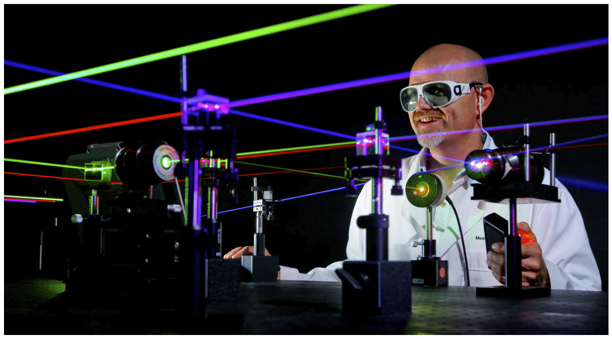
OPTI-511L

Lasers & Solid State Devices (Lab)

Fall 2022



Class lectures	TBD
Class location	Meinel 432
Lab location	Meinel 452
Class website	d2l.arizona.edu/d2l/home/1045628

Instructor

Dalziel Wilson

Office:	Meinel 650
Lab:	Meinel 676
Phone:	520-621-2584 (office)
Email:	dalziel@optics.arizona.edu

Office hours

During scheduled lab sessions. You are also welcome to track me down at my office or lab, or schedule an appointment. (I'm usually around.)

TAs

Aman Agrawal & Charles Condos

Learning outcomes

The objective of OPTI-511L is to illuminate, through experiment, many of the topics covered in OPTI-511R, including fundamentals of laser operation, different types of lasers, and basic applications of lasers, such as spectroscopy and cooling/trapping. These topics will be covered in the following labs, in roughly chronological order (contingent on time contraints):

Gaussian beams and optical cavities
Nonlinear optics: second harmonic generation
Fundamentals of mode-locked lasers
Fiber lasers and ultrafast pulse generation/characterization
Semiconductor diode lasers

Saturation spectroscopy
(Optional) Magneto-optical trapping and cooling of Rb atoms
(Optional) Argon-ion lasers and optical tweezers

After completing the course, students should be able to

- Explain how a laser works.
- Perform basic measurements with oscilloscopes, optical spectrum analyzers, and electronic spectrum analyzers.
- Use mirrors and lenses to manipulate laser beams.
- Predict the propagation characteristics of laser beams using Gaussian beam formulas.
- Assemble a Fabry-Perot cavity and characterize its finesse and free spectral range.
- Assemble a He-Ne laser and characterize its frequency spectrum using a Fabry-Perot cavity.
- Assemble a diode laser and characterize its thermal and electronic tuning capabilities using an optical spectrum analyzer.
- Generate ultrafast laser pulses using active and passive mode-locking techniques, and be able to describe their difference.
- Characterize ultrafast laser pulses using an intensity autocorrelator.
Align a nonlinear crystal and use it to double the frequency of a laser.
- Probe the hyperfine structure of an atom using saturated absorption spectropy.

References (not required)

Fundamentals of Photonics, Saleh and Teich
Lasers, A. Siegman
Lasers, Milonni and Eberly
Quantum Electronics, A. Yariv
Quantum Electronics for Atomic Physics, W. Nagourney

Course structure

The course consists of weekly lectures (Friday) and $\sim$ 6 lab projects to be completed over the semester during weekly lab sessions. For lab sessions, the class will be divided into groups of $\sim$ 3 students. Each group will meet at a scheduled time each week, with a TA, for up to 3 hours to work on the assigned lab project. Longer stay is negotiable if it doesn't interfere with other groups.

For each lab there will be a handout covering experimental objectives, procedures, and topics to explore. Fundamental concepts related to the labs will be briefly reviewed and discussed in the lectures prior to the labs. Lecture attendance is expected.

Each student needs to acquire a lab notebook for recording data and observations and answering questions while working in the lab. An example will be shown in class on the first day. Please purchase a composition notebook (no spiraled notebooks or 3-ring binders, please). If the pages are not numbered, please number them and reserve the first page as a Table of Contents to record the starting page for each lab section. **The objective of the lab notebook is to provide you, by the end of the semester, with a helpful reference for concepts, calculations, and observations you made during the course.** It may be helpful to put useful formulas (e.g. Gaussian beam parameters) in the first several pages of the notebook or each lab section for reference. **The lab book will also be used for grading,** so please do not use it for lecture notes.

Grading

Grades will be based on the following:

Lab participation	(20%)
Lab notebook[1]	(30%)
Lab reports	(30%)
Lab presentation	(20%)

Grading policy: A: 90-100%, B: 80-90%, C: 70-80%

Participation: **Full participation in each lab session is a required part this course.** This does not mean you need to excel at setting up laser-based experiments. Rather, you need to make a serious effort to contribute to each project. **Please understand that successfully completed experiments are not required for a good grade.**

To the last point: Experiments fail often and for many reasons. It is usually **more beneficial to understand why an experiment did not work than to not understand why an experiment did work**. Due to the structure of this course, lab sessions generally cannot be made up at a later point in the semester. If you foresee an absence from your weekly lab session, discuss with me and the TA beforehand to find an alternative time during the week when you can participate with another lab group, or better yet, arrange to swap places with someone in another lab group.

Lab notebook: For each of the labs, you will be required to record data in your lab notebook and answer questions asked in the handouts (record answers in your lab notebook). I expect that you will maintain legible and complete records of experimental setups, observations, data collected, experiments tried, results obtained, and answers to questions asked in the handouts. Be sure to make careful sketches of the experimental setup. There may be pre-lab or post-lab questions assigned. In these cases, it is required that these are recorded in your lab notebook. I may collect the lab notebooks once or twice during the semester (I will notify you in advance) for evaluation.

Lab reports: Written lab reports will be required for some of the labs (1-3). These reports will be a succinct and clearly written summary based on a detailed analysis of a lab and/or topic covered in the course. Each report should be 3-4 pages (no more, no less). More details on format and which labs will require written reports will be discussed in class.

Working in the laboratory

Please (1) show up on time and (2) familiarize yourself with the principles discussed in class and in the lab handouts *before* working on the experiments. Depending on your habits and schedule, this may be facilitated or hampered by the Friday lecture format.

You should not plan on relying on your lab partners or your TA to walk you through all of the concepts and procedures of an experiment. This may mean that you need to spend some time reviewing fundamental concepts discussed in the Monday lectures or the lab handouts. A good conceptual understanding will be extremely helpful when working in the lab.

Lasers can be dangerous tools. Some of the lasers you will be using can burn your skin or permanently

[1]This includes pre- and post-lab assignments.

damage your eye if the beam is pointed directly into your eye. Either can inadvertently happen during laser beam alignment with mirrors and lenses. Laser safety eyewear is provided and should be worn as needed. If necessary, watches, rings, and other reflective objects and jewelry that can obstruct a laser beam and reflect light into your eyes or your partners' eyes should be removed prior to laser work. **You and your lab partners should watch out for each other, and remind each other of laser safety precautions. No rules can replace common sense in a laser lab!**