

PHYSICS



EXAM QUESTION PACK

7 WAVES

SCORE

/

PERCENTAGE

%

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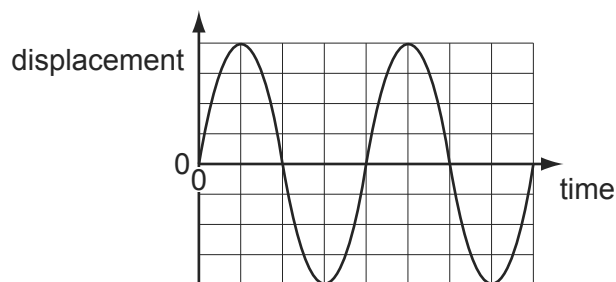
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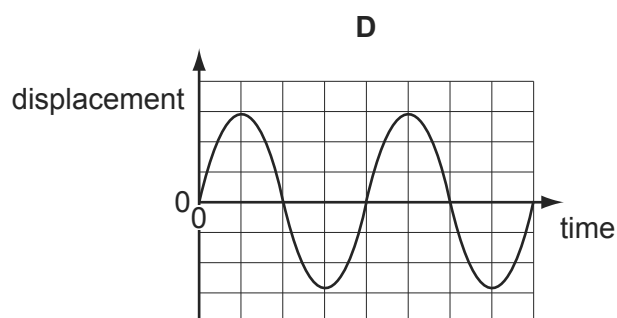
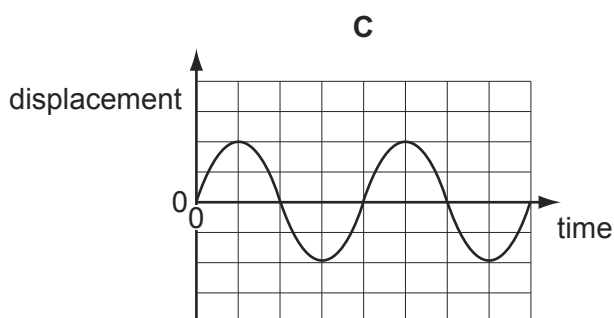
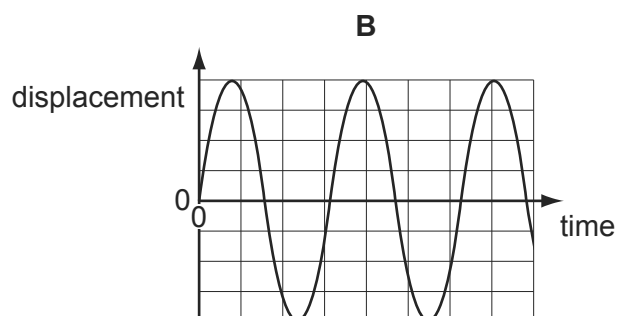
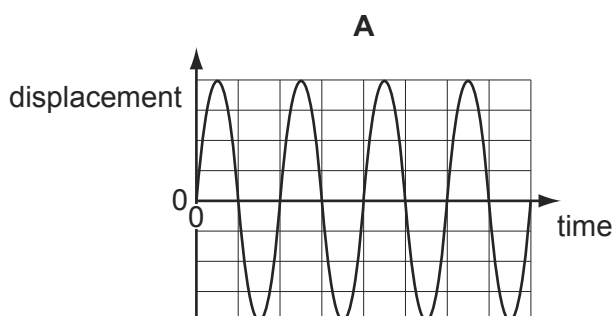
89 The diagram shows a graph of displacement against time for a sound wave.

9702/11/O/N/12/Q26



The intensity of the sound is halved.

Which graph shows the displacement of this sound wave?



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

9702/11/O/N/12/Q27

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

91 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 $2I$.

9702/13/O/N/12/Q29

What is the corresponding amplitude of the sound wave?

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

- 92 Diffraction can be observed when a wave passes an obstruction. The diffraction effect is greatest when the wavelength and the obstruction are similar in size. 9702/13/O/N/12/Q28

For waves travelling through air, what is the combination of wave and obstruction that could best demonstrate diffraction?

- A** microwaves passing a steel post
- B** radio waves passing a copper wire
- C** sound waves passing a human hair
- D** visible light waves passing a gate post

- 93 A wave has a speed of 340 ms^{-1} and a period of 0.28 ms . 9702/11/M/J/13/Q25

What is its wavelength?

- A** 0.095 m **B** 95 m **C** $1.2 \times 10^3 \text{ m}$ **D** $1.2 \times 10^6 \text{ m}$

- 94 Which line in the table summarises the change in wave characteristics on going from infra-red to ultraviolet in the electromagnetic spectrum? 9702/11/M/J/13/Q26

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

- 95 A light wave of amplitude A is incident normally on a surface of area S . The power per unit area reaching the surface is P . 9702/11/M/J/13/Q24

The amplitude of the light wave is increased to $2A$. The light is then focussed on to a smaller area $\frac{1}{3}S$.

What is the power per unit area on this smaller area?

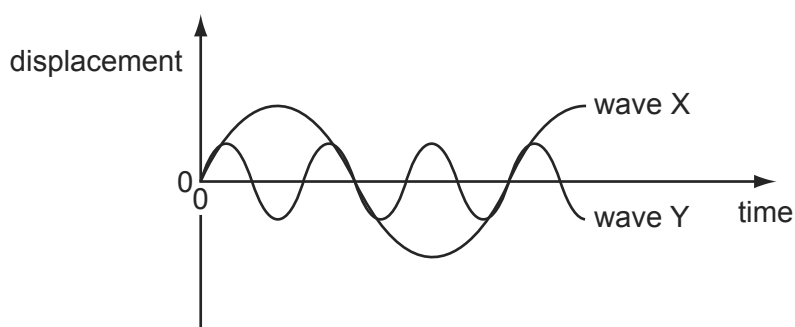
- A** $36P$
- B** $18P$
- C** $12P$
- D** $6P$

- 96 The order of magnitude of the frequency of the shortest wavelength of visible light waves can be expressed as 10^x Hz. 9702/12/M/J/13/Q24

What is the value of x ?

- A** 12 **B** 13 **C** 14 **D** 15

- 97 The diagram shows two waves X and Y. 9702/12/M/J/13/Q25



Wave X has amplitude 8 cm and frequency 100 Hz.

What are the amplitude and the frequency of wave Y?

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

- 98 What is correct for all transverse waves? 9702/12/M/J/13/Q26

- 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.

- 99 Which statement about different types of electromagnetic wave is correct? 9702/13/M/J/13/Q22

- A** The frequency of infra-red waves is less than the frequency of blue light.
B The frequency of radio waves is greater than the frequency of gamma rays.
C The wavelength of red light is less than the wavelength of ultraviolet waves.
D The wavelength of X-rays is greater than the wavelength of microwaves.

- 100 Electromagnetic waves of wavelength λ and frequency f travel at speed c in a vacuum.

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

9702/13/M/J/13/Q24

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

- 101 Orange light has a wavelength of 600 nm.

