

Physics 8 : Physics for Architects I

University of Pennsylvania — Fall 2023

- 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>
 - **This page started from the fall 2021 page and is still being updated for fall 2023**
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Prospectus items

Course ID : PHYS 0008-001 2023C (2023-03)

Status

We will meet in-person, Mondays and Wednesdays, 1:45-3:15pm, in an active-learning classroom (DRL 3N1H) (my map), where we will sit in groups of three at round tables and work in teams to complete each week's worksheet 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 has been recast in the form of asynchronous videos. I'm aiming for something like this (but sped up a bit for efficient use of your time) for “lightboard” work

<https://www.youtube.com/watch?v=bD8JUwscPgw&t=1336s>

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

<https://www.youtube.com/watch?v=bD8JUwscPgw&t=615s>

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 VI (Physical World)** of the College general-education curriculum, while our companion course, PHYS 009, fulfills **Sector VII (Natural Science Across Disciplines)**, formerly called *Natural Sciences and Mathematics*.

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 quantities 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 2023

In-person sessions: Mondays and Wednesdays 1:45-3:15pm. 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 at the end of each class meeting. For a change of pace, we will sometimes use hands-on activities and live demonstrations to build intuition about physics concepts.

Lecture videos: I’ve put together a set of video lectures, with two main types of content. One type is chalkboard-style (“lightboard”) introductions to a given day’s topic. A second type is 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 “architectural 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 or 3rd 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% : twice-weekly problem-sets, which take the form of worksheets completed cooperatively during in-person class meetings
 - You must complete these worksheets in class. You must participate fully with your workgroup in our class meetings. Because it is likely that on any given day, a few people may have personal reasons for missing class, we will offer Zoom-based make-up sessions on Friday afternoons (or possibly during the weekend), with details tbd. If you must miss a class, write to me *in advance*, and then plan to be available that Friday afternoon (or weekend by consensus) for a Zoom-based make-up session. Each person should only use this option a couple of times this term, for good reason (whose details you need not disclose to me), not routinely.
- 25% : completing reading/video assignments and answering online questions
- 25% : final exam, during registrar's scheduled exam period
- In addition, you can earn up to 5% extra credit. There are several optional chapters you can read for extra credit, and many worksheet assignments will include some extra-credit problems. I may 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 the textbook, watch videos, come to class, and cooperatively solve (in-class) worksheet 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, nearly all 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

with occasional guest visits/lectures by
Richard Farley
registered architect, professional engineer, adjunct professor of architecture
Prof Farley has taught Architectural Structures for many years at Penn.
rfarley@design.upenn.edu

with hands-on activities coordinated by
Dr Ryan Batkie
SAIL-course coordinator for Physics & Astronomy
rbatkie@physics.upenn.edu (web page)

Teaching Assistant

TBD
undergrad physics major
??@sas.upenn.edu

Handouts / PDFs

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

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.
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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.
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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 problems. Once you’ve understood a worksheet 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 group members 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! You and I should both be confident that your own brain has learned how to solve every problem.

Schedule

This is the fall 2021 schedule! I will update the schedule for fall 2023.

Monday	Wednesday
	Sep 01 worksheet01 introduction: work in small groups before first class, watch introductory video and answer online questions.
Sep 06 <i>Labor Day holiday</i> during weekend, skim chapter 1: “foundations” (intro, units, solving problems, estimation). No connection to lower floors of buildings.	Sep 08 worksheet02 describing 1D motion using graphs & equations by 3pm, read chapter 2: motion in 1D (distance, displacement, speed, velocity)

Monday**Sep 13**

worksheet03

acceleration

by 3pm, read chapter 3: acceleration

Sep 20

worksheet05

by 3pm, read chapter 5: energy

Sep 27

worksheet07

by 3pm, read chapter 7: interactions

(potential energy, transformation and dissipation of energy)

Oct 04

worksheet09

by 3pm, finish chapter 8: force

Oct 11

worksheet11

by 3pm, start chapter 10: motion in a plane

(decomposing vectors, friction, inclined planes, projectile motion in 2D)

Oct 18

worksheet13

by 3pm, part 3of3 of chapter 10

Oct 25

worksheet15

by 3pm, start chapter 11: motion in a circle

(centripetal acceleration, rotational inertia, angular velocity, angular momentum)

