

**PHYSICS 431**  
**A Short Guide to the**  
**Advanced Undergraduate Physics Laboratory**

### **I. The Aims of the Course**

1. To give students experience learning to use sophisticated laboratory apparatus to observe interesting phenomena in modern physics.
2. To provide an introduction to the kind of work which is done in research laboratories, as well as to the instruments which are routinely used in the research laboratory. None of the experiments in this lab can be described as an original research project, yet an attempt is made to have the student approach each experiment as if he/she were doing a truly original piece of work. For that reason the experimental write-ups provide only a guide to the experiment - each student is expected to work out the details for himself. This will inevitably mean making some false starts, but that is characteristic of research in real life.
3. To provide the student with some practice in writing a report or research paper. Most physics students will obtain jobs in which their activities will be totally useless to their employer (whether it be an industry, a government or a university) unless they can provide a well written description of the results of their work. For those engaged in original research the end point is a formal journal publication which will only be accepted (usually) if it is of high quality. In either case clarity, conciseness and attention to detail are of great importance.

### **II. The Experiments**

A student should prepare for each experiment before coming to the lab by reading the laboratory write-up and by consulting suggested references. In many cases reference material is available in the lab either in the form of books or reprints of original articles published in research journals. However, our small collection is not meant to be a substitute for the main library. It is particularly important to read the instruction manuals which describe the operation of our commercial apparatus, since one of the purposes of this laboratory is to provide the student with a broad experience in the capabilities of modern sophisticated electronic devices. Before starting any experiment make sure to discuss your experimental strategy with your instructor. Each student must complete **at least 5 experiments** by the end of the semester.

### **III. The Laboratory Notebook (very important)**

Every research scientist keeps a diary in which they records details of the apparatus, experimental procedure, and data. Everything is recorded in the diary and dated, so that unusual results can be later checked to determine whether they are real or the result of an inadvertent error of the experimenter or perhaps an instrument malfunction. The students in this laboratory course are also required to maintain such a diary, using for this purpose a bound notebook (e.g. one of the bound lab notebooks available from the S.F.U. Bookstore.) One uses a bound notebook so that pages can not be accidentally lost. It is advisable to plot the data more or less at the same time as the measurements are made because in this way erroneous data or points which obviously do not follow the general trend can be repeated. All data and pertinent events during the course of the experiment should be recorded. Do not erase simply cross out something that appears to be a mistake. It sometimes happens that that material is worthwhile referring to at a later date. Do not

forget to label carefully all diagrams and graphs. Also label the axes on a graph, and be sure to record the units of the quantities involved. Computer printouts should be stapled into the lab notebook. Generally a minimum of two notebooks will be required so that one can be handed in with the relevant written report.

## **IV. The Written Report**

The student is required to turn in a formal written report for all experiments. The experiment has not been completed until such a report has been handed to the instructor. The report should be brief, but complete and should conform to accepted standards for English prose style. The student should hand in the lab notebook with the data and analysis corresponding to the given report.

Each laboratory report should contain the following 5 components, although the exact presentation is subject to some variation depending on the circumstances of the experiment, as the student can see by a brief look at a few scientific papers.

### **1. Abstract:**

This should be very brief, perhaps four or five sentences long. It should describe the point of the experiment, the method of measurement, and the result of the measurement with an estimate of the uncertainty in the result.

### **2. Introduction:**

A brief development of the background to the experiment with a statement of relevant theoretical formulas. This should not be simply copied verbatim from a textbook or on-line source. Justify statements or formulas by giving references. (References should be indicated by superscript numbers in the text and the full references should be collected at the end of the report.)

### **3. Report of the Experiment:**

A concise but complete description of the experiment, including sketches of apparatus, block diagrams, circuit diagrams etc. all clearly labelled. Data should be listed in tables where relevant or presented in the form of graphs (remember - label all axes including the units). All final results should be tabulated, and appropriate graphs should be used to illustrate the relationship between important quantities. Uncertainties in experimental quantities should be indicated.

### **4. Discussion of the Results:**

This section should contain an analysis of the results of the experiment together with estimates of their reliability. These estimates of reliability should be based upon the standard rules for error analysis as outlined in e.g. Baird's book (2<sup>nd</sup> year lab)

### **5. Conclusions**

This section should include a brief summary of the important conclusions or key points of the paper.

## **V. Plagiarism**

Plagiarism will not be tolerated in any form. Excerpts from other sources, whether on-line or paper-based journals or textbooks, must be properly cited using the standard format for references (see any scientific paper for examples). The use of figures obtained from online sources is also prohibited unless properly referenced. In general it is preferred that students create their own diagrams and figures rather than cutting and pasting from online sources. Plagiarism will result in a grade of zero for the report. Additional sanctions are described in the SFU policy on plagiarism:

## **VI. Comments on the Experiments**

We would appreciate it very much if you would bring misprints and errors to the attention of the instructor, so that corrections can be incorporated into future editions of the write-ups. Any suggestions for the improvement of an experiment will be gratefully received.

## **VII. Lab Schedule**

The laboratory will be open two afternoons per week from 1:30 p.m. to 4:30 p.m. Students may occasionally use the laboratory at other times, but they must arrange this with the instructor.

## **VIII. Requirements and Grading**

Grades will be determined on the basis of:

- (a)      Laboratory skill
- (b)      Laboratory notebooks
- (c)      Laboratory reports

The report and corresponding notebook should be submitted for grading within 10 days of completing an experiment. For the last experiment the deadline is the first day of the exam period. Grades will be reduced for those who display substantial tardiness.

**Very important:** the report and notebook will be graded as a unit. If the claims and results reported in the formal report are not documented in the notebook, the report will receive a failing grade. In this context, it is always good to err on the side of too much note taking rather than too little.

## **VIII. Books, Reprints and Instruction Manuals**

These are kept in the bookcase and filing cabinet. Most of these you may sign out (use a card in the box provided) but you must have them in the lab during laboratory periods. Please also be considerate of other students who may wish to use the same material.

## **IX. Lab Benches**

When you are finished an experiment please tidy up the area that you have been working on. (Put all cables back on the racks, dispose of old paper etc.)

## **Current list of experiments**

**X-ray diffraction**

**Faraday Rotation**

**Earth's field NMR (lab partner recommended)**

**Optical pumping (lab partner recommended)**

**Superconductivity**

**Muon physics**

**Scanning tunneling microscope**

**Transport in semiconductors**

**Experiments with transmission lines**

**Sonoluminescence**

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