9702/13/M/J/13/Q23

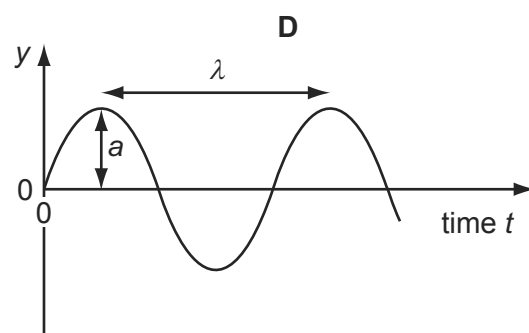
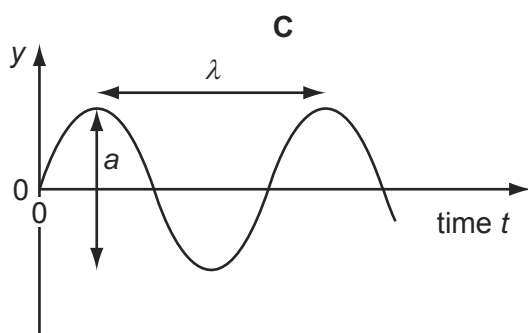
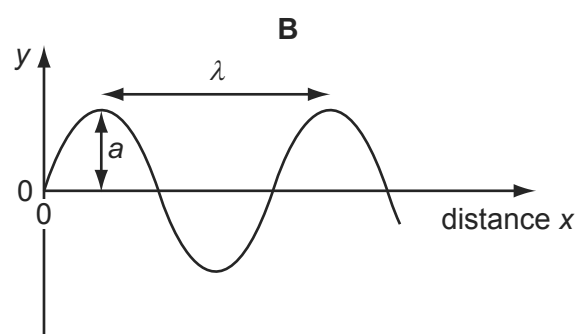
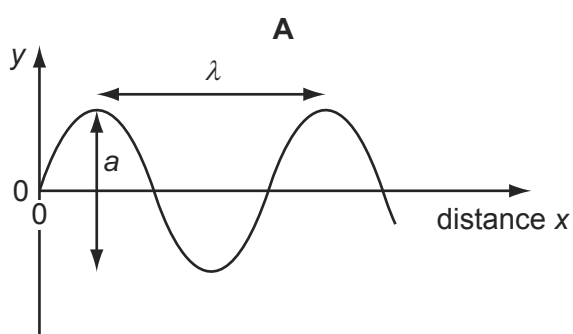
What is the frequency of this light?

- A** 180 GHz **B** 180 Hz **C** 500 THz **D** 500 kHz

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

9702/13/M/J/13/Q26

Which graph correctly shows the amplitude a and the wavelength λ of the wave?



- 103 When the liquid crystal display of a calculator is observed through a polarising film, the display changes as the film is rotated. 9702/13/M/J/13/Q25

Which property describes the radiation from the calculator display?

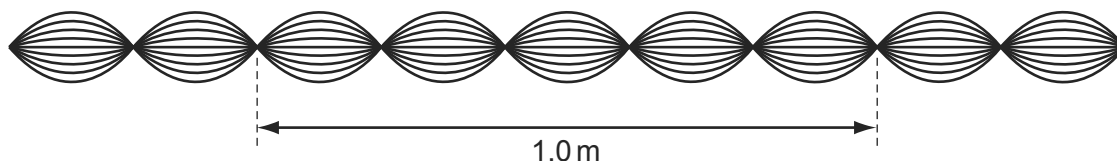
- A unpolarised
- B a longitudinal wave
- C a transverse wave
- D a wave with a 3 cm wavelength

- 104 A wave has a frequency of 5 GHz. 9702/11/M/J/13/Q4

What is the period of the wave?

- A 20 000 μs
- B 20 ns
- C 2 ns
- D 200 ps

- 105 The diagram shows a sketch of a wave pattern, over a short period of time. 9702/11/O/N/13/Q25



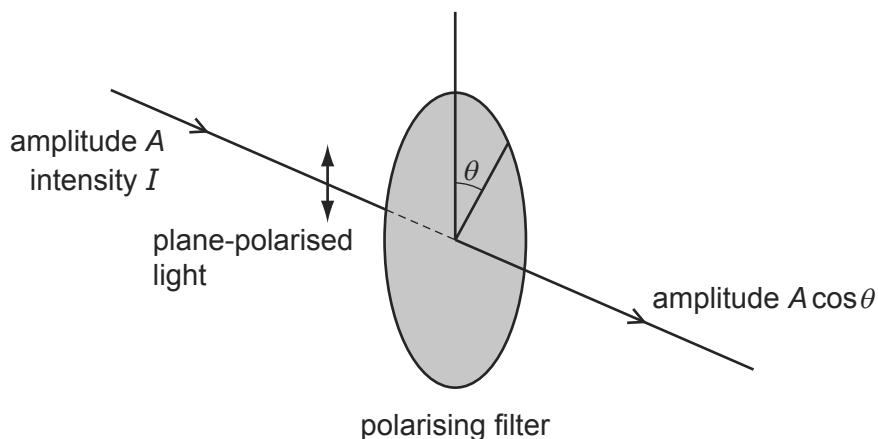
Which description of this wave is correct?

- A The wave is longitudinal, has a wavelength of 20 cm and is stationary.
- B The wave is transverse, has a wavelength of 20 cm and is stationary.
- C The wave is transverse, has a wavelength of 40 cm and is progressive.
- D The wave is transverse, has a wavelength of 40 cm and is stationary.

- 106 Which statement about a light wave and a sound wave is correct? 9702/11/O/N/13/Q26

- A Both can be polarised.
- B Both can travel through free space.
- C Both have a frequency inversely proportional to their wavelength.
- D Both have an intensity proportional to their amplitude.

- 107 When plane-polarised light of amplitude A is passed through a polarising filter as shown, the amplitude of the light emerging is $A \cos \theta$. 9702/11/O/N/13/Q30

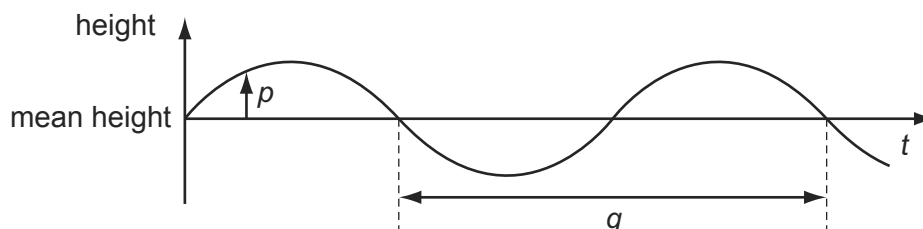


The intensity of the initial beam is I .

What is the intensity of the emerging light when θ is 60.0° ?

- A** $0.250I$ **B** $0.500I$ **C** $0.750I$ **D** $0.866I$

- 108 The graph shows how the height of the water surface at a point in a harbour varies with time t as waves pass the point. 9702/13/O/N/13/Q25



What are p and q ?

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

- 109 Electromagnetic waves from an unknown source in space were found to be significantly diffracted when passing through gaps of the order of 10^{-5} m.

9702/13/O/N/13/Q24

Which type of wave are they most likely to be?

- A** radio waves
- B** microwaves
- C** infra-red waves
- D** ultraviolet waves

- 110 A cathode-ray oscilloscope (c.r.o.) displays a waveform corresponding to a sound wave.

In order to determine the frequency of the sound wave, which part of the displayed waveform must be measured and which c.r.o. setting must be known?

9702/13/M/J/14/Q25

	on-screen measurement	c.r.o. setting
A	amplitude	time-base
B	amplitude	Y-gain
C	wavelength	time-base
D	wavelength	Y-gain

- 111 Which statement about longitudinal waves is correct?

9702/11/M/J/14/Q22

- A** Longitudinal waves include radio waves travelling through air.
- B** Particles in a longitudinal wave vibrate at right-angles to the direction of transfer of wave energy.
- C** Some types of longitudinal wave can be polarised.
- D** Stationary waves can be produced by the superposition of longitudinal waves.

