ELECTRO-OPTICS

- Doctor of Philosophy in Electro-Optics (p. 1)
- Master of Science in Electro-Optics (p. 1)

Partha Banerjee, Program Director

The interdisciplinary programs of study leading to the Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) in electro-optics are administered by the School of Engineering with the cooperative support of the College of Arts and Sciences.

Doctor of Philosophy in Electro-Optics (EOP)

To be considered for admission to the Ph.D. program in Electro-Optics, a student must have received a M.S. degree in Electro-Optics or equivalent. Only the most promising student with a graduate GPA of 3.5 out of 4, or higher, or equivalent, may be admitted.

The minimum semester-hour requirement for the doctoral degree is 90 semester hours beyond the bachelor’s degree (which must include the EO core or its equivalent), or 60 semester hours beyond the EO M.S. degree or equivalent. This includes the credit for the doctoral dissertation. Doctoral candidates are required to register for two semester hours of dissertation during the semester in which the dissertation is defended.

The Plan of Study of a student seeking the Ph.D. in Electro-Optics must successfully complete a minimum of 90 semester hours beyond the bachelor’s degree which must include the following:

1. Core courses as given in the EO Master’s program or equivalent
2. Twelve semester hours of approved 600-level Electro-Optics courses.
3. Six semester hours of approved graduate mathematics courses.
4. Twelve semester hours of Technical Electives.
4. Thirty semester hours of Ph.D. dissertation credits in Electro-Optics.

See also the Doctoral Degree Requirements in School of Engineering section in the bulletin and consult with the Chair of Electro-Optics and Photonics.

Non-Thesis option must include EOP 598 Non-Thesis Project AND six additional, approved technical elective courses.

Courses

EOP 500. Introduction to Research in Electro-Optics. 0 Hours
Introduction to research methods, laboratory safety, ethics, proposal writing, technical presentations.

EOP 501. Fundamentals of Optical Design. 3 Hours
Foundation of geometrical optics, Gaussian optics, paraxial ray tracing, aperture stops and pupils, first-order optical design of basic optical instruments, optical materials, chromatic aberrations, third-order monochromatic aberrations, introduction to computer-based ray tracing, optical design of elementary optical components. Prerequisite(s): Acceptance into the graduate EOP department or permission of the department chair.

EOP 502. Light and Matter Interaction. 3 Hours
Classical and quantum mechanical description of light-matter interaction; electromagnetic waves; polarization; dipole radiation; interaction of radiation with electrons; crystal optics; electro-optic effect; Fermi’s golden rule; absorption and dispersion. Prerequisite(s): Acceptance into the graduate EOP department or permission of the department chair.

EOP 503. Optical Information Processing. 3 Hours
2D linear systems and Fourier transforms; analysis of diffraction using transfer function, impulse response and transport of intensity; optical elements for imaging and Fourier transformation; transfer functions of coherent and incoherent systems, design of complex spatial filters and holograms; optical information processing; 3D imaging. Prerequisite(s): Acceptance into the graduate EOP department or permission of the department chair.

EOP 504. Guided-Wave Optics. 3 Hours
Light propagation in slab and cylindrical wave guides; signal degradation in optical fibers; optical sources, detectors, and receivers; coupling; transmission link analysis; fiber fabrication and cabling; fiber sensor system. Prerequisite(s): EOP 502 or permission of department chair.

EOP 505. Introduction to Lasers. 3 Hours
Laser theory; coherence; Gaussian beams; optical resonators; properties of atomic and molecular radiation; laser oscillation and amplification; methods of excitation of lasers; characteristics of common lasers; laser applications. Prerequisite(s): EOP 502 or a working knowledge of Maxwell’s Equations; physical optics) or permission of instructor or department chair.

Master of Science in Electro-Optics (EOP)

The individual Plan of Study will include the specific courses and all other requirements of the M.S. EO degree the student is expected to complete. The Plan of Study must be filed with the School of Engineering Office of Graduate Studies prior to registration for the tenth graduate credit hour or before registration for the third semester. The Plan of Study and any amendments thereto must be approved by the advisor, the Program Director, and the Associate Dean of the School of Engineering Office of Graduate Studies.

