Physics 131 Physics for Biologists I

Physics for Biologists I

Description and Prerequisites

This course is intended for biology majors and pre-health care professionals. The physics topics chosen are selected for these students and the contexts emphasize authentic biological examples. Prerequisites for the course include:

- One year of college biology (BSCI 105 and 106 or the equivalent)
- One semester of college chemistry (CHEM 131 or the equivalent)
- One year of college mathematics (MATH 130 and 131 or the equivalent -- calculus and an introduction to probability)

This is not your parent's physics! This class will focus on the physics relevant to living things from molecules to worms to woodpeckers. While physics, chemistry, and biology are well established fields, some of the scientific questions you will explore in this class have only recently been tackled. You will focus on physics at the convergence with biology, where physical, chemical and biological principles all come into play. A primary theme for this first semester is the concept of motion -- and the difference between coherent, directed motion and the random motion that occurs at the molecular level.

What do I need to buy?

There is no textbook to buy for this course. We are developing a WikiBook that you will be able to read online. There is also no lab manual to buy. The lab instructions will be made available online. You will need to have:

- **A Clicker** -- a remote control device from TurningPoint that allows you to contribute answers in lecture. It is available at the Campus Book Store. This is the campus standard. If you have one from another class, you are likely to able to use it here. If you have an iPhone or iTouch you should be able to use it as a clicker. See the campus clicker page for more information.

  After you have purchased a clicker or iphone/itouch clicker account please register it here: https://myelms.umd.edu/courses/1020311

- **Online HW service** -- HW will be done online through the online service, *Webassign*. You can expect it to cost around $65 for each semester. For instructions on how to purchase this, download and follow the instrutions in the document, WebAssign Student Quick Start Guide. The Institution Code is "**umd**" and the Class Key is: **3059 5468**

What else do I need to get?

A lot of what we'll be doing this term will be on the computer. Our readings and our homework will be on canvas and webassign. You will also need access to a spreadsheet, and you will learn to download and use a video analysis program in labs. If you do not have your own laptop, you will need to seek out the campus computer rooms and find the places where you can access the appropriate programs. You need:

- **Access to a computer** -- if you have your own laptop you will be able to use that. If not, you will have to seek out campus computers that run the programs we will be using and to see our Announcements and to track your grades on Canvas.
- **A Spreadsheet** -- You can either use Excel or the spreadsheet available at Googledocs (http://docs.google.com/) to do repetitive calculations. If you plan to use Googledocs you will need to have a Google account (a free Gmail account will work.)
  For those of you who are unfamiliar with spreadsheets, there are a number of good tutorials on the web. These below look particularly appropriate. Many others are easily found by putting "Excel tutorial" into your favorite search engine. We will do our own training on Excel in the first lab.
  (http://phoenix.phys.clemson.edu/tutorials/excel/ ,http://www.excel-easy.com ,http://www.baycongroup.com/excel.htm)
- **A Video Analysis Program** -- You will learn how to quantitatively analyze images and videos. The tool we will use for this will be ***ImageJ***. This program is freely available, developed for use in biology and medicine at NIH, and is the professional standard. If you have your own laptop, we will help you install this in the laboratory period during the second week of class.

What do I need to do to succeed in this class?

Here is a brief outline of what you will need to do throughout the class. For more details, see the Course Mechanics page.

