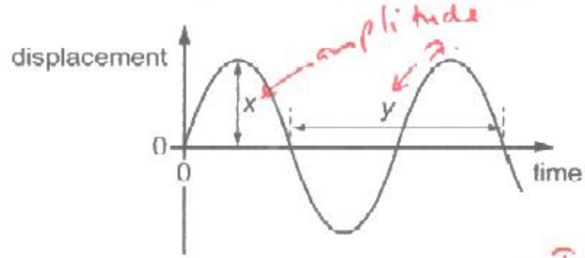
Waves – 2023 June AS Physics 9702

1. June/2023/Paper_ 9702/11/No.21

The graph shows the variation with time of the displacement of a particle in a progressive wave.



1λ = 1 period for progressive wave.

Two measurements, *x* and *y*, are labelled on the graph.

What do *x* and *y* represent?

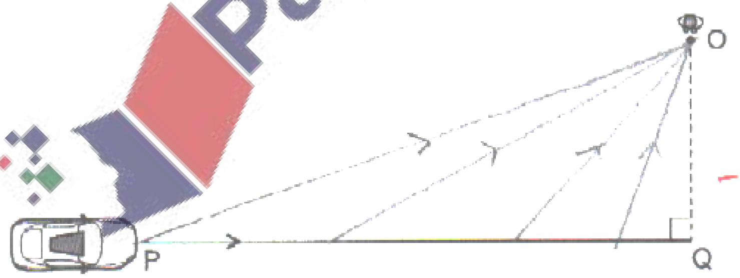
	x	*y*
A	amplitude	period
B	frequency	period
C	amplitude	wavelength
D	frequency	wavelength

- If it was stationary wave then y will be equal to λ.

2. June/2023/Paper_ 9702/11/No.22

A car travels at a constant speed along a straight line PQ.

A loudspeaker attached to the car emits sound of constant frequency *f*. A stationary observer is at point O.



- As car moves to Q, frequency will increase more than f.
- But as the distance the sound travels from car to O, the f decreases.

What does the observer hear as the car moves from P towards Q?

A a frequency less than *f* that decreases as the car moves from P towards Q

B a frequency less than *f* that increases as the car moves from P towards Q

C a frequency more than *f* that decreases as the car moves from P towards Q

D a frequency more than *f* that increases as the car moves from P towards Q

3. June/2023/Paper_ 9702/11/No.23

Some sources of electromagnetic waves in free space are listed.

1 a radio wave transmitter

2 a source of X-rays

3 a 30 mm wavelength radar transmitter

4 a light-emitting diode that emits red light

Which list gives the sources in order of increasing wavelength, from left to right, of the waves emitted by the sources?

A 1 → 3 → 4 → 2

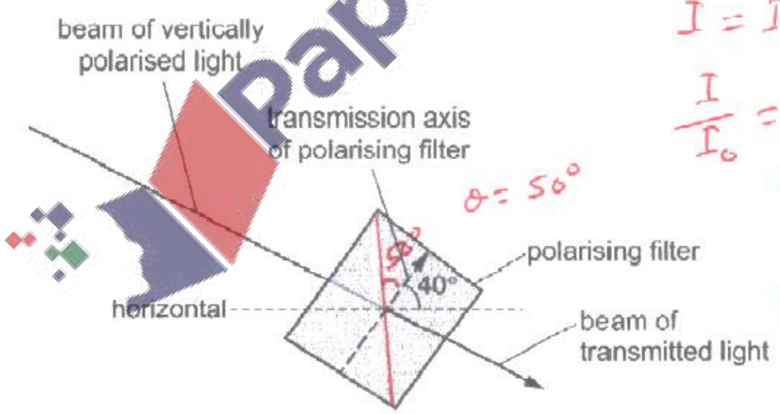
B 2 → 4 → 1 → 3

C 2 → 4 → 3 → 1

D 3 → 1 → 4 → 2

4. June/2023/Paper_ 9702/11/No.24

A vertically polarised beam of light is incident normally on a polarising filter. The transmission axis of the filter is at an angle of 40° to the horizontal.



