

Name: _____ Period: _____

Newton's Second Law Lab

Imagine a race between two horses, each of which is pulling a wagon. The wagons are identical, but one is filled with bags of cement while the other is empty. Ten seconds into the race, which of the wagons would you expect to be in the lead? Which wagon will be traveling the fastest?

Consider a second race. Both of the wagons are loaded with bags of cement, but this time one wagon is pulled by a team of four horses, while the other is pulled by only one horse. Ten seconds into this race, which wagon will be in the lead? Which will be traveling the fastest?

These scenarios provide examples of how the mass of an object, as well as the force acting on the object, affect its acceleration. The relationship is expressed mathematically as Newton's Second Law of Motion. It is one of the most powerful and far-reaching laws in all of science.

Part 1: Force and Acceleration

In Part 1 of the lab, you will examine how different forces applied to an object affect its acceleration. The object, in this case, will be a cart, and the forces will be applied by fans sitting on the cart. When the fan blows to the left, the force on the cart is directed to the right, and vice versa.

Procedure:

1. Launch Internet Explorer
2. Go to www.explorellearning.com
3. Click on Login.
4. Enter the Username: blue1112 Password: green1112
5. Search for Fan Cart Physics
6. Click on *Launch Gizmo* for **Fan Cart Physics**. Be patient for it to load.
7. Make sure that the Gizmotm is reset and that Initial velocity of cart, in the **DESCRIPTION** pane, is set to 0.0 m/s. Drag all three fans - A, B, and C - to the top of the cart. The fans should be blowing to the left. (DIRECTION should be set to +.) Turn on Fan A. (Click the ON/OFF button for Fan A so that it turns red.) Leave the other two fans turned off. Click Play (▶). Watch the cart at the bottom of the Gizmo. When the cart has traveled about 8 or 9 meters, before it hits the wall at the end, click Pause (⏸).
8. Click the **GRAPH** tab. Be sure that **x vs t** is selected from the dropdown menu.
 - a. Is the **x vs t** graph straight or is it curved? _____
 - b. What was the position of the cart at the start (at $t = 0$ s)? _____
 - c. What was the position at $t = 6$ s? _____

9. Click the **GRAPH** tab and select v vs t from the dropdown menu.

a. Is the v vs t graph straight or is it curved? _____

b. What was the velocity of the cart at the start (at $t = 0$ s)? _____

c. How about at $t = 4$ s? _____

d. By the graph was the cart speeding up or slowing down? _____

10. Click the **GRAPH** tab and select a vs t from the dropdown menu.

a. Is the a vs t graph straight or is it curved? _____

b. What is the value for acceleration? _____

11. Click Reset () to return the cart to its original position. Turn on Fan B so that both Fan A and Fan B are running. Both fans should be blowing to the left (DIRECTION set to +). Click Play and observe the motion of the cart. Click Pause before the cart strikes the wall.

a. In which case did the cart gain speed more quickly - with one fan running or with two fans running? Explain. _____

b. Look at the x vs t , v vs t , and a vs t graphs for this motion. How do the shapes of these graphs compare to those from the preceding trial? _____

c. What is the acceleration when both Fan A and Fan B are running? _____

12. Display the v vs t graph. Note that the graph is a straight line. Using the coordinates of two points on the line, which you can get from the **TABLE** pane, calculate the slope of this line. (Remember that the slope of a line is the change in y divided by the change in x , or in this case, the change in v divided by the change in t .) Show your work.

a. How does the slope of the v vs t graph compare with the value for the acceleration in the previous question _____

13. Reset the simulation again. Turn on Fan C so that all three fans are running and facing to the left (DIRECTION should be +). Click Play and observe the motion of the cart.

a. What is the value for the acceleration in this case? _____

b. How does it compare to the accelerations with one fan running and with two fans running? _____

Part 2: How Mass Affects Acceleration

In Part 2 of the lab you will apply the force from a single fan to the cart as it carries various masses.

