

## Questions compiled by Leong Yee Pak

### 15 Waves

#### Content

- 15.1 Progressive waves
- 15.2 Transverse and longitudinal waves
- 15.3 Polarisation
- 15.4 Determination of speed, frequency and wavelength
- 15.5 Electromagnetic spectrum

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## Section A

### Progressive waves

### Transverse and longitudinal waves

#### \*1 June 02 P1 Q27

27 Which statement correctly relates the intensity of a sound wave to the vibrations of the molecules?

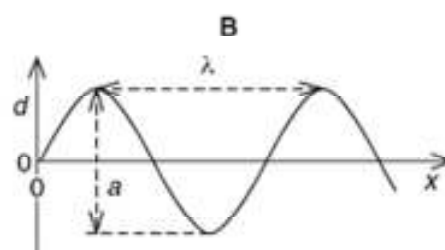
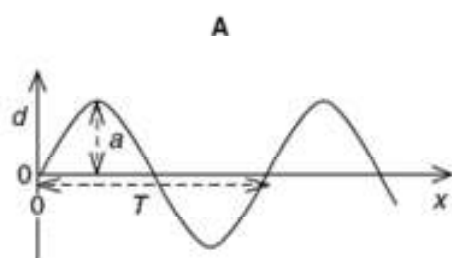
- A intensity  $\propto$  amplitude
- B intensity  $\propto$  (amplitude)<sup>2</sup>
- C intensity  $\propto$  displacement
- D intensity  $\propto$  (displacement)<sup>2</sup>

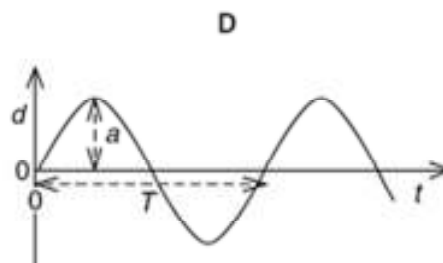
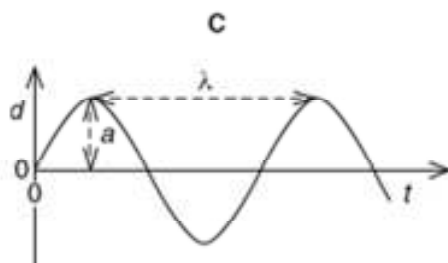
#### \*\*2 Nov 02 P1 Q26

The four graphs represent a progressive wave on a stretched string. Graphs A and B show how the displacement  $d$  varies with distance  $x$  along the string at one instant. Graphs C and D show how the displacement  $d$  varies with time  $t$  at a particular value of  $x$ .

The labels on the graphs are intended to show the wavelength  $\lambda$ , the period  $T$ , and the amplitude  $a$  of the wave, but only one graph is correctly labelled.

Which graph is correctly labelled?





**\*\*3 Nov 02 P1 Q27**

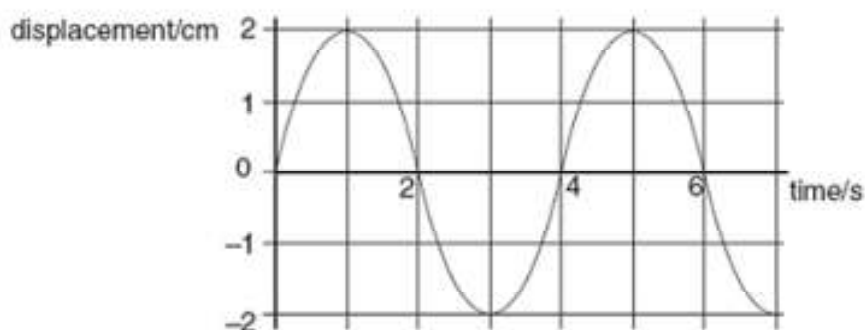
27 A wave of amplitude  $a$  has an intensity of  $3.0 \text{ Wm}^{-2}$ .

What is the intensity of a wave of the same frequency that has an amplitude  $2a$ ?

- A  $4.2 \text{ Wm}^{-2}$       B  $6.0 \text{ Wm}^{-2}$       C  $9.0 \text{ Wm}^{-2}$       D  $12 \text{ Wm}^{-2}$

**\*\*4 Nov 03 P1 Q23**

The graph shows how the displacement of a particle in a wave varies with time.



Which of the following is correct?

- A The wave has an amplitude of 2 cm and could be either transverse or longitudinal.  
 B The wave has an amplitude of 2 cm and must be transverse.  
 C The wave has an amplitude of 4 cm and could be either transverse or longitudinal.  
 D The wave has an amplitude of 4 cm and must be transverse.

