SUPERCHARGED SCIENCE

Unit 4: Energy (Part 1)

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Appropriate for Grades:
Lesson 1 (K-12), Lesson 2 (K-12)
Duration: 6-15 hours, depending on how many activities you do!

Energy is the mover and shaker of the universe. Heat from the Sun, sounds from your radio, riding a bike and watching a movie are all expressions of different forms of energy. As you sit there reading this, there is energy flowing all around you in the form of light waves, sound waves, radio waves, heat and more. You are constantly being bombarded by energy. Energy is everywhere, all the time. We're going to focus on pulleys, levers, and simple machines. Are you ready to get started?

Table of Contents

Materials for Experiments

How many of these items do you already have? We've tried to keep it simple for you by making the majority of the items things most people have within reach (both physically and budget-wise), and even have broken down the materials by experiment category so you can decide if those are ones you want to do. *NOTE: This material list is for the entire Experiment section online.*

Pulleys
50'+ Rope (use nylon rope with >200 pound tensile strength that fits through your pulleys)
Pulleys (at least 6 small ones)
Fishing line and one small pulley
Two broomsticks (or use a tree)
Pen (any size)
Large, heavy nut
6" length of ½" PVC pipe
Wire coat hanger
Thread spool
Vice grips and pliers

Optional: Thick slab of wood to make a pulley-swing
Optional: Roller skate (the old-fashioned kind with a wheel at each corner) and a large rubber band

Levers
Stud (2×4x96" or other long, strong piece of scrap wood to play with)

Hydraulic/Pneumatic Earth Mover (You may order this as a kit from us at a discounted price – includes everything here except for the tools.)

Disposable plastic cup
20+ tongue-depressor-size popsicle sticks
6 syringes (anything in 3-10mL size range will work)
6 brass fasteners
Thin wire or narrow zip ties
5' of flexible tubing (fits over the nose of syringes)
four wheels (use film canister lids, yogurt container lids, milk jug lids...)
4 rubber bands
two naked (unwrapped) straws
skewers that fit inside your straws
hot glue gun (with glue sticks)
sharp scissors or razor (get adult help)
drill with small drill bits (you'll be drilling holes large enough to fit the stem of a brass fastener)

Optional Additional Items for For Grades 9-12:

Trebuchet (order from us at a discounted price).

Key Vocabulary

Energy is the ability to do work.

Force is a push or a pull, like pulling a wagon or pushing a car.

Mechanical advantage is simply how many times easier it is to lift an object using a simple machine. Officially, mechanical advantage is the factor by which a mechanism multiplies the force put into it. A simple machine with a mechanical advantage of 100 could lift a 100 pound load with the effort of one pound.

Power measures how quickly work can be done. Mathematically, power is work divided by time. Power can be measured in horsepower or Watts.

Pulleys, like all simple machines, sacrifice distance for force. The more distance the effort moves, the less force is needed to lift the load. The **pulley** is a very powerful **simple machine**.

Simple machines give you mechanical advantage. A major job of simple machines is to decrease the force needed to move something. The more pulleys that are rigged together, the more effective a pulley system can be.

Work is moving something against a force over a distance. Mathematically, work = force x distance. Work can be measured in Joules or calories.

Unit Description

Energy is the mover and shaker of the universe. Heat from the Sun, sounds from your radio, riding a bike and watching a movie are all expressions of different forms of energy. As you sit there reading this, there is energy flowing all around you in the form of light waves, sound waves, radio waves, heat and more. You are constantly being bombarded by energy. Energy is everywhere, all the time. We're going to focus on pulleys, levers, and simple machines. Are you ready to get started?

Objectives

Lesson 1: Levers

We're beginning a block on energy. I'm not going to lie to you… this stuff is tough. At least at first. Many of these concepts are quite abstract and it takes a while for them to sink in.

The first bit will focus on some of the major definitions of energy so that you can get a feel for what energy is and what it does. Then we will begin to learn about some of the many forms of energy (sound, thermal, light, heat, electrical) and what they do. Are you ready? Let's get going.

Highlights:

- Energy is the ability to do work.
- Work is moving something against a force over a distance.
- Mathematically, work = force x distance.
- Work can be measured in Joules or calories.
- Power measures how quickly work can be done.
- Mathematically, power is work divided by time.
- Power can be measured in horsepower or Watts.
- Next lesson we will deepen our study of energy by investigating the two main categories of energy, potential and kinetic.

