

Physics 340: Optics

Spring, 2010

Contact Information:

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Meeting Times:

Lecture: 1:00-2:10 pm, M (Laser Palace)

Lab: 1:00-4:00 pm, W, F (Laser Palace)

Office Hours: 1:30-3:00 pm T, Th, and by appt.

Web: Moodle (Physics 340)

Course Outline and Goals:

This course focuses on optics from a practical standpoint: How do you create an image? How do you construct an interferometer? How do you align a laser? At the end, you should have a good sense of geometric and physical optics, and how these ideas are applied in a contemporary laboratory setting.

Required Text:

E. Hecht, *Optics*, 4th ed. Addison-Wesley (2002), ISBN: 0-8053-8566-5

Course Philosophy:

This course is all about a hands-on approach to optics. Our hope is that by presenting you with opportunities to practice using the types of modular optical equipment found in a contemporary research lab, you will build an intuitive understanding of geometrical and physical optics.

Moreover, this course is focused on innovation in the context of optics. You will be pushed to tinker, try new solutions, fail, and learn from your failures on the way to what we hope will be resounding success. Not only this, but you’ll be working in teams!

This course requires the following commitments from each of you:

- to engage in the pre-lab exercises so that you come to lab ready to start working on lab-based solutions
- to be willing to take reasoned (and occasionally unreasoned) risks in your approach to experiments
- to accept *and dissect* failure as a mode to better learning
- to engage in brainstorming with and constructive criticism of your classmates

Things we care about (and hence will grade):

Pre-lab assignments are due at 10 am each Wednesday and Friday. These exercises will be your primary out of class assignments, and *must* be taken seriously. They are designed to prime your mind for the rigors of the lab, and make sure you come to class ready to work. We have an ambitious program that simply will not work if you come to lab unprepared. The way for you to make the most of your experience in this course is to make sure you are prepared for each class.

Laboratories each week are divided into two generic categories: “canned” labs, where you will learn new techniques, and “challenge” labs where you will be challenged with an outcome, but left free to devise the best combination of techniques to achieve that outcome. The canned labs are there to help you build background knowledge and develop modular techniques. The challenge labs are there to train you to think innovatively about problems and try out your own ideas.

Canned labs typically last one three-hour session, culminating in a small (15-30 minute) innovation challenge, the outcomes of which you are to share with the class. Challenge labs typically last two three-hour sessions, with reporting back to the class at the end of each session. We encourage a spirit of friendly competition where groups try to come up with the best solutions. However, to help ensure some level of success, we also ask you to share and critique each other’s ideas at the midpoint so each group can come to the best solution.

A Final Project will consume the last two weeks (four three-hour sessions), in which you develop a project of your own design. This activity, however, does not start at the beginning of week nine. You are required to submit a one-page proposal around week six that documents your objective and plan of approach. This means that you need to be thinking early on about the type of project you’ll undertake. After obtaining instructor approval, you’ll need to start thinking about design elements, and how you’ll actually test whether you have achieved your desired outcome. Any additional parts you need must be submitted to the instructors in week seven to ensure they arrive on time. By the beginning of week nine, you should be ready to hit the ground running on this final project. At the end of this project, each group will give a report, including a tour, of its project to the rest of the class. Along the way, there will be intermediate brief reports and chances for brainstorming, collaboration, and critiques.

The lab notebook is your primary (and often only) record of work. Before setting foot in the lab each day, you should think through your strategy for that day and write down a half page or so in your notebook to prepare. In lab, keep track of your reasoning, activities, and outcomes as they occur. *A lab notebook is a journal, not a memoir!* We will grade notebooks on an ad hoc basis in the lab each day so that you are never left without your notebook to jot down ideas.

The final in this course will consist of a physical challenge, in which you have two hours to build and demonstrate a project identified at the beginning of the final. This exercise will be serious, but should also be a bit of fun.

Grading Formula:

Pre-labs:	20%
Small innovation challenges:	5%
Challenge lab outcomes:	10%
Final project:	35%
Lab notebook:	15%
Final physical challenge:	15%

Equipment:

You will be working for the entire term in small groups on a flexible lab station. Each station is identically equipped with \$5,000-\$10,000 worth of optical equipment, color coded and specific to that station. *It is your responsibility to keep your lab station clean and functional.* On day one, you will check your allotted equipment against a checklist. As additional equipment is added, you will need to add these items to your checklist. At the end of the course, you will need to check out with the same equipment you began with.

Safety:

The main danger in this course is danger to your eyes. You only have two retinas, and you need them both. Let's avoid damaging them. How can damage occur? *Direct or reflected laser emission into your eye.* The lasers you use in this course are classified II or IIIa, meaning your blink reflex or head turning aversion *should* prevent permanent damage. Note "should", not "will." Never look directly into the beam. Never put your eyes at the beam level without absolutely certifying that the beam is off. Be thoughtful and deliberate with beam manipulation – danger to your classmates is as great as to yourself. In essence, safety can be summarized as:

- (i) Do Not Look Into The Beam! *You are responsible for your own eye safety.*
- (ii) Do Not Screw Around With Lasers! *You are responsible for your classmate's eyes too.*

Honor Code:

No Lawrence student will unfairly advance his or her own academic performance or in any way limit or impede the academic pursuits of other students of the Lawrence community. Honor the honor code. Collaboration on the pre-lab is permitted, but it is your responsibility under the honor code to ensure you understand the material. Solutions must be written up in your own handwriting.

Possible 2009-2010 Optics Schedule

Week beg.	Monday (Lecture)	Wednesday (Lab)	Friday (Lab)
Mar. 29	Nature of light, reflection, refraction	<i>Canned</i> Image formation, reflection, refraction	<i>Canned</i> Beam steering and manipulation
Apr. 5	Geometric optics: Thin lens, thin lens systems	<i>Canned</i> Beam collimation, spatial filtering, profiling	<i>Canned</i> Aberrations
Apr. 12	Geometric optics: Multi-element geometrical optics	<i>Challenge</i> Long-distance imaging, capture, and resolution characterization	
Apr. 19	Wave nature of light: polarization and interference	<i>Canned</i> Characterize polarized light	<i>Canned</i> Interference and interferometry
Apr. 26	Wave nature of light: interferometry and coherence	<i>Canned</i> Build a Michelson interferometer	<i>Challenge</i> White-light interferometry
May 3	Wave nature of light: diffraction and spatial filtering Final project proposals due	<i>Canned</i> Diffraction and spatial filtering	NO LAB: Reading period
May 10	Wave nature of light: metrology, Fourier optics Final project parts lists, initial presentation	<i>Challenge</i> Interferometric metrology	
May 17	Wave nature of light: Fourier optics Final project checkpoint presentation	<i>Challenge</i> Optical Fourier computing	
May 24	Projects pep-talk Final projects: Present motivation and last brainstorming	<i>Final Projects</i> Student choice	
May 31	NO CLASS: Memorial Day		