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Optics and Photonics:
A Guide for Students at Johns Hopkins Engineering

Optics is playing an increasingly important role in science and engineering today. Since the invention of the laser, there has been extensive growth, and prolific research and development in optics. Entirely new fields within applied science and technology, such as remote sensing, nonlinear optics, fiber optics, biophotonics and integrated optics, have opened up, and old subfields of engineering, such as communications, computers, and systems have been greatly extended. Fields such as remote sensing and quantum computing are significantly enhanced by modern optical techniques. Individuals with advanced training and education in optical science and engineering are in greater demand today than ever before. There are more jobs and challenging technical positions in both government and industrial sectors for work in optics. Applications to military and non-military problems are much more numerous.

In order to support the needs of a growing industry and government involvement in optics and optical systems, the Johns Hopkins University G.W.C. Whiting School of Engineering, Engineering for Professionals offers a number of optics courses within in the Electrical and Computer Engineering (ECE, 525) and Applied Physics (615) programs. For example, the prospective student can obtain a Master of Science degree in Electrical Engineering or Applied Physics with concentration entirely in optics (see Photonics Option in catalog). Alternatively, the student may wish to concentrate in one of a variety of interdisciplinary subfields between optics and either communications, signal processing, computers, or systems.

The purpose of this guide is to provide students with listings and updated schedules of all of the optics and photonics courses offered in the EP program to help students plan their program. This guide also consolidates the course descriptions and faculty biographies into one document.

If students have further questions about the curriculum, courses, how to develop a course plan that meets their needs in optics or want to talk about the field of optics in general, they can contact anyone of the following faculty for more information:

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Optics and Photonics Courses
(Updated 7-18-2016)

Electrical and Computer Engineering		
Course Number	**Course Title**	**Term(s) Offered**
525.413	Fourier Techniques in Optics	Fall
525.425	Laser Fundamentals	Fall
525.436	Optics and Photonics Laboratory	Fall
525.491	Fundamentals of Photonics	Fall
525.753	Laser Systems and Applications	Spring (odd years)
525.756	Optical Propagation, Sensing and Photonics	Spring (even years)
525.772	Fiber-Optic Communications	Spring
525.796	Intro. To High-Speed Optoelectronics	Summer
525.797	Advanced Fiber Optic Laboratory	Summer

Applied Physics		
Course Number	**Course Title**	**Term(s) Offered**
615.471	Principles of Optics	Spring, Summer (odd years)
615.751	Modern Optics	Spring (even years)
615.758	Modern Topics in Applied Optics	Fall (even years)
615.778	Computer Optical Design	Fall (odd years)
615.780	Optical Detectors and Applications	Spring (even years)
615.781	Quantum Information Processing	Fall (odd years)
615.782	Optics and Matlab	Spring

Applied Biomedical Engineering		
Course Number	**Course Title**	**Term(s) Offered**
585.634	Biophotonics	Spring

Planned Schedule of Optics and Photonics Course Offerings
(Updated 7-18-2016)

Year	Spring	Summer	Fall
2016	**Principles of Optics** Optics and Matlab Modern Optics Optical Propagation Fiber-Optic Communication Systems Biophotonics	Advanced Fiber Optics Lab Intro. To High Speed Photonics	**Fourier Techniques in Optics** **Laser Fundamentals** **Fundamentals of Photonics** Optics & Photonics Lab Quantum Information Processing
2017	**Principles of Optics** Optics and Matlab Laser Systems and Applications Fiber-Optic Communication Systems Optical Detectors and Applications	**Principles of Optics** Advanced Fiber Optics Lab Intro. To High Speed Photonics	**Fourier Techniques in Optics** **Laser Fundamentals** **Fundamentals of Photonics** Optics and Photonics Lab Modern Topics in Applied Optics

	Biophotonics		Computer Optical Design
2018	**Principles of Optics** Optics and Matlab Modern Optics Optical Propagation Fiber-Optic Communication Systems Biophotonics	Advanced Fiber Optics Lab Intro. To High Speed Photonics	**Fourier Techniques in Optics** **Laser Fundamentals** **Fundamentals of Photonics** Optics and Photonics Lab Quantum Information Processing
2019	**Principles of Optics** Optics and Matlab Laser Systems and Applications Fiber-Optic Communication Systems Optical Detectors and Applications Biophotonics	**Principles of Optics** Advanced Fiber Optics Lab Intro. To High Speed Photonics	**Fourier Techniques in Optic** **Fundamentals of Photonics** **Laser Fundamentals** Optics and Photonics Lab Modern Topics in Applied Optics Computer Optical Design
2020	**Principles of Optics** Optics and Matlab Modern Optics Optical Propagation Fiber-Optic Communication Systems Biophotonics	Advanced Fiber Optics Lab Intro. To High Speed Photonics	**Fourier Techniques in Optics** **Laser Fundamentals** **Fundamentals of Photonics** Optics & Photonics Lab Quantum Information Processing

Basic courses used as prerequisites are in bold.

Photonics Option

Part-time students in ECE or Applied Physics who take a certain number of optics courses will be recognized by having 'photonics option' printed on their diploma. For ECE students the photonics option comprises a required core of three courses (525.413, 525.425 and 525.491), combined with three additional optics courses selected from the list on the previous page. Applied Physics students specializing in optics must complete three required courses (615.441, 615.442 and 615.454) plus five or more optics courses from the list on the previous page. Students can take up to two courses from the day school curriculum in this program as well. This creates a diverse set of courses available to students with a wide range of interests. In fact the combination of full-time and part-time courses in optics offers to students one of the most comprehensive programs in optics in the Baltimore/Washington D.C. area.

Course Requirements

A total of 10 one-term courses must be completed for the MS degree.

Applied Physics students specializing in photonics must complete four required courses:

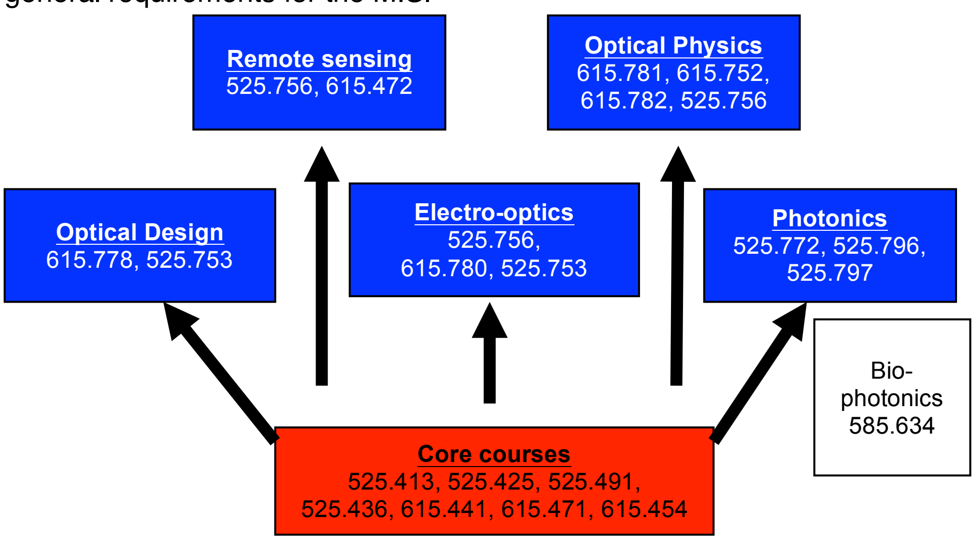
615.441 Mathematical Methods for Physics and Engineering
615.471 Principles of Optics
615.454 Quantum Mechanics
plus one course from the ECE required list

The six additional courses must include five or more from the list on the first page.

