Courses on optomechanics and optical manufacturing, optical design and systems engineering, deep learning, advanced metrology, remote sensing, detectors and imaging, and more.
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37 SPIE COURSES AND WORKSHOPS

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Optomechanics and optical manufacturing
Optical design and systems engineering
Advanced metrology
Detectors and imaging
Deep learning
LiDAR
Remote sensing
Nanoscience
Optics educators

spie.org/education

Information for Course attendees:
www.spie.org/education/course-attendees

NEW AND FEATURED COURSES
- Introduction to Fundamental Performance Limits of CCD and CMOS Imagers (James Janesick)
- Optical Measurement of Surface Topography (Peter de Groot)
- Photodetectors – A Practical Selection Guide (Slawomir Piatek)
- Mirror System Design with Freeform surfaces (José Sasián)

MONEY-BACK GUARANTEE
We are confident that once you experience an SPIE course for yourself you will look to us for your future education needs. However, if for any reason you are dissatisfied, we will gladly refund your money. We just ask that you tell us what you did not like; suggestions for improvement are always welcome.

CONTINUING EDUCATION UNITS
SPIE has been approved as an accredited provider of CEUs by IACET, The International Association for Continuing Education and Training (Provider #1002091). In obtaining this approval, SPIE has demonstrated that it complies with the ANSI/IACET Standards which are widely recognized as standards of good practice.
SPIE reserves the right to cancel a course due to insufficient advance registration.

Course prices increase by US$75 after 26 July 2019
ADVANCED METROLOGY

Sun SC213 Introduction to Interferometric Optical Testing (Wyant) 8:30 am to 12:30 pm, $365 / $425, p. 25
Sun SC1271 Optical Measurement of Surface Topography (de Groot) 8:30 am to 12:30 pm, $330 / $390, p. 26
Sun SC1164 Wavefront Data Analysis (Mahajan) 1:30 pm to 5:30 pm, $405 / $465, p. 25

DETECTORS AND IMAGING

Sun SC1222 Deep Learning and Its Applications in Image Processing (Nasrabadi) 8:30 am to 5:30 pm, $580 / $695, p. 24
Mon SC1274 Introduction to Fundamental Performance Limits of CCD and CMOS Imagers (Janesick) 1:30 pm to 5:30 pm, $470 / $530, p. 25

INDUSTRY AND EXHIBITORS

Mon SC1170 The Very Least You Need To Know About Optics (Diehl) 1:30 pm to 3:30 pm, $125 / $150, p. 30

NANOSCIENCE

Sun SC1043 Shaping Light, with Applications in Advanced Microscopy and Optical Trapping (Dholakia, Spalding) 1:30 pm to 5:30 pm, $330 / $390, p. 9
Mon SC1273 Introduction to Magnetic Random Access Memory (MRAM) : Fundamentals, Current Status, and Emerging Device concepts (Khalili) 8:30 am to 12:30 pm, $330 / $390, p. 9

OPTICAL DESIGN AND SYSTEMS ENGINEERING

Sun SC1271 Optical Measurement of Surface Topography (de Groot) 8:30 am to 12:30 pm, $330 / $390, p. 19
Sun SC690 Optical System Design: Layout Principles and Practice (Greivenkamp) 8:30 am to 5:30 pm, $615 / $730, p. 14
Sun SC1277 Photodetectors – A Practical Selection Guide (Platek) 8:30 am to 12:30 pm, $330 / $390, p. 20
Sun SC1121 Recent Developments in Laser Beam Engineering (Soskind) 8:30 am to 12:30 pm, $365 / $425, p. 17
Sun SC1272 Mirror System Design with Freeform Surfaces (Sasián) 1:30 pm to 5:30 pm, $330 / $390, p. 19
Mon SC254 Integrated Opto-Mechanical Analysis (Genberg, Doyle) 8:30 am to 5:30 pm, $650 / $765, p. 14
Mon SC912 Intermediate Lens Design (Bentley) 8:30 am to 5:30 pm, $615 / $730, p. 16
Mon SC915 Radiometry Revealed (Shaw) 8:30 am to 12:30 pm, $330 / $390, p. 16
Mon SC700 Understanding Scratch and Dig Specifications (Aikens) 8:30 am to 12:30 pm, $330 / $390, p. 15
Mon SC1017 Optics Surface Inspection Workshop (Aikens) 1:30 pm to 5:30 pm, $430 / $490, p. 16
Tue SC1247 Polarized Light and Optical Design (Chipman, Young) 8:30 am to 5:30 pm, $580 / $695, p. 18
Tue SC003 Practical Optical System Design (Youngworth, Olson) 8:30 am to 5:30 pm, $580 / $695, p. 13
Tue SC1199 Stray Light Analysis and Control (Fest) 8:30 am to 5:30 pm, $625 / $740, p. 18
Wed SC1165 Introduction to Applied Probability for Systems Engineers (Arenberg) 8:30 am to 12:30 pm, $330 / $390, p. 17
Wed SC863 Introduction to Modern Optical Drawings – the ISO 10110 Standard (Aikens) 1:30 pm to 5:30 pm, $330 / $390, p. 15
OPTICAL SYSTEMS AND LENS DESIGN
Mon SC912 Intermediate Lens Design (Bentley) 8:30 am to 5:30 pm, $615 / $730, p. 26
Wed SC1086 Optical Materials, Fabrication and Testing for the Optical Engineer (DeGroote Nelson) 8:30 am to 12:30 pm, $330 / $390, p. 27

OPTICS + PHOTONICS FOR SUSTAINABLE ENERGY
Mon SC915 Radiometry Revealed (Shaw) 8:30 am to 12:30 pm, $330 / $390, p. 20

OPTOMECHANICS AND OPTICAL MANUFACTURING
Sun SC213 Introduction to Interferometric Optical Testing (Wyant) 8:30 am to 12:30 pm, $365 / $425, p. 11
Sun-Mon SC014 Introduction to Optomechanical Design (Vukobratovich) 8:30 am to 5:30 pm, $1,105 / $1,370, p. 10
Mon SC1169 Optical Manufacturing Fundamentals (Williamson) 8:30 am to 5:30 pm, $610 / $725, p. 12
Tue SC015 Fastening Optical Elements with Adhesives (Daly) 8:30 am to 12:30 pm, $330 / $390, p. 10
Tue SC010 Introduction to Optical Alignment Techniques (Castle) 8:30 am to 5:30 pm, $580 / $695, p. 10
Tue SC1019 Mounting of Optical Components (Kasunic) 8:30 am to 5:30 pm, $660 / $775, p. 12
Wed SC1086 Optical Materials, Fabrication and Testing for the Optical Engineer (DeGroote Nelson) 8:30 am to 12:30 pm, $330 / $390, p. 12
Thu SC1085 Optomechanical Systems Engineering (Kasunic) 8:30 am to 5:30 pm, $580 / $695, p. 11

PROFESSIONAL DEVELOPMENT
Sat WS1249 Student Chapter Leadership Workshop (Doumont) 8:00 am to 5:00 pm, $50 / $50, p. 31

REMOTE SENSING
Sun SC1220 Imaging Spectrometry (Hagen) 1:30 pm to 5:30 pm, $330 / $390, p. 22
Mon SC915 Radiometry Revealed (Shaw) 8:30 am to 12:30 pm, $330 / $390, p. 21
Mon SC567 Introduction to Optical Remote Sensing Systems (Shaw) 1:30 pm to 5:30 pm, $330 / $390, p. 21
Tue SC1232 Introduction to LIDAR for Autonomous Vehicles (Shaw) 1:30 pm to 5:30 pm, $330 / $390, p. 22

SIGNAL, IMAGE, AND DATA PROCESSING
Sun SC157 MTF in Optical and Electro-Optical Systems (Boreman) 8:30 am to 5:30 pm, $625 / $740, p. 24

X-RAY, GAMMA-RAY, AND PARTICLE TECHNOLOGIES
Sun SC1277 Photodetectors – A Practical Selection Guide (Platek) 8:30 am to 12:30 pm, $330 / $390, p. 20

WORKSHOPS FOR OPTICS EDUCATORS
Tue WS1141 Problem-Based Learning: Engaging Students in STEM (Donnelly) 10:00 am to 12:00 pm, $15 / $20, p. 27
Tue WS1156 Dumpster Optics: Teaching Optics with Junk (Magnani, Viera-González) 1:30 pm to 3:30 pm, $15 / $20, p. 28
Wed WS1248 Training the Trainer in OPTIKS: Outreach for Professionals Who Teach in Informal Environments and K-12 Schools (McKee, Magnani) 8:30 am to 12:30 pm, $15 / $20, p. 30
Wed WS1201 I SEE THE LIGHT! Demonstrations and Activities for Outreach Events (McKee) 3:30 pm to 5:30 pm, $15 / $20, p. 28
## COURSE SCHEDULE

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| **Industry and Exhibitors** | | | | |
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<p>| <strong>Nanoscience</strong> | | | | |
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- SATURDAY - Professional Development

WS1249 Student Chapter Leadership Workshop (Doumont) 8:00 am to 5:00 pm, $50 / $50, p. 31
COURSES

NANOSCIENCE

Shaping Light, with Applications in Advanced Microscopy and Optical Trapping

SC1043
Course Level: Introductory
CEU: 0.4 $330 Members | $186 Student Members
$390 Non-Members USD
Sunday 1:30 pm to 5:30 pm

Wavefront correction and generation are important topics in many areas. This introductory course will cover: the basic Gaussian beam, the need for other beams such as: Hermite-Gaussian and Laguerre-Gaussian laser modes, Bessel beams, Airy beams, and other notable beams and how they may be generated. In addition, we will cover some approaches used for adaptive optics / wavefront correction. We will consider uses of Deformable Mirror Arrays, Spatial Light Modulators, Acousto-Optic Deflectors, etc. Applications include sub-diffraction imaging / super-resolution microscopy, OCT, optical trapping, multi-photon microscopy at enhanced depth, and optimal excitation of plasmonic structures.

LEARNING OUTCOMES
• assess a variety of approaches to beam shaping and wavefront correction
• explain simple alignment protocols for optimizing some optical beam types of broad interest
• describe various aspects of data analysis for some wavefront correction algorithms
• identify key options for enhanced degrees of beam control, resolution, and sensitivity

INTENDED AUDIENCE
This material is appropriate to researchers who are considering work in a wide variety of areas where wavefront correction or generation of novel beams is of interest.

INSTRUCTOR
Kishan Dholakia is the 2016 winner of the OSA Woods Prize, and a Professor of Physics at the University of St. Andrews (Scotland) and co-Chair of the Conference on Optical Trapping and Optical Micromanipulation. He is a Fellow of the Royal Society of Edinburgh, of OSA, and of SPIE.

Gabriel Spalding is a Professor of Physics at Illinois Wesleyan and co-Chair of the Conference on Optical Trapping and Optical Micromanipulation.

Introduction to Magnetic Random Access Memory (MRAM): Fundamentals, Current Status, and Emerging Device Concepts

SC1273
Course Level: Introductory
CEU: 0.4 $330 Members | $186 Student Members
$390 Non-Members USD
Monday 8:30 am to 12:30 pm

This course introduces the students to one of the key emerging memory technologies in the semiconductor industry: Magnetic random access memory (MRAM). We review the changing paradigm of computing in the era of artificial intelligence, and the resulting need for new high-performance and high-density embedded memory technologies. We present the basics of MRAM, from device concepts to circuits, and the current implementation status of spin-transfer torque memory (STT-MRAM) across the industry. We then discuss scalability, density and performance challenges of STT-MRAM, and review emerging device concepts that attempt to overcome these. Among these, we will discuss voltage-controlled and spin-orbit torque MRAMs, and their key device and material considerations.

LEARNING OUTCOMES
This course will enable you to:
• describe the fundamental operation principles, device, and circuit architectures of MRAM
• explain the spin-transfer torque (STT) write mechanism widely adopted in today’s MRAM
• identify the key performance metrics, challenges and tradeoffs of STT-MRAM
• compare different types of emerging (beyond-STT) MRAM technology concepts

INTENDED AUDIENCE
Scientists, engineers, or managers who wish to learn more about the fundamentals of MRAM, its current status in the industry, and its outlook and potential future technology generations. Undergraduate training in engineering or science is assumed.

INSTRUCTOR
Pedram Khalili (PhD 2008, Delft University of Technology) is Associate Professor of Electrical and Computer Engineering at Northwestern University, and director of the Physical Electronics Research Laboratory (PERL). Prior to joining Northwestern, he was an Adjunct Assistant Professor in the department of Electrical and Computer Engineering at the University of California, Los Angeles (UCLA), where he was co-leader of the memory program within the NSF TANMS engineering research center. In 2012 he co-founded Inston Inc., a startup company where he served as board member and chief technology officer until 2017. He and his team placed top-6 out of 3,000 entries worldwide in the Cisco Innovation Grand Challenge in 2015. Pedram has published 100+ papers in peer reviewed journals and holds 15 issued US patents. He is on the editorial board of Journal of Physics: Photonics, and is a Senior Member of the IEEE.
COURSES

OPTOMECHANICS AND OPTICAL MANUFACTURING

Introduction to Optical Alignment Techniques

SC010
Course Level: Introductory
CEU: 0.7 $580 Members | $308 Student Members
$695 Non-Members USD
Tuesday 8:30 am to 5:30 pm
This course discusses the equipment, techniques, tricks, and skills necessary to align optical systems and devices. You learn to identify errors in an optical system, and how to align lens systems.

LEARNING OUTCOMES
This course will enable you to:
• determine if errors in the optical system are due to misalignment errors or other factors such as fabrication, design, or mounting problems
• recognize and understand the fundamental imaging errors associated with optical systems
• diagnose (qualitatively and quantitively) what is wrong with an optical system by simply observing these fundamental imaging errors
• use the variety of tools available for aligning optical systems, and more importantly, how to "tweak" logically the adjustments on these devices so that the alignment proceeds quickly and efficiently
• align basic lens systems and telescopes
• align more complex optical systems such as those containing off-axis aspheric surfaces, and maintain alignment using automatic mounting techniques

INTENDED AUDIENCE
This course is directed toward engineers and technicians needing basic practical information and techniques to achieve alignment of simple optical systems, as well as seemingly more complicated off-axis aspheric mirrors. To benefit most from this course you will need a basic knowledge of the elementary properties of lenses and optical systems (i.e. focal lengths, f-numbers, magnification, and other imaging properties) and a working knowledge of simple interferometry. Some familiarity with the basic aberrations such as spherical aberration, coma, and astigmatism will be helpful.