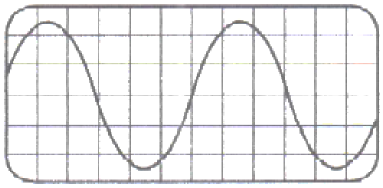
What is the ratio $\dfrac{\text{amplitude of transmitted beam}}{\text{amplitude of incident beam}}$?

A 0.41 B 0.59 C 0.64 D 0.77

5. June/2023/Paper_ 9702/12/No.20

A microphone detects a sound wave. The microphone is connected to a cathode-ray oscilloscope (CRO).

The shape of the trace on the screen of the CRO is shown.



Which property of the sound wave can be determined by using only the measurement of a horizontal distance on the screen and the value of a control setting of the CRO?

↑ time - base

Period, T = time-base × ? distance

$f = \frac{1}{T}$.

A amplitude

B frequency ✓

C speed

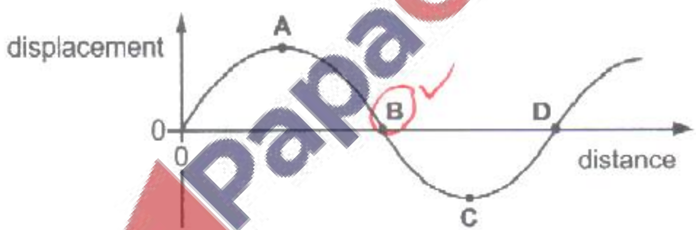
D wavelength

6. June/2023/Paper_ 9702/12/No.21

A longitudinal wave is travelling from left to right. The graph shows the variation of the displacement of the particles with distance along the wave at one instant in time.

Displacements to the right are positive; displacements to the left are negative.

Which labelled point represents a compression?



7. June/2023/Paper_ 9702/12/No.22

A source X emits a sound wave of constant frequency *f*.

The wave is subsequently received at a stationary detector Y.

The frequency of the wave that is detected by Y is less than *f*.

What could be the reason for this?

↑ Doppler effect

$f_o = \frac{f_s \times v}{v + v_s}$ ← moving away.

Since denominator is greater $(v + v_s)$, then f_o will smaller

A Between X and Y, the wave undergoes diffraction.

B Between X and Y, the wave undergoes reflection.

C X is moving away from Y. ✓

D X is moving towards Y.

8. June/2023/Paper_ 9702/12/No.23

A beam of visible light is in a vacuum.

What could be the frequency of the light?

A 5.0×10^{5} Hz **B** 5.0×10^{8} Hz **C** 5.0×10^{11} Hz **(D)** 5.0×10^{14} Hz ✓

λ of visible light = 4×10^{-7} m.

$v = 3.0 \times 10^{8}\ \text{m s}^{-1}$

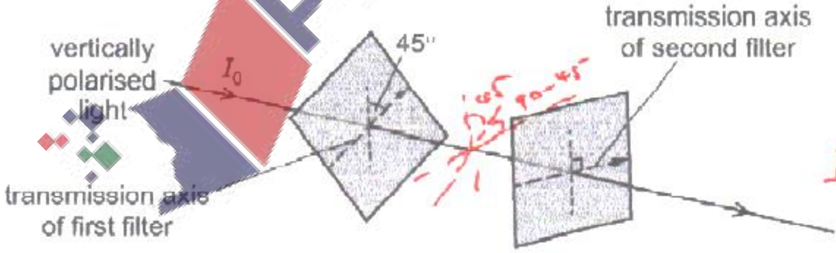
$\therefore f = \frac{v}{\lambda} = \frac{3.0 \times 10^{8}}{4.0 \times 10^{-7}}$

$= 7.5 \times 10^{14}$ Hz

9. June/2023/Paper_ 9702/12/No.24

A vertically polarised beam of light of intensity I_0 is incident normally on a polarising filter.

The transmission axis of the filter is at 45° to the vertical. The beam of light transmitted by this filter is then incident normally on a second filter. The transmission axis of the second filter is horizontal.



