PASADENA CITY COLLEGE
Laser Technology Program

LASR230, ***Optical Devices***: the Syllabus

Instructor **Dr. Brian Monacelli** can be emailed at **Brian.Monacelli@Protonmail.com** anytime.
Please communicate with me via email. I am very responsive to direct email interaction.

Located in Pasadena City College's **V Building, Room 109** during the **Spring 2022** semester, on **Thursdays from 16:30 to 22:10**, with an optional 25-minute break between lecture and lab.

This course explores the principal tools that are used when working with light, such as lasers and other light sources, cameras and sensors. Optical hardware and its constituent components with be studied, including fundamentals of lasers to gain media, pump sources, and mirror cavities; investigation of camera components and essential chemistry. Students will gain hands-on experience with industrial hardware and tools in the laboratory.

***Fundamentals of Light and Lasers*, 3rd edition, OP-TEC, 2018** (ISBN: 978-0-9998536-4-1), is the textbook that will be used as a reference throughout the semester. It is available for download at https://laser-tec.org/product/course-1-fundamentals-of-light-and-lasers/
OP-TEC's *Elements of Photonics*, Course 2, CORD/NSF, 2008 will also be used and provided electronically.

Open educational resources (OER) are being created and tested for this course, via the NSF OPAL-TEC grant. These materials will serve as references throughout the semester, available on the Canvas website.

Grading is based on **100 points** (the denominator): **A**: >90%, **B**: >80%, **C**: >70%, **D**: >60%, **F**: ≤60%
11 **lab reports** earn 5 points each, the **final exam** earns 30 points, and one **presentation** earns 20 points (N.B., this totals 105 possible points, so bonus points are already available!).

> **Weekly lab reports** are expected to be industry-quality documents, as described below.
> Lab activities will be conducted in groups, but *each individual will write their own report*.
> Lab reports are due by the end of the class following the week the lab was started.
> Lab reports shall be submitted in PDF format via email or the Canvas website:
> https://canvas.pasadena.edu/courses/1121142
>
> > *Report files shall be named* "LASR230lab**ZZ**-**lastname**.PDF",
> > where "**ZZ**" is the two-digit lab number and "**lastname**" is your last name.
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> One individual, 5-minute **presentation** will cover the technical details of a laboratory activity, an experiment, a hardware demonstration, or an optical technology of the students' choice. Presentations shall be written for an intelligent, non-technical audience. They shall include a discussion of the activity's technical purpose, the techniques used to acquire data, a comparison of measurements to theoretical expectations, a discussion of required research, conclusions, and recommendations for improvement. Presentations will be scheduled in February.
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> The comprehensive **final exam** shall be given on Thursday, 5 May 2022.

Course Content Outline

1. Laboratory Protocol
    - A. Documentation in a laboratory notebook
    - B. Data reporting and graphic representation
    - C. Measurement uncertainty and statistical analysis
    - D. Laser safety
        - i. Laser hazards, classifications
        - ii. Interlocks, warning lights, and other safety hardware
2. Physics of light
    - A. Optical regions of the Electromagnetic spectrum: ultraviolet, visible, infrared, terahertz
    - B. Elemental atomic composition
    - C. Energy band diagrams
    - D. Photon emission and absorption
3. Light sources
    - A. Lasers
        - i. Methods of operation (stimulated emission)
        - ii. Common types and applications (gas, solid-state, semiconductor, liquid)
        - iii. Output methods (continuous wave and pulsed)
        - iv. Gain media (energy levels)
        - v. Pump sources
        - vi. Construction of cavities
        - vii. Spectra and modes
    - B. Incandescent (thermal) sources
        - i. Methods of operation
        - ii. Common types and applications
        - iii. Characterization of operating parameters and spectra
    - C. Plasma (gas-discharge) sources, arc lamps
        - i. Methods of operation
        - ii. Common types and applications
    - D. Semiconductor light-emitting diode (LED) sources
        - i. Methods of operation
        - ii. Common types and applications (integrated optics and circuitry)
        - iii. Characterization of operating parameters and spectra
4. Optical displays
    - A. Technologies
    - B. Techniques
    - C. Specifications and formats
    - D. Materials and sources

5. Introduction to Optical fibers
    A. Fabrication of optical fibers
    B. Optical specifications of optical fibers
        i. Total internal reflection (TIR)
        ii. Numerical aperture
        iii. Attenuation (Loss)
        iv. Index profiles
        v. Dispersion
    C. Manipulation of light in optical fibers
        i. Coupling into and out of fibers
        ii. Fiber splitters and couplers
        iii. Bragg gratings
        iv. Fiber amplifiers
    D. Applications of optical fibers
        i. Telecommunication
        ii. Sensing
        iii. Laser delivery
6. Optical detectors
    A. Photovoltaic (photodiodes)
    B. Photoemissive (photomultipliers)
    C. Photoconductive
    D. Thermal (bolometer, thermopile, pyroelectric)
    E. Cameras
        i. Sensors and Focal plane arrays (FPAs)
        ii. Readout integrated circuitry (ROIC)
    F. Noise
        i. Signal-to-noise ratio (SNR)
        ii. Noise types (shot, Johnson, etc.)
    G. Introduction to radiometry
        i. Units
        ii. Measurement geometries
        iii. Calibrated standards
7. Optical hardware
    A. Beam-conditioning hardware
        i. Beam expanders
        ii. Spatial filters
        iii. Beamsplitters
    B. Polarizing devices
        i. Linear polarizers
        ii. Waveplates
        iii. Birefringent crystals

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Laboratory Topics

1. Observe and document the spectral output of optical sources
2. Measure the wavelength and beam divergence of lasers
3. Measure the power stability of lasers using a high-speed photodetector and an oscilloscope
4. Perform the tedious optical alignment task of laser beam spatial filtering
5. Create a laser spot with lenses and measure its size using the Foucault method
6. Observe and document various optical display technologies
7. Analyze a laser focus and its transverse mode structure using a beam-profiling camera
8. Polish an optical fiber and connectorized an optical fiber cable
9. Couple a laser beam into an optical fiber
10. Measure the attenuation of an optical fiber
11. Assess the noise-equivalent power (NEP) and the signal-to-noise ratio (SNR) of optical detectors

Student Learning Objectives (SLOs)

These are formalizations of this course's curriculum—you will learn a lot more!

1. Define and adhere to safe laboratory protocols in the operation of lasers and other optical sources.
2. Measure and manipulate the output of common light sources.
3. Measure the performance of detectors of optical radiation.

Additional facts

- Safe laboratory practices are essential. Any student demonstrating unsafe laboratory practices will be asked to leave the class, and an incident report will be submitted.
- You will learn best in this course if you attend every laboratory and document your work in a bound physical notebook and/or an electronic journal—labs are held weekly because this is a hands-on course. You will likely use these experiences in your current or future job, so ensure your documentation is written so that it will be comprehensible to you in three to five years.
- If you cannot attend a laboratory, it may be made up only if arrangements were made in advance by emailing the instructor. If advance arrangements were not made, zero points may be earned for that lab.
- Office hours will be held via Zoom from 17:30 to 18:30 on Wednesday evenings prior to each class:

  https://pasadena-edu.zoom.us/j/3214387222

- Cheating earns zero points on exams and an incident report must be submitted. Don't cheat.
- Last day to drop with "W" grade is specified on the Pasadena.edu website.

  Please discuss dropping the course with the instructor prior to dropping the course.

- Class will be held every Friday until 5 May 2022 except 10 and 31 March 2022 (spring break).