INSTRUCTOR
Kenneth Castle  PhD is president of Ruda-Cardinal, Inc., an optical engineering consulting firm located in Tucson, Arizona. Ken has worked with Mitch Ruda, the originator of this course, for 28 years. Mitch passed away August 31, 2013, and Ruda-Cardinal is continuing the tradition of working with the mechanical features of optical systems. The emphasis is on providing techniques for rapid estimation of optical system performance. Subject matter includes material properties for optomechanical design, kinematic design, athermalization techniques, window design, lens and mirror mounting.

Fastening Optical Elements with Adhesives

SC015
Course Level: Intermediate
CEU: 0.4 $330 Members | $186 Student Members
$390 Non-Members USD
Tuesday 8:30 am to 12:30 pm
Optomechanical systems require secure mounting of optical elements. Adhesives are commonly used, but rarely addressed in the literature. This course has compiled an overview of these adhesives, their properties, and how to test them. How to use them is addressed in detail with guidelines and examples provided. A summary of common adhesives is presented with justification for their use. Consideration and analysis of adhesive strength, reliability, and stability are included. Different design approaches to optimize the application are presented and discussed. Many examples are described as well as lessons learned from past experience. Discussions are encouraged to address current problems of course attendees.

LEARNING OUTCOMES
This course will enable you to:
• describe and classify adhesives and how they work (epoxy, urethane, silicone, acrylic, RTV, VU-cure, etc.)
• obtain guidance in: adhesive selection, surface preparation, application, and curing
• develop a basis for analysis of stress and thermal effects
• recognize contamination/outgassing and how to avoid it
• review design options
• create and use an adhesive check list
INTENDED AUDIENCE
This course is for engineers, managers, and technicians. This course provides a foundation for the correct design for successful optical mounting; an understanding of the best options to employ for each application, and the selection and approach conducive to production. A bound course outline (that is a good reference text) is provided, including summaries of popular adhesives and their properties.

INSTRUCTOR
John Daly has 35 years of experience in lasers and optomechanics. Over this period, he has worked optical bonding problems since his thesis projects, as an employee of several major corporations, and now as a consultant. His academic background in mechanical engineering and applied physics compliments this discipline. His work experience has been diverse covering areas such as: military lasers, medical lasers, spectroscopy, point and standoff detection, and E-O systems. His roles over these years have included analysis, design, development, and production. He is an SPIE Member, with numerous publications, and is a committee member of the SPIE Optomechanical Engineering Program.

Attendee testimonial:
That was an amazing amount of material!! Possibly the most applicable & easy to apply short course I’ve ever taken.

Introduction to Interferometric Optical Testing

SC213

Course Level: Introductory
CEU: 0.4 $365 Members | $200 Student Members
$425 Non-Members USD
Sunday 8:30 am to 12:30 pm

This short course introduces the field of interferometric optical testing. Topics covered include basic interferometers for optical testing, and concepts of phase-shifting interferometry including error analysis. Long wavelength interferometry, testing of aspheric surfaces, measurement of surface microstructure, and the state-of-the-art of direct phase measurement interferometers are also discussed.

LEARNING OUTCOMES
This course will enable you to:
• explain the basic concepts of interferometric optical testing
• describe the power, capabilities, and limitations of phase-shifting interferometry
• describe techniques, advantages, and disadvantages of long-wavelength interferometry
• compare different aspheric testing techniques
• list capabilities and techniques for measuring surface microstructure
• describe the current state-of-the-art of direct phase measurement interferometers

INTENDED AUDIENCE
Engineers, scientists, and managers who need to understand the basic concepts of interferometric optical testing.

INSTRUCTOR
James Wyant is professor of optical sciences at the University of Arizona. He is currently Chairman of the Board of 4D Technology. He was a founder of the WYKO Corporation and served as its president from 1984 to 1997. Dr. Wyant was the 1986 President of SPIE.


Optomechanical Systems Engineering

SC1085

Course Level: Introductory
CEU: 0.7 $580 Members | $308 Student Members
$695 Non-Members USD
Thursday 8:30 am to 5:30 pm

This course emphasizes a systems-level overview of optomechanical engineering. Starting with the fundamentals of imaging, it reviews how optical system concepts flow down into optomechanical requirements on optical fabrication, alignment, structural design, mechanics of materials (metals, composites, and glasses), structural vibrations, thermal management, and kinematic mounts. The focus is on real-world design problems, as well as the commercial off-the-shelf (COTS) components used to solve them.

LEARNING OUTCOMES
This course will enable you to:
• utilize the basic concepts and terminology of optical engineering required for the development of optomechanical components
• read conventional and ISO-10110 drawings used for the fabrication of lenses
• develop an alignment plan with an emphasis on critical tolerances, alignment mechanisms, and "go-no go" decisions for adjusting tilt, decenter, despace, and defocus
• quantitate the ability of a structural design to maintain alignment using efficient architectures and lightweight materials; compare low-strain lens and mirror mounts for reducing wavefront error (WFE)
• utilize the results of STOP (structural-thermal-optical) analysis for the deflection and distortion of optical components under static loads; estimate the impact of stress concentrations and contact stresses; select optical materials with appropriate structural properties
• estimate the effects of vibration environments on the alignment of optomechanical systems; select COTS components for vibration isolation
• predict the effects of conductive, convective, and radiative thermal environments on the performance of optical systems; select materials and off-the-shelf hardware to manage the effects of heat loads and temperature changes
• compare kinematic and semi-kinematic mounts and the limitations of COTS hardware

INTENDED AUDIENCE
Intended for engineers (systems, optical, mechanical, and electrical), scientists, technicians, and managers who are developing, specifying, or purchasing optical, electro-optical, infrared, or laser systems.

INSTRUCTOR
Keith Kasunic has more than 30 years of experience developing optical, electro-optical, infrared, and laser systems. He holds a PhD in Optical Sciences from the University of Arizona, an MS in Mechanical Engineering from Stanford University, and a BS in Mechanical Engineering from MIT. He has worked for or been a consultant to a number of organizations, including Lockheed Martin, Ball Aerospace, Sandia National Labs, and Nortel Networks. He is currently the Technical Director of Optical Systems Group, LLC. He is also the author of three textbooks Optical Systems Engineering (McGraw-Hill, 2011), Optomechanical Systems Engineering (John Wiley, 2015), and Laser Systems Engineering (SPIE Press, 2016), an adjunct prof. at Univ. of North Carolina – Charlotte, an Affiliate Instructor with Georgia Tech’s SENSIAc, and an instructor for the Optical Engineering Certificate Program at Univ. of California – Irvine.

Attendee Testimonial:
Excellent class - instructor was able to cover basic material clearly and well for the non-expert, while also covering enough content for the more advanced student. A rare ability.
Optical Materials, Fabrication and Testing for the Optical Engineer

SC1086
Course Level: Introductory
CEU: 0.4 $330 Members | $186 Student Members
$390 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course is designed to give the optical engineer or lens designer an introduction to the technologies and techniques of optical materials, fabrication and testing. This knowledge will help the optical engineer understand how the choice of optical specifications and tolerances can either lead to more cost effective optical components, or can excessively drive the price up. Topics covered include optical materials, traditional, CNC and novel optical fabrication technologies, surface testing and fabrication tolerances.

LEARNING OUTCOMES
This course will enable you to:
- identify key mechanical, chemical and thermal properties of optical materials (glass, crystals and ceramics) and how they affect the optical system performance and cost of optical components
- describe the basic processes of optical fabrication
- define meaningful surface and dimensional tolerances
- communicate effectively with optical fabricators
- design optical components that are able to be manufactured and measured using state of the art optical fabrication technologies
- choose the optimum specifications and tolerances for your next project

INTENDED AUDIENCE
Optical engineers, lens designers, or managers who wish to learn more about how optical materials, fabrication and testing affect the optical designer. Undergraduate training in engineering or science is assumed.

INSTRUCTOR
Jessica DeGroote Nelson is the director of technology and strategy at Optimax Systems, Inc. She is an adjunct faculty member at The Institute of Optics at the University of Rochester teaching both an undergraduate and graduate course on Optical Fabrication and Testing, and has given several guest lectures on optical fabrication and metrology methods. She earned a PhD in Optics at The Institute of Optics at the University of Rochester. Dr. Nelson is a Member of both OSA and SPIE.

Mounting of Optical Components

SC1019
Course Level: Introductory
CEU: 0.7 $660 Members | $340 Student Members
$775 Non-Members USD
Tuesday 8:30 am to 5:30 pm

This course introduces the optomechanical engineering principles for the mounting of optical components such as lenses, mirrors, windows, prisms, and filters. Oriented towards practicing engineers and managers, case studies are used to show how mount design is driven by a combination of environmental, performance, and cost requirements. Standard industry practices and common mounting techniques are reviewed, including:
- Mounting of lenses into barrels using adhesives or retaining rings
- Mounting of prisms and small mirrors using adhesives or clamps
- Mounting of assemblies using flexures
- Mounting and sealing of windows

Without using finite-element analysis (FEA), first-order engineering estimates are used to predict the performance of various mount types.

LEARNING OUTCOMES
This course will enable you to:
- identify the effects of the environment on optics
- compare critical aspects of the optic-to-mount interface
- estimate alternate low-strain mounting techniques for common types of elements
- estimate survivability for vibration and thermal loading
- design mounts that balance performance, survivability, and cost
- estimate optomechanical tolerances for optical assemblies using standard designs

INTENDED AUDIENCE
Intended for engineers (mechanical, optical, electrical, and systems), scientists, technicians, and managers who are developing, specifying, or purchasing optical, electro-optical, infrared, or laser systems. The material is at an introductory level, but a basic familiarity with optomechanical engineering principles is useful.

INSTRUCTOR
Keith Kasunic has more than 30 years of experience developing optical, electro-optical, infrared, and laser systems. He holds a PhD in Optical Sciences from the University of Arizona, an MS in Mechanical Engineering from Stanford University, and a BS in Mechanical Engineering from MIT. He has worked for or been a consultant to a number of organizations, including Lockheed Martin, Ball Aerospace, Sandia National Labs, and Nortel Networks. He is currently the Technical Director of Optical Systems Group, LLC. He is also the author of three textbooks: Optomechanical Systems Engineering (McGraw-Hill, 2011), Optomechanical Systems Engineering (John Wiley, 2015), and Laser Systems Engineering (SPIE Press, 2016), an Adjunct Prof. at Univ. of North Carolina – Charlotte, an Affiliate Instructor with Georgia Tech's SENSIAc, and an Instructor for the Optical Engineering Certificate Program at Univ. of California – Irvine.


This course is also available in online format.

Optical Manufacturing Fundamentals

SC1169
Course Level: Introductory
CEU: 0.7 $610 Members | $320 Student Members
$725 Non-Members USD
Monday 8:30 am to 5:30 pm

This course provides a familiarity with precision optical manufacturing and metrology; and an introduction to the materials, machinery, tooling, methods, processes, metrology, and production flow used to fabricate precision optical elements. The optical, thermal, and working properties of common optical materials will be compared. The processes and machinery involved in shaping, finishing, measuring, cleaning, and coating optical components will be described. Strengths and limitations of technology instruments and methods will be discussed. An overview of the ISO drawing indications will be presented.

This course serves as both successor and tribute to Bob Novak's long-running SC350 Optical Manufacturing Overview course that has been a staple at the Optifab event.
COURSES

LEARNING OUTCOMES
This course will enable you to:
• describe the normal process flow in the manufacturing of spherical optical components
• explain blank preparation, curve generating, grinding, polishing, and centering processes
• classify the metrology needed for each step in the manufacturing process cycles
• compare the metrology needed for each step in the manufacturing process cycles
• judge the relative difficulty of fabricating different materials in various configurations
• relate optical performance to tolerances and tolerances to manufacturing processes
• compute optimal lot quantity breaks
• facilitate clear communication between engineers, sales, and opticians

INTENDED AUDIENCE
The course brings mutual understanding to a dual audience: Optical fabrication technicians who seek to gain greater depth and broader context for their specialties; and engineers, sales people, and buyers who require an awareness of current optical fabrication methodology as well as "lead times" associated with low volume production.

INSTRUCTOR
Ray Williamson has a 45-year career in precision optics. He holds a BS in Physics with a concentration in optics. He has been a hands-on optician on components ranging from micro to massive; a process engineer developing fabrication and testing methods, tooling, and sequences; an engineering manager responsible for staffing, documentation, methods, budgets, and customer technical contact; and a quality assurance manager creating and administering a quality and calibration system. He has provided courses to several hundred opticians. He works with ANSI/ OEOSC as an American delegate to ISO on drawing standards. His consulting work at Ray Williamson Consulting concentrates on manufacturing, and qualifying optical components, training technicians, and technical writing. He is a Fellow of SPIE, Senior Member of OSA, and the author of the Field Guide to Optical Fabrication.


OPTICAL DESIGN AND SYSTEMS ENGINEERING

Practical Optical System Design
SC003
Course Level: Intermediate
CEU: 0.7 $580 Members | $308 Student Members
$695 Non-Members USD
Tuesday 8:30 am to 5:30 pm
This course will provide attendees with a basic working knowledge of optical design and associated engineering. The information in this course will help novice and experienced designers, as well as people who interact with optical designers and engineers, sufficiently understand these problems and solutions to minimize cost and risk. The course includes background information for optical design and an array of pragmatic considerations such as optical system specification, analysis of optical systems, material selection, use of catalog systems and components, ultraviolet through infrared system considerations, environmental factors and solutions, Gaussian beam optics, and production considerations such as optical testing and alignment. The course includes practical and useful examples emphasizing rigorous optical design and engineering with an emphasis on designing for manufacture. Even if you have never used an optical design program before, you will become fluent with how to estimate, assess, execute, and manage the design of optical systems for many varied applications.
This course is a continuation of the long-running Practical Optical Systems Design course established and taught by Robert E. Fischer.

LEARNING OUTCOMES
This course will enable you to:
• develop a complete optical system design specification
• highlight fundamental physics and engineering related to optical design
• establish a general basis for modeling optical systems using computer-aided methods
• analyze and organize system considerations to incorporate such as environmental factors
• design for manufacture, alignment, and testing
• describe multiple key aspects of optical engineering for successfully transitioning from concept to production

INTENDED AUDIENCE
This course is intended for anyone who needs to learn how to engineer optical systems. It will be of value to those who either design their own optics or those who work directly or indirectly with optical designers, as you will now understand what is really going on and how to ask the right questions of your designers.

