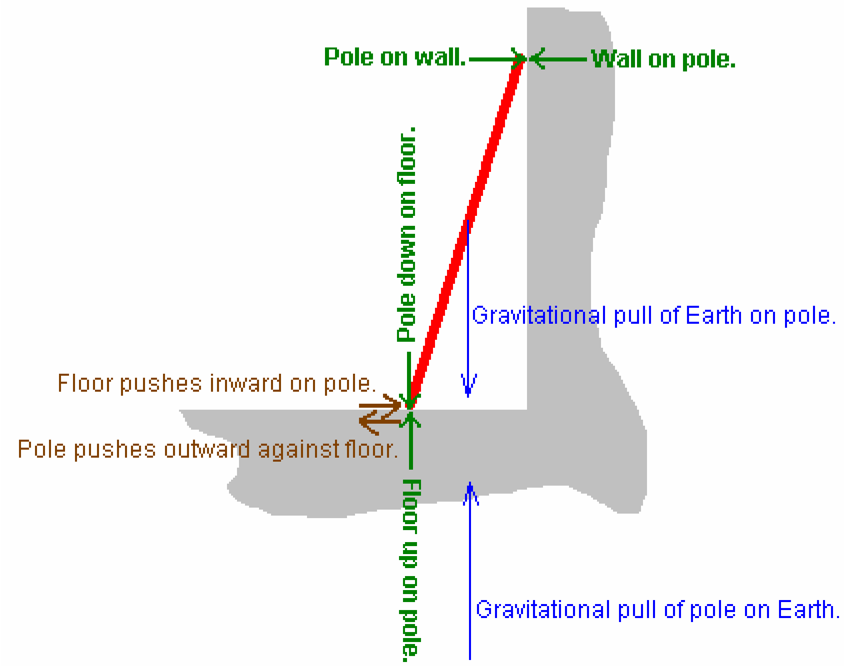
DAY 2

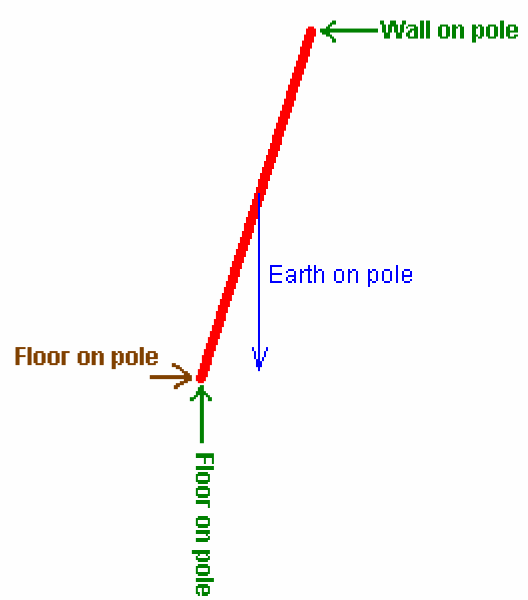
Summary of Primary Topics Covered

Free Body Diagram (FBD) – A diagram that shows an object by itself, with all forces that act on that object. It does not show other objects. It does not show forces that act on other objects.

At right is a sketch showing forces acting when a pole leans against a wall.



Below is an FBD of the pole itself. Note the only forces shown are those that act **on the pole**. This FBD allows us to better understand what the pole is doing. For example, since the pole is sitting motionless, it is not accelerating. Not accelerating means that there is no net force on the pole. No net force means all forces on the pole cancel out. The upward **"Floor on Pole"** force must cancel the downward **"Earth on Pole"**. The rightward **"Floor on Pole"** must cancel the leftward **"Wall on Pole"**.



Law of Conservation of Energy – *Energy cannot be created or destroyed, only changed in form.*

Energy is defined as ability to do a task or "work". Doing a task or work involves a force moving through a distance. If there is no motion then work is not done.

For example -- A bowling ball hangs in the classroom. The string that holds the ball exerts a force on it, but since there is no motion no work is done and energy is not relevant. The ball can hang there indefinitely, and that string can exert that force indefinitely. However, to lift the ball involves motion. A force is exerted to lift the ball and the force moves through a distance. Energy is required. That energy comes from food if a person lifts the ball, or from batteries or LGE if an electric motor lifts the ball. But whether the energy comes from food, batteries, or LGE – there will be a cost, and the use of energy cannot go on indefinitely.

Some types of energy:

Kinetic energy (energy a moving object possesses).

Gravitational Potential Energy (energy an object in a high place possesses).

Elastic Potential Energy (energy possessed by an object that is deformed and can snap back to its original shape).

