

NEWTON'S SECOND LAW

What factors affect the acceleration of an object? How are the mass of an object, the net force applied to it, and the resulting acceleration related?

Objectives

- Experimentally determine the relationship between an object's mass, acceleration, and the net force being applied to the object.
- Use the relationship to make predictions about how an object will move.

Materials and Equipment

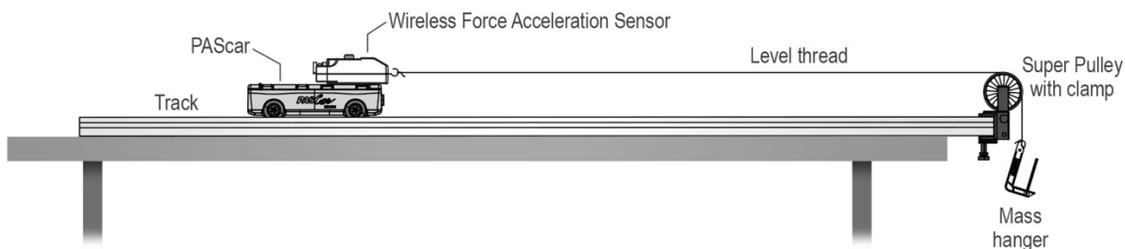
- Data collection system
- PASCO Wireless Force Acceleration Sensor
- PASCO Dynamics Track with feet
- PASCO Super Pulley with Clamp
- PASCO PAScar
- PASCO Dynamics Track End Stop
- PASCO Mass and Hanger Set
- Thread
- Balance, 0.1-g resolution, 2,000-g capacity (1 per class)

Safety

Follow regular laboratory safety precautions.

Procedure

1. Attach the wireless force acceleration sensor to the PAScar using the included thumbscrew.
2. Measure the mass of the cart and wireless force sensor and record this value in kilograms in the space above Table 1 in the Data Collection section.
3. Set up the equipment, as shown in the diagram, using a dynamics track and the Super Pulley with Clamp. Follow the guidelines below as you set up this system:



- a. Be sure the track is level, and mount the end stop to the track just in front of the pulley.
 - b. Determine the length of thread needed to have the mass hanger be near the floor when the cart reaches the end stop of the track. One end of the thread should be attached to the hook on the wireless force acceleration sensor, the other end of the thread should be tied to the mass hanger.
 - c. Adjust the angle of the pulley so that the thread is parallel to the track, as pictured.
4. Hang 20 g of mass on the 5-g mass hanger, for a total hanging mass of 25 g.

5. Connect the wireless force acceleration sensor to your data collection system.
6. On the data collection system, create a graph display of force versus time and a second graph display of acceleration-x versus time.
7. Pull the cart away from the end stop until the mass hanger hangs just below the pulley.
8. Begin recording data. Wait about two seconds and then release the cart. It should move smoothly down the track. Try to limit the swinging of the hanging mass as it falls.
9. Be prepared to grab the PAScar just as it reaches the end of the track to keep it from leaving the track and falling off the table. Stop recording after you grab it.
10. Use the tools on your data collection system to read from the graph the force on the cart after it was released. This is the region on the graph just after you released the cart, the force should have dropped a little and remained steady for a few seconds. Write the value in Table 1 in the Data Collection section. You can leave out the minus sign and just record the magnitude.
11. Use the tools on your data collection system to read from the graph the acceleration on the cart after it was released. This is the value of the acceleration during the same time period as the force measured in step 10. It should be fairly constant during this time. Write the value in Table 1 in the Data Collection section You can leave out the minus sign and just record the magnitude.
12. Add 20 g to the hanger and repeat steps 7-12 until you have 6 data points.

