Syllabus Phys 220: Advanced Physics Lab

Time: Tuesday 1:10-4pm, and Thursday 1:10-4pm.

This is a 3cr. laboratory class and hence you are expected to devote about 9-12hrs per week to this class. You are expected to spend at least 6 hours in the lab working on the lab experiments. Core Times are: MF 3-4pm. During the core times short lectures may be given.

Instructors: **Volkmar Dierolf**
LL 214
vod2@lehigh.edu

Contents:
In this class, we will cover the basics and some advanced concepts of experimental physics with a focus on electronics, computer programing, and computerized measurements. We will cover basics electronics such as transistors, OpAmp, A/D converters,…

You will learn in a practical hand-on fashion
- how to program an Arduino board to control stepping motors and to read out various sensors,
- how to program on a higher level in Labview,
- how to evaluate experimental data and compare them to models using Python.
- how to write a scientific paper or report using LaTeX
- how to communicate between different hardware components
- how to use basic instrumentation such as photodiodes, photomultipliers, temperature sensors, digital oscilloscopes, and lock-In multipliers, stepping motors,….
- how to use a 3D Printer
- how to operate a lathe and drill in the machine shop

The class will be supplemented with in-lab lectures covering basic concepts of electronics, measurements, and data analysis.
The class will be capped with a project in which you will apply all those concepts to design an instrument that tracks the position of the sun and optimize the performance of a solar panel. The course is structured in such a way that you will learn the basic elements first and apply them as you may see fit for your final project.

Required Competencies: Basic Lab Skills as obtained in Phys 12 and 22. Basic Concepts of programming. Computer proficiency.

Final Competencies:
- Able to write programs in Labview, Python, and for the Arduino
- Demonstrate how these programming environments can interact.
- Understand the function of a AD converter
- Ability to design and build an automated experiment.
- Ability to handle large data sets.
- Ability to come up with model and fit experimental data to this model.
- Ability to find creative solution with available resources
- Write coherent informative reports that can be understood by physics majors that have not taken the course yet.

- Keep a lab note book

Degree Requirements: This course is a required course for all Physics majors for students that started AY2016/17 or later. For student before, the course replaces the Phys 190 requirements. It does not replace the Phys 262 requirement. The course fulfills writing intensive requirement.

LabManual:
No formal lab manual exists yet. Since this is a writing intensive class, it is one of your tasks to collect some of the information needed from the Internet and collect them for future use. We will have some handouts but none of them will be to on the level "Do this, do this,…"
You will need to keep a lab-book to document what you are doing throughout the labs. The outcomes of the experiments are summarized in reports. These reports should be written on a level such that somebody could just use the report and do the respective activity. *In a sense, you are writing a lab manual*

Grades:
The basis for your grades will be your work in the lab as demonstrated in weekly reports and the Final Paper about your projects. The basis for your grade is the demonstration of the final competencies outlined above.

5 Reports **50pts**
Since this is a writing intensive course, your reports will be returned for revision. For the grades, the revised version will be most relevant but is expected that you don' t repeat errors that had been pointed out before. Late reports will not be excepted. Reports are due Tuesdays. You will receive revisions by Friday. Final Report will be due the following Tuesday, The reports are submitted using course site. The reports are written in the form of an scientific paper.

See for example https://www.nature.com/scitable/ebooks/english-communication-for-scientists-14053993/118519636#bookContentViewAreaDivID
to learn about what the expectations are

Labnote Book **25pts**
A lab note book that describes your activities throughout the course must be kept. Have it signed by instructor once per week. (see document about note books)

Paper about final project: **25pts**
In this paper , you will be evaluated on creativity of your approach, success in executing your approach, defining model for the collected data, discussion of results, quality of paper in terms of structure, referencing, and clarity.

Total: **100pts**

You will able to earn extra points in activities that will be labelled as challenge. Since these challenges may only by challenges at the time, no late credit will be given.

Accommodations for Students with Disabilities:
If you have a disability for which you are or may be requesting accommodations, please contact both your instructor and the Office of Academic Support Services, Williams Hall, Suite 301 (610-758-4152) as early as possible in the semester. You must have documentation from the Academic Support Services office before accommodations can be granted.

The Principles of Our Equitable Community:
Lehigh University endorses The Principles of Our Equitable Community http://www.lehigh.edu/~inprv/initiatives/PrinciplesEquity_Sheet_v2_032212.pdf.
I expect each member of this class to acknowledge and practice these Principles. Respect for each other and for differing viewpoints is a vital component of the learning environment inside and outside the classroom.

Course Schedule

Week	Activities	Expected Outcome
1	• Introduction to the Course • Install Software: Arduino, Labview, Python, LateX • Test Hardware • Write a simply program that let's you plot data using Python.	• Have Software tested and run several example to ensure the basic operation • Ensure that all the hardware components work and basic operation of them is clear.
2	• Basic Circuitry • build RC circuits and analyze using a Oscilloscope and a Lock-In amplifier	• Learn about Phase sensitive detection and how to determine time constants using a Lock-In amplifier • Report 1 written in LaTex describing the basic function of a Lock-In amplifier and how it can be used to measure RC constants. This should be a "paper" in PRB format with the title: "Using a lock-in amplifier to measure the RC value of a Circuit: Theory and Experiment".
3	• Intro to Labview. • Write a program that changes the input from the function generator and record and saves it from the oscilloscope. •	• Become familiar with programming in Labview • Being able to collect data from an instrument like a voltmeter • Have a program that collects curves from the oscilloscope and displays it on your computer. • Print out the Labview program and add them to the lab notebook.
4	• Data analysis using Python • Take the results from week 3 and extract amplitude and phase from the data • Create a plot with amplitude and data • Fit it to the expected outcome	• Learn how to use Python for reading data from and experiment, display the results and display of results. • Include the Python program to your lab notebook • Include the figures and results to your notebook. • Make conclusion of your finding
5	• Operational Amplifiers • Transistors	• Voltage Amplifier needed to measure small current with Arduino • Document in lab note book • Report 2 written in LaTex describing the amplifier design using either a transistor or an amplifier. Presentation of experimental data and their discussion.
6	• Comparator and A/D converters	• Design and test a 4-bit A/D converter • Report 3 written in LaTex describing the the basic function of a A/D converter and the particular approach taken for the 4-bit converter

Week	Activities	Expected Outcome
7*	• Intro to Arduino • Test sensors • Measure Voltages and currents with Arduino • Control Stepping motor	• Become familiar with programming the Arduino • Get a sense of the type of measurements that can be done with Arduino. • Use of the sensors in the kit to make measurements. • Have a program that can move a stepping motor into a desired direction. • Report 4 written in LaTex describing the operation of the stepping motor using Arduino. Describe in detail the measurements using two of the supplied sensors.
8*	• Machine Shop and 3-D printing	• Able to operate the 3D printing to prototype the mechanical pieces that are required for the final project • Able to machine simple pieces on the lathe or mill.
9*	• Control Arduino using Labview	• Have program that resembles an oscilloscope using the analog input and determine its limitation in terms of temporal and voltage resolution • Report 5 written in LaTex describing the method used to connect to have the Arduino and Labview talks to each other
10-14	• Design and Build tracking Device	• Device • Final Report/Paper. PRB format.

Activities in week 7,8, 9 can be done in different weeks to accommodate limited access to machine shop.