14. Reset the simulation and make sure the cart has no fans or no masses on it. Place a single fan onto the cart, facing left (DIRECTION +), and turn it on. Click Play and observe the motion of the cart.

a. Find the acceleration of the cart from either the **TABLE** pane, the **BAR CHART** pane, or the a vs t graph in the **GRAPH** pane. _____

b. How could you use the v vs t graph to determine the acceleration of the cart? _____

15. Reset the simulation once again. Drag one mass to the cart.

a. How do you expect that the addition of the mass will affect the motion of the cart?

b. Click Play to run the simulation. Repeat the process two more times, each time adding another mass to the cart. Record the acceleration in each case.

Acceleration of cart with 1 mass: _____

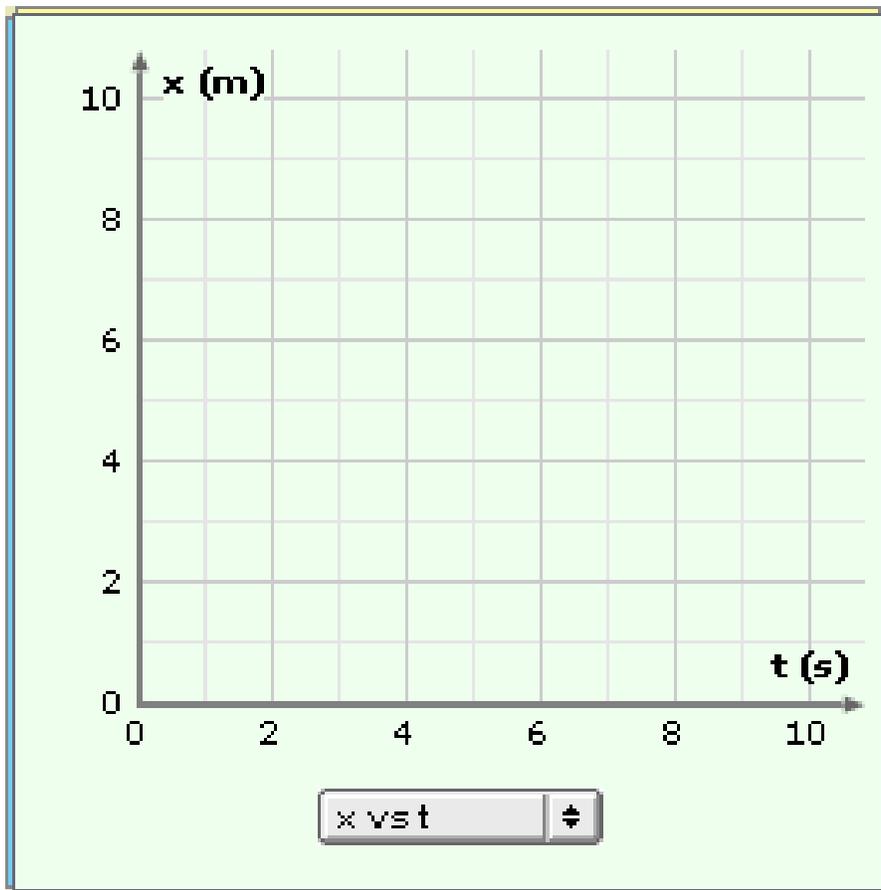
Acceleration of cart with 2 masses: _____

