciante and W. Seka) and one with a primary appointment outside of optics (which may include those with secondary appointments in Optics, such as N. Bigelow, J. Eberly, P. Fauchet, T. Foster, T. Krauss, G. Yoon and E. Wolf). Note that, 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.

IX. 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 booklet called, "The Preparation of Doctoral Theses", this is available on-line at <http://www.rochester.edu/Theses/ThesesManual.pdf>.

Once the student is ready to defend, he/she should stop down to the graduate coordinator and pick up a procedure document for filing his/her thesis. This gives a brief overview of what forms are needed in order to register a thesis. The University's Official Bulletin 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 Administrator for Graduate Studies in The Institute of Optics for the departmental archives. The Final Oral Examination consists of the following 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.

X. 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 seven years. Those entering a Ph.D. program with a Master's degree are expected to complete the Ph.D. degree within six years.

XI. 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. Credit

Ninety hours of credit are required for the Ph.D. if the student does not have graduate credit before starting the program. Normally, approximately sixty hours should be course work, including reading and special topics courses. The remaining thirty hours should be research credits. Reasonable variations in this distribution are subject to approval by the thesis supervisor, the Director, and the Associate Dean for Graduate Studies.

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, approved by the Associate Dean for Graduate Studies, toward the sixty hours of course work required for the Ph.D.

B. Foreign language requirement

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

C. 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. Ph.D. students must have satisfied their two-semester TA requirement in order to be eligible to earn the M.S. degree.

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.

Ph.D. students who wish to receive an M.S. degree can petition that the OPT 256 requirement be waived if they have performed extensive, diverse experimental work equivalent to OPT 256. The faculty or staff teaching OPT 256 must sign the petition and certify that the student's experimental experience is adequate.

TIME LIMITATIONS 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 by 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. 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.

PETITIONS FOR EXCEPTIONS FROM THE RULES

No set of rules can be expected to handle properly every situation. Any student who feels that his or her educational needs would be better served if an exception were made to the regulations given in this pamphlet should first discuss the matter with a faculty advisor, and with the Chairman of the Graduate Committee asking a formal waiver of the relevant requirement.

The petition should be in the form of a letter addressed to the Chairman of the Graduate Committee stating the desired exception and providing whatever supporting information might be useful. In the case of requests for waiver of a particular course requirement, a supporting letter from the instructor in the course is helpful.

A GUIDE TO THE 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 mornings in late August or early September. It 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.

Content of the examination

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 Studies Administrative Assistant 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 he or she is 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.

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:

Cohen-Tannoudji, Diu, and Laloe, *Quantum Mechanics*

L.I. Schiff, *Quantum Mechanics*

E. Merzbacher, *Quantum Mechanics*

Electromagnetism - 45 minutes

First-year graduate level material on electromagnetism, including (but not limited to) elementary results of Maxwell's equations, potentials and gauge transformations, Green's function method for solving inhomogeneous wave equations, Lienard-Weichert potentials, dipole radiation, radiation spectrum, the Lorentz atom model, Kramers-Kronig relations, optics of metals, polarization and crystal optics, interface problems and transfer matrix method, and guided wave optics.

References:

OPT 462 material

J.D. Jackson, *Classical Electrodynamics*

Born & Wolf, *Principles of Optics*

Physical Optics - 45 minutes

Diffraction in free space based upon Maxwell's equations, the linear system formulation for imaging systems, Fourier transform theory, optical information processing, and the elements of holography.

References:

OPT 461 material

J. W. Goodman, *Introduction to Fourier Optics*

Mathematical Methods - 45 minutes

Vector Calculus, Taylor and Laurent series. Fourier, Laplace & Hilbert transforms. Contour integrals, residues, singularities. Ordinary differential equations. Sturm-Liouville operator, Green's functions. Partial differential equations. Separation of variables.

