OPTICAL DESIGN & TESTING SHORT COURSE PROGRAM

OFFERED BY

College of Optical Sciences
THE UNIVERSITY OF ARIZONA®

CORE 宇都宮大学オプティクス教育研究センター
Utsunomiya University Center for Optical Research & Education

www.optics.arizona.edu/tokyo-short-course
www.short-course.org

August 1~3, 2017

Itabashi Green Hall
Itabashi Culture Hall

Itabashi, Tokyo, Japan

SHORT COURSE FORMAT & DESCRIPTION

The University of Arizona and Utsunomiya University is pleased to present our fifth series of Optical Science and Engineering short courses in Japan. Courses will be jointly taught by professors from the University of Arizona, College of Optical Sciences in the United States of America as well as from Utsunomiya University, Center of Optical Research and Education. Course contents are taken from our undergraduate and graduate courses in optics. Five courses will be taught in Japanese and the remainder in English. All classes will have Japanese speaking teaching assistants present to enable questions and discussions in Japanese.

Students can learn geometrical optics, basic aberration theory, and its application to optical design, higher order aberration theory and its application lens design, illumination engineering, and basic and advanced physical optics including crystal optics, Fourier optics, OCT, polarization measurement, interferometric measurement. The lectures include total of 80 minutes (four of 20 minutes) of Q&A sessions as well as a reception on the first day. Students can effectively take advantage of these opportunities by a bi-directional and one-on-one interaction with instructors. In addition to providing high quality lectures with state-of-the-art contents, the short course program is a great opportunity to establish a long lasting tie among students and instructors at University of Arizona and Utsunomiya University, which will be a great asset for all the attendees.
A certificate of completion will be offered at the end of the course.

Courses Fee: 37,500JPY/Course

Geometrical Optics Courses:

- Geometrical Optics and Optical System Layout (**Yuzuru Takashima**)
- Introduction to Optical System Design: A first step with CodeV (**Yuzuru Takashima**)
- Advanced lens design: Art and Science (**Jose Sasian**)
- Introduction to AR/VR Optical System (**Hong Hua**)

Physical Optics Courses:

- Computer Generated Hologram and Spatial Light Modulator
  ~ in holographic femtosecond laser processing ~ (**Yoshio Hayasaki**)
- Fourier Optics and Optical Coherence Tomography (**Toyohiko Yatagai**)
- Introduction to Spatio-temporal Fringe Analysis for Optical Sensing and Metrology (**Mistuo Takeda**)
- Introduction to Polarization and its Application to Polarization Metrology (**Yukitoshi Otani**)
- Computational Imaging and Digital Holography (**Yoshio Hayasaki**)
- Introduction to Crystal Optics (**Kazuo Kuroda**)

Optical Device Design Course

- Introduction to Plasmonics **(Takashi Fujimura)**
- Remote Sensing, Spectral Imaging, & Infrared Detection (**Nathan Hagen**)
- Introduction to Optical Communications as a Key Enabler of Modern Internet Era (**Milorad Cvijetic**)
- Introduction to Optical Waveguide Analysis **(Hirooki Sugihara)**
- Polarization in Optical Design (**Russel Chipman**)
- Advanced Optics: DOE, HOE, and Adaptive Optics (**Tom Milster**)

Additional information is placed on the College of Optical Sciences web, and on the course home page.

www.optics.arizona.edu/tokyo-short-course

www.short-course.org

College of Optical Sciences
THE UNIVERSITY OF ARIZONA

College of Optical Sciences

The College of Optical Sciences at the University of Arizona in Tucson Arizona is the world's premier optics research institute. Optical Sciences has 55 faculty members performing research in all areas of optical engineering and optical physics who are recognized worldwide for their strong leadership abilities and outstanding research records. The international student body includes 440 undergraduate and graduate students. Optical Sciences maintains close relationships with the optics industry including special ties with many Japanese companies. The College of Optical Sciences was founded in 1964.

Optical Sciences Distance Learning: Take Graduate Optics Courses in JAPAN and ANYWHERE in the world.

Engineers interested in our Tokyo Optical Design and Testing Short Course program might also be interested in our distance learning programs. The College of Optical Sciences offers some of its graduate classes each semester by video to individuals worldwide. Students enroll for a semester course. After each class, the lecture is delivered to enrolled students by CD or downloaded over the internet. The student's homework is submitted by email or fax, graded and returned. Tests and the final examination are administered at the student's workplace or another nearby location. The distance learning program brings the College of Optical Sciences' outstanding teaching faculty to students worldwide.

http://www.optics.arizona.edu/distance/Default.htm

CORE 宇都宮大学オプティクス教育研究センター
Utsunomiya University Center for Optical Research & Education

Optics is one of the key technologies underpinning major Japanese industries including telecommunications and visual equipment such as cameras and displays. Nevertheless, it has become increasingly difficult for Japanese students to find opportunities for a systematic education in optical technology. Canon Inc. therefore approached Utsunomiya University and proposed to help rebuild optical education in Japan. Impressed by this visionary proposal, the University decided to set up an institution for optical research and education in collaboration with Canon, culminating in the creation of the Utsunomiya University Center for Optical Research and Education (CORE) in April 2007. In partnership with related industries, the Center aims to develop highly-skilled engineers and cutting-edge optical technologies to drive forward the optics industry in Japan.

