Physics 101 Lecture 1

Hello and welcome to Physics 101, General Physics I! This course is an introduction to the systematic and mathematical description of the natural world. Later in this lecture I will provide the bird's eye view of the course, but first I want to introduce myself and the class components.

I'm Andrew Larkoski and this is my fourth year at Reed as a visiting Professor. I am a theoretical particle physicist by training, and throughout the course I'll introduce aspects of my research and how they relate to the topic we are discussing. Though I am the instructor, I see each of you as a colleague for which we are working through understanding Nature together, as a team. Thus, please address me informally, by my first name, and not "Dr." or "Prof.". I will similarly attempt to learn all of your names, too, but please have patience because there are over 100 of you! Correspondingly, I greatly appreciate <u>any</u> feedback you have regarding any aspect of the course (positive or negative). I take feedback seriously, and this is the first time I have taught this course, so I appreciate comments regarding how you feel it is going.

For class information and organization, everything can be found on Moodle, moodle.reed.edu. The most important thing on there now is the syllabus, which we will discuss now. While I am the lecturer for this course, there are others working on various components of the course. The departmental associate who coordinates labs is Owen Gross. He's the first point of contact regarding anything related to labs, and he'll watch over each lab. In addition to lab and lecture, this course also has conferences, once-a-week problem solving sessions with a faculty leader. I lead three conferences; the other conferences leaders are Mark Beck and Lucas Illing. You will get to know your conference leader very well over the course of the semester, so please use them as a resource! All four of us have office hours, and you are welcome to attend any office hour (even ones of people who aren't your conference leader!) Office hours are:

Andrew
Owen
Mark
Lucas

All of our offices are located in the Physics building, which is the next building due east of Vollum (where we are now). I want to personally get to know each of you, so I am requiring everyone to come to my office hours at least once in the first 6 weeks. You don't need to have a question; just come and chat! If my office hour times don't work for your schedule, then stop by when my door is open or send me an email to schedule an appointment. I have a generous open door policy: my door is almost always open when I am there, so please just march in unannounced and start talking!

The textbook for this course is Knight, "Physics for Scientists and Engineers", which is available from the Bookstore or from online sellers. Also, copies are held in reserve at the library, but no guarantees that there will always be copies available. The textbook is required as I will assign homework out of it and you will be required to do readings out of it. I would also appreciate feedback on the textbook; there are a lot of introductory physics books out there, and I think it's important to know if it is serving you as well as it should.

There are multiple components of this course that make up your final grade. First, homework will be assigned almost every lecture, due by 10:05 the following lecture, sharp. No late work is accepted, but you each will have 3 homework "passes" to use if you are unable to complete that assignment. Homeworks are graded by fellow students that will have hundreds of papers to handle each day. To ensure that your homework is graded, make sure that pages are stapled together, your physics box number, Reed ID number, and homework number are clearly written at the top, and remove any frayed edges.

In addition to homework, there will be three exams: two in-class midterms and one final exam. The midterms will cover the new course content since either the beginning of the course or since the previous exam. The final will be comprehensive.

Each of you will have a problem-solving conference to work with other students and faculty in a more intimate environment than in lecture. Participation in conference is required; you will receive credit for attending conference. If you can't make your scheduled conference that week, contact your conference leader; likely you can attend another conference that week.

Finally, you will also have a weekly laboratory that will engage you with the concepts introduced in lecture and the textbook in a particularly visceral way. This will also introduce you to data taking methods, error analysis, and how to construct a lab report. Physics is an empirical, experimental science, so our high-falutin ideas must be borne out in lab, or it is wrong.

More information about these graded components and how much they contribute to your final grade can be found in the syllabus on Moodle.

Before we start discussing physics, I want to lay down expectations, for all of us. First, you're not here to impress me, Owen, Mark, or Lucas; you're here to learn physics. Learning occurs most effectively when you come in open-minded, willing to engage with the material in a way that may be unfamiliar and possibly intellectually uncomfortable. You all have very different physics backgrounds and preparations, so I encouraged you to be sensitive to that fact. Physics is challenging and you will all learn and absorb the concepts at different rates. This is good! We all can learn from each other because you will each have a uniquely singular way to think about physics.

