PHYS3009 Laboratory Policy

Selected Experiments and Seminars in Astronomy

Department of Physics, Faculty of Science, Carleton University

Fall 2024

Faculty Professor: Sangeeta Murugkar
e-mail: SangeetaMurugkar@cunet.carleton.ca
Lab Supervisor: Maria Paula Rozo Martinez
e-mail: prmartin@physics.carleton.ca

Modality: In-person.

Brightspace Link:

https://brightspace.carleton.ca/d2l/home/291239

Student Hours: TBA

Introduction

The major goals of this laboratory course are: to help students enhance their ability to work independently in solving experimental problems, to learn new data analysis methods, and to develop oral presentation skills. Standard experimental methods and procedures that are used in research laboratories will be introduced, and therefore certain new material will be presented that is not normally encountered in first and second year laboratories.

Students are expected to demonstrate the following skills they are bringing from the second year laboratories:

- Follow a procedure independently
- Demonstrate knowledge of the underlying physics principles for each laboratory
- Use standard laboratory instruments and troubleshoot simple experiments independently
- Apply experimental data recording, plotting methods, and error propagation techniques
- Use statistical analysis in the assessment of results
- Write properly formatted laboratory reports
- Apply critical thinking for solving simple experimental problems
- Deliver an oral presentation in front of peers and instructors

At the end of the third year laboratory students will be able to:

- Apply theoretical knowledge to complex physics experiments
- Solve experimental problems independently
- Develop modeling and designing skills for each experiment
- Apply various software packages and statistical tools in data analysis
- Demonstrate knowledge of safety procedures in the laboratory environment
- Use analysis techniques independently
- Select and apply error analysis methods based on each experiment requirements

- Develop skills of using a logbook for data collection and experiments preparation
- Produce lab reports complying with scientific journal formats
- Enhance oral communication skills through presentations

These objectives will be reinforced through quizzes, discussions, questions, laboratory reports, oral presentations, and logbook records.

Organization

- Labs start on the first week of classes. Lab sessions will be held twice a week on campus.
- Students will perform the experiments in teams of two. Groups of three students will not be allowed. The groups and experiments will be scheduled during the first week of classes.
- Each student is expected to come to the lab on time for each lab period. If you are unable to attend (or will be late) on a certain day, inform your partner and the lab supervisor as soon as possible. If the reason for missing the lab is accepted by the lab supervisor, you must make arrangements to make up for the lost time outside of the scheduled lab time (during working hours) when staff are available to help.
- Each student will keep an electronic logbook using OneNote or other type of electronic record keeping notebook. The progress of the record keeping will be formally evaluated.
- An outline of each experiment procedure and analysis will be posted on Brightspace. Read the materials prior to each experiment and write notes in the logbook. The completeness of the record taking will be periodically checked. Be prepared to answer questions about the progress of each experiment.
- Students are expected to work on the experiments and analysis during the scheduled lab time period. Working outside lab hours is not a substitute for lost lab time.
- For data analysis students are required to use Matlab or Python programming languages. The first few lab sessions will be designated for a Matlab tutorial with exercises on statistics and error analysis. These sessions are meant to familiarize you with the type of analyses used for the rest of the experiments. The attendance is mandatory and the exercises must be completed. No final grade will be awarded to a student who fails to attend these sessions.
- A remote desktop connection to a computer on campus will be granted to each of the students. A VPN connection to Carleton University will be required. Access to these machines will be used for data file sharing and Matlab use. Depending on your personal computer capabilities, running the programming scripts in these computers might help speed up some of the data analysis processes.
- For safety reasons, no experiments may be carried out if you are alone. The lab will be accessible at outside lab times to do analysis, to access data files, but not to perform experiments. Continuous access to the lab outside regular lab times might be granted upon request.
- Each team will complete one short experiment and two long experiments. For the short experiment, data analysis and physics discussion will be submitted. For the rest of the experiments, formal lab reports are expected. The due dates are indicated in the lab schedule.
- Each student will write his/her own lab report. No shared formatting of tables or graphs will be allowed. A copy of the original data recorded in the logbook must be presented for review to the lab supervisor at the end of the data taking period. While in some cases the data might be shared between the members of a group, some experiments will require a set of data for each individual.