Objectives

Lesson 2: Pulleys

When we played with levers we could see that, by using a simple machine, we were able to use less force to move a heavy object than we would have had to use if we didn't use a simple machine. We also saw that with that lessening of force came an increase in distance.

Obviously, you can only make a lever so long. After a while it gets kind of ridiculous. Imagine lifting a concrete block or a car with a lever. That's a big lever and you probably still wouldn't be able to lift the car very high. This is where pulleys come in. Are you ready? Let's get going.

Highlights for Solids:

- The pulley is a very powerful simple machine.
- A major job of simple machines is to decrease the force needed to move something.
- Flag poles, fishing rods, cranes, window blinds, and wishing wells all have pulleys.
- The more pulleys that are rigged together, the more effective a pulley system can be.
- Pulleys, like all simple machines, sacrifice distance for force. The more distance the effort moves, the less force is needed to lift the load.
- Simple machines give you mechanical advantage.
- Mechanical advantage is simply how many times easier it is to lift an object using a simple machine. Officially, mechanical advantage is the factor by which a mechanism multiplies the force put into it. A simple machine with a mechanical advantage of 100 could lift a 100 pound load with the effort of one pound.

Textbook Reading

Everything in the entire universe can be categorized into two things, matter and energy. As a matter of fact, according to Einstein and some relatively new physics theories (string theory) even matter is actually energy incarnate. Energy can become matter and matter can become energy. Makes your head spin, right? So what is *energy*?

What is Energy?

Energy has a number of different forms; kinetic, potential, thermal, chemical, electrical, electrochemical, electromagnetic, sound and nuclear. All of which measure the ability of an object or system to do work on another object or system. In the physics books, **energy is the ability to do work**.

What is Work?

Work is the exertion of force over a distance. In our mechanics block we defined force as a push or a pull. So, work is when something gets pushed or pulled over a distance against a force. Mathematically it's *Work = Force x Distance* or $W = fd$.

Let me give you a few examples: If I was to lift an apple up a flight of stairs, I would be doing work. I would be moving the apple against the force of gravity over a distance. However, if I were to push against a wall with all my might, and if the wall never moved, I would be doing no work because the wall never moved. (There was a force, but no distance.)

Another way to look at this, is to say that **work is done if energy is changed**. By pushing on the non-moving wall, no energy is changed in the wall. If I lift the apple up a flight of stairs however, the apple now has more potential energy then it had when it started. The apple's energy has changed, so work has been done. (We'll define potential energy more in another lesson.)

How is Energy Measured?

If we wish to talk about energy further, we need to have a unit of measurement. For energy, a couple of units are the *Joule* and the *calorie*. A Joule is the energy needed to lift one Newton one meter. A *Newton* is a unit of force. One Newton is about the amount of force it takes to lift 100 grams or 4 ounces or an apple.

It takes about 66 Newtons to lift a 15 pound bowling ball and it would take a 250 pound linebacker about 1000 Newtons to lift himself up the stairs! So, if you lifted an apple one meter (about 3 feet) into the air you would have exerted one *Joule* of energy to do it.

The *calorie* is generally used to talk about heat energy and you may be a bit more familiar with it due to food and exercise. A calorie is the amount of energy it takes to heat one gram of water one degree Celsius. Four Joules are about one calorie. (Note - when most people talk about calories, they refer to Calories with a capital C (AKA 'kCal' or kilo-calories) which is 1,000 calories. For example, if a soda has 160 Calories, it has 160,000 calories!)

Who Cares?!

We spent a lot of time on this strange concept called work. Work happens when something moves a distance against a force. Swell...*who cares*?! Well, believe it or not, this is truly one of the most useful concepts in physics. I'm willing to bet you spend a lot of your time moving things a distance against a force.

Do you ever climb stairs, walk, ride a bicycle, or lift a fork to your mouth to eat? Of course you do. Each one of those things requires you to move something a distance against a force. You're using energy and you're doing work.

Work is not that hard...it's force that can be difficult. Imagine getting up a ten step flight of stairs without a set of stairs. Your legs don't have the strength/force for you to jump up, you'd have to climb up or find a ladder or a rope. The stairs allow you to, slowly but surely, lift yourself from the bottom to the top.

Now imagine you are riding your bike and a friend of yours is running beside you. *Who's got the tougher job?* Your friend right? You could go for many miles on your bike but your friend will tire out after only a few miles. The bike is easier (requires less force) to do as much work as the runner has to do.