References:

OPT 411 material

G.B. Arfken and H.J. Weber, *Mathematical Methods for Physicists*,

H.W. Wyld, *Mathematical Methods for Physics*,

Susan Lea, *Mathematics for Physicists*,

Dennerly & Krzywicki, *Mathematics for Physicists*.

Day 2

Lasers - 45 minutes

This subject will cover the theory of lasers and the operating characteristics of different types of lasers. Students should know the basic concepts such as spontaneous and stimulated emission, optical gain, pumping schemes, and laser threshold. The main topics

include stable and unstable resonators, longitudinal and transverse modes, ABCD law for Gaussian beams, rate equations, gain spectrum, Q-switching, and mode locking.

References:

OPT 465 material

Svelto, *Lasers*,

Milonni and Eberly, *Lasers*.

Instrumental Optics - 45 minutes

Basics of coherence, partial coherence, and incoherence: Principle of linear superimposition of propagating waves; Wiener-Khintchine theorem; Michelson interferometer; Young's experiment; the van Cittert-Zernike theorem; Michelson stellar interferometer. Scalar theory of "W" aberrations and metrics. Zernike Polynomials. Pupils/apertures. Interferometric tests for metrology: Newton/classic-Fizeau, Twyman-Green, Laser Fizeau, Mach-Zehnder, lateral shearing, and phase shifting interferometers. Null testing: Offner, Hindle sphere tests. Basic instruments: principles of microscopy, illumination and imaging: full field, dark field, phase contrast, confocal, optical coherence microscopy. Principles of projectors, illumination and imaging; Basic telescope designs: Newton, Cassegrain/Gregorian, Ritchey-Chretien, TMAs. Essentials of the human eye as an optical system. Writing an instrument specification table.

References:

Optics 442 material

Malacara, *Optical Shop Testing*

Born and Wolf, *Principles of Optics*

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

R.W. Boyd, *Radiometry and the Detection of Optical Radiation*

E.L. Dereniak and D.G. Crowe, *Optical Radiation Detectors*

R. H. Kingston, *Optical Sources, Detectors, and Systems*.

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--acromatic doublets, telescopes, microscopes, telephoto, reverse-telephoto, 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 442 material

W.J. Smith, *Modern Optical Engineering*

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.

Solid State Physics

Charles Kittel, *Introduction to Solid State Physics*, Wiley, New York, 1986, Chs 6, 7, 8,10.

Optical Materials

Read sections 5.5 and 5.6 on Saleh & Teich, *Absorption and Dispersion in Fundamentals of Photonics*.

Saleh & Teich, *The Principles of Electro-Optics in Fundamentals of Photonics*, section 18.1.

Hecht & Zajac, *Optics*, section 8.11 Induced Optical Effects.

Nonlinear Optics

R.W. Boyd, *Nonlinear Optics*, Chapter 1 in its entirety; Chapter 2, sections 2.1 through 2.3, 2. and section 2.10; Chapter 3, subsection 3.5.1; Chapter 4, section 4.1, 4.6 and 4.7; Chapter 7 in its entirety; Chapter 8, section 8.1 and Chapter 9, section 9.1.

Fibers & Waveguides

G.P. Agrawal, *Fiber-Optics Communication Systems*, John Wiley & Sons, Inc., 3rd edition (2002); chapter 1 (introduction) and chapter 2 (optical fibers).

G.P. Agrawal, *Lightwave Technology: Components and Devices*, Wiley (2004); Chapter 2 (passive fiber components), Chapter 4 (planar waveguides).

Optical Spectroscopy

"Spectroscopy: Fluorescence and Raman"

Materials: two attached PDF files

1. "Introduction to Fluorescence and Photophysics" by Robert Redmond, from "Handbook of Biomedical Fluorescence", exclude sections 3, 5, and 6.3-beyond. (available internally as FluorescenceIntro.PDF)
2. "Introduction to Raman Spectroscopy" from "Introduction to Modern Vibrational Spectroscopy" by Max Diem. Don't worry about details of derivations in 5.3; skip 5.4, 5.5, 5.83-5.85. (available internally as RamanIntro.PDF)

System Analysis and Tolerancing

As optical scientists and engineers we strive to develop systems that are capable of detecting and reporting the experimental quantities of interest. System Analysis and Tolerancing considers how the goals of an entire system get converted to the specifications of the individual sub-systems or components. The process of partitioning the system into subsystems and attributing performance characteristic to each part often involves estimation, approximation and "rules of thumb."

