

Topics in Biophysics

PHYS 3207

Course Instructor: Sangeeta Murugkar

Hear my name:

<https://www.name-coach.com/sangeeta-murugkar>

How to address me: Professor Murugkar

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, visit me during student hours (see below), or approach me after lecture.

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

What are 'Student Hours'?

Student hours are dedicated times through the week for the course instructor and TAs to meet with YOU. Pop in to introduce yourself, ask questions about the course, or discuss content from the course.

Note: If these times don't work for you, email me and we can arrange an alternate time to meet.

Office Location: Herzberg HP 2414

Class Times: Monday & Wednesday, 1:05 pm-2:25 pm

Prerequisites: PHYS 2604

Students who do not have these prerequisites must check with the course instructor and obtain permission of the Physics Department to remain in the course.

Course TA: TBD

Teaching Assistant

Email:

Welcome to PHYS 3207 !

This course will provide an introduction of how life, a mysterious and sophisticated phenomenon, actually follows basic physical rules. In the past couple of decades, physical instruments have become powerful tools for investigating biological processes. Most importantly, physical principles and mathematical models are now the keys for answering questions in life sciences.

Inclusive teaching

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. Please email me if you have any comments or concerns.

Land Acknowledgement

We recognize the Algonquin peoples as the traditional custodians of the land in which the campus is located, and where the class is taught. We give respect to the host nation, the Kitchissippi Omàmiwininì Anishinabeg (Algonquin peoples of the big river, in the Algonquin language).

Course level learning objectives

1. A sound appreciation of the interconnectedness and multidisciplinary nature of the field of biological physics.
2. A firm knowledge of the applications of a quantitative physical sciences approach to problems in the biological sciences.
3. A solid understanding of the application of statistical physics and mathematical models in biological systems.
4. An introduction to concepts underlying nanotechnology and soft materials.

Community Guidelines

The following values are fundamental to academic integrity and are adapted from the International Center for Academic Integrity^{*}. In our course, we will seek to behave with these values in mind:

	As students, we will...	As a teaching team, we will...
Honesty	<ul style="list-style-type: none"> • Honestly demonstrate our knowledge and abilities on assignments and exams • Communicate openly without using deception, including citing appropriate sources 	<ul style="list-style-type: none"> • Give you honest feedback on your demonstration of knowledge and abilities on assignments and exams • Communicate openly and honestly about the expectations and standards of the course through the syllabus, and with respect to assignments and exams

Responsibility	<ul style="list-style-type: none"> • Complete assignments on time and in full preparation for class • Show up to class on time, and be mentally/physically present • Participate fully and contribute to team learning and activities 	<ul style="list-style-type: none"> • Give you timely feedback on your assignments and exams • Show up to class on time, and be mentally & physically present • Create relevant assessments and class activities
Respect	<ul style="list-style-type: none"> • Speak openly with one another, while respecting diverse viewpoints and perspectives • Provide sufficient space for others to voice their ideas 	<ul style="list-style-type: none"> • Respect your perspectives even while we challenge you to think more deeply and critically • Help facilitate respectful exchange of ideas
Fairness	<ul style="list-style-type: none"> • Contribute fully and equally to collaborative work, so that we are not freeloading off of others • Not seek unfair advantage over fellow students in the course 	<ul style="list-style-type: none"> • Create fair assignments and exams, and grade them in a fair, and timely manner • Treat all students equitably
Trust	<ul style="list-style-type: none"> • Not engage in personal affairs while on class time • Be open and transparent about what we are doing in class • Not distribute course materials to others without authorization 	<ul style="list-style-type: none"> • Be available to all students when we say we will be • Follow through on our promises • Not modify the expectations or standards without communicating with everyone in the course
Courage	<ul style="list-style-type: none"> • Say or do something when we see actions that undermine any of the above values • Accept a lower or failing grade or other consequences of upholding and protecting the above values 	<ul style="list-style-type: none"> • Say or do something when we see actions that undermine any of the above values • Accept the consequences (e.g., lower teaching evaluations) of upholding and protecting the above values

² This class statement of values is adapted from Tricia Bertram Gallant, Ph.D.

Learning Materials

Textbook:

P. Nelson *Biological Physics: Energy, Information, Life*
(W. H. Freeman, 2008).

Updated first edition (ISBN-10: 07167-9897-2)

Assessment in this Course

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) and using rubrics.

