**Speed, Velocity, & Acceleration**

Scalar Quantity vs. Vector Quantity - A scalar quantity is a measurement that has only magnitude (a numerical value). Examples of scalar measurements (which do not depend on direction) include: length, area, volume, speed, mass, density, pressure, temperature, energy, entropy, work, and power. A vector quantity is a measurement that has magnitude AND direction. Examples of vector measurements (which do depend on direction) include: displacement, velocity, acceleration, momentum, force, lift, drag, thrust, and weight.

Distance vs. Position vs. Displacement - Distance is a scalar quantity; it describes how far an object has moved but does NOT indicate the direction of travel. Displacement is a vector quantity; it is the distance traveled WITH direction specified. Displacement is the overall change in an object’s position or Final Position – Initial Position (where an object is compared to where it started).

Speed vs. Velocity - Speed is a scalar quantity; it describes how far an object travels per unit time (distance ÷ time). Speed has magnitude but NOT direction because it does not describe the direction of travel. Velocity is a vector quantity; it describes how fast an object is moving AND the direction of motion.

* Instantaneous Velocity/Speed – the velocity of an object at a specific point or specific time along the journey.
* Average Velocity/Speed – the total distance traveled divided by the total time taken to travel said distance.

Acceleration - Acceleration is a vector quantity; it is defined as the rate at which an object changes its velocity (since velocity describes magnitude and direction so does acceleration). Alternatively, acceleration is the difference in velocity (final velocity – initial velocity) divided by the change in time. Negative Acceleration is called Deceleration.

* Constant Acceleration – the rate at which velocity changes over time remains the same (keep in mind the velocity itself is changing but the rate at which it is changing remains the same.
* Increasing/Decreasing Acceleration – the rate at which velocity changes over time varies (the velocity is changing and the rate at which it is changing is increasing or decreasing).

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| --- | --- | --- |
| **Equation** | **Gives you……** | **If you know…..** |
| Velocity = Distance ÷ Time | Velocity | Time & Distance |
| Distance = Velocity × Time | Distance | Speed & Time |
| Time = Distance ÷ Time | Time | Distance & Velocity |
| Acceleration = (Final Velocity – Beginning Velocity) ÷ Change in Time | Acceleration | Velocity & Time |

1. What is the velocity of a cheetah that travels 112.0 meters in 4.0 seconds?
2. A bicycle rider travels 60 km in 3.5 hours. What is the cyclist’s average velocity?
3. What is the average velocity of a car that traveled 300 miles in 5.5 hours?
4. How much time would it take for the sound of thunder to travel 1500 m if sound travels at a rate of 330 m/sec?
5. How far can a person run in 0.25 hours if they can run at an average velocity of 16 km/hr?
6. A snail can move 0.30 m/min. How many meters can the snail travel in 15 minutes?
7. At the top of a hill a roller coaster car is traveling 4 m/sec. Three seconds later it reaches the bottom of the hill moving at 22 m/sec. What is the acceleration of the roller coaster car?
8. A bus slows from 35 mi/hr to 25 mi/hr in 5 seconds. What is the rate of deceleration (negative acceleration)?
9. A lizard accelerates from 2 m/sec to 10 m/sec in 4 seconds. What is the lizard’s rate of acceleration?
10. A cyclist accelerates from 0 m/sec to 8 m/sec in 3 seconds. What is the cyclist’s acceleration? Is the cyclist’s acceleration greater or less than that of a car which accelerates from 0 to 30 m/sec in 8 seconds?

Domino Dash

Purpose: to determine the relationship between velocity, time, and distance.

Materials: Dominoes, stopwatch, meter stick, calculator.

Procedure: Set up all dominoes in a straight line with equal spacing between them. Measure (in centimeters) and record the length of the domino row. Use the stopwatch to measure the time it takes for the entire row of dominoes to fall. Calculate the velocity at which the dominoes fell. **Repeat 7 times using rows of different lengths**.

|  |  |  |
| --- | --- | --- |
| **Length of Domino Row (cm)** | **Time (sec)** | **Average Velocity (cm/sec)** |
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|  |  |  |
|  |  |  |
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Data Analysis: Make a line graph to show the relationship between the length of the domino row and the time it takes to fall. Place the “length of the row” on the X-axis and the “time to fall” on the Y-axis.



Post Lab Questions:

1. What is the independent variable in this experiment?
2. What is the dependent variable in this experiment?
3. What relationship do you see between the variables? In other words, how does the independent variable affect the dependent variable?
4. Which definition of velocity/speed (average, constant, instantaneous) was used in this investigation? Support your answer with an explanation.
5. What effect does distance have on the velocity/speed of a moving object?
6. What effect does time have on the velocity/speed of a moving object?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Average Velocity or Speed** | **Constant Velocity or Speed** | **Instantaneous Velocity or Speed** | **Acceleration** |
| **Definition.** |  |  |  |  |
| **When is it used?** |  |  |  |  |

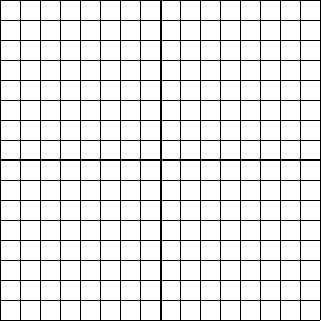
1. What is the difference between a scalar quantity and a vector quantity?
2. What is the difference between instantaneous velocity and average velocity?
3. What is the difference between distance and position?
4. What is displacement?

The Distance (position) vs. Time Graph

* The slope of a line is calculated by (rise ÷ run) or (change in X ÷ change in Y).
* The slope of a distance (position) vs. time graph is velocity (speed).

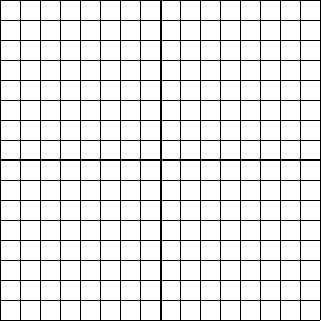
1. Graph the following data and answer the questions (label the x-axis “time” and the y-axis “distance (position)”

|  |  |
| --- | --- |
| **Time (sec)** | **Distance (m)** |
| 0 | 0 |
| 1 | 50 |
| 2 | 75 |
| 3 | 90 |
| 4 | 110 |
| 5 | 125 |



1. What is the average velocity during the first two seconds?
2. What is the average velocity during the first three seconds?
3. What is the average velocity during the first five seconds?
4. What is the average speed between one and four seconds?
5. Graph the following data and answer the questions (label the x-axis “time” and the y-axis “velocity”).

|  |  |
| --- | --- |
| **Velocity (m/sec)** | **Time (sec)** |
| 0 | 0 |
| 10 | 2 |
| 20 | 4 |
| 30 | 6 |
| 40 | 8 |
| 50 | 10 |



1. As time increases, what happens to the velocity?
2. What would the velocity at five seconds be?
3. At what time would the object reach a speed of 45 m/sec?
4. What is the object’s rate of acceleration?