In this question you will be presented with some form of either an optical system, electro-optical system or opto-mechanical system. From this system, you will partition the system into sub-systems and/or develop specifications for either the sub-systems or components such that the entire system should in principle work.

References:

W. Wolfe, editor, *Optical Engineering Handbook*, OSA/SPIE publishers 2003, Chapter 25.

W. Smith, *Modern Optical Engineering*, McGraw-Hill, 2000, Chapter 15.

W. Welford, *Useful Optics*, Univ. Chicago Press, 1991, Chapter 16.

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 Associate 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 seven 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 Associate 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 Associate 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, which is 15-20 double-spaced pages in length, 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.

A guide for the preparation of the proposal is provided in the next section.

FORM OF THESIS PROPOSALS

Thesis proposals should be typewritten (double-spaced) and photocopied. The thesis proposal should contain the following parts:

1. Title/Abstract Page

The first page of the thesis proposal 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 also 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. Total Length

The total length of the proposal, including text, figures, appendices, etc., should not exceed 20 pages.

RECENT M.S. RESEARCH PAPERS

2002

Long Period Fiber gratings and their applications

Unobscured Reflective Afocal Telescopes

Characterization of Healthy and Tumor Containing Breast Tissue Using NIR Optical Mammography

Design of Dispersion-Compensating Fibers and Their Applications in Modern Lightwave Systems

Design Considerations or Constructing a Two-Channel Microscope for Near Infrared Raman Spectroscopy in Biological Samples

Demultiplexing Technologies in DWDM Systems

Issue in Near-Field Scanning Optical Microscopy

2003

Adaptive Optics in Astronomy and Visual Science

Measuring Surface Micro-roughness with White Light Interference

Geometrical and Physical Optics in Nature: Common, Rare and the Future

Retrieval Methods for Femotsecond Laser Pulses

NIR Diffuse Optical Methods for Functional Brain Monitoring

Real-Time Volumetric Three Dimensional Displays

Organic Light Emitting Diodes

Photodetectors in the Mid-Infrared Region

Optical Water Pollution Measurement Using Laser-Induced Fluorescence

The Ion Beam Sputtering Process and Its Effects on the Optical Thin Film Industry

2004

Liquid Crystal Light Waves

Analysis of Microspectrometers

Fabry-Perot Interferometers for Solar Astronomy

Automatic Optical System Design

Immersion Lithography

Novel Methods of Interferometric Phase Detection

III-V Nitride Light Emitters Grown by Molecular Beam Epitaxy

Advancements in Light Emitting Quantum Dots

Stitching Interferometry for Testing High Quality Optical Lithography Surfaces

Current Status of Free-Space Optical Communication Links

Polarization Microscopy

X-Ray Interferometry

Three-Dimensional Imaging Using Structured Illumination

Optical Tweezers: Grasping the Future

Stable Lasers

Lateral Shearing Interferometer at 193nm Wavelength, Using Ronchi Phase Gratings

2005

Analysis of Corneal Topography

A Critical Comparison of Digital & Film

Action Mechanisms of Laser Therapy

A Prospective Use of Luminescent Quantum Dots for In Vivo Multiphoton Imaging of Amyloid β in Alzheimer's Disease

Liquid Lens: Tunable Miniature Lens for the Future

Low-Power Laser Therapy and Current Theories of Its Action Mechanisms

2006

High-Resolution Retinal Imaging: Adaptive Optics with Optical Coherence Tomography (AO-OCT)