Grade Breakdown

COMPONENT	GRADE VALUE
ASSIGNMENTS	30%
MIDTERM	20%
PROJECT	20%
FINAL EXAM	30%

Assignments

There will be a total of 9 weekly assignments. A problem set will be assigned every Wednesday and will be due by midnight on the following Monday. However, if you need an extension on this deadline, please email Dr. Murugkar and ask for one.

Assignment solutions should be submitted electronically as a single '.pdf' file. Note 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. The assignments are a critical part of the course and working through the problems yourselves is essential to learn the material. Your homework solutions should be thorough, self-contained, and logical, with all steps explained.

Midterm Exam

There will be an 80-minute mid-term exam held during the lecture time on Monday, February 26th, 2024.

Final Exam

The final exam will take place during the final exam period in April and will cover the entire course.

Project

Groups will be formed of 2 students. Each group will do a presentation in class (15 minutes + 5 minutes for questions) and produce a written report of 2- 4 pages on a published journal article (choice of articles will be provided by February 28th) involving an application of a biophysical technique applied to biological cells and/or tissue. The report and presentation should highlight an application, explain the application with respect to biological physics principles and techniques covered by this course, and summarize in a conclusion. Groups should aim to share the work evenly between members.

Special Information Regarding Public Health

It is important to remember that COVID is still present in Ottawa. In addition there are risks from flu, RSV and other viruses. There are a number of actions you can take to lower your risk and the risk you pose to those around you including being vaccinated, wearing a mask, staying home when you're sick, washing your hands and maintaining proper respiratory and cough etiquette.

Feeling sick? Remaining vigilant and not attending work or school when sick or with symptoms is critically important. If you feel ill or exhibit COVID-19 symptoms do not come to class or campus. If you feel ill or exhibit symptoms while on campus or in class, please leave campus immediately. In all situations, you must follow Carleton's symptom reporting protocols.

Masks: Carleton has paused the COVID-19 Mask Policy, but continues to strongly recommend masking when indoors, particularly if physical distancing cannot be maintained. It may become necessary to quickly reinstate the mask requirement if pandemic circumstances were to change.

Vaccines: While proof of vaccination is no longer required to attend campus or in-person activity, it may become necessary for the University to bring back proof of vaccination requirements on short notice if the situation and public health advice changes.

Students are strongly encouraged to get a full course of vaccination, including booster doses as soon as they are eligible. Please note that Carleton cannot guarantee that it will be able to offer virtual or hybrid learning options for those who are unable to attend the campus.

All members of the Carleton community are required to follow requirements and guidelines regarding health and safety which may change from time to time. For the most recent information about Carleton's COVID-19 response and health and safety requirements please see the University's COVID-19 website and review the Frequently Asked Questions (FAQs). If you have additional questions after reviewing, please contact covidinfo@carleton.ca.

Note About COVID-19 & Mental Health

The global pandemic has led to extra stress and uncertainty for each one of us, although to different extents. If you are struggling, please do not hesitate to reach out. I am happy to listen, and/or direct you to resources that might help. Remember that Carleton also offers an array of mental health and well-being resources, which can be found [here](#).

University Policies

In accordance with the Carleton University Undergraduate Calendar Regulations, the letter grades assigned in this course will have the following percentage equivalents:

A+ = 90-100	B+ = 77-79	C+ = 67-69	D+ = 57-59
A = 85-89	B = 73-76	C = 63-66	D = 53-56
A- = 80-84	B- = 70-72	C- = 60-62	D- = 50-52
F = <50			

WDN = Withdrawn from the course

ABS = Student absent from final exam

DEF = Deferred

FND = (Failed, no Deferred) = student could not pass even with 100% on final exam

Academic Accommodations, Regulations, Plagiarism, Etc.

Carleton University is committed to providing access to the educational experience in order to promote academic accessibility for all individuals.

Academic accommodation refers to educational practices, systems and support mechanisms designed to accommodate diversity and difference. The purpose of accommodation is to enable students to perform the essential requirements of their academic programs. At no time does academic accommodation undermine or compromise the learning objectives that are established by the academic authorities of the University. More information can be found at: <https://students.carleton.ca/course-outline/>

University rules regarding registration, withdrawal, appealing marks, and most anything else you might need to know can be found on the university's website, here:

<https://calendar.carleton.ca/undergrad/regulations/academicregulationsoftheuniversity/>

Academic Accommodations for Students with Disabilities

If you have a documented disability requiring academic accommodations in this course, please contact the Paul Menton Centre for Students with Disabilities (PMC) at 613-520-6608 or pmc@carleton.ca for a formal evaluation or contact your PMC coordinator to send your instructor your Letter of Accommodation at the beginning of the term. You must also contact the PMC no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with your instructor as soon as possible to ensure accommodation arrangements are made. For more details, visit the [Paul Menton Centre website](#).

