PH3101 - Physics Laboratory 1

Credits: 15.0  Semester: 2  
Number of Lab afternoons: 21  Co-ordinator: Dr Cameron Rae  
Academic Year: 2017-18

Overview
This module is made up of a set of sub-modules, each one lasting for four afternoon sessions with students undertaking five sub-modules in the course of the semester. Sub-modules presently on offer include: Lasers, Low Temperature Measurement, Electronics, LabView, and Towards the Quantum Limit. These may change, for example as new experiments are introduced. Descriptions of the present sub-modules are given below. The class is divided into groups, usually of eight persons, which then circulate around the sub-modules sequentially. The structure of the sub-modules differs from one to another. In some, students work on the same set of experiments, usually in pairs. In others, there are a number of experiments based around a common theme; following an introductory overview, students work singly or in pairs on specific experiments. Some of the sub-modules conclude with feedback sessions where students present the outcomes of their experimental work to their peers and demonstrators, followed by discussion. Other sub-modules aim at building basic skills such as in electronics or computer-based data handling. All the experiments are up-to-date and relevant to the training of a practicing physicist, with a number of the experiments closely related to those found in contemporary research laboratories. The variety of approaches offered ensures that you will find this laboratory both enjoyable and stimulating. The first session is taken by the class as a whole and includes an important safety seminar, covering electrical, chemical, cryogenic and laser safety, followed by practical advice on the keeping of laboratory note-books and additional administrative information.

Aims & Objectives
To give you practical experience of some pervasive experimental techniques relevant to a practicing physicist, e.g. electronic design, computer-based data handling, cryogenic handling. To introduce you to important contemporary developments in experimental physics, e.g. scanning tunnelling microscopy, lasers and nonlinear optical devices, optical and electromagnetic traps. To strengthen your understanding of important physical concepts, e.g. phase transitions, quantum interference, atomic scattering, quantum tunnelling. To develop sound practice in a number of important generic skills such as planning of experiments, risk assessment, record keeping, data handling and evaluation, error analysis, drawing evidence-based conclusions, identifying future work. To enhance manual and mental dexterity at performing experiments. To develop transferable skills with regard to the presentation of research outcomes through both written work and oral presentations. To gain experience of carrying out experimental work while working alone, in partnership, and in small groups.

Learning Outcomes
You will have acquired: familiarity with a range of important and pervasive experimental techniques, practical experience of contemporary experimental equipment, including some used in present-day research laboratories, a fuller understanding of a range of important physical concepts through exploring them in experimental situations, key generic skills required by an experimentalist in the physical sciences, encompassing documentation, assessment, deduction, and presentation, ability to work both on your own and collaboratively.

Synopsis
LabView (LV):
LabVIEW is an industry-standard programming and control environment. It is used throughout science and engineering as a means of creating programs, and is ubiquitous in laboratories that require instrument control. A familiarity with LabVIEW is therefore a very saleable transferable skill. The purpose of this sub-module is to give the student an introduction to programming and the use of LabVIEW. By the end of this sub-module the student should be able to build a LabVIEW virtual instrument (VI) to undertake a specified task. The sub-module develops the student through finding out about the LabVIEW environment, ensuring they become familiar with the various windows, menus and tools. Next a simple VI is created, edited and debugged. The use of sub-VIs is discussed and two means of creating these undertaken; including setting up an icon and connector pane. Loops, program structures, arrays, charts and graphs are also introduced and used in the
development of various VIs. The lab culminates in using LabVIEW’s control ability to interrogate a GPIB instrument simulator. The student learns how to communicate with a GPIB instrument, and puts into practice some of their newfound skills in interpreting and visualising simulated experimental measurements. At the end of these four afternoons the student will have the skill needed to start using LabVIEW to tackle future projects.

Lasers (L):
In the first half of the sub-module the group will be working together investigating aspects of the longitudinal and transverse modes of lasers. This will allow students to explore important aspects of laser physics that also lie in with ideas in quantum mechanics and in oscillations and waves. The activities also develop aspects of experimental technique and the interpretation of the science behind various observations. In the second pair of afternoons students will work individually on their choice of one of a number of laser experiments. These may include various laser systems, conversion of laser light from one frequency to another, fibre optics, holography, remote sensing of speed with lasers, and the optics of optical data storage.

Electronics (E):
Electronics and in particular an understanding of its basic principles are invaluable skills in the Physics research laboratory. Whilst many designs are constructed and tested on the bench in a trial and error fashion, it is often highly desirable to be able to model the behaviour of a circuit on a computer to aid component value selection and hone its characteristics. Of particular interest in experimental research is the design and application of filters, which use capacitors, inductors, resistors or a combination of these. It is often very difficult to diagnose the characteristics of these circuits on the very short (transient) time scale, and so computer modelling becomes very important indeed. In this module you will be introduced to such a modelling program, (National Instruments - Multisim), and use it to investigate various simple circuits in the transient and steady-state regime to get a feel for how they react.

Towards the Quantum Limit I (QLI):
The invention of such devices as the scanning tunnelling microscope and the development of various methods of trapping particles either electromagnetically (e.g. Paul Trap) or optically (e.g. Optical Tweezers) has taken physics to the quantum limit of "seeing" entities such as individual atoms or molecules. The two-slit interference experiment when conducted with only single photons in the apparatus at any one time is another example of observation taken to the quantum limit. These are the experiments that you will encounter in this sub-module. Following an overview of the experiments during the first afternoon, the group will break up into four pairs with each pair carrying out one of the four experiments over the next two afternoons. The final afternoon will be the feedback session in which students, in pairs, will discuss the perspective of their experiment, elucidate its conceptual foundations, present and evaluate their results, and reach conclusions for further discussion by the group as a whole; very much along the lines of presenting an invited paper at a conference.

Low Temperature Measurement (LTM):
Small cryostats with base temperatures of either 77K (using liquid nitrogen) or ~4K using liquid helium will be used for basic training in making measurements at low temperatures. This will include handling cryogens and using temperature controllers. Electrical resistance or magnetic susceptibility vs temperature will be used to probe the physics of materials.

Pre-requisites
PH2011, PH2012, MT2001 or (MT2501 and MT2503)

Anti-requisites
None

Assessment
Continuous Assessment = 100%

Additional information on continuous assessment etc
Please note that the definitive comments on continuous assessment will be communicated within the module. This section is intended to give an indication of the likely breakdown and timing of the continuous assessment.
This module has five sets of four afternoons on a range of experiments. A contemporary lab book is maintained by students, and is submitted for assessment after each set of four afternoons. This is a 15 credit module, so is expected to take 150 hours of study for the average student at this level. The module's work is finished by revision week, so students can expect to commit about 14 hours a week to the module in weeks 1 to 11, including the 70 hours scheduled in the lab.

**Accreditation Matters**

This module may not contain material that is part of the IOP “Core of Physics”, but does contribute to the wider and deeper learning expected in an accredited degree programme. The skills developed in this module, and others, contribute towards the requirements of the IOP “Graduate Skill Base”.

**Recommended Books**

Please view University online record:
http://resourcelists.st-andrews.ac.uk/modules/ph3101.html

**General Information**

Please also read the general information in the School's honours handbook.