

Introduction to Motion

Astronomy

Lesson 14

How do you know you're moving? If you've ever traveled on a train, you know you cannot always tell if you're in motion. Looking at a building outside the window helps you decide. Although the building seems to move past the train, it is you who are moving. However, sometimes you may see another train that appears to be moving. Is the other train really moving, or is your train moving? How do you tell?

Describing Motion

Deciding if an object is moving is not as easy as it may seem. An object is in motion if its distance from another object is changing. But, how can you tell. The sun appears to move across the sky, when the earth is actually spinning and causing that apparent motion. The "motion" of the Sun across the sky is relative motion.

Usually, we consider motion with respect to the ground or the Earth. Within the Universe there is no real fixed point. The basis for Einstein's *Theory of Relativity* is that all motion is relative to what you define as a fixed point.

Relative motion: whether or not an object is in motion depends on the reference point you choose.

To decide if you're moving you use something in your environment as a reference point. A reference point is a place or object used for comparison to determine if something is in motion. An object is in motion if it changes position relative to a reference point.

Stationary objects make good reference points. So, what around us makes a good reference point? (What is stationary? What are some examples? Why is it important to use a stationary object as a reference point?)

Calculating Speed

A measurement of distance can tell you how far an object traveled. If you know the distance an object traveled in a certain amount of time, you can calculate the speed of the object. Speed is a special type of rate. Can anyone tell us what a rate is? [A rate tells you the amount of something that occurs or changes in one unit of time.] The **speed** of an object is the distance the object travels per unit of time.

So, how could we calculate the speed of ourselves traveling 100 feet? [We'd need to know the time it takes us to travel 100 feet.] Let's do it! [whoever wants

to participate can calculate their speed...those not wanting to participate can help by standing at the starting line, standing at the finish line, watching the stop watch, recording speeds, etc.]

To calculate the speed of an object, divide the distance the object travels by the amount of time it takes to travel that distance:

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

The Big But...

Does everyone know their speeds? Great. But, did you all start off going that fast? Did you instantaneously begin running as fast as you were when you crossed the 100-ft mark? Of course not....it takes a bit to go from nothing to fast! So, then what did we just calculate? We didn't calculate your speed the whole time, right? [We calculated the average speed] To calculate the average speed, divide the total distance traveled by the total time.

Describing Velocity

Knowing the speed of an object does not tell you everything about the motion of that object. What else would you need to know in order to know the motion of the object? For instance, if I were going to give you directions to Shaws from here, and I were to tell you it was 2 miles away, what else would you need to know to get there? [The direction] To describe an object's motion completely, you need to know the direction the object is traveling in.

When you know both the speed and direction of an object, you know the **velocity** of that object. Speed in a given direction is called velocity. When is knowing the velocity important?

Acceleration

The pitcher throws. The ball speeds towards the batter. Off the bat it goes. It's going, going, gone! A home run! [I like to bring out a wiffle ball bat and ball for this example, or you can pass a ball to one of your students and have them pass it back, or you could dribble a basketball]

Before landing, the ball went through several changes in motion. It sped up in the pitcher's hand, and lost speed as it traveled towards the batter. The ball stopped when it hit the bat, changed direction, sped up again, and eventually came to a stop when it hit the ground. Most examples of motion involve similar changes. In fact, rarely does an object's motion stay the same for very long.

What do you all think of when you hear the term acceleration? (maybe: speeding up). Acceleration has a more precise definition in science. Scientists define **acceleration** as the rate at which velocity changes. What is velocity again? [speed and direction] So, a change in velocity can involve a change in

either speed or direction, or both! In science, acceleration refers to increasing speed, decreasing speed, or changing direction. Can we give some examples of each of these scenarios?

Acceleration describes the rate at which velocity changes. If an object is not changing direction, you can describe its acceleration as the rate at which speed changes. To determine the acceleration of an object moving in a straight line, you must calculate the change in speed per unit of time:

$$\text{Acceleration} = \frac{\text{Final Speed} - \text{Initial Speed}}{\text{Time}}$$

What units does this calculation give us? (distance/time²)

Can we calculate our acceleration as we run 100 feet? What would we need to do? [If there's enough time left, I suggest you do this...]