Physics 410 Biological Physics Spring 2018

Instructor: Daniel Robb
Office: TREX 266B
Email: robb@roanoke.edu
Phone: 375-5250

Class Times: MWF 9:40-10:40 (TREX 272)
Office Hrs: MWF 4-5, Th 2-4
(and by appt.)

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) understanding 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% (6 @ 5% 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 (at least) 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.

Disability Support Services:

Accessible 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 Dr. Sue Brown, Director of Academic Services and Acting Coordinator of Accessible Education Services, at 540-375-2247 or by e-mail at sbrown@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 Dr. Brown at your earliest convenience to schedule an appointment. You need to discuss your accommodations with her before they can be implemented. Also, please note that arrangements for extended time on exams in a distraction-reduced environment must be made with the Center for Learning & Teaching at least 2 weekdays (M-F) *before every exam*.

#	Date	Topic	Reading	Due
		UNIT 1: What's inside cells		
1	Jan. 15	Introduction and preview	--	
2	17	What the ancients knew (plus heat and free energy)	1.1-1.5	
3	19	Molecular parts of the cell	2.1-2.2	
4	22	Molecular devices I	2.3	
5	24	Molecular devices II	2.3	Programming 1
		UNIT 2: Diffusion and movement		
6	26	Probability distributions and thermal distributions	3.1-3.2	
7	29	Brownian motion	4.1	
8	31	Random walks and diffusion	4.3-4.4	
9	Feb. 2	Applications of diffusion	4.5-4.6	Programming 2
10	5	Friction in fluids	5.1	
11	7	The Reynolds number	5.2	Problem Set 1
12	9	Fun applications (worksheet)	5.3-5.4	
13	12	Review and catch-up		
14	14	**TEST 1**		
		UNIT 3: Entropic forces and self-assembly		
15	16	Entropy, temperature and the second law	6.1-6.4	
16	19	Entropy, temperature and the second law	6.1-6.4	
17	21	Open systems	6.5	
18	23	Entropic forces and osmotic pressure	7.1-7.2	Programming 3
19	26	Osmotic flow	7.3	
20	28	Chemical potential	8.1	Problem Set 2
21	Mar. 2	Chemical reactions		
		Spring break	8.2	
22	12	Dissociation	8.3	
23	14	Self-assembly of amphiphiles	8.4	Programming 4
24	16	Self-assembly in cells I	8.6	
25	19	Self-assembly in cells II	8.6	
26	21	Review and catch-up		
27	23	**TEST 2**		
		UNIT 4: Nerve impulses		
28	26	Electroosmotic effects	11.1	
29	28	Ion pumping	11.2	
	30	**Good Friday**		
30	Apr.. 2	The problem of nerve impulses	12.1	
31	4	The action potential I	12.2	Problem Set 3
32	6	The action potential II	12.2	
33	9	The Hodgkin-Huxley mechanism I	12.3	Programming 5
34	11	The Hodgkin-Huxley mechanism II	12.3	
35	13	The Hodgkin-Huxley mechanism III	12.3	
36	16	The Hodgkin-Huxley mechanism IV	12.3	Programming 6
37	18	Synapses and neural computation	12.4	
38	20	Synapses and neural computation	12.4	
39	23	Review and catch-up		
	26	**FINAL EXAM: 2:00-5:00 PM, Thursday, April 26**		