OPTI 423/523: Optomechanical Design and Analysis

Updated 1/4/2022

Spring 2022

Lecture Monday/Wednesday 8am-9:15am 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, College of Optical Sciences
Email: bchal@arizona.edu
Office: Meinel 733
Office hours: Mondays 4-5 pm MST in Meinel 733, or by appointment
Office hours zoom link: https://arizona.zoom.us/j/82395749922 (password: 0pt0mech)

Teaching assistant: Zhenye "Rex" Li

Email: rex2268@email.arizona.edu
Office hours location: Meinel TBD
Office hours: Thursdays 4-5 pm MST, or by appointment
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, Matlab, SolidWorks, Zemax OpticStudio.

You are free to use finite element analysis or ray tracing software of your choice, with the understanding that there is little or no support for software other than the packages listed above. Required Matlab use will be minimal.

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

Assessment

Grading will be based on 3 homeworks and a design project:

Element	Due date	Fraction of grade
Homework		
Homework 1	2/8	15%
Homework 2	3/1	15%
Homework 3	4/5	15%
Design project		
Proposal	2/1	5%
Midterm review	3/21 – 3/22	15%
Final report	5/3	30%
Presentation and participation	4/28, 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.

COVID-related information

Classroom attendance

- If you feel sick, or if you need to isolate or quarantine based on University protocols, stay home. Except for seeking medical care, avoid contact with others and do not travel.
- Notify your instructor(s) if you will be missing a course meeting or an assignment deadline.
- Non-attendance for any reason does **not** guarantee an automatic extension of due date or rescheduling of examinations/assessments.
    - Please communicate and coordinate any request directly with your instructor.
    - If you must miss the equivalent of more than one week of class, please contact the Dean of Students Office DOS-deanofstudents@email.arizona.edu to share documentation about the challenges you are facing.
- Voluntary, free, and convenient COVID-19 testing is available for students on Main Campus.
- If you test positive for COVID-19 and you are participating in on-campus activities, you must report your results to Campus Health. To learn more about the process for reporting a positive test, visit the Case Notification Protocol.
- The COVID-19 vaccine and booster is available for all students at Campus Health.
- Visit the UArizona COVID-19 page for the most up-to-date information.

Academic advising

If you have questions about your academic progress this semester, please reach out to your academic advisor (https://advising.arizona.edu/advisors/major). Contact the Advising Resource Center (https://advising.arizona.edu/) for all general advising questions and referral assistance. Call 520-626-8667 or email to advising@arizona.edu.

Life challenges

If you are experiencing unexpected barriers to your success in your courses, please note the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office can be reached at (520) 621-2057 or DOS-deanofstudents@email.arizona.edu.

Physical and mental-health challenges

If you are facing physical or mental health challenges this semester, please note that Campus Health provides quality medical and mental health care. For medical appointments, call (520) 621-9202. For After Hours care, call (520) 570-7898. For the Counseling & Psych Services (CAPS) 24/7 hotline, call (520) 621-3334.

Tentative schedule

Detailed schedule and **deadlines**	Date	Reading*
Unit 1: Fundamentals of optomechanical system design		
Lecture 1: Introduction and overview	1/13	
Lecture 2: Review of optomechanical effects	1/18	
Lecture 3: Error budgeting and preliminary design	1/20	
Homework 1 released	**1/25**	
Lecture 4: Surface errors: fitting polynomials	1/25	DGM 3.1
Lecture 5: Incorporating surface errors into ray tracing	1/27	DGM 4.4-4.5
Project proposal due (11:59pm MST)	**2/1**	
Lecture 6: Error budgeting with Zernike coefficients	2/1	DGM 4.6-4.7
Lecture 7: Detailed design and analysis	2/3	
Unit 2: Introduction to FEA		
Homework 1 due (11:59pm MST)	**2/8**	
Lecture 8: Basic concepts in FEA	2/8	DGM 1.2-1.4
Lecture 9: Generating stiffness matrix	2/10	
Lecture 10: Finite element…elements	2/15	
Homework 2 released	**2/17**	
Lecture 11: Calculating radial displacement	2/17	DGM 4.1-4.3
Lecture 12: Plates, shells, 2D elements	2/22	DGM 5.1.3-5.1.4
Lecture 13: Non-linear analyses and connections	2/24	
Unit 3: Detailed FEA		
Lecture 14: Adhesive bonds	3/1	DGM 6.1
Homework 2 due (11:59pm MST)	**3/3**	
Lecture 15: Equivalent stiffness models	3/3	
Spring recess	3/7-3/11	
Lecture 16: Load cases	3/15	
Lecture 17: Thermal loading and boundary conditions	3/17	DGM 1.4.4-1.4.5, 9.1-9.2
Midterm report due	**3/18**	
Midterm project reviews – No lecture	**3/21, 3/22**	
Lecture 18: Thermal effects	3/24	DGM 9.3-9.6
Homework 3 released	**3/29**	
Lecture 19: Incorporating thermal effects in ray tracing	3/29	
Lecture 20: Vibration	3/31	DGM 7.1-7.4
Lecture 21: Vibration	4/5	DGM 7.7, 7.11
Unit 4: Large and flexible mirrors		
Lecture 22: Large mirror architectures	4/7	Y&V 2.1-2.2
Homework 3 due	**4/12**	
Lecture 23: Mounting large mirrors	4/12	Y&V TBD
Lecture 24: Segmented mirrors	4/14	Y&V TBD
Lecture 25: Deformable mirrors	4/19	DGM 10.1-10.7
Lecture 26: Film stress	4/21	DGM 5.2
Project abstract due	**4/26**	
Lecture 27: Surface-parallel actuators	4/26	
Student presentations	**4/28, 5/3**	

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