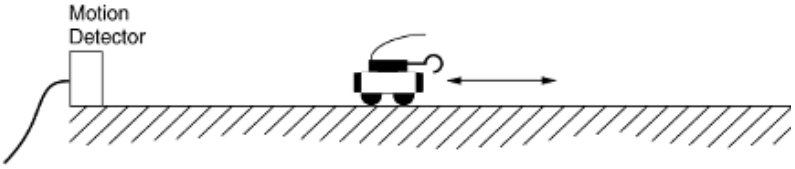
Activity 2-1: Pushing and Pulling a Cart

Students have completed labs to understand velocity and acceleration, and have just completed an activity to familiarize them with the force sensors and with proportional relationships. In this activity they will make the first connection between force and motion. This activity catches many students by surprise, as it targets a very common misconception.

In this activity you will move a low-friction cart by pushing and pulling it with your hand. You will measure the force, velocity, and acceleration. Then you will be able to look for mathematical relationships between the applied force and the velocity and acceleration, to determine if any such relationships exist.

1. Obtain a force sensor, motion detector, two USB links and one USB bus. Attach the USB links to the sensor and detector. Then attach the free end of each link to the USB bus in the ports labeled "PORT 1" and "PORT 2." The USB bus should have two black cords attached, a USB cord attached to the "ROOT PORT" and a power cord attached to the DC outlet. Plug the USB cord into the port on the back of your computer, and the power cord into the power strip at your lab station. Make sure that the switch on the USB hub is set to "Self" and not "Bus". Start up the computer if it is not already running. The computer may send messages that it has detected new hardware and is installing new software; allow your computer to complete any installation. Within a few seconds the computer should announce a sensor detected and ask you what to do. Select "Launch DataStudio" and wait until it has finished loading and detected the sensor. Click on the "Start" button along the bar at the top and move something away and towards the motion detector to verify that it is working. You should hear it making a clicking sound and see the Position line being graphed move up and down. Push and pull on the hook of the force sensor to verify that it is also working. The Force line being graphed should move up and down. Click on "Stop" (the same button as "Start") and clear the data by going to "Experiment" on the top menu, selecting "Delete Last Data Run" and answering "OK" to the prompt. *Make sure the motion detector is set to detect "cart" motion.*

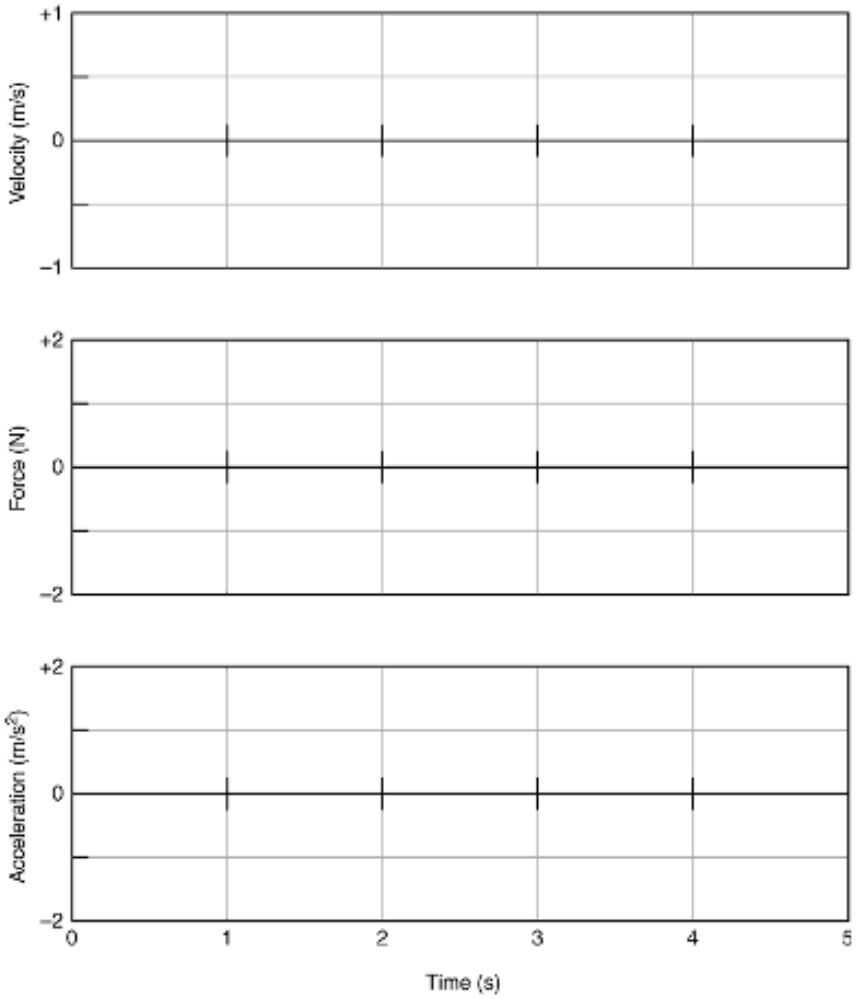
Set up the cart, force sensor, and motion detector on a smooth level surface as shown below. The cart should have a mass of about 1kg with force sensor included. Fasten additional mass to the top if necessary.



The force sensor should be fastened *securely* to the cart using the attachment screw *so that its body and cable do not extend beyond the end of the cart facing the motion detector.* Note that there are two holes on the force sensor; put the attachment screw through the one labeled "cart," otherwise the force sensor will not attach snugly.

Prediction 2-1: Suppose you grasp the force sensor hook and move the cart forward and backward in front of the motion detector. Do you think that either the velocity or the acceleration graph will look like the force graph? Is either of these motion quantities related to force? (That is to say, if you apply a changing force to the cart, will the velocity or acceleration change in the same way as the force?) Explain.

2. To test your predictions, open the experiment file called **MotionAndForce.** This will set up velocity, force, and acceleration axes with a convenient time scale of 5 s, as shown below.



3. **Zero** the force sensor. Grasp the force sensor hook and **begin graphing**. When you hear the clicks, quickly pull the cart away from the motion detector and quickly stop it. Then quickly push it back toward the motion detector and again quickly stop it. Pull and push the force sensor hook along a straight line parallel to the ramp. *Do not twist the hook. Be sure that the cart never gets closer than 30 cm away from the motion detector.*

4.Carefully sketch your graphs on the axes above.

Question 2-1: Does either graph – velocity or acceleration – resemble the force graph? Which one? Explain.

Question 2-2: Based on your observations, does it appear that there is a mathematical relationship between either applied force and velocity, applied force and acceleration, both, or neither? Explain.