Upper Level Laboratories at University of Alberta

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Stand alone laboratory courses at the University of Alberta are offered throughout the second and third year of program and are customized for students from different streams. We present the general layout of individual laboratory courses for different programs. We will discuss the advanced laboratories objectives, contents, and relevance to the overall curriculum. We will also share some of the challenges facing advanced laboratories on campuses, including delivery method, assessment, computation, space and human resources.

Introduction:

Upper level laboratories at the University of Alberta start in the second year of the program and continues into the third year with a possibility of an optional fourth year project in experimental physics. We offer five laboratory courses in total, four of which are offered in the second year and one in the third year. All upper level laboratories are stand-alone courses and are not tied to other course work.

On the second year level (PHYS 29x), laboratories are designed for three different streams depending on the students background and their program of study. Those streams are:
PHYS 292: A full year (2 semester) laboratory course limited to Engineering Physics students only in coordination with the Faculty of Engineering. Course load is typically one biweekly lecture session incorporated into a weekly 3-hour laboratory period. Every experiment in PHYS 292 runs over a two week period.
PHYS 294: Designed for General Science and non-physics-majors including students from Education and Arts. It is offered in the first term of the second year. Students attend one lecture/computational session and a 3-hour laboratory period per week.
PHYS 295/297: A sequence offered in first and second terms of the second year, respectively. These are geared toward Physics Honors and Specialization students. Students attend two 3-hour laboratory periods per week including a lecture session and an optional computational period. Honors and Specialization students in Geophysics complete Phys 295 only.

The third year laboratory course, PHYS 397, is a more advanced course targeting Engineering Physics and Honors/Specialization Physics students (ratio of 60/40). It is offered in the second term of the third year. Students are expected to spend a minimum of 6 hours per week in the laboratory with no formal lecture component.

All Honors/Specialization Physics students must enroll in a special project course in their fourth year, PHYS 499. They are given the opportunity to consult with a faculty member of their choice and negotiate the possibility of carrying out a brief research

project in line with the faculty member's ongoing research. The choices are not limited to experimental physics, however, about 50% of the candidates do their project in an experimental lab. The project must be completed in one academic term. An oral presentation by the student is given to all interested members of the department. We will defer discussing this course due to the limited involvement of Undergraduate Laboratories Unit.

Second year laboratories PHYS 29x

Objectives:
Transitions from structured first year laboratories
Exposure to classical experiments in physics
Promotion of best practices in laboratory work, namely the use of log books, writing formal lab reports and the use of scientific error analysis.

At this stage we prefer that students have had seen the theory behind the experiments. Theoretical background has been covered in first year courses as pre-requisites and second year as co-requisites.

Contents:

Introduction to statistics:
Throwing darts. Concepts covered in first year statistic course.

Optics:
Newton rings, Michelson interferometer, Speed of light.

Mechanics:
Gyroscope, Kater pendulum

Thermal Physics:
Constant volume gas thermometer

Electricity and Magnetism:
e/m for electrons, Resistance of metals and semiconductors, Faraday effect, Magnetic torque, LRC resonance, Magnetic torque balance

Condensed Matter Physics:
High temperature superconductivity, Bragg diffraction of Microwaves

Subatomic Physics:
Balmer series of hydrogen, radioactive decay of radon, Absorption of radiation and Geiger-Muller counter

Classical Experiments:

Electron diffraction, Photo-electric effect, Millikan oil drop, Frank-Hertz experiment, Cavendish experiment, analysis of bubble chamber photographs.

Assessment:

PHYS 294 (General Science and others): Nine marked brief laboratory reports and hand written log books signed by a TA each week (60% of total mark). Final written laboratory exam (40% of total mark).

PHYS 292/295/297: Five brief laboratory reports accompanied by properly documented log books. Three formal laboratory reports with more details on analysis, results, and conclusions. Final oral presentation for PHYS 297 on an experiment of choice and a final exam for PHYS 292/295.

Third year laboratory PHYS 397:

Objectives:
Introduction to instrumentation and measurement techniques.
Promotion of critical thinking, independence and use of research skills to design and interpret experiment.
Formal use of log books and observations recording
Exposure to more sophisticated technical procedure than those learned in first and second year.

This is an open-ended laboratory exercise in which students are often expected to design their own version of experiments using available equipment. We hope that this experience gives students an idea about how the world look like in an actual physics research laboratory. Student are provided with small amount of written instructions that serves as a starting point for each project. The exercise requires further research to decide what and how to investigate. Students should consider ways to improve the precision of their measurements and explore other possibilities.

Theoretical background for most projects have been loosely introduced (if hardly at all) in other course work, which adds a learning value to the course. However, the technical application of such background is something new to the students.