- ***Do the reading and commentary for each lecture and selected labs***! -- For each lecture and some labs there will be a required reading of a few web pages. For two of these you will be asked to summarize the page on your *Webassign* online homework program and ask a question about it. Occasionally, you may be asked to follow a link and answer questions, instead. The lecture reading write ups will be due eight hours before the lecture class. You can find the lecture reading assignments on the Schedule page, and the Lab pre-readings under Recitation/Labs
- ***Attend and participate in all the lectures, recitations, and labs!*** -- This is a class very much about *doing*, not just about learning facts or equations. In lecture we will be doing very little lecturing but a lot of answering questions, doing group problem solving, and holding class discussions. You will get participation points for some of this stuff, but that's not the point -- the point is that in the *doing* in lecture and recitation, and in labs is where a lot of the real learning in this class takes place. A major part of what you will be learning is how to talk about and make sense of physics through problem solving with your classmates and by designing, doing and analyzing experiments in lab.
- ***Do the weekly homework!*** -- While the lecture and recitation is where you will learn to talk about and make sense of physics through problem solving, the homework is where you will get to try it out with your classmates on your own. You are encouraged to work with others. We have a Course Center (room 0208) set up, where you can find people to work with (and get help when you are stuck). **But be careful!** If you work together DO NOT create a common solution and everyone copy it. Once you have worked out a solution together, each person must write it up separately in your own words. If two solutions are too nearly identical, neither will get credit! Homework assignments themselves are found on our Homework Assignment page.
- ***Keep up!*** -- We know that you're busy, and in many other classes you can let things slide and then catch up for the exam. In this class that will be very difficult. Each lecture builds on the last, and on the homework from previous weeks. Not to mention the increased pace of fitting a 15 week class into 6 weeksIf you miss too much you may find yourself lost. In addition, your grade in this class is based on the accumulation of points in many different categories throughout the term. For details see our Course Mechanics page.

Times and Places

Event			Place
Lecture	MTuWThF	9:30 - 10.50 AM	Physics 1410
Discussion	MW	11:00 - 11:50 AM	Physics 3310
Laboratory	TuTh	12:00 - 1:50 PM	Physics 3310

Instructors

Instructors	Name	Room	Phone	Office Hours	EMail
Instructor	Prof. D. Buehrle	PHY 1330	x5 6045		dbuehrle@umd.edu
TA	Kimberly Moore	PHY 1322	x5 6185		kmoore17@umd.edu

Honor code:

The University of Maryland, College Park has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. This Code sets standards for academic integrity at Maryland for all undergraduate and graduate students. As a student you are responsible for upholding these standards for this course. It is very important for you to be aware of the consequences of cheating, fabrication, facilitation, and plagiarism. For more information on the Code of Academic Integrity or the Student Honor Council, please visit this link. If you have any questions about policy or procedures, please feel free to ask. We are looking forward to working with you and hope that you will both enjoy and learn a lot from the class.

Disability arrangements:

Students who have arrangements for extra time on exams should check in with the instructor at the beginning of the class. In this class, arrangments will be made for extensions of time on site rather than at the DSS site. This is to account to permit the student to ask the instructor questions for occasional corrections or clarifications that are made during the exam period as the result of student questions.

Religious holidays and other excused absences:

This class follows campus policy for granting exemptions for religious holidays. For absences for illness, please email your professor stating the cause and date of your absence. For other potential absences, please consult your instructor.

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Course Mechanics & Grading

This class is an active learning experience! Think "aerobics class" rather than "watching a good science program on TV"! In all parts of the class you will be engaged in thinking about, talking about, figuring out, and learning physics.

Readings

There are readings in this class, but we have chosen not to use a standard text. In part this is because there is no standard introductory physics text that covers the physics that is most useful for applications in the life sciences. Our goal is to start with what you know from introductory biology and chemistry -- and your everyday experience! -- and teach you the physics that is most relevant for understanding living things. We are in the process of writing such a book as an online wiki-book. Before each class there will be a few (fairly short) web pages for you to read and comment on (using *Webassign*). Here are your pre-lecture tasks (If you would like to purchase and access a text, you can either add one to your WebAssign or purchase a paper copy. Ask your instructor for some recommendations.)

Classes

The "lectures" will typically begin with a brief recap of the content of the previous night's reading and a discussion based on the questions you and your classmates have entered. The rest of the class will be group problem solving, demonstrations and discussions, and other activities.

Recitations

The recitation sections will be group problem solving. Typically, you will work through an extended multi-part problem often with a biological context.

Homework

In addition to the reading commentaries there will be weekly homework assignments.

