## PHYS 2212 for Fall 2026

Wave Mechanics and Thermodynamics

We, the people of the Faculty of Science at Carleton University, acknowledge that our campus is located on the traditional, unceded territories of the Algonquin Anishinabeg people. Miigwetch for your hospitality and stewardship of this territory and the teachings that come from it. We are grateful for this land, the air that we breathe, and the water that sustains us all as well as for the animals, plants and other living beings: these enable us to research, teach, mentor, support, study, and learn. We recognize our responsibility to our natural environment and to reconciliation with Indigenous peoples.

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**Course Instructor:** Sangeeta Murugkar

**How to address me:** Sangeeta

**Gender Pronouns:** (she/her/hers)

**Email:** sangeeta.murugkar@Carleton.ca

Note: If you have a question or would like to talk with me, you can send an email (include 'PHYS 2212' in the subject line), visit me during student hours (see below), or approach me after lecture.

**Best Ways to be in Touch:** in class, via email, or during student hours

**Student Hours**: To be posted on Brightspace

**Office Location**: Room 2414, Herzberg Building

**Class Location:** Please check Carleton Central for the room location.

**Class Times:** Tues, Thurs, 11:30-1 pm

**Prerequisites:** PHYS 1001 and PHYS 1002, or PHYS 1003 and PHYS 1004 (PHYS 1007 and PHYS 1008 are also acceptable provided a minimum average grade of B- is presented); plus MATH 1004 and MATH 1104, or MATH 2152, and MATH 2004 or MATH 2000 (MATH 2000 or MATH 2004 may be taken concurrently).

**Department/Unit:** Physics

**Course TA: Devon Leskiw**

# Welcome to PHYS 2212 !

**This introductory course in Wave mechanics and Thermodynamics has two main parts. The first part covers Wave Optics: after an introduction to types of waves and the classical wave equation, the focus is on electromagnetic waves, their polarization and superposition leading to optical phenomena such as interference and diffraction, coherence and wave packets. The second part of the course includes topics in Thermal Physics such as temperature and thermodynamic equilibrium, heat, work, the first law of thermodynamics, entropy, the second law of thermodynamics and applications.**

# Topics Covered and Learning Outcomes

## Inclusive teaching statement:

I am committed to fostering an environment for learning that is inclusive for everyone regardless of gender identity, gender expression, sex, sexual orientation, race, ethnicity, ability, age and class. It is my hope that our class will support diversity of experience, thought, and perspective. I will continually strive to create inclusive learning environments and would therefore appreciate your support and feedback.

## Topics to be Covered

| Week | Week of (Date) | Lecture | Unit | Chapters in Pedrotti^ 3 | HW/ ICP | Topics |
|---|---|---|---|---|---|---|
| **1** | 10-Sep | 1 | **Wave Optics** | Ch. 4 | | Course Introduction, harmonic waves and properties |
| **2** | 15-Sep | 2 | | | Post HW 1 | Wave Equation, Complex representation |
| | 17-Sep | 3 | | Ch. 4 | ICP 1 | Phasors, Plane and spherical waves |
| **3** | 22-Sep | 4 | | | Post HW2 | EM Waves, Polarization, Superposition |
| | 24-Sep | 5 | | Ch. 6 | ICP 2 | Superposition of waves of same frequency, Standing waves |
| **4** | 29-Sep | 6 | | | Post HW3 | Beats, Phase and Group velocity, Coherence_Interference Two beam, Young's double slits |
| | 01-Oct | 7 | | | | Interference in thin films |
| **5** | 06-Oct | 8 | | Ch. 7 | Post HW4 | Midterm Exam – I |
| | 08-Oct | 9 | | | ICP 3 | Interference |
| **6** | 13-Oct | 10 | | Ch. 8 | Post HW5 | Michelson interferometer (MI) |
| | 15-Oct | 11 | | | ICP 4 | Single slit Diffraction |
| **7** | 20-Oct | 12 | | Ch. 10 | | Double-slit diffraction |
| | 22-Oct | 13 | | | | Circular aperture, Rayleigh criterion |