Electrical and Computer Engineering students specializing in photonics must complete the following four required courses:

525.413 Fourier Techniques in Optics
525.425 Laser Fundamentals
525.491 Fundamentals of Photonics
plus one course from the Applied Physics required list

Three additional courses must be selected from the list on the first page. The three additional courses needed to complete the degree may be any courses approved by the adviser, selected so as to fulfill the general requirements for the M.S.



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Fourier Techniques in Optics 525.413

Course Description

Optics is presented from the perspective of linear systems theory. This viewpoint arose from the cross-fertilization that began in the 1930's between traditional optics and the more modern Fourier techniques. Use is made of the mathematical tools traditionally available to the electrical engineer: Fourier analysis and linear systems theory. Topics include scalar diffraction theory, Fourier transforming and imaging properties of lenses, spatial frequency analysis of optical systems, spatial filtering and information processing, and holography. Applications of these concepts include non-destructive evaluation of materials and structures, remote sensing, and medical imaging.

Prerequisite: Background in Fourier analysis and linear systems theory.

Fall Semester..Young

Course Objectives and Synopsis

The goal of this course is to acquaint the electrical engineer with the modern spatial frequency theory of optic systems. The course will deal with the generalization of concepts and mathematical tools already at the student's disposal and will introduce him/her to a variety of optical processing and measurement techniques.

Why "Fourier" Optics?; the propagation of light, plane waves, eigenfunctions, analytic signals, various Fourier transforms, properties of the Fourier transform.

Analysis of two-dimensional linear systems, two-dimensional sampling, Green's functions.

Scalar diffraction theory, the Huygens-Fresnel diffraction principle, generalization to non-monochromatic sources, Fresnel and Fraunhofer approximations, Rayleigh ranges, the concept of a plane wave spectrum, apertures as band-limiting functions

Fresnel wavefront division, zone plates, self-imaging objects.

Imaging and transforming properties of thin lenses, Fourier analysis of optical systems, temporal and spatial coherence, coherent and incoherent systems, aberrations.

Three-dimensional imaging (confocal microscopy), tomographic concepts, imaging system performance evaluation (measurement of optical transfer and point-spread functions).

Spatial filtering, optical signal processing, frequency domain synthesis, Vander Lugt filters, spatial light modulators, synthetic aperture radar.

Laser speckle, speckle correlation techniques in non-destructive evaluation, interferometric speckle techniques, electronic speckle pattern interferometry (ESPI).

Principles of wavefront reconstruction (holography), types of holograms (based on geometrical configuration), holography based on film and solid state detectors, computer-generated holograms, optical and numerical reconstruction techniques, holographic concepts in non-destructive test and evaluation.

Laser Fundamentals 525.425

Course Description

This course reviews electromagnetic theory and introduces the interaction of light and matter with an emphasis on laser theory. A fundamental background is established, necessary for advanced courses in optical engineering as well. Topics include: Maxwell's equations, total power law, introduction to spectroscopy, classical oscillator model, Kramers-Krönig relations, line broadening mechanisms, rate equations, laser pumping and population inversion, laser amplification, laser resonator design and Gaussian beam propagation.

Prerequisite: An undergraduate course in electromagnetic theory.

Fall Semester..Thomas, Willitsford

Course Objectives and Synopsis

The goal of this course is to provide a basic background concerning the interaction of light and matter in general and laser phenomena in particular. The following topics are covered in whole or part:

Introduction to laser properties (spectral and spatial coherence, and brightness), laser cavities, laser media, light-matter interactions with gain and loss. Review of laser systems.

Maxwell's equations, classical oscillator model, complex index of refraction, dipole radiation.

Classical theory of absorption and classical oscillator model, Sellmeier formula for gases and solids, total power law, line strength and line shape functions, halfwidths, and absorption coefficient.

Introduction to spectroscopy of gases, liquids, and solids with emphasis on laser materials (e.g., CO_2, CO, HF, Ne, Ar, dyes, Nd:YAG, Ti:Al_2O_3, semiconductors, etc.).

Introduction to quantum mechanics, time dependent solutions, and the density matrix.

Fundamentals of laser amplification population inversion, saturation and rate equations

Laser oscillation, gain, threshold and hole burning. Laser system performance and examples, oscillator conditions and output power, gain saturation, optimal operation, and laser amplitude fluctuations.

The ray matrix formulation of paraxial geometrical optics (ABCD matrix formulation), resonator stability, Gaussian beams, paraxial diffraction theory, transverse resonator modes for stable and unstable resonators.

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Optics and Photonics Laboratory 525.436

Course Description
The objective of this course is to develop laboratory skills in applied optics and photonics by performing detailed experimental measurements and comparing these measurements to theoretical models. Error analysis is used throughout to emphasize measurement accuracy. A partial list of topics include: geometric optics, optical properties of materials, diffraction, interference, polarization, non-linear optics, fiber optics, non-linear fiber optics, optical detectors (pin, APD, PMT), optical sources (lasers, blackbodies, LED's), phase and amplitude modulators, lidar, fiber-optic communications, IR radiometry. The specific experiments will depend on hardware availability and student interest.

Prerequisite: 525.491 Fundamentals of Photonics or 615.751 Modern Optics or equivalent

Fall Semester...Sova, Terry

Course Objectives and Synopsis
The goal of this course is to expose students to essential optical measurement techniques to develop useful skills and enhance and complement their theoretical understanding of optics. This is achieved by performing experiments in fundamental optical measurements and modern optical systems. Typically six to eight optical experiments are performed during the semester. Examples of the breath of experiments that can be performed are given below

Geometric Optics and Polarization
Characterize the optical properties of lenses and lens systems. Topics include thin lenses, thick lenses, telescope, and aberrations. Verify the Fresnel equations and calculate the index of refraction of a material using the Brewster angle.

Radiometry and Detector Characterization
Perform radiometric measurements with the following sources: Lambertian blackbody, visible point source, and collimated laser. Perform a variety of tests to characterize the properties of infrared detector and visible detector. Detector parameters include: responsivity, noise (D* and NEP), linearity, spatial uniformity, bandwidth, etc.

