Speed Calculations

Now that you know your definitions, you'll learn how to calculate some of the quantities. The following formulas are all very similar, but their slight differences are important since they determine *which* quantity is being calculated.

Speed

In general, speed is calculated by taking the distance travelled and dividing it by the time it took to travel that distance. The formula can be written as:

$$v = \frac{d}{t}$$

Average speed is calculated by taking the total distance travelled and dividing it by the total time:

$$v_{avg} = \frac{d}{t}$$

Remember that for any speed calculation, there are no directions involved. This is used in situations where the direction is not important such as the average speed of a marathon runner, a lap swimmer, or an Indy car.

Example

A triathlete swims 0.50 km in 15 minutes, bikes 10 km in 10 minutes, and runs 5.0 km in 30 minutes. What is her average speed for each part of the race in km/h? What is her total average speed in km/h?

Given and Required

d1 = 0.50 km
d2 = 10 km
d3 = 5.0 km
t1 = 15 minutes
t2 = 10 minutes
t3 = 30 minutes

v1 = ?
v2 = ?
v3 = ?
vt = ?

Analysis and Solution

First convert all of the times to hours.

$$t_1 = (15\,\text{min})\left(\frac{1h}{60\,\text{min}}\right)$$

$$t_1 = 0.250\,h$$

$$t_2 = (10\,\text{min})\left(\frac{1h}{60\,\text{min}}\right)$$

$$t_2 = 0.166\dot{}\,h$$

$$t_3 = (30\,\text{min})\left(\frac{1h}{60\,\text{min}}\right)$$

$$t_3 = 0.500\,h$$

1. Now use $v_{avg} = \frac{d}{t}$ to calculate the average speed for each part of the race.

2. Now to calculate the total average speed, add up all the distances and divide them by the total time.

1

$$v_1 = \frac{0.50\,km}{0.250\,h}$$

$$v_1 = 2.00\frac{km}{h}$$

$$v_2 = \frac{10\,km}{0.166\dot{}\,h}$$

$$v_2 = 60.0\frac{km}{h}$$

$$v_3 = \frac{5.0\,km}{0.500\,h}$$

$$v_3 = 10.0\frac{km}{h}$$

2

$$v_t = \frac{d_1 + d_2 + d_3}{t_1 + t_2 + t_3}$$

$$v_t = \frac{0.50\,km + 10\,km + 5.0\,km}{0.250\,h + 0.166\dot{}\,h + 0.500\,h}$$

$$v_t = \frac{15.5\,km}{0.916\dot{}\,h}$$

$$v_t = 16.9\frac{km}{h}$$

Note: that you can't just add up the velocities for each part and divide by three since this doesn't take into account the amount of time spent at each speed

Paraphrase

The average speed for the swim was 2.0 km/h.
The average speed for the bike was 60 km/h.
The average speed for the run was 10 km/h.
The total average speed was 17 km/h

Questions

1. You are travelling at an average speed of 50 km/h. How many metres do you travel each second? (Hint: Convert to m/s)

2. An athlete completes a 100 m sprint in 11.3 s. What is his average speed in m/s? What is his average speed in km/h? Would the athlete have had this speed during his entire race?

3. If a car is travelling at an average speed of 23 m/s, how far would it travel in 1.0 minute?

1. **Given and Required**

$$v_{avg} = 50\frac{km}{h}$$
$$t = 1s$$
$$d = ?$$

Analysis and Solution

$$v_{avg} = \left(50\frac{km}{h}\right)\left(\frac{1000\,m}{1\,km}\right)\left(\frac{1\,h}{3600\,s}\right)$$
$$v_{avg} = 13.\dot{8}\frac{m}{s}$$

Note that the dot on top of the 8 means that it is repeated and that the answer in the calculator reads 13.88888889 m/s.

Paraphrase

At 50 km/h, you would travel 14 m/s.

2 . . . . Since the athlete starts from rest, he needs to accelerate to his maximum speed, so he would not be at the average speed for long. Instead, he would accelerate past it since his maximum speed must be higher than his average speed.

