Physics 202 Dr. Edward J. Brash
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Office Hours: TR 2:00pm-3:00pm, F 11:00am-noon, and at other times by appointment.

GENERAL PHYSICS II

Textbook: *University Physics – Volume 2 – Chapters 5-16,* OpenStax
http://www.cnx.org/

Goals:

To learn the fundamental principles and theories of electromagnetism and electromagnetic phenomena.
To apply these fundamental principles and theories to solve problems.
To gain a broad understanding and appreciation of the intellectual activity that characterizes the history of physics.

Physics Topics: Electric Charges and Fields, Gauss's Law, Electric Potential, Capacitance, Current and Resistance, Direct-Current Circuits, Magnetic Forces and Fields, Electromagnetic Induction, Inductance, Alternating-Current Circuits, Electromagnetic Waves

INW Course Objectives:

This class is a lecture course that is certified to fulfill part of the Investigating the Natural World (INW) requirement in the Liberal Learning Curriculum. The learning objectives for INW lecture courses are:

Identify the methods of inquiry that lead to scientific knowledge.

We will be discussing the historical development of many of the concepts that will be presented allowing you to observe how these principles were elucidated.

Distinguish science from pseudo-science.

All scientific theories must make predictions and those predictions must be verified by experiment. We will touch upon some non-theories which were presented as explanations for observed effects.

Make predictions about natural phenomena using theories and models as unifying principles.

As we develop the theories to be presented, we'll investigate the consequences of those theories and verify that the implied predictions are witnessed in nature.

Discriminate between association and causation and identify the types of evidence used to establish causation.

A mathematical formula only associates two phenomena, we will discuss the experiments that helped determine that one actually caused the other.

Homework: Assignments will typically be available on Thursday, and in most cases are due eight days later (Friday of the following week). The idea is that you spend the weekend working on the homework assignment, which covers the material just presented during that previous week, and then in the following two classes (on Tuesday and Thursday of the following week), you will have the opportunity to ask questions in class about the homework problems! Cool!!!

There will NOT be homework assignments due on some weeks – when there is a scheduled test, and during Spring Break week. Even cooler!!!

Homework will not be turned in but will instead be submitted via the ExpertTA web portal.

TO RECEIVE HOMEWORK CREDIT, YOU MUST SUBMIT YOUR ANSWERS VIA THE ExpertTA PORTAL.

Attendance: Attendance is mandatory and may be recorded at the beginning of each class. If you miss more than three classes in the semester, for ANY REASON, you will not be allowed to write the final exam and will receive a failing grade in the course.

Exams: Two hourly exams and a comprehensive final. See schedule below.

Grading:	Homework	25%
	Each hourly exam	20% x 2 = 40%
	Final exam	35%

Homework is due by MIDNIGHT on the due date. If you do not complete the web-based assignment by this time, the system will NOT allow you to submit the assignment. Normally, no extensions will be given, except with a valid documented excuse (typically medical reasons or other university sanctioned activities).

If you miss one of the hourly exams because of a valid, documented reason, the grade portion for that exam will be added to your final exam weighting. No make-up exams will be given under any circumstances.

The evaluation of your performance in this course will be based entirely on the regular homework assignments and scheduled exams. There is no possibility to do extra work for extra credit.

Final grades will be assigned as follows:

A = 87-100%; A^- = 80-86 %
B^+ = 77-79 %; B = 73 –77 %; B^- = 70 – 73 %
C^+ = 67-69%; C = 63 -67 %; C^- = 60 – 63 %
D^+ = 57-59%; D = 53 –57 %; D^- = 50 – 53 %: F < 50%

Additional Information, provided by the CNU Administration, which you may find useful (and with which I happen to agree):

Disabilities:

In order for a student to receive an accommodation for a disability, that disability must be on record in the Office of Student Affairs, 3rd Floor, David Student Union (DSU). If you believe that you have a disability, please contact Dr. Kevin Hughes, Vice President of Student Affairs (594-7160) to discuss your needs. Dr. Hughes will provide you with the necessary documentation to give to your professors.

Students with documented disabilities are required to notify the instructor no later than the first day on which they require an accommodation (the first day of class is recommended), in private, if accommodation is needed. The instructor will provide students with disabilities with all reasonable accommodations, but students are not exempted from fulfilling the normal requirements of the course. Work completed before the student notifies the instructor of his/her disability may be counted toward the final grade at the sole discretion of the instructor.

