OPTI 423/523: Optomechanical Design and Analysis

Updated 1/10/2023

Spring 2023

Lecture Monday/Wednesday 11:30am-12:45pm 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

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/89110822399 (password: 0pt0mech)

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 students.

Assessment

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

Element	**Due date**	**Fraction of grade**
Analysis Reports		
Report 1	2/8	15%
Report 2	3/1	15%
Report 3	4/3	15%
Design project		
Proposal	2/1	5%
Midterm review	3/22 – 3/23	15%
Final report	5/3	30%
Presentation and participation	4/29, 5/1, 5/3	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	Reading*
Unit 1: Fundamentals of optomechanical system design		
Lecture 1: Introduction and overview	1/11	
Lecture 2: Review of optomechanical effects	1/18	
Lecture 3: Error budgeting and preliminary design	1/23	
Analysis Report 1 specification released	**1/23**	
Lecture 4: Surface errors: fitting polynomials	1/25	DGM 3.1
Lecture 5: Optomechanical analysis workflows	1/30	DGM Ch. 4
Project proposal due (11:59pm MST)	**2/1**	
Lecture 6: First-order flexure design and analysis	2/1	
Analysis Report 1 due (11:59pm MST)	**2/6**	
Lecture 7: More flexure design and analysis	2/6	DGM 6.2, 6.4.2
Unit 2: Introduction to Finite Element Analysis (FEA)		
Lecture 8: Basic concepts in FEA	2/8	DGM 1.2-1.4
Analysis Report 2 specification released	**2/13**	
Lecture 9: Static structural FEA	2/13	
Lecture 10: Finite element…elements	2/15	
Lecture 11: Shells, symmetry	2/20	DGM 1.5, 5.1.3-5.1.4
Lecture 12: Non-linear analyses, contacts/connections	2/22	
Analysis Report 2 due (11:59pm MST)	**2/27**	
Unit 3: Detailed FEA		
Lecture 13: Adhesive bonds	2/27	DGM 6.1
Lecture 14: Equivalent stiffness models	3/1	
Spring recess	3/6-3/10	
Lecture 15: Thermal analysis *(RECORDED ONLY)*	3/13	DGM 1.4.4-1.4.5, 9.1-9.2
Lecture 16: Thermal effects on ray tracing	3/15	DGM 9.3-9.6
Midterm report due	**3/19**	
Midterm project reviews [No lecture on 3/22]	**3/22, 3/23**	
Lecture 17: Stress birefringence	3/27	DGM 8.4-8.5
Analysis Report 3 specification released	**3/27**	
Lecture 18: Thermal FEA examples	3/29	
Lecture 19: Modal analysis	4/3	DGM 7.1-7.3
Lecture 20: Evaluating response to vibration	4/5	DGM 7.4, 7.7, 7.11
Analysis Report 3 due	**4/10**	
Lecture 21: Simulating shock loading	4/10	DGM 7.6
Unit 4: Large and flexible mirrors		
Lecture 22: Large mirror architectures	4/12	Y&V 2.1-2.2, 3.2, 3.7-3.8, 4.5-4.6, 5.6
Lecture 23: Lightweight mirror models	4/17	
Lecture 24: Fabrication and film stress	4/19	DGM 5.2
Lecture 25: Deformable mirrors	4/24	DGM 10.1-10.7
Student presentations *(Zoom)*	**4/26 – 5/3**	
Final project due	**5/3**	

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