**\*5 Nov 03 P1 Q25**

25 Which of the following applies to a progressive transverse wave?

	transfers energy	can be polarised
<b>A</b>	no	no
<b>B</b>	no	yes
<b>C</b>	yes	no
<b>D</b>	yes	yes

\*6 June 04 P1 Q24

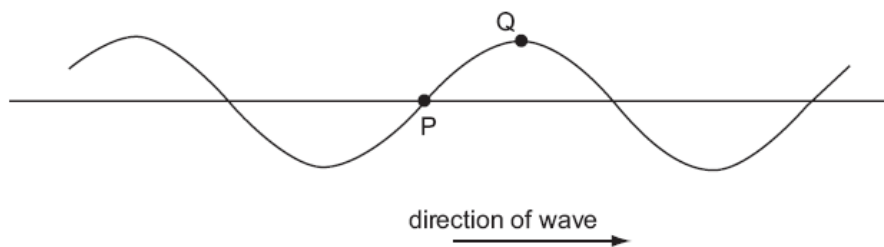
24 Which observation indicates that sound waves are longitudinal?

- A** Sound can be reflected from a solid surface.
- B** Sound cannot be polarised.
- C** Sound is diffracted around corners.
- D** Sound is refracted as it passes from hot air to cold air.

\*\*7 June 04 P1 Q25

25 The diagram shows a transverse wave on a rope. The wave is travelling from left to right.

At the instant shown, the points P and Q on the rope have zero displacement and maximum displacement respectively.



Which of the following describes the direction of motion, if any, of the points P and Q at this instant?

	point P	point Q
<b>A</b>	downwards	stationary
<b>B</b>	stationary	downwards
<b>C</b>	stationary	upwards
<b>D</b>	upwards	stationary

**\*\*\*8 June 04 P1 Q26**

- 26** A plane wave of amplitude  $A$  is incident on a surface of area  $S$  placed so that it is perpendicular to the direction of travel of the wave. The energy per unit time reaching the surface is  $E$ .

The amplitude of the wave is increased to  $2A$  and the area of the surface is reduced to  $\frac{1}{2}S$ .

How much energy per unit time reaches this smaller surface?

- A**  $4E$                       **B**  $2E$                       **C**  $E$                       **D**  $\frac{1}{2}E$

**\*9 Nov 04 P1 Q24**

- 24** Which of the following is a longitudinal wave?

- A** a light wave travelling through air  
**B** a radio wave from a broadcasting station  
**C** a ripple on the surface of water  
**D** a sound wave travelling through air

**\*\*10 Nov 04 P1 Q26**

- 26** A wave of amplitude 20 mm has intensity  $I_X$ . Another wave of the same frequency but of amplitude 5 mm has intensity  $I_Y$ .

What is  $\frac{I_X}{I_Y}$ ?

- A** 2                      **B** 4                      **C** 16                      **D** 256

**\*\*11 June 05 P1 Q25**

- 25** A health inspector is measuring the intensity of a sound. Near a loudspeaker his meter records an intensity  $I$ . This corresponds to an amplitude  $A$  of the sound wave. At another position the meter gives an intensity reading of  $2I$ .

What is the corresponding sound wave amplitude?

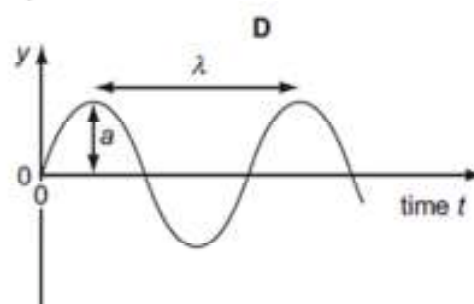
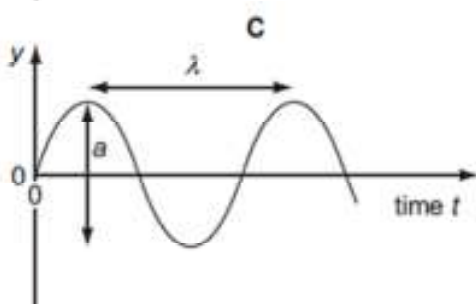
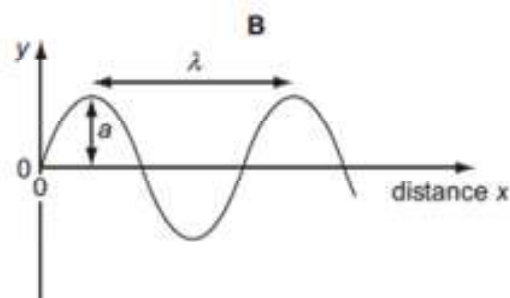
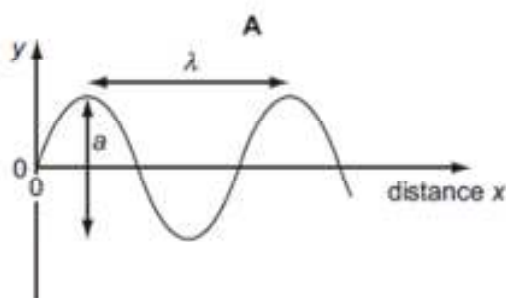
- A**  $\frac{A}{\sqrt{2}}$                       **B**  $\sqrt{2}A$                       **C**  $2A$                       **D**  $4A$

