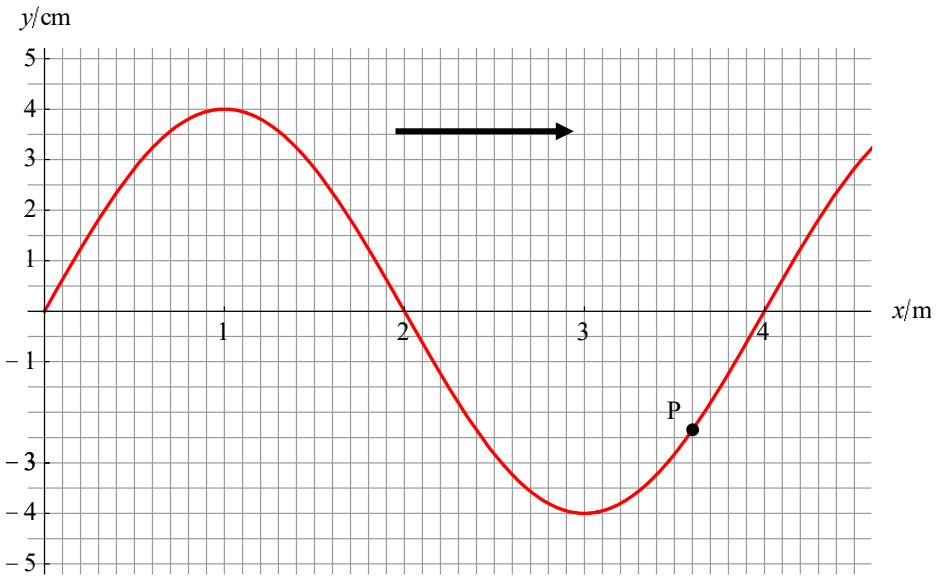
Worksheet on waves

A transverse wave W_1 is travelling in a medium from left to right with speed 160 m s^{-1}. The graph shows, at time $t = 0$, the variation of the displacement of the wave with distance x from the left end. A point in the medium has been marked P.



(a) State what is meant by a transverse wave.

(b)

(i) State the amplitude of W_1.

(ii) Calculate the period of W_1.

(c)

(i) Describe the motion of P.

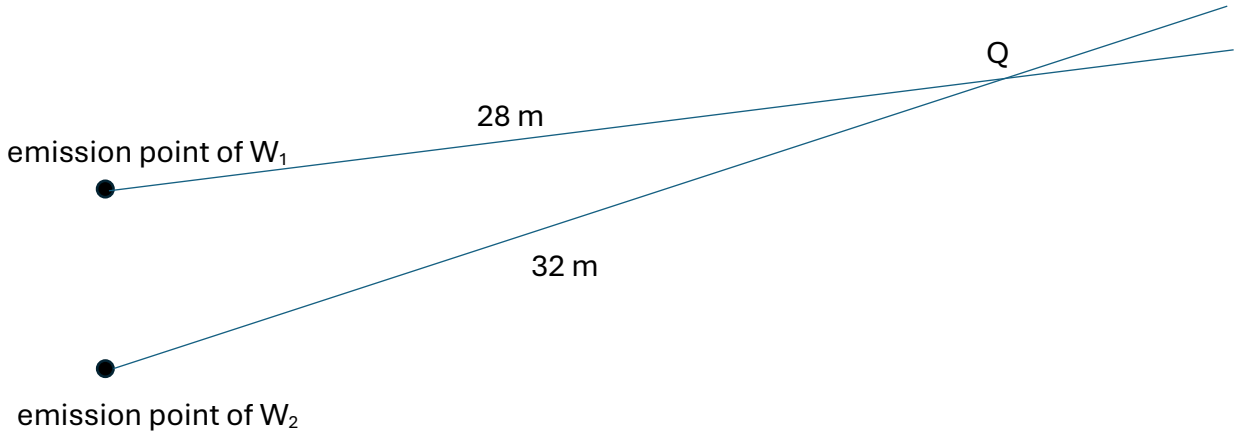
(ii) Calculate the average speed of P during one full oscillation.

