Physics 8 : Physics for Architects I

University of Pennsylvania — Fall 2019

- Up-to-date version of this page can be found at http://positron.hep.upenn.edu/physics8
- The web page for the other half of this course, Physics 9 (Physics for Architects II), is at http://positron.hep.upenn.edu/physics9

Contact info

Instructors

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I'm generally on campus 10am–6pm M–F, but this fall I plan to work from home most Tuesdays

with occasional guest lectures by
Richard Farley
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Teaching Assistant

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Handouts / PDFs

Homework PDFs, class notes, etc. can be found at
http://positron.hep.upenn.edu/physics8/files

Course policies

Why you are here

- If you are a student in Architecture or a related field, you may someday lead a team of engineers who will help you to fill in the details of your design. The more deeply you understand Newton's laws of physics and their applications, the more confident you can be that you are asking your engineers the right questions about your design.
- Whether you are a budding architect or are simply looking for a fun and informative way to fulfill the college's Physical World Sector requirement, Physics for Architects I will strengthen both your conceptual and your quantitative understanding of the physics of the everyday world that surrounds us.
- We spend the first two-thirds of the semester learning (or re-learning, for many of you) the key ideas of Newtonian mechanics: time, velocity, acceleration, mass (a.k.a. inertia), momentum, energy, force, torque, etc.
- If you took high-school physics, you will find that this course's unusual approach (following Eric Mazur's textbook) complements the approach taken by traditional textbooks. By studying (perhaps familiar) ideas from a different and more intuitive perspective, you will find much more meaning in the equations that you write down to solve a physics problem. Instead of "plug and chug," you will learn to express key ideas, such as "The energy of a closed system is constant" and "The momentum of an isolated system is constant." These statements are true because energy and momentum are conserved quantitites in nature. We will learn what all of that means, and much more. Physics is much more fun when you focus first on the ideas, and then on how those ideas are expressed in equations.
- After building up your understanding of forces, vectors, torque, and so on, we spend the last one-third of the semester seeing how those ideas inform the way we look at the many architectural structures that surround us in everyday life.
- We will see how forces, torques, and the decomposition of vectors into their Cartesian components allow us to analyze cables, trusses, beams, arches, and other structural patterns. We hope that by the end of the semester, you will never again pass a truss railroad bridge without pausing to imagine which members are in compression and which are in tension. We hope that your gaining lots of practice with these fun applications will be eye-opening and that they will bring the physics to life for you as you imagine the forces and torques that keep real-world structures standing.
- We deeply believe that learning physics should be fun and interesting, so we do everything we can to make this course fun, interesting, and stress-free. As with any acquired skill, learning physics takes some effort and practice, but the work for this course is paced out evenly such that most students enjoy doing it. And you will learn a lot!

Grading

The course grading policy is designed to motivate you to learn steadily week-by-week. The goal is to keep both stress and cramming to a minimum. Yes, you need to do the work, but the work should not be a source of stress.

- 50% : weekly homework (a.k.a. "problem sets")
- 20% : final exam (Thursday, December 12, 2019, noon—2pm)
- 10% : practice final exam due on Friday, December 6 (penultimate day of class)
- 10% : completing reading assignments with online feedback
- 5% : participation in collaborative exercises in class (work/discuss with your neighbors)
- 5% : in-class problems ("quizzes") worked on individually or in pairs (about once a week)
- To avoid penalizing people who need to miss a few classes for religious, family, or extracurricular events, the in-class total will be scaled so that a score of 80% or more receives full credit.
- In addition, you can earn up to 5% extra credit: There are a few optional chapters you can read for extra credit, and most homework assignments will include several extra-credit problems.
- A total score of 90% or more will earn you a letter grade no lower than A-minus. A total score of 80% or more will earn a letter grade no lower than B. If your total score is 99% or more (which is feasible if you do very well and also do some extra-credit homework problems or reading), you can earn an A+. Keep in mind that in past years, the median exam score was around 80%, while the median homework score was around 90%, so the final exam will reduce most people's total scores.
- I try my best to reward how much you learn and how diligently you work week-by-week, not how much you knew before you arrived, and not your ability to do well on timed exams.
- You can do very well in this course even if you generally find physics to be a challenging topic. Just keep up and do the work consistently each week. Take advantage of the opportunity to discuss physics week-by-week with us and with your fellow students.
- If you have found physics to be easy in the past, this course will deepen your understanding through problem solving, and by taking a conceptually different approach to familiar topics.

