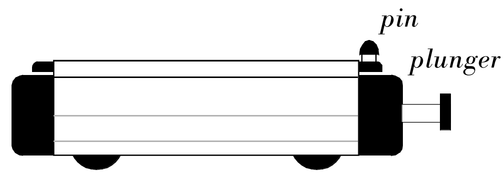
PhyzLab: Putting the Force Before the Cart

an investigation of force and motion
(REMEMBER: PENCIL)

PERIOD	1.		
	2.		
GROUP	3.		
	4.		

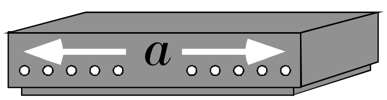
• Purpose •
In this activity, you will investigate the relationship between force, mass, and acceleration. Specifically, how does the acceleration of an object depend on the force acting on it and how does the acceleration depend on the mass of the object?

• Apparatus •
___ PASCO plunger cart (500 g)
___ PASCO aluminum track
  __adjustable leveling feet
___ mass blocks (500 g and 250 g)
___ Velcro end stop
___ super pulley and clamp
___ string
___ paperclip
___ 4 hex nuts
___ PASCO Visual Accelerometer (250 g)

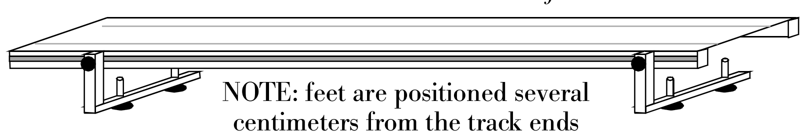


The PASCO Dynamics Cart:
Top of the line: precision, low-friction bearings, three-setting plunger, retractable wheels, magnetic bumpers, Velcro bumpers; in a word: **expensive!**

Visual Accelerometer



PASCO track with feet



• Set-Up •
1. Arrange the track.
a. Attach the adjustable feet to both ends of the track.

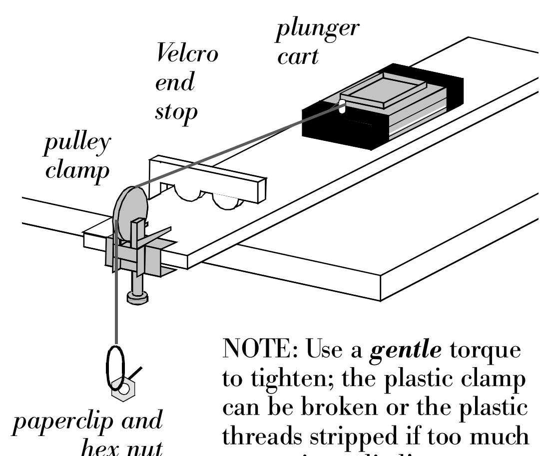
b. Set the line level on the track and level the track by adjusting the feet. Fine-tune the level of the track by setting a dynamics cart on the track and pushing it lightly one way then the other. It should coast equally well in either direction. When not in use, keep the dynamics car in its drawer or on its "back."

c. Attach the Velcro end stop near one end of the track.

d. Attach the pulley clamp to the end of the track, beyond the Velcro end stop. Attach the clamp thumbscrew-side down. Move the end of the track beyond the edge of your table. Use a **gentle** torque to tighten the pulley clamp; too much torque will break the plastic clamp or strip the plastic threads.

e. Tie a loop at each end of the string. Attach one end to the knob on the plunger cart and the other end to a paperclip.

f. Pass the string across the pulley wheel and load the paperclip with a hex nut for weight. Take care to ensure the pulley wheel is above the end stop so the string does not rub against the end stop. The string should be long enough so that the hex nut nearly gets to the floor when the cart has collided with the Velcro end stop. If the hex nut hits the floor, shorten the string and try again.



NOTE: Don't let the string rub the end stop, and make sure the clip/nuts aren't swinging when you release the cart.