- All the lab reports are due before the start of a new experiment (see lab schedule). Penalties are applied for late submissions. All the lab reports are to be submitted online via Brightspace. Lab reports must be submitted as a single document in PDF format along with any relevant data analysis files in *.m, *.mlx or *.xls format.
- Each group will give two 15-minute presentation to the rest of the class (the time limit will be strictly enforced) about two of the experiments and their results. These presentations are intended to be a practice for future seminars and presentations at meetings and conferences, and should be formatted accordingly. Practice your presentation in advance, MS PowerPoint is recommended.

Experiment Schedule

Lab sessions are held in person on Wednesdays and Fridays from 13:05 to 15:55. The term starts on Sept 4th, 2024 and ends on Dec 6th, 2024.

<table>
<tr><th>Week</th><th>Date</th><th>Experiment</th><th>Lab work due*</th></tr>
<tr><td rowspan="2">1</td><td>04-Sep</td><td>Introduction</td><td></td></tr>
<tr><td>06-Sep</td><td rowspan="2">Matlab Tutorial</td><td></td></tr>
<tr><td rowspan="2">2</td><td>11-Sep</td><td>Logbook 1 / Matlab Test</td></tr>
<tr><td>13-Sep</td><td rowspan="3">Hubble's Law</td><td></td></tr>
<tr><td rowspan="2">3</td><td>18-Sep</td><td>Logbook 2</td></tr>
<tr><td>20-Sep</td><td>Short lab report</td></tr>
<tr><td rowspan="2">4</td><td>25-Sep</td><td rowspan="6">One of:
Zeeman Effect
X-ray Fluorescence
Planck's Radiation Law</td><td>Logbook 3</td></tr>
<tr><td>27-Sep</td><td></td></tr>
<tr><td rowspan="2">5</td><td>02-Oct</td><td>Logbook 4</td></tr>
<tr><td>04-Oct</td><td></td></tr>
<tr><td rowspan="2">6</td><td>09-Oct</td><td>Logbook 5</td></tr>
<tr><td>11-Oct</td><td></td></tr>
<tr><td rowspan="2">7</td><td>16-Oct</td><td>Logbook 6</td></tr>
<tr><td>18-Oct</td><td>Formal lab report</td></tr>
<tr><td rowspan="2">8</td><td>23-Oct</td><td colspan="2" rowspan="2">Fall Break</td></tr>
<tr><td>25-Oct</td></tr>
<tr><td rowspan="2">9</td><td>30-Oct</td><td>Experiment Talks</td><td>Logbook 7</td></tr>
<tr><td>01-Nov</td><td rowspan="6">Studying the Milky Way Galaxy
with Radio Astronomy</td><td></td></tr>
<tr><td rowspan="2">10</td><td>06-Nov</td><td>Logbook 8</td></tr>
<tr><td>08-Nov</td><td></td></tr>
<tr><td rowspan="2">11</td><td>13-Nov</td><td>Logbook 9</td></tr>
<tr><td>15-Nov</td><td></td></tr>
<tr><td rowspan="2">12</td><td>20-Nov</td><td>Logbook 10</td></tr>
<tr><td>22-Nov</td><td></td></tr>
<tr><td rowspan="2">13</td><td>27-Nov</td><td>Final Logbook Submission</td></tr>
<tr><td>29-Nov</td><td>Experiment Talks</td><td>Lab report due on Dec 6th</td></tr>
</table>

*Logbook record uploads will be due at the start of the session on the specified dates. The submission links on Brightspace will be kept open during the week and the content will be periodically checked and discussed. It is the responsibility of the student to demonstrate the continuing progress of the experiment by keeping the files updated to the most current version throughout the week. Ensure that all entries are dated.

Lab report submissions will be due at 23:59 on the specified dates.

Grades

In order to pass the lab course, all experiments must be completed and a lab report for each submitted. No late submissions will be accepted after the last day of the term. In evaluating a student's work, the following aspects of his or her performance will be taken into account.

Lab work: The students must study the physics literature to the extent that they acquire an understanding of the theory and instrumentation relevant to their experiment. In-class quizzes, tests, and logbook completeness will be part of the in-lab work. Notes of the related theory recorded in the logbook together with reflections and questions asked during class will be graded for each experiment. Lateness and how well the lab time is used to work on experiments and analysis will also be considered.

Presentation: The last two experiments will require a 15-minute presentation. This is a practice to develop some skills on how to give a talk and help you prepare for future presentations at conferences. It might be presented as a group work, but each student will be individually graded.