INSTRUCTOR
Richard Youngworth, PhD is founder and chief engineer of Riyo LLC, an optical design and engineering firm providing engineering and product development services. His industrial experience spans diverse topics including optical metrology, design, manufacturing, and analysis. Dr. Youngworth has spent significant time working on optical systems in the challenging transition from ideal design to successful volume manufacturing. He is widely considered an expert, due to his research, lectures, publications, and industrial work on the design, producibility, and tolerance analysis of optical components and systems. Dr. Youngworth teaches “Practical Optical System Design” and “Cost-Conscious Tolerancing of Optical Systems” for SPIE and is a Fellow of the society. He has a BS in electrical engineering from the University of Colorado at Boulder and earned his PhD in optics at the University of Rochester by researching tolerance analysis of optical systems.
S. Craig Olson, PhD is principal engineer for Imaging and Optical Systems at L3 Technologies in Santa Rosa, CA. His experience spans both commercial and government markets, with over 19 years’ experience in managing the full life cycle of a wide variety of reflective and refractive optical systems in the visible and infrared. His practical knowledge spans everything from requirements generation through design, analysis, testing, and production of optical systems with aperture sizes anywhere from 5 to 500 mm. He has a BS in Electrical Engineering from the Georgia Institute of Technology and a Master’s and PhD in Optics from the University of Rochester Institute of Optics. Dr. Olson is a Fellow of SPIE.

This course is also available in online format.

Integrated Opto-Mechanical Analysis

SC254

Course Level: Advanced
CEU: 0.7 $650 Members | $336 Student Members
$765 Non-Members USD
Monday 8:30 am to 5:30 pm

This course presents optomechanical analysis methods to optimize the performance of imaging systems subject to environmental influences. Emphasized is the application of finite element techniques to develop efficient and practical models for optical elements and support structures from early design concepts to final production models. Students will learn how to design, analyze, and predict performance of optical systems subject to the influence of gravity, pressure, stress, harmonic, random, transient, and thermal loading. The integration of optical element thermal and structural response quantities into optical design software including ZEMAX and CODEV is presented that allow optical performance metrics such as wavefront error to be computed as a function of the environment and mechanical design variables. Advanced techniques including the modeling of adaptive optics and design optimization are also discussed. Examples will be drawn from ground-based, airborne, and spaceborne optical systems.

LEARNING OUTCOMES

This course will enable you to:
• develop FEA models of optical mounts, flexures, and metering structures
• design and analyze optical bonds including structural adhesives and RTV
• effectively model lightweight mirrors
• predict line-of-sight jitter in vibration environments
• perform thermo-elastic analysis of optical systems
• predict the effects of stress birefringence on optical performance
• develop models and perform analyses to predict assembly induced errors
• integrate thermal and structural results into optical models
• predict and represent the distortion of optical surfaces using Zernike polynomials
• perform analyses to predict optical surface correctability using adaptive optics
• learn benefits of numerical optimization techniques for optical structures

INTENDED AUDIENCE

This course is intended for mechanical and optical engineers interested in learning about optomechanical analysis techniques and the use of modern software tools including finite element analysis and optical design software to design and analyze optical systems. Working knowledge or familiarity with finite element software and/or optical design software is recommended.

INSTRUCTOR

Victor Genberg has over 50 years’ experience in the application of finite element methods to high-performance optical structures and is a recognized expert in optomechanics. He is currently President of Sigmadyne, Inc. and an adjunct Professor of Mechanical Engineering at the University of Rochester where he teaches courses in optomechanics, finite element analysis, and design optimization. He has over 40 publications in this field including two chapters in the CRC Handbook of Optomechanical Engineering. Vic is coauthor of the SPIE textbook Integrated Optomechanical Analysis.

Keith Doyle has over 30 years’ experience in the field of optical engineering, specializing in optomechanics, design optimization, and the multidisciplinary modeling of optical systems. He is currently employed at MIT Lincoln Laboratory as a Group Leader in the Engineering Division. Previously he served as vice president of Sigmadyne Inc., a senior systems engineer at Optical Research Associates, and a structural engineer at Itk Optical Systems. Dr. Doyle has authored or coauthored over 40 technical papers, is co-author of the SPIE textbook Integrated Optomechanical Analysis, is a SPIE Fellow, recipient of the SPIE Technical Achievement Award (2015), and is an adjunct professor at the College of Optical Sciences, University of Arizona. He received his PhD in engineering mechanics with a minor in optical sciences from the University of Arizona in 1993.


Optical System Design: Layout Principles and Practice

SC690

Course Level: Introductory
CEU: 0.7 $615 Members | $322 Student Members
$730 Non-Members USD
Sunday 8:30 am to 5:30 pm

This course provides the background and principles necessary to understand how optical imaging systems function, allowing you to produce a system layout which will satisfy the performance requirements of your application.

This course teaches the methods and techniques of arriving at the first-order layout of an optical system by a process which determines the required components and their locations. This process will produce an image of the right size and in the right location. A special emphasis is placed on understanding the practical aspects of the design of optical systems. Optical system imagery can readily be calculated using the Gaussian cardinal points or by paraxial ray tracing. These principles are extended to the layout and analysis of multi-component systems. This course includes topics such as imaging with thin lenses and systems of thin lenses, stops and pupils, and afocal systems. The course starts by providing the necessary background and theory of first-order optical design followed by numerous examples of optical systems illustrating the design process.

LEARNING OUTCOMES

This course will enable you to:
• specify the requirements of an optical system for your application including magnification, object-to-image distance, and focal length
• diagram ray paths and do simple ray tracing
• describe the performance limits imposed on optical systems by diffraction and the human eye
• predict the imaging characteristics of multi-component systems
• determine the required element diameters
• apply the layout principles to a variety of optical instruments including telescopes, microscopes, magnifiers, field and relay lenses, zoom lenses, and afocal systems
• adapt a known configuration to suit your application
• grasp the process of the design and layout of an optical system
COURSES

INTENDED AUDIENCE
This course is intended for engineers, scientists, managers, technicians and students who need to use or design optical systems and want to understand the principles of image formation by optical systems. No previous knowledge of optics is assumed in the material development, and only basic math is used (algebra, geometry and trigonometry). By the end of the course, these techniques will allow the design and analysis of relatively sophisticated optical systems.

INSTRUCTOR
John Greivenkamp is a professor at the College of Optical Sciences of The University of Arizona where he teaches geometrical optics and optical system design to undergraduate and graduate students. John is the editor of the SPIE Field Guides and is the author of the Field Guide to Geometrical Optics (SPIE Press, 2004). John serves as the 2019 SPIE President-Elect.


SPECIAL NOTE: This course is a continuation of Warren Smith’s long-standing SPIE course SC001, Optical System Design: Layout Principles and Practice and incorporates many of the same approaches and material used for that course.

Understanding Scratch and Dig Specifications

SC700
Course Level: Introductory
CEU: 0.4 $330 Members | $186 Student Members
$390 Non-Members USD
Monday 8:30 am to 12:30 pm

Surface imperfection specifications (i.e. Scratch-Dig) are among the most misunderstood, misinterpreted, and ambiguous of all optics component specifications. This course provides attendees with an understanding of the source of ambiguity in surface imperfection specifications, and provides the context needed to properly specify surface imperfections using a variety of specification standards, and to evaluate a given optic to a particular level of surface imperfection specification. The course will focus on the differences and application of the Mil-PRF-13830, ISO 10110-7, and ANSI OP1.1002. Many practical and useful specification examples are included throughout, as well as a hands-on demonstration on visual comparison evaluation techniques.

The course is followed by SC1017 Optics Surface Inspection Workshop, which provides hands-on experience conducting inspections using the specification information provided in this course.

LEARNING OUTCOMES
This course will enable you to:
• describe the various surface imperfection specifications that exist today.
• compose a meaningful surface imperfection specification for cosmetic imperfections using ISO, ANSI, or MIL standards.
• identify the different illumination methods and comparison standards for evaluation.
• demonstrate a surface imperfection visual inspection.
• understand the options available for controlling surface imperfections in a vendor/supplier relationship.

INTENDED AUDIENCE
This material is intended for anyone who needs specify, quote, or evaluate optics for surface imperfections. Those who either design their own optics or who are responsible for optics quality control will find this course valuable.

INSTRUCTOR
David Aikens a.k.a “the scratch guy”, is among the foremost experts on surface imperfection standards and inspection. Dave is President and founder of Savvy Optics Corp., and is the head of the American delegation to ISO TC 172 SC1.

COURSE PRICE INCLUDES a copy of the latest ANSI approved surface imperfections specification standard.

Introduction to Modern Optical Drawings – the ISO 10110 Standard

SC863
Course Level: Introductory
CEU: 0.4 $330 Members | $186 Student Members
$390 Non-Members USD
Wednesday 1:30 pm to 5:30 pm

Since the late 1990’s, the optics community has gradually been converting optics drawings from a free-form, notes-based method to a standardized, international pictographic method. In 2013, the (USA) joined the international community by adopting a version of ISO 10110 as the American National Standard for optics drawings. This new method is a great boon for an industry in need of standardization, but can be very confusing to the uninitiated. In addition, the standard has continued to evolve with new revisions and additions to address the needs of more applications and markets.

This course provides attendees with an introduction to ISO 10110, the international standard for optics drawing notations. The course concentrates on the fundamentals of the drawing layout and how to read the notations required for typical optics, such as glass parameters, radius, wave-front, surface imperfections and roughness. Attendees are also informed about how the American version differs from the current international standard. Practical and useful examples are included throughout.

LEARNING OUTCOMES
• read and interpret an optical drawing prepared to ISO 10110
• identify the meaning of the symbology and specifications of ISO 10110 for materials imperfections, surface form, wedge, surface imperfections, and surface texture
• describe which symbol corresponds to each of the fundamental optical parameters
• compose and interpret an ISO 10110-compliant optical element drawing

INTENDED AUDIENCE
This material is intended for anyone who has a basic understanding of optics, and encounters or generates optical drawings in the course of their work. Those who either design their own optics, work with optical designers, work with optical suppliers, or manufacture optics will find this course valuable.

INSTRUCTOR
David Aikens is president and founder of Savvy Optics Corp., and has been involved in optics drawings and specifications for over 30 years. He is the head of the American delegation to ISO TC 172 SC1, and is the chairman of the committee to adopt ISO standards as the American National Standard for optics drawings.
COURSES

Intermediate Lens Design
SC912
Course Level: Intermediate
CEU: 0.7 $615 Members | $322 Student Members
$730 Non-Members USD
Monday 8:30 am to 12:30 pm
Have you ever wondered why refractive, reflective, and zoomed optical systems look the way that they do? This course begins with a brief review of paraxial optics, third-order aberration theory, and computer aided optimization. A survey of refractive optical design forms from the landscape lens to the double gauss lens is given. Telephoto and retrofocus lenses, Petzval and microscope objectives, and wide angle lenses are discussed. Zoom lens principles and first order layout are presented in detail with easy to understand examples. Visible band color correction techniques and UV and IR design constraints are discussed. This full day course also examines the basics of reflective optical system design including reflective design analogies, advantages and disadvantages of reflective systems, obscured vs. unobscured design forms. Reflective systems ranging from the Cassegrain to the reflective triplet to three and four mirror anastigmats are presented.

LEARNING OUTCOMES
This course will enable you to:
• determine which lens types are suitable for various applications
• create a new system design from scratch
• layout a zoom lens from first principles
• describe reflective system designs and constraints

INTENDED AUDIENCE
This course is intended for optical engineers and scientists who have some previous knowledge of geometrical optics, aberration theory, and lens design and who want to increase their optical design proficiency through a better understanding of the subject.

INSTRUCTOR
Julie Bentley is an associate professor at The Institute of Optics, University of Rochester and has been teaching two graduate level courses in optical design for more than 10 years. She received her BS, MS, and PhD in optics from the The Institute of Optics, University of Rochester. After graduating she spent two years at Hughes Aircraft Co. in California designing optical systems for the defense industry and then twelve years at Corning Tropel Corporation in Fairport, New York designing and manufacturing precision optical assemblies such as microlithographic inspection systems.

This course was designed to bring photonics personnel up to an immediate high level of proficiency.

Optics Surface Inspection Workshop
SC1017
Course Level: Introductory
CEU: 0.4 $430 Members | $226 Student Members
$490 Non-Members USD
Monday 1:30 pm to 5:30 pm
Understanding the correct way to inspect optical surfaces is one the most important skills anyone working with or around optics can have, including technicians, material handlers, engineers, managers, and buyers. While understanding the specifications is the first step, learning how to actually perform the inspection is just as important. This hands-on workshop will allow attendees to learn the “Best Practice” for cleaning and inspecting optical surfaces. The course has many demonstrations and labs and gives attendees practice handling and inspecting opticals to develop a high level of proficiency.

This course was designed to bring photonics personnel up to an immediate working knowledge on the correct methods to conduct a surface inspection in accordance with MIL, ANSI, and ISO standards. It is designed to complement SC700 Understanding Scratch and Dig Specifications and provide hands-on experience applying the specification and inspection parameters covered in that course.

Radiometry Revealed
SC915
Course Level: Introductory
CEU: 0.4 $330 Members | $186 Student Members
$390 Non-Members USD
Monday 8:30 am to 12:30 pm
This course explains basic principles and applications of radiometry and photometry. A primary goal of the course is to reveal the logic, systematic order, and methodology behind what sometimes appears to be a confusing branch of optical science and engineering. Examples are taken from the ultraviolet through the long-wave infrared portions of the electromagnetic spectrum. Anyone who wants to answer questions such as, “how many watts or photons do I have?” or “how much optical energy or radiation do I need?” will benefit from taking this course.

LEARNING OUTCOMES
This course will enable you to:
• describe the fundamental units and quantities used to quantify electromagnetic radiation at wavelengths from the ultraviolet through the visible and infrared
• use, understand, and convert between radiometric and photometric quantities
• apply radiometry to typical applications, such as calibrating an imaging system, determining human-perceived brightness of a display, or calculating electricity produced by a solar cell
• calculate areas and solid angles to determine the energy, energy density, or brightness in an optical system
• explain the role of rays, stops, and pupils in defining the field of view and light-gathering capability of an optical system
• determine the throughput of an optical system and use it in radiometric calculations
• quantify the radiant energy in optical images from point and extended sources
• transfer radiant energy into and throughout optical systems
• identify radiometric standards and calibration methods
• be familiar with radiometers and photometers

INTENDED AUDIENCE
Scientists, engineers, technicians, or technical managers who wish to learn more about how to quantify radiant energy in optical systems and measurements. Undergraduate training in engineering or science is assumed.

