

Physics 331 Physics for Biologists I

Fall 2018 edition...

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- E-mail: arappapo@umd.edu (best way to contact me)

Description and Prerequisites

This course is intended for biology majors and pre-health care professionals. The physics topics are very similar to those used in the version of the course taught at College Park. However, aspects will be added that tie these topics to the physics at the cellular and molecular level where thermal energy is dominant. 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)

Please talk to me if you have any concerns about prerequisites or anything else

This is not your parents' physics! This class will focus on the physics relevant to living things. We 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.

What do I need to buy?

An online WikiBook was developed that you will be able to read for free. However, the most important readings and problems are found in **the 6th edition of the textbook: Physics by Giancoli**. Yes this is an older edition but it will do just fine and costs much less. Lots of used copies are available for purchase on line. The answers to most of the problems in this book are available on-line:

<http://www.slader.com/textbook/9780130606204-giancoli-physics-principles-with-applications-6th-edition/>

These are good learning tools.

There is no lab manual to buy. The lab instructions will be made available online.

What else do I need to get?

A lot of what we'll be doing this term will be on the computer. The readings are accessible through links on this site. You will also need access to a spreadsheet, and you will learn to download and use a video analysis program in labs. You need:

- **Access to a computer** -- if you have your own laptop or desktop 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. You will be invited to share a folder on BOX with the professor. You will hand in assignments either as hard copies or as files in BOX.
- **A Spreadsheet** – Please use Excel to do calculations and graphs. For submission please save the files as an Excel 2010 or earlier version. 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://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 but please read carefully [the course details page](#).

- **Do the reading *before* each lecture and selected labs!** – The on-line reading material is closely aligned with the topics and depth of knowledge expected of you in this course. The readings from the Giancoli textbook are very helpful in clarifying the concepts and applying the knowledge to problem situations. 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 period there will only be a small amount of actual lecturing. Most of the time will be spent on answering questions, doing group problem solving, and holding class discussions. By actively applying what you learned in the readings to problems during the lecture time and recitation and in labs you will gain true ownership of the science...you will be able to use it. 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 or on your own. You are encouraged to work with others. **But be careful!** If you work together, DO NOT create a common solution and have 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. If 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 [the course details page](#).

Times and Places

Event		Location
Lecture	TuTh 9:30-10:45	Bldg III Rm 2206
Recitation	Friday 1:00-5:00	Bldg I Rm 217
Laboratory	Friday 1:00-5:00	Bldg II Rm 4012

Professor Office Hours: Friday 9:00-10AM and noon-1:00 PM in adjunct office

Instructors

Instructors	Name	Room	Email
Professor	Aaron Rappaport	Bldg II Adjunct office	arappapo@umd.edu
uTA	Joe Amrine		mailto:kamrine@terpmail.umd.edu
uTA	Abigail Salazar		asalaza1@terpmail.umd.edu
uTA	Cameron Wilcox		mailto:cjwilcox@terpmail.umd.edu

Know the policies of the University:

<http://www.ugst.umd.edu/courserelatedpolicies.html>

These include policies on academic integrity, missed assignments, accessibility, discrimination, absences etc.

Academic Integrity

It is especially important that you read the section of the link above that cover academic integrity, because in my experience, when cheating starts, learning ends. In particular, while we encourage working with other students on homework and lab reports, your final output must be your own, and not a verbatim or near-verbatim replica of someone else's answer. This also applies to answers from online sources such as Chegg and CourseHero. Note as well that the correctness of the answers on these sites is often suspect.

The professor and uTAs reserve the right to require that any personal items, including but not limited to cell phones and wrist watches, be inaccessible to students during exams. Please see the professor if you require an exemption from this policy.

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[Web Accessibility](#)

Course Details

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. The information below is tentative and will likely change as adjustments are made to meet your needs.

Readings

There are on-line readings in this class and there is a textbook: Physics 6th edition by Giancoli. 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. Before each class you must do the readings and think about the concepts. Here are your pre-lecture tasks: [Schedule](#)

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 raise. Individual students will be asked to express their understanding of some aspect of the readings done to prepare for class. The rest of the class will be group problem solving, demonstrations and discussions, and other activities. New ideas will be introduced from time to time as the course is improved to better address the physics relevant to living systems. Your participation in class is a significant part of your final grade so don't be shy and make sure you are prepared for each class (i.e. you did the readings AND have given them serious thought).

