Beginnings: What if there is more than one force?

Review of effects of a single force

When an object is at rest

- If a single force acts on an object **at rest**, the object will begin to move in the direction of the force.
- If there are **no forces** acting on an object **at rest**, then the object will ***remain at rest***.

When an object is in motion

- If a single force acts on an object in the **same direction** as its motion, the object's speed will increase.
- If a single force acts on an object in the direction **opposite** to its motion the object's speed will decrease. If the force continues to act, the object may eventually stop and even reverse direction.
- An example of a force that *always* opposes motion is **friction**. It is caused by the interaction between tiny bumps and irregularities in the surfaces of objects as they rub together.
- If **no forces** act on an object in motion, then the object will ***remain in motion at a constant speed***.
- If **no forces** act on an object in motion, then the path of the object will be a **straight line**.

Effect of changing force strength and mass

- When the speed of an object changes either increasing or decreasing, scientists say it is **accelerating**. Acceleration is the time rate of change of an object's speed.
- When a single force acts on an object, the **greater the strength of the force**, the higher the rate of change of the object's speed will be.
- When a single force acts on an object, **the more mass the object has**, the lower the rate of change of the object's speed. (Scientists call this property of objects, their **inertia**.)

Purpose

The effect of a single force on an object is to change its speed (and/or direction) in some way. However, in most circumstances, more than one force acts on a single object at the ***same time***. For example, as two men push a heavy box across the floor, they are each applying a "forward" force to it. At the same time, a "backward" frictional force is also being applied to the box by the floor. In today's activities, you will examine what effect such a ***combination of forces*** has on an object?

To start, we will think about what happens when a combination of forces acts on an object that is not moving.

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

What happens when a combination of forces acts on an object that is not moving?

What do we think?

Two brothers are arguing over a stuffed toy and begin to pull on it in opposite directions. The toy was not moving when they started pulling.

What do you think would happen if the forces applied to the toy by the two brothers have **exactly the same strength**? Would it start to move or not? If so, in which direction?

What do you think would happen if the strength of one brother's pull was **greater than** that of the other brother? Would the toy start to move or not? If so, in which direction?

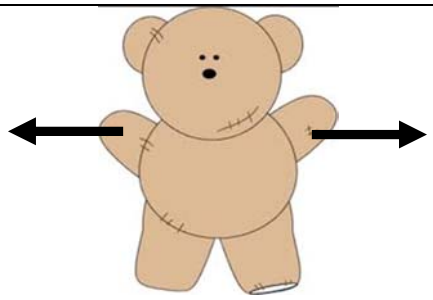
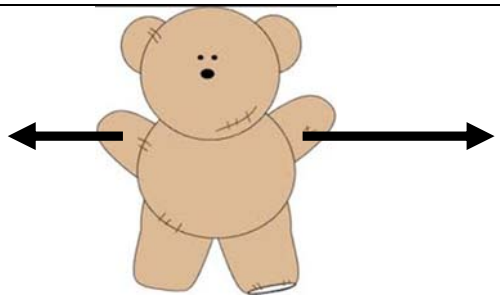
Your PD leader will lead a class discussion about everyone's answers to these questions, and the explanations of their thinking.

Balanced and Unbalanced Combinations of Forces

When equal strength forces act on an object in opposite directions, we say the forces are **balanced**. When the two brothers pulled equally hard on the toy, their forces were balanced.

When the strengths of the force acting in opposite directions are not the same, we say the forces are **unbalanced**. When one brother pulled harder on the toy than the other, the combination of their forces was unbalanced.

We can draw a **force diagram** for an object using arrows to show the forces acting on it. The length of the arrows shows the strength of the forces. Force diagrams for the toy when the two brothers were pulling on it in each case, are shown below.