EOP 500  Introduction to Research in Electro-Optics  0
EOP 501  Fundamentals of Optical Design  3
EOP 502  Light and Matter Interaction  3
EOP 505  Introduction to Lasers  3
EOP 506  Photonic Devices & Systems  3
EOP 510  Contemporary Topics in Electro-Optics and Photonics  0
EOP 513  Linear Systems & Fourier Optics  3
EOP 514  Guided-Wave Optics  3
EOP 541L  Geometric & Physical Optics Laboratory  1
EOP 542L  Electro-Optic System Laboratory  1
EOP 543L  Advanced Electro-Optics Laboratory  1
Technical Elective  3
EOP 599  Thesis  6
OR
EOP 598  Non-thesis Research Project  0
Plus 6 approved additional credits of technical electives

Total Hours  30

See also Master’s Degree Requirements in School of Engineering section in the catalog and consult with the Chair of Electro-Optics and Photonics.

Courses

EOP 500. Introduction to Research in Electro-Optics. 0 Hours
Introduction to research methods, laboratory safety, ethics, proposal writing, technical presentations.

EOP 501. Fundamentals of Optical Design. 3 Hours
Foundation of geometrical optics, Gaussian optics, paraxial ray tracing, aperture stops and pupils, first-order optical design of basic optical instruments, optical materials, chromatic aberrations, third-order monochromatic aberrations, introduction to computer-based ray tracing, optical design of elementary optical components. Prerequisite(s): Acceptance into the graduate EOP department or permission of the department chair.

EOP 502. Light and Matter Interaction. 3 Hours
Classical and quantum mechanical description of light-matter interaction; electromagnetic waves; polarization; dipole radiation; interaction of radiation with electrons; crystal optics; electro-optic effect; Fermi’s golden rule; absorption and dispersion. Prerequisite(s): Acceptance into the graduate EOP department or permission of the department chair.

EOP 503. Optical Information Processing. 3 Hours
2D linear systems and Fourier transforms; analysis of diffraction using transfer function, impulse response and transport of intensity; optical elements for imaging and Fourier transformation; transfer functions of coherent and incoherent systems, design of complex spatial filters and holograms; optical information processing; 3D imaging. Prerequisite(s): Acceptance into the graduate EOP department or permission of the department chair.

EOP 504. Guided-Wave Optics. 3 Hours
Light propagation in slab and cylindrical wave guides; signal degradation in optical fibers; optical sources, detectors, and receivers; coupling; transmission link analysis; fiber fabrication and cabling; fiber sensor system. Prerequisite(s): EOP 502 or permission of department chair.

EOP 505. Introduction to Lasers. 3 Hours
Laser theory; coherence; Gaussian beams; optical resonators; properties of atomic and molecular radiation; laser oscillation and amplification; methods of excitation of lasers; characteristics of common lasers; laser applications. Prerequisite(s): EOP 502 or a working knowledge of Maxwell’s Equations; physical optics) or permission of instructor or department chair.
EOP 506. Photonic Devices & Systems. 3 Hours
Solid state theory of optoelectronic devices; semiconductor photoemitters: LEDs, optical amplifiers and semiconductor lasers; photodetectors: PIN, APD, photocells, PMT; detection and noise; solar cells; cameras and displays; electro-optic and magneto-optic devices; integration and application of electro-optical components in systems of various types. Prerequisite(s): EOP 502 or permission of instructor.

EOP 510. Contemporary Topics in Electro-Optics and Photonics. 0 Hours
Discussion, inquiry and feedback of research progress towards a thesis in electro-optics and photonics; Review of background research literature; Discussion of experimental or computation methods and results; Presentation of research progress reports; Review of laboratory safety protocols; Participation in technical conferences and professional workshops and/or Stander Symposium.

EOP 532. Optical Thin Film Design. 3 Hours
Fundamental principles of optical thin film design and interference filters including: single-layer and multi-layer anti-reflection designs; High-reflection multi-layer designs; Broad band reflectors; High-pass & low-pass filters; Line filters; Bandpass filters; Metal film designs; Design methods for oblique incidence; Thin film beam splitters; Numerical methods and optimization; Thin film manufacturing methods. Prerequisite(s): EOP 502, or equivalent, or instructor permission.

EOP 533. Principles of Nanofabrication. 3 Hours
Basic principles of processes used in microelectronic and photonic device fabrication: vacuum systems, plasma processes, physical and chemical vapor deposition, properties of silicon and other substrate materials, photolithography and non-optical lithography, wet chemical and plasma etching, thermal oxidation of silicon, semiconductor doping, ion implantation, metallization, electrical contacts and micro-meterology.

