Frequency, Wavelength and Amplitude

Waves

1. Define "wave." *Deformation that propagates through a vacuum or through a medium that contains matter*

2. Summary table of types of waves

	Mechanical waves	*Electromagnetic* waves
Medium in which it moves	Material medium	Material medium or vacuum
Three examples	*Water wave, sound, seismic wave*	*Radio waves, light waves, UV rays*

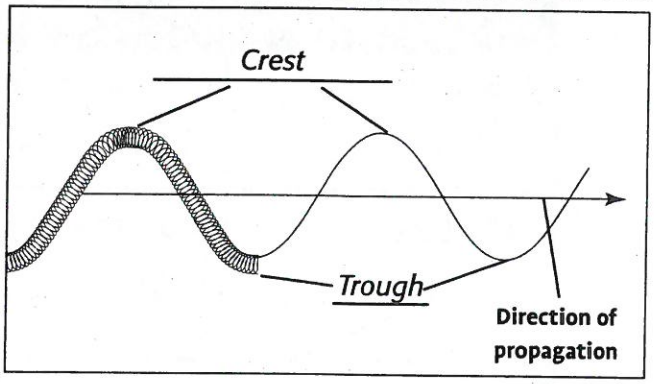
Types of waves

3. *a)* Complete the following diagram:

   b) This type of wave produces a deformation that is *perpendicular* to the direction in which it propagates.

   c) Provide three examples of this type of wave: *Electromagnetic waves, water waves and earthquakes*

Transverse wave

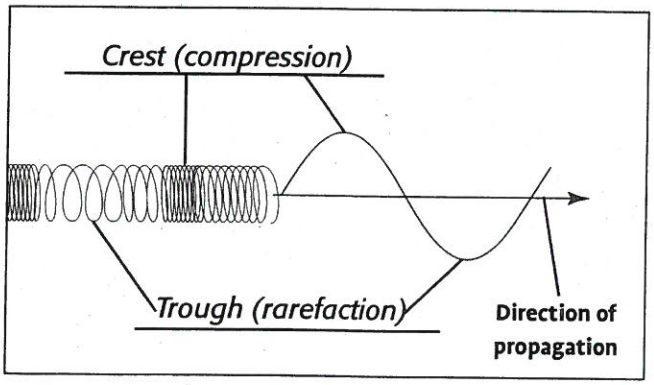


4. *a)* Complete the following diagram:

   b) This type of wave produces a deformation that is *parallel* to the direction in which it propagates.

   c) Provide an example of this type of wave: *Sound*

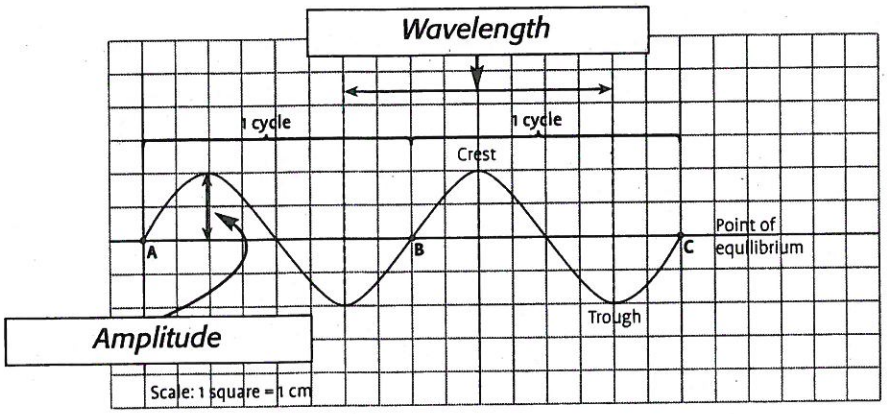
Longitudinal wave



The characteristics of waves

5. List the four characteristics of a wave: *Length, frequency, amplitude and period*

6. The following illustration is a schematic diagram of a wave. Complete this diagram by identifying the two characteristics of a wave that can be identified on a schematic diagram.



