OPTI 421/521: Introductory optomechanical engineering

Fall 2024 (Updated 9/29/2024)
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 2-3:30pm MST, Room 654
Office hours zoom link: https://arizona.zoom.us/j/87990587168?pwd=nivHCQHJbzjG7owwbaJEbpQ29AvzgR.1
(password: 0pt0mech)

Teaching assistant: Kevin Laverty

Email: kevinlaverty@arizona.edu
Office hours: Fridays 1-2pm MST, Room 654
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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 8 homework assignments, a midterm exam, and a design project:

Element	Due date	Fraction of grade
Homework		45%
Homework 1	9/3	5%
Homework 2	9/11	5%
Homework 3	9/23	7.5%
Homework 4	10/2	7.5%
Homework 5	10/14	7.5%
~~Homework 6~~	~~10/14~~	~~5%~~
Homework 7	10/21	5%
Homework 8	11/20	7.5%
Midterm exam	11/4	25%
Design project*	12/11	30%

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

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: Optical mount geometry		
Lecture 1: Optomechanical engineering	8/26	
Lecture 2: Optics and rigid body motions	8/28	S&B: pp. 1-12 Lens motion notes (D2L)
Homework 1 due	**9/3**	
Lecture 3: Optical mounts and their geometry	9/4	[skim] V&Y: §4.2.3, 4.3.2, 5.4, 5.7, 5.9, Ch. 7
Lecture 4: Basic lens tube design	9/9	[skim] V&Y: §5.2, 6.3, 6.5-6.7
Homework 2 due	**9/11**	
Lecture 5: Mechanical fabrication	9/11	Videos (D2L)
Lecture 6: Lens mount fabrication, mechanical drawings	9/16	Recommended tolerances notes (D2L)
Unit 2: Optomechanical mount design for survival		
Lecture 7: Statics, stress, strain, strength, and springs	9/18	
Homework 3 due	**9/23**	
Lecture 8: Springs, preload, loss of contact	9/23	Loss of contact notes (D2L)
Lecture 9: Point and line contact stiffness	9/25	V&Y: §5.6, 5.8.1, 11.3.7
Lecture 10: Thermal expansion	9/30	
Homework 4 due	**10/2**	
Lecture 11: Thermal loss of contact	10/2	Thermal loss of contact notes (D2L)
Lecture 12: Beam bending	10/7	
Lecture 13: Flexures	10/9	V&Y: §11.1-11.3
Homework 5 due	**10/14**	
Lecture 14: Stress and failure	10/14	S&B: pp. 14-20
Lecture 15: Optomechanical materials	10/16	
Homework 7 due (11:59pm MST)	10/21	
Lecture 16: Analysis of retaining ring mounts	10/21	V&Y: §6.4.1-6.4.6
Lecture 17: Adhesive bonding	10/23	V&Y: §7.5,9.4
Practice exam released	**10/23**	
Lecture 18: Analysis of adhesive bonded mounts	10/28	V&Y: §5.7
Midterm exam review	**10/30**	
Midterm exam (no lecture)	**11/4**	
Unit 3: Optical tolerancing		
Lecture 19: Introduction to optical tolerancing	11/6	
Lecture 20: Compensators	11/13	
Lecture 21: Optical tolerancing with automated tools	11/18	
Homework 8 due (11:59pm MST)	11/20	
Lecture 22: Screws and stages	11/20	S&B: pp. 27-40
Lecture 23: Optomechanical compensation mechanisms	11/25	
Lecture 24: Thermal focus shift	11/27	V&Y: §6.4.4, 6.4.7
Lecture 25: Athermalization	12/2	Athermalization notes (D2L)
Unit 4: Advanced topics		
Lecture 26: Film stress and temperature gradients	12/4	
Lecture 27: Vibration and shock	12/9	
Final project report due	**12/11**	
Lecture 28: Introduction to finite element analysis	12/11	

* S&B: Schwertz and Burge; V&Y: Vukobratovich and Yoder