**\*\*12 Nov 05 P1 Q23**

A sound wave has displacement  $y$  at distance  $x$  from its source at time  $t$ .

**\*\*12 Nov 05 P1 Q23**

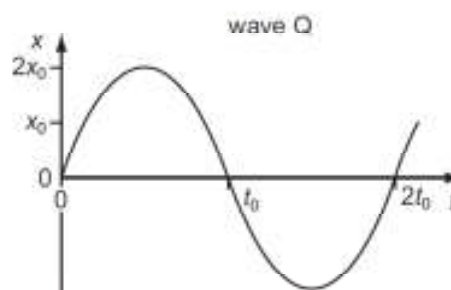
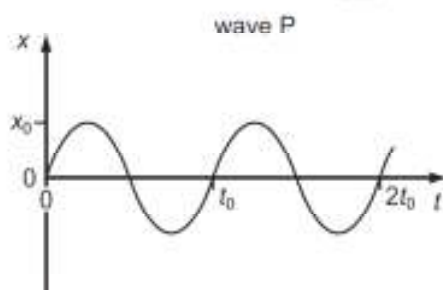
Which graph correctly shows the amplitude  $a$  and the wavelength  $\lambda$  of the wave?



\*\*\*13 Nov 05 P1 Q24

- 24 The intensity of a progressive wave is proportional to the square of the amplitude of the wave. It is also proportional to the square of the frequency.

The variation with time  $t$  of displacement  $x$  of particles in a medium, when two progressive waves P and Q pass separately through the medium, are shown on the graphs.



The intensity of wave P is  $I_0$ .

What is the intensity of wave Q?

- A**  $\frac{1}{2} I_0$       **B**  $I_0$       **C**  $8 I_0$       **D**  $16 I_0$

\*\*14 Nov 05 P1 Q25

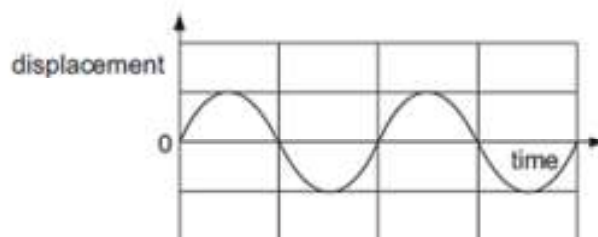
- 25 A sound wave of frequency 150 Hz travels in water at a speed of  $1500 \text{ m s}^{-1}$ . It then travels through the surface of the water and into air, where its speed is  $300 \text{ m s}^{-1}$ .

Which line in the table gives the correct values for the wavelengths of the sound in water and in air?

	wavelength in water / m	wavelength in air / m
<b>A</b>	0.10	0.10
<b>B</b>	0.10	0.50
<b>C</b>	10	2.0
<b>D</b>	10	50