Course Program, Schedule, and Fee

Geometrical Optics, Optical Design and Illumination Engineering Program

Tuesday (Aug. 1, 2017) 9:00 am – 6:00 pm	Geometrical Optics and Optical System Layout (**Yuzuru Takashima**) ¥ 41,500**Includes book
Wednesday (Aug. 2, 2017) 9:00 am – 6:00 pm	Introduction to Optical System Design: A first step with CodeV (**Yuzuru Takashima**) ¥ 37,500
Thursday (Aug. 3, 2017) 9:00 am – 6:00 pm	Introduction to AR/VR Optical System (**Hong Hua**) ¥ 37,500
Thursday (Aug. 3, 2017) 9:00 am – 6:00 pm	Advanced Lens Design: Art and Science (**Jose Sasian**) ¥ ¥ 37,500
Early Bird Special: A ¥2500 Discount for Registration BEFORE June 30, 2017 (¥35,000/Course). An additional fee, ¥ 4,000, is charged for the classes, "Geometrical Optics and Optical System Layout" A student discount available. Please ask! A certificate of completion will be issued at the end of each course.	

Physical Optics Program

Tuesday (Aug. 1, 2017) 9:00 am – 6:00 pm	S Computer Generated Hologram and Spatial Light Modulator ~ in holographic femtosecond laser processing ~ (**Yoshio Hayasaki**) ¥37,500
Tuesday (Aug. 1, 2017) 9:00 am – 6:00 pm	Fourier Optics and Optical Coherence Tomography (**Toyohiko Yatagai**) ¥37,500
Tuesday (Aug. 1, 2017) 9:00 am – 6:00 pm	Introduction to Spatio-temporal Fringe Analysis for Optical Sensing and Metrology (**Mistuo Takeda**) ¥ 37,500
Tuesday (Aug. 1, 2017) 9:00 am – 6:00 pm	Introduction to crystal optics (**Kazuo Kuroda**) ¥ 37,500
Wednesday (Aug. 2, 2017) 9:00 am – 6:00 pm	Introduction to Polarization and its Application to Polarization Metrology (**Yukitoshi Otani**) ¥ 37,500
Wednesday (Aug. 2, 2017) 9:00 am – 6:00 pm	Computational Imaging and Digital Holography (**Yoshio Hayasaki**) ¥37,500
Early Bird Special: A ¥2500 Discount for Registration BEFORE June 30, 2017 (¥35,000/Course). A student discount available. Please ask! A certificate of completion will be issued at the end of each course.	

Optical Device Design Program

Tuesday (Aug. 1, 2017) 9:00 am – 6:00 pm	Remote Sensing, Spectral Imaging, & Infrared Detection (**Nathan Hagen**) ¥ 37,500
Wednesday (Aug. 2, 2017) 9:00 am – 6:00 pm	Introduction to Plasmonics **(Takashi Fujimura)** ¥ 37,500
Wednesday (Aug. 2, 2017) 9:00 am – 6:00 pm	Introduction to Optical Communications as a Key Enabler of Modern Internet Era (**Milorad Cvijetic**) ¥ 37,500
Thursday (Aug. 3, 2017) 9:00 am – 6:00 pm	Introduction to Optical Waveguide Analysis **(Hirooki Sugihara)** ¥ 37,500
Thursday (Aug. 3, 2017) 9:00 am – 6:00 pm	Polarization in Optical Design (**Russel Chipman**) ¥ 37,500

Thursday (Aug. 3, 2017) 9:00 am – 6:00 pm	Advanced Optics: DOE, HOE, and Adaptive Optics (**Tom Milster**) ¥ 37,500
Early Bird Special: A ¥2500 Discount for Registration BEFORE June 30, 2017 (¥35,000/Course). A student discount available. Please ask! A certificate of completion will be issued at the end of each course.	

Course Schedule

Tuesday (August 1, 2017)

Lectures: 9:00 am – 6:00 pm
Reception: 6:00 pm – 8:00 pm (No Charge)

Wednesday (August 2, 2017)

Lectures: 9:00 am – 6:00 pm

Thursday (August 3, 2017)

Lectures: 9:00 am – 6:00 pm

		Schedule
8:00 am – 10:00 am	Exhibits Open	Registration
9:00 am - 9:50 am		**Lecture 1**
9:50 am - 10:00 am		Q&A, Break
10:00 am - 10:50 am		**Lecture 2**
10:50 am - 11:00 am		Q&A, Break
11:00 am - 12:00 pm		**Lecture 3**
12:00 pm - 1:30 pm		Lunch, Q&A, Break
1:30 pm - 2:20 pm		**Lecture 4**
2:20 pm - 2:30 pm		Q&A, Break
2:30 pm - 3:20 pm		**Lecture 5**
3:20 pm – 3:50 pm		Q&A, Break
3:50 pm – 4:40 pm		**Lecture 6**
4:40 pm – 4:50 pm		Q&A, Break
4:50 pm – 5:40 pm		**Lecture 7**
5:40 pm – 6:00 pm		Q&A
6:00 pm – 8:00 pm		**Reception (March 17)**

Venue:

Itabashi Green Hall (Main Venue)
Sakae-machi 36-1, Itabashi Tokyo, Japan (03-3579-2221)
Itabashi Culture Hall (Satellite Venue)
Ooyama Higashi 51-1, Itabashi Tokyo, Japan (03-3579-2222)

http://www.itabun.com/access/index.html

Easy Train Access

- 3 minutes' walk from the North Gate of Oyama Station on Tobu-Tojo Line.

College of Optical Sciences
The University of Arizona

Course Faculty from University of Arizona

Russell A. Chipman

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Professor, Optical Sciences
University of Arizona
Course Director

Russell Chipman is a Professor of Optical Sciences at the University of Arizona, Tucson AZ. He runs the Polarization Laboratory which performs research into polarization elements, liquid crystals, and polarization aberrations. He managed optics departments at JDS Uniphase and Johnson and Johnson and was also a Physics professor at the University of Alabama in Huntsville. Professor Chipman has developed many unique spectropolarimeters and imaging polarimeters and conducted studies into polarization in fiber components, waveguides, liquid crystals, polarization elements, and natural polarization signatures. He holds fourteen patents in optics. He received his BS from MIT and his M. S and Ph. D. in Optical Science from the University of Arizona. Prof. Chipman is a Fellow of OSA and SPIE and the 2007 recipient of SPIE's G. G. Stokes award for work in polarization.