You will be asked to do 4-6 challenging problems including estimations, explanations, essay questions, worked out problems, and even some challenging multiple choice questions. You are encouraged to work on these with friends, but write up your solutions independently. Be careful: If two or more submitted answers are essentially identical, neither will receive credit. Some problems (1-2 per week) will be written out on paper and will be due at the BEGINNING of the Friday class of each week. The other problems will be due by 5pm and submitted through Webassign

Solutions to these problems will be posted on Canvas. You will need to go over those solutions carefully and compare to what you have done to be sure you understand.

Homework and in-class problem solving is where most of the learning in this class gets done! Do a careful and complete job on your homework. If you are not earning full credit and looking at the solutions doesn't help you for next time, check with an instructor and go over what more you need to do.

Quizzes

We will have (graded) 10-minute quizzes at the beginning of class on each **TUESDAY** when we are not going over an exam. They will consist of a number of questions projected on the screen and students will answer using their clickers. Quizzes will focus on important -- and sometimes subtle fundamental issues (often from the previous week's material). Each quiz will be worth 10 points. The point of these quizzes is to help you see where you might still be confused. There will tentatively be 5 quizzes.

Exams

We will have two hour exams and a final. Each exam will test how well you have learned to use and make sense of the material. As a result, **you will be expected to think on exams.** Each exam will include (points approximate): one set of short answer or multiple choice problems (25 pts -- often connected representation translation problems), two multi-part problems (25 pts each -- problem solving), one estimation problem (15 pts), and an essay question (10 pts). Although exams are important, they total only ~40% of your grade -- and there are ways to improve your result after the fact. See below for the rules for regrades and makeup exams.

Laboratories

The laboratories in this class will let you experience and explore the topics of lecture and recitation in the real world. You also will learn techniques that are directly applicable to living things, for example how to characterize the motion of an object moving under a microscope.

The lab experiments are different from the traditional "protocol" labs where you are told exactly what to do and expect to get a result that agrees with some theoretical prediction. These are *design labs* -- labs in which your job is to design and carry out an experiment to answer a question.

Each lab experiment will be carried out over two or more weeks to give you time to learn a new technique and to answer a question. An important part of the lab is a discussion at the end where you present and discuss your results to the other members of your class.

Lab reports will be done during the lab periods and handed in before you leave the final lab period of an experiment. For more details and for the lab handouts, go to our Lab page.

Excuses

If you have a valid excuse for missing an exam, quiz, or homework, send an email to your instructor to arrange what to do about it, beforehand if at all possible. Specify the date and day you will be (or were) absent and the reasons. *Ex post facto* (after the fact) excuses will require validation and may not be acceptable. (Wanting to leave early before a holiday is NOT a valid excuse, even if it's for a friend's wedding.) You must contact your lead instructor. Your TA does not have the authority to excuse you from any required class activity.

Grading

Grades in this class arise from a mix of many different ways to judge your work, NOT solely from your performance on exams. Be sure you understand the components!

The result is a grade that is a more accurate representation of your performance in the class. It also means that you can

blow one midterm exam and still get an A if your work in other categories is first rate! Here is the breakdown. It also means if you do very poorly on any one category -- say you don't hand in any homework -- it can be difficult to get a decent grade!

- ***Components*** --

Hour exams (100 pts each)	200
Quizzes	50
Final exam	200
Homework	150
Lab	165
Lecture Participation	80
Recitation/Lab Participation	75
Pre-Class and Pre-Lab Reading	80
Total	**1000**

These divisions are not guaranteed. We may adjust due to unforseen circumstances that cancel classes or HW - snow, tornadoes, etc.

- ***How grades are assigned*** -- We assign a grade level for each category (e.g., how many points you need to get to get an A on the quizzes, what you need to get an A on the HW, etc.) and then add up the points for each grade level to obtain what is need for each final grade. We anticipate that the top third of each grade range will be "+" and the bottom third will carry a "-".

- ***Curving: Labs and HW yes, exams and quizzes no*** -- For exams, we do NOT grade on a curve. We have an absolute expectation. On most exams, 75% will be an A, 60% a B, 45% a C. **This means that someone else's doing well on an exam will never negatively affect your grade. If you all do well on an exam we will give you all A's for that exam.**

- ***Exams*** -- Exam problems will not be standard end-of-chapter problems. You will be expected to think, not recall previously memorized information. Questions of the type found on our exams will be included in the homework problems and problems from previous exams will be available on our web site.

