Lesson Topic: Equal and Opposite Reactions: Newton's Third Law

Objective:
Students will be able to:

1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.

Time Required: 60 minutes

Materials Needed:

- Worksheet
- Video and a device for showing it
- Object to use on table and hold in hand

Teacher Preparation:

- Assign a Legends of Learning Instructional Quick Play playlist for the day(s) you will be teaching the lesson.
    - Instructional - Middle School - Equal and Opposite Reaction: Newton's Third Law
- Make copies of the Newton's Third Law handout (1 per student)

Engage (5 minutes):

1. Place an object (book, apple, box, etc.) on a table. Ask students to describe any forces acting on the object.
    a. Students may suggest gravity, air pressure, weight of the object, or no forces at all.
    b. In actuality there are two forces *between* the objects - the desk is pushing up on the object and the object is pushing down on the desk - these forces will be explored in this lesson.
2. Ask students if *all* forces cause motion.
    a. Some students will assume this is true. Lead the discussion toward balanced and unbalanced forces. This may have been discussed previously when discussing Newton's Laws of Motion, but should be reviewed to develop a deeper understanding.

Explore (15 minutes):

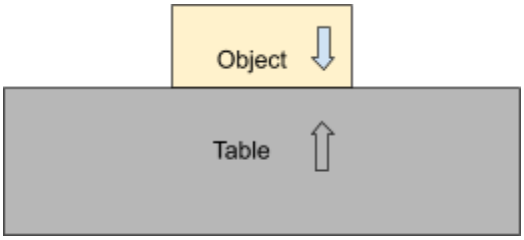
1. Watch the Moo Moo Math and Science video (2:35 minutes) on balanced and unbalanced forces. This is needed in order to offset the common misconception among middle school students that force always causes motion.
2. Ask students to reconsider the object on the desk. There are two forces, the force exerted by the table pushing up and the force of the object pushing down. Are these forces more similar to balanced or unbalanced forces?
    a. Students should respond that since the object is not moving, the forces are balanced.
3. Pick up the object from the desk and hold it (enlist a student to do this if you wish).
4. Ask students to identify the two forces acting on the object.

a. The hand pushing up on the object and the object pushing down on the hand.

5. Explain to students that these two forces are being exerted on each other- *two different objects - not one.*
6. The object should be dropped to the floor. Again, ask students what forces are present. Are these forces balanced or unbalanced?
    a. The answers should involve gravity pulling the object down and the object pulling the floor/Earth upward. Air resistance (friction between the object and the air molecules) may also be brought up in this conversation.
    b. These are unbalanced forces because the object is moving toward the floor. They are also acting on the same object. These are NOT the same forces we are discussing in this lesson. We are discussing the forces *between a pair of interacting objects*.

Explain (15 minutes):

1. Explain that we will focus on a pair of interacting objects (table and object, hand and object, floor and object) and the forces they exert on each other. This is referred to as Newton's Third Law of Motion. It is often described as for every action, there is an equal but opposite reaction.
2. These forces are actually equal forces, but they work in opposite directions.They are a force pair.
3. Draw a force diagram showing the force pair (the object on the table and the table) from the engagement activity. This will reinforce the idea of forces pulling in opposite directions.



4. Describe that the forces are equal in magnitude (size). Students often struggle with this statement after learning the other laws of motion. These forces do not cancel each other out (or have a net force of zero) because *each force acts on a different object*
5. Show video- Best Film on Newton's Third Law. Ever. to assist students in understanding how the forces are equal.

Elaborate (15 minutes):

1. Have your students sign in to Legends of Learning. Instruct students to complete the Instructional playlist.
2. Assist students as needed during game play, pause playlist if you need to address content or questions to the entire class.

Evaluate (10 minutes):

1. Complete the worksheet (attached)

Additional Lesson Strategies:

- To use Legends for additional instruction, create a custom playlist with an instructional game and pre and post assessment.
- To use Legends for a quick formative assessment, create a 5-question assessment in a playlist.
- To use Legends for a student-directed experience, create a targeted freeplay playlist.
- Encourage students to play on their own at home in Legends of Learning: Awakening for a student-driven experience including avatars, battling, and quests all centered around topics they are covering in class.

Equal and Opposite Forces: Newton's Third Law

Name:

Directions: Read each Newton's Third Law of Motion scenario and respond to the prompts.

Scenario 1:
A car accelerates forward because the ground pushes forward on the drive wheels, in reaction to the drive wheels pushing backward on the ground. You can see evidence of the wheels pushing backward when tires spin on a gravel road and throw the rocks backward.

- *What is the force pair (action - reaction pair) in this scenario?*
- *Why don't the forces in a force pair cancel each other?*

Scenario 2:
The burning fuel in a rocket engine produces hot gas. The engine pushes the hot gas out in a downward direction. The gas pushes upward on the engine. When the upward force of the gas becomes greater than the downward force of gravity on the rocket, the new force is upward. The rocket then accelerates upward.

- *What is the force pair (action - reaction pair) in this scenario?*
- *The motion of a rocket is often described using Newton's Third Law, but there is another force that is involved with the unbalanced force action that propels the rocket upward. What is that force?*

Scenario 3:
When you jump, you push down on the ground and the ground pushes up on you. The upward force of the ground combines with the downward force of gravity to create a net force acting on you. If you push down hard enough, the upward force becomes greater than the downward force and you accelerate upward in the direction of the net force.

- *If gravity were not part of this system, how would your jump change?*
- *The gravity on our moon is approximately 17% of Earth's gravity. If you jumped on the moon, how would your jump change from jumping on Earth?*

Equal and Opposite Forces: Newton's Third Law Answer Key

This activity is designed as a formative assessment opportunity to allow students to think about how Newton's Third Law is applied in relation to other laws of motion. Teachers should listen to students and review their responses to address misconceptions.

Scenario 1:

- The ground pushes forward on the drive wheels, the drive wheels pushing backward on the ground.
- These forces are acting on different objects, not the same as with balanced or unbalanced forces. Those always act on the same object.

Scenario 2:

- The engine pushes the hot gas out in a downward direction. The gas pushes upward on the engine.
- Gravity

Scenario 3:

- The jump would propel you upward. Air resistance would eventually slow you down, but the inertia would keep you moving upward until the air resistance slowed you to a stop.
- You would have less gravity pulling you down, so you would have a "bouncier" step.