Answers to exam-style questions

Topic 4

Where appropriate, 1 ✓ = 1 mark

1 A

2 C

3 B

4 A

5 D

6 D

7 D

8 C

9 B

10 A

11 **a** In a longitudinal wave the displacement is along the direction of energy transfer (DOET) ✓ whereas in a transverse wave it is at right angles to the DOET. ✓

b **i** The amplitude is 4.0 mm. ✓

ii The wavelength is 0.20 m. ✓

iii The period is 10 s and so the frequency is $f = \frac{1}{T} = \frac{1}{10} = 0.10$ Hz. ✓

c The speed is $v = \lambda f = 0.20 \times 0.10$. ✓

$v = 0.020\ \mathrm{m\,s^{-1}}$ ✓

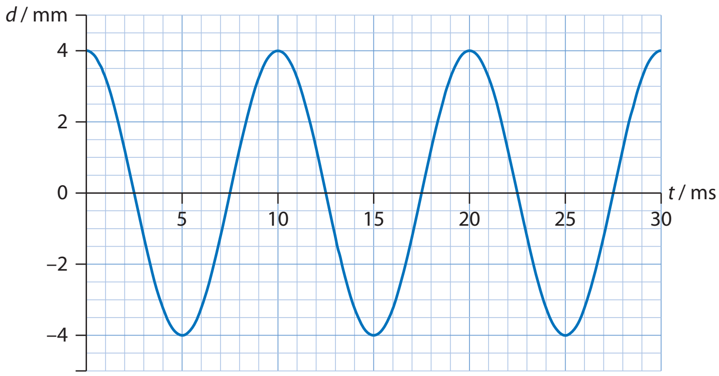
d Particle P has zero displacement at t = 10 s. ✓

A short time later the displacement becomes positive (we look at the second graph). ✓

To make the displacement of the point at 0.20 m positive a short time after 10 s the first graph must be shifted to the right, so the wave moves to the right. ✓

e At t = 10 s point Q has displacement 4.0 mm. ✓

Hence we must have the following graph. ✓



f **i** The wavelength of the first harmonic is $4L$, ✓

and so $4L = 0.20 \Rightarrow L = 0.050$ m. ✓

ii Standing waves do not transfer energy; travelling waves do. ✓

Standing waves have variable amplitude; travelling waves have a constant amplitude. ✓

iii It is the speed of one of the travelling waves, ✓

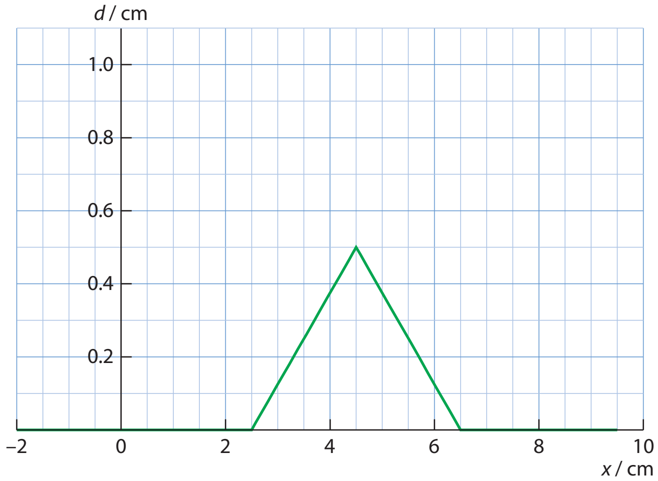
making up the standing wave. ✓

12 **a** When two waves (of the same type) meet, ✓
the resultant displacement is the algebraic sum of the individual displacements. ✓

b The speed of the black pulse is the same as that of the grey pulse since the medium is the same. ✓

c i The centres of the pulses are separated by a distance of 5.0 cm. The relative speed of the pulses is 30 m s^{-1} and so will completely overlap at a time of $\frac{5.0}{30} = 0.167 \approx 0.17$ s. ✓

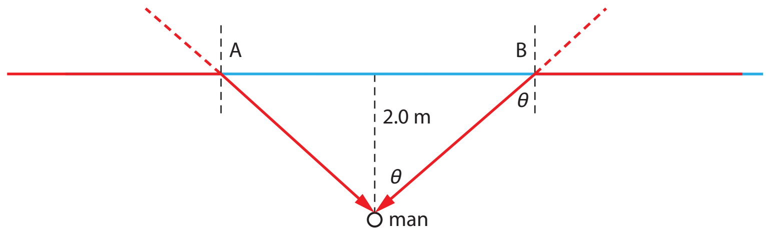
ii In 0.167 s each pulse will move a distance of 2.5 m, ✓
and so the resulting pulse has the shape of the following graph. ✓



d i The pulses have the same shape after the collision. ✓
So no energy is lost (the collision of the pulses is elastic). ✓

ii The energy carried by a pulse is proportional to the (square of the) height of the pulse. ✓
The pulse is short during overlap. ✓
But the string is moving vertically during overlap and so makes up for the apparently missing energy. ✓