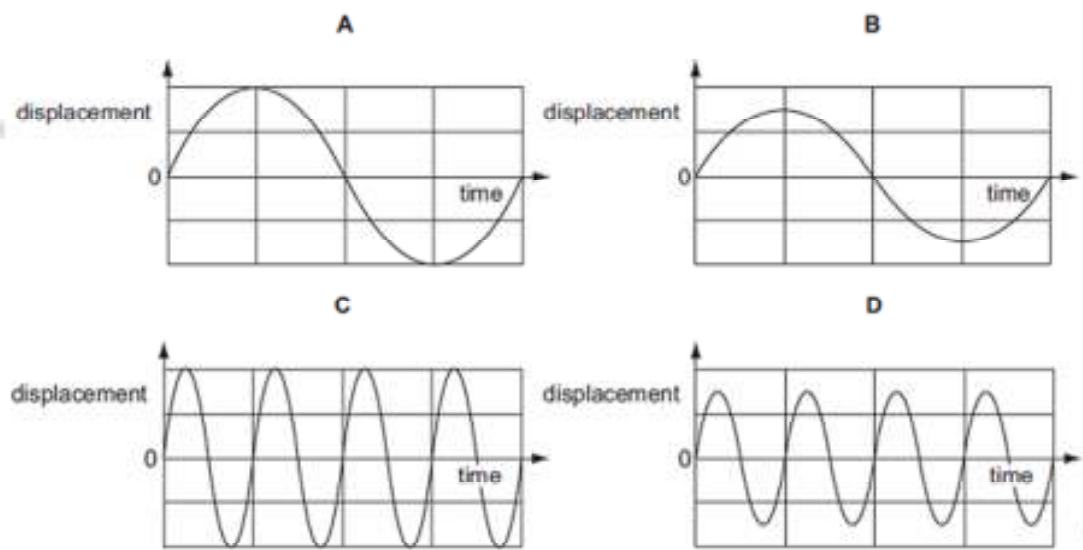
**\*\*15 June 06 P1 Q24**

A displacement-time graph is shown for a particular wave.



A second wave of similar type has twice the intensity and half the frequency.

When drawn on the same axes, what would the second wave look like?



**\*\*16 June 06 P1 Q25**

**25** The frequency of a certain wave is 500Hz and its speed is  $340\text{ m s}^{-1}$ .

What is the phase difference between the motions of two points on the wave 0.17 m apart?

- A  $\frac{\pi}{4}$  rad      B  $\frac{\pi}{2}$  rad      C  $\frac{3\pi}{4}$  rad      D  $\pi$  rad

**\*17 Nov 06 P1 Q24**

**\*17 Nov 06 P1 Q24**

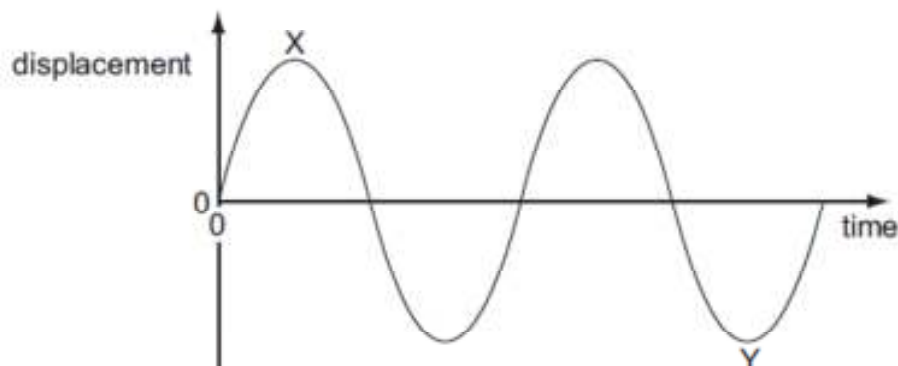
**24** A wave motion is described by the oscillation of particles.

What is the name given to the number of complete oscillations of a particle in one second?

- A amplitude  
B frequency  
C wavelength  
D wave speed

**\*\*18 Nov 06 Q25**

**25** A displacement-time graph for a transverse wave is shown in the diagram.



The phase difference between X and Y can be expressed as  $n\pi$ .

What is the value of  $n$ ?

- A 1.5      B 2.5      C 3.0      D 6.0

**\*\*19 June 07 P1 Q22**

**22** Sound wave X has intensity  $10^{12}$  times greater than that of sound wave Y.

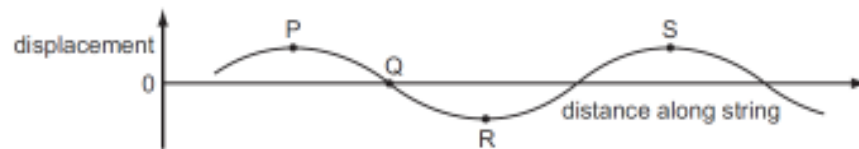
By how much is the amplitude of X greater than the amplitude of Y?



- A  $10^6$  times
- B  $3.16 \times 10^6$  times
- C  $5 \times 10^{11}$  times
- D  $10^{12}$  times

\*\*\*20 June 07 P1 Q23

- 23 The graph shows the shape at a particular instant of part of a transverse wave travelling along a string.



Which statement about the motion of points in the string is correct?