Data Collection

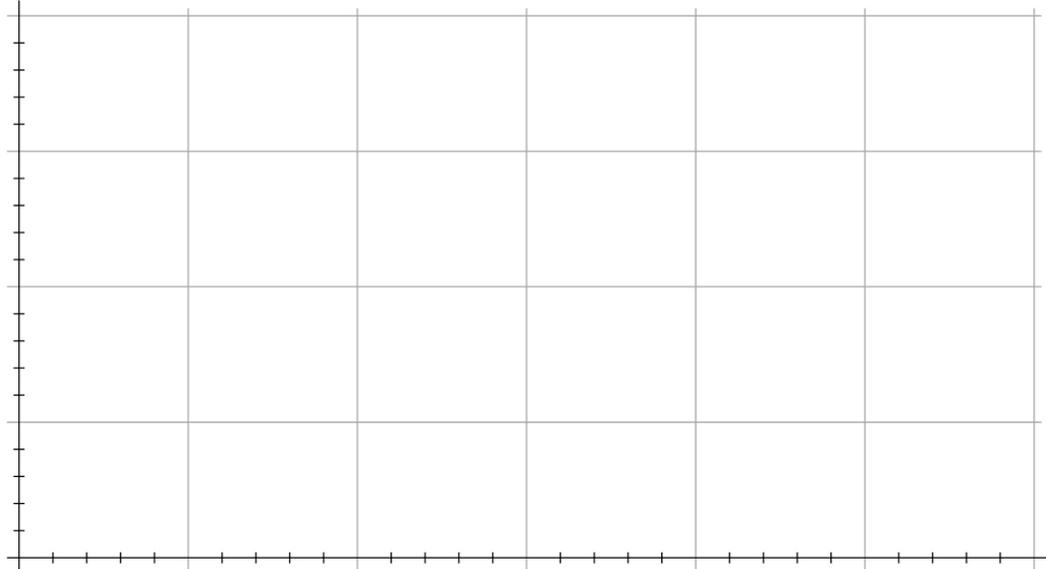
Mass of PAScar and wireless force sensor: _____ kg

Table 1: Force and Acceleration of a cart with varying hanging weight

Trial	Force on PAScar (N)	Acceleration of PAScar (m/s ²)
1		
2		
3		
4		
5		
6		

1. Plot a graph of force on the y-axis and acceleration on the x-axis on the blank Graph 1 axes. Be sure to label both axes with the correct scale and units.

Graph 1: Force versus acceleration



Questions and Analysis

1. Draw a best-fit line using a straight edge on your graph. Pick two points on the line and calculate the slope. Show your work below. Your slope should be very close to the same value as one of the quantities you measured in this lab. Look over your data and see if you can figure out what it is. Hint: The units of the slope can be helpful. A Newton is the same as a $\text{kg}\cdot\text{m}/\text{s}^2$. Since the slope has the units of Force/acceleration or $\text{N}/\text{m}/\text{s}^2$, what are the units of the slope after you simplify?

2. Write an equation for your best fit line in $y = mx + b$ form. You can substitute Force (F) for y and acceleration (a) for x . Your slope should have been very close to the same value as the mass of the PAScar and wireless force acceleration sensor. The units of your slope are kilograms, the same as the units for mass. This is a strong clue that the mass (m) is the slope. The y -intercept represents the force when the acceleration is zero. This should be very small and can be ignored. Write your equation below.

3. Your equation from question 2, $F = ma$, is known as Newton's Second Law. It is a powerful relationship that lets us predict how something will move. Use your equation to predict the acceleration of the PAScar if the force from the string is 0.9 N. Show your work below.

4. Use your equation from question 2 to predict the acceleration of the PAScar if the force from the string is 0.9 N and an additional 0.5 kg of mass is added to the PAScar. Show your work below.

5. Another group of students repeats your experiment using a PAScar with more mass. How would that change their graph compared to yours? Draw a possible line for their data on your graph, use a different color pencil if possible.

6. Write a sentence describing the relationship known as Newton's Second Law. Describe how the data you collected in this lab and your analysis supports it.