Physics 11 — Spring 2023

Lectures: Tuesdays and Thursdays, 12:00 - 1:15, SEC-Robinson 253

Discussion sections and Labs: The complete schedule is posted on SIS.

Professor: David Hammer — david.hammer@tufts.edu

Teaching Assistants:
TBA

Learning Assistants:
TBA

Help hours: These will take place in room 402 of 574 Boston Ave

If you need an individual meeting, send For me, David, please check my calendar of times I'm available for appointments.

What you need:

1) **FlipItPhysics:** I'll assign 20-minute video "prelectures" and "checkpoint" conceptual questions, typically one of each before each lecture. **The Course Access Key is tufts2023**. This costs $41-44, but the site lets you sign up for a trial period, so you don't have to pay immediately. *If buying FlipIt is a financial difficulty, sign up for the trial, and let me know.*

2) **Poll Everywhere**: This is free, and we will use it every lecture for "clicker questions." Go to https://www.polleverywhere.com/mobile to download the app. The address for this course is https://pollev.com/phys11. *If you don't have a mobile device to use in lecture, come see me.*

3) **Piazza**: Students suggested Piazza as the forum instead of Canvas because it allows anonymous posting. Click on the link to get to our course. *Piazza is free*.

That's all you *need* for the course, but I also recommend you get a textbook. The department has recommended Giancoli *Physics for Scientists and Engineers*, 4th edition. That's OK, but it's expensive. **Old editions are perfectly fine and much less expensive.**[1] Other standards are Tipler (same title) and Halliday & Resnick *Fundamentals of Physics*. Two less popular but I think better options are *Understanding Physics,* by Cummings, Laws, Redish and Cooney, and *College Physics,* by Etkina, Gentile, and van Heuvelen, For wonderful supplement, *Conceptual Physics* by Hewitt doesn't use calculus. Again, go for older editions.

[1] The main reason for most new editions is that they are profitable for the publishers.

About learning physics

"The whole of science is nothing more than a refinement of everyday thinking. It is for this reason that the critical thinking of the physicist cannot possibly be restricted to the examination of concepts of their own specific field. They cannot proceed without considering critically a much more difficult problem, the problem of analyzing the nature of everyday thinking."
Einstein, 1936

My first priority is that you learn *how to learn physics.* You might expect that means memorizing equations and getting efficient at solving problems, but it doesn't. It means working to make sense of the physical world, in this course about how objects move and what affects how they move. The first thing to recognize is that you already know an awful lot about that.

You have *years of experience,* every day, seeing and feeling how objects move or don't. I'm talking about stuff every ten-year-old knows: that you can throw a rock across a field but not a balloon, that it would hurt to kick a heavy stone, what it feels like to be in a car when the driver suddenly hits the brakes, how far the car goes in 3 hours at 30 miles/hour, and so on and on. That's the "everyday thinking" Einstein had in mind.

All of physics begins from common sense.

It only begins there, though, because, for one, **common sense is incomplete**. As much as we've experienced of the world, there's always more we haven't. Maybe you have experience on skateboards or ice skates or bicycles; maybe you've hit piñatas, gone bowling or rock climbing, played basketball or hockey, tried slacklining… not everyone has, but it's all good stuff.

Even more important, especially for us in this course, **common sense is inconsistent**. Here's an example: You know you need a warm coat for a Massachusetts winter, warm gloves for your hands, a warm blanket for your bed. That's all the same piece of common sense: If you're cold, cover up. You also know not to grab a hot frying pan with your bare hand. Use an oven mitt or a potholder, to keep from getting burned. That's also good common sense!

Now suppose you wrap an ice cube in a thick blanket. Will it melt faster or slower than if you leave it unwrapped on the table? The "cover up to be warm" part of common sense says it will melt faster; the "protect from hot things" part says slower. If this is the first time you've thought of both of those parts of common sense together, you might feel torn about how to answer.

Feeling confusion is part of learning.

That kind of thing is going to happen all the time in this course, that you'll feel unsure. That's *good*! The feeling of confusion, that there's something missing or not quite right, is what drives physicists—it's means the chance to learn something new, to experience the pleasure of new insight. Feeling confused is part of doing physics, the way breathing hard is part of working out.