Homework

- This Equation Sheet [http://positron.hep.upenn.edu/p8/files/equations.pdf] may be helpful for the homework. I will continue to update it as the semester continues.
- There will be a homework assignment due at the start of class most Fridays, starting September 6.
- The homework problems should take you about 2 or 3 hours to complete.
  - If you find yourself spending more than a few hours on each homework assignment, you should:

    * form a study group with one or more of your classmates; and
    * come to the Wednesday/Thursday study sessions for help.
  - In fact you should do these two things in any case, because you will gain more from the course by discussing the homework problems with Bill, Greg, and your classmates.
- The homework is worth 50% of the course grade. You cannot pass the course without doing the homework. But the homework is fun! And I truly believe that the only way to develop a skill is through practice.
- See below for policy on late assignments.
- Working together on homework is strongly encouraged, but all work you turn in must be the result of your own thinking.
  - Figuring out problems together is a very good thing, but **simply copying other people's solutions is not acceptable, and constitutes academic dishonesty, which Penn takes very seriously.**
    * If you invest the time throughout the semester to give your own brain the benefit of working through the steps of each homework problem, you will have a much easier time preparing your own brain to take the final exam.
    * That's why I put so much weight on the weekly homework — because anything you cram into your brain just before an exam will be promptly forgotten just after the exam.
  - If you work through a problem together with a friend at the blackboard, that's great, but you should then both go and write up your own solutions separately (not just mindlessly copying line-by-line what you wrote on the board).
  - This works far better if you first try to work through each question on your own, then team up with a friend to trade ideas, then compare your solutions once you've both solved the problem.
  - In any case, two of the best ways to learn physics are by solving practice problems and by explaining physics to someone else. Working together on homework achieves both of these aims. Just be sure that your own brain is honestly solving each problem.
- Explain your reasoning in complete sentences — equations alone will not get full credit except in the simplest cases.
  - For instance, you might begin your solution by writing, "Because the system consisting of Cart A and Cart B is isolated, the sum of the two carts' momenta must be the same before and after the collision." Or you might begin another problem by writing, "Because joint J of the truss is in static equilibrium, the vector sum of the forces acting on J must equal zero." This demonstrates that you are thinking about what you are doing, rather than mindlessly writing down equations.
  - Writing out your reasoning in complete sentences also helps your mind to focus on the *physics*, rather than the equations. I want to deepen your understanding of the world that your future creations will occupy, not to train you to manipulate algebraic symbols.
- In lieu of the traditional discussion section or office hours, I have reserved classrooms at the following times so that you can work with Greg, with me, or with each other if

you wish:
  - Greg will be in **DRL 3C4 on Wednesdays from 4-6pm**, starting September 4.
  - Bill will be in **DRL 2C4 on Thursdays from 6-8pm**, starting September 5.
  - Even if you don't have questions, you can show up just to work with your classmates.
  - You're also welcome to contact me any time by email and to stop by my office any time the door is open. On MWF, any time after class is fine, but not before class. On Tu/Th, any time I'm around is fine. I am usually on campus approximately 10am to 6pm, but this semester I plan to work at home most Tuesdays (so you can still reach me, but I won't be on campus).

Late assignments

- It is important to us that you keep up with the course week-by-week.
  - Cramming doesn't produce good learning.
  - Your brain needs time to assimilate new knowledge.
  - Many topics in physics build upon one another.
  - If you fall behind, you will benefit much less from our class meeting time, and your classmates will miss out on opportunities to have informed discussion with you about the physics you are learning.
  - Cramming is stressful. Reading, discussing, and gradually assimilating can be quite enjoyable.
- We want to hand back graded work promptly so that you can learn from your mistakes before you forget what you were thinking when you made them.
- Therefore, late work will be given reduced credit as follows:
  - By "day" we mean class meeting day — Monday, Wednesday, or Friday.
  - 1 day late: 10% penalty
  - 2 days late: 20% penalty
  - a week or more late: 30% penalty
- We recognize that your life is busy, and does not revolve completely around physics. For that reason:
  - You can ask me once per term for an extension, as long as you contact me by email before the deadline. You can tell me the reason if you wish, but it is not necessary for you to do so.
  - To be fair to people who turn in the work on time, I will only waive the late penalty on one assignment per term.

