EK 131 Photonics E3– Engineering with light

Photonics is used in advanced technology as well as everyday familiar objects. This freshman engineering module offers a brief introduction to the physical principles of light and how light is used in many different engineering applications- from familiar consumer products, optical communication to novel bio-sensing methods. The course will highlight different research opportunities for engineering students during their undergraduate career. Apart from lab based demonstrations and lectures, you will:

- Build a wireless phone, converting sound to voltage to light, to transmit wirelessly in free space and via optical fibers to a corresponding photo-receiver.
- Visit laboratories in the photonics center for demonstrations.
- Research and present topics related to photonics.

Topics:

Optics

Particle and wave nature of light

Ray-optics: total internal reflection (optical wave guides)

Wave-optics: Interference, Diffraction

Electrical circuits

Ohm's law, Kirchhoff's current and voltage laws,

Electronics components: resistors and capacitors, LED's, Transducers (optical detectors and LEDs, Microphones and speakers) Op-Amps and modulators.

Optical communication

AM and FM modulation, Optical fibers

Photonics Research

Lab visits (optical fibers, optical diodes)

Learning outcomes:

As an outcome of this course module, students will learn:

1. Optics general: Different types of light sources, optical spectrum, wavelength and energy range of visible light. Ray Optics: Index of refraction, Snell's law, Total internal reflection and Optical fibers (lab visit) Wave optics: Character of a wave, diffraction and interference, constructive and destructive interference.
2. Electronics: Ohms law, Kirchhoff laws, voltage division, current division, serial and parallel circuits. Op amp: golden rule, follower, non-inverting amplifier, inverting amplifier Optoelectronics: Band gap, Optical detection, light emitting diode. Lab visit
3. Engineering concepts: Transducer, Modulation, Error analysis
4. Practical: Using breadboards, oscilloscope, voltmeter, function generator, using op-amps, reading C and R, Reading, building and debugging circuits.
5. Design small parts of the photo phone circuit (measuring response and choosing appropriate resistors for proper amplification)
6. Communication Skills: report on lab results and write reflections each lecture on the course electronic bulletin board. Photonics research project: work in pairs, write outline of presentation (Draft +final), rehearse presentation (Content, timekeeping and presentation skills) and give feedback with peers, Oral presentation of project.

Schedule and tentative Syllabus:

Lec 1-4 Intro to Optics labs
Lec 5-7 Intro to Electronics labs
Lec 8-11 Photo phone labs
Lec 12, 13, 14 Student presentations, lab tours

Date	Lecture topic	Lab
M 9/9	**LECTURE-1** Introduction; wave nature of light; light sources and lasers	PreLab: Precision
M 9/16	**LECTURE-2** Interference and diffraction	Lab 2: Diffraction
M 9/23	**LECTURE-3** Refraction; lenses; waveguides	Lab 3: Refraction
M 9/30	**LECTURE-4** Fiber optics; polarization effects	
M 10/7	**LECTURE-5** Introduction to optoelectronics; elements of electric circuit theory	Lab 5: Voltage Divider
T 10/15 (Monday holiday)	**LECTURE-6** Elements of electric circuit theory continued	Lab 6: Op Amps
M 10/21	**LECTURE-7** Semiconductor optoelectronic devices; photodetectors; LEDs	Lab 7: LEDs
M 10/28	**LECTURE-8** Photophone 1: receiver	Photophone lab
M 11/4	**LECTURE-9** Photophone 2: transmitter	Photophone lab
M 11/11	**LECTURE-10** Photophone 3: complete system	Photophone lab
M 11/18	**LECTURE-11** Photophone demo	Photophone lab
M 11/25	**LECTURE-12** Student presentations 1	
M 12/2	**LECTURE-13** Student presentations 2	
M 12/9	**LECTURE-14** Lab tours	

Course information

Instructor:	Professor Michelle Sander	PHO 534 msander@bu.edu
Lab assistant:	Pan (Thachachanok Menasuta)	pan2021@bu.edu
Meetings:	The class meets 10.10 – 11.55am, Mondays in PHO 105	
Office hour:	After class on Monday, in PHO 105, and on request	
Homework:	No hand in homework. Instead, prepare for class, finish labs before next class if not done during class hours. Show results, analysis and comments before next class to lab assistants and get checked off. The group projects are prepared outside class	
Material:	A thin binder with loose leafs, or a notebook for your lab notes. Lecture notes and reading materials will be posted on Learn.bu.edu	
Absences	This is a very short course, and most of the work happens during class hours. You will automatically **fail the course with more than 2 absences**. You will not get the in class lab credits for missed classes, regardless of reason. If you know that you have a conflict, please let me and your lab partner know IN ADVANCE when you will be missing. In case of illness, email me before class.	

Group work expectations

This course is very collaborative. You will do your work in pairs, where your pair will be part of a larger group which is primarily responsible to help each other out. You are expected to contribute to your own and other student's learning by discussing with other students and carefully noting down your analysis in your lab notebook.

Academic conduct

You are expected to be helpful and respectful to your peers, in the classroom, in private communication and on the discussion board. *The only exception when you cannot collaborate is during the quizzes. Please note that both giving and receiving help during a test is at odds with the BU academic code of conduct.* http://www.bu.edu/academics/policies/academic-conduct-code/. You will work on the photo phones over several classes and any tampering with other pairs' devices is not acceptable.

Grading

Pair grades

Lab-projects	(50%)	Optics labs, optoelectronics, photo phone, see below
Presentations	(25%)	Outline, practice, feedback and presentation, see below

Individual grades

Participation and Quizzes	(25%)

********** **Pair Grades** **********

Lecture/lab Grading (50%)

Each lecture/lab is graded by

30%	Pre lab preparation
50%	In class lab, lab results
20 %	Results, discussion and analysis, comments

Each lecture/lab has three parts:

1. Preparation: You will need to prepare for each class so that you can finish the lab on time and with the best possible execution. Pre lab preparation will be assessed by checking in with the teaching staff before the beginning of class.
2. Classroom work: In the classroom, you will work together on the material you studied before the lab, second half is doing the lab in pairs.
3. Reporting and Discussion of the results in your notebook and in class.

Presentation (25%)

Outline 25 %	On time, title of posting (group, pair & topic), outline, references, and response
Feedback 25%	On time, Document title, Content, references
Presentation 50%	Overall quality, slide content (not too much text), technical content and accuracy, societal impact, **Individual grade**: Voice projection, knowing material well, eye contact.

********** **Individual Grades** **********

Quizzes and Participation (25%)

Short quizzes can be given on any day in class. You will be able to use your lab note books and the class slides (printed form) during the quizzes, so be sure to take good notes!