***Reading Week (Oct 26 - 30th)***

| Week | Week of (Date) | Lecture | Unit | Chapters in Halliday | HW | Topics |
|---|---|---|---|---|---|---|
| **8** | 03-Nov | 12 | | | | Midterm Exam-II |
| | 05-Nov | 13 | **Thermal Physics** | Ch. 18 | | Introduction (Thermal Physics) |
| **9** | 10-Nov | 14 | | | Post HW6 | Heat capacity, Probability |
| | 12-Nov | 15 | | | ICP 5 | Temperature, Boltzmann factor |
| **10** | 17-Nov | 16 | | Ch. 19 | Post HW7 | Kinetic Theory of gases, velocity distribution in a gas |
| | 19-Nov | 17 | | | ICP 6 | Pressure, Ideal gas law |
| **11** | 24-Nov | 18 | | | Post HW8 | First law of thermodynamics |
| | 26-Nov | 19 | | Ch. 20 | ICP 7 | Heat engines, Second law of thermodynamics |
| **12** | 01-Dec | 20 | | | Post HW9 | Second law of thermodynamics |
| | 03-Dec | 21 | | | ICP 8 | Entropy |
| **13** | 08-Dec | 22 | | | | Review |
| | 10-Dec | 23 | | | | Review |

## Course level learning outcomes:

Upon completion of this course,

1. Students will be able to recall and utilize at an introductory level, foundational knowledge in calculus-based wave motion and description of light in terms of wave equations, and wave-interpretation of phenomena such as interference and diffraction.

2. Students will be able to identify whether to approach a situation from a microscopic or macroscopic perspective. Given a real system, they will be able to simplify and model that system and predict thermodynamic properties of the system.

2. Students will have developed basic problem-solving skills in wave motion and optics as well as thermal physics, and be able to use appropriately the tools of physics, calculus, and algebra.

3. Students will have developed basic written communication skills for reporting their analysis of solved problems.

## Assessments

Research about learning strongly suggests that the most important factor in learning is doing the work of reading, writing, recalling, practicing, synthesizing, and analyzing. Learning happens best when people actively engage material on a consistent basis, and that is why we have high standards in this course. We are confident that, with appropriate effort, you all can meet those standards.

We also make an effort to reduce unintentional bias in grading by, for example and when possible, grading assignments one question at a time (grading all of question 1 before grading any of question 2), grading anonymously, and using rubrics.

**Grade Breakdown**

| COMPONENT | GRADE VALUE |
|---|---|
| **ASSIGNMENTS** | 10% |
| **IN-CLASS PROBLEM** | 10% |
| **MIDTERM EXAM I** | 25% |
| **MIDTERM EXAM II** | 25% |
| **FINAL EXAM** | 30% |

**Assignments**

There will be a total of 9 weekly assignments; a problem set will be assigned every Tuesday and will be due by midnight on the Tuesday of the following week. However, if you need an extension on this deadline, please email me (include 'PHYS 2212' in the subject line) and ask for one. You should include an estimate of when you can get the homework done by. Refer to the 'late and missed work policies' section below for homework submitted late without notifying the instructor (me).

Assignment solutions should be submitted electronically in a single '.pdf' document. Note that the assignment may be typed up or handwritten and scanned in. Photos taken with a

cell phone are not admissible, as the lighting and contrast are usually bad, and resolution poor.

You are encouraged to discuss the problems on assignments with other students in this course; however, the work you turn in must be your own.

**In-class Problem (ICP)**
There will be a 5-10 minute in-class assessment that students will do in class and hand it back in class. It will be related to the concept covered in class and in the homework problems. The goal will be to help students stay on track and assess their conceptual understanding of the material.

**Midterm Exam-I**
There will be a 90-minute exam held during the lecture time on **Tuesday, October 6, 2026**. You will be allowed to bring a non-programmable calculator. The content will cover the wave mechanics part of the course (more details will be provided closer to the date).

**Midterm Exam-II**
There will be a 90-minute exam held during the lecture time on **Tuesday, November 3, 2026**. You will be allowed to bring a non-programmable calculator. The content will cover the wave mechanics part of the course (more details will be provided closer to the date).

**Final Exam**
The exam will take place during the final exam period in December. The 3-hour exam will evaluate students' understanding of most of the thermal physics content (more details will be provided closer to the date).

