OPTI 423/523: Optomechanical Design and Analysis

Updated 01/09/2024

Spring 2024

Lecture Monday/Wednesday 11:00am-12:15pm MST.

Course Description

This course will focus on the optomechanical engineering design process, building on material covered in OPTI 421/521 and filling in some gaps. We will cover detailed analysis using finite element modeling and coupling with optical analysis software. Students will complete a design project on an optomechanical topic of their choosing.

Instructor information

Brandon Chalifoux
Assistant Professor, Optical Sciences
Assistant Professor, Aerospace and Mechanical Engineering
Email: bchal@arizona.edu
Office: Meinel 733
Office hours: By appointment
Office hours Zoom link: HTTPS://ARIZONA.ZOOM.US/J/5972446832 (password: 0pt0mech)

TA information

Yexin Pei
PhD student, Optical Sciences
Email: ypei18@arizona.edu
Office hours: TBD
Office hours Zoom link: TBD

Learning outcomes

After taking this course, students should be able to:

- Construct error budgets for optomechanical systems
- Identify design aspects that require detailed analysis
- Evaluate numerical models for accuracy using several approaches
- Integrate numerical and optical simulation tools

400/500 Co-convened Course information

Graduate students will complete a design project with wider scope than undergraduate students, and will be assigned additional problems.

Required Texts and Materials

Doyle, Genberg, Michels, "*Integrated Optomechanical Analysis,"* 2nd Edition, SPIE Press, 2012

Opto-Mechanical Systems Design, Volume 2: Design and analysis of large mirrors and structures, edited by Paul Yoder and Daniel Vukobratovich, Taylor & Francis Group, 2015.

These are available at **no cost to you** through UA libraries.
https://ebookcentral.proquest.com/lib/UAZ/detail.action?docID=1693413

https://www-spiedigitallibrary-org.ezproxy4.library.arizona.edu/ebooks/PM/Integrated-Optomechanical-Analysis-Second-Edition/eISBN-9780819492494/10.1117/3.974624?SSO=1

Software

The following software will be used: Microsoft Excel, SolidWorks, Zemax OpticStudio, Matlab.

Students are free to use finite element analysis or ray tracing software of their choice, with the understanding that there is little or no support for software other than the packages listed above.

All software is available from UArizona or the College of Optical Sciences at no cost to you.

Assessment

Grading will be based on 3 Analysis Reports and a design project:

Element	Due date	Fraction of grade
Assignments		45%
Report 1	2/5	*15%*
Report 2	2/26	*15%*
Report 3	4/8	*15%*
Design project		55%
Proposal and preliminary requirements	1/29	*5%*
Midterm review	3/25 – 3/26	*15%*
Final report	5/1	*30%*
Presentation and participation	4/22-5/1	*5%*

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

Detailed schedule and **deadlines**	Date	Suggested reading*
Unit 1: Fundamentals of optomechanical system design		
Lecture 1: Introduction and overview	1/10	
Lecture 2: Review of optomechanical effects	1/17	
Lecture 3: Requirements and error budgeting	1/22	
Analysis Report 1 specification released	**1/22**	
Lecture 4: Preliminary design	1/24	
Lecture 5: Surface errors and fitting polynomials	1/29	DGM 3.1, DGM Ch. 4
Project proposal and requirements due (11:59pm MST)	**1/29**	
Lecture 6: First-order flexure design and analysis	1/31	
Analysis Report 1 due (11:59pm MST)	**2/5**	
Lecture 7: Stiffness matrices	2/5	DGM 6.2, 6.4.2
Lecture 8: Rigid body vibration modes and mirror bending	2/7	DGM 1.2-1.4
Unit 2: Introduction to Finite Element Analysis (FEA)		
Analysis Report 2 specification released	**2/12**	
Lecture 9: Static structural and modal FEA	2/12	
Lecture 10: Modeling adhesive bonds	2/14	DGM 6.1
Lecture 11: FEA theory	2/19	DGM 1.5, 5.1.3-5.1.4
Lecture 12: Simplified models	2/21	
Analysis Report 2 due (11:59pm MST)	**2/26**	
Lecture 13: Connections, linearity	2/26	
Unit 3: Thermal and dynamic FEA		
Lecture 14: Thermal analysis	2/28	
Spring recess	3/4-3/8	
Lecture 15: Thermal effects on ray tracing	3/11	DGM 1.4.4-1.4.5, 9.1-9.2
Lecture 16: STOP analysis	3/13	DGM 9.3-9.6
Lecture 17: STOP analysis examples	3/18	DGM 8.4-8.5
Midterm report due	**3/18**	
Lecture 18: Stress birefringence	3/20	
Midterm project reviews [Zoom, No lecture on 3/25]	**3/25, 3/26**	
Lecture 19: Introduction to dynamic analysis	3/27	DGM 7.1-7.3
Analysis Report 3 specification released	**3/27**	
Lecture 20: Evaluating response to vibration	4/1	DGM 7.4, 7.7, 7.11
Lecture 21: Simulating shock loading	4/3	DGM 7.6
Unit 4: Large and flexible mirrors		
Lecture 22: Large mirror architectures *[Recorded only]*	4/8	Y&V 2.1-2.2, 3.2, 3.7-3.8, 4.5-4.6, 5.6
Lecture 23: Lightweight mirror models *[Recorded only]*	4/10	
Analysis Report 3 due	**4/10**	
Lecture 24: Fabrication and film stress	4/15	DGM 5.2
Lecture 25: Deformable mirrors	4/17	DGM 10.1-10.7
Student presentations [Zoom]	**4/22 – 5/1**	
Final project due	**5/1**	

* DGM: Doyle, Genberg, Michels; Y&V: Yoder and Vukobratovitch, volume 2.