Success:

I want you to succeed in this course and at Christopher Newport. I encourage you to come see me during office hours or to schedule an appointment to discuss course content or to answer questions you have. If I become concerned about your course performance, attendance, engagement, or well-being, I will speak with you first. I also may submit a referral through our Captains Care Program. The referral will be received by the Center for Academic Success as well as other departments when appropriate (Counseling Services, Office of Student Engagement). If you are an athlete, the Athletic Academic Support Coordinator will be notified. Someone will contact you to help determine what will help you succeed. Please remember that this is a means for me to support you and help foster your success at Christopher Newport.

Academic Support:

The Center for Academic Success offers free tutoring assistance for Christopher Newport students in several academic areas. Staff in the center offer individual assistance and/or workshops on various study strategies to help you perform your best in your courses. The center also houses the Alice F. Randall Writing Center. Writing consultants can help you at any stage of the writing process, from invention, to development of ideas, to polishing a final draft. The Center is not a proofreading service, but consultants can help you to recognize and find grammar and punctuation errors in your work as well as provide assistance with global tasks. Go as early in the writing process as you can, and go often!

You may visit the Center for Academic Success to request a tutor, meet with a writing consultant, pick up a schedule of workshops, or make an appointment to talk one-on-one with a University Fellow for Student Success. The Center is located in Christopher Newport Hall, first floor, room 123.

Schedule (subject to change!)

Week	OpenStax	HW Due	Comments
01/07/19	Ch 5		
01/14/19	Ch 6	01/18/19	
01/21/19	Ch 7	01/25/19	
01/28/19	Ch 8	02/01/19	
02/04/19	Ch 8/9		Test 1 – Thurs. 02/07 – covers Ch. 5, 6, and 7
02/11/19	Ch 9/10	02/15/19	
02/18/19	Ch 10/11	02/22/19	
02/25/19	Ch 11/12	03/01/19	
03/04/19			Spring Break – no classes!!
03/11/19	Ch 12	03/15/19	
03/18/19	Ch 13		Test 2 – Thurs. 03/21 - covers Ch. 8,9,10,and 11.
03/25/19	Ch 14	03/29/19	
04/01/19	Ch 15	04/05/19	
04/08/19	Ch 15/16	04/12/19	
04/15/19	Ch 16	04/19/19	

How to Succeed in First-Year Physics

Posted on August 7, 2010 by Med School Odyssey

I've been meaning to post some advice for succeeding in that first year of physics that everyone has to take. Before I weigh in on that, I want to highlight two reasons why I think that the two mandatory semesters of physics are such an important part of the pre-med curriculum.

More than any other subject, physics stresses problem solving and analytical reasoning. A common refrain among students in freshman physics is "Once the problem is set up, I can always get the right answer". Yes, once all the problem solving has been done, most people can crank through the algebra with relative ease. But, that's the point – setting the problem up is what you're actually supposed to be learning.

Another standard complaint is that physics isn't relevant to biology or any of the other material that pre-med students are required to study. My perspective is rather unique, in that I studied physics for four years before taking all the rest of the prerequisites. I can tell you unequivocally that virtually all of the topics covered in the two-semester physics sequence will appear later in biology and both organic and inorganic chemistry. I could give scores of examples but I don't have the space to really do it justice – you'll just have to trust me. If you take the time to really understand the physics concepts you encounter, it will pay dividends in your future classes.

Now I want to quickly go over what you can expect in your physics course. Understand that your mileage will seriously vary, depending upon the course and professor you have. For the sake of generality, I'm going to assume you're taking a calculus based course. My personal recommendation is to take that particular variant if possible, primarily since it tends to be more rigorous and usually has the better teachers in the department. Please understand that I'm not trying to scare anyone – your sequence might be easy (mine was not). But a professor that dumbs everything down or teaches at a low level isn't doing you any favors. If you have a hard professor, that's good; you'll be counting your blessings come time to study for the MCAT.