INSTRUCTOR
Joseph Shaw is director of the Optical Technology Center and professor of Electrical Engineering and Physics at Montana State University in Bozeman, Montana. He previously worked at the NOAA research labs in Boulder, Colorado. He is a widely recognized expert in the development, calibration, and analysis of optical systems used in environmental and military sensing. Recognition for his work in this field includes NOAA research awards, a Presidential Early Career Award for Scientists and Engineers, and the World Meteorological Organization’s Vaisala Prize. He earned a PhD in Optical Sciences at the University of Arizona and is a Fellow of both the OSA and SPIE.

This course is also available in online format.
COURSES

LEARNING OUTCOMES
This course will enable you to:
• perform a visual review of the surface
• create a surface map
• conduct a visual inspection according to MIL-PRF-13830B
• conduct a visual inspection according to ANSI OP1.002
• conduct a visual inspection according to ISO 10110-7 and ISO 14997 standards
• acquire and apply the accumulation rules
• review the tools available for microscope-based inspection to ANSI and ISO standards
• evaluate a surface and determine if a surface passes or fails

INTENDED AUDIENCE
This course is designed for all optical practitioners who need to handle and evaluate optics or optical assemblies. Other suggested attendees include mechanical engineers, purchasing agents, quality assurance personnel and other persons working with or around optical components. SC700 Understanding Scratch and Dig Specifications is a pre-requisite for the course.

INSTRUCTOR
David Aikens a.k.a "the scratch guy", is among the foremost experts on surface imperfection standards and inspection. Dave is president and founder of Savvy Optics Corp., and is the head of the American delegation to ISO TC 172 SC1.

COURSE PRICE INCLUDES a copy of the latest ANSI approved surface imperfection specification standard, if desired. Due to the hands-on nature of this course, class size is limited to 12 participants. Early registration is recommended.

Attendee testimonial:
Wonderful! I've learned many skills that I can use every day.

Recent Developments in Laser Beam Engineering
SC1121
Course Level: Introductory
CEU: 0.4 $365 Members | $200 Student Members
$425 Non-Members USD
Sunday 8:30 am to 12:30 pm
This course covers fundamental principles and recent developments in laser beam engineering, including the formation of propagation-invariant laser beams and their transformations, formation of structured illumination, beam shaping, and beam combining. The course instructor will provide a detailed description of different laser beam types, their properties and propagation characteristics, as well as beam quality criteria. This includes the criteria required for resolving ambiguities in beam quality defined based on the M2 parameter. The course will also provide a comprehensive overview of laser output power scaling techniques, including coherent and incoherent beam combining. Based on numerous examples presented by the instructor, attendees will learn about exciting applications of modern beam shaping techniques and how laser beams are employed in a variety of modern photonics instruments, including laser scanners for autonomous navigation LIDAR systems, laser projection systems for 3D metrology, wearable display and augmented reality devices, laser machining, materials processing, and micro-manipulation.

LEARNING OUTCOMES
This course will enable you to:
• describe the unique properties of laser beams, including propagation invariance and self-healing, and the differences between a variety of laser beam types
• state the terminology associated with laser beam propagation and characterization, as well as describe the propagation characteristics of simple, astigmatic, and general astigmatic beams
• compare techniques for producing structured laser fields employed in metrology, autonomous navigation, and interactive gaming applications
• summarize the benefits and limitations of beam shaping and beam combining
• describe recent developments and trends in laser beam engineering, including Optical Phased Arrays (OPAs)

INTENDED AUDIENCE
This material is intended for engineers, scientists, college students, and photonics enthusiasts who would like to expand their knowledge into the area of modern laser beam engineering and applications, better understand the unique characteristics of laser beams and their coherent combinations into OPAs, and become familiar with the state of the art in laser-based instrumentation.

INSTRUCTOR
Yakov Soskind is a renowned expert in physical optics and innovative photonics instrumentation development. For over 35 years, Dr. Soskind has made extensive contributions in the areas of laser resonators, beam shaping and control, diffractive optics and nano-photonics, optical engineering, imaging, and illumination. Dr. Soskind is the author of the Field Guide to Diffractive Optics (SPIE Press, 2011) provided as part of this course, and has been awarded more than 25 domestic and international patents in the field of photonics.


Introduction to Applied Probability for Systems Engineers
SC1165
Course Level: Introductory
CEU: 0.4 $330 Members | $186 Student Members
$390 Non-Members USD
Wednesday 8:30 am to 12:30 pm
This course explains basic principles for the use of probability analysis as applied to systems engineering and applies them to the central problem of performance budgeting. A primary goal of the course is explaining the probabilistic methodology of performance budgeting. A primary goal of the course is explaining the logic, construction and application of performance and error budgeting. This probabilistic methodology of performance budgeting should be a tool in every engineer's tool kit as it is fundamental to understanding the probability of a successful system. Examples are taken from various problems in systems engineering of astronomical and laser systems. This course will be of benefit to anyone who wants to answer the question, "what are the chances of success of my project?" and "how can I maximize the probability of success?"

LEARNING OUTCOMES
This course will enable you to:
• compose a performance or error budget
• calculate the distribution of likely outcomes of a design process
• calculate the most likely value for the performance of a component or system
• identify the sensitivity of performance to all parameters in the system
• explain the probability of the success of design project
COURSES

INTENDED AUDIENCE
Scientists, engineers, technicians, or managers who wish to learn more about how to apply probability to engineering problems. Undergraduate training in engineering or science is assumed.

INSTRUCTOR
Jonathan Arenberg has been working as an optical and systems engineer for over 35 years. His work experience includes tactical and high-power laser components and systems and major space astronomical projects such as Chandra and the James Webb Space Telescope and numerous technology efforts. He holds degrees in physics and engineering from the University of California, Los Angeles and currently the Chief Engineer for Space Science Missions at Northrop Grumman Aerospace Systems. Dr. Arenberg is the co-author of a recent SPIE Press book on systems engineering and an SPIE Fellow.

Stray Light Analysis and Control
SC1199
Course Level: Introductory
CEU: 0.7 $625 Members | $326 Student Members
$740 Non-Members USD
Tuesday 8:30 am to 5:30 pm
This course explains the basic principles of designing, building, and testing optical systems whose stray light performance is adequate for their intended purpose. It teaches methods to identify stray light problems in the design phase when they can be most easily and inexpensively fixed, and does not emphasize the use of any particular stray light analysis software, but rather the fundamental principles of radiometry and optical design necessary to use such software effectively. Application of the course material is demonstrated in class by measuring the stray light performance of a simple camera system and comparing the measurement to both first order estimates and detailed ray tracing results.

LEARNING OUTCOMES
This course will enable you to:
- explain the meaning of the phrase "Move it or block it"
- differentiate between in-field and out-of-field stray light
- differentiate between internal and external stray light
- explain the pros and cons of basic radiometric analysis vs. detailed ray tracing analysis
- quantify stray light in an optical system using standard metrics such as Point Source Transmittance and Veiling Glare
- quickly estimate the stray light performance of a simple optical system using basic radiometry
- identify problematic stray light paths in an optical system by performing a backwards ray trace in stray light analysis software
- use techniques such as ray aiming and statistical analysis to reduce the time required to complete a ray trace
- verify the result of a ray tracing analysis with basic radiometry
- list the primary mechanisms of stray light
- predict the BSDF of a contaminated optical surface from its IEST-1246C cleanliness level
- predict the BSDF of an optical surface from its surface roughness statistics
- measure the BSDF of a surface
- list popular black surface treatments (such as anodize) used to control stray light
- use anti-reflection coatings to reduce stray light due to ghost reflections
- explain the root cause of large unit-to-unit variability in stray light performance
- design an optimal set of baffle vanes
- design primary mirror baffles for Cassegrain telescopes
- design stray light control features such as field stops and relayed pupils
- measure the stray light performance of an optical system
- define meaningful stray light performance requirements
- explain the benefit of having a stray light model whose predictions have been correlated with measurements

INTENDED AUDIENCE
Designers, builders, testers, and users of optical systems who wish to learn more about the causes of stray light and the best methods to control it. Undergraduate training in engineering or science is assumed.

INSTRUCTOR
Eric Fest has been developing stray light control systems for the optics industry for 25 years, and is currently an optical scientist at Facebook Reality Labs. He is the author of numerous publications on the topic of stray light, including the SPIE Press best-selling book Stray Light Analysis and Control. He has a PhD in Optical Sciences from the University of Arizona.

COURSE PRICE INCLUDES the ebook Stray Light Analysis and Control (SPIE Press) by Eric Fest.

Polarized Light and Optical Design
SC1247
Course Level: Intermediate
CEU: 0.7 $580 Members | $308 Student Members
$695 Non-Members USD
Tuesday 8:30 am to 5:30 pm
Polarized Light and Optical Systems surveys polarization effects in optical systems and their simulation by polarization ray tracing. First polarized light is reviewed with Jones vector and Stokes parameter descriptions. Polarization elements and effects, including retardance and diattenuation, can be described by Jones matrices for coherent and ray tracing calculations, or with Mueller matrices for incoherent calculations. A framework for polarization ray tracing is presented for nearly spherical waves in optical systems to include the large set of polarization effects which occur: polarization elements, Fresnel equations, thin films, anisotropic materials, diffractive optical elements, stress birefringence, and thin films. These polarization aberrations adversely affect the point spread function/matrix and optical transfer function/matrix.

LEARNING OUTCOMES
This course will enable you to:
- explain fundamentals of polarized light and polarization elements in optical systems
- explain Jones and Mueller calculus
- describe polarized light propagating in 3D
- classify Fresnel aberrations, thin films, and polarization aberrations
- describe image formation with polarization aberrations
- identify anisotropic materials, crystal polarizers and retarders
- describe polarization of diffractive optical elements, gratings and wire grid polarizers
- distinguish stress birefringence
- identify polarization effects in liquid crystal cells
- compare the polarization ray trace and polarization aberrations of a telescope

INTENDED AUDIENCE
This is an intermediate level class is intended for educators, students, lens designers, optical engineers, scientists, and managers who need to understand and apply polarization concepts to optical systems. Prior exposure to optical design programs, polarization, and to linear algebra would be helpful.
COURSES

INSTRUCTOR
Russell Chipman is professor of Optical Sciences at the University of Arizona and a visiting professor at the Center for Optics Research and Education (CORE), Utsunomiya University, Japan. He founded Airy Optics Inc. which provides polarization analysis software. He teaches courses in polarized light, polarimetry, and polarization optical design at both universities. Prof. Chipman received his BS in Physics from MIT and MS and Ph. D. in Optical Science from the University of Arizona. He is a Fellow of OSA and SPIE. He received SPIE’s 2007 G. G. Stokes award for research in Polarimetry and OSA’s Joseph Fraunhofer Award/Robert Burley Award for Optical Engineering in 2015. He is a Co-Investigator on NASA/JPL’s Multi-Angle Imager for Aerosols, a polarimeter scheduled for launch into earth orbit around 2021 for monitoring aerosols and pollution in metropolitan areas. He is also developing UV and IR polarimeters for other NASA exoplanet and remote sensing missions. He has recently focused on developing the Polaris-M polarization ray tracing code, available from Airy Optics, which analyzes optical systems with anisotropic materials, diffractive optical elements, stress birefringence, polarized scattered light, and many other effects.

Garam Young graduated with a BS in Physics from Seoul National University in Korea and received her doctorate from University of Arizona’s College of Optical Sciences, also earning Valedictorian and Outstanding Graduate Student honors. She then developed polarization features and optimization features for CODE V and LightTools with Synopsys in Pasadena. Then she joined Apple Camera Hardware team working on various illumination projects for iPhone and iPad. She currently works as an optical and illumination engineer at Oculus, Facebook. She is a co-author of the textbook Polarized Light and Optical Systems published by CRC Press in 2018.

Optical Measurement of Surface Topography
SC1271
Course Level: Introductory
CEU: 0.4 $330 Members | $186 Student Members
$390 Non-Members USD
Sunday 8:30 am to 12:30 pm
Optical measurement plays an important role in non-contact strategies for 3D visualization and quantification of surface topography. The dominant techniques today involve imaging microscopy combined with confocal, focus-variation, quantitative phase imaging, digital holographic or interferometric principles to achieve sensitivity to height variations in the object surface. In this tutorial, we will review the fundamentals of these advanced techniques, including principles, implementation and best practice examples of applications and data interpretation. We will then move on to interference microscopy as an illustrative example of the current state of the art. Hot topics include performance enhancements, new objective designs for wide-field imaging, vibration robustness, accommodation of highly sloped surfaces, correlation to contact methods, metrology for additive manufacturing, and transparent surface films characterization. We will also consider the impact and importance of calibration, surface texture parameters, and standardization. Finally, a gallery of applications illustrates the current state of the art as well as the future potential for optical methods of surface structure analysis.

LEARNING OUTCOMES
This course will enable you to:
• describe the principles of confocal, focus-variation, digital holographic and interferometric microscopy for surface topography measurement
• identify, name and describe the optical, mechanical and electrical components of generic instrument configurations, including the types of objectives, types of light sources, scanners, filters and cameras
• summarize the most common data analysis methods, as well as the signal modeling techniques that are increasingly common in advanced processing
• explain the meaning and importance of relevant performance specifications, as well as potential sources of uncertainty and error
• explain the meaning of calibration, verification and adjustment
• provide and define the most common ISO surface texture parameters

INTENDED AUDIENCE
The intended audience includes R&D scientists, process and quality control engineers, and measurement specialists from all applications areas requiring high-precision, high-resolution surface characterization.

INSTRUCTOR
Peter de Groot is the executive director of R&D at ZYGO, where he manages innovation and new product discovery. As an innovator and educator in optical metrology, his individual contributions include 135 US patents and 160 technical papers, tutorials and book chapters. He is an Honorary Professor at the University of Nottingham, a recipient of the SPIE Rudolf Kingslake medal in optical engineering, an SPIE Fellow, and member of the Board of Directors of the SPIE.
This is a beginning to intermediate level course, with material ranging from basic to complex, to provide both an overview and reference for further study.