13 **a** The diagram shows how rays of light coming in parallel to the water surface will refract. ✓



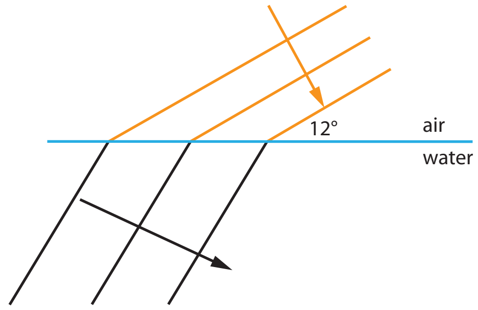
So the rays that can enter the man's eyes lie within a circle of diameter AB. ✓

b From the diagram above and Snell's law $1.00 \times \sin 90° = 1.33 \times \sin\theta$ so that $\theta = 48.8°$. ✓
Hence $R = 2.0 \tan\theta = 2.0 \times \tan 48.8° = 2.28 \approx 2.3$ m. ✓

c The angle θ will be the same. ✓
But since the depth is greater so will the radius. ✓

d i Snell's law says that $\frac{\sin 12°}{340} = \frac{\sin\theta}{1500}$ ✓
so that $\theta = 66.5° \approx 67°$. ✓

ii Three wavefronts as shown:
Rays bending away from normal. ✓
Wavelength greater. ✓



iii The sound tends to move parallel to the surface of the water, ✓
and not to penetrate deeper into the water where a swimmer might be. ✓

14 a Light in which the electric field oscillates on only one plane. ✓

b The intensity transmitted through the first polariser will be 160 W m^{-2}. ✓
The intensity through the second will be $160\cos^2\theta$ W m^{-2} and through the third $160\cos^4\theta$ W m^{-2}. ✓
Hence $160\cos^4\theta = 10$ giving $\theta = 60°$. ✓

c Let the intensities of the polarised and unpolarised components be I_P, I_U respectively: at maximum transmitted intensity the polariser's axis will be parallel to the polarised light's electric field and the transmitted intensity will then be $I_P + \frac{I_U}{2}$; at minimum intensity the polarised component will not be transmitted and so the intensity will be $\frac{I_U}{2}$. ✓

We have that $\frac{I_P + \frac{I_U}{2}}{\frac{I_U}{2}} = 7$ and so $\frac{I_P}{I_U} = 3$. ✓

The required fraction is then $\frac{3}{4}$. ✓

d The wall is vertical and so the reflected light is partially polarised. ✓
In a direction that is parallel to the wall, i.e. vertical. ✓
And so a polariser with a horizontal transmission axis will cut off the reflected glare. ✓

15 a Light leaving each of the slits diffracts at each slit, ✓
and so light from each slit will arrive at the middle of the screen. ✓

b With both slits open light arrives at the middle of the screen in phase and so the amplitude is twice the amplitude due to one slit. ✓
The intensity is proportional to the amplitude squared. ✓
So with one slit open the amplitude will be half and the intensity one quarter, i.e. 1 W m^{-2}. ✓

c The intensity of the side maxima is not the same as that of the central maximum. ✓

d The separation of the maxima on the screen is 0.60 cm and the separation is given by $s = \frac{\lambda D}{d}$ and so $\lambda = \frac{sd}{D}$. ✓

Hence $\lambda = \frac{0.60\times10^{-2}\times0.39\times10^{-3}}{3.2} = 7.3\times10^{-7}$ m. ✓

e Blue light has a smaller wavelength than red light. ✓
Hence the separation of the maxima will be less. ✓

16 a A standing wave is formed when two identical travelling waves moving in opposite directions. ✓

Meet and superpose. ✓

b i The travelling wave from the source reflects off the water surface. ✓

The reflected wave superposes with the incoming wave creating a standing wave in the tube. ✓

ii The standing wave will have a wavelength equal to $\frac{4L}{n}$ where L is the length of the air column and n is an odd integer. ✓

So for a given wavelength λ this will happen only when $L = \frac{\lambda n}{4}$, i.e. for specific values of the air column length. ✓

iii The difference in air column lengths is half a wavelength (explained in the next part) and so the next length is 42 cm. ✓

iv The difference in air column lengths is $\frac{\lambda n}{4} - \frac{\lambda(n-2)}{4} = \frac{\lambda}{2}$, i.e. half a wavelength and the wavelength is $\lambda = 2 \times 0.12 = 0.24$ m. ✓

So $v = f\lambda = 1400 \times 0.24 = 336 \approx 340\ \text{m s}^{-1}$. ✓