PASADENA CITY COLLEGE
Laser Technology Program

LASR215: *Fundamentals of Light and Lasers*, the Syllabus

Professor **Dr. Brian Monacelli** can be emailed at **Brian.Monacelli@Protonmail.com** anytime.

Located in Pasadena City College's **E Building, Room 303** during the **Fall 2021** semester, on **Fridays from 16:30 to 22:10**, with an optional 25-minute break between lecture and lab.

> *This course introduces the fundamental properties of light, including its interaction with and generation from materials. Optical hardware is used in lecture demonstrations and laboratory experiments to show how light can be controlled. Essential components of optical systems are studied, including lenses, mirrors, prisms, windows, sources, detectors, optoelectronics, polarizers, fibers, and gratings. Students will gain hands-on experience with industrial hardware and tools as they construct basic optical component test setups and systems in the laboratory. Total of 36 hours lecture and 54 hours 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/

Open educational resources (OER) are being 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%
13 weekly **lab reports** earn 5 points each, the **final exam** earns 20 points, and one **presentation** earns 20 points (N.B., this totals 105 possible points, so bonus points are already available!)**.**
Reports are due three weeks after each lab is conducted.

> **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 shall be submitted electronically in PDF format via the Canvas website:
> https://pcc.instructure.com/courses/1116571
>
> > *Report files shall be named* "LASR215lab**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 measurement 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 November.
>
> The comprehensive **final exam** shall be given on Friday, 10 December 2021.

PASADENA CITY COLLEGE
Laser Technology Program

Lab reports shall consist of four sections:

1. **Workplace Scenario and Theory**: a statement of the industrial situation that requires data to be measured, and a discussion of the theory behind the science that will be studied, including equations and parameter definitions (This will be provided to you.)
2. **Hardware Setup**: simple instructions on how to orient and configure lab equipment, including a sketch or photograph of the lab setup, and identification of the parameters to be measured (This will be based on a demonstration by the instructor.)
3. **Experimental Procedure and Data Acquisition**: a description of what data needs to be recorded and how to make measurements, including data-recording methods, measurement resolution, and measurement accuracy (A high-level outline will be provided, but you have to add details.)
4. **Data Reduction and Analysis**: a comparison of the measurements with theory and discussion of your measured results, including data plots, error analysis, and recommendations for improvement (This will be your description of what you observed and learned.)

Laboratory Topics

1) Make measurements to assess the laws of reflection and refraction
2) Measure the reflection, transmission, and absorption of optical filters
3) Attenuate a laser beam using polarization by Malus' Law
4) Determine Brewster's angle of a material by measuring the polarization of light reflected
5) Find the angle of total internal refraction and understand the principle of beam deviation
6) Form images with optical components: lenses, mirrors, prisms
7) Construct basic optical instruments: telescopes and microscopes
8) Create a model of the human eye to understand vision and photometry
9) Explore interference of coherent light
10) Examine diffraction and interference of light through different apertures
11) Measure the irradiance distributions of different sources and the associated radiometry
12) Construct an optical detector circuit and measure a source signal

Student Learning Outcomes (SLOs)

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

1) Explore the basic properties of optical radiation and its interaction with matter.
2) Demonstrate ability to acquire and document optical laboratory measurements according to standard laboratory protocols and safety procedures.
3) Construct and manipulate simple optical systems consisting of optical components such as la sers, LEDs, lenses, prisms, mirrors, and detectors.
4) Propose the best optical source or detector for a given optical application.

PASADENA CITY COLLEGE
Laser Technology Program

Course Content Outline

1. Properties of Optical Radiation
    A. Electromagnetic spectrum and its optical regions: ultraviolet, visible, infrared, terahertz
    B. Optical amplitude, energy, power, irradiance, introduction to radiometry
    C. Wave phase and coherence
    D. Wave-particle duality of light
2. Safety and Laboratory Protocol
    A. Documentation in a laboratory notebook (physical or electronic)
    B. Optical lab equipment: components, mounts, stages, benches, etc.
    C. Data reporting and graphic representation
    D. Measurement uncertainty and statistical analysis
    E. Optical, laser, chemical, and electrical safety
3. Light-matter interaction
    A. Refraction (refractive indices, dispersion, Snell's Law, and critical angle)
    B. Transmission
    C. Reflection (specular and diffuse scattering)
    D. Absorption (attenuation)
4. Polarization
    A. Brewster's Angle
    B. Malus' Law
    C. Photoelasticity
5. Optical elements
    A. Plane surfaces (windows, flats, prisms)
    B. Mirrors
    C. Lenses
    D. Spherical and other curved surfaces (aspheres)
    E. Introduction to Fiber Optics
    F. Introduction to Aberrations
6. Introduction to optical system parameters
    A. f-number
    B. Numerical Aperture
    C. Effective Focal Length
7. Introduction to optical instruments
    A. Magnifiers
    B. Microscopes
    C. Telescopes
    D. Cameras
    E. Detectors, etc.
8. Optics of the human eye

9. Diffraction and Interference
    A. Diffraction (near-field and fair-field)
    B. Interference
    C. Thin-film phenomena
10. Introduction to optical sources
    A. Incandescent and blackbody (thermal) sources
    B. Plasma (gas-discharge), flash, and arc sources
    C. Semiconductor (LEDs) sources
    D. Lasers
11. Coatings and Filters
    A. Thin-film phenomena
    B. Deposition Techniques
12. Introduction to radiometry and optical detectors
    A. Radiometric terms
    B. Photon detectors (photovoltaic, photoemissive, photoconductive)
    C. Thermal detectors (bolometer, thermopile, pyroelectric)
    D. Introduction to cameras and focal plane arrays (FPAs)
    F. Introduction to noise

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 the Thursday evenings prior to each class, as well as on Wednesdays, 1 and 8 December at the same time:

    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 10 December 2021 except 26 November 2021 (National Shopping-in-America Day/Black Friday/Friday after Thanksgiving)