Simple Machines, Part1:
Energy and the Physical Setting

A softball bat hits a ball. A bucket is lifted up out of a well. Scissors clip coupons out of the paper. A dolly is pushed up a ramp at a warehouse. A homeowner uses a splitting wedge when chopping wood for the fireplace. All of these scenarios have something in common…what is it?

You might get a clue from the title of this email…or you might just recognize all of these as classic examples of **simple machines**. We've spent several weeks studying energy and ecosystems. Now we're moving from the living environment to the physical world, continuing our exploration of **energy**; this time it's **energy** and **simple machines**.

So what?

Ok, so why this email series? *Energy and ecosystems*, sure, they're part of our everyday world of living things. But how are **energy** and **simple machines** related, and what's so important about this relationship?

Simple…they are part of our everyday world of *non*-living things. For instance, without simple machines, we'd never have these jokes[1]:

- How many mystery writers does it take to screw in a light bulb?
  Two. One to screw the bulb almost all the way in, and one to give a surprising twist at the end.
- How many optimists does it take to screw in a light bulb?
  None, they're convinced that the power will come back on soon.
- How many procrastinators does it take to screw in a light bulb?
  One, but he has to wait until the light is better.

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OK, well, maybe you can do without those particular jokes, but what about a hammer? A playground slide? A doorknob? A screwdriver? A knife? All of these are examples of simple machines that get used everyday, all over the world.

The case for energy

Simple machines seem pretty important, but why bring **energy** into the discussion? Let's work backwards. We use **simple machines** to do *work*, and **energy** is the ability to do *work*. Simple machines do *work* in different ways. We can use taking a pressed-on cap off a soda bottle to illustrate how simple machines do *work*.

Position 1

Position 2

Position 2

1. Bottle with bottle opener at "start position;" hand has not done work on bottle opener. (Position 1)
2. Bottle opener at "finish position;" cap has been released. (Position 2)

When you push up on the bottle opener, the bottle opener pushes up on the cap and moves the cap upward. The bottle opener, a **simple machine**, does *work* on the cap.

That brings us to energy, which we've defined in terms of **work**[2]:

<u>**Work**</u> is done when:

- A ***force*** is applied on an object, *and*
- The object moves in the direction of the ***force***, *and*
- The ***force*** and motion occur simultaneously.

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But the bottle opener is an inanimate object. It does *work* on the cap only if you supply the **energy**. To get the cap off the bottle, you did *work* on the bottle opener. You pulled up on the bottle-opener, and it moved in the direction of the force you exerted.

And where did you get the energy to do work on the bottle opener? From the food you ate.

So that's the relationship between **simple machines** and **energy**. You use the energy you get from the food you eat to do *work* on simple machines, and then the simple machines do *work*.

So why do we use **simple machines**? They allow us to multiply force and to change the direction of forces.

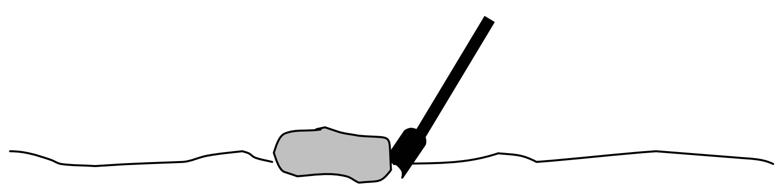
Multiplication of Force

Think again about using the bottle opener.

If you were incredibly strong, you might be able to pry the cap off a bottle of soda using your fingers. (Don't even think about using your teeth.) But for the rest of us, we need a bottle opener. Instead of just using fingers to pry up the cap, we need to move the bottle opener from position 1 to position 2 (see pictures above). The *force* you apply to the bottle opener is less than the *force* you would have to apply to the cap to remove it. The *force* the bottle opener exerts on the cap is greater than the *force* you exert on the bottle opener. The bottle opener allows you to *multiply the force* on the cap.

Changing Direction of Force

Now think about using a shovel to lift a heavy stone. The shovel is a **simple machine**.



When you push down on the handle of the shovel, the shovel pushes up on the stone.
The shovel is a **simple machine** that changes the direction of the force. (It also multiplies the force on the stone.)

Why do we use the shovel to change the direction of the force? We want the stone to move up out of the ground, but it is physiologically much easier for us to push down, and we have gravity working on our side.

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Simple machines enable us to multiply the force we can exert and to change the direction of the force we exert. However, using **simple machines** is not without cost. This cost-benefit is a **trade-off.** That leads us to a question to consider during the upcoming week:

Coming up

Here are some examples of simple machines in action. For each one, see if you can identify:

- What's the benefit for using the machine; are you multiplying the force or are you changing direction of the force?
- What's the **trade-off**? What price do you have to pay for using the simple machine?

1. **You use a hammer to pry a nail out of the wall.**
2. **You push a box up a ramp.**
3. **You use a pulley to raise a flag.**

We'd love to hear your thoughts on these!

What do the NYS standards say?

Elementary Core Curriculum, Standard 4, The Physical Setting,

Major Understanding states:

- 5.1f Mechanical energy may cause change in motion through the application of force and through the use of simple machines such as pulleys, levers and inclined planes.

Intermediate Core Curriculum, Standard 4, The Physical Setting,

Major Understandings state:

- 5.2f Machines can change the direction or amount of force, or the distance or speed of force required to do work.
- 5.2g Simple machines include a lever, a pulley, a wheel and axle, and an inclined plane. A complex machine uses a combination of interacting simple machines, e.g., a bicycle.

[1]http://www.energyquest.ca.gov/games/jokes/light_bulb.html
[2]from Energy Part I: Work, 10/01/03, http://crsep.org/ScienceInquiriesbyEmail.htm

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