Unfortunately, school has taught many of you that confusion is bad, that it's something to be ashamed of, something instructors should help you avoid or make go away. *If you're not ever feeling confused, you're not ever really learning*, just like if you're not ever feeling out of breath, you're not getting real exercise. It's a systemic problem: Students and faculty tend to associate feeling confused with not learning, when it's the other way around. (There's lots of evidence—here's one recent study.)

Maybe more to the point, *physicists are professional learners* (as are engineers, mathematicians, chemists…). They *look for confusion* and take it on. I want you to learn how to do that, and I'm going to work hard to make opportunities, over and over, for you to find confusion and take it on. That's the fun of physics, and I so hope you'll enjoy it, the way you might already enjoy puzzles, or the challenge of learning a difficult dance move or piece of music or baking technique.

There is intelligence in "wrong" ideas.

Whatever you predict for the ice cube, there's an intelligent sense to your reasoning, and it is important to understand that sense. If your prediction is wrong, and you want to learn, you need to figure out what about your reasoning needs repair. When you have a wrong idea, it's because you're using thinking that is *right* in some other situation — that's how you came to have that idea, because it comes out of thinking that has served you somewhere somehow. Try to find it, the origins the idea in your mind. That's what Einstein meant, the "refinement of everyday thinking"; that's "analyzing the nature of everyday thinking."

Everything we do in this course will connect to some part of your experience. **Most of the hard work will be in finding and reconciling contradictions in knowledge you already have**. More advanced courses in physics are about refining those refinements. The ideas we'll get to in this course, about acceleration, force, energy, momentum, become the beginnings of other learning about more phenomena, leading to ideas and questions about relativity, quantum theory, nuclear fission and fusion, black holes, how the universe began…

Mathematics is helpful!

The refinement of everyday thinking is toward consistency, and a key reason the discipline of physics makes progress is because of help from mathematics. It's kind of amazing and wonderful that math is so helpful for understanding the physical world. But only *if we use it for reasoning*.

Unfortunately, many physics courses use mathematics *instead* of reasoning. It's a risk for some students who've had physics before, if the course was about giving you formulas and instructions on when and how to use them. For example, many students solve kinematics problems with the formula $v^2 = v_0^2 + 2a\Delta x$, but if I ask them what that formula means and why it's true, they say their teacher taught it to them. That's not doing physics! We're going to try to avoid it.

From years of course evaluations, I know that some of you will think that's avoiding math. But it's not: Math will be central to the course, but only, I hope, in meaningful ways.

What's required and why

1. Attendance in lectures, discussion sections, and labs

Lectures will involve a lot of your answering and talking with others about multiple-choice "clicker questions," using Concept Warehouse. Choosing any answer gets you a "participation point."

Some students object to participation points in lectures. If you do, come speak to me to see about the possibility of calculating your grade only by problem sets, lab reports and exams.

Discussion sections meet once a week. SIS calls them "recitation" sections (still!?). The idea is to have time for more extended, in-depth discussion and collaboration. Please participate.

L**abs also meet once a week**, with some exceptions we'll schedule. Their purpose is to give you experience designing, conducting, and analyzing data from experiments. There won't be step-by-step instructions; there will be some empirical challenge, and you'll come up with ideas.

2. Assignments

There are three kinds of assignments you'll hand in or post for credit: (1) Online FlipIt "prelecture" videos and "checkpoint" questions, (2) problem sets and (3) labs and lab reports.

FlipIT prelecture videos are about 20 minutes long, and you'll watch them in advance of each lecture, so typically twice a week. **Checkpoint questions** accompany the videos. You'll get participation points for watching prelectures and answering checkpoint questions. Log on at www.flipitphysics.com.

I do not assign the problems on FlipIt. I used to remove them from the course site entirely, but some students asked that I leave them available. They're labeled "optional problems." Do them if you think they'll help you learn. (I'm skeptical about that, for most students.)

Problem sets are due before lecture once a week on Tuesdays (mostly).

As with other aspects of the course, my problems are different from what you might expect—and different from the FlipIt problems. I don't write problems for you to repeat and rehearse something I've shown you how to do. I write them first for you to have practice in finding confusion and taking it on, and second to press for the sort of real, robust understanding that comes out of that grappling with confusion.

Sometimes you'll get stuck. When you do, one great thing to do is to *explain what has you stuck.* Describe your confusion, as clearly as you can. That's doing physics, and it counts for credit on problem sets. Yes, it counts. The point of problem sets is to get you doing physics, and that means being honest with yourself (and with us) about what you understand and what you don't.

