BiteScis

Student Handout

Acceleration Isn't Only Speeding Up

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Introduction

When you think about acceleration you probably picture something like a car revving up and taking off down a road, but acceleration isn't just about speeding up! In this lesson you will explore ways that forces can be used to both speed up and slow down objects. Then, you'll read about some scientists who are using the forces from laser light to slow down molecules in their labs. Why? Read on to find out!

What To Do

Observe your teacher's demonstration of what happens when you apply a force to an object, or follow your teacher's directions to do the demonstration yourself. Afterwards, answer the analysis questions below, reading the Bite when instructed.

Analysis Questions

1. In the demonstration, what happens initially to the moving object if you don't apply a force?

2. What happens if you apply a force in the same direction that the object is already moving?

3. What happens *initially* if you apply a force in the opposite direction from the object's motion?

4. If you were trying to slow down a moving object, what would you need to do?

5. A bowling ball is rolling to the right and slowing down. A student says, “The ball must be experiencing a net force to the right, because it’s moving to the right.” Do you agree with the student’s claim? Why or why not? Use evidence from your observations in this activity to justify your answer.

Two equations involving acceleration are shown below using both variables and words.

$$a = \frac{\Delta v}{\Delta t} \qquad F_{net} = ma$$

$$acceleration = \frac{change\ in\ velocity}{change\ in\ time} \qquad Net\,force = mass \times acceleration$$

6. Describe the magnitude (large or small) of the acceleration needed to suddenly make a fast moving object come to a complete stop. Use the relationships in the equation above to explain your reasoning. (*Hint:* In this situation, Δv is large; Δt is small.)

7. When is it possible for a small net force to cause a large acceleration? Use the relationships in the F_{net} equation above to justify your response and explain your reasoning. Include a discussion of mass in your response.

STOP & read Science Bite:

How Do You Slow Molecules to a Standstill? With a Laser!

8. Why do scientists want to be able to slow down molecules?

9. What is the first step in slowing down the molecules? Why do you think this step is important?

10. What is the purpose of poking a hole in the refrigerator box?

11. Why is it important for the molecules to all start out going the same direction?

12. How is laser cooling similar to the activity we performed at the beginning of class? Draw a picture of the activity and compare it to what you see in **Figure 1** to the right.

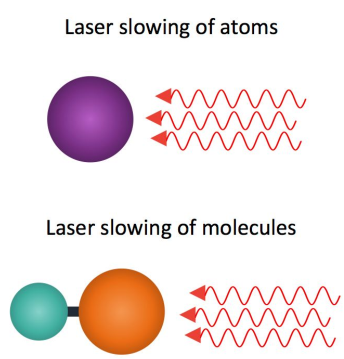

Figure 1. Laser Slowing of Atoms and Molecules. A model of how a laser beam is able to slow down an atom or a molecule by exerting a force in the direction opposite its direction of motion.

13. As scientists increase the mass of the molecules they study using laser cooling, how will the force needed to slow the molecules down by the same amount change? Justify your answer.

14. **Connect to the Big Question.** In this experiment, scientists had to actively manipulate molecules to observe their interactions. Based on this example, do you think scientific observation always means looking at something without touching it? Can you think of other examples of scientific observations that were made possible by actively manipulating the things the scientists wanted to observe? Examples could be from science class or from other experiments you have heard about.