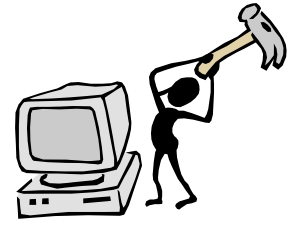


## SCIENCE BACKGROUND FORCE, MOTION AND ENERGY: SIMPLE MACHINES 3.2



In our daily lives we all do work. Students write papers and solve math problems, farmers plant and harvest crops, and carpenters build houses. In science, work has a different definition. Work is a measure of effort that is calculated by multiplying force times distance. That might sound complicated at first, so let's clear things up a little with an example:

Imagine that you need to lift a 10-pound bowling ball from the floor to a rack 3 feet off of the floor. The force on the bowling ball is the force of gravity – and it's a force of 10 pounds. The distance that you have to lift the ball is three feet. Here's our formula:

$$\text{Work} = \text{Force} \times \text{Distance}$$

So...

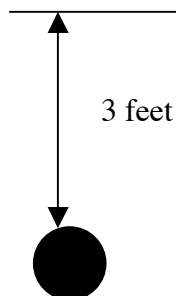
$$\text{Work} = 10 \text{ pounds} \times 3 \text{ feet} = 30 \text{ foot-pounds}$$

It's important to understand this formula because it will help you understand simple machines. Let's get started!

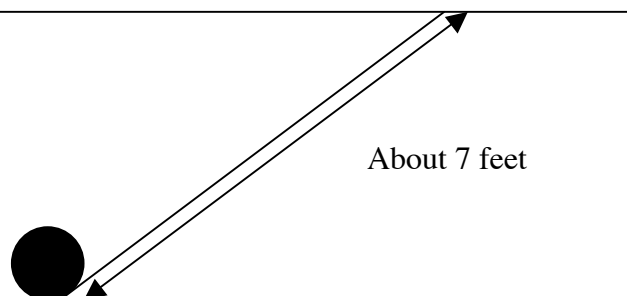
First, a definition: A simple machine is something that helps us do work, either by reducing force needed or by changing the direction of the force needed.

**But there's a catch...** We've all seen those infomercials on TV that promise something amazing for only a few easy payments of \$29.99. Then we find out that there is a giant shipping and handling charge and the deal doesn't seem as great as we were led to believe. Simple machines do help us do work by reducing force needed, but the distance part of the formula is increased. If we think about our bowling ball, at first we moved it a distance of three feet, but it was pretty heavy. If we used a ramp and rolled our ball to the three-foot rack, it would be easier, but we'd have to move the ball farther. Take a look.

Example #1



Example #2



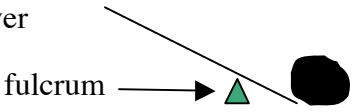
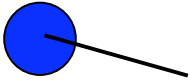
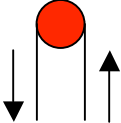


Either way, we do 30 foot-pounds of work, but if the distance increases to 7 feet, our force needed is less. Let's go back to the formula:

$$30 \text{ foot-pounds} = \text{force} \times 7 \text{ feet}$$

$$30 \text{ foot-pounds} = 4.29 \text{ pounds} \times 7 \text{ feet}$$

That's 4.29 pounds of force needed instead of 10 pounds – less than half. As you can see, there is a trade-off, but most of us are happy to trade force needed for distance and we use simple machines constantly every day.

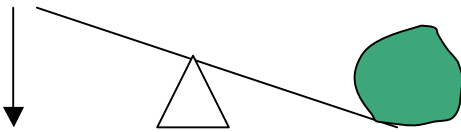
### **SIMPLE MACHINES TYPES AND EXAMPLES YOU MIGHT RECOGNIZE...**

Simple Machine Type	Examples	Purpose
Lever 	crow bar, seesaw, shovel	to lift heavy objects or to pull objects apart
Wheel and Axle 	crank, screw driver, ratchet	to turn objects
Pulley 	pulley	to lift heavy objects
Inclined Plane and its variations:  The Wedge (a moveable inclined plane)  The Screw (a twisted inclined plane)	ramp, staircase  axe, knife  corkscrew, screw, vise, spiral staircase	to lift heavy objects  to split objects or pull them apart  to squeeze objects together, to move an object in any direction

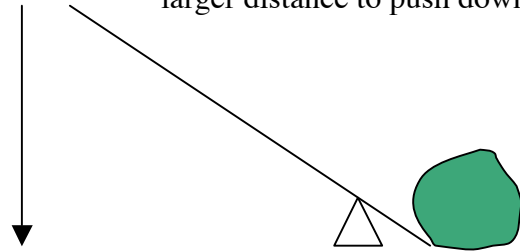
## SOME ADDITIONAL INFO ABOUT SIMPLE MACHINES...

