Mark scheme for Topic 11

1 The fundamental frequency in a pipe of length L is $f = \frac{v}{2L}$ where v is the speed of the wave. Therefore, $\frac{f_X}{f_Y} = \frac{\frac{v}{2 \times 2L}}{\frac{v}{2L}} = \frac{1}{2}$, **A**.

2 Points within two adjacent nodes are in phase in a standing wave, **B**.

3 Angular width is the angle subtended by the two minima on either side of the central maximum. The angle of each is $\theta = 1.22\frac{\lambda}{b}$ and so the angular width is double that, **D**.

4 Angular separation equals the diffraction angle and so

$$1.22\frac{0.21}{b} = 6.0 \times 10^{-3} \Rightarrow b = \frac{1.22 \times 0.21}{6.0 \times 10^{-3}}\text{ m} \approx \frac{1.2 \times 0.2}{6.0 \times 10^{-3}}\text{ m} \approx \frac{0.2}{5 \times 10^{-3}}\text{ m} \approx \frac{200}{5}\text{ m} \approx 40\text{ m}$$ so **C**.

Exam tip: Notice the arithmetic simplifications done without a calculator.

5 The incident light is unpolarized so its intensity is reduced to $\frac{I_0}{2}$ after the first polarizer. The light is now vertically polarized so passes through the second polarizer with no loss in intensity, **B**.

6 **a** A travelling wave transfers energy, a standing wave does not.

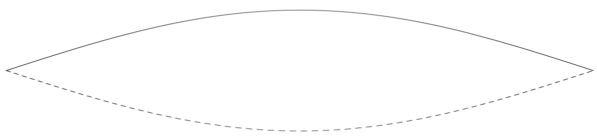
A travelling wave has constant amplitude, a standing wave does not. **[2]**

b **i** One end of the string is attached to an oscillator.

That is made to oscillate at exactly the frequency of the harmonic that we wish to establish on the string. **[2]**

ii We need the fundamental:

fixed at the ends with one loop.

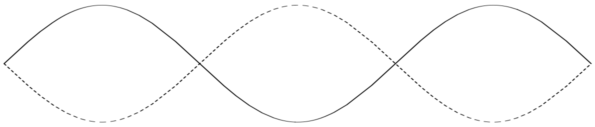


[1]

iii We need the third harmonic:

fixed at the ends;

three loops.



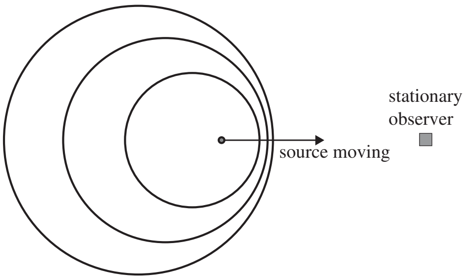
[2]

c The wavelength in the third harmonic is $\lambda = \frac{2L}{3} = \frac{2 \times 1.8}{3} = 1.2\ \text{m}$.

And so the wave speed is $v = f\lambda = 72 \times 1.2 = 86.4 \approx 86\ \text{m s}^{-1}$. **[3]**

7 a i The change in received frequency when there is relative motion between the source and the receiver. **[1]**

ii **[1]** for a diagram.



[1] for a description. **[2]**

b The Doppler effect is determined by the component of the velocity of the source along the line of sight to the receiver.

And in this case, this component keeps changing with time. **[2]**

c i The highest frequency received is 4460 Hz and the frequency emitted is 4200 Hz,

so $4460 = 4200 \frac{1}{1 - \frac{19}{c}} \Rightarrow c = 325.9 \approx 330\ \text{m s}^{-1}$. **[2]**

ii The disc completes one revolution in 1.0 s,

and so $19 = \frac{2\pi R}{1.0} \Rightarrow R = 3.0\ \text{m}$. **[2]**

d Measuring the speed of cars on a highway:

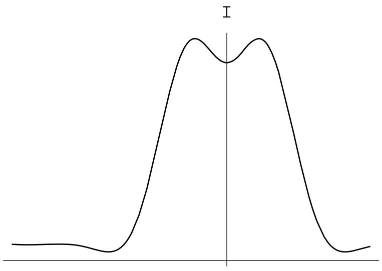
Waves of known frequency are directed towards a moving car and the reflected wave's frequency is measured.

