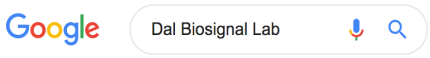
**Dalhousie University**
**Faculty of Science, Department of Physics and Atmospheric Science**
**PHYC 2150 / 3.0 Credit Hours / Physics Tools: Experiment**
**Fall 2025/2026**

*Dalhousie University acknowledges that we are in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq People and pays respect to the Indigenous knowledges held by the Mi'kmaq People, and to the wisdom of their Elders past and present. The Mi'kmaq People signed Peace and Friendship Treaties with the Crown, and section 35 of the Constitution Act, 1982 recognizes and affirms Aboriginal and Treaty rights. We are all Treaty people.*

*Dalhousie University also acknowledges the histories, contributions, and legacies of African Nova Scotians, who have been here for over 400 years.*

## Instructor Information

**Instructor:** Dr. Tim Bardouille
**Office:** Dunn 229
**Office Hours:** To be determined
**Email:** tim.bardouille@dal.ca
**Teaching Assistant:** Andrew Hess
**Email:** Andrew.hess@dal.ca




## Course Description

In this class, you will learn to measure and address random and systematic error in scientific experiments, operate data acquisition and device control equipment, and complete and report on fundamental physics experiments. Instruction will follow principles of interactive learning and peer instruction. Conceptual understanding and problem solving will be the focus of this project-based course, with instructor-student and student-student engagement fostered through group work and discussion. You will also work in groups to conceptualize and complete experiments, report on your findings, and provide formative feedback to your peers.

The aim is to learn and apply techniques commonly used in physics research. You will be introduced to experimental tools and techniques to explore concepts including instrumentation, developing a testable hypothesis, planning and executing methods to test your hypotheses, interpreting results in the context of objectives and hypotheses, and reporting on your findings.

Teaching assistants will help you learn to use lab equipment appropriately, and share best practices for data acquisition, data analysis and reporting.

## Course Learning Outcomes

On successful completion of this course, you will be able to:

- ✓ Use an Arduino board to perform data acquisition and device control
- ✓ Quantify random and systematic error in data using the appropriate statistical analyses for the

problem
- ✓ Follow instructions to successfully complete physics experiments
- ✓ Develop a testable hypothesis and appropriate methods to test your hypothesis
- ✓ Present the comprehensive details of a physics experiment in written and oral form

## Course Pre-requisites, Co-requisites and/or other Restrictions

Prerequisites:
- ✓ PHYC 1190/1290 and a 1000-level calculus course, or
- ✓ PHYC 1310/1320 and a 1000-level calculus course, or
- ✓ SCIE 1506/1507 and a 1000-level calculus course, or
- ✓ permission of instructor.

## Course Structure

| *Class Time:* | | *Laboratory Time:* | |
|---|---|---|---|
| Tuesday | 14:35 - 15:25 (Dunn 221C) | Tuesday | 15:35 - 17:25 (Dunn 221E) |
| | | Wednesday | 14:35 - 17:25 (Dunn 221E) |

This course is 100% in-person. This laboratory course is composed of lab and class time. Class time will focus on learning about statistical analysis. Lab time will focus on completing physics experiments and research projects. The week-by-week schedule will be posted to Brightspace. Changes to the schedule may be required during the term based on our rate of progress.

It is important that you check your assigned Dalhousie e-mail account **daily**. Announcements pertaining to the course will be made via e-mail. This is one of the University's official channels of communication.

The Dal Brightspace page for this course is an **essential resource**. You can access this page at dal.brightspace.com. At that location, you will find class materials, assignment, instructions, announcements, as well as other information and media that are relevant for our course.

I am happy to discuss questions about course material, and physics in general, outside of class. My office hours are an excellent opportunity to supplement your learning with one-on-one (or some-on-one) mentoring. You can imagine that this type of learning is more effective in real time, rather than by e-mail. Office hours will be determined based on student availability (given the small class size), and will occur in person or via Microsoft Teams as appropriate/convenient. I am also available to meet by appointment.

For administrative requests regarding this course, please e-mail me. This will ensure that there is a "paper trail" for these requests, which can help avoid confusion.