- 112 The order of magnitude of the frequency of the longest-wavelength ultraviolet waves can be expressed as 10^x Hz.

9702/11/M/J/14/Q23

What is the value of x ?

- A** 13
- B** 15
- C** 17
- D** 19

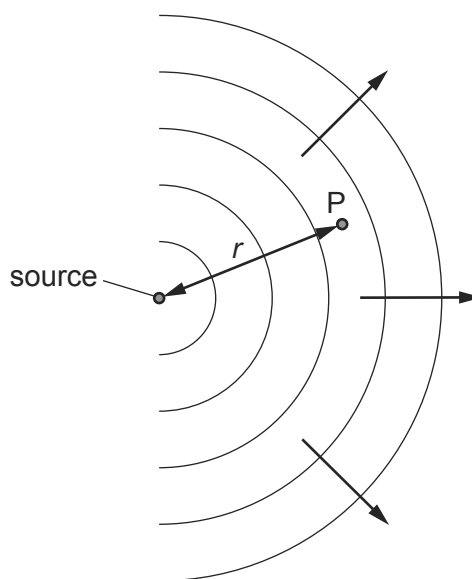
113 What is the approximate range of frequencies of infra-red radiation?

9702/13/M/J/14/Q26

- 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 $1 \times 10^{17} \text{ Hz}$

114 A small source emits spherical waves.

9702/13/M/J/14/Q27



The wave intensity I at any point P, a distance r from the source, is inversely proportional to r^2 .

What is the relationship between the wave amplitude a and the distance r ?

- A** $a^2 \propto \frac{1}{r}$ **B** $a \propto \frac{1}{r}$ **C** $a \propto \frac{1}{r^2}$ **D** $a \propto \frac{1}{r^4}$

115 The speed v of waves in deep water is given by the equation $v^2 = \frac{g\lambda}{2\pi}$

9702/11/M/J/14/Q24

where λ is the wavelength of the waves and g is the acceleration of free fall.

A student measures the wavelength λ and the frequency f of a number of these waves.

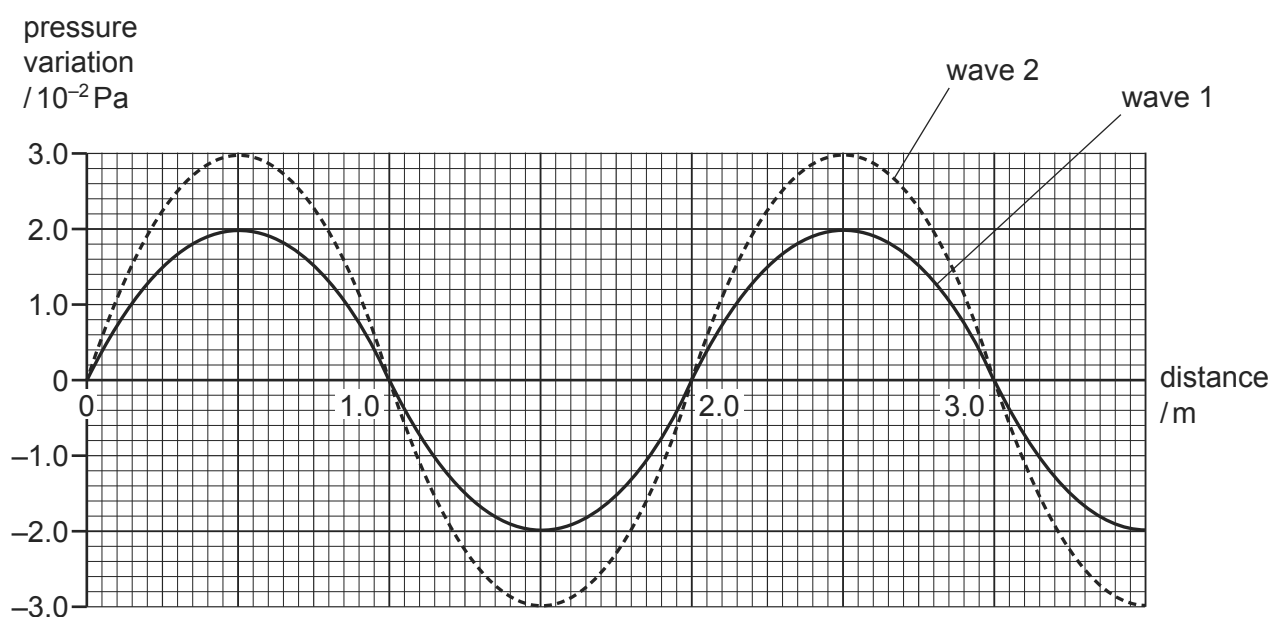
Which graph should he plot to give a straight line through the origin?

- A** f^2 against λ
B f against λ^2
C f against $\frac{1}{\lambda}$
D f^2 against $\frac{1}{\lambda}$

- 116 A sound wave consists of a series of moving pressure variations from the normal, constant air pressure.

9702/12/M/J/14/Q23

The graph shows these pressure variations for two waves at one instant in time.



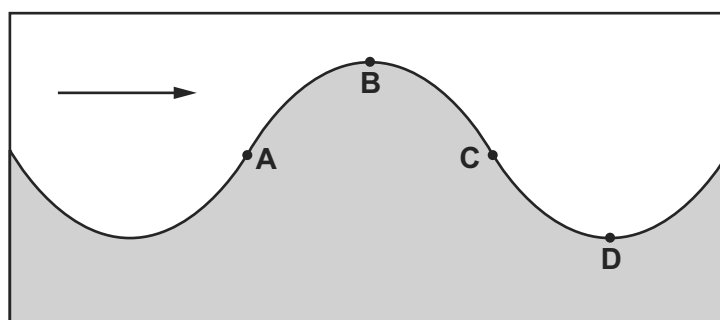
Wave 1 has an intensity of $1.6 \times 10^{-6} \text{ W m}^{-2}$.

What is the intensity of wave 2?

- A** $2.4 \times 10^{-6} \text{ W m}^{-2}$
 - B** $3.0 \times 10^{-6} \text{ W m}^{-2}$
 - C** $3.6 \times 10^{-6} \text{ W m}^{-2}$
 - D** $4.5 \times 10^{-6} \text{ W m}^{-2}$
- 117 The diagram shows a vertical cross-section through a water wave moving from left to right.

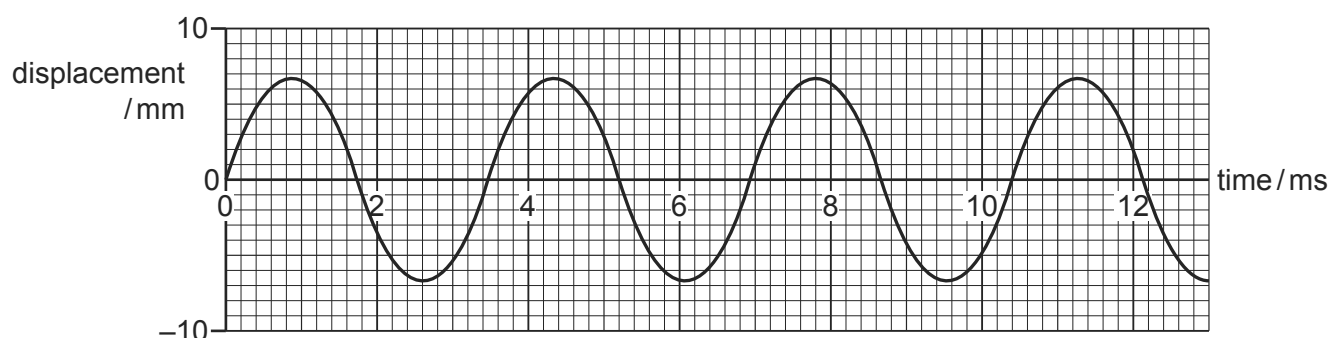
9702/12/M/J/14/Q24

At which point is the water moving upwards with maximum speed?



