Matter and Energy

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Opening Discussion

- Have you seen anything interesting in the news?
- What did we talk about last class?
- Quizzes and grades.

Science

- Science can be discovery driven or hypothesis driven.
- To be science we need three things:
  - Seek explanations for observations that rely on natural causes.
  - Progress through the creation and testing of models that explain things as simply as possible.
  - A scientific model must make testable predictions and when observations don't match, models are modified or discarded.
- A model that has stood up to repeated testing is elevated to the status of a theory.

Pseudoscience

- Claims that make statements about the observable world, but ignore evidence are called pseudoscience.
- In pseudoscience, people either make claims that are testable and ignore the evidence, or they make claims that are sufficiently vague as to be impossible to test.
- Unfortunately, pseudoscience looks like real science to most people. The best way to not be taken in is to have a better understanding of what we know from science. Science can have bias too, but with experimentation over time, the better model wins.

Astrology

- Historically astronomy and astrology was closely tied with the same people doing both. In many ways, astrology paid for early astronomy.
- The idea of astrology is that the positions of the Sun, Moon, and planets among the stars impacts our lives. In many ways it is true for the Sun and Moon in that they control seasons and tides. However, with what you now know about the stars and the planets you can fairly easily see that the claim that the location of the planets against the stars as seen from Earth quite literally has no impact upon you at all.

Matter

- Anything of substance is matter. We typically measure matter in units of kilograms. On the surface of the Earth, 1 kg weighs roughly 2.2 lbs.
- Note that lbs is not a measure of mass, it is a measure of weight. If you go to the Moon your weight drops by a factor of ~6. Your mass does not change.

Energy

- Energy comes in many forms. A simple view of energy is that it is what you need to move matter.
- The three main forms of energy are kinetic, potential, and radiative.
- In physics we use the Joule as the unit of energy. If you do everything in meters, kilograms, and seconds, you get Joules for energy.
- You are more used to seeing energy in units of Calories (1 Cal=1000 cal=4184 J).

Conservation of Energy

- While energy comes in many forms, it is never created nor destroyed. This is known as the law of conservation of energy.
- What happens instead is that energy changes from one form to another.

Kinetic Energy

- Moving things have kinetic energy. How much kinetic energy is given by the formula $E=\frac{1}{2}mv^2$.
- The more massive an object is, the more kinetic energy it has at a given speed.
- The faster an object of a given mass is, the more energy it has.
- Note that it grows faster with speed than it does with mass.
- If m is in kg and v is in m/s then E is in J. This tells us that $1J=1kg*m^2/s^2$.

Thermal Energy

- Random kinetic energy of atoms/molecules is typically called thermal energy.
- The temperature of an object is a measure of the average kinetic energy of the particles in it. Total thermal energy, or heat, also depends on particle density.
- While you are most used to the Fahrenheit temperature scale, scientists use Celsius or Kelvin more.

Potential Energy

- There are many forms of potential energy. The two we care about in astronomy are gravitational potential energy and mass-energy.
- Near the surface of the Earth, gravitational potential energy is given by $E=mgh$. ($g=9.8\ m/s^2$) When we talk about Newton's law of gravity we'll see what it is like more generally.
- Einstein also postulated that mass and energy were equivalent with a conversion of $E=mc^2$. Here c is the speed of light in a vacuum. This is what powers stars.

Exploring Energy

- Let's work through some simple problems to give you a feel for the power of the equations that we learned today.

Minute Essay

- Climbing to the back row of the lecture hall only gives me about 1 Cal of potential energy. Is that how much I actually burn? Why or why not?