Addressing Human Rights Concerns

The University and all members of the University community share responsibility for ensuring that the University's educational, work and living environments are free from discrimination and harassment. Should you have concerns about harassment or discrimination relating to your age, ancestry, citizenship, colour, creed (religion), disability, ethnic origin, family status, gender expression, gender identity, marital status, place of origin, race, sex (including pregnancy), or sexual orientation, please contact the Department of Equity and Inclusive Communities at equity@carleton.ca.

Religious Obligations

Please contact me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, please review the [Student Guide to Academic Accommodation \(PDF, 2.1 MB\)](#).

Survivors of Sexual Violence

As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: <https://carleton.ca/sexual-violence-support/>

Accommodations for Missed Work

Carleton recognizes that these are unprecedented times during the COVID-19 pandemic, and that students may be experiencing greater stress and other life factors that are not in their control. As a result, Carleton has put into place a protocol for students to apply for accommodations using a self-declaration form in the event of missed work. The form can be found at: <https://carleton.ca/registrar/wp-content/uploads/self-declaration.pdf>

For Pregnancy

Please contact me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, please review the [Student Guide to Academic Accommodation \(PDF, 2.1 MB\)](#).

Accommodation for Student Activities

Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, see the [Senate Policy on Accommodation for Student Activities \(PDF, 25KB\)](#).

Academic Integrity

Academic misconduct undermines the values of honesty, trust, respect, fairness, and responsibility that we expect in this class. Carleton University provides supports such as academic integrity workshops to ensure, as far as possible, that all students understand the

norms and standards of academic integrity that we expect you to uphold. Your teaching team has a responsibility to ensure that their application of the Academic Integrity Policy upholds the university's collective commitments to fairness, equity, and integrity. (adapted from Carleton University's Academic Integrity Policy, 2021).

Examples of actions that do not adhere to Carleton's Academic Integrity Policy include:

- Plagiarism
- Accessing unauthorized sites for assignments or tests
- Unauthorized collaboration on assignment and exams

Sanctions for not abiding by Carleton's Academic Integrity Policy

A student who has not adhered to Carleton's Academic Integrity Policy may be subject to one of several sanctions:

1. If you take full responsibility for your actions, and it is the first time you have violated the policy, you will receive zero on the assessment. If you are found to have violated the policy but do not take responsibility, an additional grade deduction will be applied (e.g. an A- will become a B+)
2. Subsequent violations of the policy may result in more severe sanctions such as failing the course, suspension from all studies and/or expulsion.

Process of an Academic Misconduct Investigation

Step 1: The instructor believes misconduct has occurred and submits documentation to the Dean of the Faculty of Science.

Step 2: The Dean reviews documentation and can proceed with or dismiss the allegation.

Step 3: If sufficient evidence, the student receives an allegation statement by email. Ombuds services is copied on the email.

Step 4: The student provides a written response to the evidence provided.

Step 5: Either party may request a meeting between student, dean, and the ombudsperson.

Step 6: Dean informs the student of the decision.

Appeal: Student has the right to appeal the decision.

Additional details about this process can be found on the [Faculty of Science Academic Integrity website](#). Students are expected to familiarize themselves with and follow the

Carleton University Student Academic Integrity Policy. The Policy is strictly enforced and is binding on all students.

Plagiarism

Plagiarism is the passing off of someone else's work as your own and is a serious academic offence. For the details of what constitutes plagiarism, refer the Faculty of Science Academic Integrity website. To further understand Academic Integrity, consider attending the Learning and Support Academic Integrity Workshop.

What are the Penalties for Plagiarism?

A student found to have plagiarized an assignment may be subject to one of several penalties including: expulsion; suspension from all studies at Carleton; suspension from full-time studies; and/or a reprimand; a refusal of permission to continue or to register in a specific degree program; academic probation; award of an FNS, Fail, or an ABS.

What are the Procedures?

3. All allegations of plagiarism are reported to the Dean of Faculty of Science. Documentation is prepared by instructors and/or departmental chairs.
4. The Dean writes to the student and the University Ombudsperson about the alleged plagiarism.
5. The Dean reviews the allegation. If it is not resolved at this level then it is referred to a tribunal appointed by the Senate.