EOP 541L. Geometric & Physical Optics Laboratory. 1 Hour
Geometric optics; characterization of optical elements; diffraction; interference; birefringence and polarization. Prerequisite(s): EOP 501 or permission of program director.

EOP 542L. Electro-Optic System Laboratory. 1 Hour
Fiber optic principles and systems: numerical aperture, loss, dispersion, single and multimode fibers, communications and sensing systems. Project oriented investigations of electro-fiber-optic systems and devices in general: sources, detectors, image processing, sensor instrumentation and integration, electro-optic component, display technology, nonlinear optical devices and systems. Prerequisite(s): EOP 514 or permission of program director.

EOP 543L. Advanced Electro-Optics Laboratory. 1 Hour
Project oriented investigations of laser characterization, interferometry, holography, optical pattern recognition and spectroscopy. Emphasis is on the applications of optics, electronics, and computer data acquisition and analysis to measurement problems. Prerequisite(s): EOP 541L or permission of program director.

EOP 599. Thesis. 1-6 Hours
Thesis in Electro-Optics.
EOP 655. Optical Communications. 3 Hours
No description available.

EOP 656. Free Space Optical Communications. 3 Hours
Laser beam propagation, random processes, wave propagation in turbulence, turbulence spectra, structure function, coherence length, anisoplanatism, Strehl ratio, scintillation index, long-time and short-time spot size, and beam wander, bit-error rates, adaptive optics corrections, performance analysis. Prerequisite(s): EOP 513, EOP 502, or knowledge of electromagnetism and radiation-matter interactions or permission from instructor.

EOP 657. Principles of Atmospheric Optics and Applications. 3 Hours
The course will elaborate on a foundation for the physics of atmospheric optics effects by building bridges between meteorology, computational fluid dynamics, and statistical wave optics. It provides solid theoretical knowledge of optical wave propagation through the atmosphere, and practical computational tools for realistic characterization assessment and performance prediction of various optical systems operated in the atmosphere including: laser beam projection (directed energy), laser communications, ladars, long-range laser vibrometry, active and passive imaging systems. Prerequisite(s): EOP 501 and EOP 513 or permission of the course Director. BS in physics or electrical engineering.

EOP 658. Principles of Ladar. 3 Hours
Survey of principals of direct detection and coherent detection ladar systems; Ladar sources and receivers; Effects of illumination path and object scattering; Basic ladar range equation; Elements of detection theory as applied to direct detection ladar systems. Prerequisite(s): EOP 501 and EOP 513.

EOP 659. Introduction to Atmospheric Optics. 3 Hours
This course elaborates on a foundation for the physics of atmospheric optics effects by building bridges between meteorology, computational fluid dynamics, and statistical wave optics. It provides solid theoretical knowledge of optical waves propagation in atmosphere, and practical computational tools for realistic characterization assessment and prediction of laser beam projection and imaging in atmosphere. The students will learn about different approaches that can be applied for mitigation and exploitation of atmospheric effects including adaptive optics, engineering of stochastic and exotic laser beams with reduced sensitivity to atmospheric distortions, lucky-region fusion imaging, laser communication with turbulence-enhanced security and turbulence-induced diversity for compressive sensing and imaging. Students registering for the course should hold a BS in physics or electrical engineering, physical and/or Fourier optics, statistics and/or statistical optics.

EOP 665. Polarization of Light: Fundamentals & Applications. 3 Hours
The fundamentals and applications of the polarization properties of light; description of state of polarization; propagation of state of polarization; polarization devices; polarization in guided waves; polarization in multilayer thin films; ellipsometry and polarimetry; birefringent filters; spatially variant polarization; polarization in subwavelength structures. Prerequisite(s): EOP 502; basic knowledge of electromagnetism and linear algebra or permission of instructor.

EOP 690. Selected Readings in Electro-Optics. 1-3 Hours
Directed readings in electro-optics areas to be arranged and approved by the chair of the student's advisory committee and the program director.

EOP 695. Special Problems in Electro-Optics. 1-3 Hours
Special topics in electro-optics not covered in regular courses. Course sections arranged and approved by the chair of the student's advisory committee and program director.

EOP 699. PhD Dissertation. 1-15 Hours
Original research in electro-optics which makes a definite contribution to technical knowledge. Results must be of sufficient importance to merit publication.