

# Physics 331 – Experimental Physics I

2023 – 2024, Winter Term 1

## General Info

Course: Physics 331 (3 credits)  
Sections: 001 (lecture) & L01 (lab)  
Pre-reqs: All of PHYS 231, PHYS 232  
Lecture: Mon. 08:00–09:30 (ART 203)  
Laboratory: Tue. 09:30–12:30 (SCI 239)  
You **must** register for the lecture and the laboratory  
URL: <https://cmps-people.ok.ubc.ca/jbobowsk/phys331.html>

Instructor: Jake Bobowski  
Office: SCI 266  
Email: [jake.bobowski@ubc.ca](mailto:jake.bobowski@ubc.ca)



*The test of all knowledge is experiment. Experiment is the sole judge of scientific “truth”.*  
– Richard Feynman

## Calendar Entry

Selected advanced physics experiments in solid-state physics, fluid dynamics, particle physics, astrophysics, optics, nonlinear dynamics or electromagnetism. Experimental design, construction, and formal presentation of results.

## Overview

Making a theoretical prediction that is then experimentally confirmed is one of the greatest achievements possible in physics research. A famous example is Einstein’s theory of general relativity – initially rejected, but later overwhelmingly confirmed. However, it is very often the case that experimental observations guide theoretical developments. An example is superconductivity. A successful theory of conventional superconductivity (such as in the elements Al, Pb, and Hg and alloys PbSn

and NbTi) was developed only after experiments showed that lattice vibrations, or phonons, played an essential role.

In this course you will work in pairs to carry out two experiments over the course of the term. The tasks that you are expected to carry out could include experimental design, construction/assembly of an apparatus, data collection, data analysis, and formal presentation of results (written reports and oral presentations). You will keep a detailed log of your activities in a bound lab notebook. A list of available projects with *brief* descriptions will be published on the course website.

The lecture portion of the class will be used in two ways. First, it will be used to present some material relevant to nearly all types of experiments. Second, the lecture will be used for student presentations. The presentations will be given in-person during the schedule lecture time.

## **Textbook**

There is no required textbook, however, you may find *Data Reduction and Error Analysis for the Physical Sciences* by Bevington & Robinson and/or *An Introduction to Error Analysis* by Taylor to be useful resources.

You are required to have a bound lab notebook (available from the UBCO bookstore). You need to have your lab book with you whenever you are in the lab. If you have space remaining in your notebooks for either PHYS 231 or 232, you may continue to use those notebooks.

## **Lab Notebook**

Your lab notebook is a very important part of the course. Your notebook should contain a complete log of what you do in the lab. It should include enough details that a knowledgeable person could reproduce your experiments and data analysis methods based solely on what you wrote in your notebook. It should be complete and coherent enough that if you were to come back to your notebook several months (or years!) later, you would be able to understand exactly what you did in the lab. As an example, in July of 2021 I was asked about the details of a set of measurements I made in June of 2008! When you plan your experimental setup or research background material, you should be making notes in your lab notebook. Data should be recorded in your lab notebook along with your analysis. Print out plots, trim the white-space, and then tape them neatly into your notebook. Any loose pages included in your lab notebook will **not** be graded. You need to write things down as you do them, in your book - not on scrap paper, and not sometime “later”.

**At random times during the term, I will collect your lab notebooks for evaluation.**

## Learning Outcomes

If you invest the appropriate amount of time and effort into this course, by the end of PHYS 331 you will have developed the following skills:

From the *lecture*...

- Use Fourier transforms to determine the frequency content of a signal that is pulsed in time (or vice-versa).
- Identify when transmission line effects in electronics need to be considered.
- Develop and deliver a succinct and engaging technical presentation.

From the *lab*...

- Conduct a sophisticated physics experiment without the benefit of a lab manual.
- Make some of your own decisions about an experimental investigation (experimental design, data collection strategy, data analysis methods, ...).
- Repeatedly make, execute, and revise experimental plans.
- Identify and summarize results from peer-reviewed journal articles that are relevant to your experimental physics project. Use this information to motivate your study.
- Maintain an up-to-date and detailed lab notebook that includes: a log lab activities, relevant theory, experimental design, data, analysis, meaningful discussions of results and the next steps.
- Write succinct and engaging lab reports that demonstrate a deep understanding of the physics relevant to your project.

## Data Analysis

We will use Jupyter Notebooks and Python to analyze data that you collect during the lab. Here is a link to a set of [tutorials](#) that you can make use of to help you complete your data analysis.