$I_1 = I_0 \cos^2\theta$
$= I_0 \cos^2 45°$
$= \frac{1}{2} I_0$.
$I_2 = I_1 \cos^2\theta$
$= I_1 \cos^2 45$
$= I_1 \times \frac{1}{2}$
$\therefore I_2 = \frac{1}{2} \times \frac{1}{2} \times I_0$
$= \frac{1}{4} I_0$

What is the intensity of the beam of light after transmission through the second filter?

A 0 **(B)** $\frac{1}{4} I_0$ ✓ **C** $\frac{1}{2} I_0$ **D** I_0

10. June/2023/Paper_ 9702/13/No.20

A progressive wave of frequency 1.5 kHz travels in a medium at a speed of $340\,m\,s^{-1}$.

What is the minimum distance between two points on the wave that have a phase difference of 70°?

A 4.4 cm **B** 8.8 cm **C** 18 cm **D** 23 cm

$p.d = 360 \times \frac{x}{\lambda}$

$\lambda = \frac{v}{f} = \frac{340}{1.5\times10^3}$

$\therefore 70° = 360 \times \frac{x}{\left(\frac{340}{1.5\times10^3}\right)}$

$x = \frac{70° \times \frac{340}{1.5\times10^3}}{360}$

$= 0.044\,m$

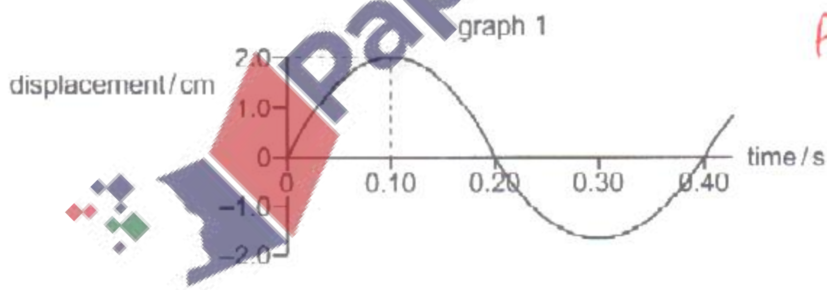
$= 0.044 \times 100$

$= 4.4\,cm$

11. June/2023/Paper_ 9702/13/No.21

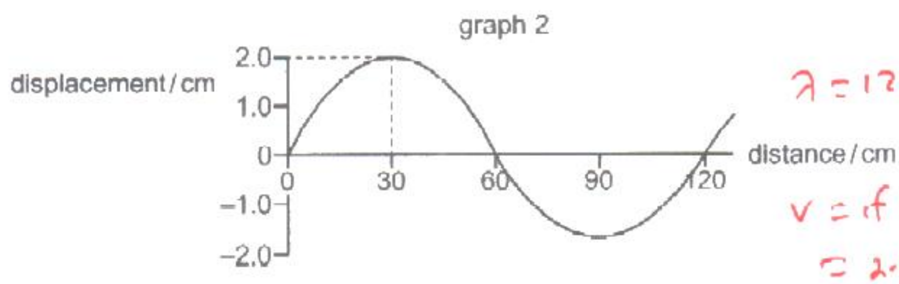
Graph 1 shows the variation with time of displacement at a fixed distance along a progressive wave.

Graph 2 represents the same wave and shows the variation with distance of displacement at an instant in time.



Period, $T = 0.40\,s$

$f = \frac{1}{T} = \frac{1}{0.4} = 2.5\,Hz$



$\lambda = 120\,cm$

$v = f \times \lambda = 2.5 \times 120 = 300\,cm\,s^{-1}$

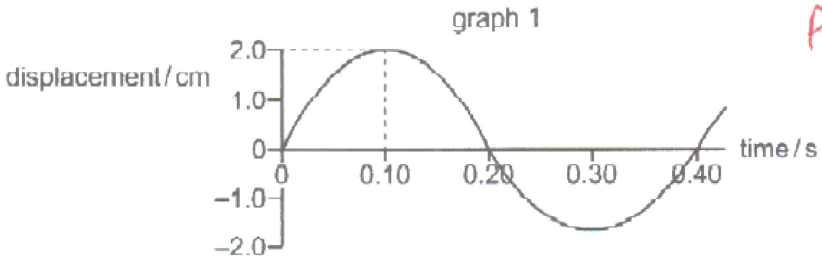
What is the speed of the wave?