Remote Sensing: An Overview of Select Instruments and Applications

Current Intraocular Lens Designs and Ideas for Further Improvement

Opto-Mechanical Design: A Review of Lens Mounting Techniques

A Review of Novel Techniques for Aspheric Metrology

Shining Light on Life: A Review of PDT

Development of Polymer Cholesteric Liquid Crystal Flakes for Electro-Optic Applications

Animal Ultraviolet Vision

Multiphoton Microscopy

Optical Coherence Tomography and Its Application in Biomedical Imaging

Type II Superlattice Detectors

2007

UV LED's Construction and Applications

Survey of Photodynamic Therapy

Laser Tweezers Raman Scattering: Theory and Modern Applications

Uncertainty Relations for Functions of Continuous and Discrete Variables and Their Applications to Optics

Imaging Polarimetry: Theory of Applications

Computer Aided Tolerancing in Lens Design

Applicability of Multiphoton Microscopy to Clinical Dermatology

2008

Comparison of Two Photon and CARS Imaging Techniques

Extreme Ultraviolet Sources for Optical Lithography

Metamaterials: Negative Index of Refraction

Compact Semiconductor Imaging Sensors and Color Filter Arrays for Consumer Devices

Lidar and Differential Absorption Lidar

Metrics of Subjective Image Quality for the Human Visual System

Single Photon Generation in Quantum Dots

Polarization and its uses in Animal Vision

Aspheres: Specification, Design, Manufacture, and Metrology

The State of Solar Cells

Subaperture Stitching Interferometry and Its Applications in Surface Metrology

Confocal Microscopy

2009

Stress Birefringence and How it is Modeled in Code V

Adaptive Optics: Properties and Applications to Modern Optical Instruments

A Survey of Microlens Array Fabrication Techniques

Optical Coherence Tomography

Review of Distortion Mapping for Symmetric and Asymmetric Maps

RECENT PHD THESIS

2002

Quantum Information and Computing in Multilevel Systems

Tolerance Assignment in Optical Design

Nonlinear Phenomena in Dipole-Waveguide Structures

The Interaction Between Metal Nanoparticle Resonances and Optical-Frequency Surface Waves

Dipole-Waveguide Coupling: Theory and Application

Gradient-Index Ophthalmic Lens Design and Polymer Material Studies

Revivals and Classical-Motion Bases of Quantum Wave Packets

2003

Narrow-Band Guided-Mode Resonance Filters: Theory and Experiments

Motion of Polymer Cholesteric Liquid Crystal Flakes in an Electric Field

Emission from Organic Light-Emitting Diodes via Surface-Plasmon Cross-Coupling

Phase Apodization for Resolution Enhancement

Wire Grid Polarization for Visible Wavelengths

Nonlinear Optical Whispering Gallery Microresonators for Photonics

2004

Holographic Interference Filters

Holography of Non-Rigid Objects

Computational Imaging System for Extended Depth of Field

Volume Holography in Optically Isomerized Polymer Media

Photonic Crystal Fibers: Characterization and Supercontinuum Generation

Mathematic Topics in Imaging: Sampling Theory and Eigenfunction Analysis of Imaging Systems

Transverse Effects in Nonlinear and Quantum Optics

Frequency Conversion of Optical Signals Using Coherently Prepared Media

Sources of the Monochromatic Aberrations Induced in Human Eyes After Laser Refractive Surgery

Multi-Photon State Engineering for Quantum Information Processing Applications

Quantum Interference Engineered by Dispersive Parameter Design

Ultra-Slow and Superluminal Light Propagation in Solids at Room Temperature

Characterization of Ultrashort Pulses Through the Use of Spectral Interferometry

2005

Coherent Population Trapping in A Real and Artificial Atom

Biological Applications of Confocal Fluorescence Polarization Microscopy

Interaction of Nanostructures with Deterministic and Stochastic Electromagnetic Fields

Focal Field Interactions from Cylindrical Vector Beams

Design of Modern Dispersion-Managed Lightwave Systems

Tunable Porous Silicon Photonic Bandgap Structures: Mirrors for Optical Interconnects and Optical Switching