7. Summary table of the characteristics of a wave

Characteristic and symbol	Definition	Formula
Wavelength (λ)	Distance between two identical deformations (measured in units derived from the metre)	$\lambda = \frac{\text{Total distance}}{\text{Number of cycles}}$
Frequency (f)	Number of deformations (or cycles) produced per unit of time, usually per second	$f = \frac{\text{Number of cycles}}{\text{Total time}}$
Amplitude (A)	Maximum height reached by a wave from its point of equilibrium (measured in units derived from the metre)	*A = Maximum height reached by the wave (measured with a ruler)*
Period (T)	Time it takes a wave to complete a full cycle (measured in seconds)	$T = \frac{\text{Total time}}{\text{Number of cycles}}$ or $T = \frac{1}{f}$

7. Jasmine is a hairdresser. She uses an aqueous solution of hydrogen peroxide (H_2O_2) as a lightener. To save money, she gets a 60% V/V solution. Since she has two colouring jobs scheduled that day, she needs to prepare 1.5 litres of the solution at a concentration of 35% V/V. Tell her how to do this without wasting any of the hydrogen peroxide solution.

Formula	Data	Calculations
$C_1V_1 = C_2V_2$	$C_1 = 60\%\ V/V$	$60\%\ V/V \times V_1 = 35\%\ V/V \times 1.5\ L$
	$V_1 = ?$	$V_1 = \frac{35\%\ V/V \times 1.5\ L}{60\%\ V/V}$
	$C_2 = 35\%\ V/V$	
	$V_2 = 1.5\ L$	$V_2 = 0.875\ L$ or $875\ mL$

Answer: *She needs to take 875 mL of the solution at a concentration of 60% V/V, then add distilled water to obtain a volume of 1.5 L.*

8. You need 45 mL of an aqueous solution of $K_2Cr_2O_7$ at a concentration of 20 g/L for an experiment. To make the solution, the laboratory technician gives you 50 mL of an aqueous solution of $K_2Cr_2O_7$ at a concentration of 80 g/L. Describe the tasks you will need to perform to obtain 45 mL of the solution you have been asked to make without wasting any of the original solution.

Formula	Data	Calculations
$C_1V_1 = C_2V_2$	$C_1 = 80\ g/L$	$80\ g/L \times V_1 = 20\ g/L \times 45\ mL$
	$V_1 = ?$	$V_1 = \frac{20\ g/L \times 45\ mL}{80\ mL}$
	$C_2 = 20\ g/L$	
	$V_2 = 45\ mL$	$V_1 = 11.25\ mL$

Tasks:

1. Measure 11.25 mL of the concentrated solution in a graduated cylinder.

2. Top it up with water to obtain 45 mL of the solution.

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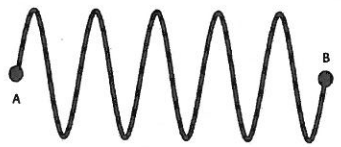
Calculating Frequency, Wavelength, Period and Amplitude

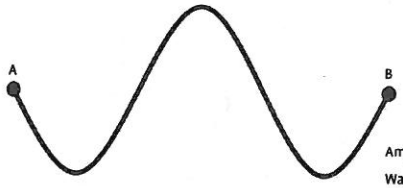
1. Using a ruler, calculate the amplitude and wavelength of each of the following examples:

a)



Amplitude: *1.5 cm*
Wavelength: *1.5 cm*

b)



Amplitude: *2 cm*
Wavelength: *6 cm*

c) Each of these waves takes 16 seconds to go from point A to point B. Calculate the frequency and period of each wave.

Wave A:

$$\text{Frequency } (f) = \frac{\text{number of cycles}}{\text{total time}} = \frac{5\ \text{cycles}}{16\ s} = 0.31\ \text{cycle/s or } 0.31\ Hz$$

$$\text{Period } (T) = \frac{\text{time total}}{\text{number of cycles}} = \frac{16\ s}{5\ \text{cycles}} = 3.2\ s\ \text{(for 1 cycle)}$$

Wave B:

$$\text{Frequency } (f) = \frac{1.5\ \text{cycle}}{16\ s} = 0.094\ \text{cycle/s or } 0.094\ Hz$$

$$\text{Period } (T) = \frac{16\ s}{1.5\ \text{cycle}} = 10.6\ s\ \text{(for 1 cycle) or } 10.7\ s\ \text{(for 1 cycle)}$$

