

Pre-Lab Information

Purpose	Explore the effect of force and mass on the acceleration of an object using a laboratory procedure.
Time	Approximately 50 minutes
Question	How do force and mass affect the acceleration of an object?
Hypothesis #1	If the force applied to a cart increases, then the acceleration of the cart increases when the mass of the cart is held constant, because force and acceleration are directly proportional to each other according to Newton's second law.
Hypothesis #2	If the mass of a cart increases, then the acceleration of the cart decreases when the force applied to the cart is held constant, because mass and acceleration are inversely proportional to each other according to Newton's second law.
Variables for H1	<i>Independent Variable:</i> force applied to the cart <i>Dependent Variable:</i> acceleration of the cart <i>Constant:</i> mass of the cart
Variables for H2	<i>Independent Variable:</i> mass of the cart <i>Dependent Variable:</i> acceleration of the cart <i>Constant:</i> force applied to the cart
Summary	This experiment is divided into two parts. For each part, you will set up a dynamics track with a pulley, and a mass will be hung from the pulley. This mass will apply a force to the cart, which will pull the cart along the track. A sensor will be used to measure the displacement, time, and velocity of the cart. For the first part of the experiment, you will examine how a force applied to the cart affects the acceleration of the cart by varying the mass hung from the pulley. Varying the mass on the pulley varies the force applied to the cart, causing the cart to accelerate at different rates. For the second part of the experiment, you will examine how the mass of the cart affects the acceleration of the cart by changing the mass of the cart, while keeping the mass on the pulley the same.

Safety

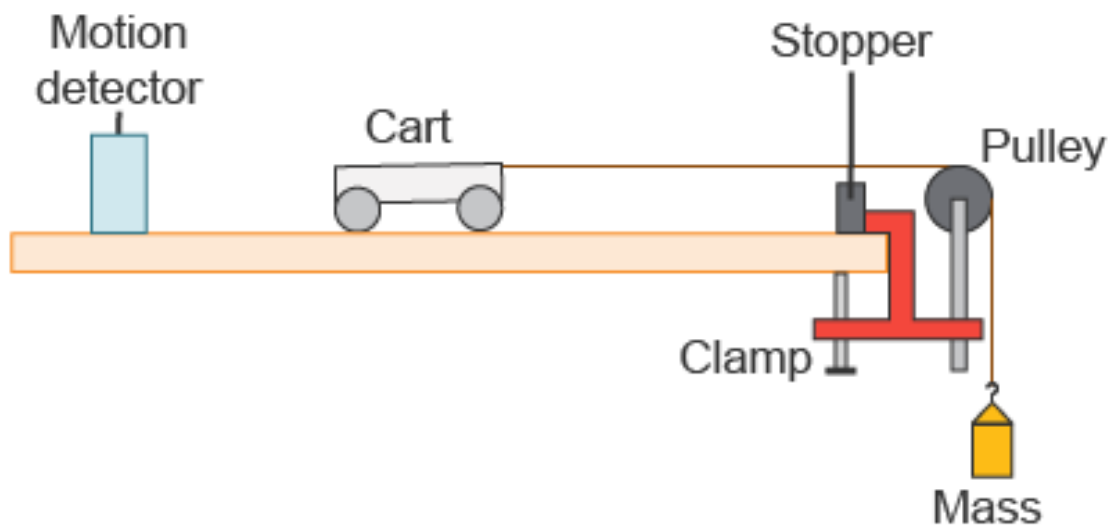
- Always wear safety goggles when performing an experiment, especially with objects in motion.
- Make sure you understand the proper use and assembly of the cart, track, pulley, and sensors.
- Use caution when assembling and adjusting the dynamics track. Dynamics tracks may have sharp edges or other parts that may pinch hands or fingers.
- Behavior in the lab needs to be purposeful.
- Report all accidents—no matter how big or small—to your teacher.

Lab Procedure

Step 1: Gather materials.

- 1 dynamics track (1.2 m)
- 1 low-friction dynamics cart (500 g mass)
- 1 sonic motion sensor
- 1 frictionless pulley
- Thin fishing line or string (2 m)
- Mass set (one 10g, two 20 g, one 50 g, one 200 g, and one 500 g)
- 1 LabQuest[®] data collector with USB cord
- Logger Pro[®] software

Step 2: Use this diagram as a guide to set up the track.



- Assemble the dynamics track on a level table. Be sure that the track is flat by adjusting the leveling screw.
- Attach the pulley to one end of the dynamics track. Be sure that the pulley hangs over the edge of the table and that the distance from the table to the floor is at least 1 meter.
- Attach the adjustable stop to the track just in front of the pulley.
- Set the motion sensor at the end of the track opposite the pulley. Be sure that it points along the track.
- Place the cart on the track in front of the motion sensor.
- Attach one end of the string to the cart and tie a small loop in the other end of the string. Place the string over the pulley and allow the free end (the one with the loop) to hang down just below the pulley.

Student Guide (continued)

Part I: Changing the Force Applied to the Cart

Step 3: Run the first trial.

- Hang a 10 g mass on the end of the string hanging over the pulley.
- Trigger the start of the Logger Pro[®] software as you release the cart. This will record displacement, time, and velocity data.
- Once the trial is done, record the displacement and velocity data in Table A.