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 questions there will be weekly homework assignments.

You will be asked to do 3-5 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. Each problem solution should include at its beginning a brief written plan of how you go about solving the problem, followed by your solution itself. The completed problems must be deposited in your Box folder by 9 AM Sunday morning.

Homework and in-class problem solving is where most of the learning in this class gets done! Do a careful and complete job. If you have difficulty, take advantage of the office hours Friday morning.

Exams

We will have two midterm 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**. The final exam will be approximately double in length and it will be cumulative (though it may emphasize the material covered after the second exam).

Although the final and two in-class exams are important, they total 36% of your grade. We want you to do your learning well before the exams so the exams are merely a way to verify that you have learned the lessons. If you rely on others to do the thinking for you, you will not do well in the course.

Laboratories

Due to the large size of the class, the class will be divided in two parts. The first half of the class will go to Bldg. III rm. 2215 for a recitation and lab prep session from 1-3 PM. The second half of the class will do the lab work in Bldg. II rm. 4012 between 1 and 3 PM. Then the two groups will switch locations and tasks working from 3–5 PM.

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 labs where you are told exactly what to do and expect to get a result that agrees with some theoretical prediction. Some labs will allow you to observe the phenomena we cover in the course while others require to think about experimental design in order to achieve a stated goal. Overall the aim is for you to experience physical phenomena in a controlled setting that includes real-world complexity but with procedures that allow information to be gathered while minimizing interferences. You need to be mentally engaged to get the most out of the experience, both learning and grades.

Often lab experiments will be carried out over more than one lab period 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 generally be done outside of lab and handed in at the beginning of class on Tuesday morning. For more details and for the lab handouts, go to [the Lab page](#).

Attendance at every lab is required. If you anticipate missing a lab session contact myself or a 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 two excused absences. **If you miss more than two weeks (have more than two 'zeros', i.e., if you miss more than two lab sessions), you may receive an incomplete or a failing grade for the entire class.**

Excuses

If you have a valid excuse for missing an exam, quiz, or homework, send an email to me 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.) You must contact me as a 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. There is no heavy weight on any one activity thus reducing stress and hopefully improving performance. Here is the breakdown.

- **Components --**

Homework	300
Midterm exams (100 pts each)	200
Final exam	200
Lab Reports	165
Lab/Recitation Participation	75
Lecture Participation	160
Total	1100

- **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.
 - Exams will be **open book/open notes**. You must bring a calculator but you may not use computers or cell phones. You should generate a summary of knowledge rather than try to go through your notes during an exam because time is limited.
 - Since the class is small, the professor will do all the grading. If you feel that your answer was misunderstood, you should see the professor for clarification. You may not get additional points but you will learn.
 - **Exams are not curved** - For exams, we do NOT grade on a curve. On most exams, >75% will be an A, >65% a B, >55% a C. **This means that someone else's doing well on an exam will never negatively affect your grade. If you all do extremely well on an exam (however unlikely that may be) we will give you all A's for that exam. The same consideration will likely apply for the final grades. Your final grade is an assessment of your degree of mastery of the course. My hope is that everyone will do well...but I'm an optimist.**

Schedule

(Also see separate Homework and Recitation/Lab schedules)

Notes:

- This schedule is subject to change.
- **RECITATIONS/LABS BEGIN September 2**
- Do your utmost not to miss a class. If you miss a class, get together with someone who attended and do your best to catch up!
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Date	Class	Reading (web pages)	Content/Giancoli Readings
<i>Week 1</i> Recitation: How big is a worm			Lab 0: Survey and Intro
T 8/28	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	Why are you here?/ Chapter 1
Th 8/30	2	2. Modeling with mathematics 2.1 Using math in science 2.1.1 How math in science is different from math in math 2.1.2 Measurement 2.1.3 Dimensions and units 2.1.3.1 Complex dimensions and dimensional analysis 2.1.3.2 Changing units 2.1.4 Estimation 2.1.4.1 Useful numbers	Modeling, dimensions/ Chapter 1
<i>Week 2</i> Recitation: Cat and Antelope			Lab 1: Quantifying motion from Images and Videos
T 9/4	3	I-1 Interlude 1: The Main Question: How do things move? 3 Kinematics: Where and When? 3.1.1 Coordinates 3.1.2 Vectors 3.1.3 Time 3.1.4 Kinematics Graphs	Coordinates and vectors/ 2-1 to 2-4; 3-1 to 3-4
Th 9/6	4	2.2.5 Values, change, and rates of change 2.2.5.1 Derivatives	Rates of change & velocity/ 2-1 to 2-6

Date	Class	Reading (web pages)	Content/Giancoli Readings
		2.2.5.1.1 What is a derivative, anyway?	
		3.2 Kinematic Variables	
		3.2.1 Velocity	
		3.2.1.1 Average velocity	
		3.2.1.2 Instantaneous velocity	
		3.2.1.3 Calculating with average velocity	
Week 3	Recitation: Thinking about forces for objects and systems		Lab 1: Quantifying motion from Images and Videos
		3.2.2 Acceleration	
T 9/11	5	3.2.2.1 Average acceleration	Acceleration/ 2-4 to 2-8
		3.2.2.2 Instantaneous acceleration	
		3.2.2.3 Calculating with constant acceleration	
		4.1.1 Physical content of Newton's Laws	
		4.1.1.1 Object egotism	
		4.1.1.2 Inertia	
		4.1.1.3 Interactions	
		4.1.1.4 Superposition	
		4.1.1.5 Mass	
		4.1.1.6 Reciprocity	
Th 9/13	6		Intro to Newton's Laws
		4.1.2 Formulation of Newton's Laws as foothold principles	
		4.1.2.1 Quantifying impulse and force	
		4.1.2.2 Newton's 0th Law	
		4.1.2.2.1 Free-body diagrams	
		4.1.2.2.2 System Schema Introduction	
Week 4	Recitation: The spring constant of DNA		Lab 2: Characterizing Motion in Liquids and Gases.
		4.1.2.3 Newton's 1st law	
		4.1.2.4 Newton's 2nd law	
		4.1.2.4.1 Reading the content in Newton's 2nd law	
T 9/18	7	4.1.2.4.2 Newton 2 as a stepping rule	Newton 1 and 2/ 4-1 to 4-7
		4.1.2.4.2.1 Newton 2 on a spreadsheet	
		4.1.2.5 Newton's 3rd law	
Th 9/20	8	4.1.2.5.1 Using system schemas for Newton's 3rd law	Newton 3/ 4-8 to 4-9

Date	Class	Reading (web pages)	Content/Giancoli Readings
		4.2 Kinds of Forces 4.2.1 Springs 4.2.1.1 Realistic springs 4.2.1.2 Normal forces 4.2.1.2.1 A simple model of solid matter	
<i>Week 5</i>	Recitation:	Motion of a paramecium	Lab 2: Characterizing Motion in Liquids and Gases.
T 9/25	9	4.2.1.3 Tension forces 4.2.2 Resistive forces 4.2.2.1 Friction	Tension and friction/ 4-8
Th 9/27	10	4.2.2.2 Viscosity 4.2.2.3 Drag Viscosity, a biological perspective	Viscosity and drag/ 10-11,
<i>Week 6</i>	Recitation:	Electrostatic force and Hydrogen bonds	Lab 3: Observing Brownian motion
T 10/2	11	4.2.3 Gravitational forces 4.2.3.1 Flat-earth gravity 4.2.3.1.1 Free-fall in flat-earth gravity 4.2.3.3 The gravitational field	Gravity/ 4-6
Th 10/4	12	MIDTERM 1 (on lectures 1-10) BLDG II rm 2032	
<i>Week 7</i>	Recitation:	Electrophoresis	Lab 3: Observing Brownian motion
T 10/9	13	4.2.4 Electric forces 4.2.4.1 Charge and the structure of matter 4.2.4.2 Polarization	
Th 10/11	14	3.1.2.1 Adding Vectors 3.1.2.1.1 Example: vector addition 3.1.2.1.2 Example: vector subtraction	Electric forces/ 16-1 to 16-6
		4.2.4.3 Coulomb's law 4.2.4.3.1 Coulomb's law -- vector character 4.2.4.3.2 Reading the content in Coulomb's law	
<i>Week 8</i>	Recitation:	Diffusion in cells	Lab 4: Diffusion of dye and cytochrome c
T 10/16	15	4.2.4.4 The Electric field	Electric field/ 16-7 Momentum/ 7-1 to 7-5