Nov 01

worksheet17

by 3pm, part 3of3 of chapter 11:

motion in a circle

Nov 08

worksheet19

by 3pm, part 2of3 of chapter 12:

torque

Nov 15

worksheet21

by 3pm, skim Onouye chapters 1&2:

what is structure; review forces

Nov 22

worksheet23

by 3pm, skim Onouye chapter 5:

strength of materials

Wednesday**Sep 15**

worksheet04

momentum

by 3pm, read chapter 4: momentum

Sep 22

worksheet06

by 3pm, read chapter 6: relative motion
(inertial frames, center of mass)**Sep 29**

worksheet08

by 3pm, start chapter 8: force

(free-body diagrams, Hooke's law, Newton's laws of motion, gravitational force near Earth's surface)

Oct 06

worksheet10

by 3pm, read chapter 9: work

Oct 13

worksheet12

by 3pm, part 2of3 of chapter 10

Oct 20

worksheet14

Oct 27

worksheet16

by 3pm, part 2of3 of chapter 11:

motion in a circle

Nov 03

worksheet18

by 3pm, start chapter 12:

torque

Nov 10

worksheet20

by 3pm, part 3of3 of chapter 12:

torque

Friday, read Giancoli chapter 9:

statics & elasticity

Nov 17

worksheet22

by 3pm, video for Onouye chapter 3:

trusses

Friday, skim Onouye chapters 3&4:

determinate systems (trusses etc),

load tracing

Nov 24*Thanksgiving break*

by 3pm, skim Onouye chapter 6:

cross-sectional properties

(centroids, second moment of area)

Monday	Wednesday
<p>Nov 29 worksheet24 by 3pm, video for O/K ch6+7 (beams I)</p>	<p>Dec 01 worksheet25 by 3pm, skim Onouye chapter 7: beams I (simple beams) Friday, skim Onouye chapter 8: beams II</p>
<p>Dec 06 worksheet 26</p>	<p>Dec 08 worksheet27</p>
<p>(skipping this year) read Mazur chapter 15: periodic motion</p>	<p>by 3pm, video for O/K ch8 (beams II) <i>last day of class</i></p>
<p>(skipping this year) skim Giancoli chapter 11 (first half): vibration Extra-credit reading options: Mazur ch13 (gravity), Mazur ch14 (special relativity), Onouye ch9 (columns)</p>	<p>Dec 11-14: <i>reading days</i> Dec 15-22: <i>final exams</i> Final exam () is (tbd), (tbd) at (tbd) Dec 22: <i>fall term ends</i></p>

() If we reach a consensus, as a class, on whether and how to do so, we can consider replacing all or part of the final exam with oral presentations (either in a classroom or via zoom) of solved problems, with the members of each 3-person workgroup taking turns leading the discussion of how to solve each exam problem. The main complication is that every group of 2-3 students needs to schedule its own 2-hour exam block, ie we need to schedule about a dozen separate exam slots to cover all groups. (We can do it; it's just harder to schedule than a traditional exam.) This format was a nice fit for spring 2020, fall 2020, spring 2021, as well as fall 2021. Unless we unanimously decide to do otherwise, we will have a normal in-classroom closed-book final exam at the registrar's scheduled exam time: **(tbd)**. 3pm.

Registrar's final exam schedule.

Student comments from recent years

Physics 8, fall 2021

Here are all of the student comments, unredacted, unedited, from **Physics 8** (this course) in fall 2021, which was taught in-person in a format very similar to our plan for fall 2023. Note that I've been trying to work harder each year to edit videos down to manageable length!

- One of the most well organized and functional classes I have ever been in, Bill has an exceptional ability to adapt to the students and current situations without taking away from the course as a whole. As an architecture major, having to watch lectures between Monday and Wednesday was sometimes difficult as Monday nights and Tuesdays were studio-heavy, but that was not too difficult to work around.
- pros: - SAILS done excellently; focus on active learning, lack of stress, efficient use of instructor/student time both in and out of class - difficulty hits a nice sweet spot for someone with just high school physics; the course and the instructors met me exactly where I was and challenged me to learn new things while making sure to build on past competences. great class for non-architects looking to remind themselves

they can still do maths/physics - teaching team, esp. Dr Bill, is fantastic. Cares for his subject and his students - knows that the learning does not have to be stressful (esp for a 008 level course) while still understanding that learning must be engaging. i cannot appreciate that enough. cons: - more a suggestion, really, it's hard to listen and work on problems at the same time in class, so if there are important announcements/lecture bits, make them clearly demarcated or do it before handing out the problem sets so students know their work time is not being reduced when they listen etc. - some lecture videos were too long

