Lesson 4.13: Wave graphs

Students often confuse displacement/distance graphs (from which wavelength can be deduced) with displacement/time graphs (e.g. on an oscilloscope, from which frequency can be deduced).

Summary

**Student Activity: Drawing longitudinal waves. (15 minutes)**

**Discussion: Extending the first activity. (20 minutes)**

**Discussion: Practice with phase. (15 minutes)**

Student activity:

Drawing longitudinal waves

By plotting the displacements of individual particles through which a wave is passing, students can develop their ideas of the underlying process of a wave.

Provide graph paper. Students should use a particle spacing of 1 cm. The pattern is best seen by doing one particle at a time.

The completed diagrams can be used in discussion later. The same exercise can be done for transverse waves, but this might be overkill.

TAP 310-1: Graphs for a longitudinal wave

Discussion:

Extending the first activity

Check the outcome of the graph plotting activity, particularly the final displacement/ position graph which gives the wavelength; discuss the link with pressure if this seems appropriate. If the particles either side of an undisturbed one are both displaced towards it, it will be in a compression; if they are displaced away from it, it will be a rarefaction.

Ask students to draw a displacement/time graph for particle 1 of the exercise above; it will be seen to be the same shape as the displacement / distance graph but starting at a different point.

Discuss the following quantities and their units, and how they can be deduced from the appropriate graphs:

Displacement y

Period T

Frequency f

Amplitude A

Point out that wave velocity *v* (or *c*) cannot be deduced directly from a graph.

At this point, you might discuss the symbols (and units) for the various quantities related to waves. Warn your students that each textbook will be different. For example, amplitude may be represented by *a,* A*,* x0 or y0. (Check your specification.)

Discussion:

Practice with phase

Now for a mathematical interlude. The phase difference between two waves is the fraction of a cycle (in radians) by which one wave would have to be advanced or retarded to be in phase with the other.

It is best if students can work in both degrees and radians. If there is anyone who has not met radians before a swift detour will be necessary to introduce them.

Students should appreciate that ‘out of phase’ can mean by any amount. If they mean 180° they should say ‘completely out of phase’, ‘in opposite phase’ or ‘in antiphase’.

Check they understand that a phase difference of zero, *n* × 360o or *n* × 2 is in phase, 180o or odd multiples of π is completely OUT of phase. Then try 1/3 or 1/4 of a cycle out of phase; relate these to fractions of π radians, such as π/2.

A demonstration can help. Set a pendulum swinging by releasing it at *t =* 0; set another of the same length swinging exactly as the first goes through equilibrium position, travelling in the same direction. In this way you can illustrate 90° lag. (Note that, because the two pendula won’t have exactly the same period, they will move regularly in and out of phase; it is worth drawing attention to this.)

displacement

time

starts here

0

B is ¼ cycle behind A

**B**

### A

Practical advice

Graphs of longitudinal travelling waves

Longitudinal waves are somewhat harder to represent graphically – mainly because graphs plotted on x–y axes always look ‘transverse’.

This activity is more instructive and less tedious than it might seem at first – we do recommend that students work through it (perhaps starting in class and finishing for homework). When students are plotting the displacement graph, make sure they know to plot each particle above or below its equilibrium position (not its displaced position). To generate the pressure graph, students need only to identify places where the pressure is maximum, minimum or ‘normal’, i.e. where particles are close together, far apart or ‘normal’.

For ‘time 20’ the displacements of the first ten particles are as shown in the table below. Their positions, and the corresponding displacement and pressure graphs, are shown in Figure 1.



Tap 310-1 makes the point that the extreme pressures occur when the displacement is zero, and vice versa. The two graphs differ in phase by π/2 radians.

Answers and worked solutions







External reference

This activity is taken from Salters Horners Advanced Physics, section TSOM, activity 7