Acceleration of cart with 3 masses: _____

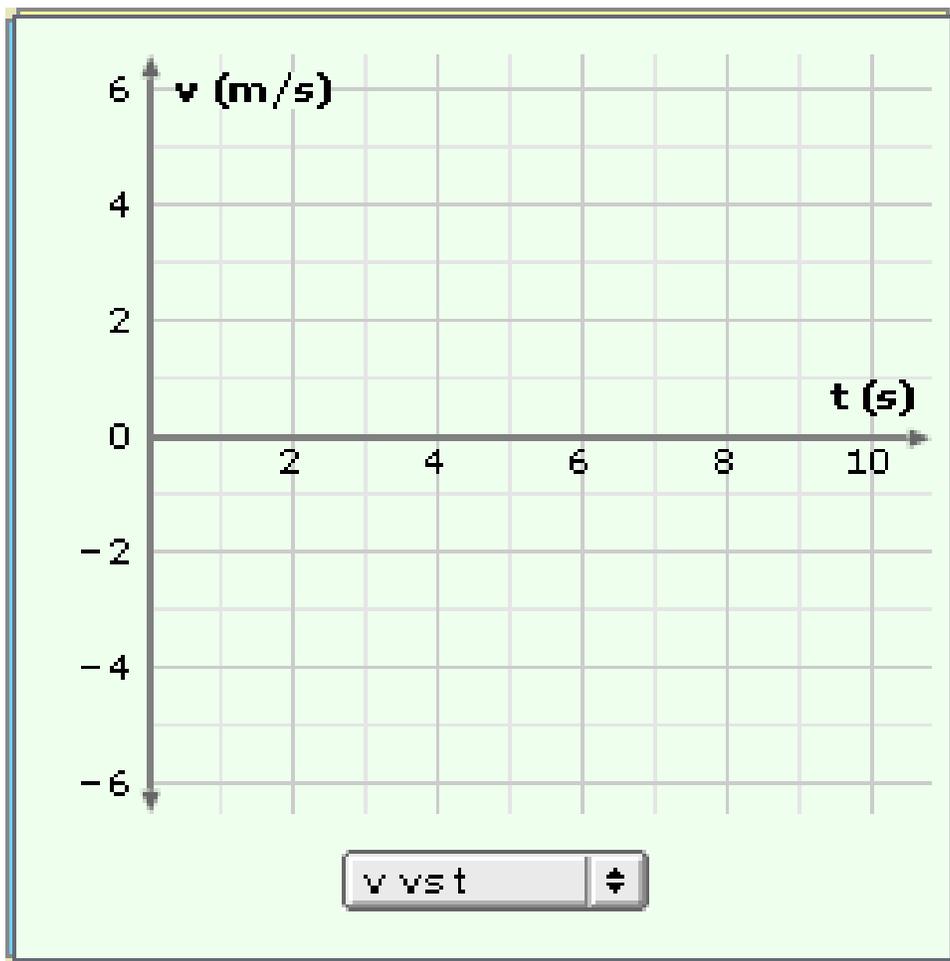
c. How is the acceleration affected as more mass is added? _____

- d. Assume that the cart can hold an unlimited number of blocks, and that you have an unlimited supply of blocks. Would it be possible to pile so many blocks on the cart that the acceleration would be zero or negative? Explain. _____

- e. How does adding mass, with a fan blowing in the positive direction, affect the x vs t graph? Make a sketch of at least two lines on the graph below to support your answer.



- f. How does adding mass, with a fan blowing in the positive direction, affect the v vs t graph? Make a sketch of at least two lines below of the graph to support your answer.