Now here's an important point, you and your friend do about the same amount of work. You also do the same amount of work when you go up the stairs verses climbing up the rope. The work is the same, but the force needed to make it happen is much different. Don't worry if that doesn't make sense now. As we move forward, it will become clearer.

Highlights for Energy

Energy is the ability to do work.

Work is moving something against a force over a distance.

Mathematically, work = force x distance.

Work can be measured in Joules or calories.

Power measures how quickly work can be done.

Mathematically, power is work divided by time.

Power can be measured in horsepower or Watts.

Next lesson we will deepen our study of energy by investigating the two main categories of energy, potential and kinetic.

Simple Machines

This "making the force less" thing is where simple machines come in. Way back when, folks needed to move stuff. Long before there were cranes and bulldozers. They needed to move heavy stuff, rocks, boulders, logs, boats etc. These clever folks discovered machines. **A machine, in science language, is any device that transmits or modifies energy.** In other words, energy is put in to the machine and comes out of the machine but along the way the energy does work, changes direction, changes form or all of the above.

We're going to focus on the fact that machines can allow you to use less force to do work. Most folks say that there are six simple machines. These are the inclined plane, the wheel and axle, the lever, the pulley, the wedge, and the screw. Every machine with moving parts, from a tape player to a car, from a computer to a freight train is made up of simple machines. We are going to spend time with two of the simple machines. By learning how they work you will get a nice picture of all the simple machines and what they do. In this lesson, we will be spending some quality time with levers and in the next lesson we will spend time with pulleys.

The Power of Simple Machines

Archimedes (286 to 212 B.C.) said "Give me a place to stand and I can move the Earth." As you can see, Archimedes was quite fond of simple machines. In fact, he was a master of all the simple machines. He did not invent them but he did put them to some amazing uses.

For example, a story goes that the Greek King Hiero had a problem. He had had a boat made that was so large no number of men could get it into the water. What good is a boat that is stuck on land? The king told Archimedes his problem and Archimedes said "Pfffft, I can launch that boat with one hand!"

Sure enough after several days, Archimedes created a system of levers and pulleys that allowed him to move the boat by himself...with one hand.

According to one version of the story, the king did not believe that Archimedes was doing it on his own and that there must be some trick. Archimedes said, "Okay, you do it." The king hesitantly gave it a try and sure enough, in front of a huge crowd, the king moved the ship. At that point, the king shouted out, "From this day forth, Archimedes is to be believed in everything that he may say".

Archimedes was an unbelievable scientist and mathematician. There are many terrific stories surrounding his life and discoveries. I would highly recommend taking the time to look into him a bit further.

The Lever

So what is this lever thing anyway? Well, at it's most basic level, it's a stick and a rock...pretty simple machine huh? The lever is made up of two parts, the lever (the stick part) and the fulcrum (the rock part). Believe it or not, using this very simple machine you can lift hundreds of pounds with your bare hands and very little effort.

Highlights for Simple Machines

Most folks say there are six simple machines. They are the inclined plane, the wheel and axle, the lever, the pulley, the wedge, and the screw.

All machines with moving parts are made up of simple machines.

A machine is any device that transmits or modifies energy.

Simple machines are often used to reduce the amount of force it takes to move something.

Work in equals work out. Although as you'll see later, work out is always less due some work being lost to heat and sound.

Simple machines usually sacrifice distance for force. The amount the effort moves is much more then the amount the load moves. However, the force the effort needs to push with to move the load is much less.

Levers have three different parts. The lever, the load and the effort.

There are three different kinds of levers.

A first-class lever is a lever in which the fulcrum is located in between the effort and the load.

In a second-class lever, the load is between the fulcrum and the effort.

The third-class lever has the effort between the load and the fulcrum.

The Pulley

When we played with levers we could see that, by using a simple machine, we were able to use less force to move a heavy object than we would have had to use if we didn't use a simple machine. We also saw that with that lessening of force came an increase in distance.

Obviously, you can only make a lever so long. After a while it gets kind of ridiculous. Imagine lifting a concrete block or a car with a lever. That's a big lever and you probably still wouldn't be able to lift the car very high. This is where pulleys come in.

