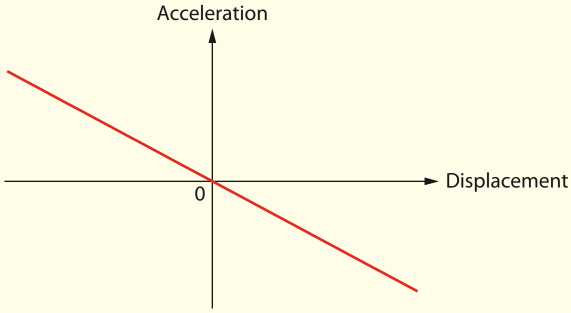
Additional Topic 4 questions

Test yourself

4.1 Oscillations

1 The graph shows the variation with displacement of the acceleration of a particle that is performing oscillations.

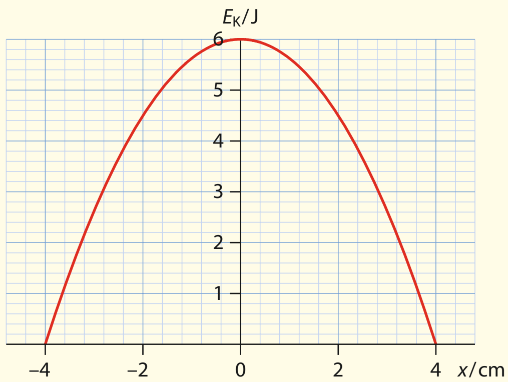


a Explain why the oscillations are simple harmonic.

b Make a copy of the graph and mark with the letter V a point on the graph where the speed is a maximum.

c The amplitude of oscillations is reduced from 2.0 cm to 1.0 cm. On your graph draw the variation with displacement of the acceleration of the particle.

2 The graph shows the variation with displacement of kinetic energy of a particle of mass 0.25 kg that is undergoing simple harmonic oscillations.



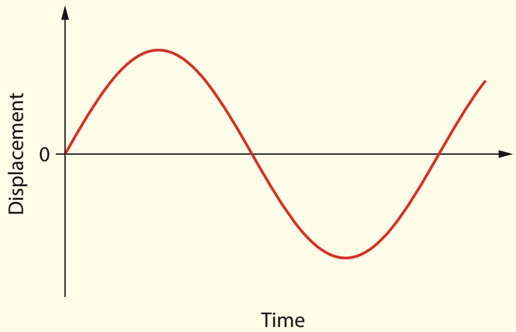
a Use the graph to calculate:

i the maximum speed of the particle

ii the potential energy when the displacement is 2.0 cm.

b On a copy of the axes draw a graph to show the variation of the potential energy with displacement.

3 The graph shows the variation with time of the displacement of a particle undergoing simple harmonic oscillations.



a On a copy of the graph mark a point where:

i the velocity is zero (mark this with the letter V)

ii the acceleration has maximum magnitude (mark this with the letter A)

iii the kinetic energy is maximum (mark this with the letter K)

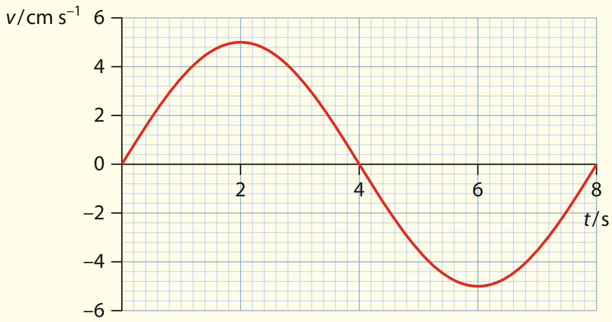
iv the potential energy is maximum (mark this with the letter P).

b For the motion shown, sketch a graph of:

i velocity versus time (no numbers on the axes are necessary)

ii acceleration versus time (no numbers on the axes are necessary).

