RELATIVE MOTION

For a moving object, how does the velocity of the object compare to the velocity measured by an observer who is also moving?

Objectives

• Determine the velocity of an object when in a moving reference frame.

Background

In this experiment, the velocity of a red cart and a blue cart are measured using their internal sensors. Additionally, the velocity of the red cart is also measured by a motion sensor that is attached to the blue cart. Since the motion sensor is attached to the blue cart, the motion sensor is measuring velocity in a moving reference frame. When the blue cart is moving, the velocity measured by the motion sensor (the relative velocity) will not match the velocity measured by the red cart.

Materials and Equipment

• Smart Cart (Blue)
• Smart Cart (Red)
• Smart Cart Motor
• Wireless Motion Sensor
• Fan Sail

• Smart Cart Rod Stand Adapter
• Pulley Rod
• Dynamics Track and Track Feet
• SPARKvue Software
• Configuration File: `relative_motion.spklab`

Safety

Follow regular laboratory safety precautions.
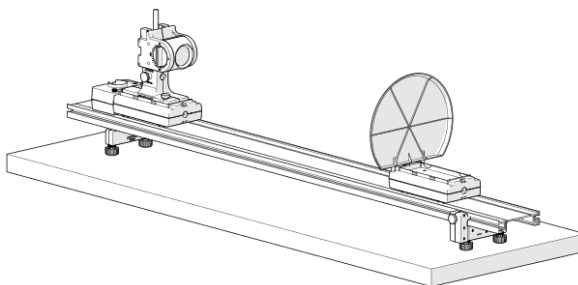
Procedure

Setup

Figure 1. Experiment setup.

1. Set up the track with the feet as shown in Figure 1.

2. Set up the Blue Smart Cart and place it on the track as shown in Figure 1:

    a. Attach the Smart Cart Motor to the cart.

    b. Attach the Smart Cart Rod Stand Adapter to the cart.

    c. Insert the Pulley Mounting Rod into the Smart Cart Rod Stand Adapter.

    d. Attach the Motion Sensor to the rod.

3. Attach the sail to the Red Smart Cart and place it on the track.

4. Open the `relative_motion.spklab` file.

5. Connect the Blue Smart Cart, Red Smart Cart, and the Wireless Motion Sensor to SPARKvue.

Only Red Cart Moving

In this part of the lab, the red cart moves toward and away from the blue cart which remains at rest.

1. Place the carts on opposite ends of the track facing each other.

2. Disable Code Execution in the Code tool in SPARKvue.

3. Click Record and slowly move the red cart toward the blue cart for about 50 cm then slowly move the red cart back to its original position then click Stop.

4. Enable Code Execution in the Code tool (for the remaining parts of the lab).

5. Sketch the resultant graphs in Graph 1. Provide a title for the graph and label each measurement in the Key.

Only Blue Cart Moving

In this part of the lab, the Blockly program will cause the blue cart to move toward the red cart at rest. When the blue cart comes within 20 cm of the red cart, it will change direction and move away from the red cart, stopping when it returns to its original position.

1. Place the carts on opposite ends of the track.

2. Click Record while leaving the red cart at rest. Data collection will automatically stop when the Blue cart returns to its original position.

3. Sketch the resultant graph in Graph 2. Provide a title for the graph and label each measurement in the Key.

Carts Moving in Opposite Directions

In this part, the blue cart and red cart move in opposite directions toward each other. When the blue cart is within 20 cm of the red cart it will change direction.

1. Place the carts on opposite ends of the track.

2. Click record then slowly move the red cart toward the blue cart. Move the red cart away when the blue cart changes direction.

3. Sketch the resultant graph in Graph 3. Provide a title for the graph and label each measurement in the Key.

Carts Moving in the Same Direction

In this part, the blue cart and red cart move in the same direction, staying at least 20 cm apart at all times. When the carts reach the opposite end of the track, the blue cart will change direction and the red cart will follow the blue cart.

1. Place the blue cart on one end of the track and move the red cart within 20 cm of the blue cart.

2. Click Record and move the red cart slowly away from the blue cart, both moving in the same direction. Make sure that the blue cart is never closer than 20 cm until both carts reach the end of the track.

3. When the blue cart changes direction, move the red cart towards the blue cart, always making sure to keep the red cart 20 cm away from the blue cart.

4. Sketch the resultant graph in Graph 4. Provide a title for the graph and label each measurement in the Key.
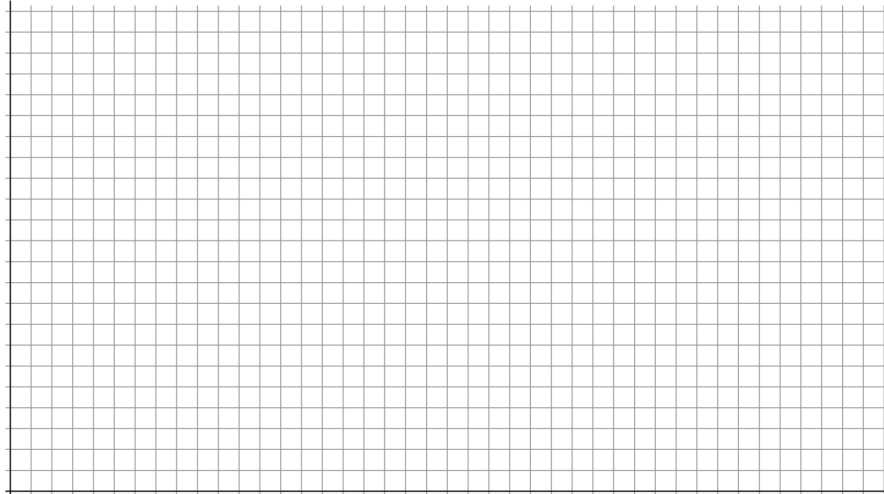
Data Collection