Date	Class	Reading (web pages)	Content/Giancoli Readings
Th 10/18	16	4.3 Coherent vs. random motion 4.3.1 Linear momentum 4.3.1.1 Restating Newton's 2nd law: momentum 4.3.1.2 Momentum conservation 4.3.2 The role of randomness: Biological implications 4.3.3 Diffusion and random walks 4.3.3.1 Fick's law 3.1.2.3 The gradient: a vector derivative	Random motion and diffusion/ 13-14 <u>random motion, diffusion and General Flux Equation</u>
<i>Week 9</i>		Recitation: Gas properties and pressure	Lab 4: The competition between Brownian motion and directed forces
T 10/23	17	5. Macro models of matter 5.1.1 Density-solids 5.1.2 Young's modulus 5.1.6 Soft matter 5.1.6.1 Mechanical properties of cells 5.2 Fluids 5.2.1 Pressure	Solids/ 9-5, 10-1 to 10-6; 13-7 to 13-9
Th 10/25	18	I-2: Interlude 2: The Micro to Macro Connection 7.1 Kinetic theory: the ideal gas law	Fluids and kinetic theory/ 13-7 to 13-11
<i>Week 10</i>		Recitation: Fluid flow	Lab 4: The competition between Brownian motion and directed forces
T 10/30	19	5.2.2 Archimedes' Principle 5.2.3 Buoyancy 5.2.5.2.1 Surface tension	Buoyancy and surface tension/ 10-7, 10-13
Th 11/1	20	5.2.6 Fluid flow 5.2.6.1 Quantifying fluid flow 5.2.6.2 The continuity equation 5.2.6.3 Internal flow -- the HP equation	Fluid flow/ 10-8, 10-9, 10-12

Date	Class	Reading (web pages)	Content/Giancoli Readings
Week 11	Recitation: Energy skate park		
	<ul style="list-style-type: none"> • Estimating capillaries • Hold the mayo 		Lab 5: Motion and Work in living systems
T 11/6	21	6. Energy: The Quantity of Motion 6.1 Kinetic energy and the work-energy theorem 6.1.1 Reading the content in the Work-Energy theorem	Work and energy/ 6-1 to 6-3
Th 11/8	22	MIDTERM 2 (cumulative, focusing on lectures 11-20) BLDG II rm 2032	
Week 12	Recitation: Protein stability		
		6.2 Energy of place -- potential energy 6.2.1 Gravitational potential energy 6.2.2 Spring potential energy 6.2.3 Electric potential energy	Lab 5: Motion and Work in living systems Potential energy/ 6-4
T 11/13	23		
		6.3 The conservation of mechanical energy 6.3.1 Interpreting mechanical energy graphs 6.3.2 Mechanical energy loss -- thermal energy	Conservation of energy/ 6-5 to 6-7
Th 11/15	24		
		6.3.3 Forces from potential energy	
Week 13	No Recitation		No Lab
		6.4.1 Energy at the sub-molecular level 6.4.2 Atomic and Molecular forces 6.4.2.1 Interatomic forces 6.4.2.2 Chemical bonding	Chemical energy/ 29-1 to 29-3
T 11/20	25		
Week 14	Recitation: Temperature regulation		
		5.3 Heat and temperature 5.3.2 Thermal properties of matter 5.3.2.1 Thermal energy and specific heat 5.3.2.2 Heat capacity 5.3.2.3 Heat transfer	Lab: Makeup Lab and survey Heat and temperature/ 13-1 to 13-4, 14
T 11/27	26		