First-year physics is really a survey – in two semesters, you'll see all of the major parts of classical physics. Some courses include modern physics (quantum mechanics, relativity, etc.), but most don't. That's a lot of material. In fact, a 4-year physics degree is largely just a repetition of the first-year again and again at a deeper level with a lot more math. I'm going to give a quick overview of each topic and offer some comments as to which ones students tend to have the most difficulty with. I'm also trying to preserve the order in which these tend to be introduced.

First-Semester:

Vectors. Incredibly important topic that most students never get a solid handle on. This comes back to haunt them later in a bunch of areas, notably during the second-semester when you start covering electromagnetics and you really start working with the concept of vector fields. Learn this subject well and get used to writing things explicitly as vectors (yes, that means all the little unit vectors). If you're sloppy with your vector notation, you'll get shelled when you start computing scalar and vector products.

Linear and projectile motion. This is where you'll start seeing kinematic equations. It's all pretty easy, but students complicate things immensely because they try to memorize all those kinematic equations and think that physics is nothing more than a bunch of equations – don't try memorizing, even though everyone else does. Focus on understanding what they are and where they come from. Having a clear understanding of basic calculus makes this stuff a breeze, once you realize that position, velocity, and acceleration are all related.

Newton's laws and particle dynamics. These are important and really form the foundation for most of what you're going to cover this semester. It's also the first place where students start suffering from a poor understanding of vectors. The fact that an object moving at a constant speed can still be accelerating typically leaves students in an intellectual quagmire that takes them a long time to escape from. It's here, with all those forces acting on a particle, that you'll really start to learn this mantra: the picture solves the problem. More on this later.

Work and energy. These topics are almost always introduced after particle dynamics because they allow you to shortcut all that vector algebra you were doing previously. The concept of energy actually forms the backbone of nearly all the physics seen in upper division courses as well as organic chemistry and biology. In fact, I would argue that it's probably the most important topic in physics. The algebra tends to be really easy – work lots of problems here until you feel really confident with this stuff because you'll see it in every course you take, in one form or another.

Linear momentum. Pretty easy topic, as long as you really understand vectors. Usually, you'll revisit Newton's 2nd law here and talk about how F = ma isn't really accurate and that forces acting on a body are equal to the time derivative of it's linear momentum. You'll generalize the 2nd law here and your professor will warn everyone that they need to understand everything really well because otherwise torque and angular momentum will be impossible. Few will listen.

Torque and angular momentum. These are probably the hardest topics you'll see this semester and the exam over this material historically has the lowest average of the semester. There are two reasons for this. First, torque and angular momentum are the angular analogues of all that you've done up to this point. Torques are the angular analogues to forces and angular momentum is obviously the angular analogue to linear momentum. Here's the rub: many students don't really understand the first half of the semester too well and usually realize their deficiency here. Second, vectors (noticing a pattern here?) – if you don't really understand vectors and have just been trying to keep track of them in your head, you'll get lost here. Angular momentum comes back for seconds next semester when you start talking about charged particles in magnetic fields and all sorts of bizarre stuff starts happening – understand it well, because you'll see it again next semester.

Gravitation and Kepler's laws. You may or may not see Kepler's laws, but you'll most definitely see gravitation at some point and you'll integrate Newton's laws with angular momentum to start looking at planetary motion and things of that nature. It sounds hard, but it really isn't – for the most part, if you understood those topics the first time, this is just a review and a novel way of applying them. This is usually a nice relaxing time after the nightmare of angular momentum that tends to punish a lot of people (about 75 people dropped out of my class after that exam). If you've made it this far, enjoy the rest – assuming you've done the work up until now, it's relatively easy until the end of the semester.

Fluid mechanics. Fluids are an interesting subject. They're either incredibly easy or incredibly hard – I'm talking hard and something you win a $1,000,000 prize for if you figure out. For this class, everything is easy – fluids are largely just a rehash of dynamics from earlier in the semester. Interestingly, this is also the second place you'll actually use integrals, the first being determination of centers of mass and moments of inertia. It's pretty assuming your doing the homework – regardless of the subject, you need to be working problems religiously.

Simple harmonic motion. To the physicist, this is a subject of huge importance since virtually everything can be approximated as a simple harmonic oscillator. Sadly, it's also one of the more mathematical parts of the course because you'll start learning about damped oscillators and needing to determine the type of damping based upon the form of the equation of motion or of a plot. Don't try to memorize things here – focus on understanding the idea of periodicity and determining the period given a particular set of forces and initial conditions.

