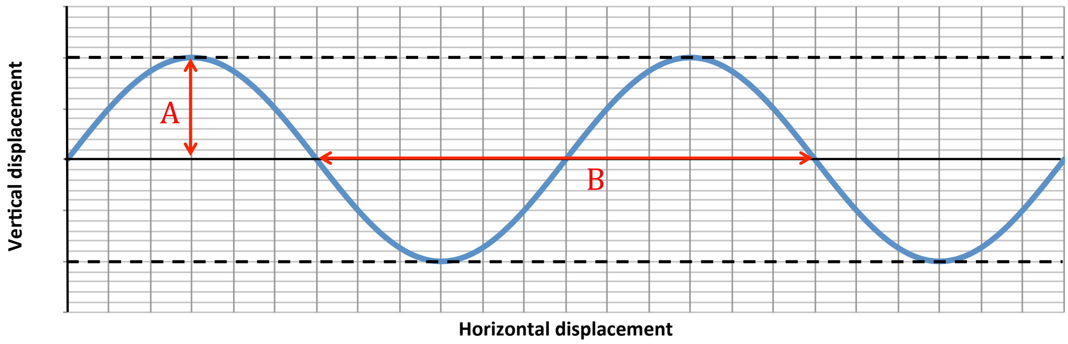
FLIPPED around PHYSICS

3.1 Progressive waves

Progressive waves are waves which carry energy from one place to another. Waves which travel in a medium cause the particles in the medium to be displaced from their equilibrium position. Particles can either be displaced parallel to the direction the wave is progressing or at right angles. These are called longitudinal and transverse waves, respectively.

videos

Let us consider a transverse wave:



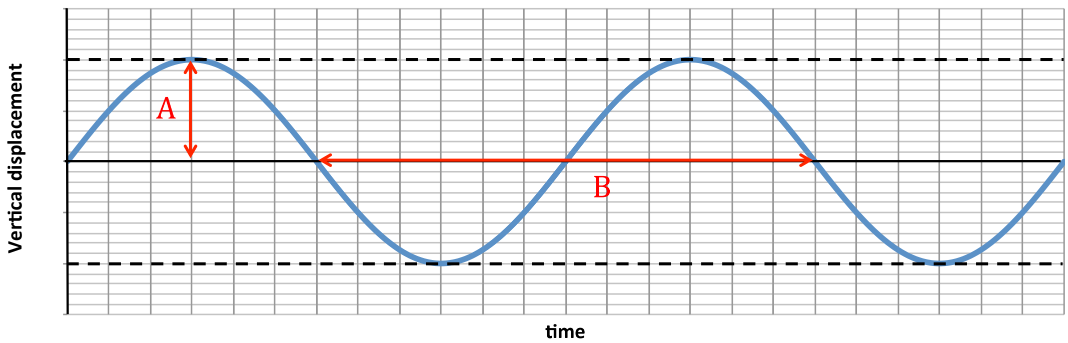
We can see a 'snapshot' of the wave at a certain time. The vertical displacement is shown for particles at different horizontal positions.

(1) What do arrows A and B represent?

(2) What units could B be measured in?

(3) What is the equilibrium position on this graph – label it.

Now consider the same wave, where vertical displacement is plotted against time. In this case we are considering the motion of a particle at a fixed position as the wave passes:



(4) What do arrows A and B represent?

(5) The frequency of the waves is the number of waves that pass a fixed point in one second. How could we find the frequency from the displacement-time graph?

(6) What units is frequency measured in?

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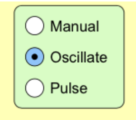
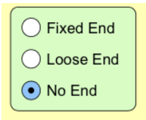
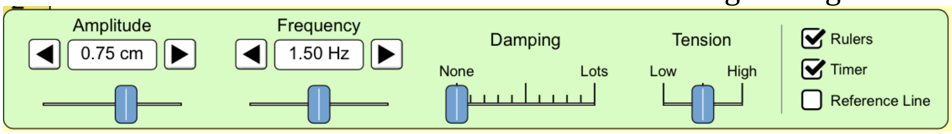
PhET simulation

Open the following sim: https://tinyurl.com/mtwczmj

Choose 

and 

. Select the following settings:



(7)✐Look at one of the green particles. What do you notice about the motion compared to the direction of wave travel? Is this a transverse or longitudinal wave?