4 The graph shows how the velocity of a particle undergoing simple harmonic oscillations varies with time.



a On a copy of the graph mark a point where:

i the displacement is zero (mark this with the letter Z)

ii the displacement has maximum magnitude (mark this with the letter M).

b Sketch an acceleration versus time graph for this motion (no numbers on the axes are necessary).

c The mass of the particle is 0.20 kg. Draw a graph to show the variation with time of the kinetic energy of the particle.

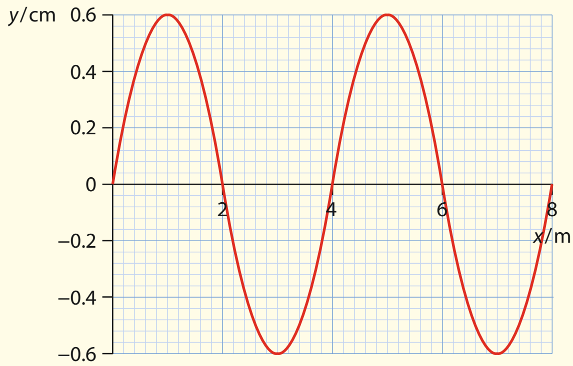
4.2 Travelling waves

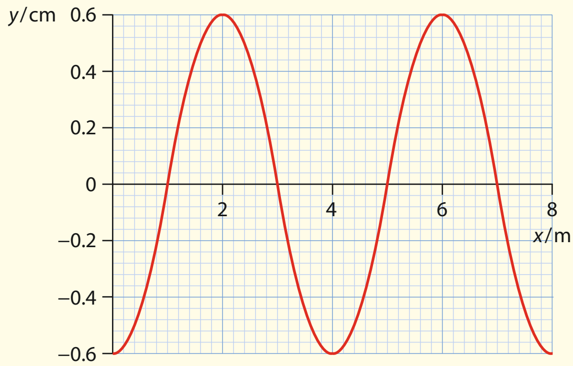
5 The speed of ocean waves approaching the shore is given by the formula $v = \sqrt{gh}$, where h is the depth of the water. It is assumed here that the wavelength of the waves is much larger than the depth (otherwise a different expression gives the wave speed).

a Calculate the speed of water waves near the shore where the depth is 1.0 m.

b Assuming that the depth of the water decreases uniformly, draw a graph of the water wave speed as a function of depth from a depth of 1.0 m to a depth of 0.30 m.

6 These displacement–position graphs show the same wave at two different times. The wave travels to the right and the bottom graph represents the wave 0.20 s after the time illustrated in the top graph.





a For this wave determine:

i the amplitude

ii the wavelength

iii the speed

iv the frequency.

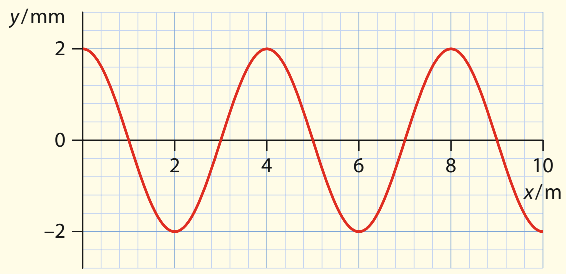
b Suggest whether the graphs may be used to determine if the wave is transverse or longitudinal.

7 An earthquake creates waves that travel in the Earth's crust; these can be detected by seismic stations.

a Explain why three seismic stations must be used to determine the position of the earthquake.

b Describe **two** differences in the signals recorded by three seismic stations, assuming they are at different distances from the centre of the earthquake.

8 The graph shows the variation with distance x, and of the displacement, y, of a sound wave travelling towards the right along a metal rod. This is the displacement at $t=0$. The frequency of the wave is 1250 Hz.



a Calculate the speed of the wave.

b Determine the displacement of a point on the rod:

i at $x=129$ m and $t=0$

ii at $x=212$ m and $t=10$ ms.

