Physics 8 : Physics for Architects I

University of Pennsylvania — Fall 2021

- 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

Prospectus items

Course ID : PHYS 008-001 2021C

Status

We will meet in-person, Mondays and Wednesdays, 3:30-5pm, in an active-learning classroom (TBD, first choice DRL 3N1H, second choice DRL A5), where we will sit in groups at round tables and work in teams to complete each week's "homework" problems.

To whatever degree is feasible, I will sometimes distribute to each table a hands-on activity, such as colliding small rolling carts of various masses, to build intuition in an engaging way about key concepts such as momentum and energy. The *enormous* number of in-class demonstrations that in past years were the focus of our lecture time will mostly be moved into asynchronous videos, but I will try to do live versions of the most fun demonstrations.

Whereas in past years, students spent 2–3 hours/week at home solving pencil-and-paper homework problems individually, all of that problem-solving will now be done cooperatively during class meetings.

The lecturing that I used to do will be recast in the form of asynchronous videos. I'm aiming for something like this (but with better editing for efficient use of your time) for "lightboard" work

https://youtu.be/9cG_g1Op4WQ

and for something like this (maybe with the help of a real camera-person) for fun classroom demonstrations:

https://www.youtube.com/watch?t=955s&v=LYm410J822c

Course description and level

An introduction to the classical laws of mechanics, including static equilibrium, elasticity, and oscillations, with emphasis on topics most relevant to students in architecture. Students first learn and practice the use of mechanics concepts such as momentum, energy, force, and torque, then apply these ideas to analyze basic structural elements such as cables, trusses, and beams. Students considering the ARCH major will find that PHYS 008 provides a solid foundation for later study of architectural structures (e.g. ARCH 435).

I strive to make this a fun, interesting, and stress-free physics course. I pace the work evenly from week to week. As long as you consistently put in the time each week to do the work, you will do very well in the course.

PHYS 008 fulfills **Sector V (Physical World)** of the College general-education curriculum, while our companion course, PHYS 009, is planned (pending approval) to fulfill **Sector VII (Natural Science Across Disciplines)**.

Here is a longer description of what I hope you will learn in PHYS 008:

- 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!

Class structure for Fall 2021

In-person sessions: Mondays and Wednesdays 3:30-5pm. Most days, we will use this class meeting time to work together (with me, with your classmates, with the TA) on discussing and solving physics problems, which you will write up and turn in on Canvas each week. For a change of pace, we will sometimes use hands-on activities and live demonstrations to build intuition about physics concepts.

Lecture videos: I will pre-record short lectures, with two main types of content. One type will be chalkboard-style ("lightboard") introductions to a given day's topic. A second type will be demonstrations (using props from the physics department) intended to bring each physics topic to life, to make it real, to leave a visual impression that makes the key ideas easy to remember.

Reading: In a typical week, you will read a concise set of notes that I will type up to introduce and summarize the key points of the week's material, and you will quickly **skim** a chapter of one of our two textbooks.

Required books:
(1) For the first part of the course (the main "physics" part, roughly two-thirds of the semester), you will access the book electronically through Canvas, so there is no need to purchase a book in physical form.
(2) For the "archictectural applications" segment of the course (roughly the last one-third of the semester), you will need a copy (preferably used, preferably an older edition, to minimize cost) of *Statics and Strength of Materials for Architecture and Building Construction* by Onouye and Kane. Used copies of the 2nd edition are available for about $10 on amazon. Or, if you find it more convenient, you can venmo me $10 to buy one of the many used copies of Onouye/Kane's 2nd edition that I keep in my campus office; it would then be your choice either to keep it or to sell it back to me for the same $10 in January. We plan to skim/reference chapters 1–8 of Onouye/Kane, though my notes will condense these topics down to the essentials.

Grading

- 50% : weekly "homework" problems, mostly completed during in-person class meetings
- 10% : two-stage small-group cooperative interactive exam/review
  - 5% : stage 1: discuss every problem "offline" with your group and submit a preliminary set of solutions
  - 5% : stage 2: group members take turns presenting your solutions to me in person
- 25% : completing reading assignments with online feedback
- 15% : participation in in-person class meetings
  - To avoid penalizing people who need to miss a few classes for religious, family, or extracurricular events, the class-participation total will be scaled so that a score of 90% or more receives full credit.
- In addition, you can earn up to 5% extra credit. There are several optional chapters you can read for extra credit, and most "homework" assignments will include some extra-credit problems. I will also try to organize a few extra-credit hands-on exercises for anyone who wishes to join me. (One small-group hands-on example could be using whisk brooms to steer bowling balls around a curved path marked out on a parking lot, to feel Newton's laws in action.)
- 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 100% or more (which is feasible if you do very well and also do some extra-credit work), you can earn an A+.
- The grading system strives to reward consistent weekly effort, rather than your ability to do well on timed exams.
  - Each week, you have to read, come to class, and solve (in-class) "homework" problems. In exchange, you largely avoid the stress of cramming for exams.
  - This is a physics course that you can do very well in even if you generally find physics to be a challenging topic.
  - Or if you have found physics to be easy in the past, this course's emphasis on problem-solving should deepen your understanding.

Typical weekly time commitment

- 3 hours reading notes & textbook chapters
  - You submit your answers to open-ended questions responding to each reading assignment. As often as I can, I will respond individually to your answers, particularly if you ask me for clarification.
- 1–2 hours watching video lectures/demonstrations
- 3 hours solving physics problems, most of which occurs during in-person class-meeting time

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Contact info

Instructors

Bill Ashmanskas
senior lecturer in physics
telephone: 215-746-8210
mobile: (I'll write on chalkboard)
ashmansk@hep.upenn.edu
office: DRL 1W15 (map)
drop in any time you see my door open, or email to fix a time

I'm generally on campus 10am–6pm M–F — but it is likely that I will work from home most Fridays

with occasional guest lectures by
Richard Farley
registered architect, professional engineer, associated faculty in architecture
Prof. Farley has taught Architectural Structures for many years at Penn.
rfarley@design.upenn.edu

Teaching Assistant

Mija Jovchevska
undergrad physics major
mija@sas.upenn.edu

Handouts / PDFs

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

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Course policies

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 weekday — M, T, W, R, F.
  - 1–5 days late: 5% penalty/day
  - a week or more late: 25% 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 venmo me $10 for one of my used copies (fully refundable at end of term, unless you prefer to keep the book). 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.

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

This schedule currently reflects the Fall 2019 semester. During summer 2021, I will update this schedule to reflect Fall 2021 dates and weekly meeting 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

Monday	Wednesday	Friday
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*
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*

Monday	**Wednesday**	**Friday**
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, DRL A1 **Dec 19 (Thu)** *fall term ends*