  - ***You can improve an exam grade 1: Regrades*** -- Since we go over midsemester exams in class, you will be able to get a good sense of how it was graded. If you think the grader misunderstood what you were saying, or failed to give you proper credit, you can apply to your lead instructor for a regrade by writing a clear description of why you think you should have more points and turning it in with your exam. In addition to grading error, if you can make a case that you made an early error, but correctly carried out later parts that depended on that error, you can request consistency points. Again, you will have to explain carefully in writing your argument.

    Be sure not to write on your exam itself since this will mean we would have to look up the scanned exams to see what you originally wrote. If you alter a graded exam and request a regrade we will automatically report it to the honor committee. Don't do it!

- ***You can improve an exam grade 2: Makeup exams*** -- Each midterm exam will be followed by a makeup exam on the Friday a week after the exam, in the late afternoon. If you miss a midterm, you must take the makeup. If you are unhappy with your grade on an exam, you may take the makeup. If you take both the original and makeup exams, your grade for that exam will be the average of the two grades (whether you do better or worse). In our experience, students who carefully consider their errors and understand what they did wrong on the first exam almost always improve. Students who don't do this and just "take another shot" and "study some more" are as likely to go down as to go up.

- ***Equation sheets on exams? No!*** -- Equation sheets will not be permitted on exams. This is NOT because we want you to memorize all the equations, but because if you focus on lots of equations you will miss making sense of the physics. We will expect you to know some equations -- but only a few; and they should make sense to you and be easy to remember. Exam problems will NOT be simple plug-and-chug applications of equation calculations but will require thinking and, on some questions, writing.

- ***Overall grades*** -- From past experience, we expect that an A will require about 800 points, a B will require about 700 ± 30 points and a C will require about 600 ± 30 points. Passing (not getting an F) will require about 500± 30 points. These grades reflect that the average points needed for a grade level on the homework and labs tend to be higher than on the exams. (The "±" ranges are not guaranteed but are standard deviations -- our best estimate for the range that the result will fall in 2 times out of 3.)

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- 131 Home
- Mechanics/Grading
- Homework
- Recitation/Labs

Schedule

You can find an overview of the readings for this class (plus readings I am not assigning) at: Working Content II

Notes: This schedule is tentative and subject to change. Reading Assignments are online; commentary in WebAssign is due 10 PM the evening prior to the lecture.

The content column links to slides from the PowerPoint presentation used in class. They will be posted either **just before or just after the class takes place**. Note that these slides only represent a skeleton of the presentation and do not include solutions to problems and questions posed, derivations, or representations of class discussions. If you miss a class, these notes do not suffice to fill you in on what happened! Be sure to check with someone who actually attended. The files are Adobe PDF files.

Date	Class	Reading	Content	Quiz
Week 1				
6/1	1	1. Introduction to the class 1.1 The disciplines: Physics, Biology, Chemistry, and Math 1.1.1 Science as making models 1.1.4 What Physics can do for Biologists 1.2 Thinking about Thinking and Knowing 1.2.1 The nature of scientific knowledge	Introduction to the class	
6/2	2		Modeling dimensions	
6/3	3		**NO LECTURE**	
6/4	4		Coordinates & vectors	
6/5	5		Rates of change; velocity	
Week 2				
6/8	6		Acceleration	
6/9	7		Intro to Newton's laws	**Quiz 1**
6/10	8		Newton 1 & 2	
6/11	9		Newton 3	