Upconversion in Erbium-Doped Transparent Glass Ceramics

Post-Exposed Fiber Bragg Gratings

Towards Coherent Control of Ultracold Molecule Formation

Near-Field Extinction Microscopy

2006

Post-Exposed Fiber Bragg Gratings

Towards Coherent Control of Ultracold Molecule Formation

Near-Field Extinction Microscopy

Scalable Fiber-based Femtosecond Laser Systems and Applications

Linear and Nonlinear Properties of Tapered Fibers and Applications in Femtosecond Science and Technology

Fiber-Optic Parametric Amplifiers: Their Advantages and Limitations

Metal Grating Resonators in Silicon-on-Insulator Waveguides

Mode Locking of Fiber Lasers at High Repetition Rates

2007

Experimental Studies of Two-Mode Squeezed States in Rubidium Vapor

Polarization and Fiber Nonlinearities

Gradient-Index Fiber Array for Imaging

Optical Detection of Nanoparticles and Viruses

High Resolution *in vivo* Imaging of Retinal Cells with Adaptive Optics Fluorescence Scanning Laser Ophthalmoscopy

Sizing and Classification of Biological Particles Using Ring-Wedge Detector and Neural Networks

Surface Interactions Between Nanodiamonds and Glass in Magnetorheological Finishing (MRF)

Stress-Engineered Optical Elements

2008

In Vivo Imaging of the Retinal Pigment Epithelial Cells

Corrected near-infrared Spectroscopy, C-NIRS: An optical system for extracting hemodynamic signatures unique to the brain

Materials for Nonlinear Optics: Semicontinuous Gold Films and Fast Saturable Absorbers

2009

When Nano Meets Bio: Biological Molecule Detection based on Silicon Two-Dimensional Photonic Crystals

Imaging, Scattering, and Spectroscopic Systems for Biomedical Optics: Tools for Bench Top and Clinical Applications

Application of Phase Retrieval to the Measurement of Optical Surfaces and Wavefronts

Phase Diversity for Segmented and Multi-Aperture Systems

Local-Field Effects and Nanostructuring for Controlling Optical Properties and Enabling Novel Optical Phenomena

Integrated Raman and Angular Scattering of Single Biological Cells

Focused Monochromatic Fields

Integrated Raman and Angular Scattering of Single Biological Cells

Micro-processing of Polymers and Biological Material Using High Repetition Rate Femtosecond Laser Pulses

Compound Optical Arrays & Polymer Tapered Gradient Index Lenses

High-Power Single-Frequency Fiber Lasers

**THE INSTITUTE OF OPTICS
GRADUATE STUDENTS 2009 – 2010**

Adelsberger, Kathleen	PHD	4	Zavislan
Anderson, Sean	PHD	6	Fauchet
Balois, Maria	MS	2	
Baran, Timothy	PHD	3	Foster
Bauer, Aaron	PHD	1	
Baveja, Prashant	PHD	4	Agrawal
Beams, Ryan	PHD	5	Novotny
Beckley, Amber	PHD	4	Brown
Beier, Brooke	PHD	5	Berger
Bentley, Joel	PHD	4	Nedergaard
Bergkoetter, Matthew	MS	1	
Berman, Rebecca	PHD	1	
Bissell, Luke	PHD	6	Stroud
Brown, Dean	PHD	5	Brown
Brown, Matthew	PHD	1	
Brown, Michael	PHD	3	Moore
Canavesi, Cristina	PHD	3	Foster
Chang, Nien-An	PHD	7	George
Christensen, Daniel	PHD	3	Nedergard
Christensen, Eric	PHD	5	Moore
Chu, Kaiqin	PHD	8	George
Cui, Liping	PHD	5	Knox
Daniel, Brian	PHD	3	Agrawal
Darling, Zachary	PHD	1	
DeSantis, Zachary	PHD	1	
Deutsch, Bradley	PHD	6	Novotny
DiVitt, Shawn	PHD	1	
Fang, Kejia	MS	1	
Fuerschbach, Kyle	PHD	2	Rolland
Fu, Yijing	PHD	5	Fauchet
Gehring, George	PHD	7	Boyd
Gao, Boshen	PHD	2	Boyd
Geng, Ying	PHD	5	Williams
Glazowski, Christopher	PHD	6	Zavislan
Guizar, Manuel	PHD	5	Fienup
Han, Xiaoxing	PHD	6	(BME) Ed Brown (BERGER)
Heiniger, Adam	PHD	3	Fauchet
Heins, Alan	PHD	4	Guo
Hwang, Taek Yong	PHD	4	Guo
Jha, Anand	PHD	7	Boyd
Jiang, Wei	MS	1	

