Balanced and Unbalanced Forces

Throughout the guide teaching tips are in red.

Activity Description and Estimated Class Time

In this three part activity, students explore changes in motion and/or direction that happen as a result of balanced and unbalanced forces. During the first part, students gain firsthand experience in a "tug-of-war." The second part of the activity examines the effect of friction on motion. The third part explores how magnetic forces can change the motion of magnetic objects. This third part provides experience with change in direction for objects that are already moving at a constant speed in a straight line and are subjected to an unbalanced force. It also explores change in speed that can be brought about by an unbalanced force.

Objectives

Students will develop an understanding of the following ideas and content:

- An unbalanced force acting on an object changes its speed and/or direction.
- If forces acting on an object are balanced, the object does not change speed or direction.
- Friction, gravity, and magnets are examples of forces that can change an object's speed and direction.

Correlations to North Carolina Science Standards

7.P.1.2 Explain the effects of balanced and unbalanced forces acting on an object (including friction, gravity and magnets).

Brief Science Baground

An object can be subject to powerful forces, yet remain unmoved. For example, gravity causes a building to apply many tons of force downward, but its foundation pushes upward just as hard. The building doesn't move because the forces are the same in opposing directions - balanced.

However, when forces on an object are unbalanced, its motion changes. For example, pushing a pedal on a bicycle puts a forward force on the back wheel, and if the force is unopposed by another force, the bicycle travels forward. With the brakes on, two equal forces oppose each other (balanced forces), and the bike does not move. Another case is a canoe changing direction when wind blows from one side. Its motion changes because of the unbalanced force from wind pushing on one side more than the other.

Finally, a more difficult concept (not thoroughly covered in this activity) involves the "state" of motion of a moving object. An object can be moving in a constant state of motion without being subject to an unbalanced force. Its "state" of motion is its direction and speed. It keeps moving in the same direction at the same speed until an unbalanced force acts upon it. A car traveling straight at a constant 30 miles per hour is in a constant state of motion. It has forces on it, but they are balanced – the thrust of the motor and the friction of the car are equal in opposite directions, so it neither speeds up nor slows down. If no one turns the wheel, it keeps going straight. Speeding up, slowing down, or changing direction requires an unbalanced force - more power from the motor, the brakes being applied, or turning the steering wheel.

Part 1 – Tug-o-War (35 minutes)

Materials and Procedures

Materials for groups of 2 students

- Rope
- twist tie
- student notebook*

*item supplied by teacher
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Exploration – 5 minutes

1. Ask students to share what they know about force. **Accept all answers without correction.**
2. Ask students to share examples of different types of forces.
3. Ask students to speculate what happens when forces acting on something are equal in opposite directions. **Again, accept all answers.**
4. Ask students to speculate what happens when two opposing forces act on something, and the two forces are NOT equal? **Again, accept all answers.**

Explorations are intended for students to engage with materials and concepts, ask questions, and share what they notice. Avoid teaching content in an exploration, even during discussions.

Activity – 30 minutes

1. Inform students that we will begin to explore balanced and unbalanced forces and what happens as a result.
2. Hand each pair of students the following:
   - a rope
   - a twist tie
3. Instruct students to attach the twist tie near the middle of the rope. Have pairs of students sit across from one another with each student holding one end of the rope such that the twist tie is in the middle between them.
4. Ask students to pull on the rope so that the twist tie does not move.
5. Ask them to share what they did to get the twist tie to remain motionless.

   Students might say they felt how hard the other person was pulling and tried to pull just the right amount so that the twist tie did not move. Some might report they each tried to pull the same amount.
6. Ask one student to pull the rope so the twist tie moves toward them. Again, ask them to describe how they accomplished the task.

7. Explain to the class that a balanced force is equal forces acting in opposite directions. Looking back at the two examples, ask students to determine when the forces were balanced and when were they unbalanced. Ask them to describe what happened to the twist tie.

8. In their notebooks, have students write a rule that relates motion and balanced and unbalanced forces.

   At this point students should be able to describe that an object that is motionless has balanced forces acting on it, and unbalancing the force causes the object to move.

9. Challenge students to come up with another way to demonstrate balanced forces acting on the rope without pulling on the rope with their bodies. Ask them to be able to tell you what forces are acting on the unmoving rope.

   One example might be to lay the rope on the desk so that it does not move. The goal is for students to show a motionless rope and explain that the rope does not move because the forces are balanced.

10. Challenge students to come up with a way to demonstrate unbalanced forces acting on the rope without pulling on the rope.

    Examples of unbalanced forces might include pushing the rope, or hanging part of the rope over the edge of a table, causing it to fall to the floor.

