The conservation of energy

Astronomy 101
Syracuse University, Fall 2019
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Announcements

Exam 2 is next Thursday. That means:

- Review session 2-5 PM Monday in the Physics Clinic (by Walter)
- "Suggest-a-question" warmup question is on the course website

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I am behind answering messages. I hope to catch up tomorrow morning. Sorry!

We saw last time that Newton's two big ideas let us predict the motion of all the planets.

Newton's second law

$F = ma$ or $a = F/m$

Tells us the size of the acceleration created by any force

Gravitation

$$F_g = \frac{Gm_A m_B}{r^2}$$

Tells us how big the gravitational force is between two objects A and B whose centers are a distance r apart

Finish *Lecture Tutorials* pp. 29-32 if you haven't yet.

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... but we need a *supercomputer* to do that, and it takes either very hard math or a computer simulation to even get Kepler's second law out of them!

Kepler knew that there were underlying causes of his laws, but he wasn't good enough at math to discover them. Can we do better than Kepler? Can we find *general principles of physics* that give us insight without needing hard math?

The conservation of energy

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Energy comes in two kinds:

- Kinetic energy: the motion of objects
  - Heat, light, and sound energy are technically kinds of kinetic energy, but we usually call them by those names instead
- Potential energy: objects are in a place where they are attracted to each other
  - If I let them go, they'll move toward each other
  - *Potential* to become kinetic energy
  - Chemical energy is a kind of potential energy
  - The one we really care about is *gravitational potential energy*

The big idea: conservation of energy

Energy can never be created or destroyed.
It can only be changed from one form to another.

A pendulum swings back and forth: it converts gravitational potential energy to kinetic energy and back again.

This perspective is universal: all forces just convert energy from one sort into another

A short history of some energy:

- Hydrogen in the sun fuses into helium
- Hot gas emits light
- Light shines on the ocean, heating it
- Seawater evaporates and rises, then falls as rain
- Rivers run downhill
- Falling water turns a turbine
- Turbine turns coils of wire in generator
- Electric current ionizes gas
- Recombination of gas ions emits light

- Nuclear energy $\rightarrow$ thermal energy
- Thermal energy $\rightarrow$ light
- Light $\rightarrow$ thermal energy
- Thermal energy $\rightarrow$ gravitational pot. energy
- Gravitational PE $\rightarrow$ kinetic energy and sound
- Kinetic energy in water $\rightarrow$ KE in turbine
- Kinetic energy $\rightarrow$ electric energy
- Electric energy $\rightarrow$ chemical potential energy
- Chemical PE $\rightarrow$ light

The pendulum, revisited

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As it moves downward, what happens?

A: It converts some potential energy into kinetic energy
B: The Earth's gravity makes it accelerate down
C: Its total energy goes up, since its kinetic energy increases
D: Its total energy goes down, since its potential energy decreases
E: Its kinetic energy and potential energy both go up

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At its starting height it has no kinetic energy; to make it go higher, we'd need to get more energy from *somewhere* to convert into gravitational potential energy.

Complete the handout Tutorial.

After this, we'll discuss Exam 2 from last year.