(8)✐Pause the animation and record the wavelength of the wave.

(9)✐Now use the timer to time 10 complete waves passing a certain point (e.g. out the window).

(10)✐If 10 waves pass in the time you have measured and each wave has the length you have measured, what is the wave speed?

The wave equation relates wave speed (v), frequency (f) and wavelength (λ):

$$v = f\lambda$$

(11)✐Use your values above to see if this equation works for your measurements.

Phase difference

If we look at the two graphs at the top of this worksheet, we see that they are identical, apart from the x-axis label. We often find it useful to talk about waves in terms of cycles. A cycle is the portion of a wave between two wave crests or between two wave troughs, or indeed between any two identical points on the wave graph.

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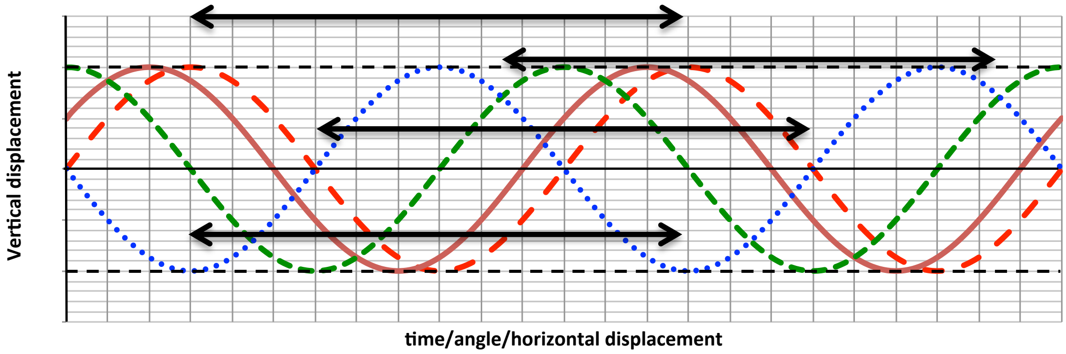
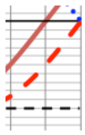
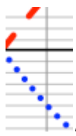
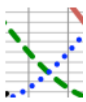
Consider the waves below:



All the arrows indicate a wave cycle. For time on the x-axis, one whole wave cycle represents the <u>period</u> of a wave. For displacement on the x-axis, one whole cycle represents the wavelength. For the sinusoidal function, one whole cycle represents 360°.

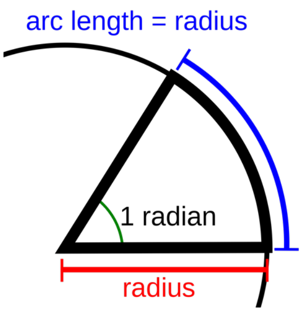
If we think about cycles in terms of angles, we can describe the relationship between waves. For example, comparing the two waves , we can see that the large-dash wave is 30° ahead of the solid line wave. We say there is a phase difference of 30°.

(12)✐ What is the phase difference between *?*

(13)✐ What is the phase difference between *?*

Phase difference in radians

Phase differences are often expressed in radians. A radian is a dimensionless unit of angle and relates arc length to the radius of the circle:



For example, it the angle is 1 radian, then the arc length = radius, as shown in the diagram.

We find that there are 3.142 radians (or pi radians) in 180°.

So, to convert from degrees to radians:

$$angle\ in\ radians = \frac{angle\ in\ degrees}{180} \times \pi$$

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(14)✏Convert your phase differences (above) into radians.

Where we have a phase difference between two waves of π (180°), we say that waves are 'in antiphase'. Where we have zero phase difference, we say waves are 'in phase'.

(15)✏What two waves above are in antiphase? How do you think they would combine together?

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