- 118 What, to two significant figures, are the period, the frequency and the amplitude of the wave represented by the graph?

9702/12/M/J/14/Q22



	period /s	frequency /Hz	amplitude /m
A	0.0027	370	0.0067
B	0.0031	320	0.013
C	0.0035	290	0.0067
D	0.0042	240	0.013

- 119 Which statement about waves is correct?

9702/13/O/N/14/Q26

- A** All electromagnetic waves travel at the same speed in a vacuum.
- B** Longitudinal waves can be polarised.
- C** The amplitude of a wave is directly proportional to the energy transferred by the wave.
- D** The frequency of infra-red light is greater than the frequency of ultra-violet light.

- 120 Which statement describes a situation when polarisation could **not** occur?

9702/11/O/N/14/Q24

- A** Light waves are reflected.
- B** Light waves are scattered.
- C** Microwaves pass through a metal grid.
- D** Sound waves pass through a metal grid.

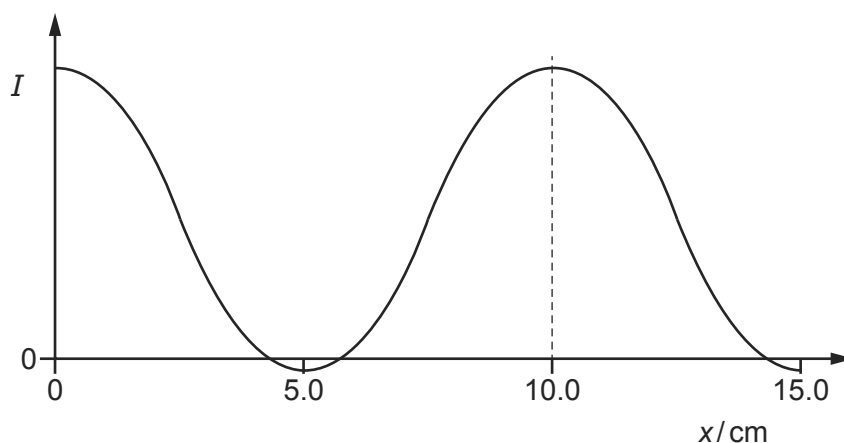
- 121 A stationary sound wave is produced in a tube.

9702/11/O/N/14/Q25

Which statement describes the wave speed?

- A** It is the distance between two adjacent nodes divided by the period of the wave.
- B** It is the speed at which energy is transferred from one antinode to an adjacent antinode.
- C** It is the speed of a particle at an antinode.
- D** It is the speed of one of the progressive waves that are producing the stationary wave.

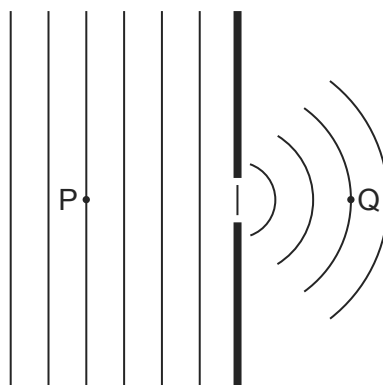
- 122 The variation with distance x of the intensity I along a stationary sound wave in air is shown by the following graph. 9702/13/O/N/14/Q27



The speed of sound in air is 340 ms^{-1} .

What is the frequency of the sound wave?

- 123 Plane wavefronts in a ripple tank pass through a gap as shown. 9702/13/O/N/14/Q28

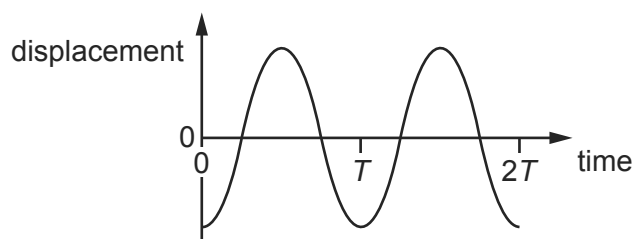


Which property of the wave will be different at Q compared with P?

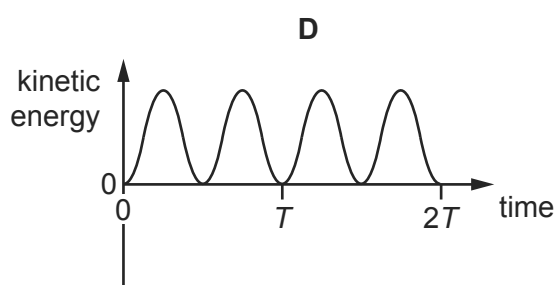
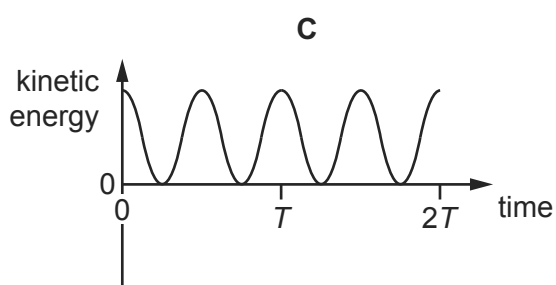
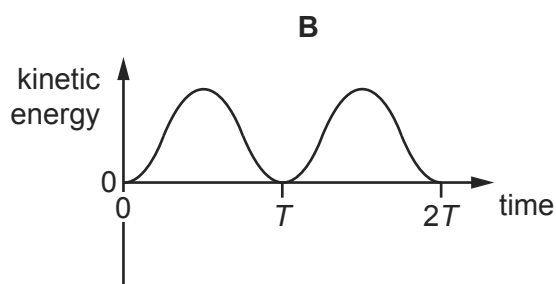
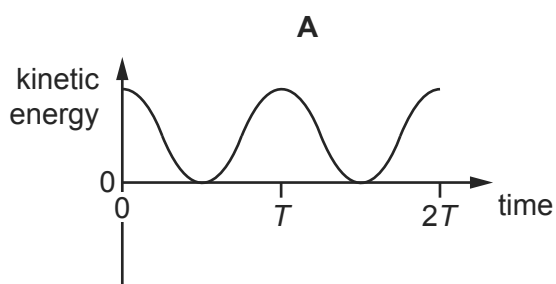
- A velocity
 - B frequency
 - C amplitude
 - D wavelength
- 124 Which statement about electromagnetic radiation is correct? 9702/11/O/N/14/Q22
- A Waves of wavelength $5 \times 10^{-9} \text{ m}$ are high-energy gamma rays.
 - B Waves of wavelength $3 \times 10^{-8} \text{ m}$ are ultra-violet waves.
 - C Waves of wavelength $5 \times 10^{-7} \text{ m}$ are infra-red waves.
 - D Waves of wavelength $9 \times 10^{-7} \text{ m}$ are light waves.

- 125 When sound travels through air, the air particles vibrate. A graph of displacement against time for a single air particle is shown.

