Physics 413_2 Lab

Textbook:

Melissinos and Napolitano, "Experiments in Modern Physics"
Lyons, "Data Analysis for Physical Science Students"

Suggested Reading:

Preston and Dietz, "The Art of Experimental Physics"
Berendsen, "A Student's Guide to Data and Error Analysis"
Bevington, "Data Reduction and Error Analysis for the Physical Sciences"

Outline:

Students are required to complete 6 experiments from the following list. As well as demonstrating key experiments in the development of modern physics, this laboratory introduces the student to techniques and methods of experimental physics. The textbooks provide detailed guidlines for some of the experiments.

Students are expected to set up their own apparatus and maintain an orderly lab notebook. The lab notebook should have numbered pages, dated entries, diagrams and descriptions of the apparatus and procedures, and data should be analyzed as well as recorded. Error analysis and report writing are an important aspect of each experiment. Report writing is facilitated by maintaining a proper lab notebook. Assessment is based on written reports which are required for each experiment, a written exam and a final oral exam which tests the student's knowledge of experiment and theory. The notebook and laboratory performance will also be assessed.

Learning Outcomes:

The students will be able to design, execute, analyze and report a physics experiment.

Evaluation:

6 experiments	60%
written exam	10%
oral exam	10%
lab notebook	10%
personal observation	10%

Tentative Due Dates:

expts. 1-6	Sept. 15, 29, Oct. 13, 27, Nov. 10, Dec. 6
written exam	Oct. 20
oral exam	Dec. 15

There will be a penalty for late reports.

Experiments 1 and 2, done by all students in set order:		More information:	
1.	Poisson statistics of background radiation.	{Section 9.4.2 and Chapter 10, Melissinos} [p.132, Preston and Dietz] <Lyons>	
2.	Hydrogen atom spectrum and sodium fine structure.	{Sections 1.4 – 1.6 M}	
Select three more experiments, to be done in no set order:			
3.	Millikan oil drop.	{Section 1.2 M}	
4.	Franck-Hertz experiment.	{Section 1.3 M}	[Expt. 11 P&D]
5.	Photoelectric effect.		[Expt. 9 P&D]
6.	Thermionic emission.		[Expt. 7 P&D]
7.	Hall effect.	{Section 2.3 M}	[Expt. 17 P&D]
8.	Electron charge to mass ratio.		[Expt. 7 P&D]
9.	Blackbody radiation and Planck's constant.		[Expt. 8 P&D]
10.	Semiconductor junction diode.	{Section 2.4 M}	
11.	Speed of Light.		
12.	Chaos.	{Section 3.7 M}	
Final experiment, done by all students:			
13.	Operational Amplifier.	{Section 3.5 M}	

Report Format (the report must have the following)

- title.
- your name.
- abstract.
- the abstract is a 2 or 3 sentence summary of the essential results of the experiment.
- the report is usually divided into several sections.
- introduction/theoretical background/methods/results/analysis and interpretation/conclusions.
- bibliography and numbered reference list are placed at the end.
- the text should be clear and concise.
- error analysis is required.
- the result of a measurement cannot be interpreted unless an error bar is given.
- for examples of form, content and style, see Physical Review A or other physics journals.
- all pages must be numbered.
- each figure and table must be numbered (displayed equations should be numbered).
- use schematic diagrams, graphs and tables to describe the apparatus and present the results.
- each diagram, graph, and table must have a caption identifying and explaining it.
- axes of graphs must be labeled.
- each diagram, graph and table must be referred to in the text.
- each reference must be cited in the text.

Brief descriptions of the first two experiments:

1. Poisson statistics of background radiation.

Objectives: Introduction to statistical distributions.
Estimation and interpretation of random errors.

- set plateau voltage on Geiger counter.
- record number of counts per interval, in sets of 0.1, 1 and 10 minute intervals.
- also record counts in a set of 0.1 min intervals with the detector in the lead "castle".
- graph the count-per-interval distributions.
- compute statistical measures: mean and standard deviation.
- compute the Poisson distribution corresponding to each data set.
- compare with the Gaussian distribution which approximates the Poisson dist'n.
- do the measurements follow the Poisson dist'n? (use χ^2 test)
- for each set of measurements, what is the best estimate of the background countrate?
- did the countrate vary significantly during the measurements?

2. Hydrogen atom spectrum and sodium fine structure.

Objectives: Introduction to optical spectroscopy.
Precision measurements, data analysis and least-squares fitting.

- align and focus grating spectrometer.
- calibrate spectrometer with mercury spectral lines; use least-squares fit.
- measure hydrogen atom spectral line positions and determine wavelengths.
- determine Rydberg constant.
- measure fine structure intervals in the sodium atom spectrum.
- does each measurement give the same $^2P_{1/2}$ - $^2P_{3/2}$ energy difference?

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