Forces and Machines 4

Today is moving day. The moving van arrives early and parks facing down a slight hill. Before the workers start, one of them places a wedge in front of each wheel. Another worker pulls a long ramp out of the back of the van.

The workers use the ramp to load the van. They first lift a heavy piano onto a rolling platform. The platform is pushed up the ramp and into the van. They then lift boxes and roll them onto the ramp using a two-wheeled hand truck.

Finally, the van is loaded. The wedges are removed, and the workers drive away. These kinds of workers use a knowledge of simple machines to make their work easier and safer.

Consider

- How hard would it be to load the truck without any ramps?

Suppose a young child asked you to give him a ride in a wagon. How would you move the wagon? You could grab the handle and pull the wagon. Or you could push the wagon and allow the child to "drive." Whether you pull or push, you are providing a force to move the wagon.

Forces

A **force** is a push or a pull. To move the wagon with the child aboard, you apply a force. You put forth an effort to cause the wagon to move. You apply forces on objects all the time. You pull a brush or comb through your hair as you get ready in the morning. You push your pencil across your paper as you write. You pull on the sleeves of your coat as you put it on.

Other things also apply forces. The wind's pushing against a kite causes it to fly. A boat's propeller pushes against the water to cause the boat to move. A magnet pulls a piece of iron toward itself. Gravity and friction are two forces that we experience every day.

Gravity

On the earth **gravity** is the force that pulls all objects toward it. This force pulls on objects without touching, or having contact, with them. Rain falls to the earth because of gravity. When you jump, you return to the earth because of gravity.

The children and dog apply pulling forces.

Friction

Friction is the force that resists the movement of objects against each other. Friction occurs when one object is in contact with another object. It can cause a moving object to slow down, speed up, or stop. You experience friction when rubbing coarse sandpaper on a rough piece of wood. The sandpaper does not move easily. The wood resists the movement of the sandpaper. As the wood becomes smoother, you can move the sandpaper more easily because there is less friction.

Friction can be helpful. Without friction objects would slip and slide. Look at the soles of different shoes. The friction of the ridges on athletic shoes causes the shoes to grip smooth surfaces. A basketball player can run and stop on a polished gym floor without worrying about slipping. Other shoes may have smoother soles. You may need to walk carefully to avoid slipping when wearing these kinds of shoes when walking on smooth floors.

Using Forces

Motion

An object that is not moving is at rest. Its location is called its position. An object will stay at rest until a force causes a change. **Motion** is a change in position.

It takes a greater force to move a greater mass.

Several things need to happen for motion to occur. The applied force needs to be greater than the force of gravity or friction. The motion also depends on the mass of the object being moved and the amount of force put on the object. Suppose you want to push a wagon with one young child in it. You can easily overcome the friction to put the wagon into motion. But if two more children and their dog climb into the wagon, you will have a harder time moving it. The full wagon has a greater mass than the wagon with only one child in it. A greater mass requires a greater force to move it.

Work

We use the word *work* to describe many activities. Scientists, though, have a specific meaning for *work*. **Work** is done when a force moves an object over a distance. You use energy when you do work. **Energy** is the ability to do work.

When you push or pull a door open or closed, you are doing work. You are using force to move something. You are also doing work when you wash a car or mow a yard. However, suppose you try to open a door without turning the knob. You can push or pull as hard as you can, but if the door does not move, no work has been done.

Scientists measure work by measuring how much force it takes to move an object and how far the object moves. The amount of work you do depends on how much force you use to move an object. Suppose you have to move

two boxes the same distance. One is a 25 kg (55 lb) box of books, and the other is a 3 kg (6.6 lb) box of packing peanuts. Because the box of books has a greater mass, it will require more force to move. This means that you will do more work and use more energy moving the books than you will moving the packing peanuts.

The amount of work you do also depends on how far you move something. There are some books on the floor to put away. You can put them on a shelf that is 0.25 m (10 in.) high or one that is 1.5 m (59 in.) high. Placing them on the shelf that is 1.5 meters high would require more work because you would move the books a greater distance.

