Newton's Third Law

9.1 Observe and Explain

Both student *A* and student *B* sit on scooters. Student *B* pushes student *A* (or the scooter that student A is sitting on) abruptly.

a) Draw a force diagram for student A. Draw a force diagram for student B.

What do you think the length of the force arrows should be on the diagrams?	

9.2 Observe and Find a Pattern

You and your friend each hold a spring scale and you hook the scales to each other.

a) Observe what your friend's spring scale reads if you pull yours, exerting a force of 3 units.

b) Observe what your spring scale reads if they pull, exerting a force of 5 units.

c) What can you say about the magnitude and direction of the forces that one spring scale exerts on the other?

d) How can you show that they are equal in magnitude? What can you add to one to show that it is in the opposite direction?

9.3 Test Your Idea

Consider the following experiment: You and your friend each hold a spring scale and you hook the scales to each other. Is it possible for you to pull with 5 N of force and your friend with 3 N of force? You pull with 5 units of force and your friend holds their spring scale still.

Use your rule to predict what your friends scale will read.

IF _____ **AND** *you pull with 5 units of force and your friend holds their spring scale still* **THEN** _____**.**

Perform the experiment. Revise your hypothesis (explanation) if your prediction did not match the outcome.

9.4 Test Your Idea

Student *A* and student *B* are sitting on scooters. The mass of student *A* is smaller than the mass of student *B*. Use what you came up with in part d to predict what will happen to each person's motion when student A throws the ball and student B catches the ball. Check whether your prediction matches the outcome by conducting the experiment.

IF _____**AND** *students A and B start throwing a heavy medicine ball back and forth* **THEN** _____**.**

9.5 Test Your Idea

Student *A* and student *B* are on scooters. They each are holding one end of a rope Student *B* pulls on the rope, which in turn pulls on student *A*.

a) Based on your revised hypothesis, predict what should happen to each person's motion.

b) If the force student *A* exerts on student *B* is equal in magnitude (number) and opposite in direction, can we add these two forces together to get a total force of zero Newtons? Draw a force diagram for each student to answer this question.

Did You Know?

You have just developed the idea of **Newton's third law:** When objects A and B interact, the force that A exerts on B is **always the same in magnitude (number)** and **opposite in direction** to the force that B exerts on A. These forces are exerted on **different objects** and therefore cannot be drawn on the same force diagram or added together to find a total force.

$$\mathbf{F}_{\text{object 1 on object 2}} = -\mathbf{F}_{\text{object 2 on object 1}}$$

Answer all questions on a separate piece of paper

9.6 Reason

Two students sit on scooters. Student A pushes student B away from him. Student B does nothing. Does student B exert a force on A? How do you know?

9.7 Reason

a) You hit a stationary puck with a hockey stick. The stick exerts a 100-N horizontal force on the puck. What is the force exerted by the puck on the stick. How do you know?

b) A truck rear ends a small sports car that is moving in the same direction as the truck. The collision makes the truck slow down and the sports car is propelled forward. What object exerts a larger force on the other object: the truck on the car or the car on the truck. Explain how your answer reconciles with Newton's third law and with the fact that the sports car is damaged more than the truck.

c) The Earth pulls on apple exerting a 1.0 N force on it. What is the force that the apple exerts on the Earth? Why does the apply fall towards the Earth but the Earth does not move towards the apple?

d) The tree branch exerts a 1.0 N force holding the apple. What is the force that the apple exerts on the tree branch?

9.8 Reason

Use Newton's third law to predict what will happen if you try to open a door wearing rollerblades. Draw a force diagram for yourself to help make the prediction.

9.9 Represent and Reason

Your friend says that if Newton's third law is correct, no object would ever start moving. Here is his argument: You pull a sled exerting a 50 N force on it. According to Newton's third law the sled exerts the force of 50 N on you in the opposite direction. The total force is zero, thus the sled should never start moving. But it does. Thus Newton's third law is wrong. What is your opinion about this answer? How can you convince your friend of your opinion?

9.10 Reason

The Sun's mass is 2.00×10^{30} kg. It pulls on the Earth, exerting a force of about 10^{20} N. What is the force that the Earth exerts on the Sun?

9.11 Reason

The moon orbits the Earth because the Earth exerts a force on it. The Moon, therefore, has to exert a force on the Earth. What is the visible result of this force?