By the use of a pulley (otherwise known as a block and tackle), car mechanics lift 600 lb car engines with one hand! Cranes that lift steel girders and thousand pound air conditioning units are basically pulleys! (By the way, Archimedes is credited for inventing the crane. He actually used a crane as a weapon to defend Syracuse from Rome. When the Roman ships got close to the Syracuse walls, Archimedes' crane would grab them and turn them over! Go science!)

Mechanical Advantage

There's one more thing I'd like to add here, is the concept of mechanical advantage. The definition of mechanical advantage is that it is the factor by which a mechanism multiplies the force put into it. The whole idea behind simple machines is that they give you an advantage. In other words, they help you do things more easily.

The nice thing about pulleys is that it is very easy to see the mechanical advantage. You noticed when you used one pulley that it took about the same amount of effort to lift the load. That would be a mechanical advantage of one. However, when you used two pulleys, half the effort lifted the load. You only had to pull half as hard to lift the load. The pulleys doubled your strength. In this case, the mechanical advantage is two.

Can you guess what the mechanical advantage was of three pulleys? Yup, three. The pulleys tripled your strength. Who needs exercise when you have pulleys?

So, you ready to do some weight lifting? The best way to learn about this is to actually try it out. Let's start on your experiments right now!

Highlights for Pulleys

The pulley is a very powerful simple machine.

A major job of simple machines is to decrease the force needed to move something.

Flag poles, fishing rods, cranes, window blinds, and wishing wells all have pulleys.

The more pulleys that are rigged together, the more effective a pulley system can be.

Pulleys, like all simple machines, sacrifice distance for force. The more distance the effort moves, the less force is needed to lift the load.

Simple machines give you mechanical advantage.

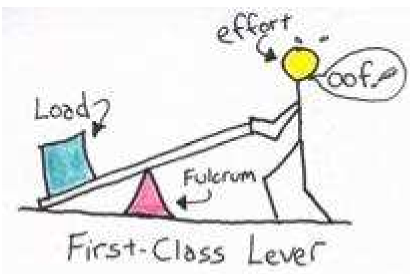
Mechanical advantage is simply how many times easier it is to lift an object using a simple machine. Officially, mechanical advantage is the factor by which a mechanism multiplies the force put into it. A simple machine with a mechanical advantage of 100 could lift a100 pound load with the effort of one pound.

Activities, Experiments, Projects

Lesson 1: Levers

Note: This section is an abbreviated overview of the experiments online.

Experiment: First Class Lever



A first-class lever is a lever in which the fulcrum is located in between the effort and the load. This is the lever that you think of whenever you think of levers. The lever you made in Experiment 1 is a first-class lever. Examples of first-class levers are the see-saw, a hammer (when it's used to pull nails), scissors (take a look, it's really a double lever!), and pliers (same as the scissors, a double lever).

For this experiment, you'll need:

1. A nice strong piece of wood. 3 to 8 feet long would be great if you have it.
2. A brick , a thick book or a smaller piece of wood (for the fulcrum)
3. Books, gallons of water or anything heavy that's not fragile

Be careful with this. Don't use something that's so heavy someone will get hurt. Also, be sure not to use something so heavy that you break the wooden lever. Last but not least, be sure to keep your head and face away from the lever. I've seen folks push down on the lever and then let go. The lever comes up fast and can pop you pretty hard.

1. Put your fulcrum on the ground.

2. Put your lever on the fulcrum. Try to get your fulcrum close to the middle of the lever.

3. Put some weight on one end of the lever.

4. Now push down on the other side of the lever. Try to remember how hard (how much force) you needed to use to lift the heavy object.

5. Move the fulcrum under the lever so that it is closer to the heavy object.

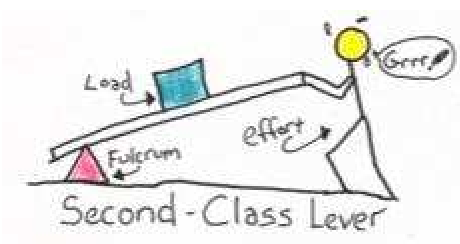
6. Push down on the other side of the lever again. Can you tell the difference in the amount of force?

7. Move the fulcrum closer still to the heavy object. Feel a difference now?

8. Feel free to experiment with this. Move the fulcrum farther away and closer to the object. What conclusions can you draw?

What you may have found, was that the closer the fulcrum is to the heavy object, the less force you needed to push with to get the object to move. Later we will look at this in greater detail, but first let me tell you about the other types of levers.