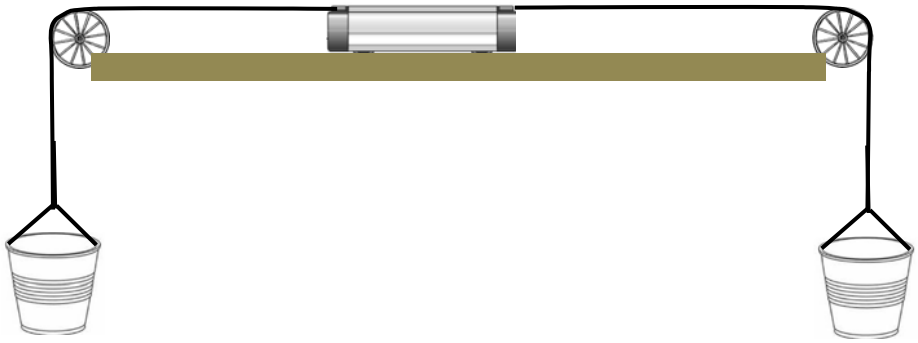
	
Balanced Forces: The two brothers apply equal strength forces in opposite directions. (Both force arrows are the same length.)	**Unbalanced Forces:** One brother applies a stronger force than the other brother. (One force arrow is longer than the other.)

Activity: Two forces in opposite directions

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

- A laptop or iPad on which to view movies.

To test the effect of combinations of forces, we will use a low-friction cart on a track. A string is tied to each end of the cart and these strings pass over pulleys connected to each end of the track. A cup is hanging from the end of each string as shown below.



When objects, such as sugar cubes are added to the cups, they will pull downward on the string. The string, in turn, will apply a force to the cart. When the cart is released, it will be free to move and so you will be able to see what effect of a combination of two forces has on the cart.

STEP 1: Open your internet browser to the following website:

https://www2.tntech.edu/leap/horizonpd

You can trust this site.

Under the heading **Unit 2, Cycle 2 Movies**, open Beginnings Movie 1: Equipment Setup.

This movie will show you the setup described above.

Now, suppose the cart was held still while an equal number of sugar cubes were placed in each of the two cups, and then the cart was released.

 Do you think the cart would start to move when released, or not? Why do you think so?

Now suppose more sugar cubes were placed in one cup than in the other while it was being held still.

 Do you think the cart would start to move now when released, or not? Why do you think so?

 Your PD leader will lead a class discussion about these questions.

STEP 2: Close Movie 1 and open Beginnings Movie 2: Force Combinations on a Cart at Rest.

The focus question of this movie is "What effect do combinations of forces have on an object that is not moving?" In this movie, various numbers of sugar cubes are added to the two cups in the setup. You will need to pause the movie at different points in order to answer a series of questions about what you have just seen.

STEP 3: Pause the movie at time 2:30 when you see "Now let's try some unbalanced combinations."

Answer the following questions about this portion of the movie which tested some combinations for which there were **equal numbers** of sugar cubes in both cups.

 In the case of **equal** numbers of sugar cubes in both cups, are the forces acting on the cart balanced or unbalanced? How do you know?

 Describe what happens to the cart **after** it is released and a **balanced** combination of forces acts on it. Does it start to move or not?

 Do ***all*** the **balanced** combinations of forces tested have the same effect? Why do you think this is?

STEP 4: Resume the movie and watch until the end then answer the following questions about this portion of the movie which tested some combinations for which there were **unequal** numbers of sugar cubes in both cups.

 In the case of **unequal** numbers of sugar cubes in both cups, are the forces acting on the cart balanced or unbalanced? How do you know?

 Describe what happens to the cart after it is released now. Does it start to move or not?

Do ***all*** the **unbalanced** combinations of forces tested have the same effect? Why do you think this is?

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. When a **balanced** combination of forces acts on an object that is not moving, what happens? Is this more like the effect of having no forces, or more like the effect of a single force? Why do you think this is?

2. When an **unbalanced** combination of forces acts on an object that is not moving, what happens? Is this more like the effect of having no forces, or more like the effect of a single force? Why do you think this is?

3. When a single force acts on an object, are the forces balanced or unbalanced? Explain your thinking.

4. When no forces act on an object, are the forces balanced or unbalanced? Explain your thinking.

5. Imagine you have a chair that is on wheels. If you push gently on it, it will start to move. Does this mean the forces acting on it are balanced or unbalanced?

6. Now imagine you take the wheels off the chair. If you now push gently on it, it will not start to move. Does this mean the forces acting on it are balanced or unbalanced? How can this be?