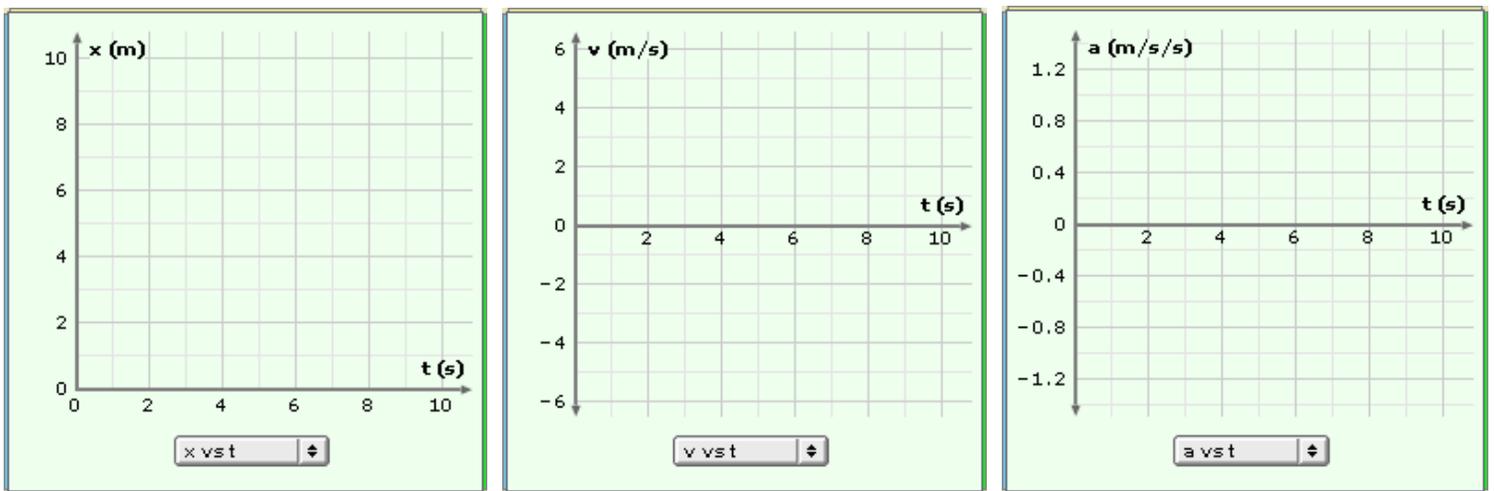


Part 3: Zero Force and Negatively Directed Force

In Part 3 of the lab, you will start the cart in motion and explore the effects of a force applied in the negative direction to the cart. You will also examine the motion of the cart when no net forces act on it.

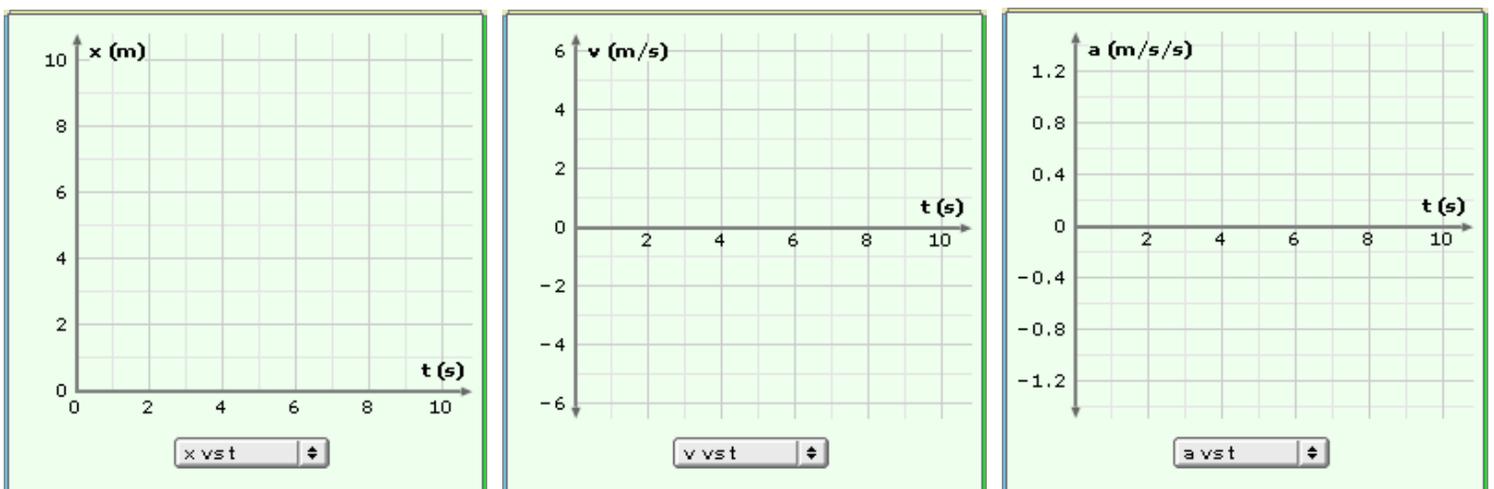
16. Click Reset and remove any fans and blocks from the cart. In the **DESCRIPTION** pane, set Initial velocity of cart to 2.0 m/s. Place a single fan onto the cart, turn it on, and switch its **DIRECTION** to negative (-). Click Play and observe the motion of the cart. Click Pause before the cart strikes either wall.