QUICK CHECK

1. What are two forces we experience every day?
2. When does work happen?

Simple Machines

Every day you use many kinds of machines. A **machine** is any object that makes work easier. Some machines, such as cars, are complex. They are made of many smaller, simple machines that work together. A simple machine may have only one moving part, or it may have several moving parts. The basic simple machines are the lever, wheel and axle, pulley, inclined plane, screw, and wedge. These machines make tasks easier. They do not always reduce the amount of force needed to do work. They may change the direction of the force.


Using a lever

All machines need a force to do their jobs. The force that you apply to cause a simple machine to do work is called the **effort**. When you push a shopping cart, you apply effort so the wheels can move the cart.

There are also forces working against an object's ability to move. One of the forces is gravity. Gravity pulls on an object and gives it weight. The weight of the object being moved is called the **load**. The groceries in the shopping cart are a load. The weight of the groceries makes the cart harder to move.

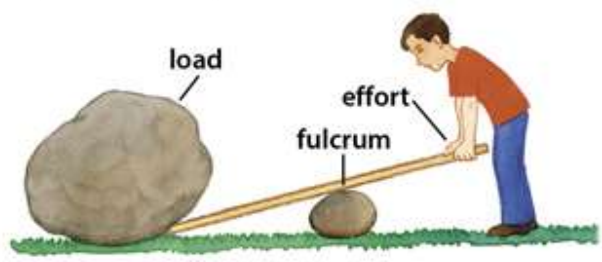

Gravity in action

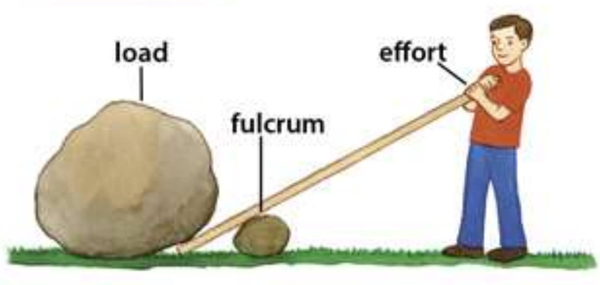
The Lever

Suppose you are helping to plant a new flower bed in a local park. Before you can plant any flowers, though, you have to remove all the rocks that have been dug up. Most of the rocks you can pick up easily.

However, there is one rock you cannot move no matter how hard you try. Someone suggests using a long board. You place one end of the board under the edge of the rock and rest the middle of the board on a smaller rock. When you push down on the other end of the board, the large rock starts to move. But you still cannot get it to roll. You try putting the small rock closer to the large rock. Now when you push down on the end of the board, the rock starts to roll.

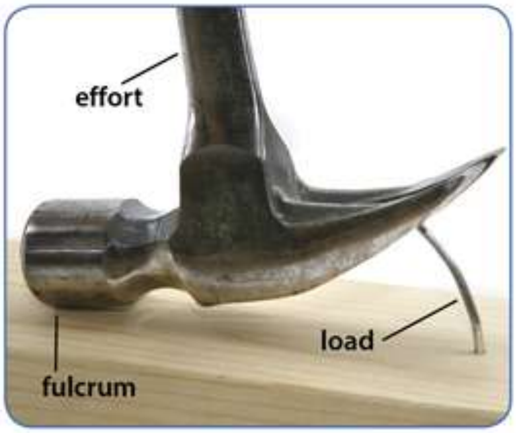
In this example, the board and smaller rock acted as a simple machine called a lever. A **lever** is a bar that turns on a point. The point is called the **fulcrum**. The fulcrum was the smaller rock. The large rock you moved was the load, and your push on the board was the effort. The more distance there is between the effort and the fulcrum, the less effort is required to move the load.





Kinds of Levers

There are different kinds of levers. The board was being used as a first-class lever. This lever has the fulcrum between the load and the effort. Many everyday tools use the same kind of lever. A paint-can opener, a crowbar, and the claws on some hammers are all common examples.