Mirror System Design with Freeform Surfaces
SC1272
Course Level: Intermediate
CEU: 0.4 $330 Members | $186 Student Members
$390 Non-Members USD
Sunday 1:30 pm to 5:30 pm
This course provides a primer in mirror system design using freeform surfaces. The course will be of interest to those engineers working with imaging systems which require the use of mirrors as lens systems may not be appropriate. A review of wave aberrations will be given, then a systematic methodology to design unobscured mirror systems will be presented, and a number of examples will be discussed. Ad-hoc freeform surfaces will be explained. The attendees should expect to obtain useful and practical knowledge in mirror system design. Some familiarity with optical design is required.

LEARNING OUTCOMES
This course will enable you to:
• explain imaging aberrations of unobscured mirror systems
• describe the method of confocal mirror design
• lay out a confocal mirror system
• use a freeform surface to correct for field aberrations
• design a two mirror aplanatic and unobscured system
• design a three mirror anastigmatic and unobscured system

INTENDED AUDIENCE
Scientists, engineers, technicians, or managers who wish to learn more about how to design unobscured mirror imaging systems. Some familiarity with optical design is required.

INSTRUCTOR
José Sasián is a professor of optical design at the College of Optical Sciences at the University of Arizona. He has been involved with the design, fabrication and testing of lens and mirror systems and has published several papers on the design of unobscured mirror systems. Dr. Sasián is a Fellow of the OSA and SPIE.
COURSES

X-RAY, GAMMA-RAY, AND PARTICLE TECHNOLOGIES

Photodetectors – A Practical Selection Guide

SC1277

Course Level: Introductory
CEU: 0.4 $330 Members | $186 Student Members
$390 Non-Members USD
Sunday 8:30 am to 12:30 pm

Many new and trending photonics applications (PET for medical imaging, LiDAR for autonomous vehicles, flow cytometry for medical point-of-care) require the use of photodetectors. This course discusses the selection process of an optimal photodetector from a pool of four (photomultiplier tube, photodiode, avalanche photodiode, and silicon photomultiplier) using the WITS$ methodology. The approach is based on four fundamental properties of light: wavelength (W), intensity (I), temporal behavior (T), and spatial characteristics (S). Reviewing the basic concepts of noise (e.g., shot, Johnson, multiplication, etc.) and cost ($), the course presents realistic case studies of the selection process for a wide range of experimental setups.

Anyone who wants to answer questions such as, “Should I switch from PMT to SiPM?” or “What are the advantages and weaknesses of each photodetector technology?” will benefit from taking this course.

LEARNING OUTCOMES

This course will enable you to:

• explain the fundamental and physics of operation of the four photodetectors
• explain the origin and assess the importance of noise sources (e.g., shot, Johnson, multiplication, etc.) in the photodetectors and the detection electronics
• identify the main applications of the four photodetectors
• describe the key properties of the detected light used in the WITS$ methodology
• estimate S/N for the given input light, photodetector, and readout electronics
• compare the performance of the photodetectors in terms of S/N
• incorporate detector cost in the selection process
• summarize realistic examples of the selection process for a wide range of input light characteristics

INTENDED AUDIENCE

Scientists, engineers, technicians, and graduate students who wish to learn how to select an optimal point photodetector for their optical system designs and experiments. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Sławomir Platek has been measuring proper motions of nearby galaxies using images obtained with the Hubble Space Telescope as senior university lecturer of physics at New Jersey Institute of Technology. Additionally, he has developed a photonics training program for engineers at Hamamatsu Corporation in New Jersey in the role of a science consultant. He has presented at various international conferences and webinars on important topics such as automotive LiDAR, flow cytometry, selection of photodetectors and more. He earned his PhD in Physics at Rutgers, the State University of New Jersey.

OPTICS + PHOTONICS FOR SUSTAINABLE ENERGY

Radiometry Revealed

SC915

Course Level: Introductory
CEU: 0.4 $330 Members | $186 Student Members
$390 Non-Members USD
Monday 8:30 am to 12:30 pm

This course explains basic principles and applications of radiometry and photometry. A primary goal of the course is to reveal the logic, systematic order, and methodology behind what sometimes appears to be a confusing branch of optical science and engineering. Examples are taken from the ultraviolet through the long-wave infrared portions of the electromagnetic spectrum. Anyone who wants to answer questions such as, “how many watts or photons do I have?” or “how much optical energy or radiation do I need?” will benefit from taking this course.

LEARNING OUTCOMES

This course will enable you to:

• describe the fundamental units and quantities used to quantify electromagnetic radiation at wavelengths from the ultraviolet through the visible and infrared
• use, understand, and convert between radiometric and photometric quantities
• apply radiometry to typical applications, such as calibrating an imaging system, determining human-perceived brightness of a display, or calculating electricity produced by a solar cell
• calculate areas and solid angles to determine the energy, energy density, or brightness in an optical system
• explain the role of rays, stops, and pupils in defining the field of view and light-gathering capability of an optical system
• determine the throughput of an optical system and use it in radiometric calculations
• quantify the radiant energy in optical images from point and extended sources
• transfer radiant energy into and throughout optical systems
• identify radiometric standards and calibration methods
• be familiar with radiometers and photometers

INTENDED AUDIENCE

Scientists, engineers, technicians, or technical managers who wish to learn more about how to quantify radiant energy in optical systems and measurements. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Joseph Shaw is director of the Optical Technology Center and professor of Electrical Engineering and Physics at Montana State University in Bozeman, Montana. He previously worked at the NOAA research labs in Boulder, Colorado. He is a widely recognized expert in the development, calibration, and analysis of optical systems used in environmental and military sensing. Recognition for his work in this field includes NOAA research awards, a Presidential Early Career Award for Scientists and Engineers, and the World Meteorological Organization’s Vaisala Prize. He earned a PhD in Optical Sciences at the University of Arizona and is a Fellow of both the OSA and SPIE.

This course is also available in online format.
Introduction to Optical Remote Sensing Systems

SC567

Course Level: Introductory
CEU: 0.4 $330 Members | $186 Student Members
$390 Non-Members USD
Monday 1:30 pm to 5:30 pm

This course provides a broad introduction to optical remote sensing systems, including both passive sensors (e.g., radiometers and spectral imagers) and active sensors (e.g., laser radars or LIDARs). A brief review of basic principles of radiometry and atmospheric propagation (absorption, emission, and scattering) is followed by a system-level discussion of a variety of ground-, air-, and space-based remote sensing systems. Key equations are presented for predicting the optical resolution and signal-to-noise performance of passive and active sensing systems. Sensor system examples discussed in the class include solar radiometers, passive spectrometers and hyperspectral imagers, airborne imaging spectrometers, thermal infrared imagers, polarization imagers, and active laser radars (LIDARs and LADARs). The course material is directly relevant to sensing in environmental, civilian, military, astronomical, and solar energy applications.

LEARNING OUTCOMES

This course will enable you to:

- review the principles of optical radiometry used to describe and calculate the flow of optical energy in an optical sensor system or solar energy system
- describe how the atmosphere affects the propagation of optical radiation
- explain how optical atmospheric effects influence remote sensing measurements or solar energy
- use system parameters in basic radiometric calculations to predict the signal received by passive and active sensors
- compare systems at the block-diagram level remote sensing measurements
- explain the difference between passive imaging based on reflection and emission
- acquire the operating principles of laser radar (lidar/ladar) systems for distributed and solid target sensing

INTENDED AUDIENCE

Scientists, engineers, technicians, or technical managers who find themselves working on (or curious about) optical remote sensing systems or data. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Joseph Shaw is professor of electrical engineering and physics at Montana State University and previously worked at the NOAA research labs in Boulder, Colorado. He is a recognized expert in development, calibration, and analysis of optical remote sensing systems used in environmental and military sensing. Recognition for his work in this field includes NOAA research awards, a Presidential Early Career Award for Scientists and Engineers, and the World Meteorological Organization's Vaisala Prize. He earned a PhD in Optical Sciences at the University of Arizona. Dr. Shaw is a Fellow of both the OSA and SPIE.

Radiometry Revealed

SC915

Course Level: Introductory
CEU: 0.4 $330 Members | $186 Student Members
$390 Non-Members USD
Monday 8:30 am to 12:30 pm

This course explains basic principles and applications of radiometry and photometry. A primary goal of the course is to reveal the logic, systematic order, and methodology behind what sometimes appears to be a confusing branch of optical science and engineering. Examples are taken from the ultraviolet through the long-wave infrared portions of the electromagnetic spectrum. Anyone who wants to answer questions such as, "how many watts or photons do I have?" or "how much optical energy or radiation do I need?" will benefit from taking this course.

LEARNING OUTCOMES

This course will enable you to:

- describe the fundamental units and quantities used to quantify electromagnetic radiation at wavelengths from the ultraviolet through the visible and infrared
- use, understand, and convert between radiometric and photometric quantities
- apply radiometry to typical applications, such as calibrating an imaging system, determining human-perceived brightness of a display, or calculating electricity produced by a solar cell
- calculate areas and solid angles to determine the energy, energy density, or brightness in an optical system
- explain the role of rays, stops, and pupils in defining the field of view and light-gathering capability of an optical system
- determine the throughput of an optical system and use it in radiometric calculations
- quantify the radiant energy in optical images from point and extended sources
- transfer radiant energy into and throughout optical systems
- identify radiometric standards and calibration methods
- be familiar with radiometers and photometers

INTENDED AUDIENCE

Scientists, engineers, technicians, or technical managers who wish to learn more about how to quantify radiant energy in optical systems and measurements. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Joseph Shaw is director of the Optical Technology Center and professor of Electrical Engineering and Physics at Montana State University in Bozeman, Montana. He previously worked at the NOAA research labs in Boulder, Colorado. He is a widely recognized expert in the development, calibration, and analysis of optical systems used in environmental and military sensing. Recognition for his work in this field includes NOAA research awards, a Presidential Early Career Award for Scientists and Engineers, and the World Meteorological Organization's Vaisala Prize. He earned a PhD in Optical Sciences at the University of Arizona and is a Fellow of both the OSA and SPIE.

This course is also available in online format.
COURSES

Imaging Spectrometry
SC1220
Course Level: Intermediate
CEU: 0.4 | $330 Members | $186 Student Members
$390 Non-Members USD
Sunday 1:30 pm to 5:30 pm
This course covers the design and analysis of imaging spectrometers, from instrumentation to evaluation and data exploitation. After surveying the fundamentals of spectral imaging, the course provides a detailed survey of various implementations of imaging spectrometers and the benefits of each approach, with special attention to snapshot systems. Noise-equivalent spectral radiance (NESR) and other evaluation metrics are introduced and explained, providing a quantitative means of comparing systems. Finally, the course will review commonly used methods for data exploitation, surveys common algorithms used with spectral imaging data, and discusses their relative strengths and weaknesses.

LEARNING OUTCOMES
This course will enable you to:
• explain spectrometry and imaging-spectrometry fundamentals from the perspective of the (x,y,?) datacube (a.k.a. hypercube)
• describe conventional grating, echelle grating, Fabry-Perot, coded-aperture, and imaging Fourier-transform spectrometers
• explain spectrometry and imaging spectrometry fundamentals from the perspective of the (x,y,?) datacube (a.k.a. hypercube)
• describe conventional grating, echelle grating, Fabry-Perot, coded-aperture, and imaging Fourier-transform spectrometers
• describe unconventional spectral sensing technologies
• explain the Jacquinot, Fellgett, and Snapshot advantages
• compare representative imaging-spectrometers
• evaluate the sensitivity of a spectrometer quantitatively
• analyze radiometric tradeoffs and the effects of signal-dependent and signal-independent noises
• demonstrate common algorithms and data-exploitation techniques
• synthesize new system designs
• describe the distortions to spectral imaging data and how to compensate for them (atmospheric effects, optical aberrations, measurement artifacts)

INTENDED AUDIENCE
This course is intended for engineers, scientists, and program managers interested in a full summary of imaging spectrometry. Anyone looking at recent advances in design and data-exploitation techniques can benefit from this practical tutorial. To benefit maximally from this course, attendees should be familiar with the materials covered in SPIE SC040, Gratings, Monochromators, and Spectrometers, or equivalent.

INSTRUCTOR
Nathan Hagen has been designing and working with imaging spectrometers since 2002, and specializes in combining algorithm development with snapshot spectral imaging system design. He graduated with a PhD from the University of Arizona in Optical Sciences in 2007, after which he worked as a postdoc at Duke University, a research scientist at Rice University, and directed system design and algorithm development at the startup Rebellion Photonics for five years. Being fluent in Japanese, in 2016 he joined the faculty of Utsunomiya University’s new Optical Engineering department.

Introduction to LiDAR for Autonomous Vehicles
SC1232
Course Level: Introductory
CEU: 0.4 | $330 Members | $186 Student Members
$390 Non-Members USD
Tuesday 1:30 pm to 5:30 pm
This course provides an introduction to the exciting and rapidly growing field of light detection and ranging (LiDAR) on autonomous vehicles. The rapid growth of new lasers and detectors, along with miniaturization of computers and high-speed data acquisition systems, is opening many new opportunities for LiDAR systems in applications that require smaller and more portable instruments. Since the invention of LiDAR in the 1960s, systems have evolved from large instruments mounted in unmovable laboratories or on trucks and trailers, to smaller and dramatically more portable instruments. This course reviews the basic principles that govern the design of any LiDAR system, emphasizing how these principles can be used to design and analyze small, portable LiDAR systems uniquely tailored to guiding and performing remote sensing measurements from autonomous vehicles on the road, in the air, and in the water.

LEARNING OUTCOMES
This course will enable you to:
• explain the parameters that determine the size and weight of a LiDAR system.
• identify application-specific requirements that drove the design of state-of-the-art LiDAR systems for use in emerging applications.
• describe the advantages and disadvantages of staring and scanning LiDAR systems.
• estimate the maximum detectable range and the range resolution for a LiDAR instrument.
• distinguish between various LiDAR system designs for use on autonomous vehicles.
• compare advantages and disadvantages of different designs for small, portable LiDAR systems.
• recognize key technologies to watch or work on for achieving your dream miniature LiDAR.

INTENDED AUDIENCE
Engineers, scientists, technicians, or managers who want to understand how LiDAR works and what limits the size and capabilities of LiDAR instruments used for autonomous vehicles and other emerging applications. Undergraduate training in engineering or science is assumed.