A $5.0\,cm\,s^{-1}$ **B** $48\,cm\,s^{-1}$ **C** $150\,cm\,s^{-1}$ **D** $300\,cm\,s^{-1}$

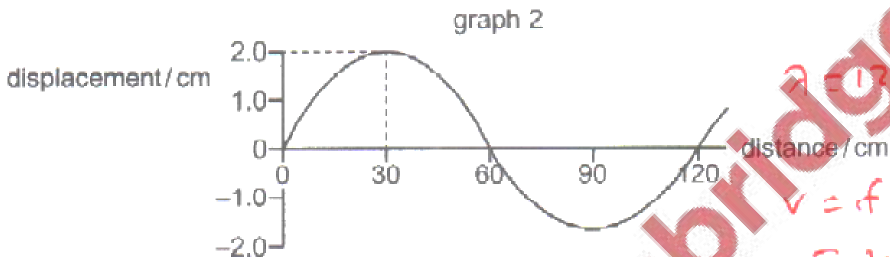
12. June/2023/Paper_ 9702/13/No.22

Graph 1 shows the variation with time of displacement at a fixed distance along a progressive wave.

Graph 2 represents the same wave and shows the variation with distance of displacement at an instant in time.



Period $T = 0.40$ s
$f = \frac{1}{T}$
$= \frac{1}{0.4}$
$= 2.5$ Hz.



$\lambda = 120$ cm.

$v = f \times \lambda$
$= 2.5 \times 120$
$= 300$ cm s^{-1}

What is the speed of the wave?

A $5.0\,cm\,s^{-1}$ B $48\,cm\,s^{-1}$ C $150\,cm\,s^{-1}$ (D) $300\,cm\,s^{-1}$ ✓

13. June/2023/Paper_ 9702/13/No.23

A vehicle moves with constant velocity along a road directly towards an observer. The observed frequency of the sound from the vehicle changes as the vehicle moves past the observer.

Which phenomenon explains the change in frequency?

A diffraction

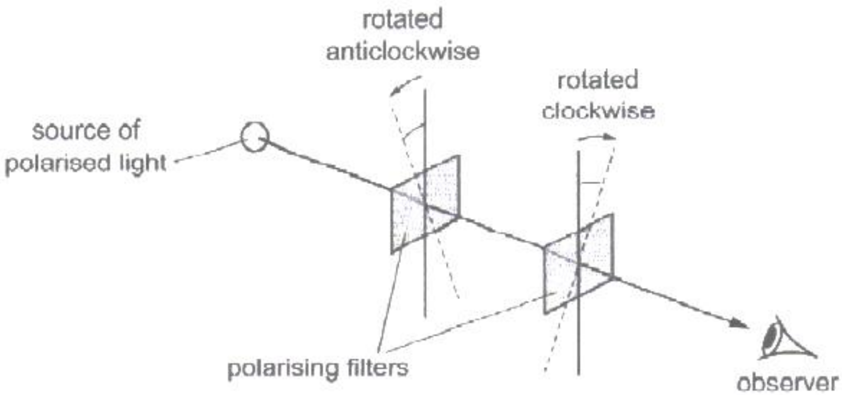
B interference

C polarisation

(D) the Doppler effect ✓ ← A change in observed frequency due to relative motion between source and observer.

14. June/2023/Paper_ 9702/13/No.24

A source of plane polarised light is observed through two polarising filters.



The filters are positioned so that the source appears at its brightest. One of the filters is then rotated clockwise and the other filter is rotated anticlockwise through the same angle.

How does the source appear when both filters have been rotated 90° and 180° from their initial positions?

	90°	180°
A	brightest	brightest
B	brightest	darkest
(C) ✓	darkest	brightest
D	darkest	darkest

- At 90°, the planes of polarisation for both are perpendicular, so light is blocked by the 2nd filter.
- At 180° the planes are parallel, so the 2nd filter will allow light to pass through.