Infrared Spectroscopy
Measure absorption properties of atmospheric gases and infrared dielectric materials. Compare experimental results to theoretical models in computer codes (LOWTRAN and OPTIMATR).

Interferometry
Perform measurements using the Michelson, Twyman-Green, and Fabry-Perot interferometers. Measure the index of refraction of atmospheric gases using the Michelson interferometer. Measure the temporal coherence of various sources including: blackbody, tungsten lamp, laser diode, and HeNe laser. Perform a Young's double slit experiment.

Diffraction and Fourier Optics
Measure Fraunhofer and Fresnel Diffraction for a variety of apertures. Setup Fourier optics experiment to perform spatial filtering. Measure resolving power, MTF and OTF of an optical system. Perform a Schlieren experiment to observe small deviations in the index of refraction. Utilize computer programs for verification of results.

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Fiber Optics
Characterize key properties of optical fibers that include dispersion, bandwidth, numerical aperture, loss, non-linearity and gain. Perform system measurements of fiber optic communication systems using both single mode and multi-mode fibers using both laser and LED sources.

Laser systems
detailed measurements of fiber lasers to characterize their optical, spectral, dynamic and noise properties. Understand the essential laser properties such as efficiency, threshold current, relaxation oscillation, longitudinal modes, threshold current, dynamical instabilities, etc.

Laser Remote Sensing
Perform measurements coherent and incoherent lidar systems that include time-of-flight measurements, Doppler and velocity measurements and aerosol backscatter measurements. Understand the difference between direct detection, heterodyne detection and photon counting systems.

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Fundamentals of Photonics 525.491

Course Description
This course provides the essential background in photonics necessary to understand modern photonic and fiber-optic systems. A fundamental background is established, necessary for advanced studies as well. Topics include: Electromagnetic optics, polarization and crystal optics, guided-wave optics, fiber optics, photons in semiconductors, semiconductor photon sources and detectors, nonlinear optics, electro-optics and acousto-optics.

Prerequisite: An undergraduate course in electromagnetic theory.

Fall Semester .... Sova

Course Objectives and Synopsis
To provide a basic background concerning the generation, modulation, transmission and detection of light using photonic and fiber optic devices. The following topics are covered in whole or part:

Review aspects of electromagnetic theory that are important to optics including properties elementary electromagnetic waves and properties of dielectric media.

Development of mathematical framework for propagation of polarized light in a variety of optical media (anisotropic media, media with optical activity and liquid crystals) and polarization devices (polarizers, wave retarders and polarization rotators)

Propagation of light in planar dielectric waveguides, single-mode fibers and multimode fibers. Understand basic concepts of optical modes, group velocity, dispersion, attenuation and pulse propagation.

Basic properties of semiconductors and fundamental understanding of the interaction of photons with the mobile charge carriers (electrons and holes).

Properties of light-emitting diodes, semiconductor amplifiers and lasers. Characterization of device properties including gain, pumping, efficiency, power, spectral properties and spatial distributions

Properties of semiconductor photodetectors including p-n, p-I-n, and APD detectors. Characterization of gain, responsivity, noise and signal-to-noise ratio

Study of nonlinear optical media that includes second-order and third-order nonlinear optics. Topics include second harmonic generation, electro-optic effect, three-wave mixing, self-phase modulation, four-wave mixing, optical phase conjuagation, frequency conversion and parametric amplification and oscillation and solitons

Fundamentals and applications of electro-optics including Pockels effect, Kerr effect, electro-optic modulators, spatial light modulators, wave retarders and directional couplers.

Fundamentals and applications of acousto-optics including Bragg diffraction, modulators, scanners, filters and frequency shifters and isolators.

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Laser Systems and Applications 525.753

Course Description

This course completes a comprehensive treatment of the generation of laser light, its properties, system design and applications. Topics include the description of pulsed lasers including Q-switching and mode locking, nonlinear optics (e.g., SHG), various laser systems (solid state lasers and gas lasers), resonator design, coherence, holography, interferometry, and other applications.

Prerequisite: Laser Fundamentals

Spring Semester (odd years) .... Thomas, A. Brown, D. Brown

Objective

To introduce the student to pulsed lasers, laser design, specific laser systems, the general properties of laser light and applications.

Course Outline

1 Multimode and Transient Oscillation. Pulsed laser operation is discussed including Q-switching, mode locking, and ultrashort pulses.

2–3 Introduction to Nonlinear Optics. Second harmonic generation and optical parametric oscillation. Nonlinear materials.

4–6 Specific Lasers and Pumping Mechanisms. Solid-state rare-earth ion lasers, dye lasers, gas lasers, excimer lasers, metal vapor lasers are presented. Pumping mechanism include optical, electron impact, gas-dynamic, chemical and electrical. Laser design problem.

7 Midterm. Special topic

8 Laser resonator design, Gaussian beams, modes of laser resonators, unstable resonators, beam quality and the M parameter.

9 Paraxial diffraction theory—Fresnel and Fraunhofer approximation, Fresnel number, Rayleigh number, numerical calculation techniques.

10 Concepts in spatial and temporal coherence, coherence of thermal and laser sources, the photon degeneracy parameter, and detection of light.

11 Manipulation of laser beams—focusing, collimation, wavefront assessment.

12–13 Measurement of position and deformation—interferometric and non-interferometric techniques, holography and speckle techniques.

14 Measurement of angular and linear velocity—the laser gyroscope, laser Doppler velocimetry. Final.

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Optical Propagation, Sensing and Photonics 525.756

Course Description

This course presents a unified perspective on optical propagation in linear media. A basic background is established using electromagnetic theory, spectroscopy and quantum theory. Properties of the optical field, optical properties of gases, liquids and solids, and their interaction are developed. Basic formulas on absorption line-strength and shape and Rayleigh scattering are developed and applied to atmospheric transmission, sea water propagation, optical windows, optical fibers, photonic materials and remote sensing. A survey of experimental techniques and hardware is presented. Computer codes are discussed and demonstrated.

Prerequisites: Undergraduate course on electromagnetic theory and elementary quantum mechanics. Laser Fundamentals, Fourier Techniques in Optics or equivalent preferred.

Spring Semester (even years) .... Thomas

Course Objectives and Synopsis

This course is intended to provide an in-depth understanding of optical propagation phenomena and to apply basic concepts to practical propagation media. The following topics are covered in whole or part:

Review of electromagnetic theory emphasizing the complex index of refraction, the Kramers-Krönig relation and the total power law. Review of quantum concepts necessary for the development of the microscopic properties of matter and the electromagnetic field.

Introductory development of the microscopic properties of light and matter. Topics include the rotational, vibrational, and electronic structure of gases, and the phonon and electronic band structure of solids.

