PPME 4031
Engineering Optics
(Toy with Light)
Department of Power Mechanical Engineering

Instructor: Wei-Chih Wang, Ph.D.
Office: Delta Hall 319
Grading: credits
Class Time: Lecture M 1:20-3:10 (TBA)
Lab Th 1:10-2:10 PM (TBA)
Class website: depts.washington.edu/me557/optics
Reading materials can be downloaded from: : depts.washington.edu/me557/readings

Moiré Interferometry shows the deformation caused by partial drying of a human tooth section. The contour interval is 0.417 µm/fringe
(courtesy of Measurements Group)

Objectives

The main goal of this course is to introduce engineers to the characteristics of light that can be used to accomplish a variety of engineering tasks especially in mechanical analysis at macro and micro scales. At the end of the course, students should have a broad understanding of the fundamental science, basic operation, technology choice, and practical aspects of free space and guided-wave optics, with an emphasis on the applications for optics in mechanical measurement, and have a sense of how to evaluate the potential of optical methods vs. non-optical methods for any task.

The course involves lectures, design homework, laboratory work and a final project. The course is focused on the study of mechanical behavior of materials through optical experimental methods. The theoretical background and technique for testing will be extensively discussed. The lab work involves several major projects as well as various testing demonstrations. Most of the projects involve analysis, instrumentation, and theoretical predictions, as well as written reports. The final design project will require both theoretical and actual hardware design as well as an oral and written presentation.

Topics

Review of Geometric Optics and Electromagnetic wave Theory
Introduction to light sources and photodetectors
Geometric Moiré: In-plane displacement measurement
Geometric Moiré: out of plane displacement measurement
Moiré Interferometry: Interference and Diffraction, Grating fabrication
Moiré Interferometry: Holographic and Laser Speckle Interferometry
Photoelasticity: theory, techniques and
Multilayer structure: waveguide, filters
Introduction to fiber optic and waveguide delivery and detection
Periodic structure sensors

Audience

This course is for persons interested in experimental mechanics, physics, stress analysis, deformation analysis, motion measurement, engineering design, structural testing, metrology, nondestructive inspection,

and similar fields. This course mainly serves students in mechanics, and civil, mechanical, and materials engineering. This course should also be of interest to those interested in validation of numerical models.
"Experimental evidence is the truth theory must mimic."

Course Prerequisite(s)

- First year physics in Optics or permission of instructor.
- Junior level Mechanics of materials or equivalent.
- Knowledgeable in CAD Software (e.g. AutoCAD or SolidWorks)
- A creative mind and willingness to get one's hands dirty in construction
- Come to class with an open mind and a willingness to participate fully!

Course Outline:
GOALS: To develop student understanding of

Week 1 Introduction of light – nature of light, Production and measurement of light Electromagnetic spectrum, Ray-Optics Approach (Snell's law, Geometric optics, thin lens, mirror and matrix method)
Week 2 Ray-Optics Approach (Snell's law, Geometric optics, thin lens, mirror and matrix method)
Week 3 Ray-Optics Performance Factors (diffraction effect, aberrations- geometry, chromatic, astigmatism, coma, field curvature, distortion, lateral color)
Week 4 Electromagnetic-Wave Approach (wave equation, polarization, diffraction, interference, grating)
Week 5 Electromagnetic-Wave Approach (wave equation, polarization, diffraction, interference, grating)
Week 6 Electromagnetic-Wave Approach (wave equation, polarization, diffraction, interference, grating)
Week 7 Optical Components (optical materials, coatings, filters, mirrors, lenses, prisms and polarizing optics)
Week 8 Light sources (broad band gas and filament light sources, LED, coherent gas and solid state light sources)
Week 9 Light sources (broad band gas and filament light sources, LED, coherent gas and solid state light sources
Week 10 Detectors (photodiode, phototransistor, photomultiplier, CCD camera)
Week 11 Optics in mechanical measurement: Free space Optics (Geometric Moiré: In-plane displacement measurement)
Week 12 Optics in mechanical measurement: Free Space Optics (Moire Interferometry: Interference and Diffraction, Grating fabrication)
Week 13 Optics in mechanical measurement: Free Space Optics (Moiré Interferometry: Holographic and Laser Speckle Interferometry)
Week 14 Optics in mechanical measurement: Free Space Optics (Photoelasticity, birefringent property measurement, digital imaging method)
Week 15 Optics in mechanical measurement: Fiberoptic and polymer waveguide sensors (Intensity modulation, phase modulation)
Week 16 Optics in mechanical measurement: Fiberoptic and polymer waveguide sensors (Intensity modulation, phase modulation)
Week 17 Optics in mechanical measurement: Fiberoptic and polymer waveguide sensors (Intensity modulation, phase modulation)
Week 18: Final Presentations

Grading:

There will be biweekly Design Homework, four labs and a final design project and presentation.

HW and design Projects: 60%
Lab: 20%
Final Project: 20%