## Course Materials

An Introduction to Error Analysis, John R. Taylor, Publisher: University Science Books (2nd edition) 1997.
- Hard copy available online for approximately $70

Lab Notebook or Binder (Quad rule paper required)

## Course Content

| Week | Class Focus | Lab Day 1 | Lab Day 2 |
|---|---|---|---|
| 23-Sep | Intro to PHYC 2150 / Error Exercise | Project 1 | Project 1 |
| 30-Sep | No Class – T&R Day | No Lab – T&R Day | Project 1 |
| 07-Oct | Error and Uncertainty Basics | Project 1 | Project 2 |
| 14-Oct | Error Propagation | Project 2 | Project 2 |
| 21-Oct | Error and the Gaussian Distribution | Project 2 | Project 2 |
| 28-Oct | The Gaussian Distribution | Project 2 | Project 2 |
| 04-Nov | Quiz 1 | Project 2 | Project 3 |
| Reading Week | | Asynchronous | |
| 18-Nov | Linear Regression | Project 3 | Project 3 |
| 25-Nov | Covariance and Correlation | Project 3 | Project 3 |
| 02-Dec | Binomial and Poisson Distributions | Project 3 | Project 3 |
| 09-Dec | Model Rejection | Project 3 | Project 3 |

## Course Assessments

| Assessment | Value |
|---|---|
| Data Acquisition and Device Control Project | 10 |
| Guided Research Project | 15 |
| Independent Research Project | 15 |
| Weekly Problem Sets | 15 |
| Reading Quizzes | 5 |
| Midterm Quiz | 20 |
| Final Exam | 20 |
| **Total** | 100 |

Conversion of numerical grades to Final Letter Grades follows the Dalhousie Common Grade Scale

Data Acquisition and Device Control Project
This major project will focus on learning to use an Arduino prototyping board as a data acquisition and device control platform. You will complete several learning modules with your Arduino kits. In-line with these modules, you will complete a hand-written assignment that will test your understanding of data acquisition and device control using Arduino technology. Following this, you will build your own Arduino project, develop a manual for this project, and present the project to your peers. Specifics of the mark breakdown of this major project will be provided before the project begins.

Guided Research Project
You will complete an experimental physics project to measure fundamental physical constants using your Arduino as a data acquisition and device control platform. While you will receive some guidance, you will also have freedom to personalize the conceptualization and methodology of your approach. You will receive feedback and guidance from the instruction team and your peers along the way. Specifics of the mark breakdown of this major project will be provided before the project begins.

Independent Research Project
You will complete an experimental physics project of your own design, which may (but is not required to) make use of your Arduino as a data acquisition and device control platform. While you will receive some guidance, you will have the freedom to personalize the conceptualization and methodology of your approach. You will receive feedback and guidance from the instruction team and your peers along the way. Specifics of the mark breakdown of this major project will be provided before the project begins.

Weekly Problem Sets
These hand-written assignments will test your ability to quantify random and systematic error in data using the appropriate statistical analyses for the problem. These assignments are based on the class content (i.e., error analysis). **Completing the homework is a critical step in test preparation.**

Reading Quizzes
These online quizzes will test your knowledge of the textbook material. Reading quizzes are due

before the class when this material will be covered.

Midterm Quiz
There will be one 50-minute in-class quiz for this course.

Final Exam
The final exam will be scheduled during the exam period. Students are required to write the Final Exam during the scheduled time, except under exceptional circumstances. Instructors reserve the right to reject unsatisfactory certificates. Please see university policies for further details.

## Course-Specific Policies

Students may record lectures.

*Late Assignments:* Requests for an extension must be received **before the due date**. Any assignment submitted after the due date without an approved extension will incur a 10% per day penalty. Any work submitted more than 5 days late will receive a zero. Due date extensions can be granted for valid medical or other reasons.

*Missed Classes/University Closure:* In the event of a university-wide closure (likely in the winter term), any missed labs will not be made up. If a closure causes a missed lecture, we will complete the lecture material in the following weeks.

*Academic Integrity:* Generative artificial intelligence and large language models (e.g., ChatGPT) should not be used for any work in this course, unless an explicit exception is provided by the instructor.

You will work with a partner in the lab components of this course. This means that some components will be completed together (e.g., lab work), but other components (e.g., reports) will be completed on your own. My expectation is that you will submit **your own work for project components submitted with your name only**.