The interaction between the electromagnetic field and matter. The Einstein relation and formulas on transition line-strength and line-shape. Maxwell-Boltzmann statistics and detailed balance. Rayleigh scattering.

Experimental apparatus and techniques. Transmission and reflection measurements with spectrometers and lasers, and scattering measurements.

Optical propagation in the atmosphere. Molecular absorption by H_2O, CO_2, etc., atmospheric refraction, molecular and particulate scattering, and continuum absorption. Using the formulas for line-strength and line-shape, models of molecular absorption by the atmosphere of the earth are obtained. Results are applied to remote sensing, computational spectra and lidar, and other topics of concern. AFGL codes LOWTRAN and FASCODE.

Optical properties of window materials. Using the background established in the first half of the course, models describing one-phonon and multiphonon processes, free-carrier effects, the electronic band edge, and Rayleigh scattering are developed. These models are applied to a variety of materials such as oxides, fluorides, sulfides, alkali-halides, semiconductors, and metals. Representation in terms of the complex index of refraction. Applications to laser windows and fiber optics. APL computer code OPTIMATR™.

Remote sensing, including the Boltzmann thermometer, pyrometers and Lidar.

Optional topics include: propagation in sea water, high power laser propagation, fiber optics.

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Fiber Optic Communication Systems 525.772

Course Description

This course investigates basic aspects of modern fiber-optic communication systems. Topics include sources and receivers, optical fibers and their propagation characteristics, optical amplifiers and optical fiber systems. The principles of operation and properties of optoelectronic components, as well as signal guiding characteristics of glass fibers are discussed. System design issues include terrestrial point-to-point optical links and wavelength division multiplexing (WDM) fiber-optic networks.

Prerequisite: 525.491 Fundamentals of Photonics

Spring Semester .... Sova

Course Objectives and Synopsis

The focus of this course is on the application of fiber optics to modern fiber optic communication systems. A series of 12 to 13 lectures will cover the major topics such as light wave fundamentals, guided wave optics, transmitter and receiver design, lightwave system design issues, optical amplifiers and wavelength division multiplexing (WDM) and soliton systems. The following topics are covered in whole or part:

Optical fibers. Propagation of light waves, optical mode configuration, losses, and dispersion are discussed. Optical pulse propagation in single mode fiber is studied in detail with a strong emphasis on the impact of fiber dispersion, non-linearity and loss. Also included are the design of specialty fibers with dispersion-flattened, dispersion-shifted, polarization-preserving features.

Basics of fiber optic interconnects, light emitting diodes, lasers, photodetectors, efficient modulation and demodulation methods, and high-speed transceiver design. The impact of transmitter and receiver characteristics on system performance is evaluated.

Design of fiber optic links. Both short and long haul systems are analyzed. Systems design issues that are addressed include: loss-limited and dispersion limited systems, power budget, risetime budget and sources of power penalty.

Optical amplifiers play a key role in modern fiber optic systems. Basic concepts are studied with examples of common amplifier types that include semiconductor amplifier, Raman amplifier and Erbium-doped fiber amplifier. System applications are demonstrated.

As data rates of fiber optical systems go beyond a few Gbits/sec, dispersion management is essential for the design of long-haul systems. The following dispersion management schemes are discussed: precompensation, post-compensation, dispersion compensating fiber, optical filters and fiber bragg gratings.

The following multi-channel systems and advanced system concepts are evaluated: WDM systems, TDM systems, analog fiber data links and soliton systems. Topics of current interest are also introduced, such as: integrated optics, free space/intersatellite lasercom system, and new developments in fiber optics.

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Introduction to High-Speed Optoelectronics 525.796

Course Description

This course provides the student with the fundamentals concepts needed to address issues in both the design and test of high speed electronic and optical systems. Topics include: electronic devices and circuits used at microwave and millimeter frequencies, optical active devices and waveguide technology, electronic and optical pulse generation techniques, high speed packaging design and testing techniques.

Prerequisite: A course in photonics or equivalent (e.g. EE 525.491.31, Fundamentals of Photonics).

Summer Semester .... Sova

Course Objectives and Synopsis

To provide an introduction to the relevant topics in the development of high speed optoelectronic systems. The following topics are covered in whole or part:

Solid state active devices. A general development of the basic physics, equivalent circuit models and applications for devices used in high speed electronics, including diodes, MESFETs, HEMTs and HBTs.

Transmission Line Theory. General concepts of impedance and reflection/transmission coefficients. A mathematical description of the standard transmission lines used in microwave integrated circuits, namely microstrip, stripline and coplanar waveguide.

Microwave Circuits. Description of MESFET amplifier design including reactive matching, stability conditions and gain-bandwidth limitations. S-parameter network synthesis and analysis will be introduced. MESFET oscillator design will also be discussed along with techniques for achieving frequency stabilization.

High Speed Electronic Packaging. Issues involved in the integration of multiple circuits into a system will be discussed, including power distribution and the use of decoupling capacitors. Frequency limitations for passive components. Board level amplifier instabilities. EMI shielding techniques for sensitive components.

Measurement Techniques. Discuss the use of network analyzers and calibration techniques in high frequency measurements. Summarize the different calibration algorithms, including SOLT, TRL and LRM. Introduce the use of time domain reflectometry (TDR) and its use in the analysis and design of high speed signal paths. Outline probing techniques.

Optical Active Devices. Develop an understanding of the operation and design of high-speed opto-electronic devices including lasers, LEDs, photodetectors, and modulators. Evaluate high-speed operation based on physical device limitations. Understand device designs for high speed operation including traveling waveguide approach, impedance matching of optical and electrical waves, high speed driving circuits, linear, high-speed analog detector structures, direct modulation of laser diodes and high-speed amplitude and phase modulators

Short Pulse Generation Compare methods for the generation of ultra-short pulses that include optical and electrical techniques. Optical techniques include mode-locked lasers, soliton lasers, passive mode-locking using Kerr-Lens modulation and pulse compression techniques. Evaluate the generation of ultra-short electrical pulses using microwave radiation bursts, swept-beam generation and shock wave generators

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Advanced Fiber-Optic Laboratory 525.797

Course Description

The purpose of this laboratory course is to expose students to state-of-the-art applications of fiber optic technologies that include continuous-wave and pulsed fiber lasers, high-speed digital fiber optic communication systems, microwave photonic links, and non-linear fiber optic signal processing and sensors. The first part of the course will focus on a thorough characterization of fiber laser systems starting with the erbium-doped fiber amplifier and implementing different laser configurations that include multi-mode cw operation, Q-switching and relaxation oscillations, non-linear based mode-locking and single longitudinal mode operation. All of the measurements will be compared to theoretical models. This will provide students with hands-on experience to concepts that are applicable to all laser systems. In the latter part of the course, students will select a few topics that demonstrate both modern fiber optic systems based on cw lasers, external electro-optic modulators and high-speed photodetectors and applications of nonlinear fiber optics using self-phase modulation, stimulated Brillouin scattering, stimulate Raman scattering and four wave mixing. These topics highlight the breath of applications of modern fiber optic systems. Again, all of the experiments will be compared to theoretical models.