Chemical Energy (possessed by gasoline, food, etc.)

Electrical Energy

Light / Electromagnetic Energy

Heat Energy

Sound Energy

Nuclear Energy

Law of Conservation of Momentum – *Momentum in a system is neither created nor destroyed.*

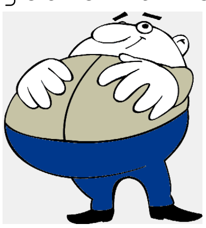
Momentum is a product of mass/inertia and velocity. Large, fast-moving objects have lots of momentum. A fast-moving freight train has lots of momentum. A fast-moving semi truck has less momentum, but even a slow-moving freight train may have more momentum than a fast-moving semi truck.

A slow-moving car would have the least momentum of all of these.

Power

Power is the rate at which work is done -- the rate at which energy is changed in form. A less powerful motor and a more powerful motor can each do the same amount of work, but the less powerful motor takes longer to do it.

A human body can do an indefinite amount of work, but the power it can produce is determined by the body's physical condition. Imagine you are a mover who has been given the job of unloading a truckload of books and carrying them up stairs to the second story of a house. If you are in lousy physical condition, you will only be able to carry a few books at a time, and you will need to stop frequently for rest. But, given enough time, you will be able to do the job.



On the other hand, if you are in good condition, you will be able to carry more books, move more quickly, and stop less for rest. You will get the job done in less time. Being in good condition means that your body's power output is greater.

Using Math

We have now covered some of the fundamental principles of physics – principles that form the basis for everything else we will do. However, at the moment we cannot put these principles to much use. If we wanted to build a better bicycle, or a safer child car seat, our knowledge as it now stands would not be very helpful. To be able to put this knowledge to real use, we need to add the language of measurement and mathematics.

Units

In this class we will use both English and metric units of measurement. Common units of distance measurement in the English system of measurement are *miles* and *feet*. Common units of time measurement in the English system are *hours*, *minutes*, and *seconds*. Units can be treated as algebraic quantities. For example, dividing units of distance by units of time yields units of speed, such as *miles/hour* (*mph*).

The English system used in the U.S. has its roots in medieval European systems in which it was important to be able to do simple halving and quartering calculations (because few people were formally educated). For this reason relationships like "4 quarts in a gallon" and "16 ounces in a pound" are common in the English system. Similarly, drill and bolts sizes in the English system are based on halves, quarters, eighths, sixteenths, etc. This makes the English system somewhat intuitive, which is probably why Americans resist leaving it for the system much of the rest of the world uses – the metric system.

The metric system was created in France following the French Revolution. It sought to create an easy-to-understand, easy-to-reproduce standard of length which would be known as the "meter". However, in one of the great triumphs of bureaucracy over reason, the meter ended up being defined in terms of the circumference of the Earth measured through a specific location in France! The metric system is decimal-based, however, and that makes it easy to use for calculations (if you are formally educated).

The common units of length in the metric system are the *meter*, *kilometer*, etc. Common time units are the same as the English system.

A special subset of the metric system, known as the SI units, is used heavily in physics. The SI unit of length is the *meter*. The SI unit of time is the *second*. The SI unit of speed would then be the *meter/second*, or *m/s*.

Example Problem #1:

A spring-powered toy such as what is often found in "Happy Meals" is wound up and released. Describe the energy transformations involved.

Solution:

- The kid winding up the toy is doing work. This work involves the transformation of food chemical energy ("Calories") into elastic potential energy (PE) stored in the spring.
- The work done by the kid is stored in the spring as elastic PE until she lets the toy go. Then the elastic PE is transformed into kinetic energy (KE) as the spring does work and makes the toy move.
- Ultimately the toy comes to a halt. Work was done by friction to turn the KE into heat energy. Sound energy was produced, too, but ultimately the sound will go into heat. The overall transformation is of "Calories" into heat with several intermediate steps in between.

Example Problem #2:

If there are 16 ounces (oz) in a pound (lb), and you have 1 lb of ground beef, can you measure it out by the oz without a special scale? If there are 1000 grams (g) in one kilogram (kg) and you have 1 kg of ground beef, can you measure it out in 100 gram units without a special scale?

Solution:

Take the 1 lb of beef and divide it in half. Now you have 8 oz. Divide that in half and you have 4 oz. Two more divisions will give you 1 oz of beef. If you do this carefully you can get a very accurate 1 oz.

You can't do this with grams and kilograms. Divide 1000 g of beef and you end up with 500 grams. You would now have to divide by 5, which is hard to do.