## Piazza

There will be a PHYS 331 Piazza page. It will be used to post information and notices that is relevant to physics students, but not directly tied to the PHYS 331 course. You can also use it to ask questions related to PHYS 331 homework assignments, labs, and lecture material and/or to initiate discussions with your classmates. To enroll in the PHYS 331 Piazza page:

- log in to the PHYS 331 Canvas shell
- retrieve the PHYS 331 Piazza access code
- follow the link provided in the Canvas shell to complete the registration

## **L<sup>A</sup>T<sub>E</sub>X**

L<sup>A</sup>T<sub>E</sub>X is a “high-quality type-setting system” specifically designed for technical and scientific documents. You are encouraged, but **not** required, to use L<sup>A</sup>T<sub>E</sub>X when preparing your formal reports. Although not formally taught in PHYS 331, support for L<sup>A</sup>T<sub>E</sub>X will be provided through the use of templates/tutorials that will be made available on the course website.

All of the software required to use L<sup>A</sup>T<sub>E</sub>X is freely available and can be installed in your own computer. For a Windows system, install Ghostscript, GSview, MiKTeX, and Texmaker. You can also find free L<sup>A</sup>T<sub>E</sub>X options for Mac and Linux systems.

If you don't want to install the L<sup>A</sup>T<sub>E</sub>X software on your own system, you can use a free online L<sup>A</sup>T<sub>E</sub>X editor called Overleaf: <https://www.overleaf.com/>.

## **Office Hours**

My office is SCI 266. Formal office hours will be announced in class and [published online](#). Otherwise, drop by or email me to schedule an appointment.

## **Evaluation<sup>1</sup>**

Lab Notebook:	12.5% × 2	25%
Assignments:	12.5%	12.5%
Presentation:	15%	15%
Formal Report #1:	17.5%	17.5%
Formal Report #2:	30%	30%
		100%

For each experiment that you do in PHYS 331 you will submit your lab notebook for marking and you will prepare a formal written report. Each group will prepare one 20 minute oral presentation for the class (either for Experiment #1 or #2). Both your peers and the instructor will contribute to the grading of the oral presentation.

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<sup>1</sup>Note that, the grading scheme is subject to change.

For the first experiment that you complete, Experiment #1, you and your partner will submit a common formal report. That is, you'll collaborate with your partner to prepare a report on the project that you completed. Of course, it is expected that you will share the workload associated with preparing the report equally. Along with the report, you will submit a one-page document outlining how the work was divided among you and your partner. The formal report that you and your partner submit will be assigned one grade (say,  $x$ ) out of 100. Then, you and your partner will be given a total of  $2x$  grades to divide among yourselves. You will have to come to an agreement on how the marks should be distributed. For example, if  $x = 76$ , then one person can be given 80 and the other  $2 \times 76 - 80 = 72$ . Of course, you could also agree to divide the marks evenly (76 each). No person can get more than 100. For  $x = 76$ , the most extreme case would be one person getting 100 and the other 52.

For Experiment #2, although you'll still be working in partners, every student in the class will submit their own independently-written report.

## **Late Policy**

Late assignments and lab notebooks will not be accepted. Assignments and lab notebooks not submitted on time will receive a grade of zero.

Presentations will be scheduled during the lecture time. Once scheduled, there will be no extensions of the presentation dates or times.

Late formal reports will be accepted, but a late penalty will be applied. The penalty will be determined by the following function:

$$P = \frac{1}{\sqrt{1 + (t/\tau)^2}}$$

where  $t$  measures the lateness of the report in hours and  $\tau = 36$  hours. Here, for example, are some sets of  $(t, P)$  values: (2, 0.998), (5, 0.990), (12, 0.949), (24, 0.832), (48, 0.600), (96, 0.351)...

If you hand in a late report and it would have received a grade of  $x$  (out of a 100) if it was received on time, then the actual grade that you will receive for the formal report is  $x \cdot P$ . Reports that are received more than 96 hours (4 days) late will receive a grade of zero.

## Tentative Schedule

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Week	Topic
1	Introduction & Experiment #1 Sign Up
2	Lock-in detection
3	Transmission Lines
4	Transmission Line Input Impedance
5	Fourier Series Review
6	Fourier Transform Introduction
7	Fourier Transform Properties
8	Fourier Transform Applications
9	Transmission Line Transient Response
10	Fourier Transform Analysis of Transmission Lines – Part 1
11	Fourier Transform Analysis of Transmission Lines – Part 2
12	Student Presentations – Day 1
13	Student Presentations – Day 2

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Note that, in the 2021 offering of PHYS 331, the lecture component was delivered online and there are set of recordings that have been posted to YouTube.

Here is a link to YouTube playlist that includes all of the 2021 PHYS 331 lectures:

<https://www.youtube.com/playlist?list=PLfhjdV-pwMOZnI6AWhWdOs3LoY6WHnZd->.

