I. Motion of a fan cart ignoring friction

In the following experiments, you will use the motion sensor and a low friction cart.
The positive direction is away from the rangers. Slide the carts **gently** on the track to get a feeling for how they move**. Do not drop them or run them off the edge of the table!**

In part I of this tutorial we will ignore friction.

A. Example 1: A fan cart moving in one direction

Turn on the fan but put your hand in front of the cart so that it does not move.

1. Draw a free body diagram for the cart/fan system. Label all the forces acting on the cart/fan by identifying:

   a. the type of force (if possible),

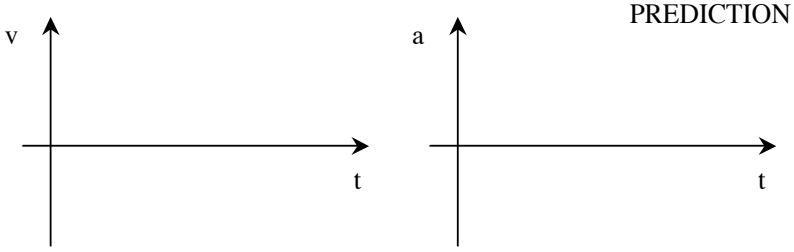
   b. the object on which the force is exerted, and

   c. the object exerting the force.

2. How, if at all, would your free body diagram change if you were to remove your hand from the front of the cart?

3. Suppose that the cart moves away from the motion sensor, starting from rest, while the fan supplies a constant force. Predict what the velocity vs. time and the acceleration vs. time graphs would look like. Explain how you arrived at your answer

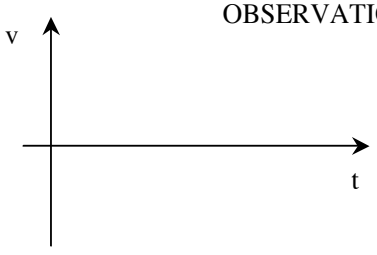
PREDICTION



Place the motion sensor so that it measures the velocity of the cart on the table.

4. Let the cart be at rest approximately 0.2 m from the motion sensor. Turn on the fan. Take data using the motion sensor starting at the moment the cart begins to move. Sketch the velocity graph on the axes at right.

OBSERVATION



5. Compare your observed graph in question 4 with your prediction in question 3. Resolve any discrepancies.

6. Use the velocity graph to describe the acceleration of the cart. Explain how you arrived at your answer.

7. By clicking your mouse in the window, you can find the value of the velocity at different times. Use these values to find the *average* acceleration of the cart during its motion. Explain how you arrived at your answer.

B. Example 2: A fan cart given an initial push in the same direction as the force of the fan on the cart/fan system

Suppose that you give the cart a small initial push in the same direction as the force exerted on cart/fan system by the fan. In such a situation, the cart/fan system is already moving away from the motion sensor at time t = 0 sec.

1. Draw a free body diagram for the cart/fan system after it is no longer touching your hand. Label all forces on the cart/fan system by identifying:

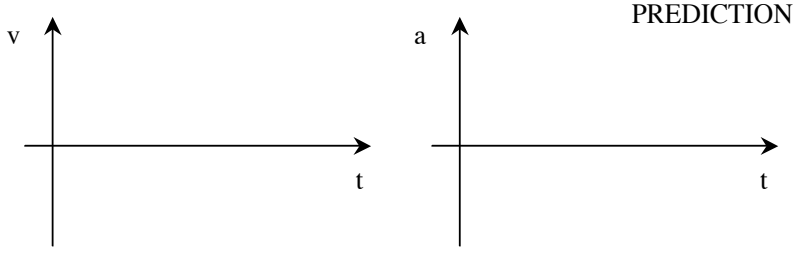
   a. the type of force (if possible),

   b. the object on which the force is exerted, and

   c. the object exerting the force.

2. Predict what the velocity vs. time and the acceleration vs. time graphs would look like. Explain.

PREDICTION

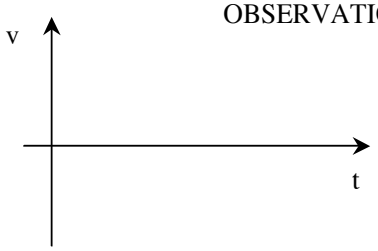


3. How, if at all, do you expect the graphs to be different from the graphs you obtained in part A, Example 1? Explain the reasong for any of the differences that you expect.

4. Take data using the motion sensor for the situation above. (Give the fan cart a gentle push *before* you start the motion detector.) Sketch the velocity graph in the space to the right.

