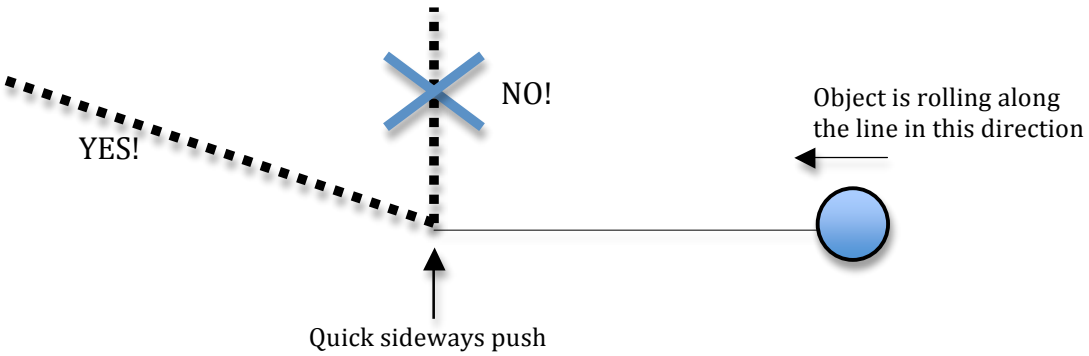
Sideways Forces and Rolling Objects:
***Blackout* reading**

#1 We see rolling objects every day, such soccer balls and marbles. Often, it is important to know how to use a [redacted] (a push or pull) to move these objects in a certain direction – such as aiming a soccer ball at a goal.

People sometimes have trouble using forces to move rolling objects in particular directions, however. For example, some people think that when you apply a quick sideways force to a rolling object that it makes an L-shaped (90 degree) turn (see Figure 1). But this isn't what happens. Instead, the object ends up moving [redacted]. Why is this? #2

Figure 1. A Rolling Object is Pushed From the [redacted] #3

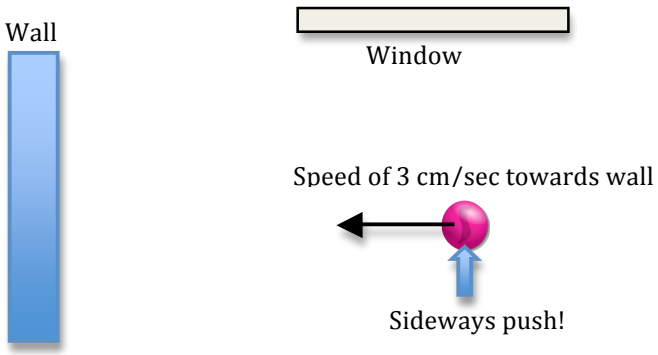


To scientists, the reason for the diagonal motion is based on an important scientific concept. The reason why the rolling object moves this way after the push is because of the idea that *a sideways force only changes an object's* [redacted] *motion*. To better understand this idea, we will look at an example. #4

Example of a Sideways Force on a Rolling Marble's [redacted] *and Direction* #5

Imagine that a marble is moving with a speed of 3 centimeters per second (cm/sec) towards a wall. A window is to the side of the marble. Unexpectedly, the marble is [redacted] by a strong sideways puff of air (see Figure 2). What happens? #6

Figure 2. A Marble is Pushed From the Side



Movement towards the wall.

Since the marble's speed of 3 cm/sec is [redacted] a sideways speed, the 3 cm/sec speed isn't affected by the sideways puff of air. This means the marble keeps moving with a speed of 3 cm/sec towards the wall. #7

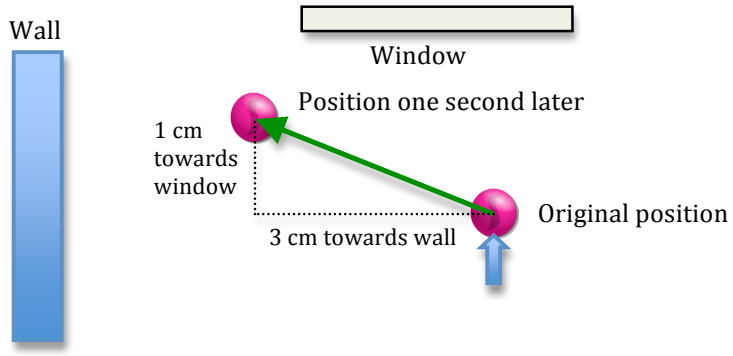
Movement towards the window.

According to our rule, because the puff of air pushes [redacted] on the marble, it changes the sideways speed of the marble. This means that the marble will now move with a new sideways speed towards the window. #8

What happens every second that the marble moves.

#9 Let's imagine that the new sideways speed of the marble is 1 cm/sec (towards the window). What is the [redacted] of the marble after being pushed?

Figure 3. The movement of the marble (after the push) in one second



As shown in Figure 3, in one second, the marble moves 3 centimeters towards the wall, and also moves 1 centimeter towards the window. Since it moves both towards the wall and towards the window, it now moves [redacted]! #10

This diagonal motion will continue, and so every second the marble will roll 3 centimeters towards the wall and 1 centimeter towards the window.