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## Late and Missed Work Policies

**Late Work**
Penalties for late homework assignments: 1 day late – 10% marks deducted

2 day late - 20% marks deducted

Assignments that are more than 2 days late will not be accepted without an acceptable reason such as illness.

**Missed Work**

Short-term ( 5 days or less): Accommodations for missed work due to unexpected, temporary situations such as sickness, injury, or extraordinary circumstances outside of a student's control, must be requested via a written email to me along with an academic considerations form.

Long-term (> 5 days): Students experiencing chronic, ongoing challenges which necessitate a broader solution are encouraged to reach out to the Paul Menton Centre and/or the Care Support team. (More information here: longer-term accommodation) .

## Learning Materials

| Learning Material | Options for Purchasing *(e.g. Bookstore, Used, etc.)* | Approximate Cost |
|---|---|---|
| **Pedrotti, Pedrotti and Pedrotti.** *Introduction to Optics*<br>Third Edition, Cambridge, 2018 or newer (Note: Third edition published by Pearson prior to 2018 will do as well) | Available from the Carleton Bookstore or elsewhere | $79.95 for a physical copy and $67.95 for e-book |
| **Walker, Halliday and Resnick,** *Fundamentals of Physics, 12th edition* ***(Ch. 18-20 for Thermal Physics)*** | Available from the Carleton Bookstore or elsewhere | $57.00 for e-book access |

**Reference Textbooks:**

Walker, Halliday and Resnick: Ch.16 – Waves- I for Wave mechanics

E. Hecht, Optics [Pearson (5th Ed.) or Addison Wesley Longman Inc. (4th Ed.)]

## Academic Accommodations and Regulations

Carleton is committed to providing academic accessibility for all individuals. You may need special arrangements to meet your academic obligations during the term. The accommodation request processes are outlined on the Academic Accommodations website (https://students.carleton.ca/course-outline/).

**Statement on Chat GPT/Generative AI usage**

As our understanding of the uses of AI and its relationship to student work and academic integrity continue to evolve, students are required to discuss their use of AI in any circumstance not described here with the course instructor to ensure it supports the learning goals for the course.

**AI use in this course:** Students may use AI tools for basic word processing functions, including grammar and spell checking (e.g. Grammarly, Microsoft Word Editor, Copilot)

**Documenting AI use**: It is not necessary to document the use of AI for the permitted purposes listed above. If you have questions about a specific use of AI that isn't listed above, please consult Prof. Murugkar.

**Why have I adopted this policy?** This policy ensures that student voices and ideas are prioritized and authentically represented, maintaining the integrity of the work produced by students while allowing basic support to enhance clarity, correctness, layout and flow of ideas. The goal of adopting a limited use of AI is to help students develop foundational skills in communication and critical thinking by practicing substantive content creation without relying on AI support.

**Limitations:** Students may not use AI for developing solutions to homework problems.

**Statement on Academic Integrity**

Students are expected to uphold the values of academic integrity, which include fairness, honesty, trust, and responsibility. Examples of actions that that compromise these values include but are not limited to plagiarism, accessing unauthorized sites for assignments or tests, unauthorized collaboration on assignments or exams, and using artificial intelligence tools such as ChatGPT when your assessment instructions say it is not permitted.

Misconduct in scholarly activity will not be tolerated and will result in consequences as outlined in Carleton University's Academic Integrity Policy. A list of standard sanctions in the Faculty of Science can be found here.

Additional details about this process can be found on the Faculty of Science Academic Integrity website.

Students are expected to familiarize themselves with and abide by Carleton University's Academic Integrity Policy.

**Student Rights & Responsibilities**

Students are expected to act responsibly and engage respectfully with other students and members of the Carleton and the broader community. See the 7 Rights and Responsibilities Policy for details regarding the expectations of non-academic behaviour of students. Those who participate with another student in the commission of an infraction of this Policy will also be held liable for their actions.

**Student Concerns**

If a concern arises regarding this course, **your first point of contact is me**: Email or drop in during student hours and I will do my best to address your concern. If I am unable to address your concern, the next points of contact are (in this order):

**Note:** You can also bring your concerns to Ombuds services.