Tom D. Milster

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Professor, Optical Sciences
University of Arizona

Prof. Tom D. Milster graduated with a BS in Electrical Engineering at the University of Missouri-Rolla in 1981 and PhD in Optical Sciences from the University of Arizona in 1987. After working three years for IBM Corporation as an Optical Engineer, he rejoined the University of Arizona as a faculty member in 1989. Prof. Milster teaches classes in Physical Optics and has active research programs in microscopy, lithography and data storage. His specialty is in utilizing evanescent energy to perform high-resolution experiments. He also has a strong engineering effort to develop gray-scale computer generated diffractive optical elements. His research thesis is to push the boundaries of optical science and engineering to produce the maximum amount of information from a given volume of space and time. He has over 100 refereed publications and holds 14 patents. He is a fellow of the Optical Society of America (OSA) and the Society of Photo-Optical Instrumentation Engineers (SPIE).

Jose Sasian

jose.sasian@optics.arizona.edu

Professor, Optical Sciences
University of Arizona

Jose Sasian is a professor at the College of Optical Sciences at the University of Arizona. He has been teaching for many years introductory and advanced lens design courses including the wave theory of aberrations. His research interests are in optics education, optical design, lithography, optical fabrication, testing and alignment, opto-mechanics, light in gemstones, art in optics and optics in art, visual optics, and light propagation in general.

Milorad Cvijetic

milorad@optics.arizona.edu
Professor of Optical Sciences
Professor of Electrical Engineering
University of Arizona

Milorad Cvijetic joined the University of Arizona - College of Optical Sciences as a Professor in 2011. Previously he served as Vice President and Chief Technology Strategist at NEC Corporation of America. In his 30+ year's long professional career, Dr. Cvijetic has been one of pioneers in dealing with high-speed optical systems and coherent detection technologies, as well as industry technology leader responsible for advanced optical networking technologies. He has taken part in numerous technical conferences and symposiums, in some as a conference/session chairman, technical committee member, short course instructor, or invited speaker. His current interests/expertise include high-speed optical transmission systems and networking, free space optical (FSO) communications and quantum communications over FSO and optical fiber channels. Prof Cvijetic received his Ph.D. degree in Electrical Engineering from Belgrade University in 1984. He is the OSA Fellow and Associate Editor of OSA/IEEE Journal of Optical Communications and Networking, as well as the author/coauthor of more than 150 technical papers, 4 books, and 23 US patents.

Hong Hua

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Professor, Optical Sciences
University of Arizona

Hong Hua, Fellow of SPIE and Senior Member of OSA, is currently a Professor with the College of Optical Sciences (OSC), The University of Arizona. She has over 20 years of experiences in researching and developing head-mounted display technologies for virtual and augmented reality applications and investigating various visual perceptual issues related to using head-mounted displays. As the Principal Investigator of the 3-D Visualization and Imaging Systems Laboratory (3DVIS Lab), Dr. Hua's current research interests include various head-worn displays and 3-D displays, optical engineering, medical imaging, collaborative virtual and augmented environments, and human-computer interaction.

Yuzuru Takashima

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Course Co-Director
Associate Professor, Optical Sciences
University of Arizona

Yuzuru Takashima is an Associate Professor at College of Optical Sciences of University of Arizona and has been on the faculty since 2011. He teaches one of the core courses: Lens Design for undergraduates and Optical Design for Multi-scale Photonic System for graduate students. Prior to joining to the University of Arizona, he was employed as a research staff by Stanford University where he has been actively involved in the field of novel optical system design and engineering, particularly for high density page-based and bit-based holographic data storage systems and Nano-photonic electron beam generators. He was employed as an optical engineer at Toshiba Corporation in Japan where he conducted research and development of ultra-precision manufacturing of optical components and products. He received B.S. in Physics from Kyoto University and M.S. and Ph.D. in Electrical Engineering from Stanford University. He holds 6 US and Japanese patents.

CORE 宇都宮大学オプティクス教育研究センター
Utsunomiya University Center for Optical Research & Education

Course Faculty from Utsunomiya University

Toyohiko Yatagai

yatagai@cc.utsunomiya-u.ac.jp

Professor and Director, Center for Optical Research and Education (CORE)
Utsunomiya University

Toyohiko Yatagai received BE and PhD in applied physics from the University of Tokyo, in 1969 and 1980, respectively. From 1970 to 1983 he was with Institute of Physical and Chemical Research, He joined the faculty of Institute of Applied Physics, University of Tsukuba in 1983, where he worked on optical instrumentation and optical information processing. In 2007 he moved to Utsunomiya University to launch Center for Optical Research and Education. He is a fellow of SPIE, OSA and JSAP. His current research interests include optical measurement, 3-D imaging and display, holographic optical memory and so on.

Yukitoshi Otani

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Course Co-Director
Professor, Center for Optical Research and Education (CORE)
Utsunomiya University

Yukitoshi OTANI is a professor at Center for Optical Research and Education（CORE）, Utsunomiya University, JAPAN. He received his master's degree from Tokyo University of Agriculture and Technology in 1990 and his doctor's degree from the University of Tokyo in 1995. After working for a brief period at HOYA Corp., he was an associate professor at Tokyo University of Agriculture and Technology until 2010. He was a visiting professor at College of Optical Sciences, the University of Arizona from 2004 to 2005. He joined the CORE from April 2010. He is also a technical adviser at Imaging Div, Photron Limited from 2011. His current interests include polarimetry and optomechatoronics. He is a fellow of SPIE from 2010.

