

PHYS 4203/5313 Fall 2026

Physical Applications of Fourier Analysis

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.

Course Coordinator:

Avery Berman (avery.berman@carleton.ca)

Best ways to be in touch: in class, via email, or during student hours

Student Hours: Tuesdays, 11am–12pm

Office Location: Herzberg 2420

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

Class Times: Mon, Wed 8:35 AM –9:55 AM

Prerequisites: MATH 3705, or permission of the Physics Department

Course TA:

Benjamin Puzantian

(BenjaminPuzantian@cmail.carleton.ca)

Topics Covered and Learning Outcomes

Week	Topic/Content	Readings/Prep for Class (class notes + selected chapters from Bracewell)
1	Intro, review Fourier series, Fourier transform (FT)	Ch. 2
2	Linear systems theory, Convolution	Ch. 3
3	Correlation, Useful functions I	Ch. 3, 4
4	Useful functions II, Impulse functions	Ch. 4, 5
5	Impulse functions, FT pairs and theorems	Ch. 5, 6, 7
6	FT pairs and theorems	Ch. 6, 7
7	System transfer function, filters, and applications (circuit analysis)	Ch. 9 (parts)
8	Reading break	
9	Sampling, Aliasing, Discrete Fourier transform (DFT)	Ch. 10, 11, Midterm on Nov 4 (written exam)
10	DFT, Fast Fourier transform	Ch. 11, Ch. 6 (Oppenheim and Schaffer), Midterm (oral exams)
11	2D transforms	Ch. 13
12	Applications to imaging	Ch. 13
13	CT reconstruction, 5313 student presentations	Ch. 13

November 15 is the final day to withdraw from the course. Important dates and deadlines can be found here: <https://calendar.carleton.ca/academicyear/>, including class suspension for fall and winter breaks, and statutory holidays.

Course-level learning outcomes:

You should have a firm understanding of, be able to explain, and be able to perform calculations related to:

- Fourier series
- Fourier transform of useful functions and more generally
- Linear systems theory, impulse response function, and system transfer function
- Convolution and correlation
- Fourier transform pairs and theorems (e.g., similarity theorem, convolution theorem, etc.)
- Filtering

- Discrete data sampling, aliasing, and interpolation
- Discrete Fourier transform and convolution of discrete data
- All the above for 2D functions
- Applications to imaging, including descriptors of spatial resolution, and principles of tomographic image reconstruction

Assessments

Grade Breakdown

COMPONENT	GRADE VALUE	
	4203	5313
ASSIGNMENTS	17%	16%
MIDTERM (WRITTEN)	28%	26%
MIDTERM (ORAL)	8%	7%
FINAL EXAM	42%	39%
PARTICIPATION	5%	4%
PROJECT	n/a	8%

Assignments

There will be ~8–10 problem sets assigned weekly. Students are permitted and encouraged to discuss concepts related to the assignments with each other; however, you must submit your own work. Clarity, rigour, and organization are important parts of your solutions and grades—be sure to explain your steps.

Assignments will be posted to Brightspace, and students will need to upload their solutions to Brightspace by the deadline.

Exams

1. There will be a written 75-minute closed-book midterm exam and an oral component. The written component will take place during the lecture period (Wed, Nov 4). The oral component will be 15 min and scheduled outside class hours the week following the written component.
2. There will be a 3-hr closed-book final exam during the exam period.

Participation

To encourage students to engage with the course content, I am asking that you visit me during office hours **at least twice during the term**. One of these visits must be **before the midterm**. I do not have high expectations for your visit; however, you must come prepared

with questions related to the course, e.g., questions related to the lecture material or upcoming or past assignments. Our discussions should last at least ten minutes. I will not be evaluating the quality of our discussion; you will either get zero, half the grade (for showing up once or only after the midterm), or the full grade for showing up at least twice (including at least once before the midterm). If you cannot make my office hours, please arrange an alternate time with me.

5313 Project

Each student in PHYS 5313 will write a report (max 15 pages) and make a class presentation (~15–20 min + questions) on an application of Fourier analysis of your choice. Some example topics include: x-ray diffraction, voice recognition, hearing aid signal processing, optical Fourier transform, MRI. You may propose your own topic. Each student's topic must be unique in the class. The goal of the presentation is to introduce the basic concept of the application. Balance general intro, theory, and application so that others can learn from you. You may use Powerpoint, Adobe, or other compatible software. The presentations will be during the last week of term.

Please discuss your choice of topic with the instructor *before* the reading break. Topics will be on a first-come, first-served basis. **Students must submit their topic, a max. 200-word rationale, and preliminary reading list by the end of the first week after the reading break.**

Late and Missed Work Policies

Late Work

Late assignments will have a **20% penalty** applied to them, and they will only be accepted **up to 24 hours after the deadline**. Each student's lowest assignment score will be dropped.

Learning Material(s) and Other Course/Lab-Related Resources

Students are not required to *purchase* textbooks or other learning materials for this course. You will, however, need to access the Bracewell textbook to supplement the lecture notes.

Learning Material	Options for Purchasing	Approximate Cost
R. N. Bracewell, "The Fourier Transform and its Applications", McGraw-Hill, either 3rd edition (2000, ISBN = 0-07-303938-1) or 2nd edition (1978, ISBN = 0-07-007013-X).	The book is out of print. It is best to get a used copy from online sellers like amazon, abebooks, biblio, etc. There is one copy on reserve at the library. One can also download a pdf from the internet.	Used from ~\$160.

Other references

A. V. Oppenheim and R. W. Schaffer, "Digital Signal Processing", Prentice-Hall, 1975		New/used from ~\$40
J.F. James, "A Student's Guide to Fourier Transforms: With Applications in Physics and Engineering", Cambridge University Press, 3rd edition, 2011	(E-book, free access for students from Carleton Library website)	Free

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, including information about the *Academic Consideration Policy for Students in Medical and Other Extenuating Circumstances*, are outlined on the Academic Accommodations website (students.carleton.ca/course-outline).

Statement on Generative AI usage:

The use of an AI chatbot is discouraged since a) depending on how it is used, it could deprive you of the work of grappling with challenging concepts—an often necessary component of learning—, b) you will not have the opportunity to use one on the midterm and final exam, and c) it could potentially be considered plagiarism, which is a violation of the Carleton Academic Integrity Policy (see next).

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 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](#).