6/12	10	Tension & friction	
Week 3			
6/15	11	Viscosity & drag	
6/16	12	Gravity	**Quiz 2**
6/17	13	**EXAM 1**	
6/18	14	Electric forces	
6/19	15	Electric fields; momentum	
Week 4			
6/22	16	Random motion; diffusion	
6/23	17	Solids	**Quiz 3**
6/24	18	Fluids; kinetic theory	
6/25	19	Buoyancy; surface tension	
6/26	20	Fluid flow	
Week 5			
6/29	21	Work & energy	
6/30	22	**EXAM 2**	**Quiz 4**
7/1	23	Potential energy	
7/2	24	Chemical energy	
7/3	25	**No Lecture**	
Week 6			
7/6	26	Heat & Temperature	
7/7	27	First law of thermodynamics	**Quiz 5**
7/8	28	Second law of thermodynamics	
7/9	29	Protein stability	
7/10	30	**FINAL EXAM**	

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- Mechanics/Grading
- Schedule
- Homework

In our Physics for Future Biologists Labs you will

- learn physics relevant to microscopic and living systems;
- use 21st century physics tools and software;
- deal with data-rich environments; and
- learn how to design your own experiment and interpret data.

The laboratories are held in a community lab style that will allow you to work together in groups of 4 students on experiments. More information on the community lab style, including information on how the labs will be graded can be found at this LINK.

Attendance at every lab is required. If you anticipate missing a lab session, contact your TA as soon as you are aware of your impending absence. Only those with a VALID WRITTEN EXCUSE for missing a lab will be allowed to do a makeup activity at the end of the semester (that will take at least two hours and may involve doing another lab or evaluating data). If you do not have a valid written excuse, you will get a zero for the week that you missed. You may make up a maximum of one excused absence. If you miss more than two lab sessions, you may receive an incomplete or a failing grade for the entire class.

Laboratories will cover 6 experiments, five of them lasting 2 periods, one lasting 1 period. At the end of each experiment you will work in the lab to finish a laboratory report and present your findings (and ideas for followup experiments) to the other laboratory working groups.

There will be pre-readings for some laboratories that you will be able to access through webassign just like the regular readings.

The **recitation sections** will be group problem solving. Typically, you will work through an extended multi-part problem often with a biological context.

Week of	Recitation	Lab Topic	Pre-Lab Reading
6/1	• How big is a worm?	Introduction to community lab style	Introduction to Community Lab Style ImageJ Download Instructions for Students
	• The cat and the antelope	Lab 1: Quantifying motion from images and videos. Part 1: How do you quantify motion?	ImageJ Download Instructions for Students (if you didn't do it already) Data Analysis with Excel Excel Quick Reference
	• Thinking about forces	Lab 1: Quantifying motion from images and	**ImageJ Intro Pre-Reading** (RA L1.2 on WebAssign)

6/8	for objects and systems	videos. Part 2: Can you learn biology from physical measurements?	ImageJ Quick Reference Sheet Technical Document Intro To ImageJ
	• The DNA spring	Lab 2: Inferring force characteristics from motion analysis	Technical Intro to Video Capture
6/15	• Propelling a paramecium	Lab 2: Inferring force characteristics from motion analysis: Error propagation	> **Technical Intro to Error Propagation** (RA L2.2 on WebAssign)
	1. Electrical forces 2. Hydrogen bonding	Lab 3a: Observing Brownian motion	Tec Doc: Microscope Basics Quick Ref.: Video Capture Tec Doc: Histograms in Excel Tec Doc: ImageJ Autotracking
6/22	Electrophoresis	Lab 3b: Observing Brownian motion	Coherent vs random motion (2013) Diffusion and random walks (2013) The role of randomness: Biological implications (2013)
	1. Cell polarization & activation 2. Signal relay	Lab 3c: Exploring the diffusion constant	
6/29	1. Gas properties 2. Pressure recitation	Lab 4: Competition between Brownian motion and directed forces	**Log-log Plots** Powers and Exponents
	1. Hold the mayo 2. Estimating capillaries	Lab 4: Competition between Brownian motion and directed forces	**Log-log Plots: Why do we like them**
7/6	• Energy skate park	Lab 5: Motion & work in living systems	**Please watch this video in preparation for lab**
	• Protein stability	Lab 5: Motion & work in living systems	**Please watch this video in preparation for lab** (if you didn't already)

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