Yoshio Hayasaki

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Professor, Digital optics, optical metrology, and laser material processing.
Utsunomiya University

Professor Hayasaki has been a Professor at Center for Optical Research and Education (CORE), Utsunomiya University since 2008. He received his B.S., M.S., and Ph.D in Applied Physics from The University of Tsukuba. Previously he was employed at Riken and The University of Tokushima. His interest is in the fusion of optical system and computer system. His research interests include holographic femtosecond laser processing, digital holographic nanoscope, and optical memory.

Mitsuo Takeda

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Professor, Center for Optical Research and Education (CORE)
Utsunomiya University

Mitsuo Takeda is a Professor of Center for Optical Research and Education (CORE) at Utsunomiya University, Tochigi Japan, and a Professor Emeritus of the University of Electro-Communications (UEC), Tokyo, Japan. He received the BE degree in EE from UEC in 1969, and the MS and Ph.D. degrees in Applied Physics from the University of Tokyo, respectively, in 1971 and 1974. After working for Canon Inc., he joined the faculty of UEC in 1977 and worked for UEC until he became a Professor Emeritus in 2012. During 1985 he was a visiting scholar at Stanford University, and also stayed at ITO Stuttgart University as a Humbolt Guest Professor in 2013. His field of expertise includes information optics, optical metrology, statistical optics and imaging theory. Prof. Takeda is a Fellow of SPIE, OSA and JSAP, and is a recipient of Humboldt Research Award, SPIE's Dennis Gabor Award, JSAP's Hiroshi Takuma Prize of Optics and Quantum Electronics.

Kazuo Kuroda

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Professor, Center for Optical Research and Education (CORE)
Utsunomiya University

Kazuo Kuroda is a Professor of Center for Optical Research and Education (CORE) at Utsunomiya University, and a Professor Emeritus of the University of Tokyo. He received BE and PhD in Applied Physics from the University of Tokyo in 1971 and 1976, respectively. He joined Institute of Industrial Science, the University of Tokyo in 1976, where he had been the Professor of Applied Optics since 1993. After his retirement he joined Utsunomiya University in 2012. His research interests include the photorefractive nonlinear optics, the manipulation of ultrashort pulses using quasi-phase matching gratings, holographic data storage and the speckle characterization in laser displays. He is a Fellow of SPIE, OSA, and JSAP, and a member of IEEE, OSJ, and LSJ.

Hirooki Sugihara

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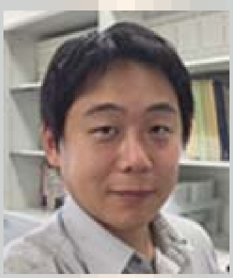
Professor, Center for Optical Research and Education (CORE)
Utsunomiya University

Hirooki Sugihara is a Professor of Center for Optical Research and Education (CORE) at Utsunomiya University. He received BS, MS and PhD in Electrical Engineering from Keio University. He had been a Professor of Center for Optical Research and Education (CORE) since 2014. Since 2008, JST “Photonics Polymer” project leader. His research interest includes: optical waveguide, optical fiber, optical; interconnect, nonlinear optics, organic photonics, organic-inorganic hybrid materials.



Takashi Fujimura

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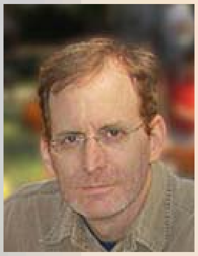
Associate Professor, Center for Optical Research and Education (CORE)
Utsunomiya University

Takashi Fujimura is an Associate Professor of Department of Optical Engineering, Graduate school of Engineering, Utsunomiya University, Japan. He received his BS degree in applied physics from Tokyo Institute of Technology in 1999, and the ME and PhD from the University of Tokyo in 2001 and 2011, respectively. In 2003, he became a research associate at the University of Tokyo. From 2012 he worked at Tokyo Institute of Technology as an assistant professor. In 2014, he joined the faculty of Utsunomiya University. His research interests include optical data storage systems, holographic recording materials, plasmonic metal nanostructures, and so on.



Nathan Hagen

Assistant Professor, Center for Optical Research and Education (CORE)
Utsunomiya University

In 2016, Prof. Hagen joined Utsunomiya University in 2016 as an Assistant Professor in the Department of Optical Engineering. He previously led the R&D and Algorithm Development group at the successful startup Rebellion Photonics, Inc through its first five years, developing a first-of-its-kind snapshot infrared spectral imager for video-rate gas cloud imaging. This system is now in the process of changing the oil & gas safety industry. Before joining Rebellion, his career focused on the development of snapshot spectral imaging systems, involving the CTIS (computed tomography imaging spectrometer) at the University of Arizona, CASSI (coded aperture snapshot spectral imager) at Duke University, and the IMS (image mapping spectrometer) at Rice University. He is the author/coauthor of 50 technical publications and 6 patents.

Geometrical Optics, Optical Design Program

Geometrical Optics and Optical System Layout

Yuzuru Takashima

Tuesday, Aug. 1, 2017 9:00 am – 6:00 pm

- ***Lecture in Japanese***
- ***Notes provided in Japanese***
- ***Supplemental text in Japanese***
- ***Question and answer periods in Japanese***

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

Participants will receive the course viewgraphs in English and a copy of Japanese language version of the book “Field Guide to Geometrical Optics” by Prof. Greivenkamp.

Learning Outcomes:

This course will enable participants 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
- Understand the process of the design and layout of an optical system

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.