9702/11/O/N/14/Q23

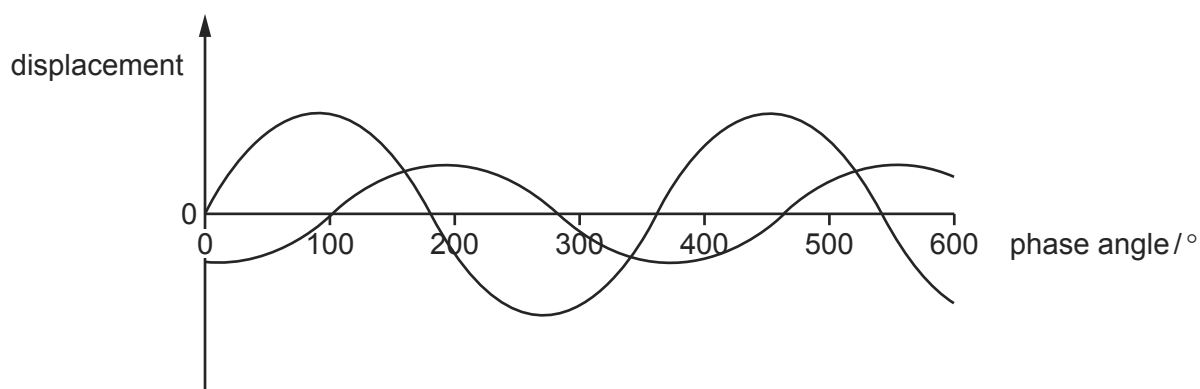


Which graph best shows how the kinetic energy of the air particle varies with time?



- 126 Two light waves of the same frequency are represented by the diagram.

9702/12/M/J/15/Q24

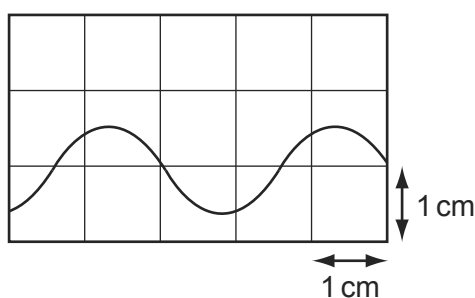


What could be the phase difference between the two waves?

- A** 150° **B** 220° **C** 260° **D** 330°

- 127 A cathode-ray oscilloscope (c.r.o.) is used to display the trace from a sound wave. The time-base is set at $5 \mu\text{s mm}^{-1}$.

9702/13/M/J/15/Q25

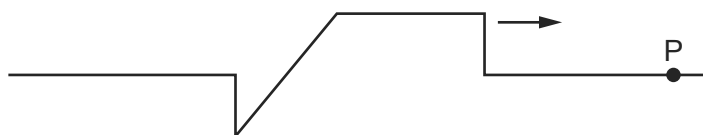


What is the frequency of the sound wave?

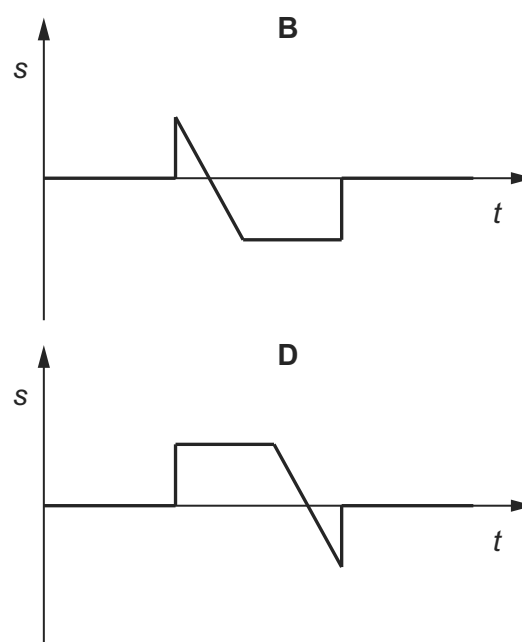
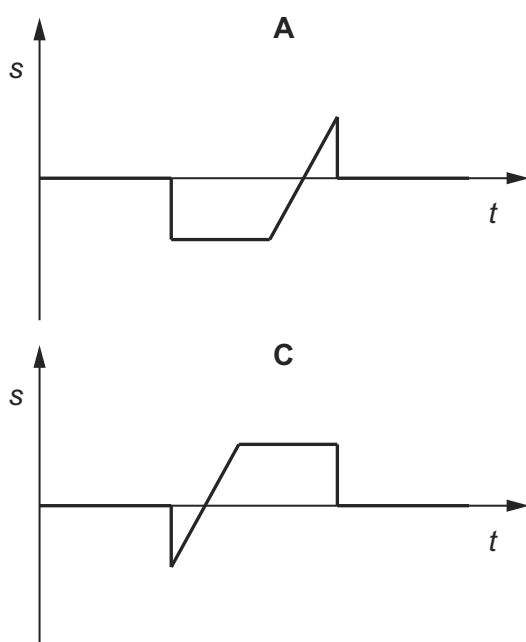
- A** 6.7 Hz **B** 67 Hz **C** 6.7 kHz **D** 67 kHz

- 128 A wave pulse moves along a stretched rope in the direction shown.

9702/13/M/J/15/Q26



Which diagram correctly shows the variation with time t of the displacement s of the particle P in the rope?



- 129 A sound wave has a speed of 330 m s^{-1} and a frequency of 50 Hz.

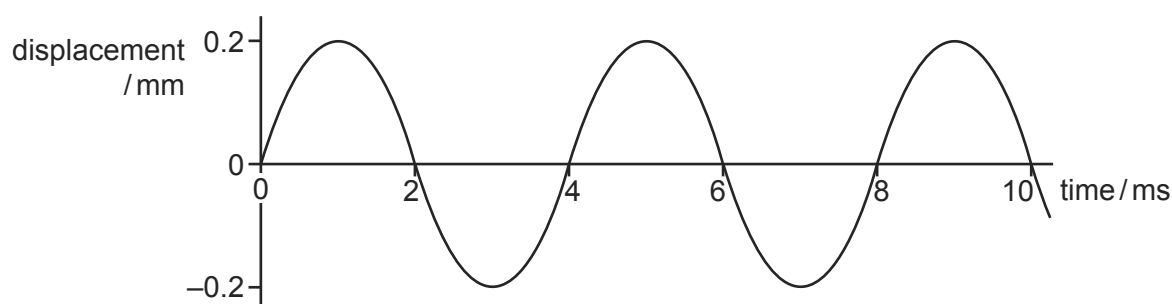
9702/12/M/J/15/Q25

What is a possible distance between two points on the wave that have a phase difference of 60° ?

- A** 0.03 m **B** 1.1 m **C** 2.2 m **D** 6.6 m

- 130 Which electromagnetic wave would cause the most significant diffraction effect for an atomic lattice of spacing around 10^{-10} m? 9702/13/M/J/15/Q28
- A** infra-red
B microwave
C ultraviolet
D X-ray

- 131 A sound wave moves with a speed of 320 ms^{-1} through air. The variation with time of the displacement of an air particle due to this wave is shown in the graph. 9702/11/M/J/15/Q24



Which statement about the sound wave is correct?

