19 Constant Force and Changing Mass

Purpose

To investigate the effect of increases in mass on an accelerating system

Required Equipment/Supplies

meterstick
2 Pasco dynamics carts and track
4 500-g masses (2 masses come with Pasco carts)
1 50-g hook mass
pulley with table clamp
triple-beam balance
string
paper clips or small weights
masking tape
graph paper or overhead transparencies
stopwatch or photogate timing system

Discussion

Airplanes accelerate from rest on the runway until they reach their takeoff speed. Cars accelerate from a stop sign until they reach cruising speed. And when they come to a stop, they decelerate. How does mass affect these accelerations?

In Activity 11, Getting Pushy, you discovered that less massive people undergo greater acceleration than more massive people when the same force is applied to each. In this experiment you will accelerate a dynamics cart. You will apply the same force to carts of different masses. You will apply the force by suspending a weight over a pulley. The cart and the hanging weight comprise a *system* and accelerate together. A relationship between mass and acceleration should become evident.

Procedure

Set up pulley-and-cart system.

Step 1: Fasten a pulley over the edge of the table. The pulley will change the direction of the force from a downward pull on the mass into a sideways pull on the cart.

Step 2: Mark off a distance on the tabletop slightly shorter than the distance the mass can fall from the table to the floor.

Step 3: Use a triple-beam balance to determine the mass of the carts. Record the total mass of the cart(s) and the four additional masses in Data Table A. Do not include the 50-g hanging mass or the mass of the paper clip counterweight.

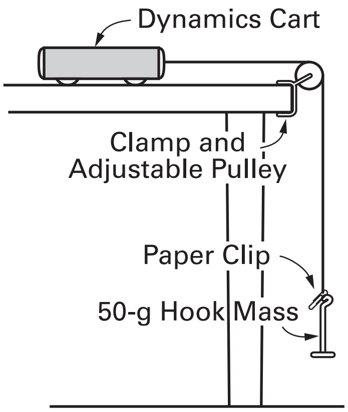

Fig. A

Step 4: Nest the two dynamics carts on top of one another, and stack the 500-g masses on the top cart. It may be necessary to secure the masses and carts with masking tape. Tie one end of the string to the cart and thread it over the pulley, as shown in Figure A. To offset frictional effects, add enough paper clips or small weights to the other end of the string so that when the cart is pushed slightly it moves at a *constant speed*. (Give your teacher a break! Stop the cart before it crashes into the pulley during the experiment by adjusting the stop bar on the dynamics track.)

Step 5: Practice accelerating the cart a few times to ensure proper alignment. Add a 50-g hook mass to the paper clip counterweight. Keep this falling weight the same at all times during the experiment.

Set up timing system.

Step 6: There are a variety of ways to time the motion of the cart and the falling weight. You could use a stopwatch or a photogate timing system. The distance is the distance between two photogates. Position the cart so that, as it is released, it passes the first photogates and starts the timer. The timer stops when the second photogate is passed.

Repeat three times, recording the times in Data Table A. Compute and record the average time.

Data Table A

Time to Cover Same Distance				Acceleration (m/s^2)
Trial 1	Trial 2	Trial 3	Avg	

Remove masses from the cart and repeat.

Step 7: Repeat Step 5 five times, removing a 500-g mass from the cart each time (the last time removing the top cart). Record the times in Data Table A, along with the average time for each mass.

Compute the acceleration.

Step 8: Use the average times for each mass from Steps 5 and 6 to compute the accelerations of the system. To do this, use the equation for an accelerating system that relates distance d, acceleration a, and time t.

$$d = \frac{1}{2}at^2$$

Rearrange this equation to obtain the acceleration.

$$a = \frac{2d}{t^2}$$

The cart always accelerates through the same distance *d*. Calculate the acceleration *a*. Provided you express your distance in meters and your time in seconds, your units of acceleration will be m/s^2.

Graph your data.

Record your accelerations in Data Table A.

Step 9: Using an overhead transparency or graph paper, make a graph of acceleration (vertical axis) vs. mass (horizontal axis).

Analysis

1. Describe your graph of acceleration vs. mass. Is it a straight-line graph or a curve?

2. Share your results with other class members. For a constant applied force, how does increasing the mass of an object affect its acceleration?