# 7.1.2 e3 Newton's 3rd Law on Wheels Narrative

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| **Time:** 45 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**<br>Systems and system models<br>Cause and Effect | **Practices**<br>**Planning and carrying out investigations**<br>**Constructing explanations and designing solutions** |

**EPISODE SNAPSHOT:** Students explain that very massive objects do have equal and opposite reactions, but it may not seem equal and opposite.

**GATHERING**

Present to (or even better, demonstrate for) the students a few situations where the action/reaction forces do not seem to be equal in the because one of the objects in the system is much more massive than the other object or one object is anchored to the earth. Here are some examples.

- You push on an elevator button, the button moves, but you do not.
- You try to move a giant boulder by pushing on it. Nothing happens.
- A mosquito is hit by a semi-truck on the freeway, the mosquito is smooshed, but the truck is fine.

Poll the class to see if they feel there is an equal and opposite reaction in these systems. Students support their claims with evidence, whether they think the reactions are equal or unequal.

(Teacher Hint: Some will probably feel that they are not equal and opposite (because both objects are not accelerated equally). Guide students during the discussion to compare the masses of the two objects in the system. Tell them they will be doing some experiments to determine if there is an equal and opposite reaction in a system when one object is more massive than the other.)

(Teacher Hint: The students will need a set of wheels to conduct an investigation. It is best if the kids can do these investigations themselves, however if it is difficult to find enough sets of wheels, these activities can be done as demonstrations.)

Students obtain information through conducting a few simple investigations. First, students stand on the ground and push against a wall. Second, they throw a ball. Lastly, students stand/sit on a set of wheels (skateboard, scooter, chair on wheels, etc) and repeat these activities.

**REASONING**

The students construct an explanation for why they did not move while standing on the floor, but then moved while they were on the wheels.

(Teacher Hint: They need to compare the action/reaction forces in these systems and decide why the results were different. The goal is for the students to recognize that when they are anchored to the earth, they don't move because their mass combines with the mass of the earth (or more correctly, the action and reaction both act on the earth because the wall and floor are attached to the earth, therefore cancel each other). If a person is falling toward the earth, the action is the earth pulling the person and the reaction force is the person pulling the earth. The earth's acceleration toward the person is imperceptible because the earth's mass is $1 \times 10^{23}$ times greater than the person's mass. When they are on wheels, the reaction force is only acting on their mass and is enough to accelerate them. Students need to conclude that the action and reaction forces were equal and opposite in both systems, but the results of those forces are not always equal because the mass of the objects involved.)

**COMMUNICATE**

Students share their explanations with their groups and then each group should share with the class. The class should construct a shared explanation of what they have observed and all students write down the shared explanation. Students

can then take turns verbally communicating the information they have just learned by applying it to the systems that were demonstrated at the beginning of class.

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| **Assessment**: A proficient student can explain that highly massive objects, such as the earth, are not affected by the relatively small reaction forces. The small reaction force is not enough to accelerate a large mass. Objects anchored to a massive object are also not affected by the reaction force. (For example a human standing on the surface of the earth and pushing on a wall will not move because the human is anchored to the earth and the earth's mass is added to the human's mass. The reaction force is too small compared to the combination of these masses and the human is not accelerated.) | **Materials, resources, handouts, etc.:**<br>  <br>● A ball to throw<br>● Wheels for the students to sit or stand on such as skateboards, chairs on wheels, or PE scooter boards.<br>● Hallway, aisle, or similar open space.<br>● Newton's 3rd Law on Wheels Worksheet |