7.1.2 e2 Newton's 3rd Law Narrative

Time: 90 minutes	**Anchor Phenomena:** Astronaut Gene Cernan struggled trying to work on the outside of his space shuttle
Big Idea: For every force between colliding objects, there is an equal and opposite force, related to mass.	
CCCs Systems and system models Developing and using models	**Practices** **Constructing explanations and designing solutions**

EPISODE SNAPSHOT: Students carry out investigations of Newton's Third Law and construct models (diagrams) of the forces involved in each system.

(Teacher Hint: By the end of this episode, students are able to construct a definition of Newton's Third Law of Motion and have an understanding of how this law applies during a collision of two objects. Students should not be told what Newton's Third Law is before starting this exploration, but rather asked to define it at the end of their investigations. The students should work with a partner or small group as they study these systems; it is not ideal to look at these systems as a whole class. The teacher should be monitoring the groups as they work, guiding them when necessary to help them reach the correct conclusions. This episode will be broken into three parts: exploring opposite reactions, exploring equal reactions, and explaining Newton's Third Law of Motion.)

Part A: Opposite Reactions (20-30 minutes)

Students obtain information about the collisions in three systems, diagram the direction of the initial action and force, and identify the reaction of that force. After studying these three systems, students identify the pattern that each force has an opposite reaction.

GATHERING

- System 1: Space Shuttle Launch. Students watch a video clip of a space shuttle launching and answer a few guiding questions about the forces and motion involved.

(Teacher Hint: You can google "space shuttle launch" and find a video clip that works for you. The video link below in the materials section is 4 minutes long. Students do not need to watch the whole clip, the segment from 1:20-2:00 should show them everything they need to see.)

- System 2: Swimming in water. Students watch a video clip of two swimmers moving through the water and answer a few guiding questions about the forces and motion involved.

(Teacher Hint: Again, you can google to find a video clip of swimmers. The video clip in the materials section below can be shortened to the segment from 0:37-0:50.)

- System 3: Walking. Students carry out a simple investigation involving taking a few steps, then identifying the objects in this system that are colliding (their foot and the floor) and the forces and motion of those objects.

REASONING

After gathering information about each system, students create a system model (diagram) of the collision in the system, showing the action force and the motion (or reaction force) that it causes. Students identify the pattern that they see: every force/action has an opposite reaction/force.

- System 1: Space Shuttle Launch. Students create a system model showing the hot gases from the fuel tanks exert a force downward on the air or the ground which then causes the space shuttle to move upwards.
- System 2: Swimming in water. Students create a system model showing the swimmer's hands push backwards through the water but swimmer moves forwards.
- System 3: Walking. Students create a system model showing the foot collides with the floor and pushes backwards on the floor, moving the student forward.

After the students have finished creating their models, students evaluate information from these systems to look for and identify a pattern from their diagrams and then construct an explanation for the motion in each system. (Teacher Hint: Students should see that every force produced motion in the opposite direction.)

COMMUNICATE

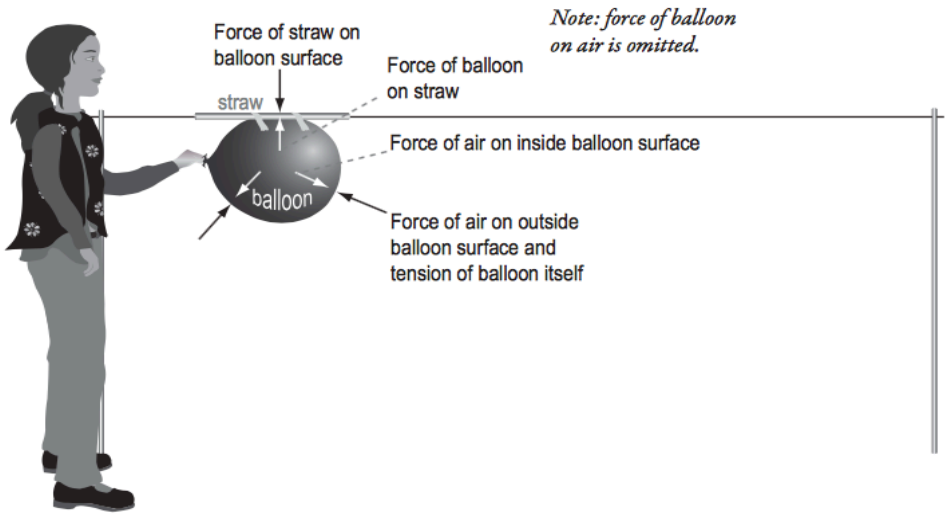
After all groups have finished creating their system models, the class should communicate the information they have discovered and have a class discussion about the findings. The teacher asks several students to share what pattern they have found and make sure the students can support their arguments with evidence from each system. If any incorrect patterns were identified or incorrect arguments were presented, the teacher should address and correct them with the help of the class before moving on to Part B. Students should also correct mistakes they may have made on their papers.

Part B: Equal Reactions (30 minutes)

Students will explore the fact that every action has an equal reaction as they carry out a balloon rocket investigation.

GATHERING

- System 4: Balloon rockets. Students will carry out an investigation using large and small balloon rockets. Students will test each size of balloon 3 times, measuring the distance that each rocket travels along the string (fishing line works best). The students should observe that the smaller balloon rockets travel a shorter distance and the larger rockets travel a longer distance. Teacher Note: to speed up the time it takes to run the balloon rockets, the strings and straws could already be set up before class and remain there all day. Then each group is only responsible for blowing up their balloons and taping them to the straw.



REASONING

- Students should average the distance the small balloon rocket traveled in the three trials and then average the trials for the large rocket.

Students should evaluate information from Systems 4 and **construct an explanation**. They should see that the reaction/motion of the object is equal to the initial/action force. A smaller balloon has smaller volume of air coming out, therefore less force and less distance traveled. The larger balloon with a large volume of air and more force travels a larger distance.

Teacher Note: Remember, Newton's Third Law of Motion says that whenever one object exerts a force on another object, the second object exerts an equal and opposite force on the first object. However, note that the two forces do not act on the same object.

COMMUNICATE

As in Part A, the class should communicate information and discuss the findings of this part and the teacher, with the help of the class, should correct any misconceptions. The class should also now create a class definition of Newton's Third Law of Motion, combining their findings from both Part A and Part B.

Assessment: NEWTON'S LAWS OF MOTION correct explanation shows understanding of Newton's 3rd Law and what and where forces are acting.	**Materials, resources, handouts, etc:** ● Space Shuttle Launch clip similar to this one: Space Shuttle Launch Audio - play LOUD (no music) HD 1080p ● Swimming video clip similar to this one: Michael Phelps-Freestyle 04 ● Colored pencils, crayons, or markers ● Small balloons, large balloons, string (fishing line), tape, straws ● Newton's Third Law--Google doc: lab and findings packet.