1

(a) Progressive waves transfer energy but not stationary waves

(b) Particles in a transverse wave oscillate/vibrate normal/perpendicular to the direction of energy transfer of wave while particles in a longitudinal wave oscillate/vibrate parallel to the direction of energy transfer of wave.

(c) **(i)** Sound waves are longitudinal waves. Hence, sound waves in a gas or liquid cannot be polarised because the medium oscillates only along the direction of wave propagation or energy transfer. Therefore they cannot be restricted to a plane normal to the direction of energy transfer.

(c) **(ii)** Relative angle between P and Q after 9.0 $s = \omega t = 18\, rad$

By Malus' Law,

$$\frac{\frac{I_0}{2}\cos^2(18)}{I_0}$$
$$= 0.218$$

2

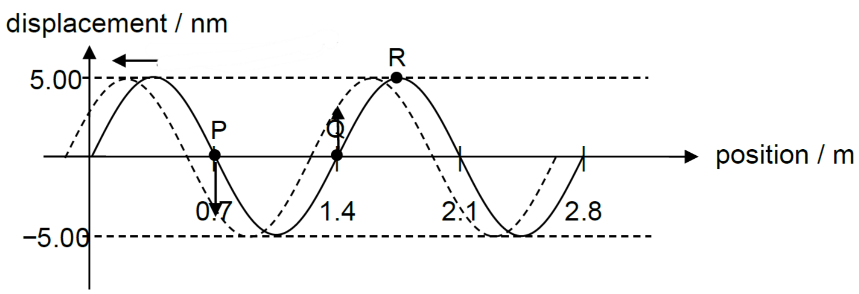
(a) Using $v = f\lambda$

$$v = \frac{1}{4.0 \times 10^{-3}} \times 1.4$$
$$v = 350\ m\ s^{-1}$$

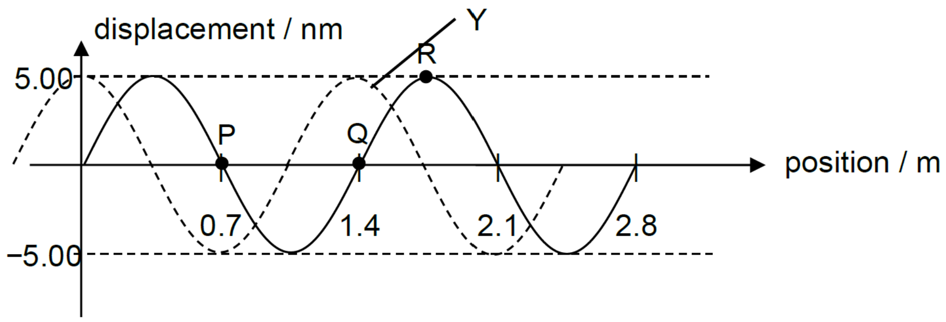
(b) **(i)** Particle R
(As the particle is undergoing SHM, at the amplitude, the instantaneous velocity of the particle is zero).

(ii) Particle Q

(iii)

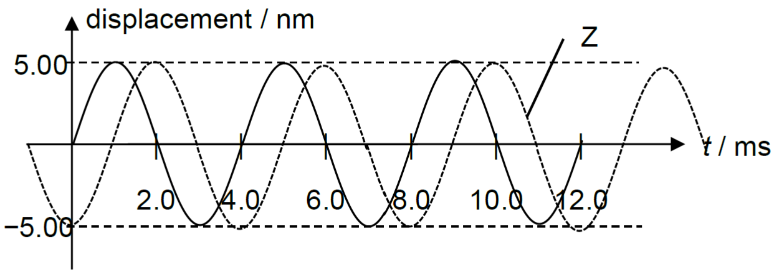


(c) **(i)** Distance travelled by wave in 1 $ms = vt = (350)(1 \times 10^{-3}) = 0.35\, m$



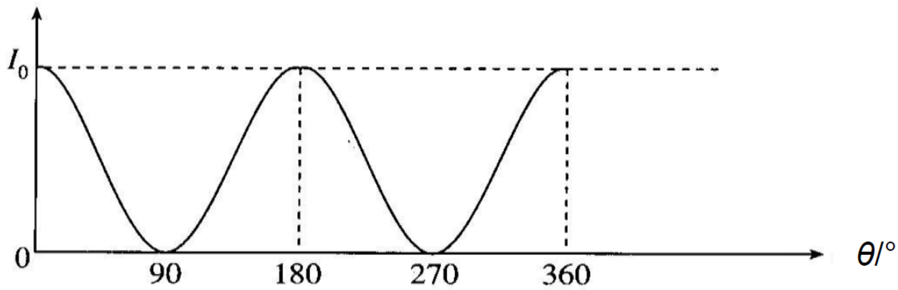
(ii) Phase difference between particle R and S