It's always great to talk with other students, LAs, TAs, or me. Post a question to Piazza, or look for what others have posted already. Even if you're not stuck, it will help: Very often I will ask you to consider multiple lines of reasoning, and for that other students will be very helpful. Any time you are working with someone, and they have a different idea than yours, you should work to try to understand the sense behind their reasoning.

If it will help you learn, find a collaboration partner for problem sets. We'll set up to let you submit assignments as a pair—you'll both get the same credit for the set.

Again, we score these assignments mainly for good, sensible effort; creativity is great. If your TA can follow your thinking and see a reasonable sense to it, you'll get credit—that includes your articulating what's confusing you.

Please follow up on your efforts by reading the problem set solutions I post, and follow-up further on things that don't make sense. Ideas from problem sets build on each other, as I think you'll see. In other words, when you're working on problem set 4, you'll need ideas from problem sets 1-3.

Labs and lab reports. Labs are also different from what you probably expect. They're about your doing *empirical* physics, that is finding out about the world by examining it carefully through experiment and observation. In the first week of each lab, we'll pose a challenge, and you'll start working with your lab partners to figure out what to do. We won't structure the experiment for you; you'll come up with ideas for yourselves. In the second week, you'll have more time to refine what you've done, write up your report, and you'll reflect on the meaning of it all. We score lab reports for intellectually honest effort and creativity.

3. Exams

There will be three exams, two during the semester, which I'm planning for Feb 21 and March 30, and a third during exam period, which will be scheduled by the deans.

The exams are about getting evidence of what you've been learning, both about how to learn physics about the particular concepts we've discussed. I use two kinds of questions for that, one multiple choice, like on FlipIt and in lectures, and the other "short answer" that require explanations, like on problem sets. On exams, the multiple choice questions are scored for correctness only. Some short answer questions require correct answers for full credit, but we give plenty of partial credit for sensible thinking we can follow. There's always one short answer question that doesn't require a correct answer for full-credit.

Some students get very anxious about exams, and it can be unhealthy. Please see me if that's you, so we can talk about alternatives. An exam is not valuable as evidence of what you're learning if you're in a state of distress.

Some advice on how to study

Cramming to memorize equations won't work! Use problems in the weekly assignments to help you discover gaps and confusions in your understanding—that's the point of problems. Don't shy away from confusion—*look for it*, and try to pin down a specific question. Here's more:

1) **Explain your thinking clearly**, to us on assignments but even more importantly **to yourself.** This is different from taking notes or annotating; this is writing to express ideas or confusions, honestly, directly, in ways someone could read and follow — the someone might be yourself after a week or two.

This is true of any learning! Explain ideas in terms you genuinely understand.

2) **Look for other ways of thinking**, too. You'll often find them in your own mind, tied to other contexts (e.g. winter weather or ovens, in thinking about gloves). You'll always find them in conversations with other people, who will have different reasoning from yours.

3) **Try to reconcile conflicting ideas; don't just pick one.** It often happens that one line of reasoning takes you in one direction, and another takes you in a different direction. It's not enough to know which reasoning is right; you need to see why the other is wrong.

This is key, and it might seem weird. If you're deciding "pizza or burrito," and you choose burrito, you wouldn't explain why pizza is wrong. In physics, it will happen often that part of you says "A" and part of you says "B." If you choose A, the next thing to do is figure out why the reasoning for B doesn't work. (If you can't find a reason, you've found a confusion.)

4) **Test your understanding**. There are two key ways for you to figure out if you understand something. (1) Try to explain it in simple terms, your own terms, terms you think a 10 year old could understand. Close the book or website, start from a blank page, and write. *If you can't explain an idea in simple terms, then there's something about it you don't understand.* (2) Try to answer some new related questions; don't just go by that feeling of "oh, now I get it" after seeing a solution.

5) **Come up with problems yourself.** They might be new questions based on a problem you've solved: What if there is friction, what if the rock is moving *up,* what if the two cars had equal mass, whatever. Not the same problem with new numerical values, a variation that needs new reasoning. (That's how I write questions for exams.)

