PHYS 4251 Syllabus

Course Prefix: PHYS

Course Number: 4251

Course Name: Biophysics

Semester: FA

Academic Year: 2026-2027

Instructor Information

Instructor: Shiladitya Banerjee

Email: sbanerjee347@gatech.edu

General Course Information

Course Description:

Biophysics, or the *physics of living systems*, is an exciting interdisciplinary frontier that seeks to understand the phenomena of life through the lens of physics. Living systems possess no magical exemption from the laws of nature; every biological process, from cell division to a firing neuron, is fundamentally constrained by mechanics and physical laws. This course introduces the core principles that govern the physical behavior of living systems, spanning from single-molecule dynamics to the collective behavior of cells and organisms. We will explore the physics concepts most vital to biological processes at the molecular (nm) and cellular (μm) scales, including energy conversion, information transfer, mechanics of movement, statistical phenomena, and fluid flow. By applying these concepts, we will build mathematical models to predict biological behavior and test those models against real-world experimental data. Students will develop an intuitive ability to frame physical problems, select appropriate theoretical frameworks, and analyze data, ultimately understanding how biophysical phenomena depend on varying time and length scales. *No prior knowledge of biology is expected*.

Course Learning Outcomes:

After completing this course, students will be able to:

- **Quantitatively model** biological systems using data-driven and mechanistic physical frameworks.

- **Apply statistical physics** to describe kinetic processes, random walks, DNA structure and organization, and diffusion in the crowded interior of biological cells.
- **Analyze cellular mechanics** by utilizing elasticity theory and fluid dynamics to understand cytoskeletal deformation, cellular movement, and molecular transport.
- **Calculate energy transduction** within the cell, particularly regarding the force generation and stepping dynamics of molecular motors.
- **Model neural signaling** and memory by linking the physics of action potentials to macroscopic network models.
- Link the materials in the course to specific examples of research in the recent scientific literature.

Required Course Materials:

- *Physical Biology of the Cell*, 2nd Edition, Rob Phillips, Jane Kondev, Julie Theriot & Hernan G. Garcia, Garland Science, 2013 (Recommended textbook).
- *Biological Physics: Energy, Information, Life*, Student Edition, Philip Nelson, Chiliagon Science, 2020.
- *Physical Models of Living Systems*, 2nd Edition, Philip Nelson, Chiliagon Science, 2020
- *Additional reading:* Lecture slides and selected recent scientific literature will be provided on Canvas.

Grading Policy:

Grading for the course will be broken down as follows:

Assessment	**Percentage of Final Grade**
Homework	20%
In-class workshops	25%
Midterm	20%
Final	30%
Class Participation	5%
Total	**100%**

- **Homework:** Four homework assignments will constitute 20% of the grade. There will be no late credit for assignments. Extensions and make up exams will be available only with a well-documented, serious, and valid excuse, such as a serious sickness, death in the family, or a university function.
  See this catalog page: https://catalog.gatech.edu/rules/4/ for more information.
- **Workshops:** Four times during the semester, specific classes will be dedicated to

collaborative Workshops where you will solve biophysics problems in small groups (of ~3), using open notes/books but no computers/electronics. These mandatory sessions account for 25% of your grade and focus on the setup and physical interpretation of systems, providing a supportive environment to test your understanding with immediate feedback.

- **Midterm Exam**: In-person, in-class, closed book and closed notes. A formula sheet will be provided.
- **Final Exam**: In-person, closed book and closed notes. A formula sheet will be provided. In order to pass this course, students are strictly required to complete and submit both the Mid-term Exam and the Final Exam.
- **Class Participation**: Active involvement in our discussions is a core component of how we will learn together, so you are expected to attend every lecture. We will operate on an honor system without taking a formal, daily roll call. However, please be aware that I reserve the right to implement formal attendance tracking later in the term (with fair warning) if general participation declines or if a student develops a pattern of missing class.

Grade Scale

A 100%-90%

B 89%-80%

C 79%-70%

D 69%-60%

F <60%

Course Policies

Attendance Policy:

A major portion of your learning will emerge from our collaborative class discussions; thus, regular attendance and active engagement are required. We will begin the semester using an honor system without recording explicit daily attendance. Should class-wide attendance wane, or if specific individuals are repeatedly absent, this policy is subject to change at my discretion. You will always be given advance notice before any formal tracking begins.

Extensions, Late Assignments & Re-Scheduled/Missed Exam:

There will be no late credit for assignments. Extensions and make up exams will be available only with a well-documented, serious, and valid excuse, such as a serious sickness, death in the family, or a university function.

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Academic Integrity:

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit http://www.catalog.gatech.edu/policies/honor-code/ or http://www.catalog.gatech.edu/rules/18/. Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Accommodations for Students with Disabilities:

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or http://disabilityservices.gatech.edu/, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Student-Faculty Expectations Agreement:

At Georgia Tech we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See this catalog page: https://catalog.gatech.edu/rules/21/ for an articulation of some basic expectation that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Pre-requisites:

Undergraduate Semester level PHYS 2212 Minimum Grade of D or Undergraduate Semester level PHYS 2232 Minimum Grade of D. Additionally, students are expected to have a working proficiency in calculus and ordinary differential equations.

Collaboration, Group Work, and the Use of Generative AI:

In this course, we highly value collaborative problem-solving, but individual mastery of the concepts is ultimately required. Because we emphasize the *process* of building physical models and deriving biological limits, the following boundaries apply to your work:

- **Take-Home Homework:** You are welcome and encouraged to discuss conceptual approaches and problem-solving strategies with your classmates. However, the final derivations, calculations, and written explanations you submit must be entirely your own work.
- **Generative AI***:* You may use generative AI as a tutor or reference, much like a textbook. However, you must cite your AI usage just as you would cite a paper (e.g., "Used AI to debug my Python code," or "Used AI to clarify the concept of viscous drag"). AI models frequently fail at complex biophysical derivations, meaning blind reliance will likely lead to incorrect answers. You are solely responsible for the physical accuracy of your submission. You must understand and be able to explain every step of your work without consulting an AI. Inability to do so will be treated as an Honor Code violation.
- **In-Class Workshops:** These sessions are specifically designed for active group work. You will collaborate in small teams (typically around three students) to unpack complex biophysical systems. While peer collaboration and open notes are the foundation of these workshops, all electronic devices, including AI tools, are strictly prohibited during these sessions.
- **Midterm and Final Exams:** These are strictly independent assessments designed to test your personal intuition and understanding. All forms of collaboration, group work, and the use of generative AI or unauthorized electronic devices are explicitly forbidden.