Prerequisites: 525.491 Fundamentals of Photonics or 615.751 Modern Optics or equivalent.

Summer Semester .... Sova

Course Objectives and Synopsis

The overall objective of this course is to provide students with hands-on experience in performing measurement, modeling and analysis of modern fiber optic technologies and systems. At the end of this course, students will thoroughly understand basic principles of fiber lasers, gain practical experience with characterizing a fiber optic link using a high-speed external modulator, and gain practical experience with performing a useful function using non-linear fiber optics.

Course Topics

1. Fiber Amplifier
   a. Erbium-doped fiber properties: absorption, fluorescence and fluorescence lifetime
   b. Erbium-doped amplifier properties: Gain, noise figure, dynamic response
2. Fiber Lasers
   a. Passive fiber resonators: Cavity Q, FSR, photon lifetime
   b. Erbium doped fiber lasers
      i. cw operation: Multi-mode operation, single-longitudinal mode operation, wavelength stabilization
      ii. Pulsed operation: relaxation oscillations, Q-switching, mode-locking
3. Fiber Optic Links
   a. 10 Gbps WDM Digital Fiber Optic Link (10 to 200 km link distance)
   b. 10 GHz Microwave Photonic Link (10 to 200 km link distance)
4. Applications of Non-linear Fiber Optics
   a. High-resolution optical spectrometer based on Stimulated Brillouin Scattering
   b. Soliton pulse train generation based on Self-Phase Modulation
   c. Wavelength conversion based on Four-Wave Mixing
   d. Broad-band optical amplification based on Stimulated Raman Scattering

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Principles of Optics 615.471

Course Description

This course teaches the student the fundamental principles of geometrical optics and radiometry. It begins with a review of basic imaging to prepare the student for the more advanced concepts. The nature of light and radiation is discussed and used to motivate the two major emphasis of this course: Geometrical Optics and Radiometry. Radiometry is covered in detail with derivations from first principles. Theory of blackbody radiation is presented. Geometrical Optics is motivated from Maxwell's Equations. Exact ray tracing is developed with motivated the topic of image aberrations. The causes and techniques for the correction of aberrations are studied. Thin and thick lens analysis is discussed. Basic optical systems illustrating fundamentals of design principles are reinforced through discussion of optical instruments such as telescopes, microscopes, etc. The human eye, functioning as an imaging, system is discussed. The intent of this course is to give the student foundation for upper level applied physic courses in optics.

Prerequisite: Undergraduate electromagnetic theory and Mathematics through calculus.

Spring and Summer Semesters (even years)..Edwards, Ohl

Course Objectives and Synopsis

1. Radiometry I
   Purpose and Scope, Relationship to Electromagnetic Field Quantities, Radiometric quantities and units, Photometry, Solid Angles and Projected Solid Angles, Throughput and Geometrical Radiometric Transfer, Rays, apertures, stops and pupils
2. Radiometry II
   Examples of throughput in optical systems, Photometry and photon radiometry, Lambert's Law, Irradiance vs. Radiance, Propagation of Radiation, Flux Transfer Equations, throughput and Configuration Calculation, Example Problems
3. Radiometry III
   Blackbody radiation, Lambertian and istropic sources, BRDF, Optical Properties of Materials, Color Theory and Color Temperature, Radiometers, spectroradiometers, and photometers, Radiometric calibration, Applications and Examples of Radiometry Calculation
4. Radiometry IV
   Human Eye, Photometry, Lumens, Review of Radiometry,
5. Review of Elementary Optics
   Light, Laws of Geometrical Optics, Mirrors and Lenses (Ray Sketching), Mirrors and Lenses (Calculations), Simple Optical Instruments, Polarization, Interference and Diffraction
6. Midterm
7. Thin Lens Ray Tracing
   Tracing Rays through a Series of Lenses, Y-U Trace, Stops Pupils and Windows, Evalution of Systems Using the Y-U Trace, Effective Focal Length, Cylindrical Lense,
8. Mirrors and Prisms
   Mirror Images, Plane Mirrors, Prisms
9. Paraxial Ray Tracing
10. Exact Ray Tracing
11. Special Topics
    Instruments, Telescopes/Microcsopes. Spectrometers, Design Process.
12. Final Exam

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Modern Optics 615.751

Course Description

This course covers the fundamental principles of modern physical optics and contemporary optical systems. Topics include propagation of light, polarization, coherence, interference, diffraction, Fourier optics, absorption, scattering, dispersion, and image quality analysis. Special emphasis is placed on the instrumentation and experimental techniques used in optical studies

Prerequisite: 615.442 Electromagnetics or the equivalent completed or taken concurrently

Spring Semester (odd years)..Boone

Course Objectives and Synopsis

Modern Topics in Applied Optics 615.758

Course Description

This course deals with optical system design involving state of the art concepts. In particular, we will analyze the impact of nonlinearity in the propagation of laser beams and also the stochastic nature of light propagation in some commonly encountered situations such as atmospheric and under-sea light propagation.

Nonlinear interactions of light and matter play a significant role in a large portion of modern optical systems. In most situations, the optical system designer needs to eliminate or reduce nonlinearities and operate in a so-called linear regime. In other situations, the optical system takes advantage of the nonlinear interaction to produce significantly new operating conditions which are a significant key to the performance of modern optical systems.

Similarly, taking into account the stochastic nature of light emission, detection and propagation is important in the design and analyses of modern optical systems. The course reviews random processes involved in optical systems and applies statistical tools to identify the impact of such processes to the optical system performance.

The lecturer will base this course in more than 20 years of experience dealing with such phenomena and how they are impacting modern optical systems.

Prerequisite: 615.442 Electromagnetics and 615.782 Optics and MATLAB. A knowledge of laser fundamentals is helpful.

Fall Semester.. Torruellas

Course Objectives and Synopsis

The goal of this course is to acquaint the engineer and applied physicist with modern optical systems showing nonlinear and stochastic behavior. We will approach this course from a very practical perspective and will review a series of commercial and military systems where nonlinear optical performance or statistical analysis or understanding of the statistical nature of the processes involved is required. After a review of the fundamentals based on phenomenology, each example will be followed with a numerical simulation of the performance of the optical system. The student will be tested in three different ways: (Homework, 48 hour take home exam resulting in a short proposed solution of a problem of current interest and a final short paper on a chosen modern topic in applied optics involving a numerical analysis).