2. Prepare the Visual Accelerometer.
a. Attach the Visual Accelerometer (VA) to the plunger cart. Use the two long, plastic screws and the threaded holes in the plunger cart. Do not overtighten since the plastic screws are easily stripped.

b. Set the range of the Visual Accelerometer to 1 m/s^2. Set the mode of the VA to Manual.

c. Park the VA on the level track. Activate the VA by quickly pressing and releasing the "On/Off/Zero" button between the red and green LEDs. The LEDs will flash and then go dark.

If any of the LEDs are ever on when the cart is at rest on the level track, quickly press and release the "On/Off/Zero"

• Procedure •

1. VARY THE FORCE
a. Two Hex Nut Observation.
i. Add another hex nut to the paperclip for a total of two. The weight of the two hex nuts will pull the cart along the track.

ii. Pull the cart back along the track until the hex nuts hang about one centimeter below the pulley wheel.

iii. Release the cart and observe the LEDs. Describe the motion of the cart and the LEDs on the Visual Accelerometer. Limit your response to describe the motion **after** the cart is released and **before** the cart is brought to a stop.

b. Four Hex Nut Observation.
i. Add two more hex nuts for a total of four hex nuts. Doing so doubles the amount of force pulling the cart.

ii. Prediction. How will the result this time be different?

iii. Pull the cart back along the track until the hex nuts hang about one centimeter below the pulley wheel.

iv. Release the cart and observe the LEDs. Describe the motion of the cart and the LEDs on the Visual Accelerometer. Limit your response to describe the motion **after** the cart is released and **before** the cart is brought to a stop.

2. VARY THE MASS

a. Empty Cart Observation.

i. Repeat the previous observation (the cart is empty and is being pulled by the weight of four hex nuts).

ii. Review your previous observations. Edit them if necessary.

b. Loaded Cart Observation.

i. Add 750 grams of mass (one 500-g block and one 250-g block) to the bed of the Visual Accelerometer. Doing so approximately doubles the mass of the cart + accelerometer.

ii. Prediction. How will the result this time be different?

iii. Pull the cart back along the track until the hex nuts hang about one centimeter below the pulley wheel.

iv. Observation. Release the cart and observe the LEDs. Describe the motion of the cart and the LEDs on the Visual Accelerometer. Limit your response to describe the motion **after** the cart is released and **before** the cart is brought to a stop.

v. Prediction. How would the result be different if only two hex nuts were used to pull the loaded cart?

vi. Observation. Arrange the experiment and record your observation.

• Analysis •

1. Review your observations from procedure 1, VARY THE FORCE. What conclusion is supported by your observations?

a. In symbols. (Circle one.)

$$\mathbf{a \propto F} \qquad \textbf{or} \qquad \mathbf{a \propto 1/F}$$

b. In words. (Check one.)

___**The acceleration of an object is directly proportional to the force acting to propel it.**
___**The acceleration of an object is inversely proportional to the force acting to propel it.**

c. Justify your conclusion based on evidence from the activity.

2. Review your findings from procedure 2, VARY THE MASS. What conclusion is supported by your observations?

a. In symbols. (Circle one.)

$$\mathbf{a \propto m} \qquad \textbf{or} \qquad \mathbf{a \propto 1/m}$$

b. In words. (Write it out.)

c. Justify your conclusion based on evidence from the activity.

3. Combine the two proportionalities.

a. In symbols. (Circle one).

$$\mathbf{a \propto F \cdot m} \quad \textbf{or} \quad \mathbf{a \propto F / m} \quad \textbf{or} \quad \mathbf{a \propto m / F} \quad \textbf{or} \quad \mathbf{a \propto 1 / (F \cdot m)}$$

b. In words. (Write it out.)

4. This relationship is known as Newton's second law of motion. Nearly all systems of measurement (units) relate mass and force using this relationship. Because of this, we can replace the proportionality symbol with an equal sign. We do not need any "constant of proportionality." Write Newton's second law of motion as an **equation**.

5. Newton's second law of motion is often written solved for force (F). Write it that way in the space below.