**Levers** turn on a **fulcrum**. As the fulcrum is moved toward the object to be moved, the work gets easier, but the distance increases. We can also say that with the same amount of work, we can exert more force. Take a look:

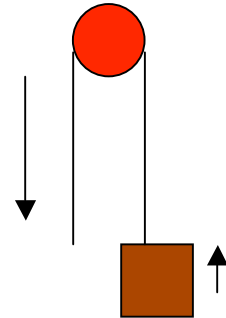
It's hard to lift, but there's a small distance to push down.



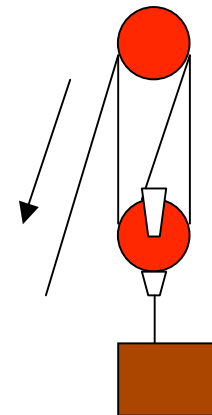
It's easier to lift, but there's a larger distance to push down.



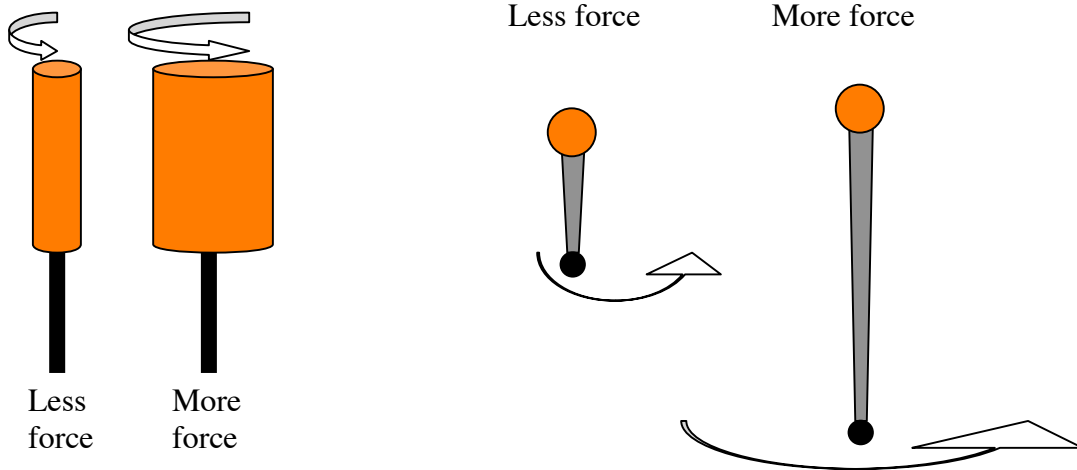
A single **pulley** can be used to change direction of force applied. This allows it to pull down, or to lift something up. When we pull down, the force of gravity pulling on our bodies helps us. When we pull up, we have to lift both the object and the part of our body that's moving up.



Multiple pulleys can be used together to make lifting easier by trading force for distance. In this case you need to pull farther, but it's easier.



A **wheel and axle** helps us turn or twist items more easily, or increases the force we can turn with if work remains the same. A screwdriver uses the wheel and axle. The larger the handle, the more turning force we have. Another example is a crank. The longer the handle, the more turning force we have.



### COMPOUND MACHINES

Many of the tools we use are **compound machines**, meaning they use more than one type of simple machine or more than one of the same simple machine. Here are a few examples:

Compound machine	Simple machines used
Pencil sharpener	Wheel and axle (crank), screw (cutting blades)
scissors	Lever (handles), wedge (cutting blades)
shovel	Lever (handle), wedge (digging blade)
Can opener	Wheel and axle (turning handle), wedge (cutting blade), lever (squeezing handle)