15. June/2023/Paper_ 9702/21/No.5(a)

(a) An electromagnetic wave in a vacuum has a wavelength of 8.4×10^{-6} m.

(i) State the name of the principal region of the electromagnetic spectrum for the wave.

Infrared .... [1]

(ii) Calculate the frequency, in THz, of the wave.

$v = f \times \lambda$

$f = \frac{v}{\lambda}$

$= \frac{3.0 \times 10^{8} ms^{-1}}{8.4 \times 10^{-6} m}$

$= 3.57 \times 10^{13}$ Hz

Tera $= 10^{12}$

$\therefore 3.57 \times 10^{1} \times 10^{12}$

35.7×10^{12}

35.7 THz $\simeq 36$ THz

frequency = ...36.......... THz [2]

16. June/2023/Paper_ 9702/22/No.5(a, b)

(a) A progressive wave travels through a medium. The wave causes a particle of the medium to vibrate along a line P. The energy of the wave propagates along a line Q.

Compare the directions of lines P and Q if the wave is:

(i) a transverse wave

P and Q are perpendicular to each other .... [1]

(ii) a longitudinal wave.

P and Q are parallel. .... [1]

(b) A tube is closed at one end. A loudspeaker is placed near the other end of the tube, as shown in Fig. 5.1.

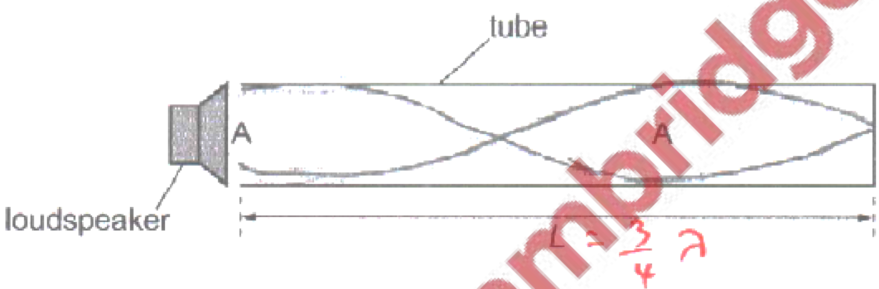


Fig. 5.1 (not to scale)

The loudspeaker emits sound of frequency 1.7 kHz. The speed of sound in the air in the tube is 340 m s^{-1}. A stationary wave is formed with an antinode A at the open end of the tube. There is only one other antinode A inside the tube, as shown in Fig. 5.1.

Determine:

(i) the wavelength of the sound

$v = f \times \lambda$

$\lambda = \frac{v}{f}$

$= \frac{340}{1.7 \times 10^3}$

$= 0.20\,m$

wavelength = 0.20 m [2]

(ii) the length L of the tube

$L = \frac{3}{4}\lambda$

$= \frac{3}{4} \times 0.20$

$= 0.15\,m$

L = 0.15 m [1]

(iii) the maximum wavelength of the sound from the loudspeaker that can produce a stationary wave in the tube.

$\lambda = 4 \times 0.15$

$= 0.60\,m$

maximum wavelength = 0.60 m [1]

17. June/2023/Paper_ 9702/23/No.4(a _ c)

(a) For a progressive wave, state what is meant by the frequency.

– The number of wavefronts passing a fi

point per unit time.

(b) A loudspeaker, microphone and cathode-ray oscilloscope (CRO) are arranged as show Fig. 4.1.