Course Level: Introductory

Introduction to AR/VR Optics

Hong Hua

Thursday, Aug. 3, 2017   9:00 am – 6:00 pm

- **Lecture in English**
- **Notes provided in English**
- **Question and answer periods in English/Japanese**

This short course provides participants with fundamental knowledge and understanding of optical systems for augmented and virtual reality (AR/VR) applications. More specifically, the course will start with reviews on human visual system, photometry, colorimetry and display technologies. The lecture will then provide a review on the historical development of AR/VR displays, present comprehensive review on the various optical design methods for AR/VR displays, and demonstrate examples of AR/VR optical system designs. The course will also present performance metrics for AR/VR displays, optical design considerations, and key human factors. Finally, the course will present reviews on the recent development of new AR/VR displays such as head-mounted light field displays and discuss potential impacts of such technologies.

BENEFITS/LEARNING OBJECTIVES

This course will prepare you to:

- Acquire the fundamental knowledge related to AR/VR optical systems, including human visual system, photometry, color systems, and display technologies.
- Become familiar with the various optical design methods for AR/VR displays.
- Understand the key design considerations, human factors, and performance metrics in the course of designing and evaluating AR/VR displays.
- Become familiar with the research frontier of AR/VR displays.

Intended Audience:

This course is intended for scientists, engineers and managers who need to understand the fundamentals of AR/VR optical systems as well as their design principles, and apply these principles in future AR/VR technology development. This course should be particularly useful for those who need to understand the role of optical design in the development of advanced AR/VR systems and applications, to understand the relationship between AR/VR display performance metrics and human factors, to be familiar with the key challenges in developing AR/VR optical systems. This course is self-contained and structured to provide straightforward guidance to audience looking to capture fundamentals and gain both theoretical and practical knowledge that can be readily applied in research and practical applications. No precondition is required for this course; the background knowledge that may be beneficial for this course is geometrical optics and optical design principles.

Course Level: Introductory/Intermediate

Introduction to Optical System Design: A first step with CodeV

Yuzuru Takashima

Wednesday, Aug. 2, 2017 9:00 am – 6:00 pm

- **Lecture in Japanese**
- **Notes provided in English**
- **Question and answer periods in Japanese**

This course provides participants with practical knowledge on optical system design by bridging the knowledge on aberrations (as presented in the "Introduction to Aberration Theory") and applications in optical system design. Optical aberrations are depend on the parameters of a lens element, such as its radii, index of refraction, and thickness as well as on the arrangement of the each element. By applying the fundamental relationships between lens parameters and aberrations, optical system engineers are able to design lens system and understand their operation. These analytical results are usually further improved by the automatic optimization processes used by lens design software. Knowledge of aberrations and their causes is very useful to assist optical engineers in selecting the most appropriate catalog lenses to build high performance AND low cost optical system within a short period of time. In the short course, we present with optical design procedure in general, and discuss the relationships between aberrations and lens parameters. Students use a ray-trace software, CodeV to practice examples. NO prior experience on CodeV is required.

Learning Outcomes:

This course will prepare you to:

- Understand the procedure of optical system design
- Understand how the third-order aberrations: Spherical Aberration, Coma, Astigmatism, Field Curvature and Distortion are related to lens and system parameters
- Understand how to correct each aberration
- Understand how to use CodeV based on analytical starting lens design

Intended Audience:

This course is intended for scientists, engineers and managers who need to understand the basics of lens design and apply these principles to correct aberrations. It is particularly useful for those who need to build high performance optical system by using catalog lenses. The related short courses, "Geometrical Optics and Optical System Layout " and "Aberrations and Image Quality" are recommended prerequisites for those who would like additional preparation for this course.

Course Level: Introducton

Advanced lens design: Art and Science

Jose Sasian

Thursday, Aug. 3, 2017 9:00 am – 6:00 pm

- **Lecture in English**
- **Notes provided in English**
- **Question and answer periods in Japanese**

This course provides useful insights and tools into the art and science of lens design. After reviewing progress in aberration theories, several topics of current interest will be discussed and illustrated with computer demonstrations. The emphasis of the course is in providing useful techniques for designing state-of-the-are lens systems.

Learning Outcomes:

This course will prepare you to:

- To understand the role of higher order aberrations including intrinsic and extrinsic aberrations
- To understand pupil aberrations and the effects they produce
- To learn advanced techniques in color correction
- To understand how to approach the design of non-symmetrical systems
- To learn the basics of mirror system design
- To understand and use of aspheric and free form surfaces
- To gain insight in effective lens tolerancing
- To better appreciate the art of lens design

Intended Audience:

This course is intended for engineers, scientists, and students who are interested in optical design.

Course Level: Introductory-intermediate

Physical Optics Program

Computer Generated Hologram and Spatial Light Modulator ~ in holographic femtosecond laser processing ~

Yoshio Hayasaki

Tuesday, Aug. 1, 2017 9:00 am – 6:00 pm

- **Lecture in Japanese**
- **Notes provided in Japanese**

This course covers the principles and usages of holography recording and reconstruction processes. When the recording process is performed in a computer, it is called a computer-generated hologram. When the reconstruction process is performed in a computer, it is called digital holography. Their usefulness have greatly increased with recent advances in optical measurement and processing technology. The first half of the course covers the most important techniques. In the second half, the many practical examples are introduced.

BENEFITS/LEARNING OBJECTIVES
After taking this course, the students will:

- **Understand the principle of a computer-generated hologram (CGH) and some optimization methods of the CGH**
- **Understand the operation principle of a liquid-crystal spatial light modulator (LCSLM) and its usage**
- **Understand the usefulness of CGH and LCSLM according to the applications to material laser processing**

Intended Audience:
This course is targeted at the undergraduate or bachelor engineer, scientist, or technician with an interest in understanding computer-generated holography and liquid-crystal spatial light modulators. If you have more interest to femtosecond laser processing, it should be better.

