78 Force, Acceleration, and Mass

In the previous activities, you learned about force, mass, and changes in motion. In this activity, you will investigate the precise relationship between the mass of an object, the force applied to it, and the object's acceleration.

You also learned earlier that scientists measure speed in m/s (meters per second), and they measure mass in kg (kilograms). In this activity, you will need to know the standard international (SI) units used to measure force and acceleration. Acceleration is the change in speed (measured in meters per second) divided by time (measured in seconds), and so the unit for acceleration is meters per second per second (m/s·s or m/s^2). Force is measured in newtons (N). This unit is named after Sir Isaac Newton, a scientist who studied forces and motion.

CHALLENGE **What is the mathematical relationship between force, acceleration, and mass?**

The golf ball in the photo far right will have a greater change in motion because it is hit with a greater force.

MATERIALS

For each student

graph paper

PROCEDURE

Part A: Graphing the Variables

1. The table below shows precise measurements from an experiment in which a force is applied to pull a block along a frictionless track.

Experiment 1		
Force (N)	**Mass of Block (kg)**	**Acceleration of Block (m/s^2)**
4.0	2.0	2.0
2.0	2.0	1.0
20.0	2.0	10.0
10.0	2.0	5.0

2. Use the Experiment 1 data to make a graph of the relationship between acceleration and force. Title the graph, "Acceleration vs. Force." Label the graphed line "Experiment 1."

   Hint: Put the data for force on the x-axis and the data for acceleration on the y-axis.

3. Answer Analysis Question 1.

Part B: Finding the Equation

4. Use the Experiment 1 data to determine a mathematical equation that shows the exact relationship between mass (m), force (F), and acceleration (a). Record the relationship in your science notebook.

   Hint: Try adding, subtracting, multiplying, and dividing two of the measurements to see if you get the third.

Part C: Double-checking the Equation

5. The data table below shows measurements from Experiment 2. See whether your equation works for this set of data.
   - If it does, go on to Step 6.
   - If it doesn't, find a different equation that does work for both experiments.

Experiment 2		
Force (N)	Mass of Block (kg)	Acceleration of Block (m/s^2)
4.0	4.0	1.0
2.0	4.0	0.5
20.0	4.0	5.0
10.0	4.0	2.5

6. Using the same graph you made in Step 2, plot the Experiment 2 data. Label the second line "Experiment 2."

ANALYSIS

1. Look at your graphed line for Experiment 1. Explain why it does or does not indicate that there is a relationship between force and acceleration.
2. Compare the two lines, "Experiment 1" and "Experiment 2" on your graph. Identify and explain:
   a. any similarities.
   b. any differences.

How does the acceleration of the dogs affect the force on the sled?

3. In your science notebook, make a table like the one below. Use your equation for force, mass, and acceleration to find the missing values.

Experiment 3

Force (N)	Mass of Block (kg)	Acceleration of Block (m/s^2)
	5	5
	2	10
10		2
50	10	
100		25
1,000	40	

4. In the first activity, Vehicle 2 has a greater acceleration than Vehicle 1, but has a less forceful engine. How can this be? Explain in terms of your equation.

5. One newton of force is the same as 1 kg m/s^2. Explain how this unit of measurement is appropriate for your equation.