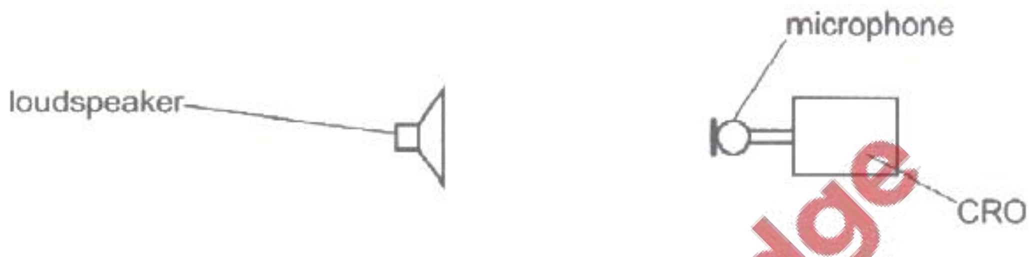


Fig. 4.1

The loudspeaker is emitting a sound wave which is detected by the microphone and displa on the screen of the CRO as shown in Fig. 4.2.

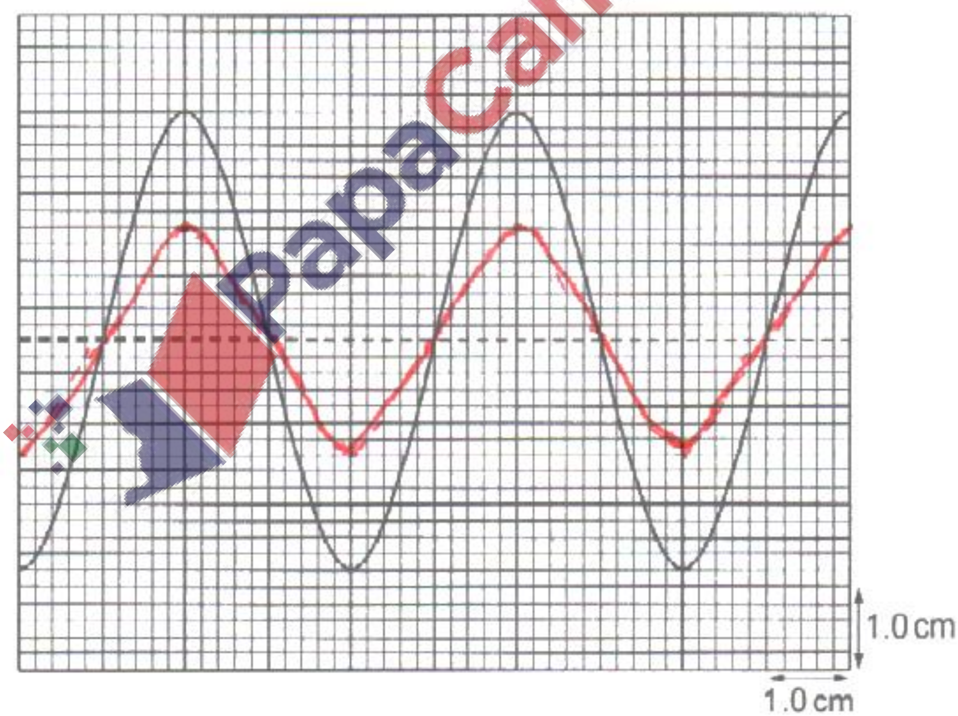


Fig. 4.2

The time-base on the CRO is set to 0.50 ms cm^{-1} and the *y*-gain is set to 0.20 V cm^{-1}.

Calculate:

(i) the frequency of the sound wave

Period, T = time-base × λ

= 0·50 ms cm⁻¹ × 4 cm

= 2×10^{-3} s

$f = \frac{1}{T}$

$= \frac{1}{2 \times 10^{-3}}$

= 500 Hz

frequency = ...500...... Hz [2]

(ii) the amplitude of the signal received by the CRO.

Amplitude = 0·2 V cm⁻¹ × 2·8 cm

= 0·56 V

amplitude = ...0·56...... V [1]

(c) The intensity of the sound wave in **(b)** is reduced to a quarter of its original intensity without a change in frequency. Assume that the amplitude of the signal received by the CRO is proportional to the amplitude of the sound wave.