Thermodynamics. You'll likely see the ideal gas law here for the first time, though it'll most likely be a review for you if you've already taken chemistry. Kinetic theory isn't typically introduced here but you'll revisit work and energy again and relate them to things like heat engines and pistons doing work. This is another area that is usually tested conceptually to see if students really understand what's happening.

Feels like a lot, eh? It is. Now let's see what's waiting for us after Christmas break:

- **Electrostatics**. First thing you'll encounter is Coulomb's law, which relates the forces between charges. Hopefully you'll realize how similar it is to Newton's law of gravitation and life will be a lot simpler for you. Draw pictures here, particularly when finding the electric field at a point given a set of charges or a charge distribution. Pretty much the only way to get confused here is if you don't really understand vectors. You'll also start seeing how action potentials in the cell are created here.
- **Electric potential, energy, and capacitance**. Make sure you understand the difference between potential (voltage) and potential energy. Mostly conceptual stuff here, though most people never really grasp the fact that capacitance is only a function of the geometry of the system.
- **Current and resistance**. You'll start seeing complicated looking resistor networks here and asked to find the net resistance, which is pretty easy as long as you can do some algebra. The hardest thing you'll be asked to do is find things like the current as a function of time when you throw a switch and start charging a capacitor. This basically amounts to solving a differential equation, but you've been solving the same kinds all year – separate the variables and integrate both sides, then plug in your initial conditions and you're done. Ohm's law and Kirchoff's laws are the primary tools you'll be working with. Learn them well.
- **Magnetism**. Initially, this is fairly simple, but it tends to throw people because magnetic fields don't act in the same way electric fields do and the vector nature of the field becomes extremely important (again, the vectors). About half the class gets blown out of the water when they start seeing charged particles moving in circles around magnetic field lines. When you add in E fields at the same time, all sorts of goofy things start happening and people pretty much think the professor is just making everything up. If you understood circular motion, vectors, and most of the stuff from first semester, you'll be set.
- **Magnetic induction**. Hands down, the hardest subject I've ever learned. I spent hours in my advisor's office having him explain Lenz's law to me and the idea of induction. Took me a long time, but I eventually got it. Strangely, most students don't have a hard time with this, but I certainly did – not really sure why, either.
- **AC circuits**. Remember Kirchoff's laws from earlier. The differential equations become a lot nastier here, so you'll learn a new mathematical tool called phasors to work with these types of problems. Some of the hooligans from the electrical engineering department will think they know everything here, but be completely lost because engineers use phasors in a different (and not altogether accurate) manner. If you don't understand these from lecture, don't try figuring them out yourself – just go to office hours and ask some questions until you do.
- **Maxwell's equations**. Depending upon how mathematical your professor is (mine was a theorist) he might take a class period and show you how,

using Gauss' Theorem and Stokes' Theorem, you can convert the four integral equations you've been working with into differential equations. When I took the class, I can't say that I really understood this section, but it was interesting. If you don't understand it all, don't sweat it – it's not something covered on the MCAT and it'll probably only be lightly tested on your exams. If your professor starts talking about curl and divergence, pay attention but don't get too worked up if you're a little lost after the lecture. It's nothing that a pint of ale won't solve. If you're planning to minor in physics, you'll you beat these ideas to death in your classical electrodynamics course.

- **Optics and light**. This is where you start to see some really cool things and you learn what light actually is. If you're professor doesn't take a few minutes to explain this, you should probably ask for your money back. This discussion usually comes as a corollary to the discussion about Maxwell's equations. Topics covered here are usually Snell's law and the lensmaker's equation, which is used to figure out magnifications and such. None of this is all that complicated, but some students have trouble learning the sign convention when talking about focal points and image distances. The key here is to work a lot of problems until you feel comfortable with the convention. Fermat's law is another topic that you'll see that is fairly simple and usually tested conceptually.
- **Quantum mechanics and relativity** (not always). If your professor includes a primer on quantum mechanics and relativity, it'll come at the end of the course. Quantum isn't really all that conceptually difficult (although mathematically, it can be incredibly abstract) – what's interesting is that it will explain the mysteries of where those *s, p, d,* and *f* things come from in chemistry. If you have a nice solid understanding of QM conceptually, you'll get a lot more out of your first semester chemistry course. Special relativity is a hard thing to understand conceptually because your intuition is completely wrong – don't worry too much about it, because you won't see it again, unless you decide to major or minor in physics. Neither general nor special relativity are MCAT topics but quantum is to some extent, since you'll see the results of it in your chemistry class. I've heard tell that MCAT writers like asking questions about the Bohr model of the hydrogen atom, so if you don't understand it from chemistry, make sure that you do.
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Don't feel overwhelmed. Everything will be introduced a little bit at a time and, as long as you work hard, you'll be fine. That said, here are some tactics that I've found to be incredibly helpful and will hopefully help you keep up with the course:

- Do the reading actively and do it before lecture. This means working the example problems on paper – don't just look at what was done in the book and believe that, since each step seems reasonable you must understand it. Of course its reasonable – it's worked correctly. What works well for me (and I still do this) is to try to solve the example problem without looking at their solution. Then, I'll compare what I did with what they did. If I did it the same way, I'll go back and figure out if I did each step for the right reason. Usually, I'm wrong, so I'll go back and make the book prove to me that their steps are correct and try to figure out why the steps I made were wrong. This is the correct way to use your solutions manual, if you have one (I used one for the first semester, but not the second).

- Go to lecture and listen actively. If your professor uses the scourge known as Powerpoint, follow what is being done and if you don't understand something, write it down in the margin and then ask your questions after lecture or at office hours.
- Start the homework the day that it is assigned and work on it every day. There is no substitution for struggling on the homework and it is expected you won't be able to complete it yourself, hence the office hours. Most physics courses are weighted heavily on homework scores (often 50% of the course grade). A lot of people tank the homework assignments because they figure they'll start on it the day before and wind up not being able to complete it. Start early and if you don't understand something, head for office hours.
- Don't cheat. My last year as a TA, we performed a little experiment – we figured a good portion of the freshman class (about 500 students from various departments) had a copy of the teacher's solutions manual. One of the problems which was assigned had been worked incorrectly in the manual, so we assigned that particular problem. A full 60% of the course had turned in the incorrect solution from the manual. You learn nothing by cheating on homework and homework is the primary way that you learn physics.
- Homework. This is highly dependent upon your professor – some professors don't assign homework at all, while many others have started using the online flavor. There is no way around the reality that, in order to really understand the physics concepts you're being exposed to, you have to struggle. I spent about 20 hours a week working on homework for my first-year physics course.
- Lectures will probably tend to skip a lot of steps during examples or derivations. At the university level, it is expected that you're able to fill in a few steps using some algebra – if professors showed every single step during their lectures, it would be prohibitive and slow them down too much. Take note of what they're saying and fill in the missing steps yourself afterward or ask during office hours.
- The picture solves the problem. If you can't figure something out, draw a picture. If that doesn't work, draw a better picture, a bigger picture, a pretty picture, whatever. This is mandatory for things like kinematics and dynamics. I can't tell you how many problems I've solved that I didn't' know how to do until I drew the picture and then realized that the solution was staring up at me from the page.
- Show your work and be neat. Most people have sloppy habits and don't show explicitly what they're doing on their paper. This is bad for a couple of reasons. First, on long problems that have a 3 or 4 page solution, you're going to wind up making an algebra error and getting lost trying to find it amidst all that chicken scratch on your paper. Buy a stack of engineering paper and use pencil. Don't cross things out, use an eraser. Second, if

you're skipping steps and you make a mistake, the grader won't be able to give you any partial credit. Over the course of a semester, this adds up. Doing things in your head doesn't show that you're smart – it shows that you're unwilling to listen to the legions of scientists that came before you and know the value of showing what you've done. The smartest physicist I've ever known shows virtually every step in the problem on his solutions.

