VILLANOVA UNIVERSITY
DEPARTMENT OF PHYSICS

Syllabus

Physics: 2417-01 **Modern Physics Lab** **Spring 2014**

INSTRUCTOR:

Dr. John K. Vassiliou, Room # M365 D, Tel# (610)519-4880, e-mail:John.Vassiliou@Villanova.edu

OFFICE HOURS:

Monday, Wednesday & Friday 12:30-1:30. You can talk to me any time you want. If I am not in office, leave a message in my mailbox or with the physics department office or send me an e-mail message.

CLASS STRUCTURE AND OBJECTIVES:

The purpose of this course is to introduce the students to selective "landmark experiments" which gave rise to modern physics such as Quantum Mechanics or experiments which measured fundamental quantities of crucial importance such as the velocity of light and the electron charge. In addition these experiments introduced methods and ideas that become standard tools of experimental physics or gave rise to new technologies. Therefore, emphasis will be given to the logic and methodology of the experiments as it is applied in a realistic scientific thinking. The course satisfies the writing enriched requirements.

We will have nine (9) mandatory experiments. In addition one experiment will be studied extensively as a work study. The experiment will be chosen jointly by the student and the instructor from a pool of experiments. The student is expected to interact closely with the instructor for guidance and help during the project.

LAB REPORTS:

You are expected to submit a four to five page lab report *for each experiment* a week after you took the data. Further delay will result to a diminished grade. The analysis of the data and the necessary graphs will be done in the lab. The reports will be corrected and judged for *content, style and language* and is expected to satisfy the *writing enriched requirements*. If the requirements are not satisfied the report will be returned for further corrections and resubmission. If the time is not enough to finish the lab during the assigned time, feel free to continue the experiment any time during the week. Cooperation is encouraged but plagiarism is not tolerated. Identical reports will count as one and the grade will be split among the perpetrators.

At the end of the semester each student will present a 20 minutes talk on the progress of his experimental project and a few page summary will be submitted to the instructor. If you use a Power Point presentation a copy of the presentation file will be forwarded to the instructor, preferably, a few days before the presentation date. The student is expected to be able to answer questions and address the audience's criticism that his/her talk could generate. The talks will be chosen from articles of current interest appearing in Journals and Magazines, such as, Nature, Science, Scientific American and the monthly report Physical Review Focus.

GRADING:

Your grade will be based on your lab reports (70%) and your experimental project and class presentation (30%). *The reports are due at the next lab session*. Lab reports submitted later than the one week allotment time, will be in the discretion of the instructor to be accepted, and will incur a 10% reduction in grade for each additional week of delay. The student is expected to be aware of the theoretical and experimental ideas involved. The instructor will orally quiz the students about their lab preparation and a grade will be assigned, which will contribute to the lab report grade.

Experiments in operation:

Photoelectric Effect and the measurement of e/h

The experiment demonstrates Einstein's assertion that light can behave like a particle in agreement with the new ideas of Quantum Mechanics. These findings are contrasted to the classical ideas of Electricity and Magnetism, which asserts that light behaves like a wave.

Frank-Hertz Experiment

This experiment demonstrates that the internal energy of the atoms takes discrete values (the energy is quantized) in agreement with the new ideas of Quantum Mechanics. This finding is contrasted to the conclusions of classical physics, according to which the energy could take all the values. The experiment introduces the new technique of *electron-atom inelastic scattering* in order to measure the atomic energy levels.

Electron Spin Resonance (ESR)

This experiment demonstrates that the electrons have an intrinsic angular momentum S called Spin, which can have only two discreet values $S = \pm 1/2$. This conclusion is a purely Quantum Mechanical effect. It can not be explained by the ideas of classical physics. The technology of "Magnetic Resonance Imaging" (MRI) is based on the property of spin of protons. We use this property of protons to view the interior of the matter.

Millikan Oil Drop Experiment

We use this experiment to demonstrate that the electric charge appears in discrete values. The smallest value it can have is equal to the charge of the electron and the experiment gives a method to measure the electric charge of the electrons.

Hall Effect

This experiment studies the interaction of an electric current with a magnetic field. We use this method to measure magnetic fields as well as to study the properties of the current carriers in metals and semiconductors.

Microwave Optics:

1) Bragg Diffraction & Double Slit Interference
2) Fabry-Perot and Michelson Interferometer
3) Reflection & Refraction of Microwaves

The experiment demonstrates that the electromagnetic radiation with wavelength in the range of microwaves has all the properties of waves. We use a variety of interference techniques to measure the wavelength of these waves and probe the properties of some composite solids.

Fiber Optics:

1) Transmission of an analogue DC signal over an Optical Fiber
2) Transmission of sound over an Optical Fiber
3) Pulse amplitude modulation: its transmission via Optic Fiber

We study the technology of transmitting information using optical light and fiber optics as transmission medium. We transform electric signals to light pulses at the emitter end of the fiber and transform light pulses to electric signals at the receiver end of the fiber optic.

Michelson Interferometer:

1) Measure of the wavelength of light waves
2) Measure of the index of refraction of air as a function of pressure
3) Measure of the index of refraction of a slab of a glass
4) Use the Fabry-Perot Mode of interferometry
   View the two distinct interference fringes of the sodium light

This experiment demonstrates the interference of two coherent optical waves with relative phase shift due to their round trip propagation along two perpendicular directions. It also develops techniques used in the measurement of the index of refraction of gasses and transparent solids.

Fuel Cells:

1) Current-Voltage characteristics of the Fuel Cell
2) Faraday's First Law and Fuel Cell Efficiency

In this experiment we explore the immerging "hydrogen technology" of electric power production using Fuel Cells. We study the physical principles, the efficiency and the electrical characteristics of the fuel cells.

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Schedule

Group # 1	**Group # 2**	**Group # 3**
Photoelectric Effect	Photoelectric Effect	Millikan Oil Drop Experiment
Millikan Oil Drop Experiment	Microwave Optics	Photoelectric Effect
Microwave Optics	Millikan Oil Drop Experiment	Microwave Optics
Hall Effect	Michelson Interferometry	Electron Spin Resonance (ESR)
Michelson Interferometry	Electron Spin Resonance (ESR)	Hall Effect
Electron Spin Resonance (ESR)	Hall Effect	Michelson Interferometry
Frank-Hertz Experiment	Fuel Cell	Fiber Optics
Fiber Optics	Frank-Hertz Experiment	Fuel Cell
Fuel Cell	Fiber Optics	Frank-Hertz Experiment

Student Members

Group # 1	**Group # 2**	**Group # 3**
Quinn, Molly C.	Peters, Christopher M.	Gropp, Jeffrey D.
Ock, Jimmin	Schechter, Tyler R.	Ruby IV, John J.
Boyd, Karim	Xhori, Paul	