Electronic Logbook Record: The completeness, precision, and clarity of the records will be considered for each experiment. Logbook records will be graded by the TA every week.

Lab reports: Reports must be carefully edited and follow the recommended guidelines.

The final grade is a weighted average of the short experiment analysis, the written reports, the oral presentations, the logbook records, the introductory work with Matlab, and a subjective evaluation by the lab instructors and TAs concerning your laboratory performance. The final mark for the course will be based on the following weighting scheme:

- Lab work and logbook records, 15%
- Introductory Matlab work, 5%
- Short experiment write up, 15%
- Lab reports, 55%
  - 25% for the first long experiment
  - 30% for the second long experiment
- Oral presentations, 10%

Late reports will incur a penalty of 20% (up to one week late). Reports that are late more than one week will not be graded (they still must be submitted to show that the experiment was performed).

Instruction Materials

Text books and useful web sites:

Barford, N.C., Experimental Measurements: Precision, Error and Truth, John Wiley and Sons, 1985
Bevington, P., Data Reduction & Error Analysis for the Physical Sciences, New York, McGraw-Hill.
Melissinos, A. C., Experiments in Modern Physics, Academic Press, 1966
Evans, The Atomic Nucleus, 1955
Haken, H., Wolf, H. C., The physics of the atoms and quanta, Springer, 2004
Dunlap, R.A., Experimental Physics, Oxford University Press, 1988
Dietz, E.R., Preston, D.W., The Art of Experimental Physics, John Wiley and Sons, 1991
Knoll, Glenn, Radiation Detection and Measurement, John Wiley and Sons, 1999
Carroll, Bradley W., and Dale A. Ostlie. An Introduction to Modern Astrophysics . 2nd ed. San Francisco: Pearson Addison-Wesley, 2007

Computer use Rules

Most of the computers in the advanced lab are connected to the network and you must log on with your Carleton account to use them.

- Use your Brightspace credentials (username and password) to log on.

- It is the student's responsibility to save their work before logging off. Save your collected data and files on a USB key, or on the P: drive, or e-mail them to yourself for analysis at home.
- The data may be lost once you log off from the computer.
- If you are collecting data for a long period of time, you will still be connected to the machine on the next day but will be asked to type your password again.
- If experimental data or a file is not saved and it is lost, the student will have to collect the data again.

Experimental Procedures

When performing an experiment there are several aspects to factor in: how to use the equipment in the best possible way to give you accurate results; what techniques to use for the data analysis; how to communicate to the reader that your results are meaningful. Follow these steps when performing an experiment or when analyzing provided experimental data:

- Read and understand what are the goals of the experiment. Before turning any equipment on and taking any measurements, you should have read the instruction materials and references. Understand the physics involved and the experimental techniques used by others. You should be prepared to answer the questions the lab instructor/TA may ask.
- Examine the equipment you will be using; understand each component of the experimental setup and record the precision of each instrument. Discuss the safety handling of the equipment with the lab staff. Keep a record of the safety considerations in your logbook.
- Write down questions that you have about the equipment and the set-up. Discuss the apparatus with the lab instructor/staff members. These questions should be addressed for the data analysis experiments as well.
- Work out a technique for taking all the measurements (or ask questions about the details of already collected data). Write notes about the process in your logbook, it will help you when you write the procedure in the report later. Think of ways to cross reference your results and ensure that you are not making mistakes.
- After collecting the experimental data, work on the analysis during the lab period (when possible) and discuss your results with the lab supervisor. This will help you spot possible mistakes in the measurements early and give you a chance to correct them. The logbook should have a record of all the measurements.

Logbook Records

The logbook is a record of your work for each experiment. An electronic submission is due on Brightspace every week. For record keeping, recommended software are: Google Docs, Overleaf, or One Note. Any other software that you are comfortable with and that allows for continues entries can be used. Hand-written notes are accepted and must be scanned for submission. For each experiment, the entries should include:

- the objectives of the experiment (described in your own words)
- the underlining physics, including references for later use
- entries of the tasks as they are completed
- entries of the new tasks and questions for next week
- entries of the results and calculations as the progress of the experiment is followed

- entries of reflections of how well the equipment works, what are difficulties encountered while working with the apparatus or with the data analysis

The log entries are due weekly on Brightspace. They will be checked, marked, and discussed during the scheduled lab sessions. The logbook record keeping should make sense if you come back in a few months. There should be enough information that allows you to complete the experiment analysis and a write up as if starting again. The logbook records will help with the contribution to the lab reports and oral presentations.

