PHYS 4203/5313 Fall 2025

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 or via email

Student Hours: Tuesdays, 12:30–1:30 pm

Office Location: Herzberg 2420

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

Class Times: Wed, Fri 11:35 AM –12:55 PM

Prerequisites: MATH 3705, or permission of the Physics Department

Course TA:
Yasaman Shafaee
(YasamanShafaee@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 Oct 29 (written exam)
10	DFT, Fast Fourier transform	Ch. 11, Ch. 6 (Oppenheim and Schafer), Midterm (oral exams)
11	2D transforms	Ch. 13
12	Applications to imaging	Ch. 13
13	CT reconstruction, 5313 student presentations	Ch. 13

Important dates and deadlines can be found here: https://students.carleton.ca/academic-dates/*, 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

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.

Exams:

1. There will be a written 75-minute closed book mid-term exam and an oral component. The written component will take place during the lecture period (likely Wed, Oct 29). 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.

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 examples: 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.**

Grade Breakdown

COMPONENT	GRADE VALUE	
	4203	5313
ASSIGNMENTS	35%	32%
MIDTERM (WRITTEN+ORAL)	28%	25%
FINAL EXAM	37%	33%
PROJECT	n/a	10%

Late and Missed Work Policies

Late Work
Late work will generally not be accepted.

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. Schafer, "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 Chat GPT/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 later).

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.