(d) On the diagram draw arrows to represent the velocity (V) and acceleration (A) of P at $t = 0$.

(e) Determine the first time after $t = 0$ at which the displacement of P becomes zero.

W_2 is another wave identical to W_1 travelling in the same medium. At time $t = 0$ the variation of the displacement of W_2 with distance is identical to that of W_1. W_1 and W_2

are emitted from different points in space at $t = 0$ and meet at point Q before travelling past Q. The distances of Q from the emission points are shown.



(f)

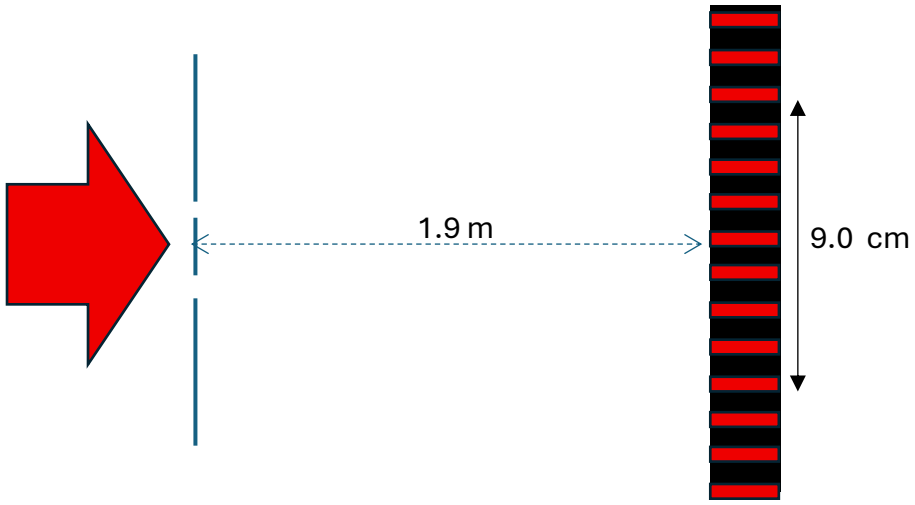
(i) State the principle of superposition.

(ii) State and explain the amplitude of the wave at Q.

(iii) State the amplitude of W_1 and W_2 when the waves have moved past Q.

(g) State what is meant by the statement that light is an electromagnetic wave.

(h) Light is incident on two parallel slits a distance 0.12 mm apart. Interference fringes are observed on a screen a distance 1.9 m from the slits.



Determine the wavelength of light.

Answers

(a) A wave where the displacement is at right angles to the direction of propagation of the wave/direction of energy transfer.

(b)

(i) 4.0 cm

(ii) $c = \frac{\lambda}{T} \Rightarrow T = \frac{\lambda}{c} = \frac{160}{4.0} = 2.5 \times 10^{-2}$ s.

(c)

(i) It performs simple harmonic oscillations in a direction at right angles to the direction of propagation of the wave with amplitude 4.0 cm and period 2.5×10^{-2} s.

(ii) $\bar{v} = \frac{4A}{T} = \frac{4 \times 4.0 \times 10^{-2}}{2.5 \times 10^{-2}} = 6.4 \text{ m s}^{-1}$.

(d) V vertically down, A vertically up.

(e) The wave must travel a distance 1.6 m. This will take 1.0×10^{-2} s.

(f)

(i) When two waves meet the resultant displacement is the sum of the individual displacements.

(ii) The path difference is one wavelength so we have constructive interference. The amplitude is 8.0 cm.

(iii) 4.0 cm

(g) Light consists of electric and magnetic fields that oscillate in phase at right angles to the direction of propagation of light.

(h) The fringe separation is $s = \frac{9.0 \times 10^{-2}}{8} = 1.125 \times 10^{-2}$ cm . Hence

$$s = \frac{\lambda D}{d} \Rightarrow \lambda = \frac{sd}{D} = \frac{1.125 \times 10^{-2} \times 0.12 \times 10^{-3}}{1.9} = 7.1 \times 10^{-7} \text{ m}.$$