5. Compare your graph with your prediction. Resolve any discrepancies.

OBSERVATION

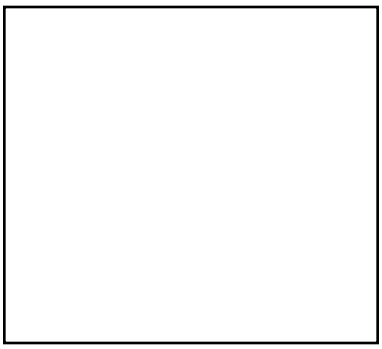


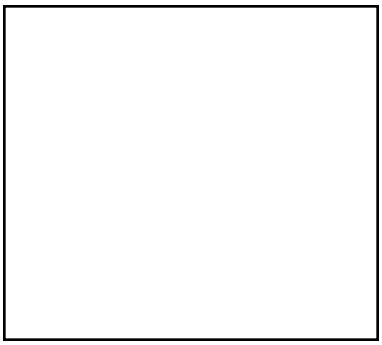
6. Compare the accelerations in the graph above to the acceleration in the graph in part A, Example 1. Discuss similarities and differences.

C. Example 3: A fan cart given an initial push in the direction opposite that exerted by the fan on the cart/fan system.

Suppose that you push the cart so that the initial velocity is in the opposite direction of the force the fan exerts on the cart/fan system and towards the motion sensor. Assume that friction is negligible.

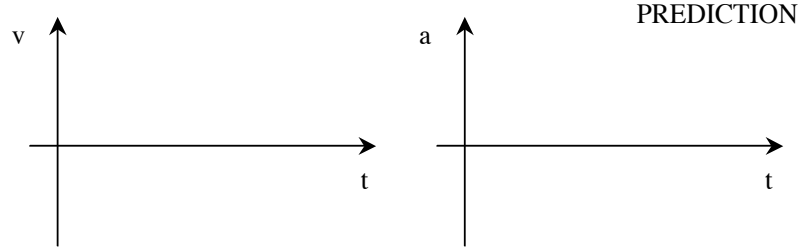
1. Draw two free body diagrams below after the cart/fan system is no longer touching your hand. On the left, draw one for the cart/fan system on its way toward the motion sensor. On the right, draw one for the cart/fan system after it turns around.





2. Predict the shape of the velocity and acceleration graphs for this situation. Sketch your predictions on the graphs below.

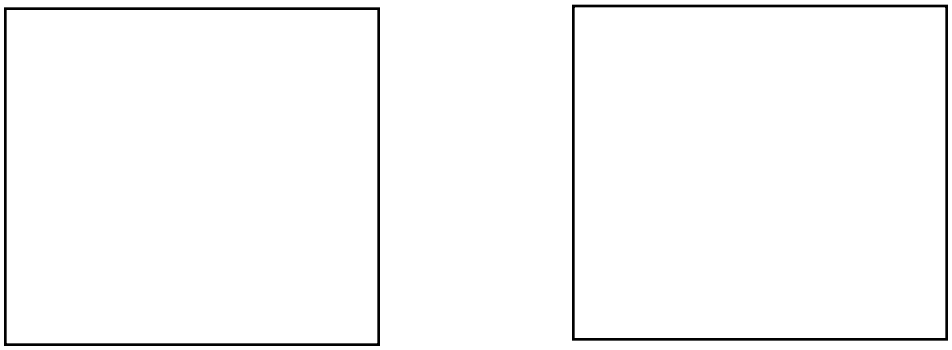
PREDICTION



II. Motion of a fan cart with friction

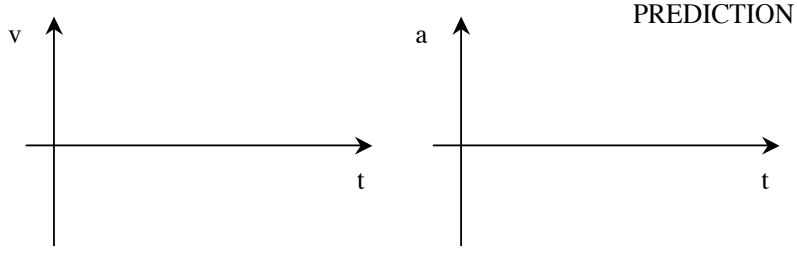
Suppose that you push the cart so that the initial velocity is in the opposite direction of the force the fan exerts on the cart/fan system and towards the motion sensor. However, now do *not* assume that the friction is negligible.

1. Draw two free body diagrams below for the cart/fan system after it is no longer in contact with the hand. On the left, draw one for the cart/fan system on its way toward the motion sensor. On the right, draw one for the cart/fan system after it turns around.



2. Predict the shape of the velocity and acceleration graphs for this situation. Sketch your predictions on the graphs below.

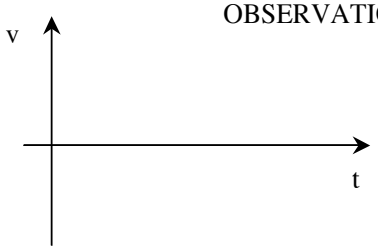
PREDICTION



3. Compare these velocity and acceleration graphs to your graphs when there was no friction. Explain any differences between the graphs.

4. Take data using the motion sensor for this situation. You may need to adjust the time axis to display up to 10 seconds. Sketch the velocity graph in the space to the right.

OBSERVATION



5. Is there evidence that there is a frictional force? Explain.

6. Estimate the value for the frictional force. Explain your reasoning. (A balance scale is provided in the room.)