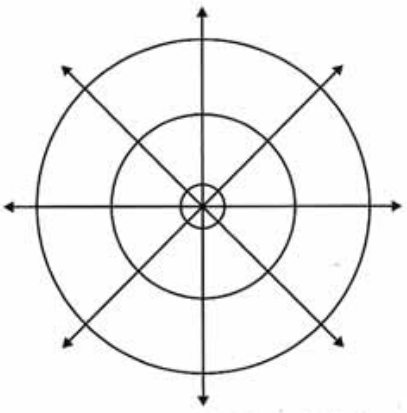

Figure 2.19 Example of cylindrical wavefronts. The cylinders go through the crests and are normal to the plane of the paper. The rays are radial lines.

Example question

Q7

A stone dropped in still water creates circular ripples that move away from the point of impact. The initial height of the ripple is about 2.4 cm and the wavelength is 0.5 m. Draw a sketch of the displacement of the ripples as a function of the distance from the point of impact.

Answer

The energy carried by the wave is distributed along the (circular) wavefronts. As the wave moves away from the point of impact, the length of the wavefront increases and so the energy per unit wavefront length decreases. Thus, the amplitude has to decrease as well. So we get the graph shown in Figure 2.20.

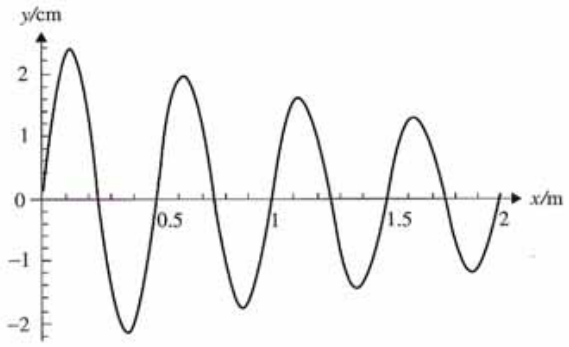

Figure 2.20.

The wavefronts of light waves leaving a point source (a very small lamp) would be spherical. We can thus speak of plane, cylindrical and spherical waves, according to the shape of the wavefronts. Note that cylindrical and spherical waves tend to become plane waves very far away from their source.

Questions

1 In football stadiums fans often create a 'wave' by standing up and sitting down again. What determines the speed of the 'wave'?

2 A number of dominoes are stood next to each other along a straight line. A small push is given to the first domino and one by one the dominoes fall over. How is this an example of wave motion? How can the speed of the wave pulse be increased? Design an experiment in which this problem can be investigated.

3 What is the wavelength that corresponds to a sound frequency of:
(a) 256 Hz;
(b) 25 kHz?
Take the speed of sound to be 330 m s^{-1}.

4 By making suitably labelled diagrams explain the terms:
(a) wavelength;
(b) period;
(c) amplitude;
(d) crest;
(e) trough.

5 The tension in a steel wire of length 0.800 m and mass 150.0 g is 120.0 N. What is the speed of transverse waves on this string? (Use $v = \sqrt{\frac{T}{\mu}}$.)

6 A string has a length of 20.0 m and is kept at a tension of 50.0 N. Its mass is 400.0 g. A transverse wave of frequency 15.0 Hz travels on this string.
(a) What is its wavelength?
(b) If the same wave is created on the same kind of string (same mass per unit length and same tension) but of double the length, what will the wavelength of the wave be? (Use $v = \sqrt{\frac{T}{\mu}}$.)

7 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 according to the graph shown in Figure 2.21.
(a) Find the speed of the water waves.
(b) Find the period and frequency of the wave.
(c) Find the wavelength and amplitude of the wave.

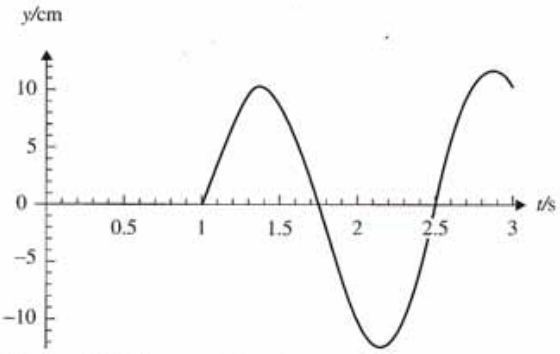

Figure 2.21 For question 7.

8 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}. What is the wavelength of the wave in:
(a) air;
(b) water?

9 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). What is the speed of water waves near the shore where the depth is 1.0 m? Assuming that the depth of the water decreases uniformly, make 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.

