EEC 243 – Optical imaging and microscopy

Winter Quarter 2021

Course Description: This course discusses the theory and techniques of optical imaging and microscopy. It intends to provide an in-depth understanding of optical imaging mechanisms, design theories and implementation techniques. The course is divided into two parts. The first part is centered on Fourier optics and discusses light propagation and light detection. The second part is dedicated to various optical and microscopy techniques, in particular, to contrast mechanisms and to the repertoire of tricks. The targeted audience is senior undergraduate students and graduate students with a basic background in optics.

Instructor: Prof. Weijian Yang (wejyang@ucdavis)

Lecture Time: Tuesday, Thursday 4:40-6:30 pm;
Location: Zoom

Office Hours: Thursday, 3:30-4:30 pm; or by appointment
Location: Zoom

Textbook:

- Jerome Mertz, Introduction to Optical Microscopy (Second Edition), Cambridge University Press, 2019.
- Joseph Goodman, Introduction to Fourier Optics (Fourth Edition), W. H. Freeman and Company, 2017.

Optional Reference:

- Kedar Khare, Fourier Optics and Computational Imaging, John Wiley & Sons, Ltd, 2016.
- Douglas B. Murphy and Michael W. Davidson, Fundamentals of Light Microscopy and Electronic Imaging (Second Edition), Wiley-Blackwell, 2013.

Course Recording: We will record the online lecture in Zoom, and the recording would be available in Canvas through "Media Gallery" within one day. We do recommend you to participate in the real-time Zoom online meeting if possible. There will be interactive questions asked during the online classes, and you could respond through zoom.

Homework: Assigned most weeks on Friday, due by 5:00pm the following Friday. You need to submit a scanned copy of your homework through Canvas. Please write your name, homework number, and course number. Use of Matlab is beneficial for solving some problems. Late submissions will not be accepted without prior approval from the instructor. Homework copied from others will be considered cheating. All students involved with copying will receive a no-appeal grade F for the course.

Report: Every student is required to present a review of recent publications (1~3 original research papers published within the past 4 years, chosen by the student) on a specific optical imaging or microscopy technology and their applications. Each student will present the work at the lectures in the last week of the class, and submit a paper following the format of publications from Nature Publishing Group or Optical Society of America.

Grading: Letter grade based on the following

- Weekly homework: 50%
- Final report: 35%

Academic Integrity: Cheating and plagiarism will not be tolerated. Professional integrity is an important aspect of all engineering and science disciplines.

Acknowledge the Code of Academic Conduct: All students are required to acknowledge the Code of Academic Conduct for each registered course, no later than the quarter add deadline. my.ucdavis.edu will notify students online and through email for the action.
Please read the code of Academic Conduct at http://sja.ucdavis.edu/files/cac.pdf
Please also visit https://participate.ucdavis.edu/

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Special notes on Zoom:
Privacy: Please note that Zoom sessions, including student comments in the chat, are being recorded. To protect your privacy, please do not post any impermissible materials in the chat.
Etiquette:
https://ucdavisit.service-now.com/servicehub/?id=ucd_kb_article&sysparm_article=KB0005639
Use your first and last name as your screen name.
In large Zoom sessions, raise your hand before speaking. (Click Participants, Raise Hand)
Prevent noisy distraction such as pets, kids or room noise.
Don't eat during a Zoom meeting.
Mute yourself if you are not asking questions or involved in a conversion.

In case of technical difficulty on Zoom:
If we experience technical difficulties during a session, we will use Canvas announcements to communicate with the class.
If the host disconnects, check Canvas announcements for information. A disconnection does not mean class is cancelled. Unless we say otherwise, we will restart the Zoom meeting and resume class.
If you disconnect, try to reconnect to the session with the same Zoom link. If you cannot reconnect, send an email to the TAs to explain your situation and connect with Zoom support to troubleshoot the issue.

Course outline:
1. Review of Fourier analysis, linear system, and geometric optics
2. Monochromatic field propagation
3. Wave-optics analysis of coherent optical systems
4. Intensity propagation
5. 3D imaging
6. Detector noise
7. Scattering and absorption

8. Phase contrast
9. Digital holography
10. Optical coherent tomography
11. Fluorescence
12. Confocal microscopy
13. Two-photon microscopy
14. Coherent nonlinear microscopy
15. Structured illumination microscopy
16. Superresolution
17. Point spread function and transfer function engineering
18. Light field imaging and microscopy