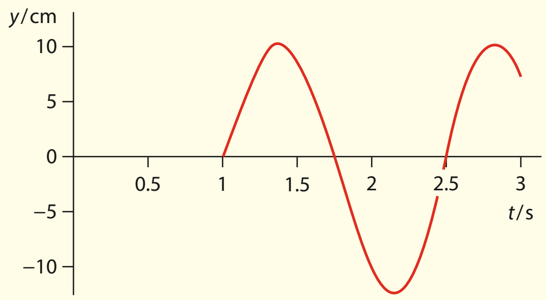
9 A stone is dropped on a still pond at $t=0$. The wave reaches a leaf floating on the pond a distance of 3.00 m away. The leaf then begins to oscillate. The graph shows how its displacement y varies with time t.

a Calculate the speed of the water waves.

b Determine the period and frequency of the wave.

c Calculate the wavelength of the wave.

d State the initial amplitude of the wave.



10 A sound wave of frequency 500 Hz travels from air into water. The speed of sound in air is 330 m s^{-1} and in water 1490 m s^{-1}. Calculate the wavelength of the wave in:

a air

b water.

11 A ship sends a sonar pulse of frequency 30 kHz and duration 1.0 ms towards a submarine and receives a reflection of the pulse 3.2 s later. The speed of sound in water is 1500 m s^{-1}. Calculate:

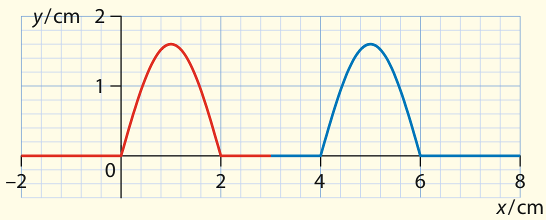
a the distance of the submarine from the ship

b the wavelength of the pulse

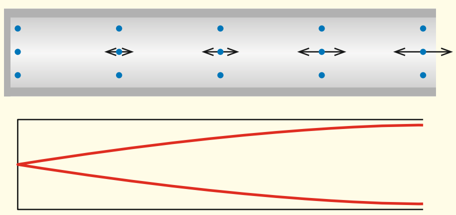
c the number of full waves emitted in the pulse.

4.3 Wave characteristics

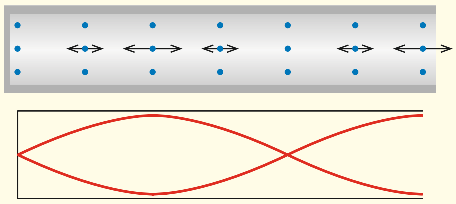
12 Two pulses are moving towards each other. The graph shows the variation of displacement y with distance x at $t=0$ s. Both pulses have a speed of 1 cm s^{-1}. Draw the shape of the string at $t=2$ s.



13 Two pulses are moving towards each other. The diagram shows the variation of displacement y with distance x at $t=0$ s. Both pulses have a speed of 1 cm s^{-1}. Draw the shape of the string at $t=2$ s.

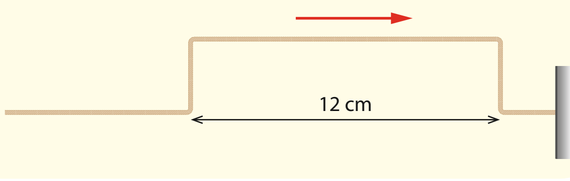


a



b

14 A pulse with the shape shown in the diagram travels on a string at 40 m s^{-1} towards a fixed end. Taking $t=0$ ms to be when the front of the pulse first arrives at the fixed end, draw the shape of the string at: $t=1.0$ ms; $t=1.5$ ms; $t=2.0$ ms; $t=2.5$ ms; $t=3.0$ ms; $t=4.0$ ms.



15 Polarised light is incident on a polariser whose transmission axis makes an angle θ with the direction of the electric field of the incident light. Sketch a graph to show the variation with angle θ of the transmitted intensity of light.

16 Unpolarised light of intensity I_0 is incident on a polariser. The transmitted light is incident on a second polariser whose transmission axis is at 60° to that of the first. Calculate, in terms of I_0, the intensity of light transmitted through the second polariser.