Textbook

- We will use one textbook for the main "physics" part of this course (the first two-thirds of the semester), and another textbook for the "architectural applications" part of the course (roughly the last one-third of the semester).

- For the first part of the course, you will access the book electronically through Canvas, so there is no need to order a book in physical form. For the second part of the course, we will use an actual physical book — you can buy your own copy, or you can sign out one of my used copies (for a refundable deposit). I will provide details in class and on Canvas.
- Textbook reading will be mandatory. Usually you will read each chapter just before we begin the corresponding topic in class, and you'll answer some online questions before class to earn credit for doing the reading. Then, when we discuss an idea in class, you will not be seeing it for the first time. This will allow us to spend more of the classroom time working together to assimilate the ideas.

Work load

- You should expect to put in about 4–7 hours per week outside of class, in addition to attending the 3 weekly class meetings. A typical week will include
  - 1–2 hours on Sunday evening reading the textbook
  - 1–2 hours on Tuesday evening reading the textbook
    * Budget your reading time for each class: it is better to skim the entire reading assignment than to read only part of it.
  - 2–3 hours on weekly homework problems due on Fridays
    * It is probably best to think about each homework problem early in the week, so that you are prepared to discuss the more difficult problems with other students or the instructors in the evening study sessions. You can then finish up the assignment on Thursday evening.
- You will need to set aside time every week for both reading and problem-solving. But the work is spread out evenly, at a regular and predictable pace. As long as you know how to organize your time (an ability I'm sure you demonstrated in order to get into Penn), the workload for this course will not be a big burden for you. If you budget the necessary time week-by-week, you will do well in this course.
- Each week, you have to read, come to class, and solve homework problems. In exchange, you largely avoid the stress of cramming for exams.

Exams and quizzes

- We will have the usual two-hour final exam (20% course weight), but no midterm exams.
  - The final exam time is Thursday, December 12, at noon.
  - Most exam problems will closely resemble the weekly homework problems. So as long as you take the weekly homework seriously, the exam should not be a source of stress for you.
  - You can bring a 3x5 card of your own notes to the exam, which you will turn in with your exam. So there is no need to memorize, but you need to think about what will be most useful for you to write down for your own use.

- In addition, there will be a take-home "practice exam" (10% course weight) due on the penultimate day of class (Friday, December 6). This is basically a "final homework assignment" to help you to prepare for the final exam.
- Once the semester gets underway, we will also have **10-minute quizzes** (total of 5% course weight) about once a week (normally on Wednesday), at the start of class. These quizzes will typically be a repeat of a homework problem that has already been turned in, graded, and handed back to you.
  - The main idea of the quizzes is to give you an incentive to be sure that your homework reflects your own thinking, even in cases where you are discussing the homework problems with other students.
  - Since the quizzes cover homework has been graded and handed back to you, with solutions attached, the quizzes also give you an incentive to look at your graded homework to understand anything that you might have missed.
  - I'd like to try something new with the quizzes this year: I plan to ask you first to work alone for 5 minutes or so, and then, for the last few minutes, to check in with a neighbor to compare your approaches and results. I hope that this will eliminate the stress of quizzes, while preserving your incentive to take the weekly homework seriously, to be honest with yourself about using your own brain to solve each homework problem, and to take the time to review your graded homework when it is handed back.
- Exams and quizzes in this course should not be a source of stress. They are mainly a mechanism to motivate you to be sure that the weekly homework you turn in is done carefully and is the product of your own thinking and learning.