INSTRUCTOR
Joseph Shaw has been developing and using optical remote sensing systems since 1989, first at NOAA and currently as professor of optics, electrical engineering, and physics at Montana State University. He has published about and patented LiDAR designs for applications ranging from traditional atmospheric measurements to nontraditional applications such as monitoring insects in flight. Recognition for his work includes NOAA research awards, a Presidential Early Career Award for Scientists and Engineers, and the World Meteorological Organization’s Vaisala Prize. He earned a PhD in Optical Sciences at the University of Arizona. Dr. Shaw is a Fellow of both the OSA and SPIE. He believes that learning should be fun and uses that belief in designing and presenting courses.
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MTF in Optical and Electro-Optical Systems

SC157

Course Level: Introductory
CEU: 0.7 $625 Members | $326 Student Members
$740 Non-Members USD
Sunday 8:30 am to 5:30 pm

Modulation transfer function (MTF) is used to specify the image quality achieved by an imaging system. It is useful in analysis of situations where several independent subsystems are combined. This course provides a background in the application of MTF techniques to performance specification, estimation and characterization of optical and electro-optical systems.

LEARNING OUTCOMES

This course will enable you to:
- list the basic assumptions of linear systems theory, including the concept of spatial frequency
- identify relationship between impulse response, resolution, MTF, OTF, PTF, and CTF
- estimate the MTF for both diffraction-limited and aberration-limited systems
- explain the relationship between MTF, line response, and edge response functions
- identify MTF contributions from finite detector size, crosstalk, charge transfer inefficiency, and electronics
- summarize the effects of noise

INTENDED AUDIENCE

Engineers, scientists, and managers who need to understand and apply the basic concepts of MTF to specifying, estimating, or characterizing performance. Some prior background in Fourier concepts is helpful.

INSTRUCTOR

Glenn Boreman served as the 2017 President of SPIE, and is chair of the Department of Physics & Optical Science at the University of North Carolina at Charlotte. From 1984 to 2011 he was on the faculty of University of Central Florida, where he supervised 25 PhD students to completion. He received the BS in optics from University of Rochester and PhD in optics from University of Arizona. Prof. Boreman is coauthor of the graduate textbooks Infrared Detectors and Systems and Infrared Antennas and Resonant Structures, and author of Modulation Transfer Function in Optical & Electro-Optical Systems and Basic Electro-Optics for Electrical Engineers. He has published more than 180 journal articles in the areas of IR sensors, IR materials, and image-quality assessment. He is a fellow of SPIE, OSA, IEEE, and MSS.


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DETECTORS AND IMAGING

Deep Learning and Its Applications in Image Processing

SC1222

Course Level: Introductory
CEU: 0.7 $580 Members | $308 Student Members
$695 Non-Members USD
Sunday 8:30 am to 5:30 pm

This course provides a broad introduction to the basic concept of the classical neural networks (NN) and its current evolution to deep learning (DL) technology. The primary goal of this course is to introduce the well-known deep learning architectures and their applications in image processing for object detection, identification, verification, action recognition, scene understanding and biometrics using a single modality or multimodality sensor information. This course will describe the history of neural networks and its progress to current deep learning technology. It covers several DL architectures such as the classical multi-layer feed forward neural networks, convolutional neural networks (CNN), restricted Boltzmann machines (RBM), auto-encoders and recurrent neural networks such as long term short memory (LSTM). Use of deep learning architectures for feature extraction and classification will be described and demonstrated. Examples of popular CNN-based architectures such as AlexNet, VGGNet, GoogLeNet (inception modules), ResNet, DeepFace, Highway Networks, FractalNet and their applications to defense and security will be discussed. Advanced architectures such as Siamese deep networks, coupled neural networks, auto-encoders, fusion of multiple CNNs and their applications to object verification and classification will also be covered.

LEARNING OUTCOMES

This course will enable you to:
- Identify the fundamental concepts of neural networks and deep learning
- Describe the major differences between neural network and current deep learning architectures
- Explain the stochastic gradient descent algorithm to train deep learning networks with different regularizations methods
- Describe the popular CNN-based architectures (i.e., AlexNet, VGGNet, GoogLeNet, ResNet)
- Compare the relative merits of various deep learning architectures, MLP, CNN, RBM and LSTM
- Formulate CNN and auto-encoders for feature extraction
- Differentiate between Siamese and coupled deep learning architectures and their use for object verification and identification
- Design multiple deep learning architectures for multi-view face identification and multimodal biometrics applications

INTENDED AUDIENCE

Scientists, engineers, technicians, or managers who wish to learn more about deep learning architectures and their applications in image processing and machine learning. Undergraduate training in engineering or science is assumed.

INSTRUCTOR

Nasser Nasrabadi is a professor in the Lane Computer Science and Electrical Engineering Department at West Virginia University. He was senior research scientist (ST) at US Army Research Laboratory (ARL). He is actively engaged in research in deep learning, image processing, automatic target recognition and hyperspectral imaging for defense and security. He has published over 300 papers in journals and conference proceedings. He has been an associate editor for the IEEE Transactions on Image Processing, IEEE Transactions on Circuits and Systems for Video Technology and IEEE Transactions for Neural Networks. He is a Fellow of IEEE and SPIE.
**COURSES**

**Introduction to Fundamental Performance Limits of CCD and CMOS Imagers**

**SC1274**

**Course Level:** Introductory  
**CEU:** 0.4  
**$470 Members | $242 Student Members**  
**$530 Non-Members USD**  
**Monday 1:30 pm to 5:30 pm**

This course provides a brief review of general theory, architecture and operation of CCD and CMOS imagers. In depth discussions then focus on four key operational imager features which collectively limit overall sensor performance (i.e., charge generation, charge collection, charge transfer and charge readout). The course will show how these parameters govern most measurements such as quantum efficiency (QE), modulation transfer function (MTF), charge transfer efficiency (CTE) and read noise measurements. Absolute test tools are presented that measure these characteristics. We will review at some length the ‘photon transfer technique’ which has become an indispensable standard test tool for the imaging community in evaluating the quality of a camera system and calibration and optimization needs. We present correlated double sampling (CDS) which is a mandatory signal processing method for imagers that delivers ultra low noise performance. The course will also take a quick look at future R&D imaging trends and new applications.

**LEARNING OUTCOMES**

This course will enable you to:
- describe theory and operation behind CMOS and CCD arrays
- summarize the four fundamental operational parameters that govern and limit performance
- present laboratory measurement techniques used to optimize performance
- review the ‘photon transfer technique’ required to achieve highest S/N performance possible
- explain how video signals are processed for maximum S/N performance
- explain current and future imaging technologies and applications

**INTENDED AUDIENCE**

This course is for scientists, engineers, and managers involved with high performance CCD and CMOS imaging sensors and camera systems.

**INSTRUCTOR**

James Janesick for the past 19 years leads the CMOS imager advanced development group for SRI International. Previously he was with Con- exant Systems Inc. developing CMOS imaging arrays for commercial applications. He was technology director of Pixel Vision, Inc. for five years developing high speed backside illuminated custom CCDs for scientific and cinema cameras. Prior to this Janesick was with the Jet Propulsion Laboratory for 22 years where as group leader developed CCD imagers and NASA flight based imaging systems. He has delivered numerous short courses for SPIE and UCLA since the early 80’s. He has authored numerous publications and has contributed to many NASA Tech Briefs and patents for various CCD and CMOS innovations. Janesick received NASA medals for Exceptional Engineering Achievement (1982 and 1992) and was the recipient of the SPIE Educator Award (2004) and was SPIE /IS&T Imaging Scientist of the Year (2007) and 2019 IISS Exceptional Lifetime Achievement Award (2019).


**ADVANCED METROLOGY**

**Introduction to Interferometric Optical Testing**

**SC213**

**Course Level:** Introductory  
**CEU:** 0.4  
**$365 Members | $200 Student Members**  
**$425 Non-Members USD**  
**Sunday 8:30 am to 12:30 pm**

This short course introduces the field of interferometric optical testing. Topics covered include basic interferometers for optical testing, and concepts of phase-shifting interferometry including error analysis. Long wavelength interferometry, testing of aspheric surfaces, measurement of surface microstructure, and the state-of-the-art of direct phase measurement interferometers are also discussed.

**LEARNING OUTCOMES**

This course will enable you to:
- explain the basic concepts of interferometric optical testing
- describe the power, capabilities, and limitations of phase-shifting interferometry
- describe techniques, advantages, and disadvantages of long-wavelength interferometry
- compare different aspheric testing techniques
- list capabilities and techniques for measuring surface microstructure
- describe the current state-of-the-art of direct phase measurement interferometers

**INTENDED AUDIENCE**

Engineers, scientists, and managers who need to understand the basic concepts of interferometric optical testing.

**INSTRUCTOR**

James Wyant is professor of optical sciences at the University of Arizona. He is currently Chairman of the Board of 4D Technology. He was a founder of the WYKO Corporation and served as its president from 1984 to 1997. Dr. Wyant was the 1986 President of SPIE.


**Wavefront Data Analysis**

**SC1164**

**Course Level:** Intermediate  
**CEU:** 0.4  
**$405 Members | $216 Student Members**  
**$465 Non-Members USD**  
**Sunday 1:30 pm to 5:30 pm**

This course begins with an overview of basic aberrations and tolerance analysis in optical imaging systems. Zernike circle polynomials and their use in wavefront data analysis are presented as are analytical methods for cases involving non-circular pupils such as annular, square, hexagonal and elliptical pupils. The calculation of orthonormal aberration coefficients from the wavefront error data obtained by phase-shifting interferometry or wavefront slope error data obtained with a Shack-Hartmann sensor is explained, and numerical analyses of both types of data are demonstrated.
LEARNING OUTCOMES
This course will enable you to:
• acquire a working knowledge of basic aberrations
• specify aberration/fabrication tolerance based on Strehl ratio and Rayleigh’s quarter wave rule
• explain what Zernike polynomials are and why they are used in wavefront data analysis
• determine Zernike coefficients from optical design or testing wavefront data
• determine Zernike coefficients from wavefront slope data
• relate Zernike coefficients to Seidel coefficients
• interpret data generated by wavefront or wavefront slope sensors
• determine Zernike coefficients from optical design or testing wavefront data
• explain what Zernike polynomials are and why they are used in application.
• specify aberration/fabrication tolerance based on Strehl ratio and Rayleigh’s quarter wave rule
• explain what Zernike polynomials are and why they are used in wavefront data analysis
• determine Zernike coefficients from optical design or testing wavefront data
• determine Zernike coefficients from wavefront slope data
• relate Zernike coefficients to Seidel coefficients
• interpret data generated by wavefront or wavefront slope sensors
• develop effective communication between system engineers or engineering managers and optical designers, fabricators, and testers.

INTENDED AUDIENCE
Scientists, engineers, and managers involved in lens and optical system design, fabrication, or optical testing. Some knowledge of aberrations and or experience with optical design, fabrication, or testing is helpful but not necessary.

INSTRUCTOR


Optical Measurement of Surface Topography

SC1271
Course Level: Introductory
CEU: 0.4 $330 Members | $186 Student Members
$390 Non-Members USD
Sunday 8:30 am to 12:30 pm

Optical measurement plays an important role in non-contact strategies for 3D visualization and quantification of surface topography. The dominant techniques today involve imaging microscopy combined with confocal, focus-variation, quantitative phase imaging, digital holographic or interferometric principles to achieve sensitivity to height variations in the object surface. In this tutorial, we will review the fundamentals of these advanced techniques, including principles, implementation and best practice examples of applications and data interpretation. We will then move on to interference microscopy as an illustrative example of the current state of the art. Hot topics include performance enhancements, new objective designs for wide-field imaging, vibration robustness, accommodation of highly sloped surfaces, correlation to contact methods, metrology for additive manufacturing, and transparent surface films characterization. We will also consider the impact and importance of calibration, surface texture parameters, and standardization. Finally, a gallery of applications illustrates the current state of the art as well as the future potential for optical methods of surface structure analysis.

LEARNING OUTCOMES
This course will enable you to:
• describe the principles of confocal, focus-variation, digital holographic and interferometric microscopy for surface topography measurement
• identify, name and describe the optical, mechanical and electrical components of generic instrument configurations, including the types of objectives, types of light sources, scanners, filters and cameras
• summarize the most common data analysis methods, as well as the signal modeling techniques that are increasingly common in advanced processing
• explain the meaning and importance of relevant performance specifications, as well as potential sources of uncertainty and error
• explain the meaning of calibration, verification and adjustment
• provide and define the most common ISO surface texture parameters

INTENDED AUDIENCE
The intended audience includes R&D scientists, process and quality control engineers, and measurement specialists from all applications areas requiring high-precision, high-resolution surface characterization.

INSTRUCTOR
Peter de Groot is the executive director of R&D at ZYGO, where he manages innovation and new product discovery. As an innovator and educator in optical metrology, his individual contributions include 135 US patents and 160 technical papers, tutorials and book chapters. He is an Honorary Professor at the University of Nottingham, a recipient of the SPIE Rudolf Kingslake medal in optical engineering, an SPIE Fellow, and member of the Board of Directors of the SPIE.

This is a beginning to intermediate level course, with material ranging from basic to complex, to provide both an overview and reference for further study.

Intermediate Lens Design

SC912
Course Level: Intermediate
CEU: 0.7 $615 Members | $322 Student Members
$730 Non-Members USD
Monday 8:30 am to 5:30 pm

Have you ever wondered why refractive, reflective, and zoomed optical systems look the way that they do? This course begins with a brief review of paraxial optics, third-order aberration theory, and computer aided optimization. A survey of refractive optical design forms from the landscape lens to the double gauss lens is given. Telephoto and retrofocus lenses, Petzval and microscope objectives, and wide angle lenses are discussed. Zoom lens principles and first order layout are presented in detail with easy to understand examples. Visible band color correction techniques and UV and IR design constraints are discussed.

This full day course also examines the basics of reflective optical system design including reflective design analogies, advantages and disadvantages of reflective systems, obscured vs. unobscured design forms. Reflective systems ranging from the Cassegrain to the reflective triplet to three and four mirror anastigmats are presented.

LEARNING OUTCOMES
This course will enable you to:
• determine which lens types are suitable for various applications
• create a new system design from scratch
• layout a zoom lens from first principles
• describe reflective system designs and constraints
INTENDED AUDIENCE
This course is intended for optical engineers and scientists who have some previous knowledge of geometrical optics, aberration theory, and lens design and who want to increase their optical design proficiency through a better understanding of the subject.