$\Delta\phi = \frac{\Delta x}{\lambda} \times 360° = \frac{0.7}{1.4} \times 360°$
$= 180°$



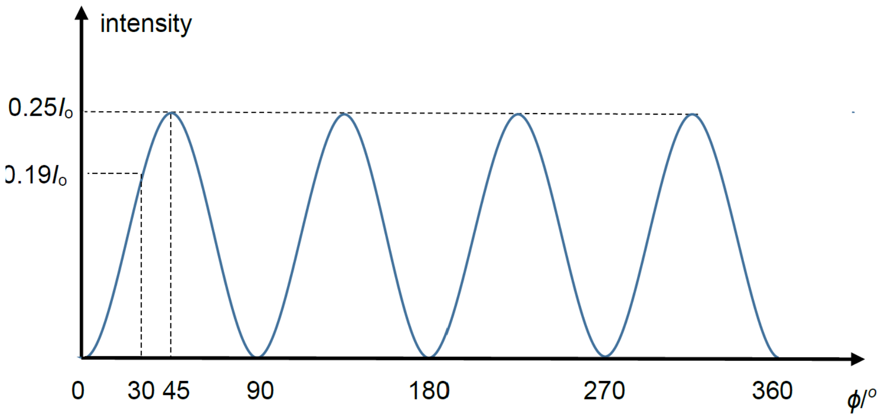
3

(a)



(b) **(i)** $I = kA^2 \cos^2\phi$, and $I_o = kA^2$
Intensity after passing through polaroid $R = I_o \cos^2 30° = 0.75\ I_o$
Intensity after passing through polaroid Q = $(0.75\ I_o)\cos^2(90° - 30°) = 0.19\ I_o$

(ii)



(c) Longitudinal waves cannot be polarised because the oscillation of particles in the wave is parallel to its direction of energy transfer.

4

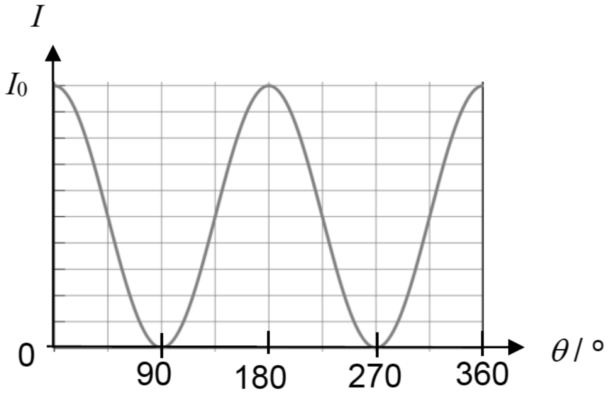
(a) **(i)** From Fig. 4.2, amplitude decreases with distance from the source. Since intensity (or power) is proportional to $(amplitude)^2$, wave is losing power as it moves away from the source.

(ii) $I \propto A^2$

$$ratio = \frac{2^2}{1.1^2}$$
$$= 3.3$$

(b) **(i)** $I = I_0 \cos^2 \theta$

(ii)



(iii) 1. $I_{AB} = I_0 \cos^2 45°$
$= 0.5 I_0$

(iii) 2. $I_{BA} = 0.5 I_0 \cos^2 45°$
$= 0.25 I_0$

5

(a) A polarised wave is one in which the vibrations/oscillations of the wave are restricted to only one direction in the plane normal/perpendicular to the direction of energy transfer.

(b) **(i)** As long as polarising filter B is perpendicular to either polarising filter A or filter C, the emergent light from filter C will be zero.

Hence, the other angle that occurs will be when polarising axis of B is 90° of C, i.e. $\theta = 135°$

(ii) Using Malus' Law,
Intensity of light emergent from polarising filter B = $I \cos^2 60°$
Intensity of light emergent from polarising filter C = $I \cos^2 60° \cos^2(60° - 45°)$
$= 0.233\, I$

6

(a) In a polarised wave, the vibrations of wave particles are limited to only one axis whereas an unpolarised wave is not

(b) **(i)** 0 as no light will be able to pass through the polariser given it is perpendicular.