From the two frequencies and the Doppler formula the velocity of the car may be determined. **[2]**

8 **a** Two objects are just resolved when the central maximum of the diffraction pattern of one source coincides with the first minimum of the other.

Diagram overall correct shape.

Two visible peaks.



[3]

Exam tip: make sure you understand how this diagram arises from the individual diffraction patterns.

b **i** The diffraction angle is $\theta \approx 1.22\frac{\lambda}{b} = 1.22 \times \frac{4.80\times10^{-7}}{3.00\times10^{-3}} = 1.95\times10^{-4}$ rad .

Two objects will be resolved if the angular separation is greater than the diffraction angle. **[2]**

ii The diffraction angle for red light is bigger than that for blue (since the wavelength is bigger).

Since the angular separation is equal to the blue diffraction angle, this is going to be less than the red diffraction angle.

And so the objects will not be resolved. **[3]**

9 **a** (Plane polarized) light in which the **electric field** oscillates on only one plane. **[1]**

Exam tip: you need the words in bold.

b **i** Light through the first polarizer has its electric field along the transmission axis of that polarizer.

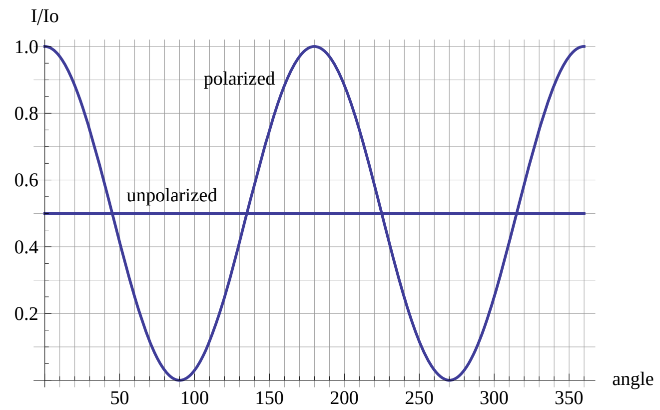
Since this is now at right angles to the transmission axis of the second polarizer, no light gets transmitted and the polarizer overlap region is dark. **[2]**

ii The light reflected from the lake is mostly horizontally polarized.

So if polarizer X has its transmission axis vertical most of the light will be blocked and it will appear darker than Y (which is therefore horizontal). **[2]**

c

i&ii



[2]

[2]

d Plastic is placed in between two crossed polarizers.

Light through first polarizer is horizontally polarized.

Light through stressed plastic has two components at right angles.

The two components, after transmission through the second polarizer, are vertically polarized and so interfere. **[4]**

10 **a** A substance in which polarized light moves through the substance.

Has its plane of polarization rotated. **[2]**

b The optically active substance is placed in between crossed polarizers.

The second polarizer is rotated until no light gets transmitted and the angle of rotation is measured.

The concentration of the optically active solution is changed and the process is repeated to see the variation with concentration of the rotation angle. **[3]**

11 **a** (Plane polarized) light in which the **electric field** oscillates on only one plane. **[1]**

b Light reflecting from a non-metallic surface will be completely horizontally polarized at a particular angle of incidence.

The reflected and refracted rays are at right angles to each other (for that particular angle of incidence). **[2]**

c **i** The angle must be the Brewster angle for which the reflected light is completely horizontally polarized,

and so cannot be transmitted through the vertical polarizer. **[2]**

ii Realization that 58° is the Brewster angle.

$n = \tan\phi = \tan 58^\circ = 1.60.$ **[2]**