Experiment: Second-Class Lever



The second-class lever is a little strange. In a second-class lever, the load is between the fulcrum and the effort. A good example of this, is a wheel-barrow. The wheel is the fulcrum, the load sits in the wheel-barrow bucket and the effort is you. Some more examples would be a door (the hinge is the fulcrum), a stapler, and a nut-cracker.

You need:

1. A nice strong piece of wood. 3 to 8 feet long would be great if you have it.
2. A brick, a thick book or a smaller piece of wood (for the fulcrum)
3. Books, gallons of water or anything heavy that's not fragile

Again, be careful with this. Don't use something that's so heavy someone will get hurt. Also, be sure not to use something so heavy that you break the wooden lever. Last but not least, be sure to keep your head and face away from the lever. I've seen folks push down on the lever and then let go. The lever comes up fast and can pop you pretty hard.

1. Put your fulcrum, the book or the brick, whatever you're using on a nice flat spot.

2. Put the end of your lever on the fulcrum.

3. Put the books or gallon jugs or whatever you're using for a load, in the middle of the lever.

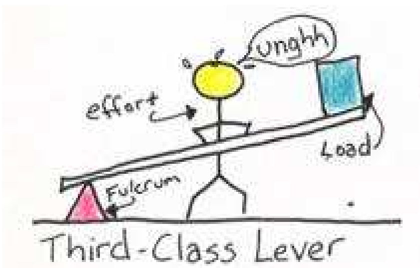
4. Now, put yourself (the effort) on the opposite end of the lever from the fulcrum.

5. Lift

6. Experiment with the load. Move it towards the fulcrum and lift. Then move it toward the effort and lift. Where is it harder(takes more force) to lift the load, near the

fulcrum or far? Where does the load lift the greatest distance, near the fulcrum or far?

Experiment: Third-Class Lever



This fellow is the oddest of all. The third-class lever has the effort between the load and the fulcrum. Imagine Experiment 1 but this time the fulcrum is at one end of the board, the books are on the other end and you're in the middle. Kind of a strange way to lift books huh?

A few examples of this are tweezers, fishing rods (your elbow or wrist is the fulcrum), your jaw (the teeth crush the load which would be your hamburger), and your arm (the muscle connects between your elbow (fulcrum) and your load(the rest of your arm or whatever you're lifting)). Your skeletal and muscular system are, in fact, a series of levers!

You need:

1. A nice strong piece of wood. 3 to 8 feet long would be great if you have it.
2. A brick , a thick book or a smaller piece of wood (for the fulcrum)
3. Books, gallons of water or anything heavy that's not fragile

Again, be careful with this. Don't use something that's so heavy someone will get hurt. Also, be sure not to use something so heavy that you break the wooden lever. Last but not least, be sure to keep your head and face away from the lever. I've seen folks push down on the lever and then let go. The lever comes up fast and can pop you pretty hard.

1. Put your fulcrum on the ground in a nice flat place.

2. Put your lever on the fulcrum so that the fulcrum is at the very end of the lever.

3. Put your load on the lever at the end farthest from the fulcrum.

4. Now, put yourself (the effort) in the middle of the lever.

5. Lift. You may need someone to hold down the lever on the fulcrum

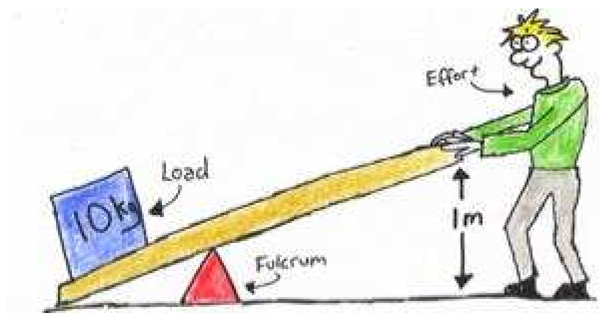
6. Experiment with the effort (you). Move towards the fulcrum and lift the load Then move toward the load and lift. Where is it harder(takes more force) to lift the load, near the fulcrum or far? Where does the load lift the greatest distance, near the fulcrum or far?

We've had a lot of fun levering this and levering that but now we have to get to the point of all this simple machine stuff. Work equals force times distance, right? Well, what have you been doing all this time with these levers? You've been moving something (the load) a distance against a force (gravity). You've been doing work. You've been exerting energy. See how it all ties in nicely?

