Speed and Velocity

Name: _____

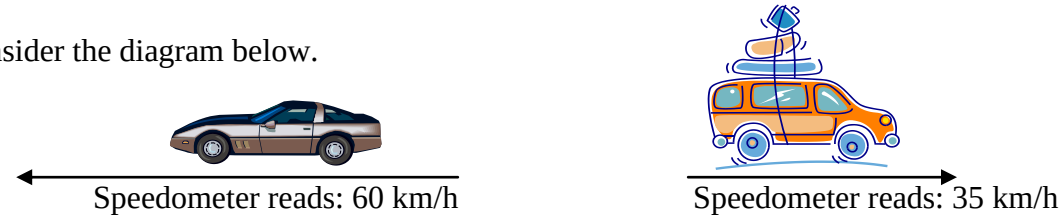
Date: _____

Information: Speed is Relative

Speed is a measure of how fast an object's distance (also called "position") changes. Distance must change or there is no speed. Right now as you are reading this, you are probably sitting still. If you were asked how fast you are moving you would probably reply that your speed is zero. However, the Earth is currently traveling around the sun at a speed of about 30,000 meters per second (m/s)! So, your speed *relative* to the sun would be about 30,000 meters per second (m/s) but your speed *relative* to the ground of the Earth is zero. Speed is always "relative" to something; usually we assume that speed is relative to the ground unless specified otherwise.

Critical Thinking Questions

1. Consider the diagram below.



a) How fast is the van traveling relative to the ground? 35 km/h

b) How fast is the van traveling relative to the car? (This is how fast it *looks* like the van is traveling to someone riding in the car.)

95 km/h

Information: Units

So far you probably realized that the units for speed involve some measure of distance (meters, kilometers, miles, etc.) and time (seconds, hours, etc.). Consider the table below:

Distance Units	Time Units	Speed Units	Symbol for Speed Units
Meters	Seconds	Meters per second	m/s
Miles	Minutes	Miles per minute	mi/min
Kilometers	Hours	Kilometers per hour	km/h

Critical Thinking Questions

2. If distance is measured in units of centimeters and time is measured in seconds, what would be the units for speed? cm/s

3. A kilogram is equal to one thousand grams. How many meters are in a kilometer?

1000 m

4. To find the correct units for the speed of a car we must…
   A) Multiply the distance the car travels by the time it takes to travel.
   B) Add the distance the car travels and the time it takes to travel.
   C) Divide the distance the car travels by the time it travels.

5. Which one of the following is an equation that you can use to calculate speed. (Note the following symbols: s=speed; d=distance; t=time; Δ=change in)

   A) $s = \Delta d + \Delta t$ B) $s = \frac{\Delta d}{\Delta t}$ C) $s = \Delta d - \Delta t$ D) $s = \Delta d \bullet \Delta t$

   __Note**__: the symbol "Δ" is necessary because for an object to have speed, its distance must change as the time ticks (the time is changing too!).

6. Use the correct equation from the previous question to answer the following…
   a) A car was at a 30 km marker and began to drive as someone else started the stopwatch. The car passed the 90 km marker when the stopwatch read 30.00 minutes. What was the average speed of the car during the time interval?

      2 km/min

   b) A man rowed a boat at a speed of 12 mi/h. He rowed for 2 hours. How many miles did he travel? 24 miles

7. Given your answer to question 5 and the fact that units for speed are something like kilometers **per** hour or meters **per** second, what does the word "per" signify?
   A) addition B) subtraction C) division D) multiplying

8. When you are in a car, what is the easiest way to find out how fast you are going in any *instant*, or moment, of time? (You don't need a calculator, right?.)

   speedometer

Information: Average vs. Instantaneous

Hopefully, your answer to question 8 involved looking at the speedometer. ☺ At any moment (in any *instant*) you can find your speed by looking at a speedometer. A police officer can find your speed at any *instant* if he uses his radar gun. The speed on the speedometer or the speed that the police officer finds using a radar gun is called *instant*aneous speed because it is the speed at an *instant* or moment of time. In question 6a you calculated the *average* speed, not the instantaneous speed.

