OPTI414/514 Optical Instrumentation

This course will introduce students to the principles, designs, applications, and recent developments of a broad variety of optical instruments. Upon completion of the course students will be able to understand optical principles, design requirements, and how to apply these instruments in practices.

Prerequisite: OPTI 340

Grading:
OPTI414 (undergraduate):
Homework 40%
Midterm 30%
Course project 30%

OPTI514 (graduate)
Homework 25%
Midterm 25%
Course project 25%
Presentation 25%

Course Outline

1. Eye
   - 1.1 Human eye
     - 1.1.1 Human structure and properties
     - 1.1.2 Schematic eye
     - 1.1.3 Human eye inspired optics
   - 1.2 Animal eye
     - 1.2.1 Animal eye structure and properties
     - 1.2.2 Animal eye inspired optics
2. Introduction to microscopy
   - 2.1 Fundamentals
   - 2.2 Objectives
     - 2.2.1 Types of objectives
     - 2.2.2 Design principles
   - 2.3 Reflective objectives
   - 2.4 Tube lens
   - 2.5 Illumination
     - 2.5.1 Critical illumination
     - 2.5.2 Kohler illumination
     - 2.5.3 Dark field illumination
   - 2.6 Stereo microscopes
     - 2.6.1 Design considerations
     - 2.6.2 Applications
   - 2.7 Eyepieces
     - 2.7.1 Types of eyepieces
     - 2.7.2 Design principles
3. Advanced microscopy
   - 3.1 Phase contrast microscope
     - 3.1.1 Principle
     - 3.1.2 Applications
   - 3.2 Differential interference contrast microscope
     - 3.2.1 Principle
     - 3.2.2 Applications

7. Displays
    - 7.1 History
    - 7.2 Projection displays
        - 7.2.1 Principle
            - 7.2.1.1 Light valves
            - 7.2.1.2 Configurations
            - 7.2.1.3 Illumination systems
        - 7.2.2 DMD projection display
        - 7.2.3 LCD projection display
        - 7.2.4 LCoS projection display
    - 7.3 Pico projector
    - 7.4 Flat panel displays
        - 7.4.1 Optical films
        - 7.4.2 Light guide plate
    - 7.5 Digital cinema
    - 7.6 3D display
        - 7.6.1 3D display with viewing aids
        - 7.6.2 Autostereoscopic displays
8. Spectral imaging systems
    - 8.1 Fundamentals
    - 8.2 Spectral imaging systems
    - 8.3 Optical configurations
        - 8.3.1 Raster scanning
        - 8.3.2 Line scanning
        - 8.3.3 Band-sequential imaging
        - 8.3.4 Band-simultaneous imaging
        - 8.3.5 Fully simultaneous imaging
    - 8.4 Design considerations
    - 8.5 Applications
9. Optical Coherence Tomography (OCT)
    - 9.1 Low coherence interferometry
    - 9.2 Optical coherence tomography
        - 9.2.1 Principle
        - 9.2.2 Time-domain OCT
            - 9.2.2.1 Optical delay lines
            - 9.2.2.2 Scanning optics
        - 9.2.3 Fourier-domain OCT (FD-OCT)
            - 9.2.3.1 Spectral-domain OCT (SD-OCT)
            - 9.2.3.2 Swept source OCT (SS-OCT)
    - 9.3 Ultra-high resolution OCT
    - 9.4 Multimodal OCT
    - 9.5 Applications
10. Confocal system
    - 10.1 Introduction
    - 10.2 Basic components and requirements
    - 10.3 Confocal scanning systems
        - 10.3.1 Scanning systems
        - 10.3.2 Relay optics
    - 10.4 Optical design of the objective lenses
    - 10.5 Fiber-optic confocal imaging systems
        - 10.5.1 Single fiber confocal system
        - 10.5.2 Fiber bundle confocal system

11. Endoscopy
    - 11.1 Introduction
    - 11.2 Basic optics for endoscopes
    - 11.3 Relay lenses
    - 11.4 Objective lenses
    - 11.5 Illuminations
    - 11.6 Wireless endoscopes
        - 11.6.1 Objective lens
        - 11.6.2 Illumination
12. Infrared systems
    - 12.1 Introduction
        - 12.1.1 Special aspects of infrared imaging
        - 12.1.2 Radiation and emissivity
        - 12.1.3 Atmospheric transmittance
    - 12.2 Infrared materials
    - 12.3 Infrared detectors
    - 12.4 Infrared imaging systems
    - 12.5 Optical design for infrared systems
    - 12.6 Athermalization
    - 12.7 Narcissus
13. Lithographic systems
    - 13.1 Introduction
    - 13.2 Physical optics aspects
    - 13.3 Performance of lithographic lenses
    - 13.4 Evolution of lithographic lens systems
        - 13.4.1 Aspherical systems
        - 13.4.2 Immersion systems
        - 13.4.3 Catadioptric systems
        - 13.4.4 Mirror systems
    - 13.5 Optical design for lithographic systems

Textbook:
No textbook required

Grading Scale:
85-100%: A
75-85% : B
65-75% : C
50-65% : D
<50% : E

Homework Policy:
Regular homework assignments will be given one week before the due date. All homework is due at the beginning of class on the due date. Late homework will receive up to 50% deduction.