## **Official Policies of the Faculty of Science & CMPS Department**

### **Missed Graded Work**

Students who, because of unforeseen events, are absent during the term and are unable to complete tests or other graded work should generally discuss with their instructors how they can make up for missed work, according to written guidelines given to them at the start of the course (see Grading Practices). Instructors are not required to make allowance for missed tests or incomplete work not satisfactorily accounted for. If ill-health is an issue, students are encouraged to seek attention from a health professional. Campus Health and Counselling will usually provide the documentation only to students who have been seen previously at these offices for treatment or counselling specific to conditions associated with their academic difficulties. Students who feel that requests for consideration have not been dealt with fairly by their instructors may take their concerns first to the Head of the discipline and, if not resolved, to the Office of the Dean. Further information can be found at: <http://www.calendar.ubc.ca/okanagan/index.cfm?tree=3,48,0,0>. There will be no make-up midterm exams. If the absence is satisfactory, the weight of the student's final exam will be increased.

### **Grading Practices**

Faculties, departments, and schools reserve the right to scale grades in order to maintain equity among sections and conformity to university, faculty, department, or school norms. Students should therefore note that an unofficial grade given by an instructor might be changed by the faculty, department, or school. Grades are not official until they appear on a student's academic record: <http://www.calendar.ubc.ca/okanagan/index.cfm?tree=3,41,90,1014>.

### **Final Examinations**

The examination period for this term will be from Sunday, December 11<sup>th</sup>, 2022, to Thursday, December 22<sup>nd</sup>, 2022. Students will be permitted to apply for out-of-time final examinations only if they are representing the University, the province, or the country in a competition or performance; serving in the Canadian military; observing a religious rite; working to support themselves or their family; or caring for a family member. Unforeseen events include (but may not be limited to) the following: ill health or other personal challenges that arise during a term and changes in the requirements of an ongoing job. An examination hardship is defined as the occurrence of an examination candidate being faced with three (3) or more formal examinations scheduled within a 27-hour (inclusive) period.

Further information on Academic Concession can be found under Policies and Regulation in the Okanagan Academic Calendar: <http://www.calendar.ubc.ca/okanagan/index.cfm?tree=3,48,0,0>.

## **Academic Integrity**

The academic enterprise is founded on honesty, civility, and integrity. As members of this enterprise, all students are expected to know, understand, and follow the codes of conduct regarding academic integrity. At the most basic level, this means submitting only original work done by you and acknowledging all sources of information or ideas and attributing them to others as required. This also means you should not cheat, copy, or mislead others about what is your work. Violations of academic integrity (i.e., misconduct) lead to the breakdown of the academic enterprise, and therefore serious consequences arise, and harsh sanctions are imposed. For example, incidences of plagiarism or cheating may result in a mark of zero on the assignment or exam and more serious consequences may apply if the matter is referred to the President's Advisory Committee on Student Discipline. Careful records are kept in order to monitor and prevent recurrences. A more detailed description of academic integrity, including the University's policies and procedures, may be found in the Academic Calendar at:

<https://okanagan.calendar.ubc.ca/campus-wide-policies-and-regulations/student-conduct-and-discipline/discipline-academic-misconduct>.

## **Cooperation versus Cheating**

Working with others on assignments is a good way to learn the material and we encourage it. However, there are limits to the degree of cooperation that we will permit. Any level of cooperation beyond what is permitted is considered cheating.

When working on programming assignments, you must work only with others whose understanding of the material is approximately equal to yours. In this situation, working together to find a good approach for solving a programming problem is cooperation; listening while someone dictates a solution is cheating. You must limit collaboration to a high-level discussion of solution strategies and stop short of writing down a group answer. Anything that you hand in, whether it is a written problem or a computer program, must be written by you, from scratch, in your own words. If you base your solution on any other written solution, you are cheating. If you provide your solution for others to use, you are also cheating.



## **Copyright Disclaimer**

Diagrams and figures included in lecture presentations adhere to Copyright Guidelines for UBC Faculty, Staff and Students (<http://copyright.ubc.ca/requirements/copyright-guidelines/>) and UBC Fair Dealing Requirements for Faculty and Staff (<http://copyright.ubc.ca/requirements/fair-dealing/>). Some of these figures and images are subject to copyright and will not be posted to Canvas. All material uploaded to Canvas that contain diagrams and figures are used with permission of the publisher; are in the public domain; are licensed by Creative Commons; meet the permitted terms of use of UBC's library license agreements for electronic items; and/or adhere to the UBC Fair Dealing Requirements for Faculty and Staff. Access to the Canvas course site is limited to students currently registered in this course. Under no circumstance are students permitted to provide any other person with means to access this material. Anyone violating these restrictions may be subject to legal action. Permission to electronically record any course materials must be granted by the instructor. Distribution of this material to a third party is forbidden.

## **Grievances & Complaints Procedures**

A student who has a complaint related to this course should follow the procedures summarized below:

The student should attempt to resolve the matter with the instructor first. Students may talk first to someone other than the instructor if they do not feel, for whatever reason, that they can directly approach the instructor.