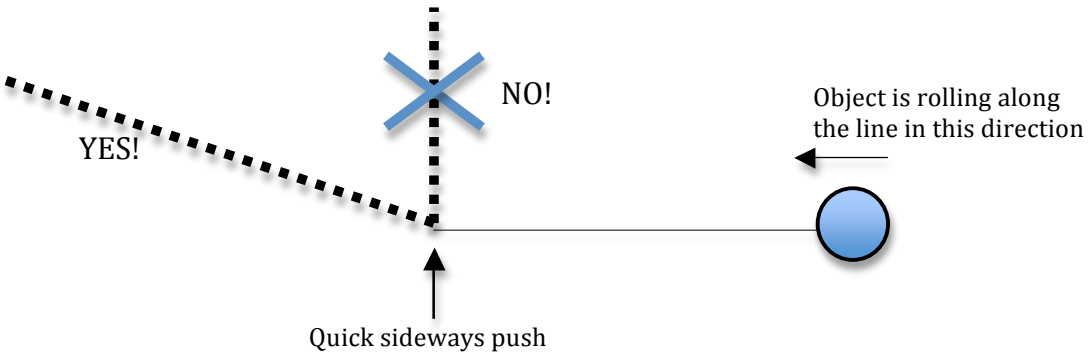
So now we have our answer. The marble moves diagonally after being pushed by a sideways puff of air (a force) because it keeps its [redacted] motion, but it also receives a new sideways motion. And it's all based on the scientific idea that *a sideways force only changes an object's sideways motion*. #11

Sideways Forces and Rolling Objects:
Original Version of Text

We see rolling objects every day, such soccer balls and marbles. Often, it is important to know how to use a force (a push or pull) to move these objects in a certain direction – such as aiming a soccer ball at a goal.

People sometimes have trouble using forces to move rolling objects in particular directions, however. For example, some people think that when you apply a quick sideways force to a rolling object that it makes an L-shaped (90 degree) turn (see Figure 1). But this isn't what happens. Instead, the object ends up moving *diagonally*. Why is this?

Figure 1. A Rolling Object is Pushed From the Side

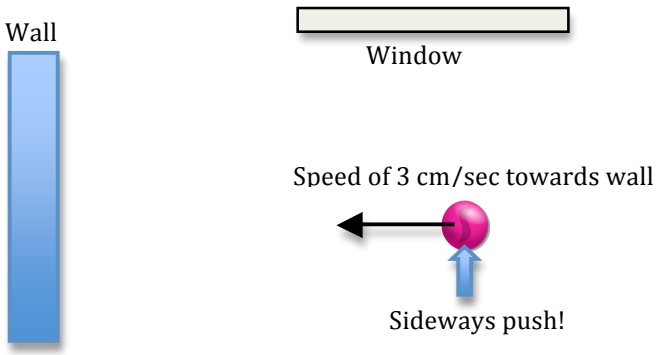


To scientists, the reason for the diagonal motion is based on an important scientific concept. The reason why the rolling object moves this way after the push is because of the idea that *a sideways force only changes an object's sideways motion*. To better understand this idea, we will look at an example.

Example of a Sideways Force on a Rolling Marble's Speed and Direction

Imagine that a marble is moving with a speed of 3 centimeters per second (cm/sec) towards a wall. A window is to the side of the marble. Unexpectedly, the marble is pushed by a strong sideways puff of air (see Figure 2). What happens?

Figure 2. A Marble is Pushed From the Side



Movement towards the wall.

Since the marble's speed of 3 cm/sec is NOT a sideways speed, the 3 cm/sec speed isn't affected by the sideways puff of air. This means the marble keeps moving with a speed of 3 cm/sec towards the wall.

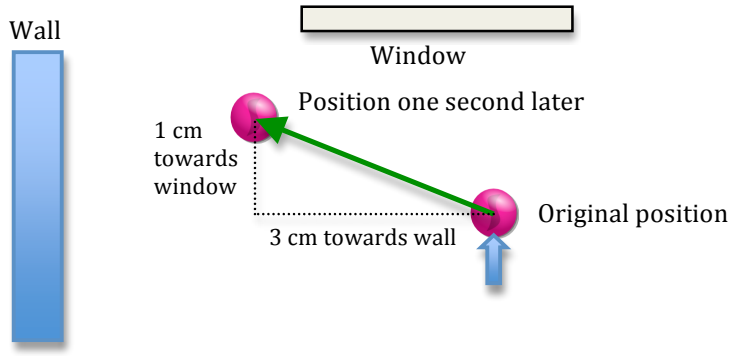
Movement towards the window.

According to our rule, because the puff of air pushes sideways on the marble, it changes the sideways speed of the marble. This means that the marble will now move with a new sideways speed towards the window.

What happens every second that the marble moves.

Let's imagine that the new sideways speed of the marble is 1 cm/sec (towards the window). What is the path of the marble after being pushed?

Figure 3. The movement of the marble (after the push) in one second



As shown in Figure 3, in one second, the marble moves 3 centimeters towards the wall, and also moves 1 centimeter towards the window. Since it moves both towards the wall and towards the window, it now moves diagonally!

This diagonal motion will continue, and so every second the marble will roll 3 centimeters towards the wall and 1 centimeter towards the window.

So now we have our answer. The marble moves diagonally after being pushed by a sideways puff of air (a force) because it keeps its original motion, but it also receives a new sideways motion. And it's all based on the scientific idea that *a sideways force only changes an object's sideways motion*.

Name:

Table for *Blackout Words* Activity

	Column A	*Column B*	*Column C*
Word #	**Your Own Best Guesses**	**Your Best Guesses: After Discussion**	**Actual Blackout Words**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			