About grades

Many students have told me that working for grades isn't the same as working really to learn, and I think that's a big problem. My goal is your learning. Since most of you feel obliged to work for grades, I try as hard as I can to get the "grade game" to align with actual learning. To that end, most of the points (about ⅔) in the course are our assessment of how you're working to learn: Are you finding confusion and taking it on? Using math for sense making? Explaining your reasoning, engaging with others' reasoning, keeping track of questions and things you've figured out? We'll get to see that in problem sets, labs, participation, and on exams. The only time there are points specifically for correctness is on the exams—about 60 out of the 100..

Participation: 15%. These are the clicker points in lecture and your work on FlipIt. There will be additional points along the way: for good participation in discussion sections and labs; for posting on Piazza; for catching me making mistakes in lecture.

Problem sets: 20%. The points are for honest engagement with the problems, based on what we can follow in your work. I post solutions to problem sets at the time they are due, which complicates our accepting them late.

Labs: 15%. Same deal, we don't grade labs by whether you "got it right." We grade for honest experimental inquiry, insight and ingenuity. It also counts that you're a good citizen, treating the lab and people with respect, including coming on time and cleaning up at the end.

Exams: 50%. The three exams count equally, except that I like to credit improvement. So, if you do poorly on the first exam but improve on the second and third, I give less weight to the first.

You're probably used to thinking of 90% and up as the A-range. That is what I use for participation points, problem sets, and labs. But the A-range for exams is 80% and up; 70% is the cut for the B-range, 55% for the C-range. Writing exams, I try for an average of 65%. (If it helps, think of my exam grades as like AP scores, where 80% would get you a "5.")

Adding them all up:

In the end, I use a spreadsheet to calculate course totals, with this as the basic formula:

$$Total = 50\left(\frac{exam.total}{exam.possible}\right) + 20\left(\frac{probset.total}{probset.possible}\right) + 15\left(\frac{lab.total}{lab.possible}\right) + 15\left(\frac{partpoints.total}{partpoints.possible}\right)$$

The A-range for the course total is 85 and up; B is 75-85; C works out to 62.5-75. That's the basic formula, but I reserve the right to go above that, when in my judgement it's appropriate.

Academic integrity

The policy at Tufts "requires faculty members to report all instances of suspected violations of academic integrity to the Office of the Dean of Student Affairs." It's good policy, and I'm committed to following it.

Any time you present someone else's work as if it's your own, or you make it look as though you did work you didn't, it's academic dishonesty. That includes copying or paraphrasing someone else's problem solution or lab, from your friend or the web or wherever; clicking for someone on Poll Everywhere; texting friends during an exam.

Accommodations and special circumstances

Please let me know right away if you need particular accommodations for a documented disability, or if there are any other special circumstances that might affect your learning and experience in the course.

Well, that's what I've always had in my syllabus, but these days life is all one giant special circumstance… covid and bomb threats and who knows what's coming next! I expect we'll all need to be flexible and especially compassionate with each other. Please put your health first, be kind and caring to others and to yourself.

The schedule for the semester

Week	Lecture dates	Topics	Prob set	FlipIt	Labs
1	Jan 19	Course introduction			
2	Jan 24 Jan 26	1-d kinematics 2-d kinematics	1	1 2	Lab 1.1
3	Jan 31 Feb 2	2-d kinematics Newton's Laws	2	3 4	Lab 1.2
4	Feb 7 Feb 9	Newton's Laws Friction	3	5 6	Lab 1.3
5	Feb 14 Feb 16	Kinetic Energy Review	4	7	Lab 2.1
6	Feb 21 Feb 23	**Exam 1** No lecture (Monday schedule)			No labs this week
7	Feb 28 Mar 2	Conservation of energy Conservation of energy II	5	8 9	Lab 2.2
8	Mar 7 Mar 9	Center of Mass Momentum	6	10 11	Lab 3.1
9	Mar 14 Mar 16	Elastic collisions Impulse	7	12 13	Lab 3.2
	Mar 20 - 24	Spring break			
10	Mar 29 Mar 31	**Exam 2**	8		No labs this week
11	Apr 5 Apr 7	Rotational motion start Torque		14 15	Lab 4.1
12	Apr 12 Apr 14	Rotational dynamics Rotational statics I	9	16 17	Lab 4.2
13	Apr 19 Apr 21	Rotational statics II Angular momentum I	10	18 19	Make-up week as needed
14	Apr 26 Apr 28	Angular momentum II Review	11	20	Make-up week as needed
	TBA	**Exam 3**			