Investigation 3.3.1 CONTROLLED EXPERIMENT

SKILLS MENU

- Questioning
- Researching
- Hypothesizing
- Predicting
- Planning
- Controlling Variables
- Performing
- Observing
- Analyzing
- Evaluating
- Communicating

Investigating Newton's Second Law

In this investigation, you will perform two controlled experiments. In Part A, you will measure the acceleration of a cart using different net forces while keeping the total mass constant. In Part B, you will measure the acceleration of a cart using different total masses while keeping the net force constant.

Testable Questions

- How does the acceleration of a cart depend on the net force acting on the cart if the total mass is constant?
- How does the acceleration of a cart depend on the total mass if the net force is constant?

Hypothesis/Prediction

SKILLS HANDBOOK A2.2

After reading through the experiment, write a hypothesis to answer each Testable Question.

Variables

Identify the independent (sometimes called manipulated) and dependent (sometimes called responding) variables in this experiment. Describe how you will measure these variables. What variables must be controlled?

Experimental Design

There are many different ways to perform this activity. **Figure 1** shows one simple way to apply a constant force to a cart.

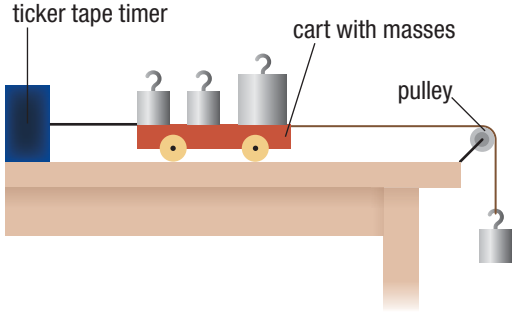

Figure 1

Keep in mind that the force of gravity acting on the hanging object is the net force on the total mass. The total mass includes the hanging object, the cart, the string, and any objects on top of the cart. If you want to change the force and keep the total mass constant, take an object off the cart and hang it from the string. If you want to change the mass and keep the net force constant, change the objects on top of the cart but do not change the hanging objects.

Discuss with your group members how you will safely stop the cart before performing the investigation.

Equipment and Materials

- dynamics cart
- electronic balance
- ticker tape timer, motion sensor, or similar device
- three 100 g objects
- three 1.0 kg objects
- pulley
- string
- ticker tape

Procedure

Part A: Acceleration and Net Force

1. Create a table to record your observations similar to **Table 1**.

Table 1

Total mass	Hanging mass	Net force	Acceleration	Net force/ total mass

2. Measure the mass of the cart.
3. Set up the equipment as shown in Figure 1 or as directed by your teacher. Make sure everything is working properly by allowing the cart to accelerate once or twice.
4. Put one 1.0 kg object and two 100 g objects on top of the cart. You might need to tape them down. Hang a 100 g object from the string. Allow the motion to occur and obtain the data required to find the acceleration ($\vec{a}_1$).
5. Take one of the 100 g objects from on top of the cart and hang it from the string. Allow the motion to occur and obtain the data required to find the new acceleration ($\vec{a}_2$).
6. Take the last 100 g object from the top of the cart and hang it from the string. Allow the motion to occur and obtain the data required to find the new acceleration ($\vec{a}_3$).

Part B: Acceleration and Mass

7. Use the data for $\vec{a}_3$ from Step 6 as the first set of data for this experiment.
8. Using the same cart setup as in Step 6, add one 1.0 kg object to the cart. Allow the motion to occur and obtain the data required to find the new acceleration ($\vec{a}_4$).
9. Add an additional 1.0 kg object to the cart. Allow the motion to occur and obtain the data required to find the new acceleration ($\vec{a}_5$).

Analyze and Evaluate

(a) In terms of the variables in this investigation, what type of relationship was being tested? T/I

(b) Calculate the acceleration for each trial. T/I

(c) Calculate the ratio of the net force to the total mass. What does this ratio represent? Explain your reasoning. K/U T/I

(d) Use your results from Part A to plot a graph of net force (y-axis) versus acceleration (x-axis). Draw a line of best fit and calculate its slope. What does this graph indicate about the relationship between acceleration and net force? What does the slope represent? T/I C

(e) Use your results from Part B to plot a graph of acceleration (y-axis) versus total mass (x-axis). Draw a smooth curve through the points. What does this graph indicate about the relationship between acceleration and total mass? T/I C

(f) Use your results from Part B to plot a graph of acceleration (y-axis) versus the reciprocal of the total mass ($1/m$; x-axis). Draw a line of best fit and calculate its slope. What does this graph indicate about the relationship between acceleration and total mass? What does the slope represent? T/I C

(g) Answer the Testable Questions. T/I

(h) Comment on the accuracy of your hypothesis. C

(i) List some possible sources of error. How could you modify the investigation to avoid or reduce these sources of error? T/I

Apply and Extend

(j) Describe how you could determine if friction had any effect on the results of this investigation. T/I

(k) Explain why a graph of net force versus acceleration must pass through the origin when the total mass is constant. T/I

(l) Explain why a graph of acceleration versus the reciprocal of the total mass must pass through the origin when net force is constant. T/I

(m) Commercial airlines are limiting the number of pieces and the mass of luggage that passengers can bring onto an aircraft. Use what you have learned in this investigation to explain why. C A