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Course: SPH 3U1
Unit: Mechanics

Lesson 7: Conservation of Energy

The most important thing about energy is that it is conserved.

What does this mean? There are different ways of stating this:

- Energy cannot be created or destroyed, only changed from one form to another.
- The total amount of energy in a closed system is constant.
- The initial amount of energy = the final amount of energy

What is the ultimate source of all energy on earth?
– sun, this is our primary energy source for everything (light, heat, food, wood, coal, oil)
– uranium (in nuclear reactors and possibly in the centre of the earth)
– geothermal energy (left over heat from when the planet was formed)
– gravitational potential energy (e.g. pulling in a meteor, it's hard to imagine this being used for anything)
– rotational energy (hopefully this is never used, as it would slow the earth's rotation)

"Since energy cannot be created nor destroyed, where did it come from?"

No one knows. Somehow the Big Bang created: space, time, energy, matter, physical and chemical laws, physical constants, and unimaginably low entropy.

Energy can only change from one form to another ...

What's wrong with this picture?

You turn on a flashlight and shine it on solar panels, you connect the wires to your batteries to charge them up. So your flashlight should now shine forever.

1. batteries: chemical potential energy changed to electrical energy
2. light bulb (assume LED): electrical energy changed to light energy
3. solar panel: light energy changed to electrical energy
4. battery (charging): electrical energy changed to chemical potential energy

Yes, it looks like it should work. (If we were in class, we could discuss this)

Everytime (almost) that we change energy from one form to another, some of it is changed to heat. This heat is pretty much impossible to recover as useful energy. We'll see later that we can only get useful energy out of heat when it is concentrated, when it is very hot. Engineers are working on ways to extract energy from only slightly hot things (e.g only 10-20 degrees above ambient temperature), but you can never change all heat back into other forms of energy.

This is what really happens:

1. batteries: chemical potential energy changed to electrical energy + heat (the battery gets hot when discharging)
   wires carrying electricity: they heat up a tiny bit too:
2. light bulb (assume LED): electrical energy changed to light energy + heat (even an LED produces some heat)
3. solar panel: light energy changed to electrical energy + heat (panel absorbs some light and gets hot; it also reflects some. There is never 100% conversion of light to electricity – except with photosynthesis. I think that is almost 100% efficient.)
4. battery (charging): electrical energy changed to chemical potential energy+ heat (the battery gets hot when charging)

We do not see things running for ever. There are no perpetual motion machines. Why? Every time energy is changed from one for to another, some energy is always changed to heat and is "lost" (ie. no longer usable). It can no longer be used for work.

Look up "heat death of the universe" for more information.

➢ When you're told to "turn off the light, conserve energy" what do they mean?

You could answer: I am conserving energy since energy is always conserved. But I don't think that your parents would appreciate that.

➢ You could turn on all the lights in the house and leave the fridge door open and you'd still be conserving energy.

No, what your parents and others mean is:

Turn off the light. Don't change useful energy into useless energy that we can't use anymore. We have to pay for useful energy (electricity, natural gas, gasoline). Conserver our stores of useful energy.

How this applies to something like a car:

- A moving object has kinetic energy.
- To get a car moving, chemical potential energy (gasoline) is changed to kinetic energy (+heat).
- The car is now moving and will continue to move forever.
- To stop it, you have to remove the kinetic nergy from the car. Otherwise it will never stop.
- The main way of doing this is using brakes: KE → heat . Without brakes, friction with the air and the road will also slowly change KE into heat slowing the car.
- It's possible also to get all of the energy out very quickly: your car collides with something: KE → deformation + heat (A lot of the energy goes into bending and breaking the metal of the car)

Sample question:

How fast will a 0.5 kg rock be going when it hits the ground after being dropped from 2.0 m?

1) use old motion formulas first. $2a\Delta d = v_2^2 - v_1^2$ gives us v2 = 6.63 m/s

2) using conservation of energy:

E initial = Eg + Ek (since v=0, Ek=0)

= mgh

= (0.5kg)(9.8m/s2)(2m)

= 9.8 J

E final = Eg + Ek (since h=0, Eg = 0)

= ½ mv^2

= ½ (0.5kg)(v^2)

Now E initial = E final

.: $9.8J = 0.25\ v^2$

v = 6.26 m/s

Question: why do we need the mass using energy, but not when using the speed formulas?
Notice that masses cancel each other out! Neat!! Physics is self consistent and makes sense!!

NOTE that we are always using positive energies. In grade 12 we can look at negative energies, but here Ek is always positive and Eg is too (g = +9.8N/kg, Δh is height above ground)

I have a homework question that I'd like people to work on. I'll put it on Slack since I want different people to answer different parts of the question.