In experiment 1,2 and 3, I wanted you to notice how much force you exerted and how much the load moved. You may have noticed that when the force was small (it was very easy to lift) the load moved a very small distance. On the other hand, when the force was large (hard to lift), the load moved a greater distance. Let me point your attention to one more thing and then we'll play with this.

When the force used to lift the load was small, you moved the lever a large distance. When the force used to lift the load was great you moved the lever a small distance. Remember, work=force x distance. There is work done on both sides of the lever. The effort (you in this case) pushes the lever a distance against a force…work is done. The load also moves a distance against a force so there too…work is done.

Now, here's the key to this that I hope you can see in the next experiment. Work in is equal to work out. The work you do on one side of the lever (work in), is equal to the work that happens to the load (work out). Let's do a quick bit of math for an example. Phillip wants to move a 10 kg (22 lb.)box. He uses a lever and notices that when he lifts the box .1meter (4 inches) he has to push the lever down 1 meter with a force of 1 kg. Now let's do some math. (Officially we should convert kilograms (a unit of mass) to Newtons (a unit of force) so that we can work in Joules which is a unit of work. However, we'll do it this way so you can see the relationship more easily.)



Phillip's work (the work in) = 1 kg x 1 m = 1

Work on the bowling ball (the work out) = 10 kg x .1 m = 1

Work in equals work out! Later in this energy unit, you'll learn about energy efficiency. At that point, you'll see that you never get all the energy you want from the energy you put in. Some is lost to sound and some to heat. A lever is incredibly efficient but you may still see, in your measurements, that the energy in is greater than the energy you get out.

For Grades 9-12:

Speaking of your measurements…let's make some. Open up your science journal and record the type of lever, weight, and location information for your different trial runs. Take a look at your data – can you figure out how much weight you'd need to lift your parents?

Let's see if we can figure this out. For a 10′ long beam with the fulcrum in the exact center, you can lift as much as you weigh. For example, if you weigh 100 pounds, you can lift some sitting on the other end, as long as they weigh 100 pounds or less. If you slide the beam and move the fulcrum so that the longer end is on your side, you can lift more than you weigh.

So if there's 7 feet of beam on Alice's side and only 3 feet on Bob's end, you can easily figure this out with a little math (and principles of torque). Here's what you do:

(Alice's Weight) * (Distance from Alice to the Fulcrum) = (Alice's Lifting Ability) * (Distance from Bob to the Fulcrum)

If Alice weighs 100 pounds and when standing on the 7-foot end of the see saw, she barely can lift Bob, let's find out how much Bob weighs.

(100 pounds) (7 feet) = (Alice's Lifting Ability) * (3 feet)

700 / 3 = Alice's Lifting Ability, and since she can just barely lift Bob…

Bob weighs 233 pounds!

Now can you figure out how much lever arm distance you need to lift your parents? If Mom and Dad together weigh 300 pounds, and you have a 10′ long beam and you weigh 100 pounds, let's find the fulcrum distance you'd need to lift them. Let's put your algebra to use here:

Let's make 'x' the distance from you to the fulcrum. This makes the distance from your parents to the fulcrum 10′ – x. (If you're 4 feet from the fulcrum, that means your parents are 6′, right?)

(100 pounds) (x) = (300 pounds) (10′ – x)

100 x = 3000 – 300 x

400 x = 3000

x = 3000 / 4

Solve for x and you'll find that the **distance from you to the fulcrum is 7.5 feet!**

Activities, Experiments, Projects

Lesson 2: Pulleys

Note: This section is an abbreviated overview of the experiments online.

Experiment: Simple Pulleys

Are you curious about pulleys? This set of experiments will give you a good taste of what pulleys are, how to thread them up, and how you can use them to lift heavy things. Are you ready?

For this experiment, you will need:

- One pulley (from the hardware store… get small ones that spin as freely as possible. You'll need three single pulleys or if you can find one get a double pulley to make our later experiment easier.)
- About four feet of string
- 2 paper cups
- many little masses (about 50 marbles, pennies, washers etc.)
- Yardstick or measuring tape
- A scale (optional)
- 2 paper clips
- Nail or some sort of sharp pokey thing
- Table

1. Take a look at the video to see how to make your "mass carriers". Use the nail to poke a hole in both sides of the cup. Be careful to poke the cup…not your finger! Thread about 4 inches of string or a pipe cleaner through both holes. Make sure the string is a little loose. Make two of these mass carriers. One is going to be your load (what you lift) and the other is going to be your effort (the force that does the lifting).

