



# Syllabus

## Biological and Medical Physics

### PHY 315 - Spring 2012



#### Professor

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#### Office hours

Mondays, 5:00 – 6:00 P.M., otherwise by appointment; the best way to contact me outside of class is by e-mail. *Please do not e-mail me questions that are already answered in this syllabus.*

#### Teaching Assistant Grader

No teaching assistant grader this year.

**Prerequisites**      PHY 212 or PHY 216

#### Course description

This is a 3 credits course for undergraduate students from physical and biochemical sciences, and engineering. This course deals with the most fundamental concepts of the laws of biological physics. You will learn how quantitative physical approaches can help to obtain a better understanding of the most basic mechanisms of the biological systems. All subjects studied in this class will be pertinent to the processes at the molecular and cellular levels. It is critically important that you realize that this is a truly advanced interdisciplinary class for undergraduate studies. The PHY 315 class will employ some background in mathematics, including differential and integral calculus.

#### Course objectives

- Obtaining a comprehensive understanding of the quantitative aspects of complex life processes;
- Exploration of biological problems by employing quantitative models, which are independent of time;
- Obtaining the ability to tackle the complexity of time-dependent biological systems that exhibit dynamic behavior;
- Obtaining the big picture of the network of information processing in biological systems;
- Obtaining an understanding of the fundamental principles used in medical physics.

#### Contents of the class:

- Why Biology by the numbers? •Design schemes for cells and organisms;
- Time scales in Biology; • Life at the organism level; •Mechanical and chemical equilibrium in the living cell; •Entropy rules; •The study of two-state systems: ion channels and cooperative binding processes; •The structure of macromolecules; •Electrostatics for salty

solutions; • Architecture rules for cells and skeletons; • Biological membranes; • The mathematics of water; • A statistical view of biological dynamics; • How does life function in disordered environments? • Rate equations and dynamics in the cell; • Dynamics of molecular motors; • Biological electricity and action potential; • The network of information processing: sequence, specificity, and evolution; • Network organization in space and time.

**Lectures** We will meet twice a week: **Tuesdays** and **Thursdays**, 5:00 – 6:20 P.M. Lectures will be held in Physics Bldg., Room 104N. It is important that you **ATTEND** and **PARTICIPATE** actively in the lectures. Class participation, through questions and discussions, is encouraged. We will introduce new ideas and concepts, and then demonstrate them by both conceptual problems and applications.

**Textbook:**

“**Quantitative Understanding of Biosystems – An Introduction to Biophysics**” by Thomas N. Nordlund, CRC Press, Taylor & Francis Group, Boca Raton, 2011; this is a truly outstanding textbook for learning the fundamentals of biological physics at the advanced undergraduate level. We will follow the book very closely. Students must use this textbook to supplement their lecture notes.

**Quizzes:**

There will be four quizzes that will be held during the lecture periods. They will be ~20 minutes in duration, and will cover material from the last two/three lectures. Please bear in your mind that the date of each quiz will **NOT** be announced. No make-up quizzes will be given (see the make-up policy).

**Exams**

There will be one mid-term examination, given during the time and in the place normally scheduled for the lecture (please see timetable). There will also be a final exam. **The date of the final examination is scheduled on Thursday, May 3rd, 5:15 - 7:15 P.M. in Room 104N.** The final examination will cover the entire course period, but with emphasis on the second part (1/3 of the first half and 2/3 of the second half). All materials taught in this class, including lectures, example problems and homework problems are subject to the mid-term and final examinations. No make-up exams will be given (see the make-up policy).

**Homework:**

The homework assignments, which are given from the textbook, will be distributed weekly on **Thursdays**. Homework will be normally due on **Thursdays** of the following week. Detailed solutions to the homework will be given after the lecture they are due. No late homework will be accepted! A deviation from this rule is permitted only in exceptional cases (e.g., you are excused due to an illness etc.; **please see the make-up policy**). Working problems is the only way to obtain a deep clarification of each topic.