- A** The frequency of the wave is 500 Hz.
B The graph shows that sound is a transverse wave.
C The intensity of the wave will be doubled if its amplitude is increased to 0.4 mm.
D The wavelength of the sound wave is 1.28 m.
- 132 A wave of frequency 15 Hz travels at 24 m s^{-1} through a medium. 9702/11/M/J/15/Q25
- What is the phase difference between two points 2 m apart?
- A** There is no phase difference.
B They are out of phase by a quarter of a cycle.
C They are out of phase by half a cycle.
D They are out of phase by 0.8 of a cycle.
- 133 A wave of amplitude a has an intensity of 3.0 W m^{-2} . 9702/11/M/J/15/Q26

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

- A** 4.2 W m^{-2} **B** 6.0 W m^{-2} **C** 9.0 W m^{-2} **D** 12 W m^{-2}

- 134 An electromagnetic wave has a wavelength that is numerically of the same order of magnitude as the diameter of a nucleus.

9702/11/M/J/15/Q27

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

- A** gamma ray
- B** X-ray
- C** visible light
- D** infra-red

Waves

Q.No	Answers
1	C
2	B
3	B
4	A
5	D
6	D
7	B
8	C
9	B
10	
11	A
12	D
13	B
14	A
15	B
16	C
17	C
18	D
19	A
20	B
21	B
22	B
23	B
24	D
25	B
26	A
27	B
28	B
29	C
30	B
31	B
32	C
33	

34	C
35	A
36	D
37	D
38	B
39	B
40	B
41	B
42	D
43	D
44	D
45	B
46	B
47	A
48	C
49	B
50	C
51	B
52	
53	
54	
55	C
56	A
57	C
58	A
59	A
60	A
61	
62	C
63	A
64	B
65	C
66	D
67	A

68	A
69	B
70	D
71	A
72	D
73	
74	D
75	B
76	B
77	
78	A
79	B
80	C
81	B
82	D
83	C
84	D
85	B
86	C
87	B
88	A
89	D
90	A
91	B
92	
93	A
94	C
95	C
96	C
97	D
98	B
99	A
100	C
101	C

102	B
103	C
104	D
105	D
106	C
107	A
108	A
109	C
110	C
111	
112	B
113	C
114	B
115	D
116	C
117	C
118	C
119	A
120	D
121	D
122	A
123	
124	B
125	D
126	C
127	C
128	D
129	B
130	
131	D
132	
133	D
134	A

Q1.

4 (a) State three conditions that must be satisfied in order that two waves may interfere.

1.
2.
3. [3]

(b) The apparatus illustrated in Fig. 4.1 is used to demonstrate two-source interference using light.

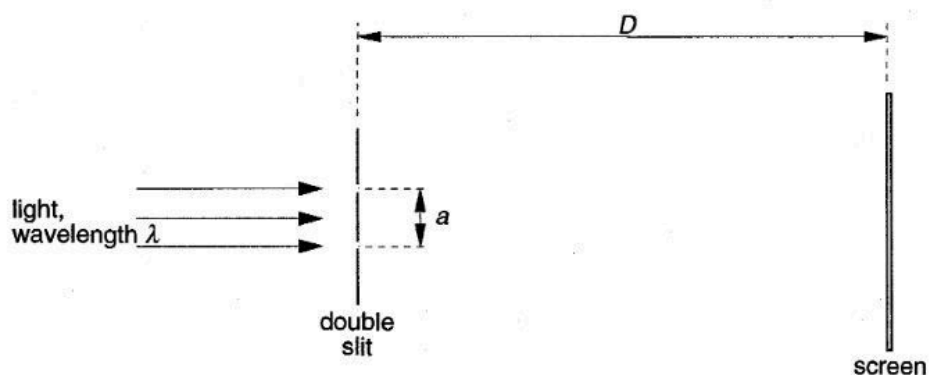


Fig. 4.1 (not to scale)

The separation of the two slits in the double slit arrangement is a and the interference fringes are viewed on a screen at a distance D from the double slit. When light of wavelength λ is incident on the double slit, the separation of the bright fringes on the screen is x .

(i) 1. Suggest a suitable value for the separation a of the slits in the double slit.

.....

2. Write down an expression relating λ , a , D and x .

.....

[2]

- (ii) Describe the effect, if any, on the separation and on the maximum brightness of the fringes when the following changes are made.

1. The distance D is increased to $2D$, keeping a and λ constant.

separation:

maximum brightness:

2. The wavelength λ is increased to 1.5λ , keeping a and D constant.

separation:

maximum brightness:

3. The intensity of the light incident on the double slit is increased, keeping λ , a and D constant.

separation:

maximum brightness:

[7]

Q2.

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

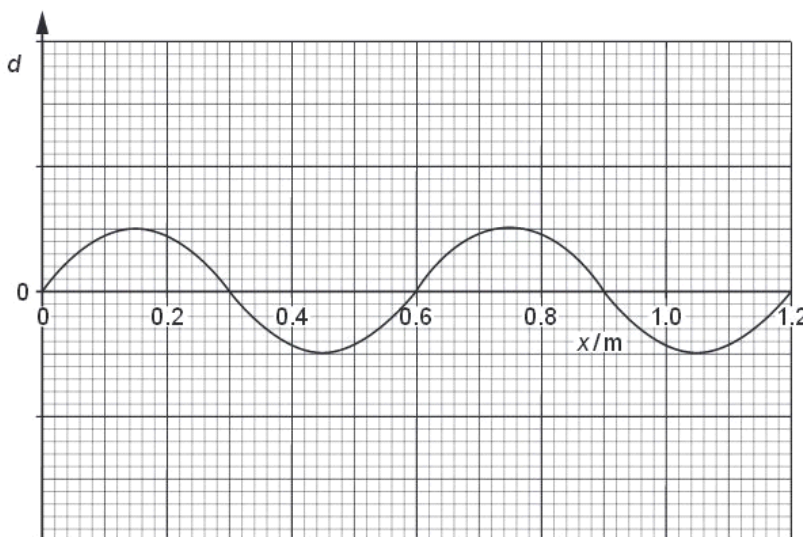


Fig. 2.1

The wave is a progressive wave having a speed of 330 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.