Syllabus

Stochastic nature of Light Emission:

- Review of random Processes
- Review of Coherence: temporal and spatial
- Impact of spatial coherence to imaging systems
- Impact of spatial coherence to optical power delivery

Stochastic processes in Light detection:

- Sources of Noise in detection
- Applications to Direct, Coherent and photon-counting detection

Propagation in random media:

- Atmospheric turbulence
- Under-Sea light propagation

Nonlinear processes in isotropic media:

- Introduction to nonlinear processes
- Nonlinear impairments in modern optical communications
- Raman amplification: distributed amplifiers achieving ultra-long transmission
- Stimulated Brillouin Scattering in High-Power optical fibers
- Thermal Blooming in directed High-Energy-Lasers
- Thermal-lensing and self focusing in High power solid state lasers
- Self-Mode-Locking or the 2006 Nobel price

Nonlinear processes in non-isotropic media:

- Introduction to harmonic and parametric processes in crystals
- Harmonic generation in the blue and UV spectral range
- Parametric oscillation: the eye-safe range finder and mid-IR counter-measures

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Computer Optical Design 615.778

Course Description

In this course students learn to use optical ray-trace analysis to design and analyze optical systems. Students use a full-function optical ray-trace program on personal computers to analyze designs beginning with simple lenses for familiarization with the software, to more complicated wide-angle and zoom lenses, and finally to three-dimensional systems such as spectrographs. Emphasis is placed on understanding the optical concepts involved in the designs while developing the ability to use the software. Upon completion of the course students are capable of independently pursuing their own optical designs. Assignments require the use of a PC with Windows and 12 MB of hard disk space.

Prerequisite: 615.777 Applied Optics or equivalent

Fall Semester (odd years) ....Howard

Course Objectives and Synopsis

The goal of this course is for the student to understand all the features of a full-function ray-trace program and to relate them to the design concepts and information presented in the prerequisite optics course (615.777 or equivalent). At the end of the course the student will be able to enter an optical system into the program, evaluate its characteristics and aberrations, and make changes to the design to improve its performance. The following topics are covered in whole or part:

The first half of the course will consist of lectures and ray-trace program demonstrations at the computer. The lectures will cover use of a ray-trace program and a discussion of the output emphasizing its importance in optical design. The second half of the course will consist of individual design projects. This will allow each student to pursue a design study on items of particular interest. The course will proceed as follows:

(1) Approximately two classes will be used to describe the capabilities of the ray-trace program.

(2) Students will be guided through some simple optical designs to familiarize them with the program output and to teach some of the principles of optical design.

(3) Students will work semi-independently on the design of increasingly complicated optical systems.

(4) Students will evaluate systems of their own choosing or on others selected by the instructor.

In the last third of the course students will work on individual projects and classes will be for discussion of common problems and review of student progress. At the end of the course each student will be expected to present his/her results to the rest of the class. There is no fixed format for this part of the course since it will have flexibility to meet the needs and interests of the students.

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Optical Detectors and Applications 615.780

Course Description

This course will examine the physics of detection of incoherent electromagnetic radiation from the infrared to the soft X-ray regions. Brief descriptions of the fundamental mechanisms of device operation will be given. Typical source characteristics will be mentioned to clarify detection requirements. Descriptions of non-spatially resolving detectors based on photoemission and photoexcitation will follow. This will include background physics, noise, and sensitivity. Practical devices and practical operational constraints will then be described. Description of scanning formats will lead into the description of spatially resolving systems (e.g., staring arrays). Main emphasis will be on charge coupled devices, and photoemissive multiplier tubes such as the image intensifier. Selection of optimum detectors and integration into complete system designs will be discussed. Applications in space based and terrestrial remote sensing will be discussed.

Prerequisite: 615.471 Principles of Optics desired; undergraduate level studies in solid-state physics and mathematics—preferably statistics—necessary.

Spring Semester (odd years) .... Koerner

Course Objectives and Synopsis

This course is intended to give the student sufficient knowledge and understanding to select and use suitable devices for a given application, and to understand the system consequences of continuing device developments. The following topics are covered in whole or part:

Physical Basis of Detection: electromagnetic spectrum. Wave-particle duality and photon energies. Scaling spectrum in energy units. Blackbody radiation and photon fluxes. Photoelectric effect, work function, quantum efficiency. Photoconduction versus thermal sensing. Secondary emission of electrons. Measuring flux versus detecting individual photons.

Semiconductor Materials as Detectors: Silicon. Li/Ge for X rays. Noise limits and relation to photon counting. InSb, PtSi and HgCdTe as IR detectors. Background and detector noise limits. Detectivity (D*) and ΔT as figures of merit. Need for cooling.

Photomultipliers: Electron optics, secondary multiplication, photocathodes, thermal emission, tube structures, channel electron multipliers and microchannel plates. Photomultipliers (PMTS) as flux sensing and photon counting sensors. Background sources and limits to sensitivity Dynamic range.

Scanning: Using detector (or light source) in a sequential manner to build up a picture. Raster scans. Display systems and visual perception. Sensitivity of point by point systems.

Image Plane Parameters: Resolution, point spread and line spread function, MTF, field curvature and distortion. Photographic film (briefly). Sampling theory as applied to step scan systems and limitations of frequency domain analogy.

Semiconductor Array Detectors: Photodiode array, spatial sampling, sensitivity improvement over single detector. CID and CCD. Charge transfer efficiency, noise, blooming, readout and preamps, correlated double sampling, dual slope integration, resolution, and array size. Sprite detector.

Image Intensifiers and MCP PMTS: Proximity and true focus imaging tubes. MCP's, cathode lifetime. Phosphor screens, direct readout tubes, wedge, strip, resistive, and multiple anodes, coded structures.

Sensing and decoding electronics. Image intensifier/CCD combination. Performance comparison with direct readout tubes.

TV Camera Tubes: Brief description of electron beam readout, Orthicon, Vidicon, and SIT.

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Quantum Information Processing 615.781

Course Description

This course provides an introduction to the rapidly developing field of quantum information processing. In addition to studying fundamental concepts such as two-state systems, measurement uncertainty, quantum entanglement, and non-locality, emphasis will be placed on specific quantum information protocols. Several applications of this technology will be explored, including: cryptography, teleportation, dense coding, computing, and error correction. The quantum mechanics of polarized light will be used to provide a physical context to the discussion and will be supplemented with computer exercises. Current research on implementations of these ideas will also be discussed.

Prerequisites: 615.454 Quantum Mechanics; familiarity with MATLAB, Mathematica, Python, or equivalent helpful.

Fall Semester (even years).. Clader, Jacobs

Course Objectives and Synopsis

The goals of this course are to provide a basic understanding of the nature of quantum information, why it is a powerful resource, and to provide realistic examples of how it can be used.

The course begins with a review of the fundamental postulates of quantum mechanics, state space representations, Dirac notation, the properties of Hermitian operators, the superposition principle, matrix mechanics, and introduces the notion of quantum bits (qubits) of information.