17 Unpolarised light of intensity I_0 is incident on a polariser. A number of other polarisers will be placed in line with the first so that the final transmitted intensity is $\frac{I_0}{100}$. Each polariser has its transmission axis rotated by 10° with respect to the previous one. Determine how many additional polarisers are required.

18 Light is incident on two analysers whose transmission axes are at right angles to each other. No light gets transmitted. Discuss whether it can be deduced whether the incident light is polarised or not.

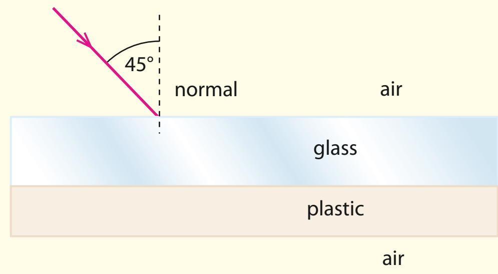
19 Unpolarised light is incident on two polarisers whose transmission axes are parallel to each other. Calculate the angle by which one of them must be rotated so that the transmitted intensity is half of the intensity incident on the second polariser.

20 A fisherman is fishing in a lake. Explain why it would be easier for him to see fish in the lake if he was wearing Polaroid sunglasses.

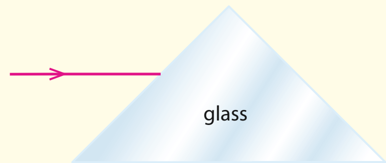
21 You stand next to a lake on a bright morning with one sheet of Polaroid. You don't know the orientation of its transmission axis. Suggest how you can determine it. (You may not use other Polaroid sheets with known transmission axes.)

4.4 Wave behaviour

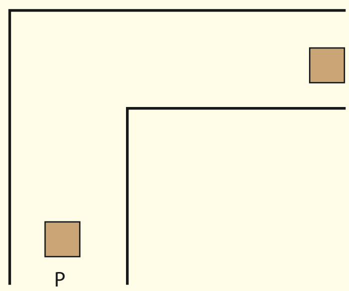
22 A ray of light enters glass from air at an angle of incidence equal to 45°, as shown in the diagram. Draw the path of this ray assuming that the glass has a refractive index of 1.420 and the plastic has a refractive index of 1.350.



23 A ray of light moving in air parallel to the base of a glass prism of angles 45°, 45° and 90° enters the prism, as shown in the diagram. Investigate the path of the ray as it enters the glass. The refractive index of glass is 1.50.



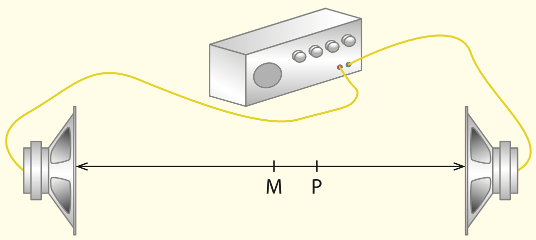
24 In the corridor shown in the diagram an observer at point P can hear someone at point Q but cannot see them. State the name(s) of the physical phenomena that may account for this. How could someone at P see Q?



25 Two loudspeakers are connected to the same audio oscillator. An observer walks along the straight line joining the speakers (see diagram). At a point M halfway between the speakers he hears a loud sound. By the time he gets to point P, a distance of 2.00 m from M, he hears no sound at all.

a Explain how this is possible.

b Determine the largest possible wavelength of sound emitted by the loudspeakers.



26 A car moves along a road that joins the twin antennas of a radio station that is broadcasting at a frequency of 90.0 MHz (see diagram). When in position A, the reception is good but it drops to almost zero at position B. Determine the minimum distance AB.

27 Two sources emit identical sound waves with a frequency of 850 Hz.

a An observer is 8.2 m from the first source and 9.0 m from the second. Describe and explain what this observer hears.

b A second observer is 8.1 m from the first source and 8.7 m from the second. Describe and explain what this observer hears. (Take the speed of sound to be 340 m s^{-1}.)

28 In the context of wave motion, state what you understand by the term **superposition**. Illustrate constructive and destructive interference by suitable diagrams.