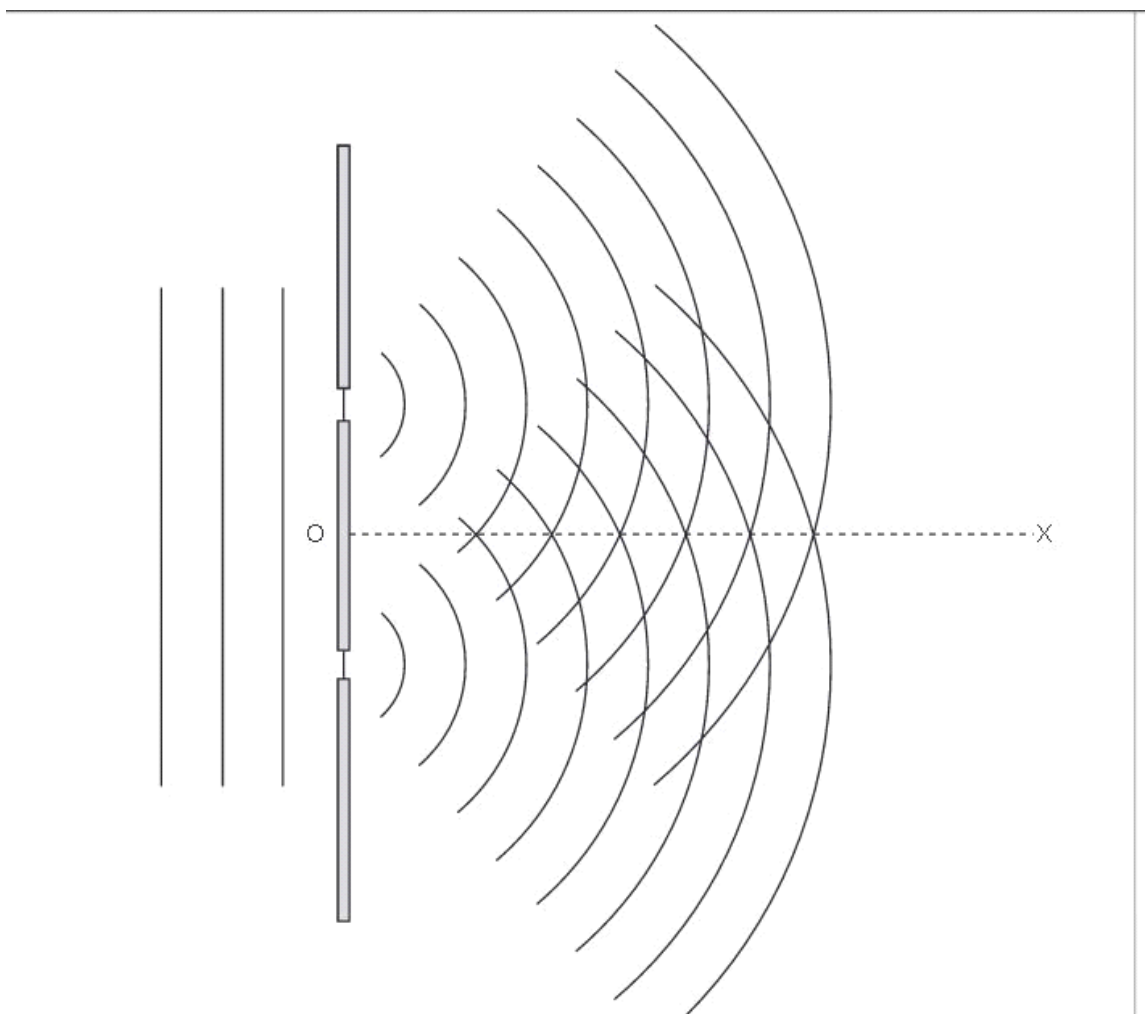
frequency = ... Hz
[3]

- (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° .

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]

Q3.

- 6 Fig. 6.1 shows wavefronts incident on, and emerging from, a double slit arrangement.



The wavefronts represent successive crests of the wave. The line OX shows one direction along which constructive interference may be observed.

(a) State the principle of superposition.

.....

 [3]

(b) On Fig. 6.1, draw lines to show

- (i)** a second direction along which constructive interference may be observed (label this line CC),
- (ii)** a direction along which destructive interference may be observed (label this line DD).

[2]

- (c) Light of wavelength 650 nm is incident normally on a double slit arrangement. The interference fringes formed are viewed on a screen placed parallel to and 1.2 m from the plane of the double slit, as shown in Fig. 6.2.

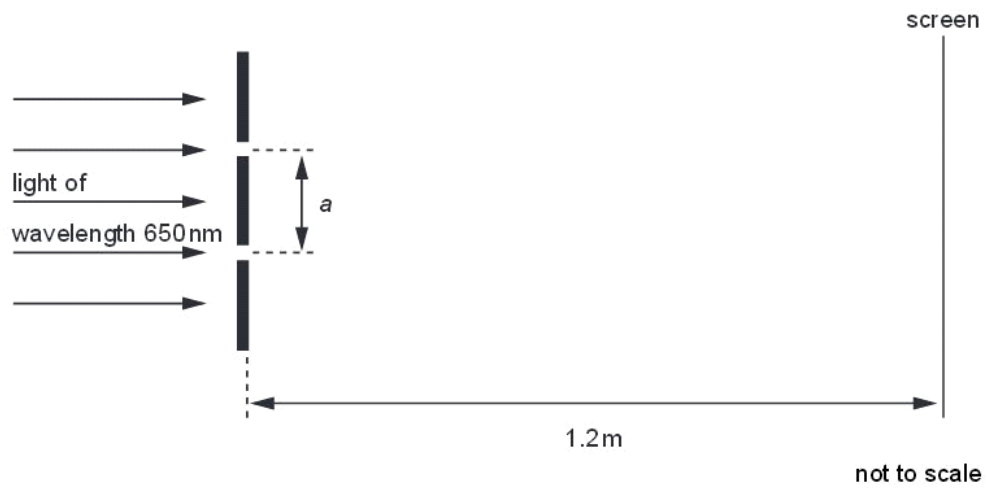


Fig. 6.2

The fringe separation is 0.70 mm.

- (i) Calculate the separation a of the slits.

separation = ... m [3]

- (ii) The width of both slits is increased without changing their separation a . State the effect, if any, that this change has on

U36

1. the separation of the fringes,

.....

2. the brightness of the light fringes,

.....

3. the brightness of the dark fringes.

.....

[3]

Q4.

- 5 (a) Explain what is meant by the *diffraction* of a wave.

Ex

.....

.....

.....[2]

- (b) Light of wavelength 590 nm is incident normally on a diffraction grating having 750 lines per millimetre.

The diffraction grating formula may be expressed in the form

$$d \sin \theta = n\lambda.$$

- (i) Calculate the value of d , in metres, for this grating.

$d =$ m [2]

- (ii) Determine the maximum value of n for the light incident normally on the grating.

maximum value of n = ... [2]

- (iii) Fig. 5.1 shows incident light that is not normal to the grating.

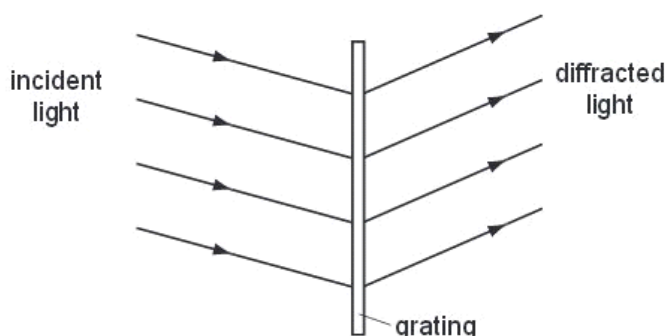


Fig. 5.1

Suggest why the diffraction grating formula, $d \sin \theta = n\lambda$, should **not** be used in this situation.

.....
[1]

- (c) Light of wavelengths 590 nm and 595 nm is now incident normally on the grating. Two lines are observed in the first order spectrum and two lines are observed in the second order spectrum, corresponding to the two wavelengths. State two differences between the first order spectrum and the second order spectrum.

1.

2.
[2]

Q5.

- 6 A long tube, fitted with a tap, is filled with water. A tuning fork is sounded above the top of the tube as the water is allowed to run out of the tube, as shown in Fig. 6.1.