On Fig. 4.2, sketch the trace that is now seen on the screen of the CRO. [3]

$I \propto A^2$

$2.8^2 = 7.84$

$7.84 \times \frac{1}{4} = 1.96$

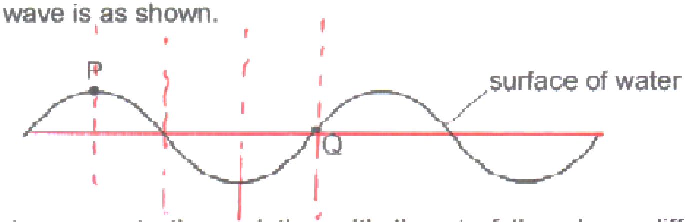
$\sqrt{1.96} = 1.4$

⇒ Amplitude = 1.4 cm.

18. March/2023/Paper_ 9702/12/No.20

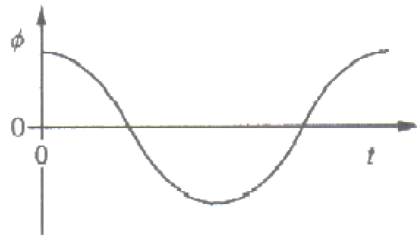
In a progressive water wave, two particles, P and Q, on the surface of the water, are a fixed horizontal distance apart. P and Q oscillate vertically.

At time t = 0, the wave is as shown.



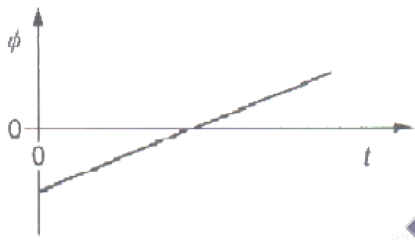
Which graph best represents the variation with time t of the phase difference ϕ between the oscillation of the water particle P and the oscillation of the water particle Q?

A

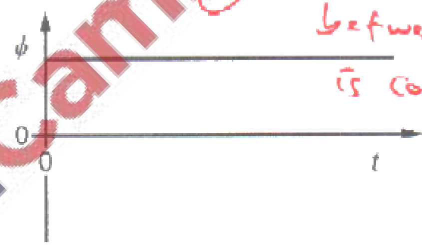


B

C



D ✓ Phase difference between P and Q is constant at $\frac{3}{4}\lambda$.



19. March/2023/Paper_ 9702/12/No.21

Which statement about longitudinal waves and transverse waves is **not** correct?

A Both waves can be polarised. ← only transverse gets polarised, the longitudinal cannot be polarised.

B Both waves can form stationary waves. ✓

C Both waves can transfer energy as progressive waves. ✓

D Both waves obey the equation $v = f\lambda$. ✓

20. March/2023/Paper_ 9702/12/No.22

An observer hears a sound wave emitted from a moving source.

The observed frequency is less than the frequency of sound emitted from the source.

What could be the reason for this?

Doppler effect

$f_o = \frac{f_s \times v}{v + v_s}$ } moving away

$f_o < f_s$

A The source is moving away from the observer. ✓

B The source is moving towards the observer.

C The speed of the sound wave in air decreases due to the movement of the source.

D The speed of the sound wave in air increases due to the movement of the source.

21. March/2023/Paper_ 9702/12/No.23

What is the approximate range of frequencies of electromagnetic radiation visible to the human eye?

A (430–750) kHz — 4.3×10^5

B (430–750) MHz — 4.3×10^8

C (430–750) GHz — 4.3×10^{11}

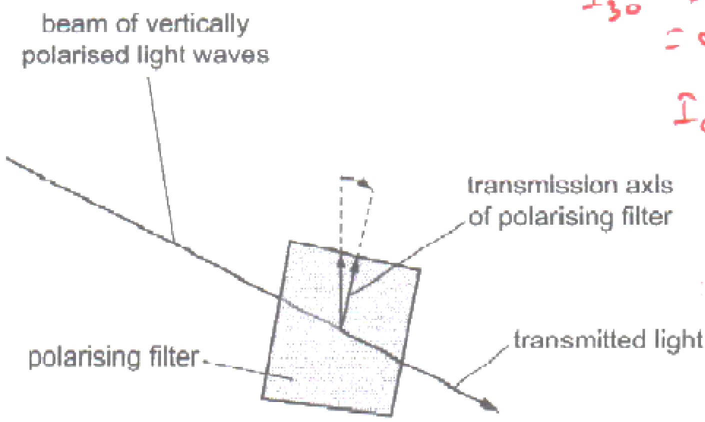
D (430–750) THz — 430×10^{12} Hz $= 4.30 \times 10^{14}$ Hz ✓

22. March/2023/Paper_ 9702/12/No.24

A beam of vertically polarised light is incident normally on a polarising filter. The filter can be rotated so that it is always in a plane perpendicular to the beam. The transmission axis of the filter is initially vertical.