**Make-up policy**

Should you miss a quiz or examination due illness or emergency, a make-up examination will be scheduled as soon as possible. The make-up tests will be given as oral examinations. **You need to bring solid documentation (doctor excuse etc.) for a requested make-up.**

**Grading Policy** You will be evaluated, based upon your performance in the class, as follows:

Quizzes:	10%
Homework:	20%
Mid-term Examination	30%
Final Exam	40%

The lowest quiz and homework grades will be dropped.

## GRADING SCALE

<u>Letter Grade</u>	<u>Grade Points</u>	<u>Percentages</u>
A	4.000	85 - 100
A-	3.666	80 - 84
B+	3.333	75 - 79
B	3.000	70 - 74
B-	2.666	65 - 69
C+	2.333	60 - 64
C	2.000	55 - 59
C-	1.666	50 - 54
D	1.000	40 - 49
F	0.000	0 - 39

### Academic Integrity:

We encourage you to find other classmates with whom to study. Working with friends can be very helpful in learning a difficult subject like physics. However, **the final work you turn in must be your own.** There is a distinction between discussing the work, and merely copying someone else's work. The idea here is that you should communicate and help each other to understand the problems and the concepts involved; you will learn more, if you work on the assignments in *groups* and explain the methods and various approaches to each other. You must engage in your own effort on solving the problems.

**The Syracuse University Academic Integrity Policy holds students accountable for the integrity of the work they submit. Students should be familiar with the Policy and know that it is their responsibility to learn about instructor and general academic expectations with regard to proper citation of sources in written work. The policy also governs the integrity of work submitted in exams and assignments as well as the veracity of signatures on attendance sheets and other verifications of participation in class activities. Serious sanctions can result from academic dishonesty of any sort. Students found to cheat will receive an F for that assignment. Students have a right to appeal. For more information and the complete policy, see <http://academicintegrity.syr.edu>**

### Disability-Related Accommodations:

Students who are in need of disability-related academic accommodations must register with the Office of Disability Services (ODS), 304 University Avenue, Room 309, 315-443-4498. Students with authorized disability-related accommodations should provide a current Accommodation Authorization Letter from ODS to the instructor and review those accommodations with the instructor. Accommodations, such as exam administration, are not provided retroactively; therefore, planning for accommodations as early as possible is

necessary. For further information, see the ODS website, [Office of Disability Services](http://disabilityservices.syr.edu/Office of Disability Services) <http://disabilityservices.syr.edu/>

**Religious Observances Policy:** the SU's religious observances policy can be found at:

[http://supolicies.syr.edu/emp\\_ben/religious\\_observance.htm](http://supolicies.syr.edu/emp_ben/religious_observance.htm), which recognizes the diversity of faiths represented among the campus community and protects the rights of students, faculty, and staff to observe religious holy days according to their tradition. Under the policy, students are provided an opportunity to make up any examination, study, or work requirements that may be missed due to a religious observance provided they notify their instructors before the end of the second week of classes. For fall and spring semesters, an online notification process is available through MySlice/Student Services/Enrollment/My Religious Observances from the first day of class until the end of the second week of class. **Please contact me by e-mail to inform you about how and when your academic requirement in PHY 315 course will be made up.**

**Webpage/Timetable:** [http://www.physics.syr.edu/~lmovilea/Biological\\_Medical\\_Physics2005.html](http://www.physics.syr.edu/~lmovilea/Biological_Medical_Physics2005.html)

### **General tips for making PHY 315 a success**

Many lectures will build on previous material. This rule does not deviate from the general way in which scientific knowledge builds. For this reason, it is important not to fall behind.

**Here is a recipe for making PHY 315 a success:**

**Set aside time to study.** Student surveys state that the average student spends six hours per week working on this course, outside of class. This number should be higher. You will do yourself a favor by scheduling at least 8 hours per week outside of class time, and sticking consistently to that schedule.

**Attend the lectures.** The purpose of the lectures is to introduce new concepts and to relate them to others. These connections are important. You need to identify these connections, and use them when necessary. If you simply memorize techniques to solve problems, then you will find Biological Physics to be an enormous and disconnected subject. On the other hand, if you learn to think of biological physics as governed by just a few rules (e.g., the conservation of mass, charge and energy), then you will find PHY 315 to be not only manageable, but also enjoyable.