Academic integrity and honesty

- The University of Pennsylvania takes academic integrity very seriously.
  - *"Every member of the University community is responsible for upholding the highest standards of honesty at all times."*
  - Both gaining and helping someone else to gain unfair advantage constitute academic dishonesty: *"Facilitating academic dishonesty: knowingly helping or attempting to help another violate any provision of the Code"*
- As a bright and creative person, you too should take seriously the honest representation of what is and what is not your own work.
  - Imagine living in a culture in which dishonesty was so pervasive that nobody believed that your own greatest design work — on which you had worked day and night for many months — was really your own work. How motivating would that be?
  - I think it is essential, as the highly creative people that you are, for you to be totally honest about what is your own creation vs. what you have borrowed from other people. If your work depends on someone else's work, take pride in saying so explicitly.
- Finally, keep in mind that my trusting you to be honest allows me to make this a better course for you:
  - I can base the course grade mainly on homework rather than on exams — resulting in more learning and less stress.
  - I can return graded work promptly, with solutions, without worrying that in any given week there may be one or two people turning in work late.
- What honesty implies for this course is that I don't want you simply to copy down other people's answers (or my answers). But I do want you to learn from your classmates, to study together, and to work together to figure out how to solve homework problems. Once you've understood a homework problem, you should be able to work out a solution without looking line-by-line at someone else's solution. Discuss a problem with your study partners in as much detail as you like, then work out your own solution, then compare your final answers to catch careless errors.
  - While I want what you turn in to be primarily the result of your own reasoning, if you feel that your reliance on someone else's thinking makes this goal impossible on some occasion, you should at least be sure that your paper honestly acknowledges the other person's contribution. There is no shame in saying, "Julie showed me how to solve this problem." But don't just copy down Julie's answer!

Schedule

Monday	Wednesday	Friday
	Aug 28 (slides) skim chapter 1: "foundations" (intro, units, digits, solving problems, estimation). No connection to bottom floors of buildings — sorry.	**Aug 30** (slides) read chapter 2: 1D motion (distance, displacement, speed, velocity)
Sep 02 read chapter 3: acceleration *Labor Day holiday*	**Sep 04** (slides) read chapter 4: momentum	**Sep 06** (slides) homework 1
Sep 09 (slides) read chapter 5: energy	**Sep 11** (slides) read chapter 6: relative motion (inertial frames, center of mass)	**Sep 13** (slides) homework 2
Sep 16 (slides) read chapter 7: interactions (potential energy, transformation and dissipation of energy)	**Sep 18** (slides) read chapter 8: force (free-body diagrams, Hooke's law, Newton's laws of motion, gravitational force near Earth's surface)	**Sep 20** (slides) homework 3
Sep 23 (slides) read chapter 9: work	**Sep 25** (slides) start chapter 10: 2D motion (decomposing vectors, friction, inclined planes, projectile motion in 2D)	**Sep 27** (slides) homework 4
Sep 30 (slides) finish chapter 10	**Oct 02** (slides)	**Oct 04** (slides) homework 5
Oct 07 (slides) start chapter 11: circular motion	**Oct 09** (slides) finish chapter 11 (centripetal acceleration, rotational inertia, angular velocity, angular momentum)	**Oct 11** *Fall Break*

Monday	Wednesday	Friday
Oct 14 (slides) start chapter 12: torque	**Oct 16** (slides) finish chapter 12	**Oct 18** (slides) homework 6
Oct 21 (slides) read Giancoli chapter 9: statics & elasticity	**Oct 23** (slides) read Onouye chapter 1: intro (what is structure?)	**Oct 25** (slides) homework 7
Oct 28 (slides) read Onouye chapter 2: statics (review forces)	**Oct 30** (slides) read Onouye chapter 3: determinate systems (equilibrium, trusses, arches)	**Nov 01** (slides) homework 8
Nov 04 (slides) skim Onouye chapter 4: load tracing	**Nov 06** (slides) read Onouye chapter 5: strength of materials	**Nov 08** (slides) homework 9
Nov 11 (slides) read Onouye chapter 6: cross-sectional properties (centroids, second moment of area)	**Nov 13** (slides) read Onouye chapter 7: beams I (simple beams)	**Nov 15** (slides) homework 10
Nov 18 (slides) start Onouye chapter 8: beams II	**Nov 20** (slides) finish Onouye chapter 8	**Nov 22** (slides) homework 11
Nov 25 (slides) read Mazur chapter 15: periodic motion	**Nov 27** (slides) read Giancoli chapter 11: vibration	**Nov 29** *Thanksgiving break*
Dec 02 (slides)	**Dec 04** (slides)	**Dec 06** (slides) practice exam due
Dec 09 (slides) *last day of class* Extra-credit reading options: Mazur ch13 (gravity), Mazur ch14 (special relativity), Onouye ch9 (columns)	**Dec 11** *reading days*	**Dec 12 (Thu)** Final exam is Thursday, Dec 12, noon **Dec 19 (Thu)** *fall term ends*