Course Level: Undergraduate

Fourier Optics and Optical Coherence Tomography

Toyohiko Yatagai

Tuesday, Aug. 1, 2017   9:00 am – 6:00 pm

- **Lecture in Japanese**
- **Textbook and Notes provided in Japanese**

This class starts with diffraction theory of scalar wave and its description of Fourier theory. Linear theory of imaging and its application to optical information processing are introduced. Applications to interferometry, spectroscopy, high-speed optical signal processing and optical coherence tomography will be discussed.

BENEFITS/LEARNING OBJECTIVES

After taking this course, the students will be able to:

- Describe imaging systems, spatio-temporal phenomena and optical measurement systems in terms of frequency and Fourier transform.
- Understand and calculate some diffraction phenomena with Fourier transform, convolution and angular spectrum.
- Use many methods in linear signal processing in optical measurement and imaging.
- Imagine the similarity between spatial and temporal signals.

Intended Audience:

This course is intended for the scientist or engineer who needs to understand Fourier transform, linear theory of imaging, holography, numerical calculation method of diffraction effects, advanced interferometric fringe analysis, spatia-temporal signal processing and optical coherence tomography.

Course Level: Undergraduate

Introduction to Spatio-temporal Fringe Analysis for Optical Sensing and Metrology

Mistuo Takeda

Tuesday, Aug. 1, 2017   9:00 am – 6:00 pm

- **Lecture in Japanese**
- **Notes provided in Japanese**

The basics of interferometry, fringe analysis, and communication theory relevant to optical sensing and metrology are presented in this introductory course.
The emphasis is on the methodological analogies between space and time in optical sensing and metrology. The physical model of interferometric fringe formation and the basic mathematics for fringe analysis are presented. Temporal carrier techniques and spatial carrier technques are introduced, and their relative strength and weakness are discussed with specific examples of the phase shift technique and the Fourier transform method. The phase unwarpping problem is addressed and some of the practical phase unwrapping algorithms are presented. Basics of white-light interferometry and spectral interferometry are presented along with their fringe analysis.

Learning Outcomes
This course will prepare you to:

- Understand basics of interferometry and interferometers.
- Realize how communicatin theory plays an important role in optical metrology and sensing.
- Understand the principle of temporal carrier techniques and spatial carrier techniques

- Understand the relative strength and weakness of the phase shift technique and the Fourier transform method.
- Know what is the phase unwrapping problem and understand some of the practical algorithms for phase unwrapping.
- Be exposed to the basics of white light interferometry and spectral interferometry.

Intended Audience:

This class is intended for engineers, scientists, and managers who need an introduction to interferometry and fringe analysis.

Course Level: Introductory

Computational Imaging and Digital Holography

Yoshio Hayasaki

Wednesday, Aug. 2, 2017   9:00 am – 6:00 pm

- **Lecture in Japanese**
- **Notes provided in Japanese**

This course covers the principles and usages of computational imaging that is new framework of imaging system. Recently we can find some new kinds of architectures have been born. I will take up some types such as a single-pixel imaging, Fourier ptychography, and multi-aperture imaging, and discuss them while organizing systematically. This course also covers the digital holography. The usefulness has greatly increased with recent advances in biomedical and industrial metrology. Various types of implementation methods in relation to applications will be discussed.

BENEFITS/LEARNING OBJECTIVES

After taking this course, the students will:

- Understand the fundamental principle of computational imaging
- Understand the operation principles of the some types in computational imaging
- Understand the principle of digital holography
- Understand various types of implementation methods according to applications

Intended Audience:

This course is targeted at the master course students or bachelor engineer, scientist, or technician with an interest in understanding industrial and biomedical imaging based on cameras with new architectures.

Course Level: Master course students

Introduction to Crystal Optics

Kazuo Kuroda

Thursday, Aug. 3, 2017   9:00 am – 6:00 pm

- **Lecture in Japanese**
- **Notes provided in Japanese**

This course provides the principle of the optical wave propagation in anisotropic media. After the quick introduction of the vector and tensor calculus, which is inevitable mathematical tools for crystal optics, the fundamental phenomena, such as, the birefringence and optical activity are discussed. In crystal optics, various kinds of geometrical surfaces (index ellipsoid, index surface, ray surface etc.) are defined. Sometimes they causes unnecessary confusion to the beginners, although they are useful if we understand them properly. The definition and mutual relations of these surfaces are carefully discussed. At the last part of this course, the extended Jones matrix method is introduced, which provides the powerful tool for the analysis of anisotropic stratified media such as the liquid crystal display devices.

Learning Outcomes:

After taking this course, the students will:

- Learn to handle the Maxwell equations in anisotropic media.
- Understand the fundamental phenomena of crystal optics, such as, the birefringence and optical activity.
- Be able to calculate the refractive index of eigen polarization for given direction of propagation in anisotropic media.
- Image graphically the propagation of optical waves in crystals using the index ellipsoid, index surface and ray surface.
- Understand the principles of polarization prisms and filters.
- Learn to analyze anisotropic stratified media such as the liquid crystal display devices using the extended Jones matrix method.

Intended Audiences:
This course is intended for the scientists and engineers who deal with crystals, liquid crystals, and any anisotropic media.

Course Level: Undergraduate

Introduction to Polarization and its Application to Polarization Metrology

Yukitoshi Otani

Thursday, Aug. 3, 2017 9:00 am – 6:00 pm

- **Lecture in Japanese**
- **Notes provided in Japanese**

This course covers the principles of polarized light, polarization elements, and its application to polarization metrology.

The basic polarization technology including polarized light, polarization elements, the Poincare sphere, Jones vectors, Stokes paparemters, and Mueller matrices are presented uing simple methematics. In its application part, Stokes polarimeters for the measurement of light polarization, birefringence mapping by ncluding rotating polarization elements, photoelastic modulators, liquid crystals and optical heterodyne, spectroscopic Mueller matrix polarimeters and ellipsometers are treated in detail.