If the complaint is not resolved to the student's satisfaction, the student should e-mail the Department Head Dr. Sylvie Desjardins at [cmeps.depthhead@ubc.ca](mailto:cmeps.depthhead@ubc.ca).

## **Student Service Resources**

### **Disability Resource Centre**

The Disability Resource Centre (DRC) facilitates disability-related accommodations and programming initiatives that ameliorate barriers for students with disabilities and/or ongoing medical conditions. If you require academic accommodations to achieve the objectives of a course, please contact the DRC at:

- room: UNC 215
- phone: 250.807.8053
- email: [drc.questions@ubc.ca](mailto:drc.questions@ubc.ca)
- web: <https://students.ok.ubc.ca/academic-success/disability-resources/>

### **Equity & Inclusion Office**

Through leadership, vision, and collaborative action, the Equity & Inclusion Office (EIO) develops action strategies in support of efforts to embed equity and inclusion in the daily operations across the campus. The EIO provides education and training from cultivating respectful, inclusive spaces and communities to understanding unconscious/implicit bias and its operation within in campus environments. UBC Policy 3 prohibits discrimination and harassment on the basis of BC's Human Rights Code. If you require assistance related to an issue of equity, educational programs, discrimination or harassment please contact the EIO.

- room: UNC 325H
- phone: 250.807.9291
- email: [equity.ubco@ubc.ca](mailto:equity.ubco@ubc.ca)
- web: [www.equity.ok.ubc.ca](http://www.equity.ok.ubc.ca)

### **Office of the Ombudsperson for Students**

The Office of the Ombudsperson for Students is an independent, confidential and impartial resource to ensure students are treated fairly. The Ombuds Office helps students navigate campus-related fairness concerns. They work with UBC community members individually and at the systemic level to ensure students are treated fairly and can learn, work and live in a fair, equitable and respectful environment. Ombuds helps students gain clarity on UBC policies and procedures, explore options, identify next steps, recommend resources, plan strategies and receive objective feedback to promote constructive problem solving. If you require assistance, please feel free to reach out for more information or to arrange an appointment.

- room: UNC 328
- phone: 250.807.9818
- email: [ombuds.office.ok@ubc.ca](mailto:ombuds.office.ok@ubc.ca)
- web: [www.ombudsoffice.ubc.ca](http://www.ombudsoffice.ubc.ca)

### **Sexual Violence Prevention and Response Office (SVPRO)**

A safe and confidential place for UBC students, staff and faculty who have experienced sexual violence regardless of when or where it took place. Just want to talk? We are here to listen and help you explore your options. We can help you find a safe place to stay, explain your reporting options (UBC or police), accompany you to the hospital, or support you with academic accommodations. You have the right to choose what happens next. We support your decision, whatever you decide.

Visit <https://svpro.ok.ubc.ca> or call us at 250-807-9640.

## **Independent Investigations Office (IIO)**

If you or someone you know has experienced sexual assault or some other form of sexual misconduct by a UBC community member and you want the Independent Investigations Office (IIO) at UBC to investigate, please contact the IIO. Investigations are conducted in a trauma informed, confidential and respectful manner in accordance with the principles of procedural fairness.

You can report your experience directly to the IIO by calling 604-827-2060.

- email: [director.of.investigations@ubc.ca](mailto:director.of.investigations@ubc.ca)
- web: <https://investigationsoffice.ubc.ca/>

## **Student Learning Hub**

The Student Learning Hub is your go-to resource for free math, science, writing, and language learning support. The Hub welcomes undergraduate students from all disciplines and year levels to access a range of supports that include **tutoring in math, sciences, languages, and writing, as well as help with academic integrity, study skills and learning strategies**. Students are encouraged to visit often and early to build the skills, strategies and behaviours that are essential to being a confident and independent learner. For more information, please visit the Hub's website.

- room: LIB 237
- phone: 250.807.8491
- email: [learning.hub@ubc.ca](mailto:learning.hub@ubc.ca)
- web: <https://students.ok.ubc.ca/academic-success/learning-hub/>

## **Student Wellness**

At UBC Okanagan health services to students are provided by Student Wellness. Nurses, physicians and counsellors provide health care and counselling related to physical health, emotional/mental health and sexual/reproductive health concerns. As well, health promotion, education and research activities are provided to the campus community. If you require assistance with your health, please contact Student Wellness for more information or to book an appointment.

- room: UNC 337
- phone: 250.807.9270
- email: [healthwellness.okanagan@ubc.ca](mailto:healthwellness.okanagan@ubc.ca)
- web: <https://students.ok.ubc.ca/health-wellness/>

## **Safewalk**

Don't want to walk alone at night? Not too sure how to get somewhere on campus? Call Safewalk at 250-807-8076.

For more information, visit <https://security.ok.ubc.ca/safewalk/>