10 (a) Explain, in the context of wave motion, what you understand by the term *displacement*.
(b) Using your answer in (a), explain the difference between longitudinal and transverse waves.
(c) A rock thrown onto the still surface of a pond creates circular ripples moving away from the point of impact. Why is more than one ripple created?
(d) Why does the amplitude decrease as the ripple moves away from the centre?

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}. Find the distance of the submarine from the ship, the wavelength of the pulse and the number of full waves emitted in the pulse.

12 Figure 2.22 shows three points on a string on which a transverse wave propagates to the right. Indicate how these three points will move in the next instant of time.

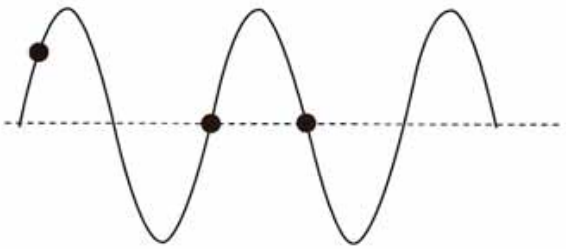

Figure 2.22 For question 12.

13 How would your answers change if the wave in question 12 were moving to the left?

14 Figure 2.23 shows a piece of cork floating on the surface of water when a wave travels through the water. On the same diagram draw the position of the cork half a wave period later.

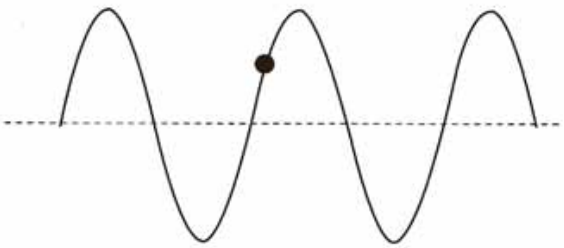

Figure 2.23 For question 14.

15 Figure 2.24 shows the same wave at two different times. The wave travels to the right and the bottom diagram represents the wave 0.2 s after the time illustrated in the top diagram. For this wave determine:
(a) the amplitude;
(b) the wavelength;
(c) the speed;
(d) the frequency.
(e) Can the graph be used to determine whether the wave is transverse or longitudinal?

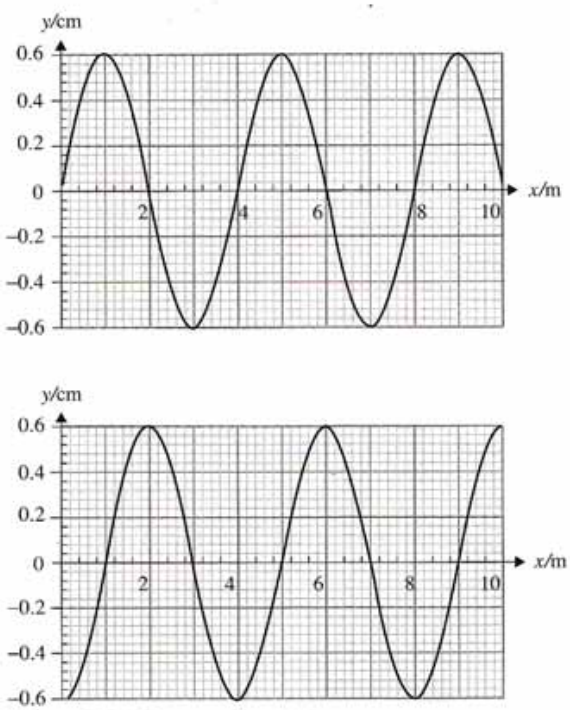

Figure 2.24 For question 15.

16 Figure 2.25 is a picture of a longitudinal wave travelling towards the right taken at a specific time. The density of the lines is proportional to the density in the medium the wave travels through.
(a) Draw this wave a very small interval of time later.
(b) Indicate on the diagram the wavelength of this wave.

Figure 2.25 For question 16.

17 Indicate on Figure 2.26 a compression, a rarefaction and the wavelength. Draw the picture of this wave half a period later.

Figure 2.26 For question 17.

18 By drawing suitable diagrams, explain the difference between transverse and longitudinal waves.

19 In the context of wave motion explain, with the aid of a diagram, the terms:
(a) wavefront;
(b) ray.

20 An earthquake creates waves that travel in the earth's crust; these can be detected by seismic stations. Explain why three seismic stations must be used to determine the position of the earthquake. Describe *two* differences in the signals recorded by three seismic stations, assuming they are at different distances from the centre of the earthquake.