Problem Set 19: Waves

19.1 $v = \frac{\lambda}{t} = \frac{12.5m}{0.850s} = 14.7\,ms^{-1}$

19.2 $v = f\lambda = 4Hz \times 0.662m = 2.65\,ms^{-1}$

19.3 $T = \frac{1}{f} = \frac{1}{120Hz} = 8.33 \times 10^{-3}$

$\lambda = \frac{v}{f} = \frac{346ms^{-1}}{120Hz} = 2.88m$

19.4 $f = \frac{4}{6.45} = 0.6202\,Hz$

$v = f\lambda = 0.6202 \times 8.00m = 4.96\,ms^{-1}$

19.5 The waves are transverse, that is the molecules move in a direction perpendicular to the direction of the flow of energy, and so the bob moved up and down with the particles in the medium (the ocean) as the wave moves past, rather than moving along the flow of energy.

19.6 The molecules in a longitudinal wave move in the direction of the energy flow.

19.7 Longitudinal waves travel faster and so will arrive first, but do much less damage. Transverse waves are slower, and so arrive later, but instead of particles moving sideways (as in longitudinal waves) they move up and down like ripples so they do more damage to rigid structures, forcefully moving them up and down (or side to side).

19.8 $340ms^{-1} = 331 + 0.6T_1$ (1)

$343ms^{-1} = 331 + 0.6T_2$ (2)

(2)-(1) $3ms^{-1} = 0.6(T_2 - T_1)$

$(T_2 - T_1) = 5°C$

19.9 $\lambda = \frac{v}{f} = \frac{3 \times 10^8 ms^{-1}}{720 \times 10^3 Hz} = 420\,m$

19.10 For sound travelling around the fence: $1310\,ms^{-1} = \frac{\pi r}{t}$

For sound travelling across the circle: $330\,ms^{-1} = \frac{2r}{t+0.3}$

Rearrange equation one to give: $t = \frac{\pi r}{1310ms^{-1}}$

Substitute for t into the second equation: $1037r + 129690 = 2620r$

r = 82 m

19.11 [a] $$\lambda = \frac{distance}{number\ of\ waves} = \frac{2m}{42} = 50\ mm$$

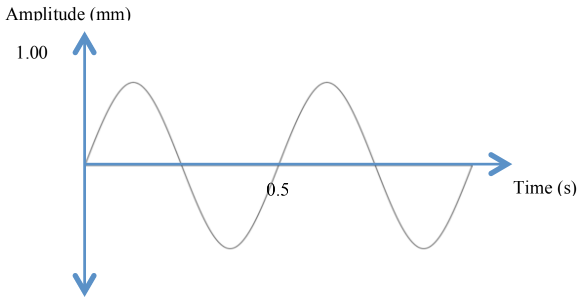
[b] $$speed = \frac{distance}{time} = \frac{2m}{5s} = 0.400\ ms^{-1}$$

[c] $$f = \frac{number\ of\ waves}{time} = \frac{42}{5s} = 8.40\ Hz$$

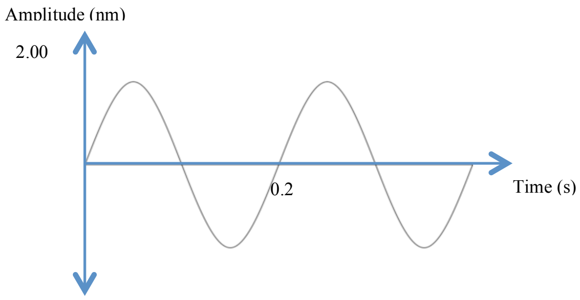
19.12 [a] $$f = \frac{number\ of\ waves}{time} = \frac{1}{2s} = 0.5\ Hz$$

[b] $$T = \frac{1}{f} = \frac{1}{0.5Hz} = 2s$$

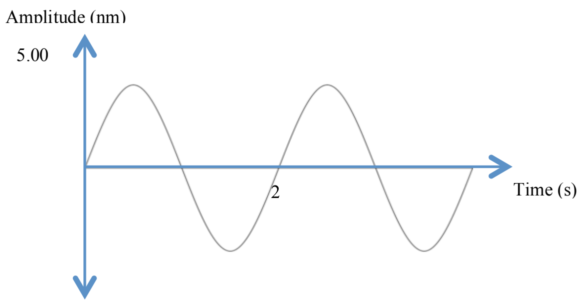
19.13 [a]



[b]



[c]



19.14 Signal 1:

T = 0.006 s

f = 167 Hz

a = 0.4 nm

$$\lambda = \frac{v}{f} = \frac{339ms^{-1}}{167Hz} = 2.03\ m$$

Signal 2:

T = 0.0072 s

f = 139 Hz

a = 0.3 nm

$$\lambda = \frac{v}{f} = \frac{339ms^{-1}}{139Hz} = 2.44\ m$$

Signal 3:

T = 0.0052 ms

f = 192 kHz

a = 0.5 mm

$$\lambda = \frac{v}{f} = \frac{339ms^{-1}}{192{,}000Hz} = 1.76\times10^{-3}\ m\ (1.76\ mm)$$

19.15 The microphone measures the compressions and rarefactions against time and converts this to an electric signal. This means the output of the microphone will be against time and so the CRO shows the voltage vs time which directly correlates to a sound pressure vs time graph (the voltage changes according to the sound pressure in the microphone).

19.16 Signal 1:

T = 0.06 s

f = 16.7 Hz

$$\lambda = \frac{v}{f} = \frac{349ms^{-1}}{16.7Hz} = 20.9\ m$$

Signal 2:

T = 0.018 ms

f = 55.6 kHz

$$\lambda = \frac{v}{f} = \frac{349ms^{-1}}{55{,}600Hz} = 6.28\times10^{-3}\ m\ (6.28\ mm)$$

19.17 [a] 10 mm

[b] 8 µs

[c] 125 kHz

19.18 Loudspeakers are connected behind each athlete so as to not give the closer racers a head start. If this were not done, the farthest athletes would be disadvantaged by the amount of time it takes the sound to reach them.

19.19 A sound increasing in pitch but keeping the same volume

A sound getting louder without changing pitch

19.20 [a] $\lambda = \frac{v}{f} = \frac{342ms^{-1}}{256Hz} = 1.34\ m$

[b] $\lambda = \frac{v}{f} = \frac{342ms^{-1}}{20{,}000Hz} = 0.0171\ m$

[c] $\lambda = \frac{v}{f} = \frac{342ms^{-1}}{70{,}000Hz} = 4.89\times10^{-3}\ m\ (4.89\ mm)$

[d] $\lambda = \frac{v}{f} = \frac{342ms^{-1}}{0.1Hz} = 3420\ m$

19.21 Initially there is no change in speed with depth as there is no change in temperature. As depth increases speed decreases, to a minimum and then begins to increase at greater depth.

19.22 Sound travels faster in hotter gases: changes in temperature change the density of air (decreases) without changing its elasticity.

19.23 Lower frequencies have larger wavelengths and are diffracted more, so more likely to be transmitted around barriers.

19.24 [a] It takes time for her to hear the sound of the starting gun

[b] Too short

[c] Assume the speed of sound in air is 343 ms^{-1}

$$time = \frac{distance}{speed} = \frac{100m}{343ms^{-1}} = 0.292\ s$$

19.25 [a] George (larger amplitude)

[b] Jane (greater distance between peaks)

[c] George (more peaks in same time)