A wheelbarrow and a nutcracker are second-class levers. For a second-class lever, the effort, load, and fulcrum are arranged differently. The load is between the fulcrum and the effort. You use this lever every time you open a door. The door is the load, and your pulling the door is the effort. The fulcrum is at the hinge.

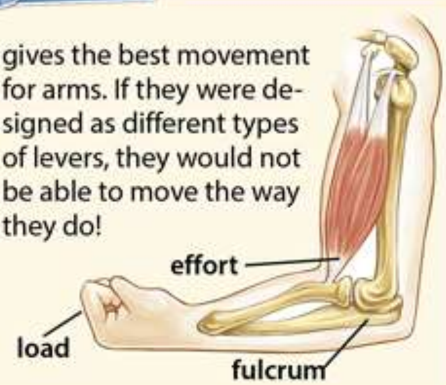
Some levers have the effort between the fulcrum and the load. A lever like this is a third-class

lever. Third-class levers use effort to move the lever a small distance near the fulcrum. This causes the lever to move a much larger distance at the load. There are many ways you use this kind of lever. When you sweep you put an effort next to the fulcrum, near the top of the broom. At the bottom, the broom travels a great distance. Other examples of third-class levers are a fishing pole and a hammer used to pound a nail.

Some tools use two levers together to make work easier. Scissors, tweezers, and pliers are examples of tools made of two levers.

CREATION CORNER

Have you ever thought of your body as a machine? Your body has many third-class levers. Your arm is one. The elbow is the fulcrum, and the load is your hand and whatever happens to be in it. The muscles that pull from the front of your elbow are the effort that moves the lower arm. This amazing design gives the best movement for arms. If they were designed as different types of levers, they would not be able to move the way they do!



QUICK CHECK

1. What is a machine?
2. What is the point on which a lever turns?

How Much Effort?

Have you ever watched two people try to balance on a seesaw? A seesaw is a kind of lever. What happens when one person is heavier than the other? To balance the seesaw, the people must move to different positions.

In this activity you will find out how the distance between the effort and the fulcrum affects the effort needed to balance a lever.

Process Skills
- Predicting
- Experimenting
- Identifying variables
- Inferring

Problem

How does the position of the fulcrum affect the amount of effort needed to balance the load?

Materials
clay
spool of thread
chenille wire
centimeter ruler
2 plastic cups, 3 oz
tape
50 pennies
Activity Manual

Procedure

1. Complete the hypothesis in your Activity Manual.
2. Push the chenille wire through the holes in the center of the spool. Pull the wire tight and twist it together. Place a piece of clay under the spool to keep it from rolling.
3. Slide the ruler between the wire and spool. Place the ruler so the 15 cm mark is directly under the wire.
4. Label one cup *effort* and the other cup *load*. Tape the effort cup to the end of the ruler closest to 0 cm. The edge of the cup should be even with the end of the ruler. Tape the load cup so its edge is even with the other end of the ruler.

5. Gently hold the ends of the spool to keep it from moving. Have your partner put 10 pennies in each cup. Slide the ruler as needed to balance the cups. The setup of your lever is complete.
6. Look at the lever. Predict whether the amount of effort (the number of pennies) will increase or decrease when the fulcrum is at 13 cm. Write your prediction in your Activity Manual.
7. Slide the ruler so the 13 cm mark is under the wire. Gently hold the fulcrum. Add or remove pennies from the effort cup until the lever is balanced. Record your observations.
8. Repeat steps 6–7 two more times, placing the fulcrum at 18 cm and then at 10 cm. Remember to record your prediction and observation each time.

Conclusions

- How did the position of the fulcrum affect the amount of effort needed to balance the load?
- What would happen to the amount of effort needed if the fulcrum were placed at other positions?
- List ways this type of lever is used. Describe a way you might use this lever to help someone.

Follow-up

- Test whether the length of the lever affects how the effort and load balance.