Fast Ball

Overview: Gravity is an acceleration. That is, it affects all objects equally. Gravity accelerates objects at 9.8m/s^2. Acceleration is a rate of change of speed or, in other words, how fast the speed is changing. We'll get some good practice with calculations and observations as we complete this lesson.

What to Learn: Students will learn that the velocity of an object is the rate of change of its position, and that acceleration is the rate of change of velocity. They will solve problems involving distance, time, speed and gravity.

Materials

- ball
- pencil
- stopwatch
- yardstick (or tape measure)

Lab Time

1. Go outside and pick one person to be the thrower and another to be the timer.
2. Have the timer say "Ready, Set, Go!" and at "Go," he or she should start the stopwatch.
3. When the timer says go, the thrower should toss the ball as high as he or she can.
4. The timer should stop the stopwatch when the ball hits the ground.
5. Write down the time that the ball was in the air using the data table.
6. Let each person take a couple of turns as timer and thrower.
7. Now, come back inside and do a bit of math (see below).

   Let's say you threw the ball into the air and it took 3 seconds to hit the ground. The first thing you have to do is divide 3 in half. Why? Because your ball traveled 1.5 seconds up and 1.5 seconds down! (By the way, this isn't completely accurate because of two things. One, air resistance and two, the ball falls a little farther than it rises because of the height of the thrower.) Now, take your formula and figure out the speed of the throw.

   $v=gt$, so $v=32$ ft/s^2 x 1.5 sec or $v = 48$ ft/s.

   So, if that's how fast it left your hand, how fast was it going when it hit the ground? Yup, 48 ft/s. It has to be going the same speed because it had just as much time to speed up as it had to slow down, 1.5 seconds. Try that with your time and see how fast your throw was.

   OK, hold your breath, just a little deeper now. Let's talk about distance. If something starts from rest you can tell how far it drops by how long it has dropped. This formula is $d=\frac{1}{2} gt^2$ or distance equals one half the gravitational constant multiplied by time squared. Let's try it. If I drop a ball and it drops 3 seconds, how far has it dropped?

D = ½ x 32ft/s^2 x $(3s)^2$ or d = 16 ft/s x $9s^2$ or d=144 ft

So it has dropped 144 ft.

Now try this with your time. What's the first thing you have to do? Divide your time in half again, right? It took your ball half the time to go up and half the time to come down. Now plug your numbers into $1/2gt^2$ and find out how high you threw your ball!

Fast Ball Data Table

Ball Time Aloft *(measure in seconds)*	**Speed:** $v=gt$ *(ft/sec or m/s)*	**Distance:** $d = ½\ gt^2$ *(feet or meters)*

Reading

Gravity accelerates all things equally…what does that mean? All things accelerate at 32 feet per second squared due to gravity. In metric, that's 9.8 meters per second squared.

What that means is that every second something falls, its speed increases by 32 feet/second or 9.8 meters/second. Believe it or not, that's about 22 miles per hour!! Gravity will accelerate something from 0 to 60 mph in about 3 seconds. That's faster than all but the fastest sports cars!

So what is acceleration anyway? Well, speed is the amount of distance something travels in a certain amount of time. Five miles per hour, for example, tells you that something can travel five miles in an hour. Acceleration is how much the speed changes over time. So acceleration would be miles per hour per hour or feet per second per second.

Acceleration is a rate of change of speed or, in other words, how fast the speed is changing. Feet per second per second is the same as ft/s/s which is the same as ft/s^2. (I told you we were going deeper!) Let's say you're riding your bicycle at a positive acceleration (you're getting faster) of 5 ft/s^2.

That means in 1 second you're moving at a speed of 5 ft/s.

After 2 seconds you're moving at a speed of 10 ft/s.

After 3 seconds you're now clipping along at 15 ft/s (about 10 mph).

So you can see that as long as you accelerate, you will be getting faster and faster. The formula for this is v=at where v is velocity, a is acceleration and t is time. (We will be doing more with acceleration in a future lesson.)

If we want to find out how fast something is going after it has been dropped, we use the formula v=gt. The letter "v" stands for velocity (which basically means speed.) "g" stands for the gravitational constant and "t" stands for time.

If we want to find out how fast a golf ball is dropping after it falls for 3 seconds we multiply 3 seconds by 32 feet/second squared and that equals 96 feet/second. So, if I dropped a golf ball off a building, it would be going 96 feet per second after 3 seconds of dropping.

The formula looks like this when we fill in the numbers:

v=3s x 32 ft/s^2

If we do more math, we'll see that after one second something will be going 32 ft/s, after 2 seconds it will be going 64 ft/s, after 3 seconds 96 ft/s, and after 4 seconds 128 ft/s. Get it? Anything dropped will be going that speed after that many seconds because gravity accelerates all things equally (air resistance will affect these numbers so you won't get exactly the numbers in practice that you will mathematically).

All right, let's go even deeper. We now know how to calculate how fast something will be going if it is dropped, but what happens if we throw it up? Well, which way does gravity go? Down, right? Gravity accelerates all things equally, so gravity will slow things down as they travel up by 32 ft/s^2. If a ball is thrown up at 64 ft/s, how long will it travel upwards? Well, since it is negatively accelerating (in physics there's no such thing as deceleration) after the first second the ball will be traveling at 32 ft/s and after 2 seconds the ball will come to a stop, turn around in midair, and begin to accelerate downwards at 32 ft/s^2. Using this, you can tell how fast you can throw by using nothing more than a timer. Let's try it – flip over to the experiment section now.

Exercises Answer the questions below:

1. Is gravity a speed, velocity, or acceleration?

2. Does gravity pull equally on all things?

3. Does gravity accelerate all objects equally?

4. How is acceleration different from speed and velocity?

Answers to Exercises: Fast Ball

1. Is gravity a speed, velocity, or acceleration? (Gravity is an acceleration of 32.2 ft/s^2)
2. Does gravity pull equally on all things? (No.)
3. Does gravity accelerate all objects equally? (Yes.)
4. How is acceleration different from speed and velocity? (Speed is distance per unit time, velocity is speed and direction, and acceleration is the change in velocity, which means a change in the speed or a change in the direction.)