Name: ____________________ Teacher: _______________ Pd. ___ Date: ________

STAAR Science Tutorial 20
TEK 6.8C: Measuring Speed

TEK 6.8C: Calculate average speed using distance and time measurements.

- **Motion** is defined as a change in position, relative to an assumed reference point. To decide whether an object is in motion, or measure its rate of motion (speed), we need to pick a **reference point**. Ideally, that reference point should itself not be moving. But that is impossible, because the ground we walk on is part of a moving tectonic plate. Our planet Earth spins on its axis, and orbits around our Sun. Our solar system in turn orbits around the center of the Milky Way Galaxy. Our galaxy moves in relation to other galaxies. In fact, no reference point that we could choose is in fact fixed. But we can *assume* that a reference point, such as a starting line on a running track, is fixed for purposes of measuring motion.

- **Speed** is one measurement of motion. Speed is defined as the distance travelled divided by the time it took to travel that distance. The formula for speed is:

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

- **Distance** is the length of the path travelled, following all of the turns or curves of the path. Distance is what a car odometer measures, the actual path of travel that the car took, without any notation of direction. For example, if you walk 100 meters forward, and 35 meters backward towards your starting point, the distance you have traveled will be 135 meters, even though you end up at a point 65 meters from the starting point.

- The units used to measure speed vary. The distance units used in science are metric: meters or kilometers. In the United States, the customary units of distance are feet or miles. The time units in either the metric or customary U.S. systems are the same: seconds, minutes or hours. The most common units you will see in science speed problems are meters per second (m/s) or kilometers per hour (km/h). If a marble rolling down a ramp is being measured, meters per second would be the appropriate unit. If the speed of a car on a road is being measured, kilometers per hour would be the best unit.

- There are two ways that we can measure speed: instantaneous speed and average speed. **Instantaneous speed** is the rate of motion at a single instant of time. The speedometer of a car, or the radar gun that police use to see if your speed is below the speed limit, measure instantaneous speed. In practice, instantaneous speed is really an average speed over a very short period of time—for example, one rotation of a car’s tire (the odometer) or during the one second between distance measurements of the police radar gun. **Average speed** is the total distance traveled in some trip divided by the total time it took to complete that trip. On a trip from Dallas to Austin, the instantaneous speed at any one time during the trip would vary: 100 km/hr on the highway, 40 km/hr on city streets, and 0 km/h when stopped at the red light. The average speed for the whole trip might be 82 km/h, close to but slower than the 100 km/h highway speed, because most (but not all) of the trip was on the highway.

- The speed formula can also be used to calculate distance and time, when the speed is known. (The "•" symbol is for multiplication, and is used rather than "x", because "x" is often used in algebra as an unknown variable.) The three forms of the speed formula are:

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

$$\textbf{Distance} = \textbf{Speed} \bullet \textbf{Time}$$

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

- The following sample problems each use one of the above formulas to solve for the unknown value, using the two given values.

1. A car travels 100 km over a period of 2 hours. What is its speed? Answer: Since speed is the unknown value, and the distance and time values are given in the question, use the first formula: S=D/T. 100 km / 2 h = 50 km/h.

2. A car travels 2 hours at an average speed of 50 km/h. What was the distance of the trip? Answer: Since distance is the unknown value, and the time and speed values are given in the question, use the second formula: D=S•T. 2 h • 50/km/h = 100 km.

3. A car travels a distance of 100 km at a speed of 50 km/h. How much time will it take to complete the trip? Answer: Since time is the unknown value, and distance and speed values are given in the problem, use the third formula: T=D/S. 100 km / 50 km/h = 2 h.

- In a lab experiment where speed is being measured and calculated, a stopwatch would likely be used to measure the time needed to travel some pre-measured distance. For example, suppose you want to measure the speed of a marble on a 3 meter long sloped ramp. The time that it takes to travel one, two and three meters could each be measured in multiple trials, and the average speed over one, two and three meters could be calculated. An example of a data tables and calculations for this lab is shown below:

Trial No.	Distance (meters)	Time (seconds)
1	1.0 m	1.2 s
2	1.0 m	1.6 s
3	1.0 m	1.4 s
Average	**1.0 m**	**1.4 s**
1	2.0 m	2.2 s
2	2.0 m	2.3 s
3	2.0 m	2.1 s
Average	**2.0 m**	**2.2 s**
1	3.0 m	3.0 s
2	3.0 m	2.8 s
3	3.0 m	3.2 s
Average	**3.0 m**	**3.0 s**

Speed = Distance / Time

Speed = 1.0 m / 1.4 s

Speed = 0.7 m/s

Speed = Distance / Time

Speed = 2.0 m / 2.2 s

Speed = 0.9 m/s

Speed = Distance / Time

Speed = 3.0 m / 3.0 s

Speed = 1.0 m/s

Practice Questions

1. What is the definition for speed? ____

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2. State the three different versions of the speed formula, solving for speed, time and distance. ____

_____________________________________ ______________________________________

2. What is distance, and how is it measured? ___________________________________

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3. A car travels a distance of 30 kilometers in 2 hours. What is its speed in kilometers per hour? ____________________ km/h

4. A car travels a distance of 100 kilometers in 4 hours. What is its speed in kilometers per hour? ____________________ km/h.

5. If a car is traveling at a constant speed of 100 kilometers per hour (km/h), how many hours will it take for the car to travel a distance of 500 kilometers?
______________ h.

6. If a car is traveling at a constant speed of 70 kilometers per hour (km/h), how many hours will it take for the car to travel a distance of 280 kilometers?
______________ h

7. If a car moves at a speed of 80 km/h for 5 hours, what distance will it travel?
____________ km

8. If a car moves at a speed of 75 km/h for 4 hours, what distance will it travel?
____________ km

9. A student completes a speed lab in which he measures how fast three different students can run a distance of 20 meters. He uses a stopwatch to record the time in seconds, and has each student run three trials, with a rest period between each trial. The data table is shown below. What is the average speed for each student? Who was fastest? Who was slowest?

Student /Trial	Distance (meters)	Time (seconds)
John - 1	20.0 m	4.1 s
John -2	20.0 m	4.3 s
John -3	20.0 m	4.6 s
John-Average	**20.0 m**	
Rita - 1	20.0 m	4.8 s
Rita - 2	20.0 m	5.0 s
Rita - 3	20.0 m	5.4 s
Rita -Average	**20.0 m**	
Bob - 1	20.0 m	3.8 s
Bob - 2	20.0 m	3.9 s
Bob - 3	20.0 m	3.8 s
Bob - Average	**20.0 m**	