Step 4: Perform more trial runs with different masses hanging from the pulley.

- Now perform two more runs with different masses hanging from the pulley: one using a 20 g mass, and one using a 40 g mass.
- Record the data for each run in Table A.

Step 5: Calculate the change in velocity of the cart for each run.

- Calculate the change in velocity of the cart for each hanging mass. Remember the formula for change in velocity (Δv), which is the difference between the final velocity (v_f) and the initial velocity (v_i):

$$\Delta v = v_f - v_i$$

Be sure to use the initial and final velocities you recorded in Table A to calculate the change in velocity. Record your answers in Table B.

Step 6: Calculate the acceleration of the cart for each run.

- Calculate the acceleration of the cart for each hanging mass. Remember the formula for acceleration (a), which is the change in velocity (Δv) over the total elapsed time (Δt):

$$a = \Delta v / \Delta t$$

Record your answers in Table B.

Step 7: Calculate the force applied to the cart for each run.

- Calculate the force each hanging mass applies to the cart. Remember the formula for force, (F) which is mass (m) multiplied by acceleration (a). In this case the acceleration is the acceleration due to gravity ($g = 9.8 \text{ m/s}^2$):

$$F = mg$$

Record your answers in Table C.

Step 8: Graph your results to examine how changing the applied force affects the acceleration of the cart.

- Construct a graph of acceleration vs. force using the acceleration and force data in Tables B and C. The force applied to the cart should be on the x -axis, and acceleration should be on the y -axis.
- Draw a single line of best fit through the data points.
- Title the graph and label the axes with units.

Student Guide (continued)

Part II: Changing the Mass of the Cart

Step 9: Run the first trial.

- Perform the first trial using the original mass of the cart (500 g). Hang a 20 g mass on the end of the string hanging over the pulley.
- Trigger the start of the Logger Pro[®] software as you release the cart. This will record displacement, time, and velocity data.
- Once the trial is done, record the displacement and velocity data in Table D.

Step 10: Perform more trial runs with different masses added to the cart.

- Now perform two more runs with different masses added to the cart: one with 250 g added to the cart and one with 500 g added to the cart.
- Record the data for each run in Table D.

Step 11: Calculate the change in velocity of the cart for each run.

- Calculate the change in velocity of the different mass carts. Remember the formula for change in velocity (Δv), which is the difference between the final velocity (v_f) and the initial velocity (v_i):

$$\Delta v = v_f - v_i$$

Be sure to use the initial and final velocities you recorded in Table D to calculate the change in velocity. Record your answers in Table E.

Step 12: Calculate the acceleration of the cart for each run.

- Calculate the acceleration of the different mass carts. Remember the formula for acceleration (a), which is the change in velocity (Δv) over the total elapsed time (Δt):

$$a = \Delta v / \Delta t$$

Record your answers in Table E.

Step 13: Graph your results to examine how changing the mass of the cart affects the acceleration of the cart.

- Construct a graph of acceleration vs. mass using the acceleration and mass data in Table E. Mass should be on the x -axis, and acceleration should be on the y -axis.
- Draw a single line of best fit through the data points.
- Title the graph and label the axes with units.

Step 14: Clean up the lab.

- Put away the track, cart, and other equipment in locations specified by your teacher.
- Dispose of the string and any unneeded paper trash.

Student Guide (continued)

Data

Record your data either in your lab notebook or in the tables below.

Table A

Mass on Pulley	10 g		20 g		40 g	
Elapsed Time t (s)	Displacement Δx (m)	Velocity $v = \Delta x/t$ (m/s)	Displacement Δx (m)	Velocity $v = \Delta x/t$ (m/s)	Displacement Δx (m)	Velocity $v = \Delta x/t$ (m/s)
0.05						
0.10						
0.15						
0.20						
0.25						
0.30						
0.35						
0.40						
0.45						
0.50						
0.55						
0.60						
0.65						
0.70						
0.75						
0.80						
0.85						
0.90						
0.95						
1.00						
1.05						
1.10						

Student Guide (continued)

Table B

Mass on Pulley (g)	Change in Velocity of Cart Δv (m/s)	Acceleration of Cart a (m/s ²)
10		
20		
40		

Table C

Mass on Pulley (g)	Force Applied to Cart F (N)
10	
20	
40	

Student Guide (continued)

Table D

Mass of Cart	500 g		750 g		1000 g	
Elapsed Time t (s)	Displacement Δx (m)	Velocity $v = \Delta x/t$ (m/s)	Displacement Δx (m)	Velocity $v = \Delta x/t$ (m/s)	Displacement Δx (m)	Velocity $v = \Delta x/t$ (m/s)
0.05						
0.10						
0.15						
0.20						
0.25						
0.30						
0.35						
0.40						
0.45						
0.50						
0.55						
0.60						
0.65						
0.70						
0.75						
0.80						
0.85						
0.90						
0.95						
1.00						
1.05						
1.10						

Student Guide (continued)

Table E

Mass of Cart (g)	Change in Velocity of Cart Δv (m/s)	Acceleration of Cart a (m/s ²)
500		
750		
1000		