Students are expected to familiarize themselves with and follow the Carleton University Student Academic Integrity Policy. The Policy is strictly enforced and is binding on all students.

Assistance for Students

Academic and Career Development Services: <http://carleton.ca/sacds/>

Writing Services: <http://www.carleton.ca/csas/writing-services/>

Peer Assisted Study Sessions (PASS): <https://carleton.ca/csas/group-support/pass/>

Math Tutorial Centre: <https://carleton.ca/math/math-tutorial-centre/>

Science Student Success Centre: <https://sssc.carleton.ca/>

Syllabus

This course will cover the chapters of the text book listed below. In addition, two lectures will focus on an introduction to medical physics and an important biophysical technique involving optical spectroscopy and microscopy used to measure cell properties.

Chapter 1. What the ancients knew

Refresh the First Law of thermodynamics: Conservation of Energy. Get some preliminary expectations about the Second Law: the relation between biological order, entropy and free energy.

Chapter 2. What is inside cells

Establish terminology and iconography, think of the cell as a dynamic place full of traffic and purposeful activity.

Chapter 3. The molecular dance

Understand the Boltzmann distribution of molecular velocities, and how the fact of thermal motion constrains the method of information storage in cells.

Chapter 4. Random walks, friction, and diffusion

Understand diffusion and friction, as consequences of molecular chaos. Understand diffusion as the dominant form of transport in the aqueous, submicron world.

Chapter 5. Life in the slow lane: The low Reynolds-number world

Understand viscous friction as a paradigm for other dissipative processes. Understand how viscosity dominates over momentum in the submicron world, and get simple consequences.

Chapter 6. Entropy, temperature, and free energy

A close look on the Second Law of thermodynamics. Develop the mathematics of entropy, free energy, and entropic forces.

Chapter 7. Entropic forces at work

Develop main physical forces responsible for molecular self-assembly and recognition. Osmosis pressure and flow, depletion forces and a hydrophobic effect.

Chapter 8. Chemical forces and self-assembly

Chemical energy is another form of free energy that drives the self-assembly responsible for the creation of bilayer membranes and cytoskeletal filaments.

Chapter 11. Machines in Membranes

Electroosmotic effects, Ion concentration and membrane potential, introduction of ion pumps. Set the stage for later discussion of nerve impulses.

Chapter 12. Nerve Impulses

Voltage-gated channels are a remarkable class of molecular devices that are crucial for transmission of nerve impulses.

Lecture Plan

Below is a tentative plan (also posted separately on Brightspace) for lecture topics that will be discussed in the course. Please consult this list for preparatory reading before each lecture.

Lecture	Date	Topics	Chapter		HW due
1	08-Jan	Intro to Course	1	Post HW1 (Ch. 1 & 2)	
2	10-Jan	What's inside cells	2		
3	15-Jan	Probability density distribution	3.1	Post HW2 (Ch. 2 & 3)	HW1
4	17-Jan	Decoding the ideal gas law	3.2		
5	22-Jan	Random walks	4	Post HW3 (Ch4)	HW2
6	24-Jan	Diffusion	4		
7	29-Jan	Diffusion	4	Post HW4 (Ch 4)	HW3
8	31-Jan	The low Reynolds Number world	5		
9	05-Feb	Biological Applications	5	Post HW5 (Ch. 5)	HW4
10	07-Feb	Entropy	6		
11	12-Feb	Temperature	6		HW5
12	14-Feb	Mid term Review	Review		
	19-23 Feb	Winter Break			
	26-Feb	Midterm Exam		Post HW 6 (Ch 6)	
13	28-Feb	Free Energy	6	Project Topics suggested	
14	04-Mar	Osmotic Pressure	7	Post HW 7 (Ch 7)	HW6
15	06-Mar	Entropic forces at work in cells	7		
16	11-Mar	Entropic forces at work in cells	7	Post HW 8 (Ch 11)	HW7
17	13-Mar	Chemical forces and Self-Assembly	8	Project Topics finalized	
18	18-Mar	Machines in Membranes	11	Post HW9	HW8
19	20-Mar	Nerve Impulses	12		
20	25-Mar	Introduction to Medical physics			HW9
21	27-Mar	Introduction to vibrational spectroscopy imaging			
22	01-Apr	Project presentation (3 groups)		Project presentation (20 minutes per group)	
23	03-Apr	Project presentation (2 groups)		Project presentation (20 minutes per group)	
24	08-Apr	Final Review	Review		