ME 297
Opto-mechanical Systems Analysis
L1

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SJSU

Course Format

- A project-based and hands on approach. Homework assignments and exams will be real problems from the industry that the students are currently working in.
- **Each** class meeting include
  – A 50-minute introductory lecture based on the reading assigned and notes prepared by the instructor, tutorials, standards, etc.
  – 10 minute brake
  – A 2-hour activity session including learning software and creating designs, discussions for design ideas, design reviews, etc.
  – A 10 minute brake
  – A 50-minute lecture on in-depth analysis of the activity and design procedure.

Course Goals; To learn

- the **major principles** of **optomechanical systems** engineering.
- the **techniques** used and challenges when designing **athermal optical systems**.
- the **material characteristics** for use in optomechanical systems.
- the techniques used and challenges **of optical system alignment when** mounting the optical components in the mechanical parts.
- the **stray light affects**, suppression techniques surface finish selection, and other system parameters affected by the **optomechanical interface**
- the **design procedures** for both optical and mechanical parts of a **simple optomechanical system**.

Student Learning Objectives

- **Create** a simple optical design based on the specifications required
- **Generate** a performance report for the design using optical design software
- **Create** a simple mechanical design to mount a simple optical component and generate mechanical drawings
- **Combine** an optical design with a mechanical design
- **Perform** tolerancing and determine error budgets in optomechanical systems
- **determine** sensitivities and choose compensators.
- **Develop** an alignment plane and procedure.
- **Specify** optical mounting systems
- **Guide** materials selection based on advance figures of merit
- **Define** and develop system design parameters to meet various environmental conditions

Required Text

- **Y: Opto-Mechanical Systems Design, by Paul Yoder. CRC Press**
- **V: Introduction to Opto-Mechanical Design By D. & S. Vukobratovich (out of print reserve copies are provided. Check with your adminstrator)**
- **CV: CodeV Introductory User's Guide**
- **LN: Online Lecture Notes and other resources available at: http://www.erbion.com/courses.htm**

Additional References

- Handbook of Optomechanical Engineering, by Anees Ahmad, CRC.
- Modern Optical Engineering, by Warren Smith, McGraw Hill
- Mounting Optics in Optical Instruments, by Paul Yoder, SPIE Press
- Optical Systems Design, second edition, by .Fsher, Tadic-Galed, and Yoder. SPIE Press 2008
- Introduction to Opto-Mechanical Design By D. & S. Vukobratovich
- SPIE short course videos on optomechanical engineering and optical engineering (Few are available at SJSU's King library)

Software

- **Code V Educational License + CodeV Introductory User's Guide**
- **SolidWorks or AutoCAD Educational License**

Grading

- Homework 30%
- Midterm project / report 30%
- Final project / report / presentation 40%

Reports

- Write **quality**, **concise** technical reports
- Writing with a sense of **audience** and **purpose**
- Organization, including all the necessary segments:
  - Tell them what you want to tell them
  - Tell them
  - Tell them what you told them
- writing reports that **emphasize results**, rather than process
- use of graphics, data to support your arguments
- use of appendices (part of organization), references, indexes, etc.

Syllabus: Week 1

wk Date	hrs	Class / content / knowledge	Reading & Assignment	Objectives /Skills
1 9/13	1h lec	Course overview and structure Teaching method Student learning objective Expectations for technical reports. Intro to Optomechanical Engineering (OME)	Y1 (means Yoder chapter 1) LN1 (Lecture notes 1)	Understand role of the optomechanical engineer (OME) in general Write quality, concise technical reports Understand key issues to be addressed in a technical report
	2h lec	Optical system terminology refresher Nature of light and basic laws First order optics of lenses & mirrors, ray tracing	LN2	Dual nature of light, harmonic wave properties, index of refraction, dispersion, Abbe number, Snell's laws, definition and purpose of optical systems, OPL, wavefront, phase, ray tracing, diffraction, matrix methods, cardinal points and planes, object, image, cardinal point relationships, system LOS, magnification, image orientation, thin prisms
	1h ws	Ordering and installation of the software Overview of the CODE V	CV1 & CV2 Creating a simple optical design using a ray trace program	Software intro and how to purchase

What is opto-mechanical engineering?

- Optical engineering (OE): Design and characterization of systems that use or manipulate light. Prediction of light's behavior based on theory and simulation.
- Mechanical engineering (ME): Design and analysis of systems with mechanical parts. Theoretical calculations and simulation based on physics, materials science, and engineering mechanics.
- Optomechanical engineering (OME): the field of engineering dealing with
  - mechanical aspects of optical systems
  - integration of optical systems with mechanical parts.

Example of tasks

- <u>Optical engineering</u> that require some optomechanics
  - Tolerancing of optical systems
  - Fabrication of optics
  - Optical alignment
  - Analysis of optical systems including mounting effects
  - Performance analysis under various working conditions
- Optomechanical engineering:
  - Design of mounts for optical elements
  - Design of a system that allows precision adjustments
  - Analysis of distortion of an optical instrument with orientation, and thermal environment
- There is a big overlap of responsibilities and close collaboration is essential for success

Roles of OE, ME, and OME in design process

- OEs and MEs are hired to **<u>build</u>** system vs. design and study them on paper.
- Building requires dealing with mechanical aspects of the system
- Good command of analytical & computer models is necessary but not enough.
- Analysis helps to:
  - make **<u>tradeoffs</u>** for maximum efficiency.
  - improve performance **<u>only to the level that is required</u>** and justified from cost point of view.
  - Make sure the system **<u>will</u>** meet the requirements **<u>prior to building</u>**
  - **<u>Optimize</u>** the system (cost-benefit analysis), entirely for **<u>performance</u>** or entirely for **<u>cost</u>** & **<u>manufacturability</u>** or somewhere in between.
- **<u>Close communication</u>** of OE and ME via OME is essential for fully exploiting the system tradeoffs in the design, such as **modifying the optical design to loosen a difficult tolerance etc**.