$I_{30} = I_0 \cos^2 30°$
$= 0.75 I_0$.

$I_{60} = I_{30} \cos^2 60°$
$= 0.25 I_0$



The filter is first rotated clockwise by an angle of 30° so that the transmitted light waves have intensity I_{30}. The filter is then rotated clockwise by a further angle of 30°.

What is the new intensity of the transmitted light waves?

A $0.25 I_{30}$ **B** ✓ $0.33 I_{30}$ C $0.75 I_{30}$ D $0.87 I_{30}$

$I_{30} = 0.75 I_0 = \frac{3}{4} I_0$

$I_0 = \frac{4}{3} I_{30}$

$I_{60} = \frac{1}{4} I_0$

$= \frac{1}{4} \times \frac{4}{3} I_{30}$

$= \frac{1}{3} I_{30} = 0.33 I_{30}$

23. March/2023/Paper_ 9702/12/No.27

A transmitting mast sends out microwaves of wavelength 1.5 cm and radio waves of wavelength 1.5 km.

NOT TO SCALE

A receiving aerial behind a mountain can detect the radio waves but not the microwaves.

What is the reason for this?

A The radio waves are coherent but the microwaves are not.

B The radio waves are diffracted around the mountain but the microwaves are not.

C The radio waves are reflected by the mountain but the microwaves are not.

D The radio waves travel at the speed of light but the microwaves do not.

24. March/2023/Paper_ 9702/22/No.5a(I, ii)

(a) A microphone and cathode-ray oscilloscope (CRO) are used to analyse a sound wave of frequency 5000 Hz. The trace that is displayed on the screen of the CRO is shown in Fig. 5.1.

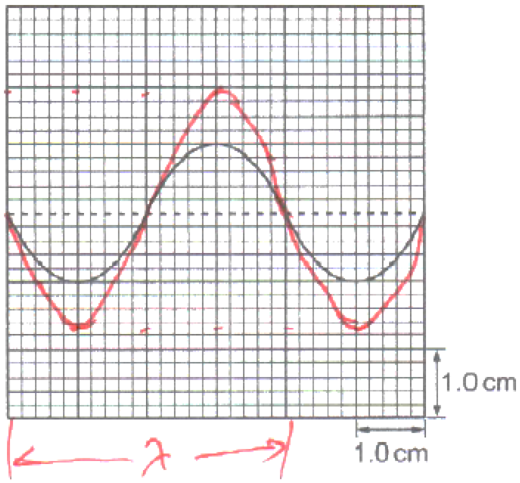


Fig. 5.1

$I \propto A^2$

$\sqrt{I} \propto A$

$\therefore \sqrt{3I} \propto (1.7A)^2$

- so the amplitude increases by 1.7 cm, when value of intensity is 3I.

(i) Determine the time-base setting, in $s\,cm^{-1}$, of the CRO.

Period T, = time-base × horizontal distance (λ).

$T = \frac{1}{f}$

$= \frac{1}{5000}$

$= 2.0 \times 10^{-4}\,s$

Time-base $= \frac{2.0 \times 10^{-4}\,s}{4\,cm}$

$= 5.0 \times 10^{-6}\,s\,cm^{-1}$

time-base setting = 5.0×10^{-6} $s\,cm^{-1}$ [2]

(ii) The intensity of the sound detected by the microphone is now increased from its initial value of I to a new value of $3I$. The frequency of the sound is unchanged. Assume that the amplitude of the trace on the CRO screen is proportional to the amplitude of the sound wave.

On Fig. 5.1, sketch the new trace shown on the screen of the CRO. [3]