ACCELERATION IS PROPORTIONAL TO NET FORCE

Materials:
- chair or desk
- objects to use as 'masses'
- spring scale
- stop watch or stopwatch with second hand
- meter stick

1. Attach the spring scale to a chair or desk and pull horizontally with a force of 3 or 4 Newtons. Why doesn't the chair accelerate? What is the value of the net acting on the chair?

2. Pull horizontally on the scale until the chair slides slowly at a constant speed. Make a diagram with arrows to show (a) the forces you are applying and (b) the force of friction acting on the chair. Label the arrows with the values of the forces.

3. When an object is sliding at constant speed, the force of friction is at its maximum. If the chair is made to accelerate, the force of friction will be known. The applied force is the reading on the scale. What is the maximum force of friction acting on the chair? How is the net force calculated?

4. When objects start from rest and have a constant acceleration, their accelerations can be compared by comparing the distances they travel in equal times. For example, if one object travels three meters in three seconds and a second object travels six meters in three seconds, the second object has twice the acceleration of the first. (The instructor can show you the equation that proves this.

Take data to determine whether the acceleration of an object depends on the force you apply to it or on the net force acting on it.

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Using a force that is 2 Newtons larger than friction, pull the chair across the floor. Strive to keep the reading on the scale from changing! Have someone mark the position of the chair at the moment it starts to move and at the end of the two seconds. Measure the distance the chair moved. Record the data in the table below.

Repeat with readings on the scale that are four, six, and eight Newtons larger than the forces of friction.

<table>
<thead>
<tr>
<th>Applied Force (scale reading in Newtons)</th>
<th>Force of Friction (Newton)</th>
<th>Net Force (Newton)</th>
<th>Distance Traveled (centimeters)</th>
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5. Remember that accelerations can be compared distances when objects accelerate uniformly from rest. Look at the "Distance Traveled" column to look for doublings of the acceleration.

6. Did the applied force even get to be twice as large as the first one? If so, did the acceleration double at the same time?

7. Did the net force ever double? Did the acceleration double at the same time? (Since it is pretty hard to keep a constant force, don't expect to find precise results. If the distance traveled approximately double, it is fair to say the acceleration double.)

8. Does your data seem to show that the acceleration is proportional to the applied force or to the net force? Write a discussion of your answer.
Newton’s 2nd Law Problems Worksheet

Directions: Answer the following questions dealing with force, mass and acceleration. Remember to use the triangular formula to help solve the problems. Do not forget to show your work and display all units.

1. You are pushing a friend on a sled. You push with a force of 20 N. Your friend and the sled together have a mass of 60 kg. Ignoring friction, what is the acceleration of your friend on the sled?

2. A student pedaling a bicycle applies a net force of 400 N. The mass of the rider and the bicycle is 25 kg. What is the acceleration of the bicycle and the rider?

3. How much force will a tennis racket need to exert on a tennis ball, with a mass of 0.67 kg, to make it accelerate at a rate of 5,600 m/s²?

4. Gravity accelerates any object falling at 9.8 m/s². What is the force that will be applied to the ground if an 88 kg box falls from the top of a shelf to the ground?

5. Whether you are standing, running or jumping Earth is exerting a gravitational force on you. This gravitational force is called an object’s weight (W). Knowing this you can find the weight of an object if you know the mass because the acceleration will be 9.8 m/s² due to gravities pull on the object. The equation to use then is: \[ W = \text{mass} \times \text{acceleration} \]. What is the weight of a 53 kg man?

6. What is the mass of a truck if it is accelerating at a rate of 5 m/s² and hits a parked car with a force of 14,000 N?

7. What is the mass of a falling rock accelerating at a rate of 9.8 m/s² if it hits the ground with a force of 147 N?

8. What is the magnitude of the force that is exerted on a 20 kg mass to give it an acceleration of 10.0 m/s²?

9. What is the magnitude of the acceleration that is produced when the brakes of a 24,000 kg car apply a 32,000 N force to stop the car?

10. How many Newton’s (N) of force are needed to accelerate a 100 kg at 4 m/s²?