Physics 410 Biological Physics Spring 2020

Instructor:	Daniel Robb	Class Times:	MWF 9:40-10:40 (TREX 272)
Office:	Massengill 243	Office Hrs:	Th 9-12
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Course Description:

Application of physics and physical principles to the cell and biological systems, including cell structure, diffusion and movement, entropic forces, self-assembly, and nerve impulses.

Textbook:

- *Biological Physics* by Philip Nelson. W.H. Freeman and Company, 2008.
  ISBN-13: 9780716798972

Purpose of the Course:

In recent years physicists have gained insight into the function of biological systems by applying physics principle to biological structures in the cell. A growing number of biologists have also become more engaged with quantitative information. In this course, we will cover a representative sample of this convergence into the field of "biophysics". In broad terms, we will work to (i) understand how organisms solve various challenges working within the laws of physics, (ii) become familiar with the main structures and processes of cell biology, and (iii) understand conceptually the key roles played by diffusion, active transport, entropy and free energy in cell processes.

MCSP Colloquium Series:

The MCSP department offers a series of discussions that appeal to a broad range of interests related to these math, computer science and physics. Members of this class are invited to be involved with all of these meetings; however participation in **at least two** of these sessions is mandatory. Within **two weeks** of attending a colloquium you must submit (via Inquire) a one-page single-spaced paper reflecting on the discussion. This should not simply be a regurgitation of the content, but rather a personal contemplation of the experience.

Feedback and Evaluation:

I will assign numerical grades to all your work. I *may* curve your final grades (upward), but otherwise you can expect to receive an "A" for 90-100, a "B" for 80-89, etc. I will assign +/- to your final grades by examining the distribution of grades and taking into account my perception of your effort in the course. These are the categories and percentages that will be used:

Problem sets:	15% (3 @ 5 % each)
Programming projects:	30% (5 @ 6% each)
Tests:	30% (2 @ 15 % each)
Final exam:	20%
Participation:	5%

Problem sets are due at the start of class. I encourage you to discuss problems with other students (or with other groups in the case of group projects) but the work you turn in should be that of you or your own group.

Programming projects will be done in the Python programming language on various topics related to biophysics. You will be given a sample program and required to alter it to accomplish a given task. I encourage you to discuss the programming with other students, but the work you turn in should be your own.

Tests during the semester will be given in our classroom during class periods. Each test will consist of several conceptual questions requiring written responses, and several calculation problems. Note that *you will be given all necessary formulas on each test.*

The final exam will be comprehensive. It will be similar in format to the tests, and will include conceptual questions and calculation problems.

Your participation grade is based on your reflections on two MCSP Colloquium Series talks, as well as on your class attendance.

Attendance Policy:

You are expected to attend every class. Attendance is checked at each class meeting, and you must be in class to participate in the in-class activities which form part of the class participation grade. If you are going to be absent from class, I must be notified in advance. If 3 classes are missed without prior notification, then I will assume you are not interested in completing the course and you will be dropped from the class with a grade of DF. Furthermore, you are accountable for all work missed because of an absence. I will provide class materials for a missed class, but will not re-teach a missed class during office hours.

Policy on Late Work:

I will grade an assignment with a 10% lateness deduction if turned in by 5:00PM on the due date. Following that, assignments will receive a further 10% lateness deduction for each successive schoolday late (schooldays are Monday-Friday; days are considered to end at 5:00 PM). As a result, after one week assignments receive a 50% deduction and after two weeks, assignments receive a 100% deduction; that is, no assignment will be accepted if more than two weeks late. Under extreme circumstances only will I consider adjusting the late policy for an assignment.

Make-up Tests:

Make-up tests and quizzes will not be given. If you miss a test, and have an official college excuse for that absence, then your final exam grade will count for the missed test.

Academic Integrity:

The College academic integrity policies are vigorously enforced. Although you are encouraged to work in groups on your homework assignments, all work turned in for a grade must be your own. Please familiarize yourself with the College's academic integrity policies.

Accessible Education Services:

Education Services (AES) is located in the Goode-Pasfield Center for Learning and Teaching in Fintel Library. AES provides reasonable accommodations to students with documented disabilities. To register for services, students must self-identify to AES, complete the registration process, and provide current documentation of a disability along with recommendations from the qualified specialist. Please contact Laura Leonard, Assistant Director of Academic Services for Accessible Education, at 540-375-2247 or by e-mail at aes@roanoke.edu to schedule an appointment. If you have registered with AES in the past and would like to receive academic accommodations for this semester, please contact Laura Leonard at your earliest convenience to schedule an appointment.

#	Date	Topic	Reading	Due
		UNIT 1: What's inside cells		
1	Jan. 13	Introduction and preview	--	
2	15	What the ancients knew (plus heat and free energy)	1.1-1.5	
3	17	Molecular parts of the cell	2.1-2.2	
4	20	Molecular devices I	2.3	
5	22	Molecular devices II	2.3	Programming 1
		UNIT 2: Diffusion and movement		
6	24	Probability distributions and thermal distributions	3.1-3.2	
7	27	Brownian motion	4.1	
8	29	Random walks and diffusion	4.3-4.4	
9	31	Applications of diffusion	4.5-4.6	Programming 2
10	Feb. 3	Friction in fluids	5.1	Problem Set 1
11	5	The Reynolds number	5.2	
12	7	**TEST 1**		
13	10	Fun applications (worksheet)		
		UNIT 3: Entropic forces and self-assembly		
14	12	Thermal physics and entropy	6.1-6.4	
15	14	Free energy and two-state systems (proteins)	6.5-6.6	
16	17	Free energy and RNA stretching	6.7	
17	19	Entropic forces: osmotic pressure, depletion force	7.1-7.2	Programming 3
18	21	Repulsive forces between macromolecules	7.4	
19	24	Special properties of water	7.5	
20	26	Chemical potential	8.1	
21	28	Chemical reactions and equilibrium	8.2	
		Spring break		
22	Mar. 9	Isoelectric point of proteins	8.3	
23	11	Emulsions and micelle self-assembly	8.4	Problem Set 2
24	13	Micelle vs bilayer self-assembly	8.6	
25	16	Micelle vs bilayer self-assembly	8.6	
26	18	Review and catch-up		
27	20	**TEST 2**		
		UNIT 4: Nerve impulses		
28	23	Nernst potential and Donnan equilibrium	11.1	Programming 4
29	25	The GHK equation I		
30	27	The GHK equation II		
31	30	The action potential I	12.1	
32	Apr. 1	The action potential II	12.2	Problem Set 3
33	3	The Hodgkin-Huxley model	12.3	
34	6	Exploring the HH model I		
35	8	Exploring the HH model II		
	10	**Good Friday**		
36	13	Exploring the HH model III		Programming 5
37	15	Synapses and neural computation	12.4	
38	17	Synapses and neural computation	12.4	
39	20	Review and catch-up		
	23	**FINAL EXAM: 2:00-5:00 PM, Thursday, April 23**		