## University Policies and Statements

### Recognition of Mi'kmaq Territory

Dalhousie University would like to acknowledge that the University is on Traditional Mi'kmaq Territory. The Elders in Residence program provides students with access to First Nations elders for guidance, counsel, and support. Visit or e-mail the Indigenous Student Centre at 1321 Edward St or elders@dal.ca. Additional information regarding Mi'kmaq and Indigenous Relations (including the Elders in Residence program, Land Acknowledgements, Understanding Our Roots, and much more) can be found at: https://www.dal.ca/about/mission-vision-values/mikmaq-indigenous-relations.html

### Internationalization

At Dalhousie, 'thinking and acting globally' enhances the quality and impact of education, supporting learning that is "interdisciplinary, cross-cultural, global in reach, and orientated toward solving problems that extend across national borders." Additional internationalization information can be found at: https://www.dal.ca/about/mission-vision-values/global-relations.html

### Academic Integrity

At Dalhousie University, we are guided in all our work by the values of academic integrity: honesty, trust, fairness, responsibility, and respect. As a student, you are required to demonstrate these values in all the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity. Additional academic integrity information can be found at: https://www.dal.ca/dept/university_secretariat/academic-integrity.html

### Accessibility

The Student Accessibility Centre is Dalhousie's centre of expertise for matters related to student accessibility and accommodation. If there are aspects of the design, instruction, and/or experiences within this course (online or in-person) that result in barriers to your inclusion, please contact the Student Accessibility Centre (https://www.dal.ca/campus_life/academic-support/accessibility.html) for all courses offered by Dalhousie with the exception of Truro. For courses offered by the Faculty of Agriculture, please contact the Student Success Centre in Truro (https://www.dal.ca/campus_life/ssc.html).

### Conduct in the Classroom – Culture of Respect

Substantial and constructive dialogue on challenging issues is an important part of academic inquiry and exchange. It requires willingness to listen and tolerance of opposing points of view. Consideration of individual differences and alternative viewpoints is required of all class members, towards each other, towards instructors, and towards guest speakers. While expressions of differing perspectives are welcome and encouraged, the words and language used should remain within acceptable bounds of civility and respect.

### Diversity and Inclusion – Culture of Respect

Every person at Dalhousie has a right to be respected and safe. We believe inclusiveness is fundamental to education. We stand for equality. Dalhousie is strengthened in our diversity. We are a respectful and inclusive community. We are committed to being a place where everyone feels welcome and supported, which is why our Strategic Direction prioritizes fostering a culture of diversity and inclusiveness (Strategic Priority 5.2). Additional diversity and inclusion information can be found at: https://www.dal.ca/about/mission-vision-values/equity-diversity-inclusion-and-accessibility/about-office-equity-inclusion.html

### Student Code of Conduct

Everyone at Dalhousie is expected to treat others with dignity and respect. The Code of Student Conduct allows Dalhousie to take disciplinary action if students don't follow this community expectation. When appropriate, violations of the code can be resolved in a reasonable and informal manner - perhaps through a restorative justice process. If an informal resolution can't be reached, or would be inappropriate, procedures exist for formal dispute resolution. The full Code of Student Conduct can be found at: https://www.dal.ca/content/dam/www/about/leadership-and-governance/governing-bodies/code-student-conduct.pdf

**Fair Dealing Policy**

The Dalhousie University Fair Dealing Policy provides guidance for the limited use of copyright protected material without the risk of infringement and without having to seek the permission of copyright owners. It is intended to provide a balance between the rights of creators and the rights of users at Dalhousie. Additional information regarding the Fair Dealing Policy can be found at: https://www.dal.ca/content/dam/www/about/leadership-and-governance/university-policies/fair-dealing-policy.pdf

**Student Use of Course Materials**

Course materials are designed for use as part of this course at Dalhousie University and are the property of the instructor unless otherwise stated. Third party copyrighted materials (such as books, journal articles, music, videos, etc.) have either been licensed for use in this course or fall under an exception or limitation in Canadian Copyright law. Copying this course material for distribution (e.g. uploading to a commercial third-party website) may lead to a violation of Copyright law.