Part 2 – Friction (60 minutes)

Materials and Procedures

Materials for groups of 4 students

- 500 gram spring scale
- 1 sheet of:
  - 60 grit sandpaper
  - 220 grit sandpaper
  - 12” piece of waxed paper
  - 12” piece of foam
  - 10”x12” plastic bag
  - Copy paper*
- student notebook*

*item supplied by teacher

Preparation

Tear 1 sheet of waxed paper, approximately 12” for each team of 4.

Exploration (20 minutes)

1. Set up groups of 4 students.
2. Give out spring scales and ask each student to remove one shoe and determine its weight using the scale. They should record this weight in their notebook and share it with the group. When they finish, collect the scales. **If a shoe is over 500 grams, use 500 grams for the weight.**

3. With all four shoes on the table, ask them to rank the shoes in order (most to least) for the amount of force required to pull each shoe across the table. Individuals should record their predictions in their own notebook. Inform them that they will test after they predict. Ask each group to compare their predictions and describe what criteria they used to rank them.
4. Give out the spring scales again and demonstrate how you want them to test the force required to pull the shoe across the table. See photo below:

Hook the scale to the back of the shoe directly above the heel. Hold the scale so it is parallel to the tabletop and pull horizontally. As the shoe begins to move, record the force applied *at the moment the shoe moved.*

5. Ask students to test the shoes. Have each student test their shoe and share the results with their group. Each student should compare the results to their predictions. At this point, collect the spring scales from the groups.

Lead a class discussion:

- Before talking about results, ask students to explain the forces acting on the shoe as it sits motionless on the table. **Students should be able to report the forces are balanced and therefore the shoe is not in motion. Students may point out the table is pushing against the shoe and the shoe is pressing on the table, but those forces are balanced.**
- Ask students to describe how the shoe was made to move. Ask: How was an unbalanced force created?
- Ask students to share which of the shoes required the most force to move across the table and which shoes required the least force.
- Ask students to speculate reasons for each. **At this point students may notice that heavier shoes require more force to move. Students may also notice differences in the soles or dirt on the soles or other factors that affect the force required to move the shoe.**
- Introduce the term friction and ask students to come up with a definition. Have the class share answers and agree on something similar to “the resistance that one surface or object encounters when moving over another.”

Activity – 40 minutes

1. Have students remain in their groups of four and hand out the remaining materials (60 grit sandpaper, 220 grit sandpaper, 12” piece of waxed paper, 12” piece of foam, 10”x12” plastic bag, and 1 sheet of copy paper).

2. Explain that each student will determine how much force is required to move their shoe across each material. Allow students to feel the materials, but be sure they do not have access to the spring scale.
3. In their notebooks, ask students to rank the materials with those that result in the most friction at the top to least at the bottom.
4. Allow students a few minutes to talk about their predictions before allowing them to test.
5. Ask students to test the shoes, one at a time, on each material. Have one student hold the two corners of the material being tested against the table. The student testing a shoe follows the same directions as before. **Reminder, record the force applied at the moment the shoe first moves (this takes a watchful eye).**
6. Ask them to record their own results in their notebooks.
7. After testing, have students compare their results to their predictions. Have students determine which materials caused the most friction and which materials caused the least.
8. Have a class discussion about the results and have students share any results that were surprising or unusual.

Notebook prompt: Describe factors that affect friction. **Students should include a description of the sole (pattern, ridge depth, etc.), the weight of the shoe, and the surface the shoe is sliding on.**

Part 3 – Magnets and Motion (30 minutes)

Materials and Procedures

Materials for groups of 2 students

- Steel ball
- Magnet
- Student notebook* with data from part 1 and part 2 of this lesson

*item supplied by teacher

Procedure

1. Remind students about the effects of balanced and unbalanced forces on motion. Point out that motion is not just whether something is moving or not, but also how fast and in what direction. Inform them we will look at effects of another force on motion and direction.
2. Give each pair of students a steel ball and have them sit across a table from each other and roll it back and forth. Ask them to describe the forces that cause the ball to move (student pushing the ball). Ask them to describe the direction or path of the motion (straight line).
3. Give each pair of students a magnet and ask them to place the magnet between them. Challenge them to roll the ball back and forth near the magnet (but not too close) so that the ball changes direction without touching the magnet.
4. Ask students to write in their notebook how they were able to use the force of a magnet to change the direction of the ball.

5. Explain that unbalanced forces from a magnet can cause a change in direction. Challenge students to move a stationary steel ball around the table or desk without touching the magnet.

   Optional challenge: Challenge students to use a magnet to move a motionless steel ball fastest in one meter, without the ball touching the magnet. To compare speed, they will use the tape measure and timer.
6. Notebook prompt 1: Describe how magnetic force can cause a change in direction. Notebook prompt 2: Describe how magnetic force can cause a change in motion.

   Students should be able to explain that the magnet put an unbalanced force on the ball that changed its direction and speed. Change in direction is a change in state of motion even if speed stays the same.