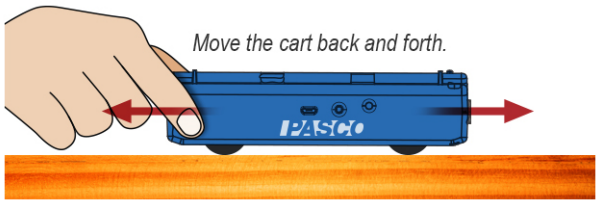
# Investigation 1A: Graphs of Motion

**Essential question: What do graphs of motion look like?**

The Smart Cart is a device that displays its motion—position, velocity, and acceleration—on your computer in real-time while you move it! Look for the connection between the forces you apply to push the Smart Cart and how the Smart Cart's position and velocity change.




Part 1: Testing the Smart Cart to see graphs of its motion

1. Open the experiment file **01A_GraphsOfMotion**, power-on the Smart Cart and connect it wirelessly to your software.
2. Start data collection and move the Smart Cart back and forth on the table.
3. Watch how the position and velocity graphs of the Smart Cart change as you move it.

Questions

a. If you push the Smart Cart across the floor and let go, what happens to its velocity? What causes this?

b. If you roll the Smart Cart down a ramp (such as a table propped up on one end), what happens to its velocity? What causes this?

c. Try to move the Smart Cart across the table with a constant velocity. What is the shape of the position versus time graph for a constant velocity?

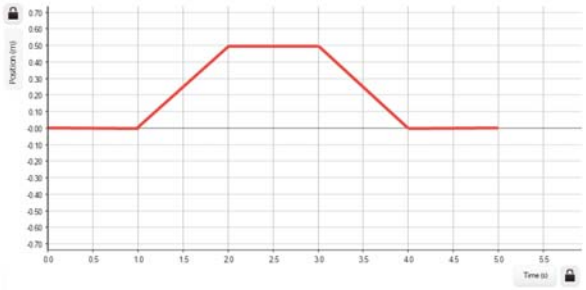
d. How does the Smart Cart track its motion? Try spinning each wheel with a finger. Does each wheel track its motion? What is the smallest distance the Smart Cart can record?

Part 2: The position versus time graph

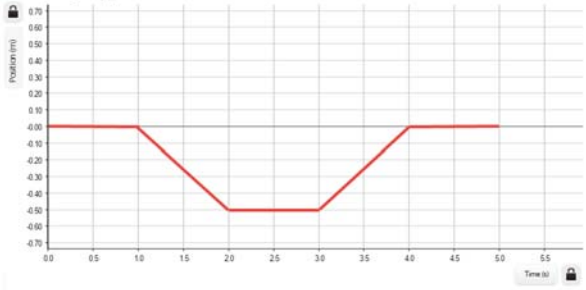
1. Go to Page 2 in the experiment file, which displays a graph of position versus time.
2. Use the Smart Cart to create the graphs shown below.

Questions

a. How do you have to move the Smart Cart to create this graph?



b. What is different about the Smart Cart's motion in this graph?



Part 3: Testing the Smart Cart to see graphs of force

1. Attach the hook to the force sensor on the Smart Cart.
2. Go to Page 3 in the experiment file, which displays a graph of force versus time.
3. Loop a rubber band around the hook and pull the cart with the rubber band while collecting data.

Questions

a. Is a pulling force positive or negative? If the cart moves in the direction of the pulling force, is the cart moving in a positive or negative direction?

b. Attach the rubber bumper to the Smart Cart and push the bumper while the cart rests against a heavy object, such as a textbook. Is a pushing force positive or negative? If the cart moves in the direction of the pushing force, is the cart moving in a positive or negative direction?

c. Is it possible for the force on the cart and the motion of the cart to have opposite signs? For example, can there be a positive force on the cart while moving in the negative direction?