- What is the acceleration in this case? _____
- Click on the **GRAPH** tab. Make a sketch of the three graphs below.

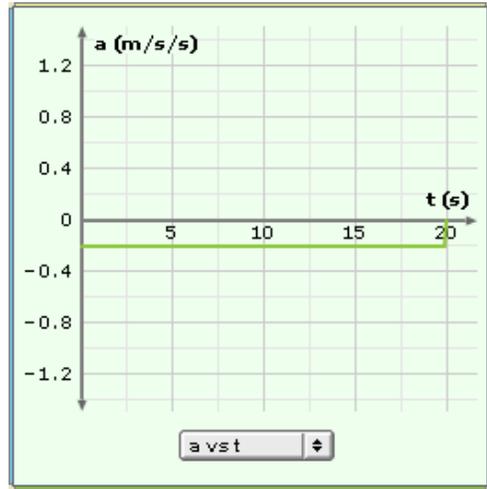
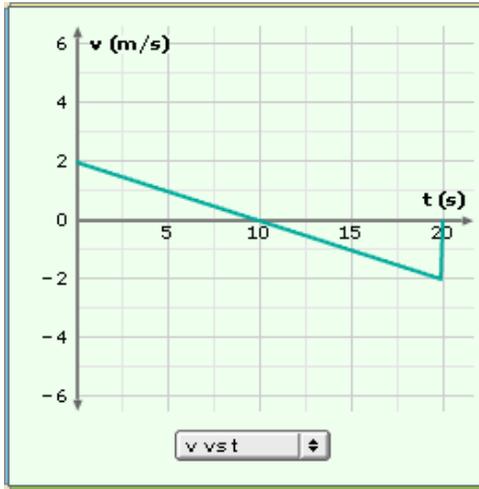
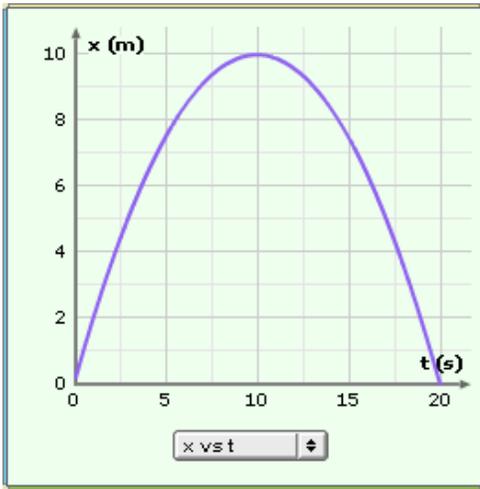


17. Click Reset and remove all fans and masses from the cart. Leave the initial velocity at 2.0 m/s. Click Play and observe the motion of the cart.

- What is the acceleration of the cart in this case? _____
- Click on the **GRAPH** tab. Make a sketch of the three graphs below.



18. Using your knowledge you have gained from the previous exercises write down two setups that will result in the following graphs.



Setup #1

Initial Velocity: _____

Number of masses: _____

Number of fans on in the positive direction: _____

Number of fans on in the negative direction: _____

Setup #2

Initial Velocity: _____

Number of masses: _____

Number of fans on in the positive direction: _____

Number of fans on in the negative direction: _____