Laboratory Reports

The results of scientific research are usually published in scientific journals. In this course, you will present your experimental results in the form of laboratory reports. By doing so, you will develop skills in scientific writing and will get to thoroughly understand the theory and data analysis involved in the experiments, gaining a better insight for the arguments supporting their validity. The format to follow is listed below. For more details please refer to the laboratory report guidelines (provided as a separate document).

- Abstract
- Theory
- Apparatus/Procedure
- Results
- Discussion
- References
- Appendices

When formatting the report make sure to use clear and short sentences. Follow the suggested format and make sure that the document is organized and that it is easy to find information in it. Give reasons for your calculations in order to validate a conclusion at the end. A good report can be written regardless of the success of the experiment.

Oral Presentation

The presentation at the end of each experiment should be prepared in Power Point. If performed in groups, both partners must equally contribute to the presentation. Before all the presentations start please have all the relevant files uploaded on Brightspace for each group member. Practice your presentation in advance, time it and ensure it fits in the time limit. Include the following slides:

- Title, author, and an outline specific to the experiment; 2 slides, one for the title page and one for the outline
- Introduction (15%), should include short history, the interest and practical applications, with a focus on the the underlying physics; 3-4 slides
- Body of the talk (50%), experimental set-up and method, data collection, data analysis (graphs, tables), sources contributing to statistical and systematic uncertainties; 4-6 slides
- Results (30%), results and uncertainties, interpretation of results, connection of experiment with theory; 2-3slides
- Short conclusion and a discussion on the method and errors (5%); 1 slide
- Diagrams should be used when appropriate to clearly illustrate the experimental setup and the underlying physics that is being addressed.

The talk should be 12 minutes long plus about 3 minutes for questions. If in groups, each member of the group has to present some of the slides. If you are unable to give a talk at the scheduled time communicate promptly with the lab instructor.

Ethics in Science Education

Here are some extracts from the Carleton University Academic Integrity Policy: "Students are responsible for being aware of and demonstrating behavior that is honest and ethical in their academic work. Such behavior includes:

- Following the expectations articulated by instructors for referencing sources of information and for group work.
- Submitting original work, citing sources fully, and respecting the authorship of others.
- Asking for clarification of expectations as necessary. Students who are in doubt as to whether an action on their part may b e viewed as a violation of the standards of academic integrity should ask their instructors, lab assistant and/or advisers.
- Identifying testing situations that may allow copying.
- Preventing their work from being used by others, e.g. protecting access to computer files, etc.
- Adhering to the principles of academic integrity when conducting and reporting research."

It is normal to consult with others and work collaboratively in the course of an experiment. Nevertheless, all sources of information must be stated, and both the substance and text of scientific reports must be one's own. Sometimes you will get things wrong because of an error in the manipulation of apparatus or malfunction of the equipment. The lab supervisor will help you figure out the problem or in the case that you can not get your own data, you may use someone else's (with the permission of the lab supervisor), provided you acknowledge it.

Fabrication or falsification of data, or using results of another student's work without acknowledgment is a serious plagiarism offense. In some cases can lead to the loss of academic status. "Plagiarism includes reproducing or paraphrasing portions of someone else's published or unpublished material, regardless of the source, and presenting these as one's own without proper citation or reference of the original source." In this course, any lab report copied in whole or in part from another source will automatically receive a grade of zero. In the case that two students present reports where parts have evidently been copied from one another, both reports will receive a grade of zero.

With the growing use of social platforms (e.g., Discord) on campuses, it is important to keep in mind that university codes of conduct still apply to the behaviours of students online. Please be considerate and respectful while engaging with peers and remember that we are all humans, and that your words matter. If any student witnesses or experiences harassment, bring it up to the lab supervisor and contact Ombuds Services or Carleton Equity and Inclusive Communities.

- In this course appropriate peer-to-peer sharing includes: identifying the proper formula to use, identifying an incorrect or missing step in a person's work, brainstorming potential reasons behind a concept, suggesting helpful sites and videos for learning a concept, posting your own work showing only a specific step or process for illustrative purposes (note: this is very different from posting your work and solution for others to simply copy)
- Examples of unacceptable peer-to-peer sharing: Posting or sharing the answers, indicating which answers are correct on assignments, sharing links to solutions, posting your own complete work for a question.