(ii) 1. $A_3 = A_2\, cos(62° - 23°)$
$A_2 = A_1\, cos(23°)$
$A_3 = A_1\, cos(23°)\, cos(62° - 23°)$
$= 0.715\, A_1$

(ii) 2. Let initial amplitude of unpolarised light $= A_0$

$$\frac{1}{2} = \left(\frac{A_1}{A_0}\right)^2$$
$$A_0 = \sqrt{2}A_1 = 1.41\ A_1$$
$$\frac{I_3}{I_0} = \left(\frac{A_3}{A_0}\right)^2 = \left(\frac{0.715A_1}{\sqrt{2}A_1}\right)^2 = 0.256$$

Percentage of intensity reduced $= (1 - 0.256) \times 100\% = 74.4\%$

7

(a) **(i)** $Wavelength = \dfrac{1.84\ -\ 0.08}{2.5} = 0.704\ m$

(ii) $v = f\lambda$
$v = 469 \times 0.704 = 330.2\ m\ s^{-1}$

(iii) $\dfrac{\Delta v}{v} = \dfrac{\Delta f}{f} + \dfrac{\Delta\lambda}{\lambda} = 5 + 8 = 13\%$
$\Delta v = \pm 40\ m\ s^{-1}$
$v \pm \Delta v = (330 \pm 40)\ m\ s^{-1}$

(b) **(i)** $\pi\ radians$

Since the vector sum of the displacements of the two waves is zero, the point is a node.

(ii) Antinode is $\frac{1}{4}$ of wavelength away.
At antinode, distance = $1.40\ -\ 0.70/4 = 1.22\ m$
Displacement = $1.1\ +\ 1.1 = 2.2\ mm$

(iii) From graph, distance between the two peaks = $0.16\ m$

Time for two peaks to meet, $t = (0.16\ /\ 2)\ /\ 330 = 0.24\ ms$

(iv) When the two waves meet in phase at their respective maximum displacements,
Maximum displacement of resultant wave = $1.6\ +\ 1.6 = 3.2\ mm$

8

(a) **(i) 1.** distance moved by a wave during one period

(i) 2. The phase difference between two particles refers to how much one particle lags or leads another with respect to a cycle.

(ii) $\dfrac{\Delta\theta}{2\pi} = \dfrac{\Delta x}{\lambda}$

(b) **(i)** Using $v = f\lambda$
$\lambda = vT = (20)(0.60)$
$= 12\ cm$

(ii) $\dfrac{\Delta\theta}{360°} = \dfrac{\Delta t}{T} = \dfrac{0.20}{0.60}$
$\Delta\theta = 120°$

(iii) Resultant displacement $= 1.00 + (-3.00)$

$= -2.00\ mm$

(iv) $\frac{I_Q}{I_P} = \left(\frac{A_Q}{A_P}\right)^2 = \left(\frac{2.0}{3.0}\right)^2 = 0.444$

(v) Two sources (waves) are said to be coherent when the phase difference is always the same

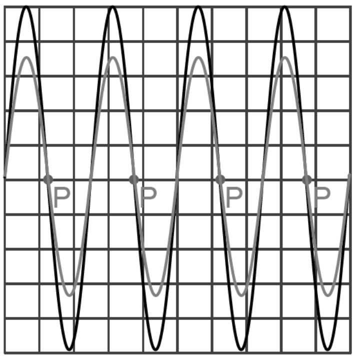
9

(a) In a longitudinal wave, the oscillations of wave particles are parallel to the direction of energy transfer or direction of propagation of the wave.

(b) **(i)**
$T = \frac{5}{2}(2)$
$= 5\ ms$
$f = \frac{1}{T} = 200\ Hz$

(ii)
$v = f\lambda$
$\lambda = \frac{v}{f}$
$= \frac{330}{200}$
$= 1.65\ m$

(iii) Particles that are displaced before P in time (right of P in the wave, left of P in the graph) are moving to the right, and particles that are displaced after P in time (left of P in the wave, right of P in the graph) are moving to the left. Thus, P is a point of rarefaction, where pressure is minimum.



(c) Since $I = \frac{Power}{Area}$, when area is doubled I is halved and A is reduced by $\sqrt{2}$

10

(a) **(i)**
$\lambda = 0.12\ m$
$T = 0.4\ ms$
Speed of wave $v = \frac{0.12}{0.4\times10^{-3}} = 300\ m\ s^{-1}$

(ii) Displacement of Q is zero. Displacement of R is maximum.
Hence displacement is $270°\ or\ 1.5\ \pi$.
Phase difference, $\Delta\phi = 1.5\pi = 4.7\ rad$

(iii) Taking rightward as positive, based on fig 6a, the particles to the left of Q is displaced to the right (positive displacement) and the particles to the right of Q is displaced to the left (negative displacement). Hence the particles at Q is compressed.

(iv) Taking rightward positive, (visualize wave is moving to the left using the $x - t$ graph, after $\frac{T}{4}$, point R would be at the compression point, max pressure)

Period of graph is as calculated in part (a).
Graph is sinusoidal with correct period (i.e. a positive sine function. At t = 0 ms, Pressure at point R is P_{atm}.

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