- I really enjoyed the structure of the course with at-home lectures and in-class worksheets. I also really enjoyed the group work. Dr. Bill was great at relaying the course material and showed his enthusiasm in class.
- Prof. Ashmanskas was extremely helpful in this course. I think it would be beneficial to not try to give information while the class is doing group work because of how loud it gets. Other than that, I love how he ran the class this semester.
- I have absolutely loved taking PHYS008. Professor Ashmanskas was always prompt in answering questions and explained concepts very well so that they could be understood by students with varying levels of physics backgrounds. I believe this course to be an excellent example of what the Sectors in the college should be and how a flipped classroom should work. The class is small enough that you get to know your peers and Professor well, and the subject is both exciting and specific enough to attract students interested in the topic and a professor who buoys teaching it. I have on several occasions recommended it to anyone who will listen, and spoke about the class efficacy in student government meetings as an example of a successful stem class. As a flipped classroom, Professor Ashmanskas does a wonderful job of balancing online lectures and in person problem solving. He provided lectures where he explained concepts and worked out problems which directly tied to the material we would work on in class in groups of 3, with another group of three. This system of working in groups of 3-6 people to solve problems, and have Professor Ashmanskas and our TA there to answer questions (which he always happily and thoroughly explained). I learned so much from this class and I truly believe it is the epitome of what STEM classes at Penn should look like.
- I really enjoyed this course. We did a flipped classroom, which was actually really nice. I didn't think I would like learning on my own, but I became used to that during covid, so this structure actually really worked for me. Professor Bill was also amazing. He is one of the nicest and most caring professors I have had at Penn.
- Overall, Physics for Architects was an enjoyable course. I wish Dr. Bill did more in class lectures, because sometimes it was difficult to essentially teach yourself the curriculum. I enjoyed the group work we did, I just wish it was complimented with in class lectures.
- Professor Bill was always concerned about not only our grasp of the material, but also our personal well-being, and this is reflected in his course policies which were very understanding. He was incredibly patient if we struggled to understand something. Melina was a great TA who would never fail to bring clarity to a problem that I struggled with.
- I really enjoyed it, I just didn't live the 3 hour long video assignments for homework I would rather have had more lecture time in class.
- This course covered a lot of material in a very short amount of time. That being said I think it should be limited to the types of material taught so that there can be a more in depth understanding. Further more as a student that did not take AP Physics in high school made this class challenging, it might be worth considering giving this course certain prerequisites OR providing a time for students to reinforce the material presented. I also wish this course involved more architecture concepts. I personally did not enjoy the layout of a flipped classroom and would have preferred for the content to be taught in class/live.

Physics 9, fall 2022

Here are all of the student comments, unredacted, unedited, from **Physics 9** (our companion course) in fall 2022, the first year we taught Physics 9 in SAIL format.

- I think PHYS 008 and 009 have been among my favorite classes at Penn. I feel that Bill genuinely cares about his students learning and wellbeing. The experiments always bring excitement to the classes and help students grasp the concepts, so know that the extra effort the Bill puts in to make these demonstrations/activities are very appreciated.
- Our time is the most precious thing we can give to one another, so to both mentors of this course, thank you for your time and insights! I can't wait for future students to take this course and learn under your guidance. And Professor Ashmanskas, your passion for physics is contagious, please never doubt the important impact your guidance, insights and perspective has on students. This class exemplifies what it is to learn and your inclusion of campus tours and visiting instructors who are active in their respective fields only enhanced our learning experience. I am now considering a physics minor; this has been one of my favorite classes to date. Please make this class a school requirement!
- I would like to commend Bill not only in fulfilling his duty of teaching but even more so his propensity to go above and beyond in arranging activities which enriched our understanding of the topics and their application in the real world of architecture. I will say that I found this to be a strange course, both because of its small class size and the remarkable flexibility with which Bill has conducted this course. It was a great contrast to my experience with PHYS 008, which was much more structured and a lot heavier on the completion of problem sets. However, I feel like the immense difference between the two courses meant that for me, they really complemented each other well, and furthermore they made PHYS 0009 all the more special. I know that Bill plans to make this class bigger in the future, and I am all for it, as there are many advantages to the bigger class size I encountered in PHYS 008. (For instance, I felt like I HAD to be actively engaged in every class this semester, and when someone an "off" day it would have be sorely noticeable to the rest of us.) But I will always cherish the unique opportunities afforded by the nature of this course, whether that was the discussions with people who work in the field, or the excursions, or the increased emphasis on hands-on activities. These experiences were what elevated the course from just another physics course to something that made me realize the importance of things such as sound, light, and heat in architecture. I will definitely carry the lessons from this course with me to the rest of my career. As an aside, I've felt like Bill was always unsure of whether he wanted some of these activities to happen, constantly asking his students for reassurance, but in future semesters he should just take the leap and arrange them (and even make them mandatory). A lot of the activities he planned were ones I wasn't sure would turn out as well as they did, and I hope in the future Bill trusts that students will see the value in doing things outside of the conventional classroom structure.