The quantum mechanics of polarized light is studied to provide a physical model of a single qubit. A correspondence between the abstract properties of qubits and the physically realizable manipulations and measurements on single photon polarization states is developed.

The important and well-developed application of quantum cryptography is presented and several optical implementations are analyzed in detail. These quantum communications systems demonstrate the utility of even single qubit operations. The nomenclature of quantum computing is introduced by presenting quantum cryptography as a multi-qubit quantum circuit.

The unique features of multi-qubit systems are presented by examining the quantum properties of photon pairs created through spontaneous parametric down conversion, including: entanglement, non-locality, and Bell's inequalities. The density matrix formulism is introduced to describe local measurement results and optical implementations of quantum teleportation and dense coding are analyzed.

The power of quantum computing is explored by examining and simulating several quantum algorithms, including: Grover's search algorithm, the quantum FFT, and Shor's factoring algorithm. The prospects for implementing quantum error correction techniques on non-ideal hardware will also be addressed.

The field of linear-optics quantum computing will be introduced and physical implementations of several fundamental gates will be discussed, including: the parity check, quantum encoder, and the destructive controlled not.

Optional topics (time permitting): Quantum non-demolition measurements, quantum repeaters and relays for quantum communications, and quantum clock synchronization.

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Optics and Matlab 615.782

Course Description

The objective of this class is to provide hands-on experience with Matlab to the student by performing weekly “labs” as assigned home-work. Each lab will explore a new topic in the optics field, while simultaneously providing the student with experience in Matlab. This course is intended to bridge that gap between the theoretical concepts and real-world applications. No prior experience with Matlab is required. While a background in optics is helpful, it is not required for successfully completing this class.

This course is intended to complement more in-depth and rigorous courses by applying some of the concepts to computer models, much like a conventional lab complements a course by allowing hands-on experience in the lab. The student already familiar with Optics will reinforce his or her understanding, while someone who is new to the field will have a basic and simple introduction that can be elaborated upon in future courses.

The intent is to provide a weekly lecture on the concept we will be exploring in that week’s lab. The students will then be presented with a written lab and Matlab codes which are useful for the assigned homework. Students will be responsible for creating their own Matlab solutions. Grades will be based on successfully completing the projects, a semester project and a final, which will be based on the concepts presented in the lectures.

Prerequisites: None

Spring Semester .... Torruellas

Course Outline

Week 1: Introduction to Matlab. Provides background into Matlab and m-file programming. Explores Matlab’s visualization capabilities, built-in libraries, creating your own functions, GUI, etc.

Week 2: 1D Fourier Transform in Optics. Discusses how Fourier theory is implemented on the computer via the FFT. This first part will be restricted to 1-D. We will consider the case of pulse propagation in optical fibers and how 1D-FFTs are useful to understand the propagation of high data rate optical data in the presence of dispersion in optical fibers.

Week 3: 2D Fourier Transform: Propagation. Under simplifying conditions the wave-equation governing electromagnetic propagation can be solved with 2D Fourier transforms, providing a tool for the description of optical patterns forming during the propagation in simple optical materials and the atmosphere.

Week 4: Geometrical Optics. Too often, simple lens design becomes a chore because lens design packages are not designed for the casual user, but rather the experienced, full-time lens designer. A simple Matlab lens design package will be used to design basic systems. The student will develop his or her own ray-tracing code, exploring simple systems and aberrations.

Week 5: Gaussian Beam Optics. Students will study and model the propagation of Gaussian beams, in free-space and through an optical system. The ideas presented will extend to a discussion and some modeling of lasers and laser cavities. Students will gain an understanding of how different laser modes arise.

Week 6: Guided Waves. Due to the advent of fiber optics communications many modern optical components involve guided waves. This lecture will explore techniques for defining the mode structure of a fiber and also a generalized optical waveguide.

Week 7: Interferometry and Diffraction. Interferences and diffraction will be discussed and implemented in Matlab. This section will consider how light interacts coherently with itself. We will consider and model several different interferometers. A simplified fringe analysis program in Matlab will be developed by the students.

Week 8: 2D Fourier Transform: Optical Processing. We will explore how image filtering is performed and show how an optical processor can be modeled on the computer. We will explore different kinds of filters and examine their results. In that sense, this falls under the category of pre-detection processing. We will also consider post-detection processing. Once an image is obtained how can we manipulate it to obtain the information we want.

Week 9: Radiometry and Detection. Students will study the basics of radiometry and model the detection of optical radiation. The students will develop a simplified means of examining the propagation and detection of light and energy in an optical system.

Week 10: Statistics and Probability Theory. The students will explore various topics from statistics and probability theory as applied to Optics. This is useful for any real-world data analysis.

Week 11: Polarization. Students will study how polarization can be modeled throughout an optical system and implement a polarization analysis for several simple systems

Week 12: Speckle and Atmospheric turbulence. Students will explore the phenomenon of speckle and study how one can model the propagation of light through the atmosphere or turbulent medium. We will also consider speckle interferometry and its applications.

Week 13: Student Presentations of Final Projects. Students are to find a current paper from any Optics journal and re-examine the stated results. The paper does not have to be a rigorous mathematical paper, but it should have enough modeling to make the assignment challenging and more importantly, interesting to the student. The level of work should be equivalent to a weekly lab.

Week 14: In-class final exam. The final will be based on the lectures and labs, and drawn from the concepts presented. It is not intended to be difficult. It will focus on the main topics and ideas brought up in each lab. Students will need only review their notes for each lab. No computer-related questions will be asked.

Biophotonics 585.634

Course Description

This course introduces the fundamental principles of bio-photonics and their applications to real-world devices. In a combination of laboratory and classroom exercises, student will design optical systems for evaluation of optical properties of biological media as well as learn computational methods to simulate light transport in such media. Modern optical measurement techniques including near infrared spectroscopy, fluorescence spectroscopy, optical coherence tomography, photo-acoustics and confocal microscopy will be covered in detail.

Prerequisites: Undergraduate engineering or biology degree

Spring Semester .... Sova

Objective

This course introduces the fundamental principles of bio-photonics and their applications to real-world devices. In a combination of laboratory and classroom exercises, students will design optical systems for evaluation of optical properties of biological media as well as learn compuational methods to simulate lihgt transport in such media. Modern optical measurement techniques including fluorescence spectroscopy, optical coherence tomography and confocal microscopy will be covered in detail.

Following the completion of this course, students will have a basic understanding of the different optical signatures found in biological systems and the various methods and instruments used to measure them. This will enable the student to evaluate modern bio-photonic instrumentation and understand the most recent literature in the field of bio-photonics.

