Modern Physics Laboratory

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Objective: This lab course is suitable for upper level undergraduates and beginning graduate students. It provides hands-on experience with experiments in modern physics that are challenging at varying levels of expertise. Much of the equipment is interfaced to personal computers which are available for data acquisition and analysis. Typically, about seven experiments are to be completed in a semester. You are encouraged to inquire into the possibility of performing an experiment of your own design, making refinements to the experiments or expanding the range of measurements suggested in the handouts.

1. Goals

Judgement: Identify the goals of the experiment, and figure out how to achieve the goals. Use lab time wisely. Try to get the right mix of time spent learning the apparatus and its limitations and time spent taking data. Take enough data, but over-doing it is a waste of lab time.

Experience with scientific apparatus: This ranges from being able to read instrument scales, to using computerized data acquisition systems, to knowing safety hazards, to effectively using specific pieces of equipment, to designing experiments of your own.

Data analysis: This is not something you do after all the data has been collected. You should make order of magnitude calculations of various effects, and assess if they may contribute to the results you're after. It is good practice to figure out what is limiting the accuracy of your results. Sometimes, reducing the error will entail taking data for a longer period of time or making additional measurements. Other times you may find that the accuracy is limited by an effect which can't be quantified without a measurement you are unable to make. You should also become familiar with the formal procedures associated with data analysis such as propagation of errors and least squares analysis.

Communication skills: You should learn how to give oral reports on your work and how to present your results in a formal written report. Guidelines are given below. I will be concerned more with content than style.

Physical concepts: This is not a lecture course. I expect you to learn the physics from your lecture courses, reference material and by asking questions.

EXPERIMENTS

The experiments that are available to be performed this semester are as follows:

Experiments

1. Zeeman Effect
2. Compton Scattering
3. X-Ray Bragg Diffraction
4. Temperature Dependent Lifetimes of Fluorescence from a Phosphor
5. Nuclear magnetic resonance
6. Hall Effect
7. FTIR
8. Cesium Heatpipe Experiment
    a. Resonance Ionization Spectroscopy of Cesium
    b. Absorption Spectroscopy of Cesium
    c. Stimulated Electronic Raman Scattering of Cesium
    d. Fabry-Perot Interferometry with a Nitrogen Pumped Tunable Dye Laser
9. The Speed of Light--Rotating Mirror Version

Other experiments that may be available are as follows:

Other Experiments

1. Saurated Absorption Spectroscopy of Rubidium
2. Wavelength vs. Temperature of a Laser Diode
3. Absorption Spectroscopy of Rubidium
4. Saturated Absorption Spectroscopy of Rubidium
5. Balmer Series with Scanning Spectrometer
6. Superconductivity Experiment
7. Cavendish Experiment--Determination of Gravitational Constant
8. Franck-Hertz Effect
9. Millikan Oil Drop Experiment
10. Alpha Spectroscopy

General Instructions

Grading

You are expected to attend class at least 6~hours per week during the scheduled laboratory hours. These are arranged during the first week of the semester. Attendence is extremely important. Miss one or two days (with cause) and I'll let you make up the time. Missing more than this is grounds for failing. Laboratory reports are due one week after the data has been taken. You will be graded on laboratory performance, written reports, and a major power point presentation on one of the experiments you and your partner(s) have performed.

Lab Conduct

Safety first: We have tried to minimize electrical and radiation hazards but there are always possibilities for injury. Follow all safety procedures for handling lasers, x-ray machine, radioactive materials and high voltage sources. **Be careful with the equipment**. Don't make connections unless you understand what you're doing. **Don't play with the equipment with "Idle Hands."** Read the equipment manuals.

Be courteous: Return tools, equipment, etc. to their proper place. Don't remove equipment from someone else's experiment for use on your own (without asking first). Return all handouts with your written report (and not bound into it).

Modern Physics Laboratory Reporting Requirements

1. One experiment will be selected in consultation with the instructor to be reported on in depth. This will be both written and a MS Powerpoint presentation to the class.

2. Reports for the remaining experiments will be brief reports which consist of the following:
    a. A title page listing the course name and number, name of the experiment, the date performed, the experiment collaborators.
    b. A diagram of the experiment with all the associated instrumentation and wiring.
    c. The raw data.
    d. Graphs of all data and analysis of data
    e. A summary of the analysis, final results, and error analysis.

3. Detailed report will consist of the following:
    a. A title page listing the course name and number, name of the experiment, the date performed, the experiment collaborators.
    b. An introduction section in which the overall experiment and its objectives are described.
    c. A description and derivation of the pertinent theory that supports the experiment to demonstrate your understanding of the principles being studied.
    d. An description of the experimental apparatus and instrumentation, complete with a schematic diagram and description of the purposes of each piece of equipment.
    e. Presentation of results section. This should include the raw data and graphs of the raw data.
    f. Analysis of Results—Description of the analysis of results including calculations and graphical analyses.
    g. Discussion of results with error analysis—identify the sources of errors and their significance in the analysis of results. Calculate the expected errors in the

4. Final grades will be calculated as follows:
    a. Performance of experiment—proper use of equipment, use of time, use of good experimental techniques, care of equipment--8 points per experiment for a total of 48 points. (This part is completely subjective by the instructor)
    b. Results and analysis of experiments—the 5 experiments with brief reports--5 points per experiment for the 5 experimentsfor a total of 25 points.
    c. Detailed report 27 points
    d. In all cases, good results are paramount. All the experiments are capable of producing good results, but depend on the care and diligence that the experimenter gives to the experiment.

Additional Notes on Written Reports

You should write your report for a physicist who understands the physics behind your work, but needs to be told exactly what went on and how it turned out.

A short introduction should explain what you tried to do and why. Little credit will be given for long histories of the experiment or theoretical derivations that can be found in the references or handouts. Give a brief explanation of the formulae you will use and how you will use them. Describe any unique characteristics of the experiment and present derivations of non-standard formulas you will use.

The experimental section should give enough information to enable someone to reproduce your results. Show the equipment used and their interconnections. Explain the data acquisition procedures. Present all raw data here or in the analysis section. Give the random errors expected and an explanation of how they were assigned. Discuss possible sources of systematic error and how you handled them.

The analysis section should show how the data and their uncertainties (random and systematic) produce the final results and their uncertainties. Present graphs or tables of derived quantities with their associated uncertainties. Show how the errors were assigned.

The results section should give a concise listing of the major findings of the experiment. Comparisons between your results and theoretical expectations or other experimental values should be made. You may also want to comment on how the experiment could be improved.