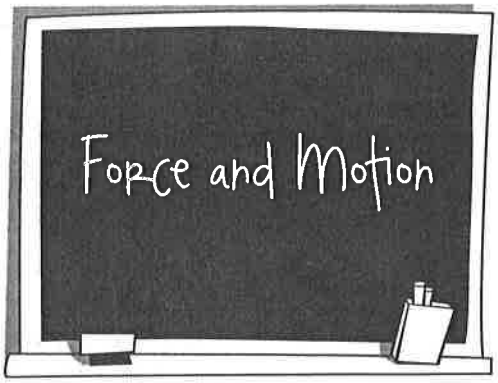
# Force and Motion Ideas

Mrs. Li's students share their ideas about force and motion. Here are some of the ideas they come up with. Put an X next to each of the ideas you agree with.




____ **A** If there is motion, then a force is acting.

____ **B** If there is no motion, then there is no force acting.

____ **C** There cannot be a force without motion.

____ **D** Objects can continue moving in a straight line without applying force.

____ **E** When an object is moving, there is always a force in the direction of its motion.

____ **F** Moving objects stop when their force is used up.

____ **G** Forces act on objects at rest.

____ **H** The stronger the force, the faster an object moves.

____ **I** Constant speed results from constant force.

____ **J** A force is necessary in order to change the direction of motion.

____ **K** Forces make things go, losing energy makes them stop.

____ **L** Force can be transferred from one object to another during motion.

Explain your thinking. Summarize your own ideas about force and motion.

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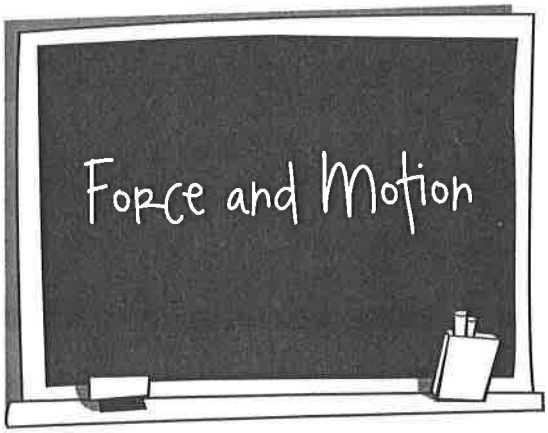
## Teacher Notes




### Purpose

The purpose of this assessment probe is to comprehensively elicit students' ideas about the relationship between force and motion. The list of possible answers includes several distracters that are based on learning research; thus the probe will tell you whether your students hold any of these research-identified, commonly held (incorrect) ideas about force and motion.

### Related Concepts

active action, constant speed, direction of motion, interaction, passive action

### Explanation

The only correct statements are D, G, and J. Statement D comes from Newton's first law of motion. Statement G helps to emphasize the difference between force and an unbalanced force—that is, that objects at rest will often have several forces acting on them, but these forces are balanced. Statement J comes from Newton's second law of motion. If an object is not moving in a straight line then there must be a net force acting on that object. An example is the Moon orbiting around the Sun, which happens because the Sun is exerting a gravitational force on the Moon.

Most of the statements (A, B, C, E, F, H, I, and K) are examples of what is often called "Aristotelian thinking." This type of thinking results from the belief that motion requires an unbalanced force. This idea was first rejected by Galileo, who first proposed constant motion as the natural motion. Later, Isaac Newton realized that it is only a *change* in motion that requires an unbalanced force and Newton was able to quantify this relationship. Many students use the word *force* as something an object possesses—for example, "it has a lot of force" or "may the force be with you." These students may be thinking of force as a property of an object rather than as an interaction between objects. Choosing statements K and L may be indications of this type of thinking.

## Administering the Probe

This probe is best used with middle school and high school students. (It can be modified for upper elementary students by removing choices that students are not yet ready to explain.) The probe can be administered as a card sort by writing each of the statements on cards (Keeley 2008). Students then sort the cards into three separate piles: statements they agree with, those they disagree with, and those they are not sure about.

## Related Ideas in *National Science Education Standards* (NRC 1996)

### K–4 Position and Motion of Objects

- The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull.

### 5–8 Motions and Forces

★ An object that is not being subjected to a force will continue to move at a constant speed and in a straight line.

★ If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another. Unbalanced forces will cause changes in the speed or the direction of an object's motion.

### 9–12 Motions and Forces

★ Objects change their motion only when a net force is applied.

## Related Ideas in *Benchmarks for Science Literacy* (AAAS 1993, 2009)

### K–2 Motion

- The way to change how something is moving is to give it a push or a pull.

### 3–5 Motion

- Changes in speed or direction of motion are caused by forces.
- The greater the force is, the greater the change in motion will be. The more massive an object is, the less effect a given force will have.

### 6–8 Motion

★ An unbalanced force acting on an object changes its speed or direction of motion, or both.

### 9–12 Motion

★ Any object maintains a constant speed and direction of motion unless an unbalanced outside force acts on it.

## Related Research

- Many students think that if an object is moving, then there is a force acting on it. There is a strong belief that a force must be constantly applied in order for motion, including constant speed, to continue (Gunstone and Watts 1985).
- Some students tend to think of force as a property of an object, rather than an interaction between objects (Brown and Clement 1989; Dykstra, Boyle, and Monarch 1992).
- Some students think that forces get things moving but do not stop things (Minstrell 1989). Some students think things stop when the force or energy in the object runs out (Driver et al. 1994).
- A common belief among students of all ages is that all objects eventually slow down and stop (Driver et al. 1994).
- Some students think force is transferred from one object to another (Brown and Clement 1989).

★ Indicates a strong match between the ideas elicited by the probe and a national standard's learning goal.

## Suggestions for Instruction and Assessment

- Teachers and researchers have developed several strategies to help students develop an understanding of forces. One strategy, developed by Camp and Clement (1994), is to use "bridging analogies." This strategy involves starting with an "anchoring example" and then extending student ideas toward a "target problem." For example, to introduce gravity ideas, the teacher has students examine the force exerted by various numbers of rubber bands stretched between their fingers (the anchor) to model the mass dependency of the gravitational force (the target). The interaction between each finger is modeled as a single rubber band. The number of fingers represents the amount of mass and the number of rubber bands represents the total force. The total number of rubber bands depends on the number of fingers on each hand (just as the total gravitational force depends on the amount of both masses). For example, three fingers of one hand interacting with two fingers on the other hand would require a total of six rubber bands. The gravitational force exerted by a mass of 2 kg with a mass of 3 kg is proportional to the masses multiplied together.
- Most approaches to teaching about force require students to have a firm understanding of kinematics (i.e., describing the motion of objects without considering the causes leading to the motion) and be able to identify changes in motion (acceleration). However, one interesting alternative is to introduce energy ideas *before* the study of motion. Students then observe different types of motion and infer changes in energy. An example of the use of this approach is found in *Interactions in Physical Science* (Goldberg et al. 2009).

## References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