On the other side of this coin is a potentially serious issue that I and many other professional physicists still experience. ~~[illegible]~~ Imposter syndrome is the fear that you are an imposter, a fraud, in some setting, and everyone else there is going to find you out and expose you. It can be debilitating and lead to intellectual road blocks that prevent you from succeeding. I want to encourage you all to be sensitive to this, too: we're unfamiliar with each others' struggles, and we are all stronger when we support each other. To those of you (myself included) that have or are experiencing imposter syndrome: you belong here. You are curious and you can succeed. Sometimes we may need to ask for help: from other students, from faculty, from tutors, etc., but we are all here to learn and our common goal unites us. So, let's open our minds, and dive into this rich subject which very literally describes everything we can experience.

For the rest of this lecture, I want to provide a global view for the topics of this semester; we will start in earnest next lecture.

Why can we trust our memories? This has a lot more to do with physics than you might think. What do we mean by "trusting memories"? We mean that our previous experiences can be used to inform future situations. This means that what we learned in the past must be applicable to the future; that is, there is a continuity through time of our experiences. A hot stove you touched yesterday hurt; therefore you know that if you touch a hot stove tomorrow it will also hurt. We can make this more physically precise by stating that experiences exhibit a time-translation symmetry. This means that our learned experiences are always the same (a symmetry) throughout translating or moving through time. This is obviously extremely important for conscious beings like us; otherwise we could never learn.

Even more grand a statement that follows from this is that the laws of physics do not change in time. Now, I don't mean that individual objects do not change in time; I mean that the way and rules for how objects interact with one another are always the same. For example, the rules of Monopoly are always the same, but any given game can have different outcomes. If the laws of physics do not change in time (they exhibit a time-translation symmetry), there ought be a concrete quantity whose value is unchanged, or conserved, in time. This is energy: that the laws of physics do not depend on time means that energy is conserved, and vice-versa. This relationship between a symmetry and conservation law is called Noether's theorem, after Emmy Noether, a German Mathematician.

It is perhaps the most important result in all of theoretical physics and provides extremely strong constraints on the interactions of objects. However, depending on the system you are studying, energy may not be conserved. We only believe that energy is conserved for the entire universe, the only truly closed system we can imagine. The energy of an object can change if <u>work</u> is done on that object. Work is necessarily a concept that is outside of the object or system that you are studying. Because you can't go outside the universe, no work can be done on it and so energy is conserved.

However, not only do the laws of physics not depend on time but they don't depend on where you are, or how you are oriented. That the laws of physics are independent of your position means that they exhibit a spatial-translation symmetry. Just like with time translations, Noether's theorem states that there is a conserved quantity: <u>momentum</u>. Momentum only changes if a <u>force</u> acts on your system or object. Further, the laws of physics don't depend on your orientation: throwing a ball to the north or to the west exhibits the exact same phenomena. Thus we say that physics is <u>rotationally-invariant</u>: everything (i.e., the laws of physics) are the same if you rotated the system. For rotations, Noether's theorem tells us that the corresponding conservation law is <u>angular momentum</u>. Angular momentum, a measure of an object's rotation about a fixed axis, can only change if there is a <u>torque</u> on an object.

These three conservation laws, energy, momentum, and angular momentum, will be the central components of this course. We will describe systems under which they are conserved, and use that to our advantage when making predictions for future behavior given current data. We will also discuss how work, forces, and torques break conservation laws for open systems (systems that interact with an external environment). Fortunately and powefully, this breaking of conservation is not arbitrary, and we will construct powerful relationships fitting it all together.

Though this class and topics are often referred to as "classical mechanics," connoting "classical" in the Greco-Roman sense, the physics you learn this semester underlies all phenomena that we know. Conservation laws are the way that modern particle physics is formulated, and so these ideas are used throughout my research. Though it may seem pedestrian or even pedantic at times, there is an amazingly rich structure lurking just beneath the surface. This semester, I'm thrilled to be your guide exploring Nature from this profound perspective.

For Friday, your first homework is due! See you then!