Science-1A Lecture: Week-3, Monday, August 23, 2021

The most important topic in physics is energy. Physicists have found that energy is never lost or gained, but rather is just converted from one form to another. When you explain that to a 5-year old, they might say "well, wait a minute, where did it come from in the first place?" The correct answer is "we don't know", but there is evidence that it appeared in a "big bang" 13.80 x 10^9 years ago. (10^9 is usually called a "billion", but in British English, a "billion" is 10^{12} years, so be aware that there can be confusion.) If you want to know more, see *https://en.wikipedia.org/wiki/Big_Bang* about this theory and its supporting evidence. Ever since the big bang, its energy formed galaxies, stars and planets. Our sun and the Earth were formed about 4.6 x 10^9 years ago. Nearly all the atoms that make up the Earth and its creatures came from previous generations of stars that created the heavy elements and exploded as they ran out of nuclear energy from hydrogen fusion reactions. Those explosions scattered their heavy elements which then could form future planets. This is discussed in your text book in an Astronomy section following the physics and chemistry sections we study in this course.

I normally show this idea of energy conversion in an exciting explosion demonstration where electrical energy is used to rip apart water molecules to produce hydrogen and oxygen gases with extra chemical energy. After several hours of doing this, a small fuse wire is inserted into the gas and melted with a small amount of additional energy. The heat from that melted wire ignites a chain reaction that causes the hydrogen and oxygen gas molecules to turn back into water molecules in a tiny fraction of a second − an impressive explosion results as they release their extra chemical energy.

A video (without sound) of one such explosion I did at my house one night is at
https://yosemitefoothills.com/Science-1A/Handouts/Week-03/Hydrogen-OxygenExplosion.mp4 .
(In that video, I am wearing a headlamp as I prepare for the explosion and check it afterwards.) More about how to do this is in the handout entitled "Using Electricity to Slowly Make H_2 and O_2 from H_2O and then Putting it Back Together in a Hurry". It is at
https://yosemitefoothills.com/Science-1A/Handouts/Week-03/ElectrolysisOfWater.pdf .

The chemical energy of the hydrogen and oxygen gas molecules is abruptly released into mechanical energy that blows apart the soft plastic bag holding it, light energy that produces a flash, and sound energy that spreads through the room and down the hallway. Eventually, it all becomes heat energy. No energy was lost, but the final heat energy is much less useful than the electrical energy that started the process. As the universe ages, its initial concentrated energy becomes more dispersed and less exciting. We are part of this process. We eat energetic food, so we can build and maintain our bodies, think, and do physical work. We then exhale, excrete, and defecate what we cannot use. No energy is lost, but it has become less useful.

So energy is the stuff that can make things change. Sorry, I can't do better than that as a definition of energy. Also, there is no true "zero" of energy; it is always measured as a change. For example, when we use the formula for gravitational "potential energy", $PE = m g h$, the height *h* is always measured against a convenient reference like the floor. The *PE* value will then be the energy difference between the floor and the height *h*.

Energy is closely connected with work and power. **Work in physics is the way energy is changed from one form to another.** When lifting a weight, you do work converting food energy into gravitational potential energy.

Power is how quickly this is done. A turtle generates very little power with its energy while a hummingbird generates a lot. Hiking up a mountain quickly requires more power than doing it slowly, but the same amount of mechanical energy is required to reach the top. Of course, when we go slowly, our normal body maintenance energy is required for a longer time. Still, I like going slowly and enjoying the view.

With that introduction, watch the following Crash Course videos:

Work, Energy, and Power (CC9) 9 min, 54 s

https://www.youtube.com/watch?v=w4QFJb9a8vo&list=PL8dPuuaLjXtN0ge7yDk_UA0ldZJdhwkoV&index=10

> You will not need to understand her use of vectors, derivatives, and integration, and we also do not talk about spring forces and energy in Science-1A.
>
> **Everything else she talks about is important to our course.**

Collisions (CC10) 9 min, 20 s

https://www.youtube.com/watch?v=Y-QOfc2XqOk&list=PL8dPuuaLjXtN0ge7yDk_UA0ldZJdhwkoV&index=11

Momentum is an important concept we will discuss in connection with the recoil of a canon.
We do not deal with the idea of impulse.
We will be concerned with center of mass when we talk about teeter-totters and mobiles, but you will not need to do calculations about it.
One interesting way to see the physics of collisions is to watch car cams of crashes. Try looking for "Russian Car Videos" on YouTube for lots of examples. You can see all the ways the rules of driving are violated. Watching these might make you a better driver.

Rotational Motion (CC11) 8 min, 55 s

https://www.youtube.com/watch?v=fmXFWi-WfyU&list=PL8dPuuaLjXtN0ge7yDk_UA0ldZJdhwkoV&index=12

We do not have time in the course to discuss rotational motion except to briefly talk about spinning ice skaters and wheels. **Just enjoy the discussion** and notice how the definitions of rotational variables and equations are analogs to those used for translational motion.

In lab, I bring in hollow and solid balls, and also hollow and solid cylinders. We then roll them down a tilted table and compare their quickness as they roll down to the bottom edge. Unfortunately, I cannot expect that everyone in the class would be able to scrounge up the necessary items. Luckily, it is discussed in this video

Torque (CC12) 8 min, 2 s

https://www.youtube.com/watch?v=b-HZ1SZPaQw&list=PL8dPuuaLjXtN0ge7yDk_UA0ldZJdhwkoV&index=13

Everyone who has done much work on cars, has twisted a bolt so hard with their wrench that the bold came apart with its end stuck tightly in part of the car. That is not only embarrassing, it can be very expensive to fix. The solution is to use a "torque wrench" that lets you know how much twist you are putting on the bolt. All car service manuals specify the proper torque to apply to every bolt on the car. When your tires are replaced, a good shop will look up the proper torque to apply to the wheel nuts.

Torque is important in balancing teeter-totters and mobiles.

Just enjoy the discussion and relax knowing that you will not need to know about the math.

I also would like you to read the following handouts relevant to this discussion:

The contrast between the way physicists calculate mechanical energy and how we experience it is the topic of the handout entitled "Reconciling Biological and Physics Energy Concepts". It is at
https://yosemitefoothills.com/Science-1A/Handouts/Week-03/ReconcilingBiologicalAndPhysicsEnergyConcepts.pdf

The 2 pages of handouts entitled "Chapter 3" and "Work, Torque, and Mechanical Machines" that are at
https://yosemitefoothills.com/Science-1A/Handouts/Week-03/Chapter-3-Notes-WorkAndTorque.pdf .