- A The speed at point P is a maximum.
- B The displacement at point Q is always zero.
- C The energy at point R is entirely kinetic.
- D The acceleration at point S is a maximum.

\*\*21 Nov 07 P1 Q21

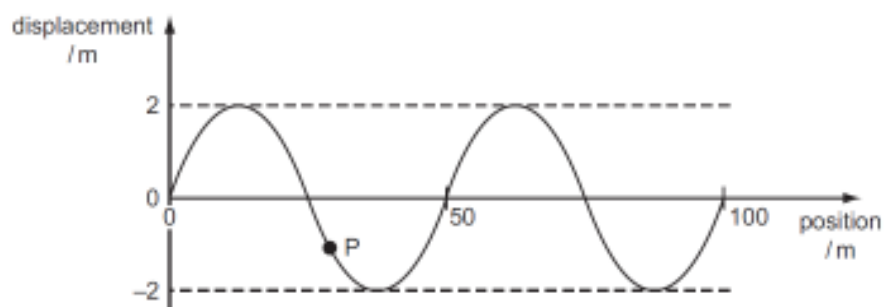
- 21 What is the relationship between the intensity  $I$  and the amplitude  $a$  of a wave?

- A  $\frac{I}{a} = \text{constant}$
- B  $\frac{I}{a^2} = \text{constant}$
- C  $Ia = \text{constant}$
- D  $Ia^2 = \text{constant}$

\*\*\*22 Nov 07 P1 Q23

- 23 The graph represents a sinusoidal wave in the sea, travelling at a speed of  $8.0 \text{ m s}^{-1}$ , at one instant of time. The maximum speed of the oscillating particles in the wave is  $2\pi af$ , where  $a$  is the amplitude and  $f$  is the frequency.





An object P of mass  $2.0 \times 10^{-3}$  kg floats on the surface.

What is the maximum kinetic energy of P due to the wave? Assume that its motion is vertical.

- A 0.026 mJ      B 4.0 mJ      C 39 mJ      D 64 mJ

**\*\*23 June 08 P1 Q25**



What are  $p$  and  $q$ ?

What are  $p$  and  $q$ ?

		$p$	$q$			$p$	$q$
h	A	displacement	wavelength	A	displacement	wavelength	
	B	displacement	period	B	displacement	period	
h	C	amplitude	wavelength	C	amplitude	wavelength	
	D	amplitude	period	D	amplitude	period	

**\*\*\*24 June 08 P1 Q26**

26 The intensity  $I$  of a sound at a point P is inversely proportional to the square of the distance  $x$  of P from the source of the sound. That is



Wave X has an amplitude of  $2.0 \mu\text{m}$ . Wave Y has an amplitude of  $4.0 \mu\text{m}$ .

Point P is situated a distance  $r$  from S.

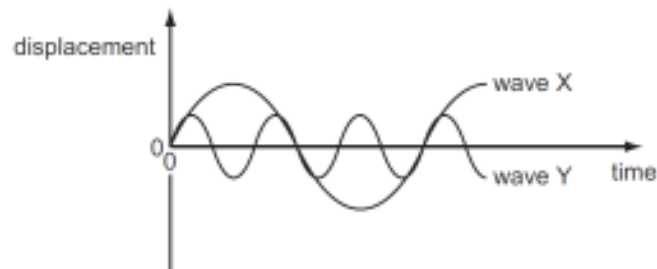
Point Q is situated a distance  $2r$  from S.

What is the amplitude of oscillation of air molecules at P? What is the amplitude of oscillation of air molecules at Q?

- A  $2.8 \mu\text{m}$    B  $4.0 \mu\text{m}$    C  $2.0 \mu\text{m}$    D  $1.4 \mu\text{m}$

**\*\*25 Nov 08 P1 Q24**

24 The diagram shows two waves X and Y.



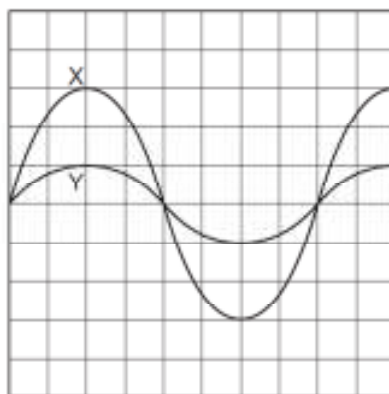
Wave X has amplitude  $8 \text{ cm}$  and frequency  $100 \text{ Hz}$ .

