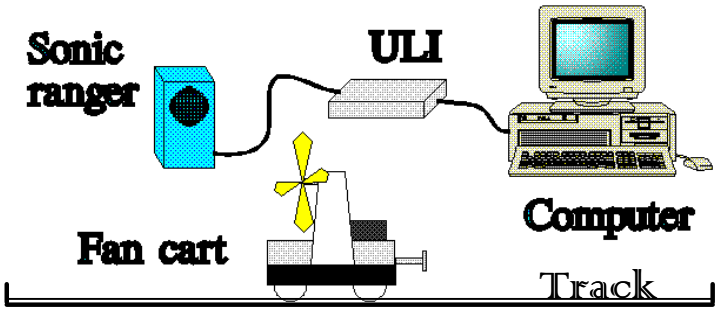
Force and Motion

I. Motion of a fan cart ignoring friction



In the following experiments, you will use the sonic ranger 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.

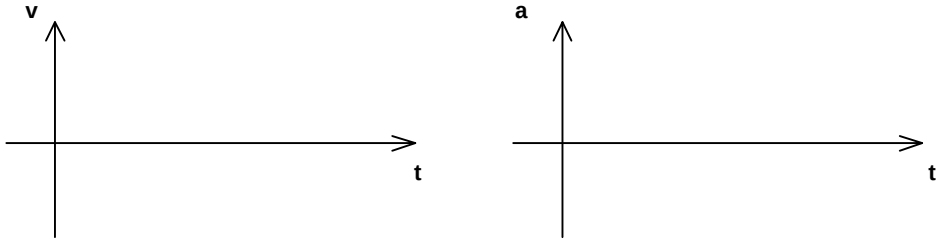
A. Example 1

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 forces by identifying: a) the type of force, b) the object on which the force is exerted, and c) the object exerting the force.

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

3. Suppose that the cart moves away from the sonic ranger, 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.



For the rest of the tutorial, the cart should stay on the track on your tabletop. Place the sonic ranger so that it measures the velocity of the cart on the track.

4. Let the cart be at rest approximately 0.5 m from the sonic ranger. Turn on the fan. Take data using the sonic ranger starting at the moment the cart begins to move. Sketch the velocity graph on the axes at right.

Compare your graph with your prediction on the previous page. Resolve any discrepancies.

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

Use the ANALYZE menu (found by holding down the right mouse button) and the ANALYZE DATA A function to tell you the value of the velocity at different times. Find a value for the *average* acceleration of the cart. Explain how you arrived at your answer.

Compare the average acceleration to the instantaneous acceleration given by the ANALYZE data on the bottom of the graph window. Resolve any discrepancies.

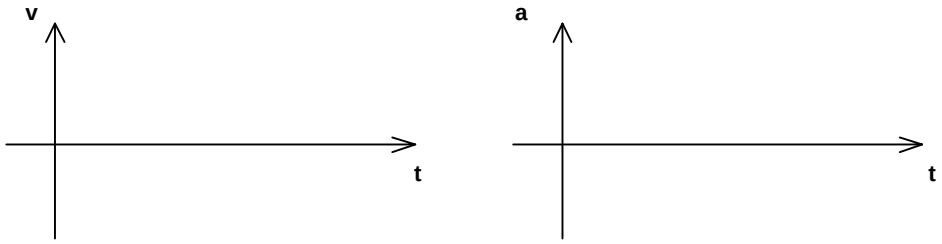
Before continuing on to the next part, store your data by clicking on the right mouse button and going to Data > Data A⇒Data B.

B. Example 2

Suppose that you give the cart a small initial push (while the fan is on) so that it is already moving away from the sonic ranger 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 by identifying: a) the type of force, 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.



3. How, if at all, do you expect the graphs to be different from the graphs you obtained in example 1? Explain your reasoning.

4. Take data using the sonic ranger 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.

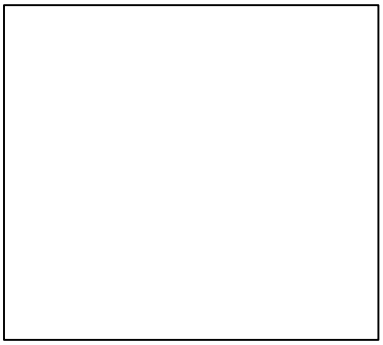
Compare your graph with your prediction. Resolve any discrepancies.

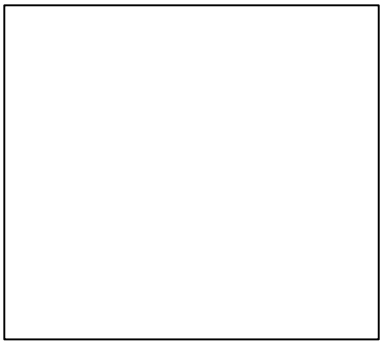
Compare the accelerations in the graph above to the acceleration in the graph in example 1.

C. Example 3

Suppose that you push the cart so that the initial velocity is in the opposite direction of the force of the fan and towards the sonic ranger. Assume that the friction is negligible.

1. Draw two free body diagrams below. On the left, draw one for the cart/fan system on its way toward the sonic ranger. On the right, draw one for the cart/fan system after it turns around.



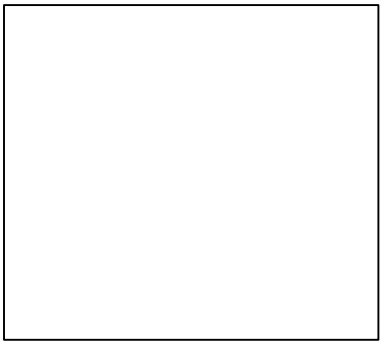


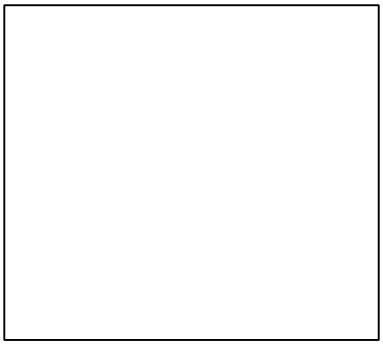
2. Predict the shape of the velocity and acceleration graphs for this situation. Sketch your predictions on the graphs below.

II. Motion of a fan cart with friction

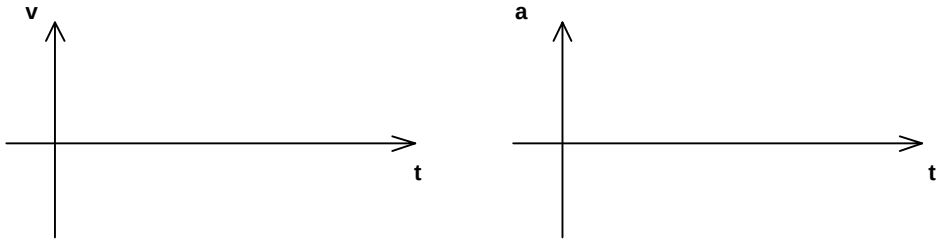
Suppose again that you push the cart so that the initial velocity is in the opposite direction of the force of the fan. However, now do *not* assume that the friction is negligible.

1. Draw two free body diagrams below. On the left, draw one for the cart/fan system on its way toward the sonic ranger. 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.



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

3. Take data using the sonic ranger 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.

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

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