Benefits/Learning Outcomes:

This course will prepare you to:

- Understand the function of the basic polarization elements: polarizers, quarter wave and half wave retarders, circular retarders, and depolarizers.
- Use Jones vectors, Stokes parameters and Mueller matrix in optical instruments
- Apply birefringence mapping, Stokes polarimeters, Mueller matrix polarimeter and ellipsometer

Intended Audience:

This class is intended for engineers and scientists who need an introduction to polarization measurements.

Course Level: Introductory

Optical Device Design Program

Spectral Imaging and Infrared Detection Optics

Nathan Hagen

Tuesday, Aug. 1, 2017   9:00 am – 6:00 pm

- **Lecture in English**
- **Notes provided in Englsh**
- **Question and answer periods in English or Japanese**

This course provides participants with the background and principles for performing quantitative measurements with optical instruments, including spectral measurement and infrared detection. The course begins with the fundamentals of radiometric sensing and a survey of existing detector technologies, in each of the ultraviolet, visible, near-infrared, short-wave infrared, and thermal infrared bands. Important to understanding quantitative sensing and spectral detection in general is the ability to characterize optical systems and measurement quality, and the course provides examples from common instruments to demonstrate system characterization. The course covers the various spectrometer and spectral imaging technologies available today, and discusses the benefits and drawbacks of the various approaches. For applications making use of spectrometry, signal processing algorithms are essential for data exploitation, and a survey of existing algorithms is provided. Finally, participants will see examples drawn from infrared sensing, including a discussion of available detectors, and the many differences between measurement in the visible and infrared world.

BENEFITS/LEARNING OBJECTIVES

This course will prepare you to:

- Understand how to use optical instrumentation for quantitative imaging, spectrometry
- Understand the fundamental differences between visible and infrared detection.
- Compare different instruments and decide which is most appropriate for a measurement application.
- Understand how atmospheric phenomena such as the absorption of atmospheric gases, scattering from fog and clouds, and thermal radiation from surfaces, effect the visible and infrared world.

Course Level:
This course is intended for scientists, engineers and managers who need to understand the fundamentals of quantitative measurement principles for optical systems. The course provides a wealth of examples drawn from everyday experience so that participants gain a practical knowledge of how to apply the course content to their daily world. Some knowledge of cameras and basic optical phenomena are assumed, but the course provides most of the prerequisite knowledge.

Introducsion to Plasmonics

Takashi Fujimura

Wednesday, August 2, 2017   9:00 am – 6:00 pm

- **Lecture in Japanese**
- **Notes provided in Japanese**

This course provides the basics and application of plasmonics. Plasmonics is a research field dealing with the interaction between the light and plasmon that is a collective oscillation of free electrons inside the metal. In recent years, it is very actively studied for applications, such as nano-optical devices, nano-fabrication, high-efficiency solar cells, biosensor, and so on. In this course, we will start with Maxwell's equations, and study the characteristic optical response of the metal. Then, two types of plasomons, propagating surface plasmon and localized surface plasmon, will be explained together with some application examples. Finally, important simulation tools in plasmonics, finite-difference time-domain method (FDTD method) discrete dipole approximation (DDA), will be explained to understand the calculation principles and its characteristic features.

Benefits/Learning Outcomes:

This course will prepare you to:

This course will prepare you to:

- understand the specific optical response of metal.
- understand the basics and application of propagating surface plasmon and localized surface plasmon.
- learn the calculation principle for FDTD method and DDA.

Intended Audience:

This course is intended for engineers and scientists who are interested in nanophotonics and plasmonics.

Course Level: Undergraduate

Introduction to Optical Communications as a Key Enabler of Modern Internet Era

Milorad Cvijetic

Wednesday, August 2, 2017   9:00 am – 6:00 pm

- **Lecture in English**
- **Notes provided in English**
- **Question and answer periods in English/Japanese**

This course provides participants with fundamental knowledge and understanding of optical communications that present a foundation of modern Internet networking. The course will pay attention to understanding of key optical components (lasers and optical modulators, optical fibers, photodiodes, optical amplifiers) and their parameters that are relevant to design of optical communication systems by bridging the knowledge on the phenomena related to modulation, propagation, and amplification of optical signals with system design and applications in optical networks. The performance of optical transmission systems and networks depends on the parameters of key optical components (such as chirp parameter in optical modulators, chromatic dispersion and selfphase modulation in optical fibers, amplifier noise figure, channel crosstalk in optical multiplexers and switches, etc.) as well as on seamless engineering procedure and employment of components and modules aimed for mitigation of different impairments. The key technologies that are essential for design of high-speed transmission systems (such as advanced modulation formats based on amplitude-phase interworking, coherent detection with balanced receivers, signal multiplexing in optical frequency domain, and employment of spatial modes) will be explained and illustrated in various application scenarios. By following the engineering principles presented in this course, the attendants will be able to understand and fundamental relationships between systems parameters, tradeoffs involved in system/network design, and apply them in relevant application scenarios.

Learning Outcomes:

This course will prepare you to:

- Understand the fundamental parameters of key optical components and modules applied in optical communication systems and networks.
- Acquire the knowledge and understand the phenomena related to modulation, propagation, and amplification of optical signals.
- Become familiar with system design principles and understand how to employ components and techniques aimed for correction of impairments and system performance optimization.
- Understand variety of optical networking scenarios in modern Internet-based infrastructure.

