Exploration #1: Forces without contact?

Purpose

You have observed that in order for you to apply a force to another object, you have to touch it in some way. For example, if you wanted to move a sled across a snowy field, you could do it by pushing it or pulling it with your hands. Even if you used a rope to pull it, then the rope would have to be tied to the sled, and so the rope would be touching it.

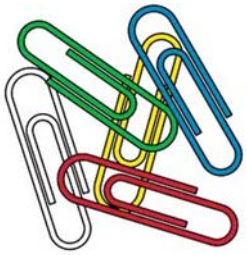
But can objects apply forces to each other without touching, or must there always be contact between two objects for a force to exist?

The big question we will address in this *Exploration* activity is:

Can any objects apply forces without touching each other?

What do we think?

Imagine there were some metal paper clips lying on the table in front of you.

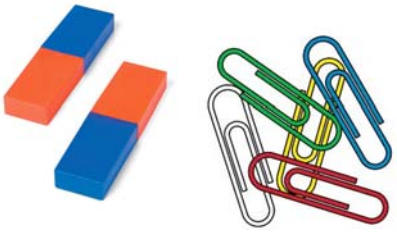


Do you think there is any way you could make them start to move without touching them? If so, how do you think you could do it?

Your PD leader will lead a class discussion about everyone's answers to this question.

Activity 1: Playing with magnets

You will work in groups for this activity. Each group will need:



- Two magnets
- Some metal paper clips

STEP 1: ***Each group member should try this.*** Hold one magnet in each hand and slowly bring their ends together until they are almost, but not quite, touching.

Do the two magnets apply forces to each other, even though they are not touching? How can you tell?

STEP 2: Place a paperclip on one side of the table/desk and lay one of the magnets on the other side of the table. Slowly slide the magnet, end first, toward the paperclip.

Describe what happens as the magnet gets close to the paperclip.

Did the magnet apply a force to the paperclip before they touched each other? How can you tell?

Activity 2: Rubbing a balloon

You will work in groups for this activity. Each group will need:

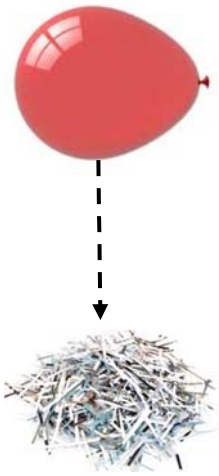
- Rubber balloon
- Some small pieces of paper

STEP 1: Inflate the balloon and tie a knot in the end.

Each group member should try this. Hold the balloon on one side and rub the other side up and down several times on your shirt or sweater. Now quickly bring the rubbed side of the balloon close to, **but not touching**, someone else's hair.

Does the balloon apply a force to the hair? How can you tell?

STEP 2: Place some small pieces of paper on the table. Again, rub one side of the balloon on your shirt or sweater. Now quickly bring the rubbed side of the balloon above the paper on the table. Bring the balloon toward, **but not touching**, the paper until you see something happen.



Describe what happens as the balloon gets close to the paper.

Did the balloon apply a force to the paper before they touched each other? How do you know?

Your PD leader will lead a class discussion about everyone's observations.

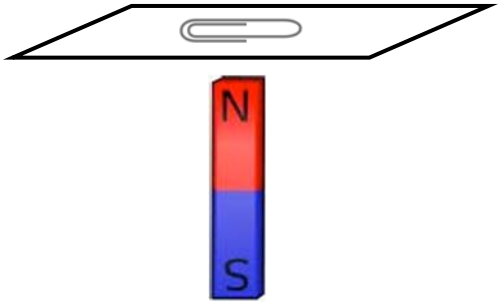
Non-touching Interactions

In order for most objects to interact with each other, and so apply forces to each other, they must be touching. For example, for you to apply a force to a ball, you must touch it, either with part of your body, or with some other object that you are holding. However, in a **few special cases** some objects can interact, and so apply forces, ***without*** touching each other.

One common example you are probably familiar with is **magnetic interactions**. You saw in Activity 1 that magnets can apply forces to other magnets, and some other objects (like steel paperclips), without touching them. In Activity 2, you saw another example, that of **electric charge interactions**. In this example, you gave a balloon an electric charge by rubbing it and then saw that it could apply forces to someone's hair and to some pieces of paper, without touching them.

One interesting thing about non-touching interactions is that sometimes they can make it appear as if an object starts to move on its own. For example, even if a magnet was hidden from view, it could still apply a force to a paperclip and make it move. To anyone who could not see the magnet, it would look like the paperclip is moving on its own.

To see this, have one of your group hold a sheet of paper with a paperclip on it. Then another person should hold the magnet below the paper and use it to move the paperclip around on top of the paper.



To someone looking down from above the paper, it appears as if the paperclip is moving on its own, but really a force is being applied to it by the magnet.

Activity 3: Dropping a ball

You will work in groups for this activity. Each group will need:

- Racquetball

STEP 1: Hold the ball above the ground and release it.

Describe what happens to the ball **after** you release it.

You know that for the ball to start moving downward a force must be acting on it. What force do you think this is?

You know that for a force to act on one object it must be interacting with another object. A force acted on the paperclips because they were interacting with the magnet, and a force acted on the strips of paper because they were interacting with the charged balloon.

What other object do you think the ball was interacting with to create the force that pulls it downward?

An object falls because of a gravitational interaction between it and the Earth. A gravitational interaction occurs between any two objects that have **mass** even though they are not touching. During this interaction, the two objects **always** exert attractive forces on each other. This can be accounted for by the idea of an invisible gravitational 'field' that extends around all objects. Any other objects within this gravitational field will feel an attractive force due to the influence of the field itself on them.

As the masses of the objects become larger, the gravitational attraction between them becomes stronger. However, with "normal sized" objects (like people, cars, buildings, etc.) the gravitational interaction between them is so small that it is not noticeable. Only when at least one of the objects is very, very massive (like the Earth) does the strength of the gravitational interaction become significant and cause noticeable effects. Also, the further apart the centers of the objects are, the weaker the strength of the gravitational interaction between them.

Since the strength of the gravitational force on an object is proportional to its mass, all objects fall with the same rate of change of speed, independent of their mass. This assumes that no other forces are affecting the objects such as air resistance.

Making Sense

Discuss with your group the answers to the following questions and be prepared to contribute to the whole group discussion lead by your PD leader.

1. Can some objects apply forces to other objects without touching them? If so, give some examples.

2. When an object falls to the ground, what other object is it interacting with that is applying a force to it?