Date	Class	Reading (web pages)	Content/Giancoli Readings
Th 11/29	27	7. Thermodynamics and Statistical Physics 7.2 The 1st law of thermodynamics	The 1st law of thermodynamics
Week 15			
T 12/4	28	7.3 The 2nd Law of Thermodynamics 7.3.1 The 2nd Law of Thermodynamics: A Probabilistic Law 7.3.2 Implications of the Second Law of Thermodynamics	The 2nd law of thermodynamics
Th 12/6	29	No new reading TBA	Review
<i>Final Exam</i> Web Accessibility			

Homework

Homework assignments are worth 27% of your final grade. More importantly, they are the BEST way of gain ownership of the course content and a great preparation for exams. Therefore, please take homework assignments very seriously. You may work on these with other students but don't cheat yourself out of the learning experience by letting someone else do the thinking for you!

Each problem solution will consist of two parts.

Part 1: You will describe in outline form **how you plan do the problem**. It must be concise, clearly presented, and easily read. If your handwriting is poor then type the information.

Stage 2: **Due Sunday by 9 AM**.... You will submit the completed problems in your Box folder as a single pdf file. (no jpegs or other image files) On occasion, the problem will need to be submitted as an Excel file. These will be graded and returned to your Box folded. This grading will be out of 50 points.

An exception to this process is that the final homework is due completed on 12/6.

Late assignments, without a valid reason, will not be accepted. (I will make an exception for HW 01 because some students will have difficulty submitting into the Box files)

You are encouraged to work on these problems with others in the class but you have to write up your solutions independently. **Be careful:** If two or more submitted answers are essentially identical, neither will receive credit.

Please submit assignments with the following filename: your name HW# ...i.e. SmithHW1

Stage 1 due date

- | | |
|--------|---|
| HW 01 | 1. Feeding the Cougar |
| (9/9) | 2. How big is a protein molecule? |
| | 3. The Poison is in the Dose (Paracelsus) |
| | 4. Your bacterial component |
| HW 02 | 1. Moving a Vesicle |
| (9/16) | 2. Testing the Motion Detector |
| | 3. A mouse and her nest |
| | 4. Changing the axis on the grand jété (Kinematic Graph reading is helpful) |

Stage 1 due date

- HW 03**
(9/23)
1. [The farmer and the donkey](#)
 2. [Pushing two boxes](#)
 3. [Freefall acceleration](#)
 4. [When does N3 hold?](#)
 5. [Making up a lap](#)
- HW 04**
(9/30)
1. [Virus in the cylinder](#)
 2. [Molly on the skateboard](#)
 3. [The book and the wall](#)
 4. [Air resistance 1: Dimensional analysis](#)
 5. [Crawling amoebas](#)
- HW 05**
(10/14)
1. [The flying squirrel and the water flea](#)
 2. [Comparing a light and a heavy object](#)
 3. [Mass of a Nitrogen Molecule](#)
 4. [Stopping a motorbike](#)
 1. [But it's just a leetle bit different](#)
- HW 06**
(10/21)
2. [Forces between charges](#)
 3. [The Millikan oil drop experiment](#)
 4. [Hydration of Ions](#)
 1. [Molecular collisions 1](#)
- HW 07**
(10/28)
2. [Carts & Graphs](#)
 3. ~~Molecular Collisions 3~~—do not do this one
 4. [Diffusion and slime molds](#)
 5. [water and ion](#)
- HW 08**
(11/04)
1. [Diffusion across capillaries](#)
 2. [A two-molecule mix of gases](#)

Stage 1 due date

3. [Deflategate](#)
 4. [Floating fish](#)
 5. [Millimeters of mercury](#)
 1. [Blood flow and pressure](#)
- HW 09**
(11/18)
2. [Swim bladder](#)
 3. [Walking on water](#)
 4. [Fan carts \$p\$ & \$E\$](#)
 5. [Putting the pressure on the IV](#)
 1. [Electric PE problems](#)
- HW 10**
(12/02)
2. [The bungee jumper](#)
 3. [Skateboarder graphs](#)
 4. [Molecular interactions](#)
 5. [Energy in photosynthesis - a toy model](#)
 1. [The Gauss gun](#)
- HW 11**
(12/06)
2. [Chemical reaction energies](#)
 3. [Heating water in a copper pot](#)
 4. [Microscopics of ankle sprain](#)
 5. [Energy in photosynthesis - light and dark reactions](#)
- Note:** On Thursday,
not Sunday