ANSWER KEY

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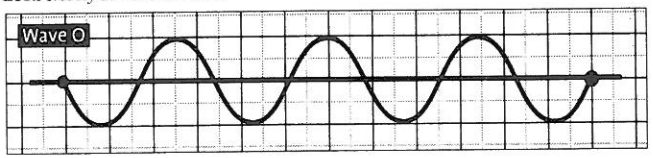
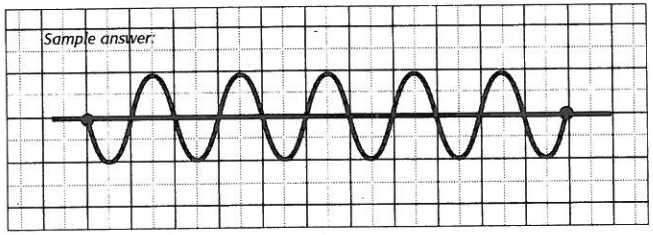
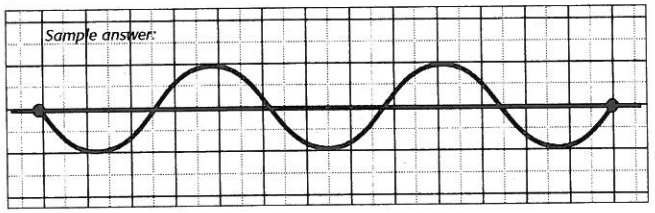
2. Look closely at wave O below:



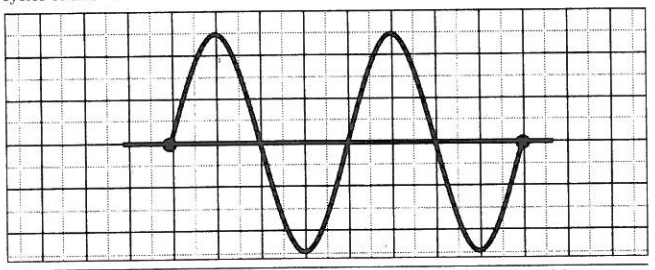
a) Draw a wave that has a higher frequency than wave O.



b) Draw a wave that has a lower frequency than wave O.



3. Draw a wave that has an amplitude of 2.5 cm and is 4 cm long. Show two complete cycles of this wave.



ANSWER KEY

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4. Two students standing 6 m apart create waves with a spring.

a) Calculate the wavelength that would be formed if the wave were made up of:

1) one crest
2) one crest and one trough
3) one crest and two troughs
4) two crests and two troughs

$$\text{Wavelength } (\lambda) = \frac{\text{total distance}}{\text{number of cycles}}$$

1) $\lambda = \frac{6\text{ m}}{0.5\text{ cycle}} = 12\text{ m (per cycle)}$

2) $\lambda = \frac{6\text{ m}}{1\text{ cycle}} = 6\text{ m (per cycle)}$

3) $\lambda = \frac{6\text{ m}}{1.5\text{ cycle}} = 4\text{ m (per cycle)}$

4) $\lambda = \frac{6\text{ m}}{2\text{ cycles}} = 3\text{ m (per cycle)}$

b) If the wave takes 14 seconds to travel from one student to the other in each of the above cases, calculate the frequency of the four waves formed.

$$\text{Frequency } (f) = \frac{\text{number of cycles}}{\text{total time}}$$

1) $f = \frac{0.5\text{ cycle}}{14\text{ s}} = 0.036\text{ cycle/s or Hz}$

2) $f = \frac{1\text{ cycle}}{14\text{ s}} = 0.071\text{ cycle/s or Hz}$

3) $f = \frac{1.5\text{ cycle}}{14\text{ s}} = 0.107\text{ cycle/s or Hz}$

4) $f = \frac{2\text{ cycles}}{14\text{ s}} = 0.143\text{ cycle/s or Hz}$

c) What is the relationship between the wavelength and the frequency of a wave?

The longer the wavelength, the lower the frequency