- Resist the urge to put numbers into your equations. I'm not sure where this asinine habit comes from, but it's the source of no end of malice for students. If you're given a block with a mass of 45 kg dropped from a height of 40 m, and are asked to find the velocity at the ground, don't put those numbers into your equations until the very end. You lose a lot of information by doing that and will often fail to understand the concept that a particular problem is teaching because a lot of times, some of the quantities cancel out. In the example I just gave, the mass of the object cancels out of the final answer and you find out that the velocity of any object dropped from a height *h* will, neglecting air resistance, have a final velocity at the ground of the square root of *2gh*. Don't put any numbers in until the very end.
- Dimensional analysis. This is a huge thing for those taking the MCAT since a lot of times, you can eliminate wrong answers because the units don't work out. If a multiple choice problem asks for the final velocity of some widget, but two of the problems have units of acceleration, they can't be right.
- Learn to check yourself throughout your calculations. If you're trying to calculate velocity, but the right hand side of your expression has the wrong units, you've clearly made a mistake. You can also play the same game by imagining what happens at the extremities of your system…so, if you have a damped oscillator and it's amplitude, as you've written it, is increasing as a function of time, you did something wrong since it's amplitude ought to go to zero as time grows infinitely large. This is an incredibly powerful tool and is something that will serve you well all throughout your courses.
- A word on math. You'll need to be familiar with things like the power rule for integration and differentiation, but that's about it. You'll learn to solve a simple first-order differential equation early on in your first semester and probably repeat it over and over all year. If you're taking an algebra-based course, they'll just hand you the solution, but you probably won't really understand it. The biggest math problem people have (especially people that took AP courses and think that means something) is the algebra. Get used to solving systems of linear equations and manipulating equations to solve for one particular variable. The binomial expansion, completing the square, and trigonometry are far more germane to these classes and most students make lots of algebra errors that cost them huge on exams. It's rarely the calculus that's a problem, assuming you learned how to take derivatives and do basic integration.
- Vectors. I've mentioned it a bunch for good reason. Get really comfortable with vector addition (graphically and numerically), scalar products, vector products, and understand how to draw a right-handed coordinate system.

If you’re professor doesn’t talk about right-handed coordinate systems, ask them to, because they need to and it’s probably just something they didn’t think to include because it’s so ingrained in them that right-handed coordinate systems are the only kind there are.

Best of luck to anyone headed into these two courses. It’s a lot of work, but as long as you work hard, go to office hours, and keep up with it, it’s doable. I hope this helps.

Q:

I am a pre-med student and I recently BOMBED a physics exam. It was the most horrible feeling in the world because now I am not sure if I can get higher than a C in the class. Do you think it is still possible to get into med school with a C in a pre-req? Also, this test put me at my edge and now I am questioning whether or not I have what it takes to succeed in med school. Have you ever bombed an exam in your undergrad? If so, how do you recover academically and emotionally right after? thanks

Well you are at a critical moment, not just concerning medical school, but in life. I have been reading a book called The Art of Learning. In it, the author talks about how studies on kids in school reveals two mentalities. The first is that what you are good at and what you are bad at is determined by genetics and talent, i.e. physics isn’t a talent of yours. The second mentality is that what you are good and bad at is a reflection of the amount of preparation you put into it, i.e. you may have done better at physics had you prepared more, or in a different way. Which group of students do you think did better after failing a test? The second group.

My point is this: if you let one failure destroy your confidence then you will have a miserable life. Life is failure, but not in the bad sense. Think about it, how many times do babies fall before they walk? How many times does a musician mess up a note before they play it right? I recently read a case study where a doctor made an amazing diagnosis that baffled many others. How did he make it? Because he missed it before and cost a woman her life.

Your life will be littered with times you messed up, but if you don’t take anything away from the experience then you really have failed. Every error you make can lead to a learning moment. I have screwed up millions of times. I have even bombed a test or two in my day. To borrow a cheesy line from one of my favorite movie characters (Rocky): “it ain’t about how hard ya hit. It’s about how hard you can get it and keep moving forward. How much you can take and keep moving forward. That’s how winning is done.” Now you just need to get up and keep moving forward.

Is it possible to get into med school with a C? Sure. Is it common? No. But I don’t see why you can’t make this a defining moment in your life. Instead of hiding it, feature it. Write a personal statement about the time you faced failure and worked through it. As trivial as this may seem, you could correlate this to your medical school aspirations.

If you adopt a mentality that you can do anything with enough work, how could you not get into medical school? I used to say “I may be 50 before it happens, but I will be damned if I don’t become a doctor.” Luckily that wasn’t the case.

Good luck.