INSTRUCTOR
Julie Bentley is an associate professor at The Institute of Optics, University of Rochester and has been teaching two graduate level courses in optical design for more than 10 years. She received her BS, MS, and PhD in optics from the The Institute of Optics, University of Rochester. After graduating she spent two years at Hughes Aircraft Co. in California designing optical systems for the defense industry and then twelve years at Corning Tropel Corporation in Fairport, New York designing and manufacturing precision optical assemblies such as microslitographic inspection systems.


This course is an analogue to Warren Smith’s long-running course SC006, Modern Lens Design.

Optical Materials, Fabrication and Testing for the Optical Engineer
SC1086
Course Level: Introductory
CEU: 0.4 $330 Members | $186 Student Members
$390 Non-Members USD
Wednesday 8:30 am to 12:30 pm

This course is designed to give the optical engineer or lens designer an introduction to the technologies and techniques of optical materials, fabrication and testing. This knowledge will help the optical engineer understand how the choice of optical specifications and tolerances can either lead to more cost effective optical components, or can excessively drive the price up. Topics covered include optical materials, traditional, CNC and novel optical fabrication technologies, surface testing and fabrication tolerances.

LEARNING OUTCOMES
This course will enable you to:
• identify key mechanical, chemical and thermal properties of optical materials (glass, crystals and ceramics) and how they affect the optical system performance and cost of optical components
• describe the basic processes of optical fabrication
• define meaningful surface and dimensional tolerances
• communicate effectively with optical fabricators
• design optical components that are able to be manufactured and measured using state of the art optical fabrication technologies
• choose the optimum specifications and tolerances for your project

INTENDED AUDIENCE
Optical engineers, lens designers, or managers who wish to learn more about how optical materials, fabrication and testing affect the optical designer. Undergraduate training in engineering or science is assumed.

INSTRUCTOR
Jessica DeGroote Nelson is the director of technology and strategy at Optimax Systems, Inc. She is an adjunct faculty member at The Institute of Optics at the University of Rochester teaching both an undergraduate and graduate course on Optical Fabrication and Testing, and has given several guest lectures on optical fabrication and metrology methods. She earned a PhD in optics at The Institute of Optics at the University of Rochester. Dr. Nelson is a member of both OSA and SPIE.

WORKSHOPS FOR OPTICS EDUCATORS

Problem-Based Learning: Engaging Students in STEM
WS1141
Course Level: Introductory
CEU: 0.2 $15 Members | $15 Student Members
$20 Non-Members USD
Tuesday 10:00 am to 12:00 pm

Can students learn content material, structured problem solving and teamwork all at the same time? Problem Based Learning (PBL) is designed to do just that by engaging students in authentic real-world problems while supporting their problem-solving skills. Developed for use in medical education in the 1970s, PBL is used in business and law education and even police training. Slowly, it’s beginning to emerge in engineering and technology education as a student-centered approach to teaching and learning. Studies show that PBL leads to deeper learning and better retention of material. In this workshop, you’ll learn more about PBL and how the New England Board of Higher Education’s PBL "Challenges" have been implemented in classrooms and extracurricular activities. You will take the part of a student and solve a PBL Challenge, in the process learning how to enhance students’ content knowledge, critical thinking skills, and ability to work in teams.

LEARNING OUTCOMES
This course will enable you to:
• incorporate problem-based learning into the classroom or informal education settings
• practice with Web-based PBL Challenges developed through the NEBHE PBL projects
• discuss how the Web-based PBL Challenges can be used in the classroom or informal education settings
• explain how to create your own PBL Challenges (case studies)
• have access to the PBL curriculum materials provided through the PBL projects of the New England Board of Higher Education

INTENDED AUDIENCE
Teachers, Science Team Leaders, School Counselors, Graduate Teaching Assistants, and students interested in learning about Problem-Based Learning or optics education.

INSTRUCTOR
Judy Donnelly is an emeritus professor of physics at Three Rivers Community College, an SPIE Fellow, and the 2003 recipient of the SPIE Educator of the Year award. She is the co-author of Light: Introduction to Optics and Photonics and has worked since 1995 with the New England Board of Higher Education on NSF/Advanced Technology Education projects to encourage student-centered learning especially in optics/photonics.
COURSES

Dumpster Optics: Teaching Optics with Junk

WS1156
Course Level: Introductory
CEU: 0.2 $15 Members | $15 Student Members
$20 Non-Members USD
Tuesday 1:30 pm to 3:30 pm
Engage in tested inquiry-based activities illustrating basic optics concepts using inexpensive, commonly found materials. This workshop is for budget-constrained teachers and outreach providers who have little to no funds for formal kits and expensive supplies. School-age children are welcome to accompany parents. What will you take home? Complete instructions including how optics can be used to illuminate mathematics, several “make-and-take” experiments, list of suppliers and other free resources, ongoing technical assistance (by email), and the opportunity to join the PHOTON listserv of educators and industry mentors. What will you do in this workshop? Dumpster Optics and Math & Optics activities include: Light and Shadows, Inverse Square Law, Reflection (including a target shoot and kaleidoscope), What is a Laser? and The Colors of Light.

LEARNING OUTCOMES
This course will enable you to:
• use recycled and repurposed materials to teach optics.
• enliven math class with optics activities
• engage students with inquiry-based activities

INTENDED AUDIENCE
Secondary and post-secondary instructors who want to teach basic optical science concepts and photonics technology. The workshop is also appropriate for anyone who wants a few engaging, low-cost, simple demonstrations to take into their community for outreach purposes. Children over 8 years old are welcome to accompany their parent to the workshop. Youth badge is required and may be picked up at Registration.

INSTRUCTORS
Nancy Magnani is a grant facilitator/science specialist for EASTCONN’s Teaching and Learning Services. Her projects include facilitating inter-district grant programs for K-12 students, including Energy for the Future, the 4th R: Robotics, Minds in Motion and Making Waves: Optics and Acoustics. In addition, Nancy facilitates EASTCONN Science Council, developing and providing science-based professional development for K-12 teachers in alignment with NGSS and Connecticut state science standards.
Perla Marlene Viera-González is a teacher at the Universidad Autónoma de Nuevo León (UANL) in Monterrey, Mexico. She obtained her PhD in January 2019 in the field of physical engineering with a thesis about optical design. Since 2011, she has been a science outreach volunteer, and she has taken part on more than 100 events and reached more than 100,000 people in activities for university students, kids, and general public. She is the leader of the science outreach group “Fisica Pato2 FGFM” which is in charge of different public science programs, including “Optics for everyone” and “Dumpster optics workshop” in Monterrey, Mexico, SPIE supports both.

Early registration is recommended. There is not a waitlist for courses.

I SEE THE LIGHT! Demonstrations and Activities for Outreach Events

WS1201
Course Level: Introductory
CEU: 0.2 $15 Members | $15 Student Members
$20 Non-Members USD
Wednesday 3:30 pm to 5:30 pm
Looking for some ideas, activities, and demonstrations you can use at outreach events? This workshop will present several demonstrations and activities that are easy to deploy and of high interest to students. In addition, each activity will include a discussion of how to best explain basic light, optics, and wave concepts to various audiences.
Some of the activities will include: Using diffraction gratings to compare and contrast the spectra seen various light sources; using a simple hand lens to image objects and compare the types of images produced; how lasers are used and are different from other sources of light such as an incandescent light bulb.
In addition to free magnifiers, diffraction glasses, and a color-changing LED light bulb, optics and photonics posters and outreach DVDs will be available for attendees, demonstrating how light-based technology is used by everyone, every day.

LEARNING OUTCOMES
This course will enable you to:
• demonstrate how energy can be carried from one place to another by waves, such as water waves and sound waves, by electric current, and by moving objects
• demonstrate how light is reflected from mirrors and other surfaces
• demonstrate how the color of light striking an object affects the way the object is seen
• demonstrate how telescopes magnify the appearance of some distant objects in the sky, including the Moon and the planets. The number of stars that can be seen through telescopes is dramatically greater than the number that can be seen by the unaided eye
• demonstrate how diffraction gratings spread out light into its component colors and compare and contrast how light from various sources can be different
• demonstrate light travels in straight lines if the medium it travels through does not change
• demonstrate how simple lenses are used in a magnifying glass, the eye, a camera, a telescope, and a microscope
• demonstrate how light can be reflected, refracted, transmitted, and absorbed by matter
• explain how a presentation should be adapted to meet the needs of the intended audience

INTENDED AUDIENCE
Scientists, engineers and college students interested in learning some basic outreach activities to take into their local schools and communities. All lessons are developed using an inquiry based approach to learning, and includes ready-to-go worksheets for students.

INSTRUCTOR
Mike McKee is the associate director for the BS in Photonic Science and Engineering program in CREOL, College of Optics and Photonics at the University of Central Florida. He was a physics teacher in Orange County Public Schools, where he also became a district lead science instructional coach. He was also an instructional coach for a charter school system in California. He has published K-5 lab manuals that are inquiry based with over 100 lessons. For 20 years, from 1998 to 2018, he was the Florida Science Olympiad state director and was the director for the Science Olympiad National Tournament at UCF in 2012 and 2014.
SPIE COURSES

Get the most out of your conference experience.
Take a course at SPIE Optics + Photonics.

Not enough time to add a course to your schedule? Schedule customized group training at your facility. Or take an SPIE online course at your desk. Contact education@spie.org to learn more about your training options.

spie.org/courses
Training the Trainer in OPTIKS: Outreach for Professionals Who Teach in Informal Environments and K-12 Schools

WS1248
Course Level: Introductory
CEU: 0.4 $15 Members | $15 Student Members
$20 Non-Members USD
Wednesday 8:30 am to 12:30 pm
It is common for industry professionals, faculty, and graduate students to conduct outreach to K-12 schools and in informal locations such as fairs, science centers, or open houses. But what are the most effective ways to engage participants in activities and how should the information be presented? As part of this workshop, participants will learn how to most effectively present activities in optics and photonics that will maximize engagement while taking into account the audience and the location. They will also learn how to train others using the skills learned in this workshop.

LEARNING OUTCOMES
This course will enable you to:
• present information taking into account audience and location
• alter an activity to maximize engagement for their audience
• recognize when a presentation is “over the heads” of a prospective audience
• adapt their presentation so they “speak simply”
• state the important factors that are required for effective presentations to varying audience
• teach others the approaches learned in the workshop

INTENDED AUDIENCE
Industry professionals, graduate students or faculty who are interested in conducting outreach and training others how to conduct workshops

INSTRUCTORS
Mike McKee is the associate director for the BS in Photonic Science and Engineering program in CREOL, College of Optics and Photonics at the University of Central Florida. He was a physics teacher in Orange County Public Schools, where he also became a district lead science instructional coach. He was also an instructional coach for a charter school system in California. He has published K-5 lab manuals that are inquiry based with over 100 lessons. For 20 years, from 1998 to 2018, he was the Florida Science Olympiad state director and was the director for the Science Olympiad National Tournament at UCF in 2012 and 2014.

Nancy Magnani is an emeritus professor of physics at Three Rivers Community College and the 2003 recipient of the SPIE Educator of the Year award. She is the co-author of Light: Introduction to Optics and Photonics and has worked since 1995 with the New England Board of Higher Education on NSF/Advanced Technology Education projects to encourage student-centered learning.

This workshop is for beginners with some experience conducting outreach.

The Very Least You Need To Know About Optics

SC1170
Course Level: Introductory
CEU: 0.2 $125 Members | $60 Student Members
$150 Non-Members USD
Monday 1:30 pm to 3:30 pm
The best way to understand how light works is to work with light. This course teaches non-technical professionals to think like a photon. Participants work with optical components to establish an intuitive understanding of core optical principles such as wavelength, refraction, interference, and dispersion. Upon completion, participants will have a fundamental grasp of how and why essential optical components, such as lenses, work, and they will be prepared to study more specialized topics related to specific industries. This hands-on class is limited to 16 participants. Early registration is recommended.

LEARNING OUTCOMES
This course will enable you to:
• describe light in a technical manner in terms of wavelength, polarization, and intensity
• intuit the behavior of light due to reflection, refraction, diffraction, and interference
• classify basic optical components by appearance and function

INTENDED AUDIENCE
This course for non-engineers, especially professionals transferring from other industries, who need a rapid, non-mathematical introduction to the core principles of optics. No prior scientific or mathematical background is assumed.

INSTRUCTOR
Damon Diehl is a scientist and technical writer who specializes in translating things scientists say into human dialects. He earned his PhD in optical engineering from the University of Rochester’s Institute of Optics and his BA in physics and mathematics from the University of Chicago. Recently he served as academic coordinator for the Optical Systems Technology program at Monroe Community College in Rochester, NY, transitioning the program, over the course of eighteen months, from having only six active students to running day and evening courses for all freshman classes. He teaches the course “Grant Writing from the Ground Up,” and writes the blog “The Very Least You Need to Know about Optics” at www.vlyn2k.com

Attendee Testimonial:
Great class, easy to understand.
**PROFESSIONAL DEVELOPMENT**

**Student Chapter Leadership Workshop**

**WS1249**

Course Level: Introductory  
CEU: 0  
Saturday 8:00 am to 5:00 pm

Student Chapter Members are welcome to participate in the SPIE Student Chapter Leadership Workshop. During this highly interactive, all-day event facilitated by Dr. Jean-luc Doumont, you will discuss what being a leader is all about (and what it is not about), how to persuade others, and how to go from ideas to achievements in your chapter. Expect to gain new insights, make new friends, and overall spend a rich and enjoyable first day at the conference.

**LEARNING OUTCOMES**

This course will enable you to:

- practice your persuasion and motivation skills
- resolve conflict in a diplomatic manner
- determine better ways to manage your chapter

**INTENDED AUDIENCE**

This course is intended for SPIE Student Chapter members who either are currently serving in a leadership position or anticipate serving in such a role in the future.

**INSTRUCTOR**

Jean-luc Doumont runs lectures and workshops in scientific communication, pedagogy, critical thinking, and more for engineers, scientists, and other rational minds. He is an engineer from the University of Louvain and a doctor in applied physics from Stanford University. Articulate, entertaining, and thought-provoking, he is a popular invited speaker at top-notch universities and research centers worldwide.