There may be specific situations not covered by these rules, and there may also be certain cases where a rule does not apply. If you are concerned, confused, or conflicted over something, please reach out to the lab supervisor through email for help. Let's do our best to support one another in this class and keep a safe, inclusive, and positive lab experience for everyone.

Safety in the laboratory

Various hazards present themselves in the physics laboratory due to the use of sophisticated equipment and techniques. Prevention of injury, to you and to others, is a matter of being aware of, and treating with respect apparatus and materials which may be potentially hazardous. One of the goals of this physics laboratory is to instruct you in the safe use of equipment and materials commonly encountered in research and industrial laboratories. We have endeavored to make the lab as safe as possible for you, but ultimately it is your responsibility to ensure your own safety and that of others. The following is a summary of the most basic rules and points:

- If an accident does occur, notify the lab staff immediately.
- In case of a fire alarm, evacuate the building in an orderly fashion, via the nearest fire stairs or exit. Do not use elevators! Congregate at the closest safe destination site.
- For detailed safety instructions on individual experiments, particularly those involving lasers and radioactive sources, consult the experiment notes and the provided references.
- For details of the hazards associated with, and precautions for the safe handling of, the various chemicals and substances used in the laboratory, consult the relevant Material Safety Data Sheet (MSDS) folder on the laboratory's bookshelf.
- Before starting any experiment always check for any potential hazards:
  - relating to the particular experiment and how to deal with them
  - never work alone in the laboratory
  - food and drink are not to be consumed at the experimental benches
  - when using lasers wear appropriate eye protection
  - never look directly into the laser output. Beware of stray reflections
  - maintain experimental setups at low height to prevent inadvertent scattering of light into your colleague's eyes
  - when working with radioactive sources, minimize your exposure by maximizing your distance. Never eat or drink when using radioactive sources and always wash your hands after handling the radioisotopes.
  - be aware of High Voltage power supplies and take the necessary precautions

  For further reading on safety, consult the University website: https://carleton.ca/ehs/resources/

Academic Accommodations

- Pregnancy Accommodations: write any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website: http://www.carleton.ca/equity/
- Religious Accommodations: write any requests for academic accommodation due to religious obligations during the first two weeks of class, or as so on as possible after the need for accommodation is known to exist. For more details visit the Equity Services website (as above).
- The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation.

If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). Requests made within two weeks will be reviewed on a case-by-case basis. After requesting accommodation from PMC, meet with the lab supervisor to ensure accommodation arrangements are made.

- Participation in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Any requests for academic accommodation must be submitted during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist.

- Accommodations for missed work. Carleton recognizes that students may experience unexpected, temporary incapacitation (i.e., illness, injury, or extraordinary circumstances outside of a student's control). Accommodations for missed work must be requested via a written email to the lab supervisor along with a self-declaration form which can be found at: https://carleton.ca/registrar/wp-content/uploads/self-declaration.pdf

  Note that these forms should be used for short-term concerns related to missed work; if you are experiencing chronic, ongoing challenges which necessitate a broader solution, reach out to the Paul Menton Centre and/or the Care Support team.

FIPPA information

For information ab out the Freedom and Privacy Protection Act follow the link:
https://carleton.ca/tls/teachingresources/assessing-student-work/fippa/

University Resources

- Academic Support: Student Academic Success Services (SASS) at Carleton offers course-targeted study groups and supports and the Science Student Success Centre (SSSC) provides help with study skills.

- Mental Health: If you are struggling, please do not hesitate to reach out. Carleton also offers an array of mental health and well-being resources, which can be found at https://carleton.ca/wellness/

- Human Rights: The University and all members of the University community share responsibility for ensuring that the University's educational, work and living environments are free from discrimination and harassment. Should you have concerns about harassment or discrimination relating to your age, ancestry, citizenship, colour, creed (religion), disability, ethnic origin, family status, gender expression, gender identity, marital status, place of origin, race, sex (including pregnancy), or sexual orientation, please contact the Department of Equity and Inclusive Communities at equity@carleton.ca

- Sexual Violence: As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: https://carleton.ca/sexual-violence-support/