Name:

Skill Builder — Solving Equations

How do you make sense of physics equations? Do they sometimes seem like alphabet soup? This skill sheet takes you step-by-step through the process of solving word problems in physical science.

1. What is a variable?

Suppose you are walking home after school. The distance from school to your home is five kilometers. On foot, you can get home in 25 minutes. However, if you rode a bicycle, you could get home in 10 minutes. How could you figure out how much faster you travel on your bicycle?

First, you need to find how fast you travel on foot and how fast you travel by bicycle.

You are probably familiar with this formula:

$$speed = \frac{distance}{time}$$

In physics, we often write the formula for speed like this:

$$v = \frac{d}{t}$$

v, d, and t are known as *variables*. The word *variable* comes from the same root as the word *vary*, which means to change. They are called variables because the numbers that they represent can change. If we know the numbers represented by any two of the variables, we can find the third.

2. Solving equations

To calculate your average speed while walking, substitute the numbers that you know for the letters in the formula.

$$\text{walking speed} = \frac{\text{distance}}{\text{time}}$$

$$v = \frac{d}{t}$$

$$v = \frac{5 \text{ km}}{25 \text{ minutes}}$$

$$v = 0.2 \text{ km/minute}$$

1. Now use the same method to figure out your speed while bicycling.

2. How much faster do you travel by bicycle?

3. Rearranging variables

Sometimes you have to rearrange the equation in order to find the information you want. For example, you may know the speed and time, but not the distance.

After getting home from school, you might decide to walk to a friend's home. This walk takes you 10 minutes. Assuming you walk the same speed as you walked home from school, how far is it to your friend's home?

Start with the same formula: $v = \frac{d}{t}$ How can you find **d**?

The formula for speed is called an *equation* because the amount on the left side of the equals sign is the same as the amount on the right. Equations are balanced.

If you multiply both sides of the equation by the same number, both sides will still be balanced. Let's try it:

$$v \times t = \frac{d}{\cancel{t}} \times \cancel{t}$$

We can simplify the right side of the equation. Dividing by t, then multiplying by t, is the same as multiplying by 1. The t's cancel each other out, leaving:

$$v \times t = d$$

Now substitute the numbers that you know into the equation:

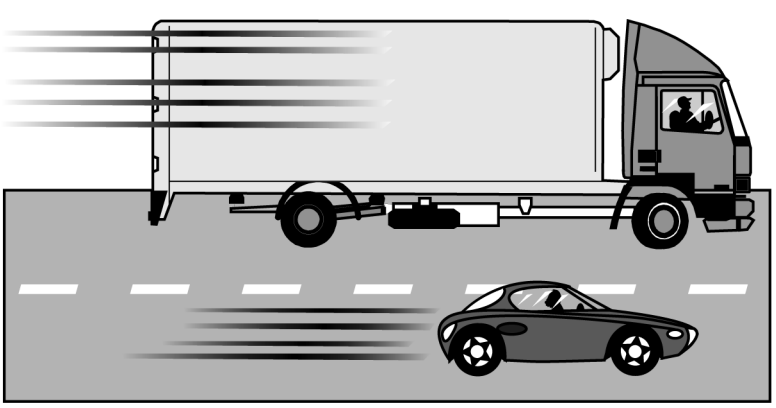
$$0.2 \text{ km/}\cancel{\text{minute}} \times 10 \cancel{\text{ minutes}} = \text{distance}$$

$$2 \text{ km} = \text{distance}$$

1. Suppose you ride your bicycle to the library. You go the same speed as you bicycled home from school. It takes you 25 minutes to get to the library. How far did you travel?

2. Challenge: You ride your bike for a distance of 30 km. You travel at a speed of 0.75 km/ minute. How many minutes does this take?

4. Solving other equations



Which is more difficult to stop: A tractor-trailer truck barreling down the highway at 35 meters per second, or a small two-seater sports car traveling the same speed?

You probably guessed that it takes more force to stop a large truck than a small car. In physics terms, we say that the truck has greater *momentum*.

We can find momentum using this equation:

$$\text{momentum} = \text{mass of object} \times \text{velocity of object}$$

Velocity is a term that refers to both speed and direction. For our purposes we will assume that the vehicles are traveling in a straight line. In that case, velocity and speed are the same.

The equation for momentum is abbreviated like this: $p = m \times v$.

P is momentum, expressed in units of kg • m/sec; m is the mass of the object, in kg; and v is the velocity of the object in m/sec.

Use your knowledge about solving equations to work out the following problems:

1. If the truck has a mass of 2,000 kg, what is its momentum? Express your answer in kg • m/sec.

2. If the car has a mass of 1,000 kg, what is its momentum?

3. An 8 kg bowling ball is rolling in a straight line toward you. If its momentum is 16 kg • m/sec, how fast is it traveling?

4. A beach ball is rolling in a straight line toward you at a speed of 0.5 m/sec. Its momentum is 0.25 kg • m/sec. What is the mass of the beach ball?

5. Extra practice problems with speed

Directions: Record your answers on separate paper or in your notebook. Show all of your work.

1. A train travels 225 kilometers in 2.5 hours. What is the train's average speed?
2. An airplane travels 3,260 kilometers in 4.00 hours. What is the airplane's average speed?
3. A kayaker paddles down river at an average speed of 10.0 km/h. After 3.25 hours, how far has she traveled?
4. The same kayaker paddles upstream at an average speed of 4 km/h. How long would it take her to get back to her starting point?
5. An airplane travels from St. Louis to Portland, Oregon in 4.33 hours. If the distance traveled is 2,742 kilometers, what is the airplane's average speed?
6. The airplane returns to St. Louis by the same route. Because the prevailing winds push the airplane along, the return trip takes only 3.75 hours. What is the average speed for this trip?
7. The airplane refuels in St. Louis and continues on to Boston. It travels at an average speed of 610 km/h. If the trip takes 2.75 hours, what is the flight distance between St. Louis and Boston?
8. The speed of light is about 3.00×10^5 km/sec. It takes approximately 1.28 seconds for light reflected from the moon to reach Earth. What is the average distance from Earth to the moon?
9. The average distance from the sun to Pluto is approximately 6.10×10^9 km. How long does it take light from the sun to reach Pluto? Use the speed of light from the previous question to help you.

6. Extra practice problems with momentum

Directions: Record your answers on separate paper or in your notebook. Show all of your work.

1. A 4,000 kg truck travels in a straight line at 10.0 m/sec. What is its momentum?
2. A 1,400 kg car is also traveling in a straight line. Its momentum is equal to that of the truck in the previous question. What is the velocity of the car?
3. Which would take more force to stop: An 8.0 kg ball rolling in a straight line at a speed of 0.4 m/sec or a 3.7 kg ball rolling along the same path at a speed of 0.9 m/sec?
4. The momentum of a car traveling in a straight line at 20.0 m/sec is 24,500 kg•m/sec. What is the mass of the car?
5. A 0.14 kg baseball is thrown in a straight line at a velocity of 30 m/sec. What is the momentum of the baseball?
6. Another pitcher throws the same baseball in a straight line. Its momentum is 2.1 kg•m/sec. What is the velocity of the ball?
7. A 1 kg turtle crawls in a straight line at a speed of 0.01 m/sec. What is the turtle's momentum?