**Do the homework.** Lectures and study assignments set the stage. But only by answering questions and effectively solving the problems and conceptual examples does deep understanding arrive. Get help early and often. Falling behind will only make your everyday life with PHY 315 harder.

**We wish you best of success with PHY 315 in Spring 2012 semester!**

### **Other good sources of Biological and Medical Physics**

There is a plethora of other useful textbooks for their different emphasis on Biological and Medical Physics, the applications chosen and the level of their presentation. Below, I give some examples beyond "**Quantitative Understanding of Biosystems - An Introduction to Biophysics.**"<sup>1-25</sup>

1. Cantor, C. R.; Schimmel, P. R. *Biophysical chemistry - Part I: the conformation of biological macromolecules*; W. H. Freeman and Company: New York, 1980.
2. Cantor, C. R.; Schimmel, P. R. *Biophysical chemistry - Part II: Techniques for the study of biological structure and function*; W. H. Freeman and Company: New York, 1980.
3. Cantor, C. R.; Schimmel, P. R. *Biophysical chemistry - Part III. the behavior of biological macromolecules*; W. H. Freeman and Company: New York, 1980.
4. Daune, M. *Molecular Biophysics - Structures in Motion*; Oxford University Press: Oxford, UK, 2000.
5. Howard, J. *Mechanics of motor proteins and the cytoskeleton*; Sinauer Associates, Inc.: Sunderland, MA, 2001.
6. Boal, D. H. *Mechanics of the Cell*; Cambridge University Press: Cambridge, 2002.
7. Nolting, B. *Methods in modern biophysics*; Springer-Verlag: Berlin Heidelberg, 2004.
8. Forgacs, G.; Newman, S. A. *Biological physics of the developing embryo*; Cambridge University Press: Cambridge, 2005.
9. Sneppen, K.; Zocchi, G. *Physics in Molecular Biology*; Cambridge University Press: Cambridge, UK, 2005.
10. Arrondo, J. L.; Alonso, A. *Advanced Techniques in Biophysics*; Springer-Verlag: Berlin-Heidelberg, 2006.
11. Atkins, P.; Paula, J. *Physical chemistry for the life sciences*; W. H. Freeman and Company: New York, 2006.
12. Jackson, M. B. *Molecular and Cellular Biophysics*; Cambridge University Press: Cambridge, 2006.
13. van Holde, K. E.; Curtis Johnson, W.; Shing Ho, P. *Principles of Physical Biochemistry*; Prentice-Hall, Inc.: Upper Saddle River, NJ, 2006.
14. Herman, I. P. *Physics of the human body*; Springer-Verlag: Berlin, Heidelberg, 2007.
15. Serdyuk, I. N.; Zaccai, N. R.; Zaccai, J. *Methods in Molecular Biophysics*; Cambridge University Press: Cambridge, UK, 2007.
16. Allen, J. P. *Biophysical Chemistry*; Wiley-Blackwell: Oxford, 2008.
17. Beard, D. A.; Qian, H. *Chemical biophysics*; Cambridge University Press: Cambridge, UK, 2008.
18. Davidovits, P. *Physics in Biology and Medicine*; Third Edition ed.; Elsevier: Amsterdam, 2008.
19. Nelson, P. *Biological physics - Energy, Information, Life*; Updated First Edition ed.; W. H. Freeman and Company: New York, 2008.
20. Raicu, V.; Popescu, A. *Integrated molecular and cellular biophysics*; Springer: New York, 2008.
21. Tuszynsky, J. A. *Molecular and Cellular Biophysics*; Chapman & Hall/CRC, Taylor & Francis Group: Boca Raton, FL, USA, 2008.

22. Waigh, T. A. *Applied Biophysics: A Molecular Approach for Physical Scientists*; John Wiley & Sons, Ltd.: Chichester, UK, 2008.
23. Sheenan, D. *Physical biochemistry: principles and applications*; Wiley-Blackwell: Oxford, 2009.
24. Walla, P. J. *Modern biophysical chemistry*; Wiley-VCH Verlag GmbH & Co. KGaA: Weinheim, 2009.
25. Phillips, R.; Kondev, J.; Theriot, J. *Physical Biology of the Cell*; Garland Science - Taylor & Francis Group: New York, 2009.