Paraphrase

The athlete's average speed is 8.85 m/s or 31.9 km/h. The athlete would not have this speed throughout the race.

$$v_{avg} = \frac{d}{t}$$
$$v_{avg} = \frac{100\,m}{11.3\,s}$$
$$v_{avg} = 8.850\frac{m}{s}$$
$$v_{avg} = \left(8.850\frac{m}{s}\right)\left(\frac{1\,km}{1000\,m}\right)\left(\frac{3600\,s}{1\,h}\right)$$
$$v_{avg} = 31.86\frac{km}{h}$$

3. Analysis and Solution

$$v_{avg} = \frac{d}{t}$$

$$d = v_{avg}\, t$$

$$d = \left(23\frac{m}{s}\right)(60\,s)$$

$$d = 1380\,m$$

Paraphrase

In one minute the car would travel 1.4 km or 1.4 x 103 m.
*Since there are only two significant digits required in the solution, the answer must be expressed in km or in scientific notation.

Velocity Calculations

Velocity

In general, velocity is calculated by taking the displacement and dividing it by the time it took to travel that displacement. The formula can be written as:

$$\vec{v} = \frac{\vec{d}}{t}$$

Note that the half arrows indicate vector quantities, meaning that directions are included. The direction of the velocity is the same as the direction of the displacement.

Average velocity is calculated by taking the total displacement and dividing it by the total time:

$$\overrightarrow{v_{avg}} = \frac{\Delta\vec{d}}{\Delta t}$$

The Greek letter delta (Δ) indicates change in a quantity or total value of the quantity. To determine the change in displacement, the initial and final **positions** can be subtracted.

$$\Delta\vec{d} = \vec{d_2} - \vec{d_1}$$

Or, the change in displacement can be determined by adding up all of the individual **displacements**.

$$\Delta\vec{d} = \vec{d_1} + \vec{d_2} + \vec{d_3} + \ldots$$

Example

A child on a bike rides 120 m [North] of her house in 58 s, she then turns around and rides 180 m [S] in 99 s. What is the child's total displacement and average velocity?

Given and Required

When dealing with opposite direction, assign one direction as being positive, the other negative. In this case, let's say that North is positive and South is negative.

$$\vec{d_1} = 120\,m\,[N] = 120\,m$$
$$\vec{d_2} = 180\,m\,[S] = -180\,m$$
$$t_1 = 58\,s$$
$$t_2 = 99\,s$$

Analysis and Solution

Since the individual displacements are given, add them together to find the total displacement

$$\vec{\Delta d} = \vec{d_1} + \vec{d_2}$$
$$\vec{\Delta d} = 120\,m + (-180\,m)$$
$$\vec{\Delta d} = -60\,m$$

$$\vec{v_{avg}} = \frac{\Delta \vec{d}}{\Delta t}$$
$$\vec{v_{avg}} = \frac{-60\,m}{(58\,s + 99\,s)}$$
$$\vec{v_{avg}} = \frac{-60\,m}{157\,s}$$
$$\vec{v_{avg}} = -0.382\,\frac{m}{s}$$

Paraphrase

The child's total displacement was 60 m [S]. The child's average velocity was 0.38 m/s [S].

Questions

1. You complete a road trip and determine that the average velocity was 75 km/h [E]. What does this mean? Would you have maintained that velocity throughout the trip? If you then returned home, what would be your average velocity for the entire trip?

2. A plane travels from Toronto to Kenora, about 1250 km [NW]. If the flight takes 3.8 h, what is the average velocity of the plane?

3. Travelling with an average velocity of 65 km/h [E], how long would it take to travel 15 km [E] in hours? In minutes?

1. This means that your total displacement divided by your total time gives 75 km/h [E]. You would not maintain this velocity throughout the trip since you would have to stop for lights, match the speed of traffic at different points, and make turns. If you returned home, your total displacement would be zero and so the average velocity for the entire trip would be zero.

2. The plane's average velocity is 3.2×10^2 km/h [NW].

3. It would take 0.23 h or 14 minutes to travel 15 km [E] at 65 km/h [E].