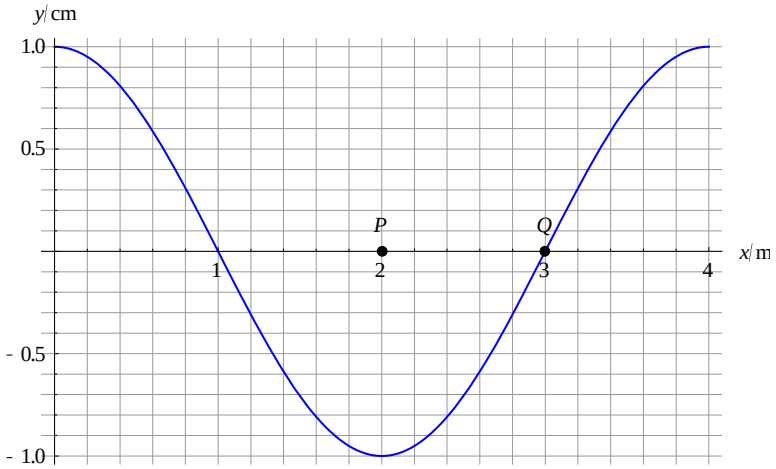
Problem of the week

The wave model

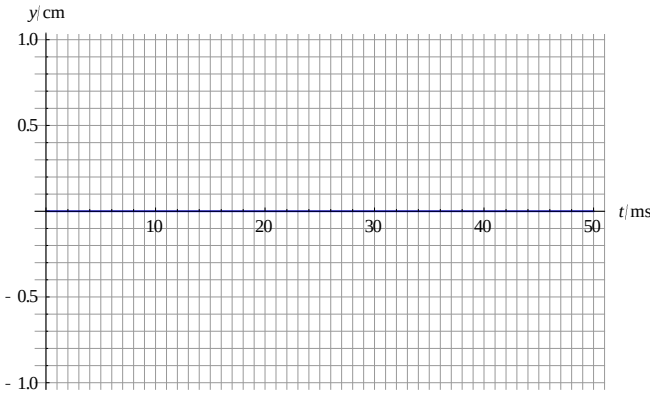
(a) State three differences between sound waves and electromagnetic waves.

(b) A wave is established on a string. The speed of the wave is 180 m s^{-1} and its wavelength is 2.0 m. The oscillating string creates sound waves in air. The speed of sound is 340 m s^{-1}. Estimate the wavelength of the sound waves in air.

(c) The graph shows, at t = 0, the variation with distance, of the displacement of medium particles when a transverse wave travels through the medium. The dots show the **equilibrium** positions of two particles P and Q in the medium. The speed of the wave is 160 m s^{-1} and the wave propagates to the right.

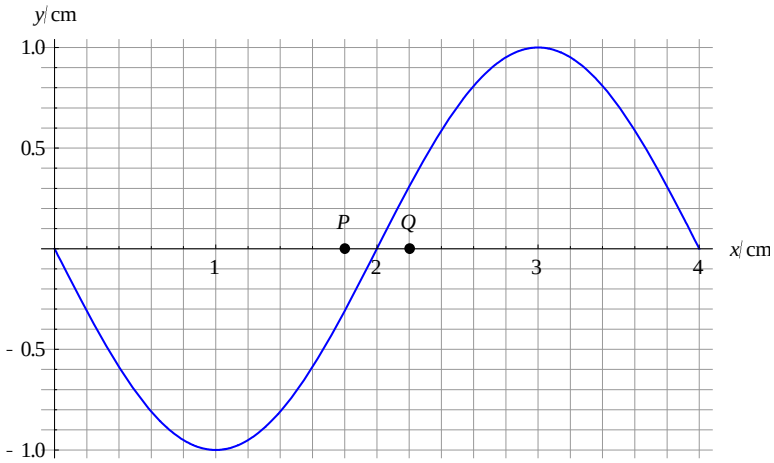


(i) Draw, on the axes, a graph to show the variation with time of the displacement of particle P.



(ii) Calculate the phase difference between P and Q.

(d) A **longitudinal** wave travels through a medium. The graph shows, at t = 0, the variation with distance, of the displacement of medium particles. The dots show the **equilibrium** positions of two particles P and Q in the medium.



(i) State the difference between a transverse and a longitudinal wave.

(ii) Estimate the distance between particles P and Q at $t = 0$.

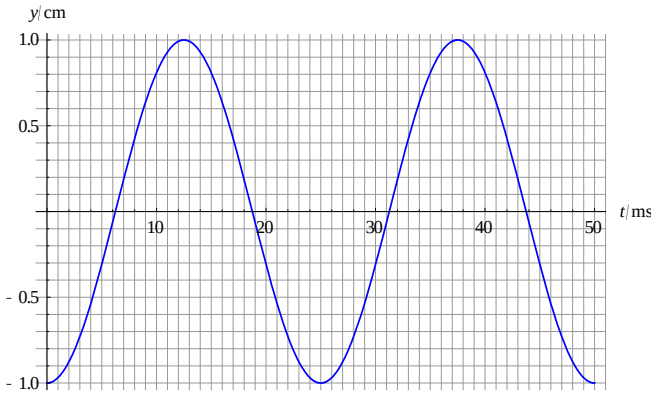
Answers

(a) Sound is longitudinal, EM waves are transverse.
Sound cannot travel in vacuum, EM waves can.
Sound involves oscillations of material particles, EM waves involve oscillations of fields.

(b) The frequency of the string wave is $f = \frac{c}{\lambda} = \frac{180}{2.0} = 90 \text{ Hz}$. This is also the frequency of the sound wave. Hence, $\lambda = \frac{c}{f} = \frac{340}{90} = 3.8 \text{ m}$.

(c)

(i) The period is $T = \frac{\lambda}{c} = \frac{4.0}{160} = 25 \text{ ms}$. Hence



(ii) $\Delta\phi = 2\pi\frac{\Delta x}{\lambda} = 2\pi\frac{1.0}{4.0} = \frac{\pi}{2}$.

(d)

(i) In a transverse wave the medium particles oscillate at right angles to the direction of energy transfer whereas in a longitudinal wave they oscillate parallel to the direction of energy transfer.

(ii) The position of P is 0.30 cm to the left of the equilibrium position at *x* = 1.80 cm i.e. at *x* = 1.50 cm. The position of Q is 0.30 cm to the right of the equilibrium position at *x* = 2.20 cm i.e. at *x* = 2.50 cm. The distance between P and Q is then 1.0 cm.