The beginnings of physics

Astronomy 101
Syracuse University, Fall 2017
Walter Freeman

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Announcements

Exam 2 is next Tuesday. That means:

- Two warmup questions posted
  - One concerns the material we'll be talking about Thursday (the nature of science)
  - One is another Suggest-A-Question for the next exam
- I am not going to be able to hold extra prep hours for this exam, but the coaches might
- Once they send me their schedules I'll let you know

Today's class

I'm still sick and will try to minimize how much talking I do today.

There was no Lecture Tutorial on today's material, so I wrote one; if you don't have a copy, make sure you get one!

We'll be looking at that, plus a bunch of demonstrations!

Last time

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

$F_g = \frac{G m_A m_B}{r^2}$

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

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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?

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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.

We'll discuss it at the end of class.