Critical Thinking Questions

9. What is the difference between average and instantaneous speed?
   "Average" refers to the speed during an interval of time. "Instantaneous" refers to the speed at one moment of time.

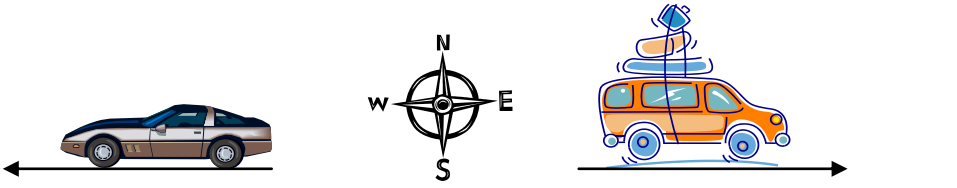
10. A snail was traveling across a sidewalk. A brilliant physics student decided to find the snail's speed and so she found a ruler and a stopwatch. Is the student going to find the snail's average speed or instantaneous speed? Explain.
    Average speed; the student is measuring the speed over an interval of time.

11. Is it possible to find instantaneous speed by measuring distance and time? Explain.
    No, measuring an interval of time and a distance will calculate average speed.

12. During a certain trip, a car traveled at an average speed of 75 km/h. Would it be possible to attain such an average speed if the car never had an instantaneous speed of more than 75 km/h? Explain.
    Assuming the car started at a speed of zero, the car would have had to reach speeds higher than 75 km/hr for the average to be 75 km/h.

Information: Velocity

Consider this picture again, but this time notice that both vehicles are traveling at the same speed:



Speedometer reads 80 km/h Speedometer reads 80 km/h

In normal, everyday speech we would use the words "velocity" and "speed" interchangeably to mean the same thing. But in physics, velocity and speed are different from one another. The two vehicles in the picture above have the same speed, but **not** the same velocity. Weird, eh?

Critical Thinking Questions

13. Velocity includes something the speed does not. Why do the two vehicles pictured above have different velocities?
    Velocity includes direction and the two vehicles are moving in opposite directions.

14. The following vehicle has the cruise control set to 20 km/h. The speed is remaining constant, but the velocity is not constant—it is changing. Explain why.

The car's direction is changing. Since velocity includes the idea of direction, velocity is changing also.

Information: Velocity's Equation

We have already seen that displacement includes the idea of the direction of motion, but distance does not. Velocity, like displacement, includes the idea of direction. Any variable that includes direction is called a "vector" quantity. Speed and distance do not include direction and are called "scalar" quantities. We will present vector variables in **bold** and scalar quantities *italicized*.

Displacement is a vector so it is in bold → $\mathbf{v} = \frac{\Delta \mathbf{d}}{\Delta t}$ ← Distance is a scalar so it is NOT bold $s = \frac{\Delta d}{\Delta t}$

Be careful not to get confused by the Δd terms. One of them is displacement and one is distance!

Critical Thinking Questions

15. In the above equations, **v** is bold and *s* is not. Explain why.

"v" is a vector and "s" is a scalar. It is common convention (although not required) for vectors to be bold and scalars to be italicized.

16. What is the average velocity of an airplane that flies…

a) … 420 km due north in 1 hour?

420 km/h north

b) … 210 km due north in ½ hour?

420 km/h north

c) … 105 km due north in 15 minutes?

7 km/min north OR 420 km/h north

17. A car drove 125 km west in 1.5 hours. Then the car turned around and drove 60 km east in 1 hour.

a) Calculate the average speed of the car.

74 km/h

b) Calculate the average velocity of the car.

26 km/h west

18. Sarah jogs with an average velocity of 1.8 m/s south. What is her displacement after 35 seconds?

63 m

19. If Sarah continues jogging with the same velocity as in the previous question, how many seconds will it take her to jog 1000 meters?

555.6 s