[Web Accessibility](#)

Recitations/Labs

In recitations, you will:

- work through an extended multi-part problem often with a biological context
- work in groups as assigned
- be applying the principles you read in the class readings and lecture

In the labs, you will:

- learn physics relevant to microscopic and living systems
- learn to use some useful tools and software
- deal with data-rich environments
- 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 on experiments. The instructions on report preparation are at this link: [Lab Reports](#)

Laboratories will cover 5 experiments, four of them lasting 2 weeks, one lasting 3 weeks. At the end of each experiment you will work in the lab to finish a laboratory report and present your findings (and ideas for follow up experiments) to the other laboratory working groups. There will be some changes in the lab exercises and you will be notified of these as the semester progresses.

There will be pre-readings for some laboratories. Please make sure to come to lab prepared so that you can make the most of the lab experience.

The **recitation sections** will be group problem solving. Typically, you will work through an extended multi-part problem, often with a biological context. The TAs will help you but will not tell you exactly how to solve the problems set before you!

Attendance at every lab is required. If you anticipate missing a lab session contact me 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 two excused absences. **If you miss more than two weeks (have more than two 'zeros', i.e., if you miss more than two lab sessions), you may receive an incomplete or a failing grade for the entire class.**

Date	Recitation	Lab Topic	Pre-Lab Reading
9/1	How big is a worm?	Introduction to the Labs Diffusion of Biological Molecules	Introduction to the Labs Diffusion of Biological Molecules ImageJ Download Instructions for Students
9/8	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)

Date	Recitation	Lab Topic	Pre-Lab Reading
9/15	<u>Thinking about forces for objects and systems</u>	<u>Lab 1: Quantifying motion from Images and Videos</u> <u>Part 2: Can you learn biology from physical measurements?</u>	<u>Data Analysis with Excel</u> <u>Excel Quick Reference</u> <u>ImageJ Intro Pre-Reading</u> <u>ImageJ Quick Reference Sheet</u> <u>Technical Document Intro To ImageJ</u>
9/22	<u>The DNA Spring</u>	<u>Lab 2: Characterizing Motion in Liquids and Gases.</u>	<u>Technical Intro to Video Capture</u>
9/29	<u>Propelling a Paramecium</u>	<u>Lab 2: Characterizing motion in Liquids and Gases</u>	<u>Technical Intro to Error Propagation</u>
10/6	<u>Electrical Forces Hydrogen Bonding</u>	<u>Lab 3a: Observing Brownian Motion</u>	<u>Tec Doc: Microscope Basics</u> <u>Quick Ref.: Video Capture</u> <u>Tec Doc: Histograms in Excel</u> <u>Tec Doc: ImageJ Autotracking</u> <u>Coherent vs random motion (2013)</u> <u>Diffusion and random walks (2013)</u>
10/13	<u>Electrophoresis</u>	<u>Lab 3b: Observing Brownian motion</u>	<u>The role of randomness: Biological implications (2013)</u>
10/20	<u>Cell Polarization and Activation Signal Relay</u>	Lab 4: <u>Diffusion of dye and cytochrome c</u>	
10/27	<u>Gas Properties Pressure Recitation</u>	<u>Lab 5: Bacterial Motion and Chemotaxis</u>	<u>Log-log Plots</u> <u>Powers and Exponents</u>
11/3	<u>Hold the Mayo Estimating Capillaries</u>	<u>Lab 6: Motion and Work in living systems</u>	<u>Please watch this video in preparation for lab</u>
11/10	<u>Energy Skate Park</u>	<u>Lab 6: Motion and Work in living systems</u>	<u>Please watch this video in preparation for lab</u> (if you didn't already)
11/17	<u>Protein Stability Additional Problems</u>	Recitation location BLDG I rooms 206 217	
12/1	<u>Temperature Regulation</u>	Recitation location BLDG II room 2062	



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