2. Dangle the pulley from the table (check out the picture).

3. Bend your two paper clips into hooks.

4. Take about three feet of string and tie your paper clip hooks to both ends.

5. Thread your string through the pulley and let the ends dangle.

6. Put 40 masses (coins or whatever you're using) into one of the mass carriers. Attach it to one of the strings and put it on the floor. This is your load.

7. Attach the other mass carrier to the other end of the string (which should be dangling a foot or less from the pulley). This is your effort.

8. Drop masses into the effort cup. Continue dropping until the effort can lift the load.

9. Once your effort lifts the load, you can collect some data. First allow the effort to lift the load about one foot (30 cm) into the air. This is best done if you manually pull the effort until the load is one foot off the ground. Measure how far the effort has to move to lift the load one foot.

10. When you have that measurement, you can either count the number of masses in the load and the effort cup or if you have a scale, you can get the mass of the load and the effort.

11. Write your data into your pulley data table in your science journal.

Double Pulley Experiment

You need:

Same stuff you needed in Experiment 1, except that now you need two pulleys.

1. Attach the string to the hook that's on the bottom of your top pulley.

2. Thread the string through the bottom pulley.

3. Thread the string up and through the top pulley.

4. Attach the string to the effort.

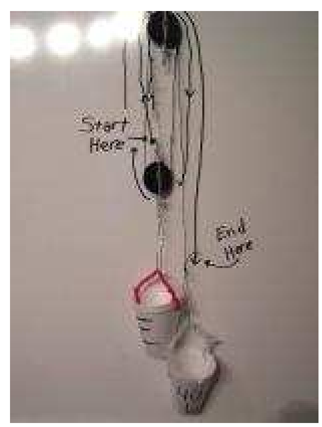
5. Attach the load to the bottom pulley.

6. Once you get it all together, do the same thing as before. Put 40 masses in the load and put masses in the effort until it can lift the load.

7. When you get the load to lift, collect the data. How far does the effort have to move now in order to lift the load one foot (30 cm)? How many masses (or how much mass, if you have a scale) did it take to lift the load?

8. Enter your data into your pulley table in your science journal.

Triple Pulley Experiment



You Need

Same stuff as before

If you have a double pulley or three pulleys you can give this a shot. If not, don't worry about this experiment.

Do the same thing you did in experiments 1 and 2 but just use 3 pulleys. It's pretty tricky to rig up 3 pulleys so look carefully at the pictures. The top pulley in the picture is a double pulley.

1. Attach the string to the bottom pulley. The bottom pulley is the single pulley.

2. Thread the string up and through one of the pulleys in the top pulley. The top pulley is the double pulley.

3. Take the string and thread it through the bottom pulley.

4. Now keep going around and thread it again through the other pulley in the top (double) pulley.

5. Almost there. Attach the load to the bottom pulley.

6. Last, attach the effort to the string.

7. Phew, that's it. Now play with it!

Take a look at the table and compare your data. If you have decent pulleys, you should get some nice results. For one pulley, you should have found that the amount of mass it takes to lift the load is about the same as the amount of mass of the load. Also, the distance the load moves is about the same as the distance the effort moves.

All you're really doing with one pulley, is changing the direction of the force. The effort force is down but the load moves up.

Now, however, take a look at two pulleys. The mass needed to lift the load is now about half the force of the load itself! The distance changed too. Now the distance you needed to move the effort, is about twice the distance that the load moves. When you do a little math, you notice that, as always, work in equals work out (it won't be exactly but it should be pretty close if your pulleys have low friction).

What happened with three pulleys? You needed about 1/3 the mass and 3 times the distance right? With a long enough rope, and enough pulleys you can lift anything! Just like with the lever, the pulley, like all simple machines, does a force and distance switcheroo.

The more distance the string has to move through the pulleys, the less force is needed to lift the object. The work in, is equal to the work out (allowing for loss of work due to friction) but the force needed is much less.