Course Outline

- Review of optics: geometric optics, wave optics, radiometry and fiber optics
- Optical instrumentation: microscope, grating spectrometer
- Optical properties of tissue—absorption and scattering
- Monte Carlo simulation
- Laboratory 1: Beer's law, optical phase function, spectroscopy
- Diffusion approximation
- Applications of diffusion
- Fluorescence spectroscopy
- Optical coherence tomography
- Laboratory 2—Fluorescence and optical coherence tomography
- Confocal microscopy
- Fiber optic sensors
- Laboratory 3—Confocal microscopy and fiber optic sensors

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EP Faculty in Optics

The sketches include brief professional history, educational credentials, and areas of technical interest and expertise. This information may be helpful to the student who wishes to take a Special Projects course (525.801/802) in optical engineering in an area of specialty of one of the instructors.

Dr. Bradley G. Boone

Dr. Andrea M. Brown

Dr. David M. Brown

Dr. David Clader

Dr. Hugo Darlington

Dr. Clint Edwards

Dr. Joseph Howard

Dr. Bryan C. Jacobs

Dr. Raymond Ohl, IV

Dr. Raymond M. Sova

Mr. David H. Terry

Dr. Michael E. Thomas

Dr. William E. Torruellas

Dr. Adam H. Willitsford

Dr. David Young

Biographies for Faculty in Optics

Dr. Bradley G. Boone

Dr. Bradley G. Boone is a physicist and member of the Principal Professional Staff at the Applied Physics Laboratory. Dr. Boone holds a B.S. (1972) in Physics from Washington and Lee University and a Ph.D. (1977) in Physics form the University of Virginia. He was a Senior Physicist in the Control Technology Group from 1977-82. He then became section supervisor of the Image and Signal Processing Section of the Electro-Optical Systems Group in 1983 and group supervisor of the same group in 1996. Prior to coming to the Applied Physics Laboratory he was Solid State Physics Analyst at the U.S. Army Foreign Science and Technology Center (1977). He was Lecturer in Physics at the University of Virginia (1977) and Adjunct Instructor of Mathematics at Howard Community College (1981–82). He has been an instructor in Electrical Engineering in the G.W.C. Whiting School of Engineering Continuing Professional Programs since 1983 and has served as student advisor and program committee member, specializing in optical engineering. He was William S. Parsons visiting professor in the Electrical and Computer Engineering Department for the 1990–1991 academic year. He is a member of SPIE and Sigma Xi.

Dr. Boone's research interests include pattern recognition, image and signal processing, electro-optical systems analysis, optical signal processing, and superconducting sensors. He has published a textbook on optical signal processing.

He has taught Digital Signal Processing and Optical Signal Processing.

Dr. Bryan C. Jacobs

Dr. Bryan Jacobs is a senior staff engineer/physicist in the physics and modeling research group at the Applied Physics Laboratory. Dr. Jacobs joined APL in 1989 after receiving a B.S. in electrical engineering from Drexel University. He received an M.S. in applied physics from the Johns Hopkins University in 1994, and a Ph.D. in physics from the University of Maryland Baltimore County in 2003. In 2001, he became a part-time faculty member of the G. W. C. Whiting School of Engineering. Dr. Jacobs specializes in quantum optics and physics-based modeling. He has been involved in the development of several operational systems for quantum cryptography and is currently performing basic research in quantum computing. He is a member of OSA and APS. His e-mail address is byran.jacobs@jhuapl.edu.

Dr. Raymond M. Sova

Dr. Raymond Sova is a member of the Principal Professional Staff in the electro-optics group at the Applied Physics Laboratory where he has been since 1986. He is also an assistant research professor in the Department of Electrical and Computer Engineering. He has received a B.S.E.E. from the Pennsylvania State University, an M.S. in applied physics and a Ph.D. in photonics from the Johns Hopkins University. With over 25 years of experience, he has numerous patents and papers related to the development of high-speed photonic and fiber optic devices and systems that are applied to communications, remote sensing and RF-photonics. He has led a number of research and development projects in the areas of high-speed fiber optic communications, microwave-photonics, fiber lasers and laser remote sensing. Dr. Sova's current research interests are in the areas of high-speed photonics, non-linear optics, fiber-optic systems and integrated optics. He is a member of OSA and IEEE. In 1994, he became a part-time faculty member of the G.W.C. Whiting School of Engineering. He currently teaches courses in Photonics and Fiber-Optic Communication Systems. His e-mail address is Raymond.Sova@jhuapl.edu.

Dr. Michael E. Thomas

Dr. Michael E. Thomas is currently a principal staff engineer at the Applied Physics Laboratory, and a Research Professor in the Department of Electrical and Computer Engineering, Johns Hopkins University. Dr. Thomas holds a B.E.E. degree (magna cum laude, 1973) in electrical engineering from the University of Dayton, and a M.S.E.E. (1976) and Ph.D. (1979) in electrical engineering from The Ohio State University. He has been at APL since 1979, and is currently in the EO/IR Systems and Technologies Group at APL. In 1982, he was postdoctoral fellow in the Department of Physics, Naval Postgraduate School. In 1988, he became a part-time faculty member and in 1998 he became a Research Professor within the G. W. C. Whiting School of Engineering at Johns Hopkins.

Dr. Thomas is a specialist in electromagnetic theory and propagation, and quantum electronics with research interests in measurement and theoretical modeling of atmospheric propagation and remote sensing, optical properties of solids and high pressure gases. He has over 190 journal type publications in these areas. Dr. Thomas is a Fellow of the Optical Society of America, a senior member of IEEE and also holds membership in SPIE, Sigma Xi and Tau Beta Pi.

Dr. Thomas is currently teaching courses on Intermediate Electromagnetics, Optical Propagation, Sensing and Photonics, Laser Fundamentals, and Laser Systems and Applications. His e-mail address is michael.e.thomas@jhuapl.edu.

Dr. William E. Torruellas

Dr. William E. Torruellas is a member of APL's Professional Staff in the Electro-Optical Systems Group of the Air Missiles Defense Department. He received an Electrical and Applied Physics Engineering degree from the Institut National Polytechnique de Grenoble in 1985 and a Ph.D. in Optical Sciences in 1991 from the University of Arizona. Over the last 20 years he has been involved in near-IR and mid-IR generation and detection. Starting with his Ph.D. dissertation where he developed a versatile near-IR spectroscopic source and at Raytheon where he was involved in the early development of mid-IR countermeasures he has worked in active near and mid-IR laser systems. Many of these systems involve nonlinear optical concepts. He was an assistant professor in physics at Washington-State-University where he received the NSF-CAREER award in 1998 to develop near-field nonlinear optical probes of surface electric fields. He moved back to industry in 2000 to help develop ultra-long distance terrestrial fiber communication networks and high peak-power fiber laser sources for terrestrial and space Lidar&Ladar applications. His current research interests involve development and assessing technologies for maturing High-Energy-Lasers for defense application. He teaches a short course in high-power fiber lasers for SPIE. His e-mail address is william.torruellas@jhuapl.edu.

Dr. David Young

Dr. Young currently teaches Fourier Optics. His e-mail address is david.young@jhuapl.edu.