Jurling, Alden	PHD	2	Fienup
Kazunas, Peter	MS	1	
Kim, Sanghoon	PHD	2	
Klimas, Aleksandra	MS	1	
Klinczar, Matthew	MS	1	
Kornhauser, Michael	PHD	3	Moore
Kumar, Abhishek	MS	1	
Landau, Mayer	PHD	9	Stroud
Lapin, Zachary	PHD	2	Novotny
Lee, Tammy	PHD	5	Foster
Leidner, Jordan	PHD	3	Marciante
Leslie, Lisa	PHD	5	Bigelow
Lesoine, John	PHD	7	Novotny
Liapis, Andreas	PHD	4	Boyd
Lou, Xinye	PHD	4	Moore
Maher, Jason	PHD	3	Berger
Malik, Mehul	PHD	4	Boyd
Masella, Benjamin	PHD	5	Williams
McCarthy, Peter	PHD	2	Moore
Moore, Dustin	PHD	1	
Nihira, Hideomi	PHD	9	Stroud
O'Sullivan, Malcolm	PHD	9	Boyd
Pal, Parama	PHD	6	Knox
Pancy, Benjamin	MS	1	
Pedrazzani, Renee	PHD	11	Wicks
Person, Steven	PHD	3	Novotny
Petersen, Travis	PHD	1	
Radunsky, Aleksandr	PHD	10	Walmsley
Rodenburg, Brandon	PHD	3	Knox
Sabesan Ram Kumar	PHD	5	Williams
Savich, Gregory	PHD	4	Wicks
Schoenly, Joshua	PHD	5	Seka
Schultz, Justin	PHD	1	
Schweinsberg, Aaron	PHD	10	Boyd
Sharma, Robin	PHD	2	Williams
Shi, Zhimin	PHD	6	Boyd
Shin, Heedeuk	PHD	6	Boyd
Shipp, Dustin	PHD	2	Berger
Shome, Krishanu	PHD	4	Fauchet
Sidor, Daniel	PHD	2	
Smith, Richard	PHD	2	
Storm, Michael	PHD	8	Guo
Sulai, Yusufu	PHD	2	Williams
Sun, Lei	PHD	6	Marciante
Theisen, Michael	PHD	4	Brown
Tippie, Abbie	PHD	4	Fienup

Unger, Blair	PHD	7	Moore
Vickery, Daniel	MS	2	Fienup
Visconti, Anthony	PHD	1	
Vo, Sophie	PHD	2	Rolland
Vornehm, Joseph	PHD	5	Boyd
Williams, Daniel	PHD	2	Moore
Wilson, Rebecca	PHD	5	Zavislan
Xiao, Yuzhe	PHD	2	Agrawal
Xu, Lisen	PHD	4	Knox
Yadav, Rahul	PHD	4	Geunyoung Yoon
Yao, Haomin	MS	1	
Yao, Yuhong	PHD	2	Knox
Yin, Lianghong	PHD	7	Agrawal
Zavattero, Paul	MS/PT	6	-----
Zerom, Petros	PHD	8	Boyd
Zheleznyak, Leonard	PHD	3	Yoon
Zielinski, Thomas	PHD	6	Fienup
Zimmerman, Brandon	PHD	1	