This course is free to technical student attendees, however we ask that you email students@spie.org to indicate your interest in attending. Officer Travel Grant recipients are already pre-registered for this event. Paid registration is only required for student chapter members who are not Officer Travel Grant recipients and who do not wish to attend the technical conference sessions.
GENERAL INFORMATION

Registration

Onsite Registration and Badge Pick-up Hours

CONFERENCE REGISTRATION
Marriott Marquis, Marina Foyer (Level 3)
Saturday, 10 August · 10:00 AM - 5:00 PM

CONFERENCE + EXHIBITION REGISTRATION
San Diego Convention Center, Sails Pavilion (Upper Level)
Sunday, 11 August · 7:15 AM - 5:00 PM
Monday, 12 August · 7:30 AM - 5:00 PM
Tuesday, 13 August · 7:30 AM - 5:00 PM
Wednesday, 14 August · 7:30 AM - 5:00 PM
Thursday, 15 August · 7:45 AM - 4:00 PM

REGISTRATION PRICING AND DATES
All online charges are made in US dollars at the current exchange rate. Conference registration prices increase by US$150 (Students US$75) and courses by US$75 - all prices increase after 26 July 2019. The online form will automatically display the increased prices.

Conference registration includes:
• Admission to all conference sessions, plenaries, panels, and poster sessions
• Admission to the Exhibition
• All-Conference Welcome Reception
• Coffee breaks
• A choice of online proceedings via the SPIE Digital Library

Special Events Pricing
• All-Conference Welcome Reception guest admission US $50
• Annual Awards Banquet tickets US $60

Course and Workshop Registration
• Courses and workshops are priced separately.
• Course-only registration includes your selected course(s), course notes, coffee breaks, and admittance to the exhibition.
• Course prices increase US$75 after 26 July 2019.
• Course prices include applicable taxes.
• Onsite, please go to Course Materials Pickup after you pick up your badge at main registration.
• Multiple facilities may be used for courses; allow yourself enough time to register, pick up your materials, and possibly walk to a nearby facility before your course begins.

Exhibition Registration
• Exhibition-Only visitor registration is complimentary.
• The Exhibition is open Tuesday, Wednesday, and Thursday

EARLY REGISTRATION PRICING AND DATES
• Conference registration prices increase by US$150 (Students, US $50) and course prices increase US $75 after 26 July 2019.
• The online form will automatically display the increased prices.

SPIE MEMBER, SPIE STUDENT MEMBER + STUDENT PRICING
• SPIE Members receive conference and course registration discounts. Discounts are applied at the time of registration.
• SPIE Student Members receive a discount on all courses.
• Student registration rates are available only to undergraduate and graduate students who are enrolled full time and have not yet received their PhD Post-docs may not register as students. A student ID-number or proof of student status is required with your registration.

PRESS REGISTRATION
• For credentialed press and media representatives only.
• See our press registration page for SPIE policy.
• Please email contact information, title and organization to media@spie.org

SPIE Cashier
San Diego Convention Center, Sails Pavilion (Upper Level)
Registration Area
Open during registration hours

REGISTRATION PAYMENTS
If you are planning to register onsite, your credit card payment will be processed during registration. If you wish to pay with cash or check, register at the Need to Register stations; you will be directed to the Cashier once you have completed registration except for final payment.
If you have already registered and wish to add a course, workshop or special event, you may do so at the Need to Register stations.

RECEIPT AND CERTIFICATE OF ATTENDANCE
Preregistered attendees who need an SPIE-stamped receipt or attendees who need a Certificate of Attendance may obtain those at Badge Corrections and Receipts.

BADGE CORRECTIONS
Badge corrections can be made at the Badge Corrections station. Please have your badge removed from the badge holder and marked with your changes before approaching the counter.

REFUND INFORMATION
There is a US$50 service charge for processing refunds. Requests for refunds must be received by 1 August 2019; all registration fees will be forfeited after this date. Membership dues, SPIE Digital Library subscriptions or Special Events purchased are not refundable.

U.S. GOVERNMENT CREDIT CARDS
U.S. Government credit card users: have your purchasing officer contact the credit card company and get prior authorization before attempting to register. Advise your purchasing agent that SPIE is considered a 5968 company for authorization purposes.

New data laws are in effect
Unless you opt in to receive email from us, you will not receive any SPIE info about SPIE Optics + Photonics.
spie.org/signup
Author / Presenter Information

Speaker Check-In and Preview Station
Convention Center, Room 11B (Upper Level)
Open during registration hours
All presenters must stop at Speaker Check-In to upload their file(s) at least two hours before their scheduled talk or day before if you present in the first session. Authors are not able to present using their own devices. All conference rooms have a laptop, projector, screen, lapel microphone, and laser pointer.

Poster Setup Instructions
Convention Center, Hall A (Exhibit Level)
**Monday 12 August**
Setup: 10:00 AM to 4:30 PM, Session: 5:30 PM to 7:30 PM

**Wednesday 14 August**
Setup: 10:00 AM to 4:30 PM, Session: 5:30 PM to 7:30 PM

Poster Setup Instructions
- Set up your poster during the setup hours listed for your poster session.
- Paper numbers will be placed on the poster boards in numerical order; find your paper number and put up your poster in the designated space.
- A poster author is required to stand by the poster during the scheduled poster session to answer questions from attendees.
- Presenters who have not placed their poster(s) on their assigned board by 60 minutes prior to the session on the day of their presentation will be considered a “no show” and their manuscript will not be published.
- Poster Guidelines: spie.org/OPPosterGuidelines

Poster Teardown Instructions
- Presenters must remove their posters immediately after the poster session. SPIE assumes no responsibility for posters and will not save abandoned posters.

Onsite Services

Internet Access
Lobbies and Meeting Rooms
Complimentary wireless internet access provided in meeting rooms and lobbies on the conference room level. Instructions will be posted onsite.

SPIE Conference and Exhibition App
Search and browse the program, special events, participants, exhibitors, courses, and more. Free Conference App available for iPhone and Android phones.

SPIE Bookstore
Conv. Ctr. Sail Pavilion (Upper Level)
Stop by the SPIE Bookstore to browse the latest SPIE Press Books, proceedings, and educational materials. While there, get a t-shirt or educational toy to bring home to the family.

SPIE Education Services
Conv. Ctr. Sail Pavilion (Upper Level)
Browse course offerings or learn more about SPIE courses available in portable formats such as online and customized, In-company courses.

SPIE Luggage and Coat Check
Convention Center, Hall A Lobby (Ground Level)
Sunday through Wednesday  ·  7:30 AM - 6:00 PM
Thursday  ·   8:00 AM - 6:00 PM
Complimentary luggage, package, and coat storage are available. Please note hours; no late pickup available.

Business Center
FedEx Kinko, Convention Center, Hall D Lobby (Ground Level)
Monday through Thursday  ·  8:00 AM - 6:00 PM
Services include photocopying, faxing, printing services, and shipping. Office supplies are also available. Phone +1 619 525 5450

Restaurant and City Information
Conv. Ctr. Hall B Lobby
Sunday through Thursday  ·  9:00 AM - 6:00 PM
Services include sightseeing, shopping, and restaurant information

Child Care Services
Marion's Childcare, Inc.
Email: amy@hotelchildcare.com
Office: +1 619 303 4379 or text +1 619 663 4379
Make a reservation online.
Note: SPIE does not imply an endorsement nor recommendation of these services. They are provided on an “information only” basis for your further analysis and decision. Other services may be available.

Lobby Services and Amenities
ATMs
Convention Center, Hall B Lobby & Hall E Lobby (Ground Level)

Courtesy Phones
Convention Center Lobbies
Free local calls.

Nursing Mother's Lounge
Convention Center, Hall A Lobby & Hall E Lobby (Ground Level)
The lounges are located inside the women’s restroom. Each lounge is equipped with comfortable furniture and a separate private area for nursing mothers. Power outlets are available. There is no storage or refrigeration available in the Nursing Mother’s Lounge.

Gender Inclusive Restroom
Convention Center, Hall A Lobby (Ground Level)

Quiet Room
Conv. Ctr., Sails Pavilion, Registration Area. Open during registration hours
The Quiet Room is intended for silent meditation, reflection or prayer. No mobile device or computer use, and no food or beverages allowed.

Urgent Message Line
An urgent message line is available during registration hours.
GENERAL INFORMATION

Lost and Found
Cashier, Conv. Ctr. Sail Pavilion (Upper Level)
Open during registration Hours
Found items will be kept at Cashier the duration of the meeting. At the end of the meeting, all found items will be turned over to the San Diego Convention Center Security, lost and found hotline: +1 619 525 5407

Travel

Welcome to San Diego
With 70 miles of beautiful beaches, near-perfect weather year-round, and a variety of magnificent settings countywide, San Diego offers a fun and inexpensive getaway, for kids and adults, any time of year. No stay in San Diego is complete without a trip to the waterfront. San Diego Bay is bustling with activity, as it serves as the homeport for Navy ships, a large sport fishing fleet, thousands of pleasure craft, and the USS Midway Museum is a retired aircraft carrier that now serves as a fascinating interactive floating museum. The largest urban cultural park in the United States, Balboa Park is often referred to as the “Smithsonian of the West.” Its 1,200 lush acres are home to 85 cultural attractions, including 15 museums, eight gardens and the San Diego Zoo.

Airport Information
San Diego International Airport (SAN) is conveniently located three miles northwest of downtown San Diego.

Transportation from the Airport
Taxi service from the San Diego Airport to the downtown hotels is approximately US $15-25 depending on traffic. Uber or Lyft from the San Diego Airport to the downtown hotels is approximately US $6-8 (shared ride) or US $12-17.

SHUTTLES AND PUBLIC TRANSPORTATION
Bayfront Shuttle
US $3 to ride all day - hop on the Big Bay Shuttle to visit the numerous hotels, attractions, shops and restaurants along the scenic San Diego bay. Shuttle route includes Hilton Bayfront, Marriott Marquis & Marina, Seaport Village, Broadway/Navy Pier, Maritime Museum, Sheraton Hotel & Marina.

San Diego Trolley - Metropolitan Transit System
Trolley cars are red and travel above ground on light rail lines every 15 minutes. If guests purchase Day Tripper Passes from the Transit e-store (on-line), before their arrival date, they can then use Bus 992 from the airport to the America Plaza Trolley Station to your hotel and to and from the convention center for unlimited rides at that one flat rate. Or you can purchase a day pass for $5 (subject to change) when you board the 992 bus at the airport from any Terminal. Get off at Broadway and Kettner Blvd. and walk to the America Plaza Trolley Station. From there, take the Orange Line with signage ‘Downtown/Convention Center’ to your hotel or to the convention center.

Driving Directions and Parking
• Driving directions to and from San Diego Convention Center, Hotels, and San Diego International Airport found with Google.com/maps
• San Diego Convention Center Parking, Exhibitor Set-Up and Hotel Parking Rates (weblink)
Use Parking Panda to reserve parking at the lots and garages surrounding the San Diego Convention Center.

Car Rental
Hertz Car Rental is the selected as the official car rental agency for this Event. To reserve a car, identify yourself as an Optics + Photonics conference attendee using the Hertz Meeting Code CV# 029B0024. Discount rates apply for rentals up to one week prior through one week after the conference dates. Note: When booking from International Hertz locations, the CV # must be quoted with the letters CV before the number, i.e. CV029B0024. Click here to book online Book Hertz Online. Be sure to enter the code to receive the meeting discount rate.
• In the United States call +1 800 654 2240.
• In Canada call 1-800-263-0600, or +1 416 620 9620 in Toronto.
• In Europe and Asia call the nearest Hertz Reservation Center or travel agent.
• Outside of these areas call +1 405 749 4434.

Food and Beverage Services

Complimentary Coffee
Sunday  ·  7:30 AM - 4:00 PM
Room 6 Lobby, Conv. Ctr. (Upper Level)
Monday  ·  7:30 AM - 4:00 PM
Room 6 Lobby, Conv. Ctr. (Upper Level)
Tuesday
7:30 AM - 10:00 AM
Room 6 Lobby, Conv. Ctr. (Upper Level)
10:00 AM - 4:00 PM
Exhibition Hall, Conv. Ctr. Sail Pavilion (Upper Level)
Wednesday
7:30 AM - 10:00 AM
Room 6 Lobby, Conv. Ctr. (Upper Level)
10:00 AM - 4:00 PM
Exhibition Hall, Conv. Ctr. Sail Pavilion (Upper Level)
Thursday
7:30 AM - 10:00 AM
Room 6 Lobby, Conv. Ctr. (Upper Level)
10:00 AM - 2:00 PM
Exhibition Hall, Conv. Ctr. Sail Pavilion (Upper Level)
2:00 PM - 4:00 PM
Room 6 Lobby, Conv. Ctr. (Upper Level)

Food and Refreshments for Purchase

STARBUCKS
Conv. Ctr. Lobby B
Sunday and Monday  ·  7:00 AM - 3:00 PM
Tuesday and Wednesday  ·  7:00 AM - 4:00 PM
Thursday  ·  7:00 AM - 2:00 PM

MRS. FIELDS COOKIES / AUNTIE ANNE’S PRETZELS
Conv. Ctr. Upper Lobby 6A
Sunday through Thursday  ·  7:30 AM - 4:00 PM

Hotels

Reserve your hotel room in SPIE contracted hotels for discounted rates. Attendees receive discounted convention rates by reserving their hotel room through the official housing reservation system for SPIE Optics + Photonics.

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Wednesday
7:30 AM - 10:00 AM
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10:00 AM - 4:00 PM
Exhibition Hall, Conv. Ctr. Sail Pavilion (Upper Level)
Thursday
7:30 AM - 10:00 AM
Room 6 Lobby, Conv. Ctr. (Upper Level)
10:00 AM - 2:00 PM
Exhibition Hall, Conv. Ctr. Sail Pavilion (Upper Level)
2:00 PM - 4:00 PM
Room 6 Lobby, Conv. Ctr. (Upper Level)

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Gain visibility with hiring companies
Network with employers and industry peers
Post your CV/Resume online
Visit the JOB FAIR
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- OLEDs and LEDs
- Lenses
- Fiber optics
- Electronics and signal-analysis equipment
- Displays
- Positioning systems
- Vibration-isolation equipment

EXHIBITION HOURS
Tuesday 13 August · 10:00 am to 5:00 pm
Wednesday 14 August · 10:00 am to 5:00 pm
Thursday 15 August · 10:00 am to 2:00 pm
San Diego Convention Center
San Diego, California, USA

JOB FAIR
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Whether you’re looking for a better job, re-entering the workforce, or just starting out, plan to visit the Job Fair at SPIE Optics + Photonics. Come prepared to discuss your skills and talents with our industry leaders.

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