Set 14: Uniform Motion

14.1 [a]

$$\text{speed} = \frac{\text{distance travelled}}{\text{time taken}}$$
$$\text{speed} = \frac{20.1}{0.75}$$
$$\text{speed} = 26.8 \text{ ms}^{-1}$$

[b]

$$\text{speed} = \frac{\text{distance travelled}}{\text{time taken}}$$
$$\text{speed} = \frac{20.1 \div 1000}{0.75 \div (60\times60)}$$
$$\text{speed} = 96.5 \text{ kmh}^{-1}$$

14.2

[a] $\text{speed} = \frac{\text{distance travelled}}{\text{time taken}}$

$\text{speed} = \frac{165}{1.5}$

speed ! 110 kmh^{-1}

[b] The most likely explanation for Jane's average velocity being smaller than her average speed is that the road between the two towns is not a straight line. Jane's velocity would be calculated using the vector drawn between the two towns (Jane's displacement) rather than the total distance travelled. As this vector is smaller than the total distance she travelled, her velocity will be less.

14.3

$$\text{speed} = \frac{\text{distance travelled}}{\text{time taken}}$$
$$\text{distance travelled} = \text{speed} \times \text{time taken}$$
$$\text{distance travelled} = 850\times3.5$$
$$\text{distance travelled} = 2.98\times10^{3} \text{ km}$$

14.4

[a] $s = 270 - 255$

$s = 15.0 \text{ km E}$

[b] $v = \frac{s}{t}$

$v = \frac{15}{0.5}$

$v = 30.0 \text{ kmh}^{-1} \text{ E}$

14.5

$$v = \frac{s}{t}$$
$$v = \frac{1}{0.25}$$
$$v = 4.00 \text{ kmh}^{-1} \text{ W}$$

$$s = vt$$
$$s = 4\times1.25$$
$$s = 5.00 \text{ km W}$$

14.6

$$v = \frac{s}{t}$$
$$t = \frac{s}{v}$$
$$t = \frac{3.84\times10^{5}\times1000}{6.40\times10^{3}}$$
$$t = 6.00\times10^{4} \text{ s or } 16.7 \text{ hr}$$

14.7

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

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

$t = \frac{280 \times 1000}{8.2}$

$t = 3.41 \times 10^4$ s or 9.49 hr

14.8

Rebecca can measure her average speed fairly by having a friend time how long she takes to run a known distance. However, as Rebecca will take a while to accelerate to her top speed, she will need to have the friend start timing once she has reached her top speed. A simple way to do this might be for Rebecca to run a standard 100 m track, but only be timed for the second half of the sprint.

14.9

One way to check your speedometer would be to drive a fixed distance (e.g. 1 km) while keeping the speedometer reading a constant speed (e.g. 50 kmh^{-1}). By timing how long it takes you to drive this distance you can determine your actual speed and compare this to the value given by the speedometer.

14.10

[a] total distance $= 800 + 600 + 1000 + 600 + 200 = 3200 = 3.20 \times 10^3$ m

[b] speed $= \frac{\text{distance travelled}}{\text{time taken}}$

speed $= \frac{3.20 \times 10^3}{20 \times 60}$

speed $= 2.67$ ms^{-1}

[c] In total, the competitors have travelled 800 + 1000 + 200 = 2000 m north, and 0 m east or west (as 600 m W - 600 m E = 0 m). Therefore, the checkpoint is located 2000 m north of the starting point.

[d] $v = \frac{s}{t}$

$v = \frac{2000}{20 \times 60}$

$v = 1.67$ ms^{-1} N

14.11

distance travelled $= 26708 - 26455$

distance travelled $= 253$ km

At 92 kmh^{-1}:

speed $= \frac{\text{distance travelled}}{\text{time taken}}$

time taken $= \frac{\text{distance travelled}}{\text{speed}}$

time taken $= \frac{253}{92}$

time taken $= 2.75$ hr

$\therefore$ break time taken $= 3 - 2.75 = 0.25$ hr or 15 min

14.12

[a]

$$\text{speed} = \frac{\text{distance travelled}}{\text{time taken}} = \frac{\text{d}}{\text{t}}$$

$$\text{speed} = \frac{800}{20\times60}$$

$\text{Marvin's speed} = 0.667\ \text{ms}^{-1}$

[b]

eed f eam $= 4 - 0.667 = 3.33\ \text{ms}^{-1}$

[c]

$$\text{speed} = \frac{\text{d}}{\text{t}} \qquad \text{t} = \frac{\text{d}}{\text{speed}}$$

$$\text{t} = \frac{10000}{0.667}$$

time taken to paddle 10km upstream

$= 1.50\times10^{4}$ s or 4.17 hr

[d]

$$\text{speed} = \frac{\text{d}}{\text{t}} \qquad \text{t} = \frac{\text{d}}{\text{speed}}$$

$$\text{t} = \frac{10000}{3.33 + 4}$$

time taken to paddle 10 km downstream

$= 1.36\times10^{3}$ s or 22.7 min

14.13

[a] Speed is the rate of change of distance with time, which is represented by the section of the graph with the steepest gradient. This is the section from D to E.

[b] The motorbike is stationary when the distance is no longer changing. This is shown by a horizontal line on the graph – the section from B to C.

[c] The motorcyclist's change in direction is represented by the distance from her starting point decreasing, rather than increasing (as it is from A to D). Therefore, she must have turned around at point D.

[d] Her total distance travelled will be 30 km as she travels 15 km to the furthest point from her starting point followed by 15 km back to her starting point.

[e]

$$\text{speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

$$\text{speed} = \frac{30}{0.8}$$

$\text{speed} = 37.5\ \text{kmh}^{-1}$

[f] I'm not sure about the answer to this question, as I think the most correct answer is that there is enough information available. Since the graph shows that the motorcyclist has come back to her starting point (as her distance from it is 0 km), her total displacement must also be 0 km. Therefore, her velocity will be 0 kmh^{-1} – no direction is needed for a vector with a magnitude of zero.

14.14 [a]

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

$$v = \frac{0.6\times1000}{1.2\times10^{3}}$$

$v = 0.5\ \text{ms}^{-1}$

$\therefore v_{\text{stream}} = 2 - 0.5$

$v_{\text{stream}} = 1.5\ \text{ms}^{-1}$ downstream

[b] If the duck is paddling downstream, we can add the velocity of the duck to the velocity of the stream:

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

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

$$t = \frac{8.4\times1000}{1.5 + 2}$$

$t = 2400$ s or 40 min