Contents:

Electricity and Magnetism:
AC measurements and techniques, Chaos in electronic circuits

Thermal Physics:
Blackbody radiation, Thermodynamics of the Peltier cell

Condensed Matter Physics:

Diode laser spectroscopy, Fiber optics, Low temperature measurements and techniques, Scanning tunneling microscope, Vacuum technology and thin film deposition

Acoustics:
Doppler shift of microwaves, Acoustic resonance and sound wave in a box

Optics:
Fresnel diffraction, Holography, Optical Fourier transforms, Single photon interference, Ultrasonic diffraction of laser light

Nuclear Physics:
Nuclear scintillation, optical pumping of Rb, Pulsed nuclear magnetic resonance NMR

Assessment:

Students are divided into groups (twos or threes) and are assigned three experiments during the term, each experiment lasts for one month. The weights for each experiment are 25%, 35% and 40% with the last experiment considered as the final exam. For any given experiment, 30% of the mark is based on the log book and 70% on the laboratory report. The report is written in the form of a scientific paper, where students are provided with a Latex template based on PRL paper format.

Teaching assistants first review student's laboratory report, make comments and suggest a mark. All reports are handed in to the course instructor who then make further comments if needed and assign a final mark after discussion with the teaching assistants.

Computation:

All second year lab rooms are equipped with computers and have network access. Students work in groups of two; there is one computer per group (total of 36 units). Computers are mainly for data entry, data analysis and word processing; limited computerized data acquisition at this level (LabView and Logger Pro). There is also a open access computer lab that is available to second year students for three hours a week. A teaching assistant will help students with their computations during this session. Data analysis/graphing is done using Origins 7 software which the department has a group license for. Student may install a copy on their own computers if desired.

Third year lab rooms have limited number of computers (6 units), four of which are used for data acquisition and two are for general use and network access. Students are encouraged to use their own personal computers/laptops for data analysis and word processing, but access is allowed to the student computational labs. Students are free to choose any software they prefer for that matter. A computer lab is also available for third year students on a first-come basis, but no formal help is provided.

Site licenced software available for student use includes LabView, Logger Pro, Origins 7.5, Matlab and MS Office.

Space:

Second year: Two rooms, one holding 36 students and one holding 25 students,are primarilly used, with a third room holding 25 students is shared with Phys 397. All three courses utilize the rooms simultaneously since they run at the same time but not necessarily the same experiment. Room set up is similar to first year lab rooms, where all equipment and components are put out in advance for the students. Average area per student is 3.6m^2. In general, students have room access during scheduled times only but exception may be allowed on a case by case basis.

Third year: Three dedicated rooms equipped with one dark room, an enclosed fume hood, and 220 V mains. The basic stationery equipment are permanently installed in the rooms while the rest of the components remain in storage until students retrieve them. Average area per student is about 4m^2.. Students have full access to the rooms and the equipment during the formal instruction hours. After hours access is granted given that a teaching assistant, technologist, or faculty member is available in case of emergency and for liability considerations. No close supervision is provided after hours.

A shop provides technical support and equipment dispensation during scheduled hours for all upper (and junior) level laboratory courses.

Human resources:

All second year laboratory courses are taught by one faculty member. Four teaching assistants and one technologist are assigned to help run supervise students and mark laboratory reports. Student to instructor ratio is 15:1

Third year laboratory course is taught be a faculty member, accompanied by three teaching assistants and one technologist. Student to instructor ratio is 6:1

All laboratory courses are served by one shop, manned with three technicians.

Faculty members are asked to commit to teaching an upper level laboratory course for a minimum of three years to ensure continuity and vision for the courses. The faculty member's research background affects the flavor of the course to a great extent. Thus, the department tries to recruit teaching faculty members with distinctly different research interests each round.

Trained teaching assistants are hard to come by since a typical graduate student usually undertakes teaching assistantship for only three years. This puts some strain on the continuity of instruction. In most cases, the instructor's graduate students are assigned as teaching assistants, which guarantees more interaction and contact time

for training. The technologist is the only full time staff who continues on the course and thus serves as a great resource for newly coming instructors and teaching assistants.

Delivery and laboratory manuals:

Second year laboratory courses laboratory manuals are delivered online through a wiki-media environment. Students are encouraged to contribute to the manual and comment on the clarity, precision, and completeness of the contents. Students have limited editing access; approved comments and suggestions are monitored and published by the course instructor and the teaching assistants. The manual then becomes a “living document” and evolves every year.

There is no “formal” laboratory manual for third year experiments. Nevertheless, a collection of relevant scientific papers and equipment manuals are kept together as a starting point for each project. Each student has access to the collection pertaining to his/her experiment.