Oakland University *College of Arts & Sciences* *Department of Physics*

Fall 2018 PHY 3170: **MODERN PHYSICS LABORATORY**

Tuesday (8 AM – 12 PM); ROOM: 68 MSC

Lab Manual: None; Each experiment has a folder in the lab with details on equipment, procedure, and related information.

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Course Goals and Objectives:

This Modern Physics Laboratory is aimed at introducing the students to method of investigation of phenomena and principles of Modern Physics.

The laboratory exercises are open-ended and are designed to provide an experience in planning and assembling advanced experiments involving measurements of physical parameters and constants.

In this laboratory, the students will

- Read through instructions on objectives of the experiments, assembling the setup, data acquisition and analysis;
- become familiar with selected physics laws and phenomena;
- get experience taking data and drawing conclusions from these;
- learn how to estimate and combine experimental errors;
- experience team work.

Course Details

4 experiments: will be done during the entire semester. Each experiment will be done over a 3-week period by a team of two or three persons. Everyone must choose their partners for the term in the first class meeting. If necessary you may change partners, but only after the conclusion of each experiment.

<u>Experiments</u>: A list of available experiments is provided at the end of this syllabus. Experiment #1 must be selected during the very first meeting. Subsequent experiments have to be chosen on or before the 3rd week of previous experiment. Your choice must be recorded in the blackboard in the lab.

<u>Preparation and performing the experiments</u>:

YOU ARE EXPECTED DO THE EXPERIMENTS ON YOUR OWN (with little help from instructors). During week-1 you have to read the materials in the folder and become familiar with the background theory and procedure for the experiment. Read the appropriate experiment description, go through the equipment/experiment manual, and come up with a plan for your experiment, data acquisition, analysis and report.

<u>Week 1:</u> Read the instructions, plan/assemble the experiment and perform some trial runs for preliminary data.

<u>Week 2:</u> Perform the experiment and analyze the data. Make sure the experiments are repeated several times if necessary. You have to have enough data sets for analysis and error estimation etc.

<u>Week 3:</u> Take care of any additional data needs and work on a draft of the report.

<u>During the class</u>: Make sure both you and your partners are involved in setting up and doing the experiments.

<u>Reports</u>: **Each student must submit a report for every experiment** complete with Introduction, data, graphs, analysis, and conclusion. **Reports are due ONE WEEK after the completion of the experiment (on the dates given in this syllabus)**.

COPYING DATA FROM PREVIOUS YEARS' REPORTS, BORROWING OTHER'S DATA, OR MAKING UP DATA IS ACADEMIC MISCONDUCT AND WILL RESULT IN A GRADE OF 0 FOR THE EXPERIMENT/COURSE

<u>Grade determination</u>

Reports (4 experiments): 100%

<u>Report Format and Credit</u>

Formal typed reports (similar to a manuscript for publication) are expected for each experiment.

Although you and your partners may have same data, graphs, etc…, the report has to be written by YOU. Identical reports will not be graded.

<u>Format and credits</u>

1. Introduction (with objectives/goals, background/theory) 25%
2. Experimental procedure and results (raw data) & graphs 30%
3. Data analysis and error estimates 30%
4. Conclusions (key inferences from the data, comments on agreement with accepted values and avenues for error reduction…etc..) 15%

Grading Scale:

A	**95-100**
A-	**90-94**
B+	**85-89**
B	**80-84**
B-	**75-79**
C+	**70-74**
C	**65-69**
C-	**60-64**
D+	**55-59**
D	**50-54**
F	**< 50**

CLASS SCHEDULE

DATE	Experiment	Remark
Sept. 11	--- Syllabus and Safety information --	
18	Ex.1	
25	Ex.1	
Oct. 2	Ex.1	
9	Ex.2	***Report 1 Ex. 1 due by class time***
16	Ex.2	
23	Ex.2	
30	Ex.3	***Report 2 on Ex.2 due by class time***
Nov.6	Ex.3	
13	Ex.3	
20	Ex.4	***Report 3 on Ex.3 due by class time***
27	Ex.4	
Dec. 4	Ex.4	

Report 4 due by 4 PM on Friday Dec.7

List of Experiments in the Modern Physics Laboratory

- Photoelectric effect:
    - Measure Planck's constant, h

- Franck-Hertz experiment:
    - Computerized experimental measurement of inelastic electron scattering in neon.

- Pulsed Nuclear Magnetic Resonance (NMR):
    - Pulsed NMR to measure relaxation processes in suitable materials.

- Black-body radiation:
    - A furnace and computer interface allows you to display the radiation spectrum in the visible and IR ranges at various temperatures.

- Resistivity of semiconductor (use the set-ups in Franck-Hertz Experiment):
    - Computerized measurement of the variation of the electrical resistivity with temperature for a given semiconductor sample.

- Determine the gravitational constant G using Cavendish Balance - Delicate torsion pendulum and optical lever (use Leybold apparatus)

- Determine the speed of light *c* using the static method with a Coulomb balance:
    - Measure μ_0 and ε_0, the permeability of free space and the dielectric constant of free space. $c = (\varepsilon_0\mu_0)^{-1/2}$

- Determine the speed of light *c* using modulated laser
    - Measure speed of light c and learn basics of modulation optical communication.

- Determine the electronic charge *e* using the Milliken oil drop experiment.
    - The motion of electrically charged oil drops between parallel plates is viewed through a microscope. (Use Welch apparatus and a video camera)

- Determine the *e/m* of electrons:
    - The curvature of a beam of electrons in a magnetic field, produced by Helmholtz coils, is measured directly. (Using Leybold apparatus)

- Optical experiment (both parts):
  Part a: Determine the Rydberg constant R: Measurement of hydrogen spectral lines with a grating spectrometer. (See OU’s 158 Physics manual, need spectrometer from the stockroom) **AND**
  Part b: Sodium fine structure. (Use a Fabry-Perot or Michelson interferometer)

- Index of refraction of air using a Michelson interferometer, air cell and a vacuum pump. (Use Pasco apparatus)

- Microwaves. Studies on interference, diffraction and polarization. (Use Cenco, Welch or Thornton apparatus.)

- Determining the density, polarity and mobility of charge carriers in a semiconductor material.

    - Apply Hall Effect to measure the mobility, density and polarity of charge carriers in n-Germanium.

- Learn Fourier methods in experimental physics.
    - Apply Fourier methods to analyze signals from an Acoustic resonator, Fluxgate magnetometer and a Coupled oscillator system.

- Electron Spin Resonance using DPPH. (New)
    - Determining the resonance frequency as function of magnetic field.
    - Determining the g-factor of DPPH
    - Determining the line width of resonance signal
- Faraday Effect. (New)
    - Observing the rotation of the plane polarized monochromatic light passing through a flint glass in a magnetic field.
    - Determining the Verdet's constant of flint glass as a function of the wavelength.

Special Topics
(The following experiments do not have any instructions. It is necessary to assemble them on your own. Facilities are in the research labs- 80, 84, 86-MSC).

1. Thin film deposition by Radio-Frequency sputtering and characterization by electrical conductivity measurements.
2. Magneto-electric composites synthesis and characterization.