Experiment
3

Newton's First Law

INTRODUCTION

Everyone knows that force and motion are related. A stationary object will not begin to move unless some agent applies a force to it. But just how does the motion of an object depend on the forces acting on it? In this experiment you will begin to examine the role that forces play in motion of an object.

OBJECTIVES

In this experiment, you will

- Collect position, velocity, and time data as a cart is launched by a spring and slowed by friction.
- Analyze the position *vs.* time and velocity *vs.* time graphs.
- Investigate the effect of varying the friction on the velocity of the cart.

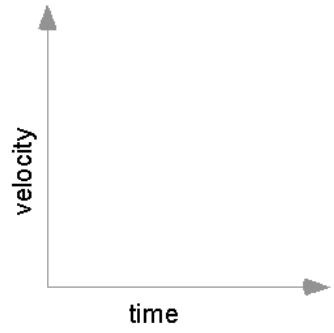
MATERIALS

Vernier data-collection interface
Logger *Pro* or LabQuest App
Vernier Motion Detector
Vernier Dynamics Track
standard cart
Cart Friction Pad
(recommended) Bumper and Launcher Kit
(optional) heavy rubber band and support stands

PRE-LAB INVESTIGATION

Place the Cart Friction Pad on one end of the cart. Adjust the friction pad so that it makes contact with the track when the cart is placed on the track. Give the cart a gentle push so that it comes to a stop before reaching the end of the track.

On the axes to the right, sketch a graph of velocity *vs.* time based on what you observed. Use a coordinate system in which the origin is on the left and positive is to the right.



PROCEDURE

1. Attach the Launcher Assembly near the one end of the track. Use the heavier of the two hoop springs that come with the kit.[1] Adjust the screws on the feet to level the track.

2. Attach the cart friction pad to one end of a standard cart. Adjust the friction pad so that it makes slight contact with the track (see Figures 1 and 2).

Figure 1

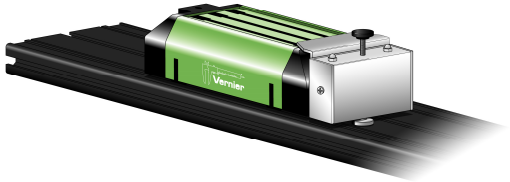


Figure 2

3. Attach the Motion Detector to the bracket that will allow you to position it near the other end of the track.

4. If your motion detector has a switch, set it to Track. 

5. Connect the motion detector to the interface and start the data-collection program. Two graphs: position *vs.* time and velocity *vs*. time will appear in the graph window.

6. Adjust both the extent to which you compress the spring and the friction pad so that the cart travels approximately 30 cm before coming to a stop. Do not compress the hoop spring more than half of its diameter.

7. Position the cart so that it is just touching the hoop spring and then zero the motion detector.

8. Push the cart against the spring, begin collecting data, wait a couple of seconds, and then release the cart.

9. Repeat Steps 7 and 8, if necessary, until you get a trial with a smooth position *vs*. time graph and a velocity *vs*. time graph that looks something like the one below.

[1] If the launcher is not available, your instructor will show you how to set up an alternative means to launch the cart.

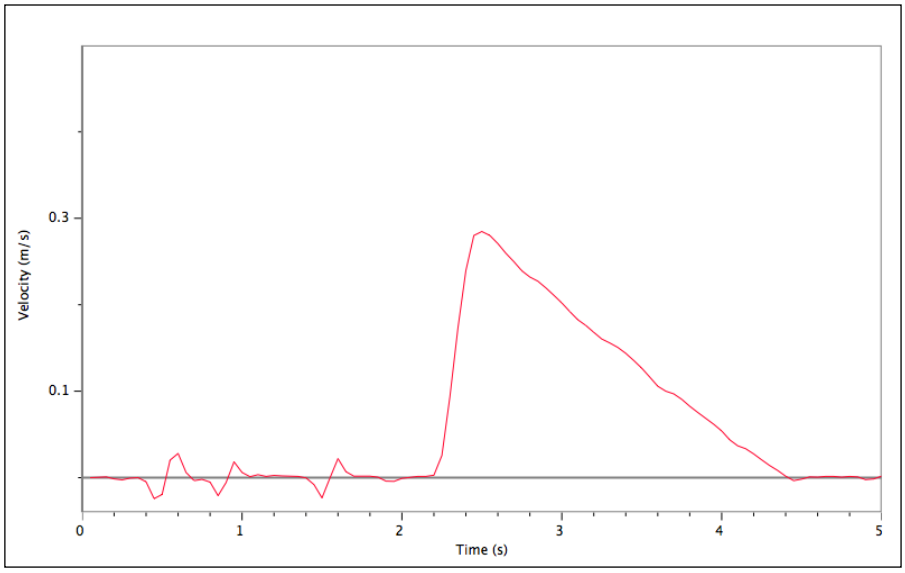


Figure 3

10. Store this run, then decrease the pressure of the friction pad on the track a bit (try a quarter turn), then repeat Step 8 until you get a smooth position graph and a velocity graph that has a less steep slope than that in the graph from the first run. Be sure to compress the spring by the same amount in each of these runs and to re-zero the motion detector from time to time.

11. Store Run 2, and continue this process, decreasing the friction slightly until you have 4–5 runs, each of which has a shallower slope in the velocity graph than that in the previous run. Be sure to store each of these runs. You may have to keep the cart from running off the end of the track in some of these runs.

12. Finally, loosen the adjusting screw until that the friction pad no longer makes contact with the track, and collect data for one last run. Be sure to save the data file.

DATA ANALYSIS

1. Hide all but your initial data set. Either print or sketch the position *vs.* time and velocity *vs.* time graphs for your first run. On the velocity graph identify:
   - Where the cart was being accelerated by the spring.
   - Where the cart was slowing to a stop.

2. Perform a linear fit on the portion of the velocity where the cart was slowing to a stop. Record the acceleration of the cart during this interval.

3. Now, show the data set for your second run. Repeat Step 2. How does the acceleration of the cart in this run compare to that in the first run?

4. Continue this process until you have analyzed the velocity graphs for all of your runs. If the window gets too cluttered, you can hide some of the earlier runs. Compare the shape of the position graph for your final run with that from the first run.

5. Recalling that acceleration is the rate of change of velocity, write a general statement describing the relationship between the rate of change of the cart's velocity and the frictional force acting on the cart.

6. Based on your statement in the previous step, how can you account for the fact that the rate of change in the cart's velocity did not reach 0 when the friction pad no longer made contact with the track?

7. Discuss what adjustment you could make to the track to reduce the change in velocity to 0. Explain why this adjustment would produce this result. Summarize your general conclusions from your discussion.

EXTENSION

Go back to your apparatus and see how close you can come to producing a run in which the change in velocity is zero.