Exercises

Unit Overview: Energy Exercises

1. Everything in the universe can be categorized as what two things?

2. What is energy?

3. What is work?

4. If someone carries a lawn chair to their roof to watch the meteor showers, is work done on the chair?

5. What if the chair falls off the roof? Is work done on the chair then?

6. If someone pushes a train with all their might, but the train doesn't move, is work done?

7. What are two units used to measure work?

8. What is power?

9. What are two units to measure power?

10. Where does all the energy you get from food originate from?

Energy Calculations

Work = Force x Distance

Power = Work / Time

1. A mouse that weighs 4 ounces, jumps, step by step, up a 2 meter tall flight of stairs. What kind of work did that little guy do? (1 newton is 4 ounces)

2. If it took him 3 minutes (180 seconds) to do it, what power did he exert?

3. Bob's car breaks down. He needs to push on the car with a force of 1000 Newtons to get the car to go 30 meters (about 100 feet). How much work does he do?

4. If Bob takes 5 seconds to do it, how much power does he use?

5. Just for fun, let's convert that to horsepower. 1 Watt = .001 horsepower

Exercises

Lesson 1: Levers

1. Can you name the six simple machines?

2. It is easier to move things using a lever but what has to happen to lessen the force needed to move the load?

3. Describe a first-class lever. Can you give an example?

4. Describe a second-class lever. Can you give an example?

5. Describe a third-class lever. Can you give an example?

Exercises

Lesson 1: Pulleys

1. If I'm talking about simple machines, what does load mean?

2. So what does effort mean when it comes to simple machines?

3. With the pulleys, as your effort got less and less, what happened to the amount of string you had to pull?

4. What is mechanical advantage?

Warning: the following questions are "mathy". Don't worry about these if it gets in the way of your enjoyment or understanding of the lesson.

5. If a lever had a mechanical advantage of 10 and you wanted to lift a 50 pound watermelon, how many pounds of force would you have to use for the effort?

6. If a pulley had a mechanical advantage of 500 and you wanted to lift a 2000 pound hippo, how many pounds of force would you have to use for the effort?

7. Same hippo different units. Newtons are the official unit of force. So to do this officially, a 2000 pound hippo would take about 9000 Newtons to lift. If you lift that hippo 2 meters, how much work did you do? Remember, work is force x distance.

8. One last question. This one's a little tricky. So if you lifted the hippo 2 meters, how much chain (because string's not going to cut it) did you pull?

Answers to Energy Exercises

1. Matter and energy.

2. The ability of an object or system to do work on another object or system. Energy is defined in the physics books as the ability to do work.

3. Work is moving an object against a force over a distance. Work = force x distance

4. Yes. The chair has been moved a distance, against the force of gravity.

5. Nope, the chair moves a distance, but it moves with the force of gravity. Work is moving something a distance against a force. In this case, the chair does not move against a force. No work is done.

6. Nope again! There's no distance moved so...no work done.

7. Joules and calories.

8. The amount of work done in a given amount of time. Power = work divided by time.

9. Watts and horsepower.

10. The sun. You are powered by the sun!

Answers to Energy Calculations

1. work = force x distance so

work = 1 newton x 2 meters

work = 2 Joules

2. Power = work/time

power = 2/180

power = .01 Watts

3. work = force x distance

work = 1000 x 30

work = 30,000 Joules (go Bob!)

4. power = work x time

power = 30,000/5

power = 6000 Watts (Wow! Big Bob!)

5. 6000 Watts x .001 = 6 horsepower (No Viper, but pretty impressive!)

Answers to Simple Machines/Levers Exercises

1. The six machines are the inclined plane, the wheel and axle, the lever, the pulley, the wedge, and the screw.

2. The distance that the effort moves is much greater than the distance the load moves.

3. A first-class lever is a lever in which the fulcrum is located in between the effort and the load. Some examples are see-saw, a hammer (when it's used to pull nails), scissors, and pliers.

4. In a second-class lever, the load is between the fulcrum and the effort. Some examples are a wheel-barrow, a door, a stapler, and a nut-cracker.

5. The third-class lever has the effort between the load and the fulcrum. A few examples of this are tweezers, fishing rods, your jaw, and your arm

Answers to Pulley Exercises

1. The load is what you are lifting or moving.

2. Effort is the force needed to lift the load.

3. As the effort got less, the amount of string (distance) got greater and greater.

4. Mechanical advantage is the factor by which a mechanism multiplies the force put into it.

5. 5 pounds. The lever has a mechanical advantage of 10 so it multiplies the force by 10. So 5 x 10 = 50. (By the way, when you cut up that watermelon invite me over!)

6. 4 pounds. 4 x 500 = 2000

7. 18,000 Joules of work. 9000 Newtons x 2 meters = 18,000 Joules.

8. 1000 meters (3280 ft) of chain!!!

