PHYS 611-Molecular Biophysics -- Spring 2015

Location: MP210 Time: Tue/Thu 12:00PM-1:15PM
Prerequisites: BIOL 301, CHEM 431, MATH 170, PHYS 112, or PERM/INSTR.

This class has no mandatory textbook. Lecture notes are available through Blackboard. However, the students interested in extending their knowledge on the topics discussed during the course may consult the following textbooks:

-*Quantitative Understanding of Biosystems : an Introduction to Biophysics*, by T.M Nordlund, Boca Raton : CRC Press, ©2011.

-*Integrated Molecular and Cellular Biophysics*, by V. Raicu and A. Popescu, Springer, 2008

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Office Hours: Mon 8:00AM-10:00AM, Tue: 8:00AM-10:00AM, or by appointment

Syllabus

Module 1: **Fundamental math and physics concepts in biophysics.** Charge, potential, electric field, energy, resistance, and capacitance. Bonds. Point charges and dipoles. VdW interactions. Hydrophobic interactions. Recall: derivatives, integrals, and simple differential equations relevant for this class.
Fundamentals of equilibrium processes. Kinetics. Rate constants. Equilibrium. Transition state theory. State occupancy and probability.

Module 2: The molecular basis of life.

2.1 Fundamental interactions in biological systems. **Physical properties of water and ions relevant to biological systems.** Biological systems and levels of organization. Chemical composition of living systems. Water and life. Physical chemistry of water within the frame of transition state theory. Ionic solutions and ionic conductivity. Ionic hydration. Amphiphiles and self-association. Optional: Debye screening – Debye Huckel theory.

2.2 Physical properties of Biomolecules. Biomolecules and interactions.

DNA: Primary and secondary structure. DNA: interactions and consequences. DNA denaturation. DNA precipitation. Amino acids: chemical identity, and physical properties. Physical properties of proteins. Applications of transition state theory: amino acid ionization. Self-assembly of phospholipids. Artificial structures. Optional: Enzyme kinetics.

Module 3: Natural and artificial lipid membranes. Transport through membranes.

The biological relevance of cell membranes. The general architecture of the cell membrane. Bilayer Lipid Membranes and Liposomes. Physical properties and biological relevance of BLMs. Passive electrical properties of BLMs. Transport across BLMs. Simple diffusion. Facilitated transport. Ion channels. Transmembrane potentials.

Module 4. Biophysics of excitable membranes. Voltage-gated ion channels. The neuron's structure and physiological relevance. The axon. Electrotonic and action potentials.Transmembrane ionic currents. Electrical modeling of the unmyelinated axon membrane. Optional: Muscle Cells.

Module 5: Macromolecular crowding. Effects of crowding on fundamental biophysical processes. The excluded volume theory. Biological implications.

Module 6: Cells in electric fields. Molecular and Biological consequences. Electroporation. Electrofusion. Applications: cell loading, gene transfer, production of monoclonal antibodies, electrochemotherapy.

Module 7: Radiation biophysics. Primary interactions of radiation with matter. Secondary effects: water radiolysis. Introduction to dosimetry. Interaction of radiation with principal biomolecules.

Objectives: To obtain a basic understanding of the key physical concepts describing biological systems, including the fundamental properties, structures, and organization at different levels. Examples relevant to cellular and molecular biology and to biomedical research are included in each lecture.

The course objectives will be accomplished through lecture, discussion of selected topics in class, problem solving in groups, working through the assigned parts of the lecture notes, assigned homework, and Lab-work. Assessment will come from exams, assigned homework, class activity, and the integrated Lab.

SYLLABUS: The syllabus describes the **intended** progression of the course. The syllabus will be revised as needed, and the changes properly announced.

EXAMS: 60% of your grade is based on the exams. The exams are based on the notes readings, the homework, the problems solved in class, and the class lectures. **ALL EXAMS WILL BE COUNTED, AND NO MAKE-UP EXAMS WILL BE GIVEN.** There will be four in-class exams (each worth 15% of the final grade), from which two of them are oral examinations. All the formulas required for each exam will be provided by the instructor. However, you may bring **your own sheet of formulas** for each exam, plus the formula sheets from your previous PHYS611 exam. All formula sheets must be labeled at the top with your name and the exam number, be **signed and handwritten** by you, and be turned in with your exam. Your formula

sheet should contain **only numbered formulas** from those sections of the chapters that are covered on the exam. No other comments, drawing, or other information are allowed on the formula sheet. It is your responsibility to know the meaning of every symbol on your formula sheet, and to understand the meaning, applicability, and use of every equation that you include on your formula sheet.

HOMEWORK: 5% of the PHYS 611 grade is based on the homework. Hand in what you have at the beginning of the first class in the first week after the homework was handed. **NO LATE HOMEWORK ACCEPTED unless special circumstances are encountered.** Homework problems will form the basis for many of the exam problems. Look over your homework carefully and make sure you can work and understand every assigned homework problem. You are strongly encouraged to talk to the instructor about homework problems that you do not understand. **Group homework is accepted and encouraged.** However, each student is expected to get a full understanding of the key concepts, the physical approach, the mathematical formulation (when required), and the interpretation of the results.

Class activity: 15% of the grade is based on class activity. Problem-solving in class will be one of the teaching approaches integrated into the active-learning process. The students will solve the problems individually or in small groups led by one of the peers. Originality and clarity of the scientific approach will constitute the main basis in evaluating the class activity. Moreover, the ability to properly communicate with colleagues (peer-instruction approach) will count for evaluation.

LECTURES & ASSIGNED READINGS: Class lectures relate closely to the assigned readings in the lecture notes posted on Blackboard. Students are expected to attend all lectures and participate actively in class. Consult the syllabus and read the assigned notes **before** the material is covered in class. **Carefully work through all examples and derivations in the assigned reading.** As you read, write down any questions you have about the reading and the examples, and ask questions in class.

Lab-Work: This class has an associated lab. The syllabus of the lab is separately presented on Blackboard. The lab work counts for 20% of the final grade.

ACADEMIC HONESTY: Although you are encouraged to discuss the class lectures, readings, and assignments with your classmates, all the work that you turn in must be your own. **NO CHEATING OR PLAGIARISM (PRESENTING OTHER PEOPLE'S WORK AS IF IT WERE YOUR OWN) WILL BE TOLERATED, INCLUDING ANY USE OF HOMEWORK SOLUTIONS FOUND ON THE INTERNET OR ELSEWHERE.** If you make use of sources besides the class lectures or textbooks, you must provide explicit written references to the sources you use. **Plagiarism of the Internet, or of any other source, is not permitted.** Failure to follow these rules of academic honesty, or any others listed in the Student

Code of Conduct, could have drastic consequences, including (but not limited to) ejection from the course with a failing grade.

The final grade will take into account the exams (E1 to E4, each graded from 0 to 100), the Lab-Work (L, graded from 0 to 100), the Class Activity (CA, graded from 0 to 100), and the Homework (H, graded from 0 to 100). The final grade is calculated according to the formula:

Grade = (15*E1+15*E2+15*E3+15*E4+20*L+15*CA+5*H)/100

GRADING SCALE:

A+	A	A-	B+	B	B-	C+	C	C-	D+	D	D-
100 –	96 –	92 –	88 –	84 –	80 –	75 –	70 –	65 –	60 –	55 –	50 – 45