Bringing Science Alive: Effects of Forces

Packet #6 M

**Standard(s): MS-PS2-2** Plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object. **PS2.A: Forces and Motion**

The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.

In this lesson, you will learn about Newton’s first and second laws of motion. These two laws describe how the forces acting on an object will change the object’s motion. You will learn about how these laws helped engineers design effective seatbelts. Along the way, you will also learn a little more about the Iditarod and read about the effects of forces in your everyday life.

1. **Net Force**

   Iditarod mushers have constraints on the number of dogs they can use. Each musher can start the race with as many as 16 dogs pulling the sled and must finish the race with at least five dogs pulling the sled. Mushers take very good care of their dogs to keep them from becoming ill or injured during the race. If a dog gets sick or is injured during the race, mushers can leave their dogs with veterinarians and continue the race with their remaining dogs. Why do mushers want to finish the race with as many dogs as possible?

   Each dog in a dog sled team exerts a force on the sled. A musher wants as many dogs as possible because the forces exerted by the dogs add up to a large force on the sled. In fact, when more than one force acts on any object, the effect of those forces can be found by adding the forces. The sum of all forces acting on an object is the net force on the object.

   The net force is found by combining all the forces on an object. Recall that forces have both strength and direction. Whether you add or subtract forces depends on the directions that the forces act. **If the forces on an object act in the same direction, the strengths of the forces are added. For example, when three people push a van that has run out of gas, they all push in the forward direction. If the people push with forces of 100 N, 125 N, and 200 N, the net force is:**

   \[
   100 \text{ N} + 125 \text{ N} + 200 \text{ N} = 425 \text{ N}.
   \]

   Because all the forces on the van are in the forward direction, the net force is also in the forward direction.

   **Check for Understanding**

   1. If the people that are pushing the van push with forces of 145 N, 175 N and 210 N. What would be the net force and in which direction are they pushing the van?

      ________________ and ________________
On the other hand, forces are subtracted to find the net force if the forces act in opposite directions. The leash in Figure 1 has forces acting on it in opposite directions. The dog jumps forward, pulling the leash with him. The girl pulls back on the leash, but is dragged forward by the dog. If the dog pulls with a force of 75 N and the girl pulls with a force of 50 N, the net force on the leash is: \( 75 \text{ N} - 50 \text{ N} = 25 \text{ N} \)

When forces are subtracted to find the net force, the direction of the net force is the same direction as the larger force. So the force on the leash is 25 N in the forward direction. As a result the leash, along with the dog and the girl, accelerate forward.

Sometimes the net force on an object is simply equal to one force on the object. Think about a train of cars on a roller coaster car coming to a stop at the end of a ride. Brakes are applied to slow the train down. The brakes exert a backward force on the train. Because all forward or backward forces on the train are very small, the net force on the train is, practically, just the force of the brakes. If the direction the train is traveling is positive, then the force of the brakes is in the negative direction. So, the net force on the train is negative, the train’s acceleration is negative, and the train slows down. Finding the net force is useful because you can use the net force to predict the effect of all the forces on an object at once. Once you find the net force you can predict if and how the object’s motion will change.

Answer the following questions according to the reading passage

1. What is generally the net force on an object?

2. Calculate the following net forces.
   a. Two people push a couch across a room. One pushes with 30 N. The other pushes with 50 N. 

   b. Two friends push their friend on a swing with a combined force of 15 N and 20 N.
2. Newton’s First Law

Suppose that you are pushing a luggage cart in an airport or a train station. By pushing with different strengths, you can make the cart speed up, slow down, or move at a constant velocity. How can net force and Newton’s first law of motion be used to predict how the luggage cart—or any object—will move?

An object’s motion is determined by the net force on it. When you find the net force, you also find whether the forces are balanced or unbalanced. Balanced forces are forces that have a net force equal to 0 N. Unbalanced forces are forces that have a net force not equal to 0 N. Newton’s first law of motion describes what happens to an object when the forces on it are balanced.

Newton’s first law of motion states that an object at rest stays at rest, and an object in motion stays in motion with a constant velocity unless acted on by unbalanced forces. This means that an object is stable, or does not change its behavior, unless an unbalanced force acts on it. The statement of the first law is long, but you can separate it into parts to fully understand the law.

“An Object at Rest” The first part of the first law of motion says that an object at rest stays at rest if the forces on it are balanced. When an object is “at rest” it is stationary, or not moving. So the first part of the first law says that, if the forces on a stationary object are balanced, the object will not move. This makes sense. If a luggage cart is standing still, and the net force on it is 0 N, such as in Figure 2A, the cart will stay still.

For example, if you push the luggage cart with a force stronger than the force of friction, the net force on the cart will be greater than 0 N and in the forward direction. This unbalanced force will cause the cart to speed up. On the other hand, if you pull back on the cart, your pulling force and friction will be in the same direction, so the net force will be greater than 0 N in the opposite direction. In this case, the cart slows down.
Check for Understanding

1. When an unbalanced force acts on an object, the object will
   a. accelerate.
   b. move at a constant velocity.
   c. stop.
   d. do nothing.

Answer the following questions according to the reading passage.

1. What is the difference between a balanced force and an unbalanced force?
   ____________________________________________________________
   ____________________________________________________________

2. What does Newton’s first law of motion say about balanced and unbalanced forces?
   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________

3. Are the forces on a stationary object balanced? Why or why not?
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   ____________________________________________________________