What are the amplitude and frequency of wave Y?

	amplitude / cm	frequency / Hz
A	2	33
B	2	300
C	4	33
D	4	300

**\*\*26 Nov 08 P1 Q26**

26 The diagram represents the screen of a cathode-ray oscilloscope displaying two sound waves labelled X and Y.



What is the ratio  $\frac{\text{intensity of sound wave X}}{\text{intensity of sound wave Y}}$ ?

- A  $\frac{9}{1}$       B  $\frac{3}{1}$       C  $\frac{\sqrt{3}}{1}$       D  $\frac{1}{1}$

### Polarisation

#### Determination of frequency, wavelength and velocity

\*1 June 03 P1 Q23

23 Which of the following is true for all transverse waves?

- A They are all electromagnetic.
- B They can all be polarised.
- C They can all travel through a vacuum.
- D They all involve the oscillation of atoms.

\*2 Nov 05 P1 Q22

Polarisation is a phenomenon associated with a certain type of wave.

Which condition **must** be fulfilled if a wave is to be polarised?

- A It must be a light wave.
- B It must be a longitudinal wave.
- C It must be a radio wave.
- D It must be a transverse wave.

\*3 June 06 P1 Q23

Which phenomenon is associated with transverse waves but **not** longitudinal waves?

- A polarisation
- B reflection
- C refraction
- D superposition

\*3 June 06 P1 Q23

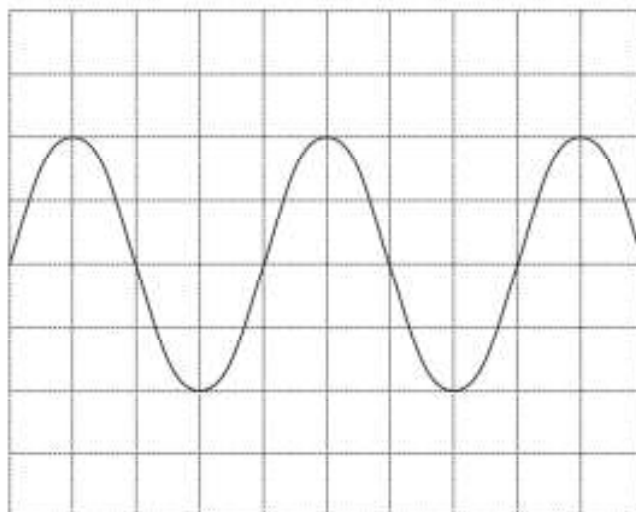
\*4 June 07 P1 Q21

21 Which of the following types of wave can be polarised?

- A a longitudinal progressive wave
- B a longitudinal stationary wave
- C a transverse stationary wave
- D a transverse sound wave

\*\*5 June 02 P1 Q26

26 The diagram shows a cathode-ray oscilloscope trace of a sound wave. The time-base is calibrated at  $2.0 \text{ ms cm}^{-1}$ .

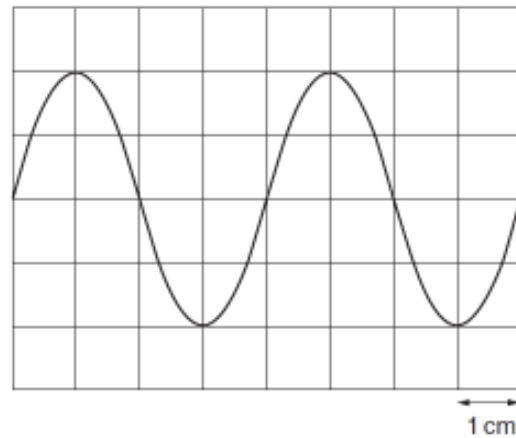


What is the frequency of the sound wave?

- A** 62.5 Hz      **B** 125 Hz      **C** 250 Hz      **D** 500 Hz

**\*\*6 June 03 P1 Q26**

**26** A sound wave is displayed on the screen of a cathode-ray oscilloscope. The time base of the c.r.o. is set at 2.5 ms / cm.



What is the frequency of the sound wave?

- A** 50 Hz      **B** 100 Hz      **C** 200 Hz      **D** 400 Hz

## Electromagnetic Waves

**\*\*1 June 02 P1 Q25**

- 25 Which of the following summarises the change in wave characteristics on going from infra-red to ultraviolet in the electromagnetic spectrum?

	frequency	speed (in a vacuum)
A	decreases	decreases
B	decreases	remains constant
C	increases	remains constant
D	increases	increases

**\*\*2 Nov 02 P1 Q25**

Which value is a possible wavelength for radiation in the microwave region of the electromagnetic spectrum?