Intended Audience:
This course is intended for scientists, engineers and managers who need to understand the fundamentals of optical transmission systems, as well as their design principles, and apply these principles in envisioned networking scenarios. This course should be particularly useful for those who need to understand the role of advanced components, methods, and tradeoffs that help to engineer reliable high performance optical transmission systems operating in various networking segments, such as nationwide network or converged broadband access networks. This course is self-contained and structured to provide straightforward guidance to audience looking to capture fundamentals and gain both theoretical and practical knowledge that can be readily applied in research and practical applications. No precondition is required for this course; the background knowledge that may be beneficial for this course is that of a typical senior-year undergraduate engineering/science students.
Course Level: Introductory/Intermediate

Introduction to Optical Wave Guide Analysis

Hirooki Sugihara

Thursday, Aug. 3, 2017 9:00 am – 6:00 pm

- **Lecture in Japanese**
- **Notes provided in Japanese**

This course covers analysis of wave propagation in optical fiber and optical waveguide, its physical significance, and applications. As optical communication, and optical interconnect are getting attention, engineers encounters to solve problems in fundamental wave guiding to its application to system. This course addresses physics of optical fiber and optical wave guding especially from a viewpoitnh of optical interconnect. Also topics on light source, detector and packaging are covered.

Benefits/Learning Outcomes:

This course will prepare you to:

- Derive mode dispersion equation from Maxell's equastions.
- Understand single and multimode wavaguiding
- Understand loss and bandwidth of optical waveguide and optical fiber.

- Understand matching between optical wavegudes and fibers to detectors, and discuss its application to optical interconnect.

Intended Audience:

This class is intended for engineers and scientists who need an introduction to fundamentals on optical wavegude and interconnect.

Course Level: Introductory, undergraduate level of knowledge is required.

Polarization in Optical Design

Russell A. Chipman

Thursday, Aug. 3, 2017 9:00 am – 6:00 pm

- ***Lecture in English***
- ***Notes provided in English***
- ***Question and answer periods in Japanese***

Polarization in Optical Design surveys methods for calculating and analyzing polarization effects in optical systems. The fundamental concepts of polarization ray tracing are presented, and a series of examples are studied using the polarization ray tracing software Polaris-M. Polarization ray tracing is concerned with simulating the effects of optical elements, polarization elements, stress birefringence, and other effects.

Optical design has recently made great advances in the analysis of polarization effects in optical systems. Optical systems have polarization properties in addition to their wavefront aberrations. Many optical systems are polarization critical and require careful attention to polarization issues. Such critical systems include liquid crystal projectors, high numerical aperture optical systems in microlithography, optical coherence tomography, interferometers, spectrometers, and coronagraphs for exoplanet detection.

First the polarization aberrations from thin film coatings are considered. Similar methods are used to ray trace liquid crystal cells. Then examples from crystal optics are ray traced, including evaluating the angle and wavelength performance of retarders and the extinction of Glan-Taylor crystal polarizers. Methods for the simulation of stress birefringence are presented, where the light propagates through stress fields resulting from mounting or injection molding, changing the wavefront, polarization state, and point spread function. Diffraction gratings and holographic optical elements are analyzed by including rigorous coupled wave analysis, RCWA, within the polarization ray trace.

By the end of the course, the attendee will be familiar with methods for combining conventional optical design by ray tracing with the methods of polarization analysis, and its application to many applications in optics.

Learning Outcomes:

This course will prepare you to:

- Become familiar with the polarization effects of the most important optical elements including
  - Lenses and mirrors
  - Thin film coatings
  - Polarization elements
  - Corner cubes
  - Diffraction gratings
  - Liquid crystal cells
  - Stress birefringence
- Understand how to follow the polarization changes along a ray path through a series of lenses, mirrors, polarization elements and anisotropic materials.
- Understand how polarization state dependent point spread functions and modulation transfer functions are calculated.

- Visualize the Maltese cross, linear polarization tilt, and other fundamental polarization aberration pattern which occur in many systems.
- Acquire the understanding to develop polarization specifications for optical systems

Intended Audience:

Scientists and engineers concerned with polarization effects in optical systems and their simulation. Familiarity with optical systems, optical design, ray tracing, aberrations, polarization elements, and linear algebra is assumed.

Course Level: Intermediate

Advanced Optics: DOEs CGHs and Adaptive Optics

Tom D. Milster

Thursday, Aug. 3, 2017 9:00 am – 6:00 pm

- **Lecture in English**
- **Notes provided in English**

This intermediate course provides a basis for understanding diffractive optical elements (DOEs) computer generated holograms (CGHs), and Adaptive Optics.
A conceptual understanding of Fresnel diffraction is developed from the concept of Fresnel zones to describe the Fresnel zone plate and diffractive optical elements (DOEs). This principles is expanded with respect to application for understanding computer-generated holograms (CGHs). The fabrication of use of DOEs and CGHs in optical systems is discussed. As approximately 1/3 of the course, Adaptive Optics will be discussed with applications in microscopy, astronomy, and high-energy laser systems.

Benefits/Learning Outcomes:

This course will prepare you to:
- Apply the principles of Fresnel diffraction to understand the function of diffractive optical elements (DOEs) and computer-generated holograms (CGHs).
- Use the concept of Fresnel diffraction to estimate diffraction profiles.
- Calculate the focusing properties of Fresnel zone plates and DOEs.
- Understand design of CGHs for display of image patterns.
- Understand the construction and use of DOEs and CGHs in optical systems.
- Understand the basic principles of Adaptive Optics and how they are used in microscopy, astronomy and high-energy laser systems.

Intended Audience:

This class is intended for engineers, scientists, and managers who need a physical introduction to interference, diffraction, DOEs and CGHs. A basic familiarity with the principles of interference and diffraction is suggested.

Course Level: Intermediate

Course Registration and Questions

www.optics.arizona.edu/tokyo-short-course

www.short-course.org

To register, ask questions regarding money transfer, and receipts (in Japanese):

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For the information about the College of Optical Sciences, and Center for Optical Research and Education, please refer to the following web site.

www.optics.arizona.edu
www.opt.utsunomiya-u.ac.jp/e_index.html

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