OPTI 421/521: Introductory optomechanical engineering

Updated 08/01/2022

Fall 2021

Lectures Wednesday/Friday 9:30am-10:45am MST, Room 307.

Course Description

This course covers the basic principles of optomechanical engineering. This course is taught for students who are familiar with optical systems and covers those mechanical engineering concepts necessary for optomechanical engineering. Topics include optics mounting, alignment, thermo-mechanical disturbances, drawings, specifications, and fabrication of mechanical components.

Instructor: Dr. Brandon Chalifoux

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Office hours: Thursdays 2-3:30 pm MST at Meinel 747, or by appointment
Office hours zoom link: https://arizona.zoom.us/j/82686793892 (password: optomech)

Teaching assistant: Trevor Schlack

Email: schlackt@arizona.edu
Office hours: Tuesdays 1-2 pm MST at Meinel 654, or by appointment
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Learning outcomes

After taking this course, students should be able to:

- Determine optomechanical tolerances for basic optical systems
- Design static and adjustable mounts for small optical components
- Read and create component and assembly drawings for optomechanical systems
- Analyze effects of thermal and mechanical loads on performance and survival of optical systems
- Make mechanical design choices that facilitate optical system fabrication, assembly, and testing

400/500 Co-convened Course information

Graduate students will complete a more complex design project than undergraduate students, and will be assigned additional problems.

Acknowledgement

Course materials were adapted from those generously provided by Dr. James H. Burge, Dr. Daewook Kim, and Dr. Jonathan D. Ellis.

Recommended Texts and Materials

Fundamentals of Optomechanics, by Daniel Vukobratovich and Paul Yoder, CRC Press, 2018.

Field Guide to Optomechanical Design and Analysis, by Katie Schwertz and James Burge, SPIE, 2012.

These are available at **no cost to you** through UA libraries. In D2L, go to Library Tools and click on the links under Unlimited-Use Ebooks. You may download and keep both books.

Assessment

Grading will be based on 4 problem sets, a midterm exam, and a design project:

Element	Due date	Fraction of grade
Homework		
Problem set 1	9/16	10%
Problem set 2	9/30	10%
Problem set 3	10/14	10%
Problem set 4	10/28	10%
Midterm exam	11/9	30%
Design project	12/7	30%

Project details and guidance will be outlined in a separate document.

Grading scale and policies

Grading will be on a regular scale: A (>=90%), B (>=80%), C (>=70%), D (>=60%), E (<60%)

Late assignments (without prior approval) will lose 25% per day, to a minimum value of 0.

All deadlines are 11:59pm MST. All assignments must be uploaded to D2L.

University policies

All university policies related to a syllabus are available at: https://academicaffairs.arizona.edu/syllabus-policies.

Subject to change notice

Information contained in the course syllabus, other than the grade and absence policies, may be subject to change with reasonable advance notice, as deemed appropriate by the instructor of this course.

Graduate student resources

University of Arizona's Basic Needs Resources page: http://basicneeds.arizona.edu/index.html

Accessibility and accommodations

At the University of Arizona, we strive to make learning experiences as accessible as possible. If you anticipate or experience barriers based on disability or pregnancy, please contact the Disability Resource Center (520-621-3268, https://drc.arizona.edu) to establish reasonable accommodations.

Tentative schedule

Deadlines (in bold) subject to change with advance notice. Lecture topics subject to change without notice.

	Date	Suggested Reading*
Unit 1: Introduction		
Lecture 1: Optomechanical engineering overview	8/24	
Lecture 2: Rigid body motion of optical components	8/26	S&B: pp. 1-12
Lecture 3: Basic lens, prism, and mirror mounts	8/31	[skim] V&Y: §4.2.3, 4.3.2, 5.4, 5.7, 5.9, Ch. 7
Unit 2: Optomechanical tolerances and mechanical design		
Problem set 1 released (5pm MST)	**9/2**	
Lecture 4: Optical assembly and tolerancing	9/2	V&Y: §5.2, 6.3, 6.5-6.7
Lecture 5: Tolerancing with compensators	9/7	
Lecture 6: Mechanical solid modeling	9/9	SW Tutorials (see D2L)
Lecture 7: Machining technologies and typical tolerances	9/14	Videos (see D2L)
Problem set 1 due (5pm MST), Problem set 2 released (5pm MST)	**9/16**	
Lecture 8: Achieving tight tolerances: shims and active bonding	9/16	
Lecture 9: Screws and stages	9/21	
Lecture 10: Mechanical and optical drawings	9/23	S&B: pp. 27-40
Unit 3: Mechanical engineering concepts		
Lecture 11: Common analyses, and statics	9/28	
Problem set 2 due (5pm MST), Problem set 3 released (5pm MST)	**9/30**	
Lecture 12: Preload, springs, and friction	9/30	
Lecture 13: Stress, strain, and strength	10/5	S&B: pp. 14-20
Lecture 14: Optomechanical materials	10/7	V&Y: Ch. 3
Lecture 15: Stiffness of beams and plates	10/12	
Problem set 3 due (5pm MST), Problem set 4 released (5pm MST)	**10/14**	
Lecture 16: Structural analysis examples	10/14	
Lecture 17: Point and line contacts	10/19	V&Y: §5.6, 5.8.1, 11.3.7
Lecture 18: Analyzing lens mounts in detail	10/21	
Lecture 19: Kinematic couplings and flexures	10/26	V&Y: §11.1-11.3
Problem set 4 due (5pm MST), Practice exam released (5pm MST)	**10/28**	
Lecture 20: Adhesive bonding	10/28	V&Y: §7.5,9.4
Unit 4: Thermal, vibration, shock effects		
Lecture 21: Introduction to thermal expansion	11/2	V&Y: §5.7
Exam review	11/4	
Midterm exam	**11/9**	
Lecture 22: Thermal loss of preload	11/11	V&Y: §6.4.1-6.4.6
Lecture 23: Simulating thermal focus shift	11/16	V&Y: §6.4.4, 6.4.7
Lecture 24: Introduction to Vibration and shock	11/18	
Lecture 25: Designing for vibration and shock	11/23	
Unit 5: Basics of finite element analysis		
No lecture – Thanksgiving break	11/25	
Lecture 26: Introduction to finite element analysis (FEA)	11/30	
Lecture 27: Static FEA	12/2	
Final project report due	**12/7**	
Lecture 28: Extracting optical information from FEA	12/7	

* S&B: Schwertz and Burge; V&Y: Vukobratovich and Yoder; SW: SolidWorks; SME: Society of Manufacturing Engineers