- A  $3 \times 10^{-2} \text{ m}$       B  $3 \times 10^{-5} \text{ m}$       C  $3 \times 10^{-8} \text{ m}$       D  $3 \times 10^{-10} \text{ m}$

**\*\*3 June 03 P1 Q25**

Electromagnetic waves of wavelength  $\lambda$  and frequency  $f$  travel at speed  $c$  in a vacuum.

Which of the following describes the wavelength and speed of electromagnetic waves of frequency  $f/2$ ?

	wavelength	speed in a vacuum
A	$\lambda/2$	$c/2$
B	$\lambda/2$	$c$
C	$2\lambda$	$c$
D	$2\lambda$	$2c$

**\*\*4 12. June 04 P1Q27**

What is the approximate range of frequencies of infra-red radiation?

- A  $1 \times 10^3 \text{ Hz}$  to  $1 \times 10^9 \text{ Hz}$   
 B  $1 \times 10^9 \text{ Hz}$  to  $1 \times 10^{11} \text{ Hz}$   
 C  $1 \times 10^{11} \text{ Hz}$  to  $1 \times 10^{14} \text{ Hz}$   
 D  $1 \times 10^{14} \text{ Hz}$  to  $1 \times 10^{17} \text{ Hz}$

\*5 15. June 05 P1 Q23

What do not travel at the speed of light in a vacuum?

- A electrons
- B microwaves
- C radio waves
- D X-rays

\*5 15. June 05 P1 Q23

\*\*\*6 June 05 P1 Q24

24 The number of wavelengths of visible light in one metre is of the order of

- A  $10^6$ .
- B  $10^9$ .
- C  $10^8$ .
- D  $10^{10}$ .

\*\*7 June 07 P1 Q24

24 The diagram illustrates part of the electromagnetic spectrum.



Which labels are correct for the regions marked 1 and 2?

	1	2
A	infrared	X-rays
B	microwaves	X-rays
C	ultraviolet	microwaves
D	X-rays	infrared

\*\*8 Nov 07 P1 Q22

22 An electromagnetic wave has a frequency of  $10^8$  Hz.



In which region of the electromagnetic spectrum does the wave occur?

- A infra-red
- B radio
- C ultraviolet
- D visible

**\*9 Nov 08 P1 Q25**

**25** Light can exhibit all of the properties listed.

Which property can sound **not** exhibit?

- A interference
- B polarisation
- C refraction
- D total internal reflection

**\*\*10 June 09 P1 Q 23**

**23** Which wave properties change when light passes from air into glass?

- A colour and speed
- B frequency and wavelength
- C speed and wavelength
- D wavelength and colour

## Section B

**1 Nov 03 P2 Q25**

- (a) Fig. 4.1 shows the variation with time  $t$  of the displacement  $x$  of one point in a progressive wave.

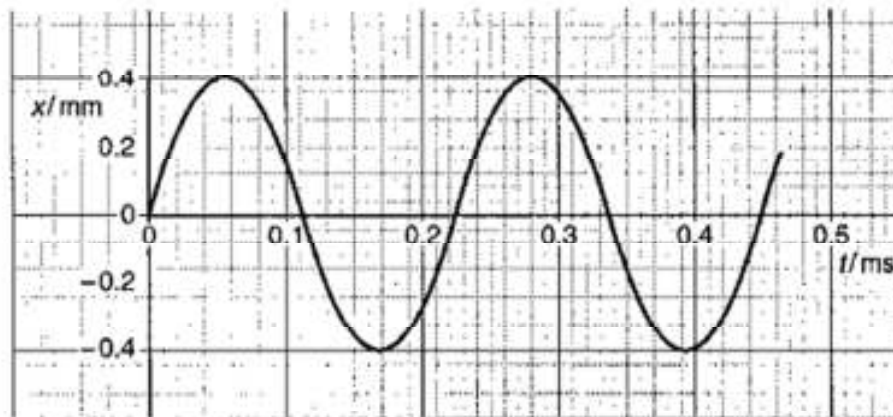


Fig. 4.1

Fig. 4.2 shows the variation with distance  $d$  along the same wave of the displacement  $x$ .

