TITLE OF LESSON PLAN:
Force -Counterforce

LENGTH OF LESSON:
One class periods

GRADE LEVEL:
6-8

SUBJECT AREA:
Physical Science

OBJECTIVES:
Students will understand the following:

1. A force is an agency or influence that, if applied to a free body, results in an acceleration of the body.

2. Gravity is such a force.

3. As the force of gravity on a body increases, the acceleration of the body increases.

4. Air resistance and friction act as counterforces to gravity.

MATERIALS:
Distribute the following materials to each group of students:

30-inch length of string

Small, freely rolling toy car

Paper clip opened to serve as a hook

A variety of weights that can be attached to the paper-clip hook

Stop watch

PROCEDURE:

1. Let students know that they will be performing an experiment that will confirm their predictions about the effect of gravity on the motion of a body.

2. Divide the class into small groups, distributing the necessary materials to each group.

3. Instruct students to set up their experiment by tying one end of the string onto the toy car and the other end to the paper-clip hook.

4. Have students place their cars on a flat table or desktop and hang the paper-clip hook over the edge of the table.

5. Calling attention to the variety of weights each group has been given, ask students to predict how the cars will move if different weights are hung from the paper-clip hook and allowed to fall to the floor. Possible predictions might include:

   (1) as the weight increases, the car will move with increasingly higher constant speeds toward the edge of the table;

   (2) different weights will have no effect on how the car moves;

   (3) as the weight increases, the car will move toward the edge of the table with greater and greater acceleration. (Correct prediction: the car will move with greater acceleration as the weight increases.)

6. After students have made their predictions, ask them to support them by creating illustrated diagrams using arrows and labels to indicate the forces and counterforces acting on the car.

7. Once the charts are complete, have students conduct experiments using the cars, weights, and stopwatch to confirm or refute their predictions. Students should record the results of their experiments.

DISCUSSION QUESTIONS:

1. Describe in terms of forces and counterforces what causes an object to experience acceleration.

2. Identify the counterforces or forces that bring a soccer ball to rest as it rolls across a field, accelerate a rocket off a launch pad, and act on a leaf as it drifts down to the forest floor.

3. Imagine a few different objects in motion—a punted football, an ice skater, and a satellite. Identify the forces and counterforces acting on them, then debate whether they are moving with constant speed or experiencing acceleration.

4. When an object is in motion, counterforces sometimes seem to get in the way. If gravity didn't act as strongly on the space shuttle, for instance, launching would be a lot easier. This is not always the case, however. Sometimes, counterforces are invaluable, as when air resistance keeps a skydiver's parachute in proper working order. Brainstorm a list of examples of useful counterforces from your everyday life. For what situations are they truly invaluable?

5. Analyze the motion of a skydiver falling to the ground. When are the forces and counterforces acting on the skydiver in balance? When are they not in balance? Describe the motion experienced by the skydiver in each situation.

6. From your personal experiences with motion, is it natural for objects to seek a state of balance or unbalance with respect to the forces acting on them? Defend your answer with examples.

EVALUATION:

You can evaluate your students on their diagrams and experiments using the following three-point rubric:

- **Three points:**diagram clearly designed and labeled, experiment carefully set up and carried out, accurate results yielded by experiment, results of experiment accurately recorded on a well-designed chart
- **Two points:**diagram clearly designed and labeled, experiment adequately set up and carried out, accurate results yielded by experiment, results of experiment adequately recorded on a sufficiently clear chart
- **One point:**diagram inadequately designed and labeled, experiment carried out, inconclusive results yielded by experiment, results of experiment only partially recorded

You can ask your students to contribute to the assessment rubric by determining criteria for a clear and accurate diagram, a well-executed experiment, and a well-designed chart for recording results.

EXTENSION:

Acceleration vs. Constant Speed

Ask your students to make a list of five different moving objects they have observed in the past 24 hours. For each item on their list, they should identify the forces and counterforces that were acting on it, and then determine whether the object was experiencing constant speed or acceleration. (Acceleration is positive when the forces acting on an object are stronger than the counterforces and negative when the reverse is the case. Negative acceleration can be thought of as deceleration.) Using words such as *force*, *counterforce*, *balanced*, and *unbalanced*, students should explain why some of the objects they observed were moving with constant speed while others were accelerating.

Air Resistance and Acceleration

Ask your students to use a stopwatch to measure the time it takes a freely rolling toy car to roll from the top to the bottom of a slightly inclined board. Instruct them to record their times. Ask students if the car appears to be rolling with a constant speed or accelerating. Then have students cut three squares out of a stiff piece of cardboard, making one square 5” x 5”, one 10” x 10”, and one 20” x 20”. Have them fasten the 10” x 10” square onto the front of the toy car so that the plane of the square is perpendicular to the forward motion of the car. Next, have students measure and record the time it takes their “sail car” to roll from the top to the bottom of the same inclined board. Instruct students to make a diagram of each part of the experiment, representing each force and counterforce acting on the car with a labeled arrow indicating the force's probable direction. Students should use their diagrams to explain the difference they observed in the times they recorded, both with and without the “sail.” Students can then use similar diagrams to predict what will happen when they replace the first cardboard “sail” with the other two and conduct experiments that will test their hypotheses.