Graph 1:
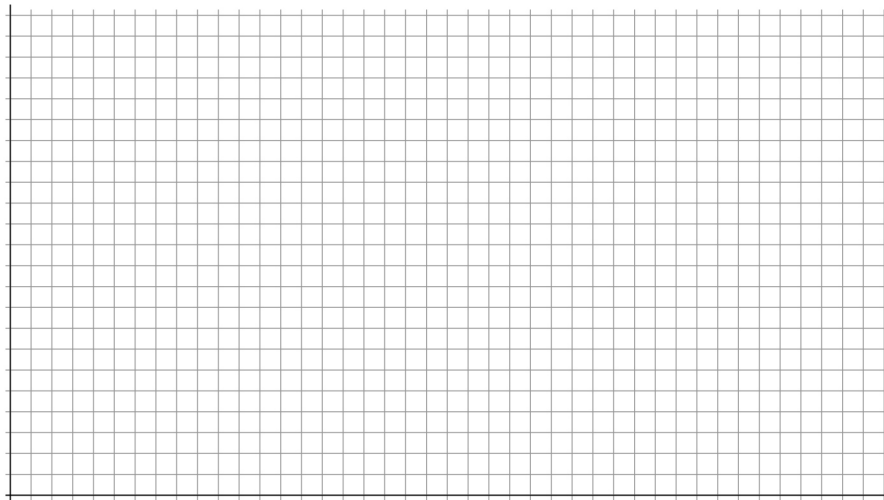
Graph 2

Graph 3

Key

Graph 4

Key
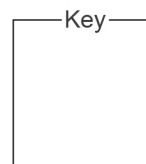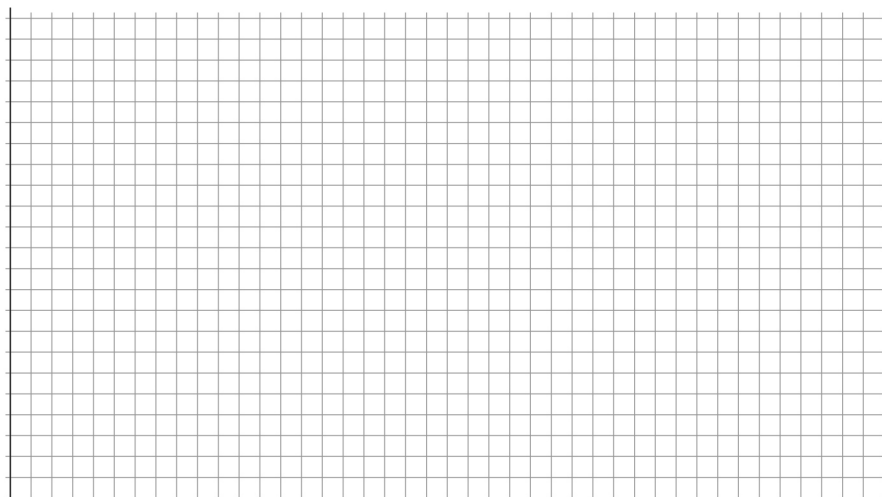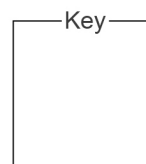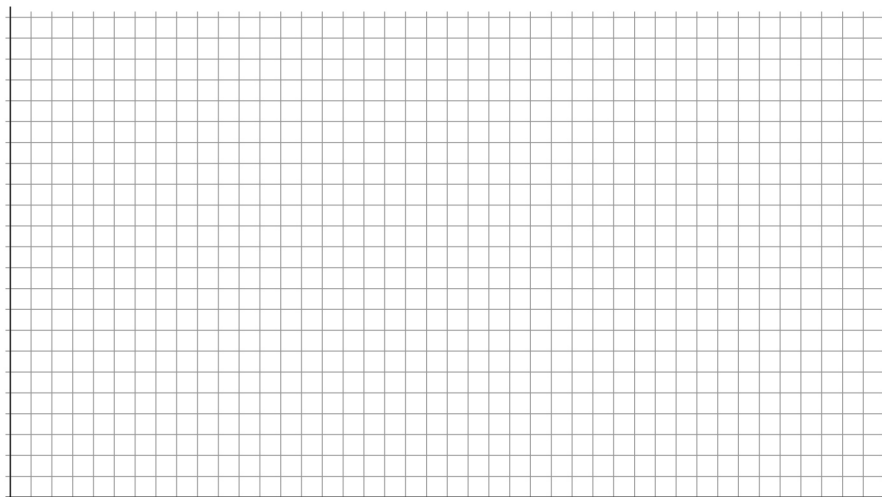
Questions and Analysis

1. When the red cart moves towards or away from the blue cart at rest, how does the relative velocity measured by the motion sensor compare to the velocity of the red cart?

2. When the blue cart moves towards or away from the red cart at rest, how does the relative velocity measured by the motion sensor compare to the velocity of the blue cart?

3. When both carts move toward or away from each other, how does the relative velocity measured by the motion sensor compare to the velocities of the blue and red carts?

4. When both carts move in the same direction, how does the relative velocity measured by the motion sensor compare to the velocities of the blue and red carts?

5. Describe how you can determine the velocity of an object if you are in a moving reference frame.