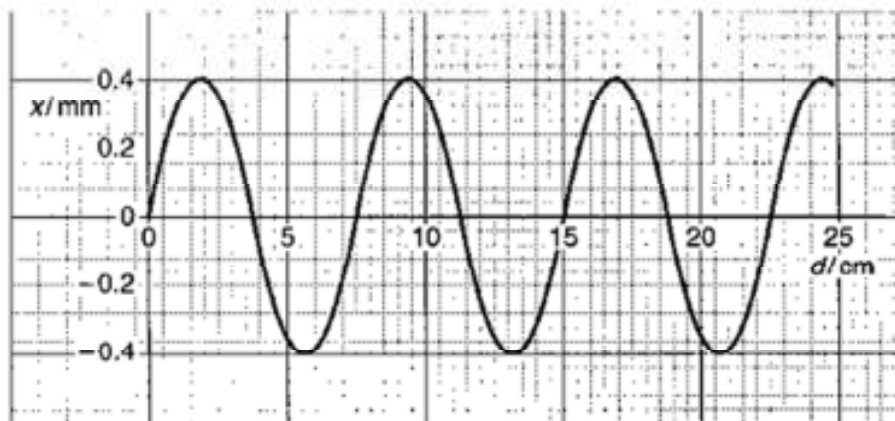


Fig. 4.2

- (i) Use Figs. 4.1 and 4.2 to determine, for this wave,

1. the amplitude,

amplitude = ..... mm

2. the wavelength,

wavelength = ..... m

3. the frequency,

frequency = ..... Hz

4. the speed.

speed = .....  $\text{m s}^{-1}$   
[6]

- (ii) On Fig. 4.2, draw a second wave having the same amplitude but half the frequency as that shown. [1]

2 June 04 P2 Q2

- 2 Fig. 2.1 shows the variation with distance  $x$  along a wave of its displacement  $d$  at a particular time.

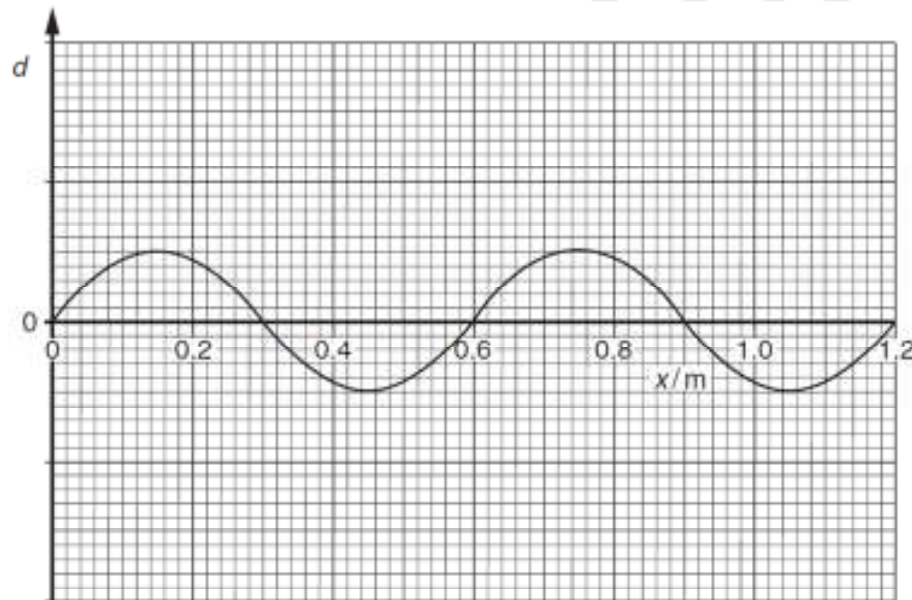


Fig. 2.1

The wave is a progressive wave having a speed of  $330 \text{ m s}^{-1}$ .

- (a) (i) Use Fig. 2.1 to determine the wavelength of the wave.

wavelength = ..... m

- (ii) Hence calculate the frequency of the wave.

frequency = ..... Hz  
[3]

- (b) A second wave has the same frequency and speed as the wave shown in Fig. 2.1 but has double the intensity. The phase difference between the two waves is  $180^\circ$ .

On the axes of Fig. 2.1, sketch a graph to show the variation with distance  $x$  of the displacement  $d$  of this second wave. [2]

### 3 Nov 04 P2 Q2

- 2 The spectrum of electromagnetic waves is divided into a number of regions such as radio waves, visible light and gamma radiation.

- (a) State three distinct features of waves that are common to all regions of the electromagnetic spectrum.

1. .... [3]
2. ....
3. ....

- (b) A typical wavelength of visible light is 495 nm. Calculate the number of wavelengths of this light in a wave of length 1.00 m.

number = ..... [2]

- (c) State a typical wavelength for

- (i) X-rays,

wavelength = ..... m

- (ii) infra-red radiation.

wavelength = ..... m  
[2]