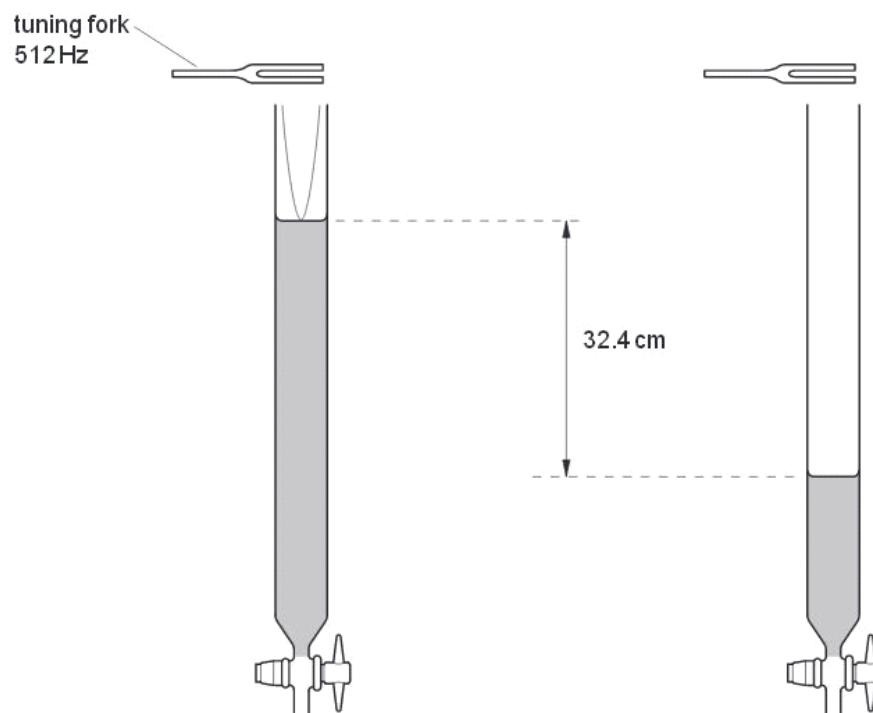


Fig. 6.1

Fig. 6.2

A loud sound is first heard when the water level is as shown in Fig. 6.1, and then again when the water level is as shown in Fig. 6.2.

Fig. 6.1 illustrates the stationary wave produced in the tube.

(a) On Fig. 6.2,

- (i) sketch the form of the stationary wave set up in the tube, [1]
- (ii) mark, with the letter N, the positions of any nodes of the stationary wave. [1]

- (b) The frequency of the fork is 512 Hz and the difference in the height of the water level for the two positions where a loud sound is heard is 32.4 cm.

Calculate the speed of sound in the tube.

speed = ... m s^{-1} [3]

- (c) The length of the column of air in the tube in Fig. 6.1 is 15.7 cm.

Suggest where the antinode of the stationary wave produced in the tube in Fig. 6.1 is likely to be found.

.....

 [2]

Q6.

- 5 Light reflected from the surface of smooth water may be described as a polarised transverse wave.

(a) By reference to the direction of propagation of energy, explain what is meant by

- (i) a *transverse wave*,

.....
 [1]

- (ii) *polarisation*.

.....
 [1]

- (b) A glass tube, closed at one end, has fine dust sprinkled along its length. A sound source is placed near the open end of the tube, as shown in Fig. 5.1.

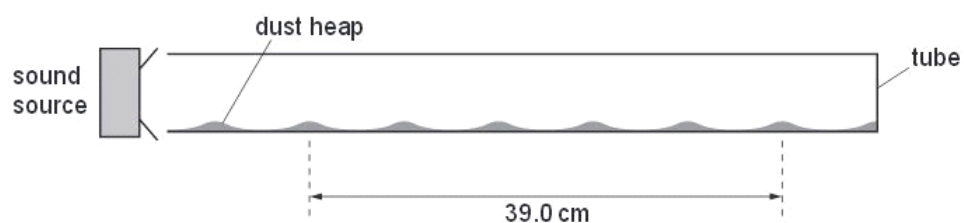


Fig. 5.1

The frequency of the sound emitted by the source is varied and, at one frequency, the dust forms small heaps in the tube.

- (i) Explain, by reference to the properties of stationary waves, why the heaps of dust are formed.

.....

.....

.....

.....[3]

- (ii) One frequency at which heaps are formed is 2.14 kHz.
The distance between six heaps, as shown in Fig. 5.1, is 39.0 cm.
Calculate the speed of sound in the tube.

speed = ...m s⁻¹ [3]

- (c) The wave in the tube is a stationary wave. Explain, by reference to the formation of a stationary wave, what is meant by the speed calculated in (b)(ii).

.....
.....
.....
.....[3]

Q7.

- 5 (a) State what is meant by

- (i) the *frequency* of a progressive wave,

.....
.....
.....[2]

- (ii) the *speed* of a progressive wave.

.....
.....[1]

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U

- (b) One end of a long string is attached to an oscillator. The string passes over a frictionless pulley and is kept taut by means of a weight, as shown in Fig. 5.1.

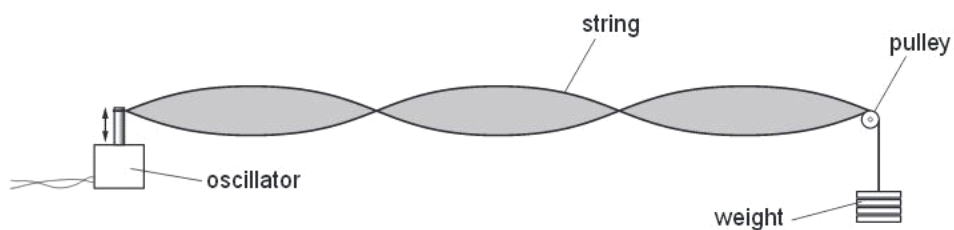


Fig. 5.1

The frequency of oscillation is varied and, at one value of frequency, the wave formed on the string is as shown in Fig. 5.1.

- (i) Explain why the wave is said to be a *stationary wave*.

.....
[1]

- (ii) State what is meant by an *antinode*.

.....
[1]

- (iii) On Fig. 5.1, label the antinodes with the letter A.

[1]

- (c) A weight of 4.00 N is hung from the string in (b) and the frequency of oscillation is adjusted until a stationary wave is formed on the string. The separation of the antinodes on the string is 17.8 cm for a frequency of 125 Hz.
- The speed v of waves on a string is given by the expression

$$v = \sqrt{\frac{T}{m}},$$

where T is the tension in the string and m is its mass per unit length.
Determine the mass per unit length of the string.

mass per unit length = ... kg m^{-1} [5]

Q8.

- 5 Two sources S_1 and S_2 of sound are situated 80 cm apart in air, as shown in Fig. 5.1.

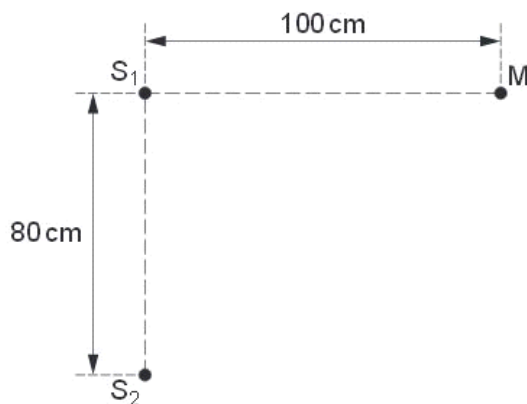


Fig. 5.1

The frequency of vibration can be varied. The two sources always vibrate in phase but have different amplitudes of vibration.

A microphone M is situated a distance 100 cm from S_1 along a line that is normal to S_1S_2 .

As the frequency of S_1 and S_2 is gradually increased, the microphone M detects maxima and minima of intensity of sound.

- (a) State the two conditions that must be satisfied for the intensity of sound at M to be zero.

1.

.....

2.

.....

[2]

- (b) The speed of sound in air is 330 m s^{-1} .

The frequency of the sound from S_1 and S_2 is increased. Determine the number of minima that will be detected at M as the frequency is increased from 1.0 kHz to 4.0 kHz.

number = ... [4]

Q9.

- 5 A double-slit interference experiment is set up using coherent red light as illustrated in Fig. 5.1.

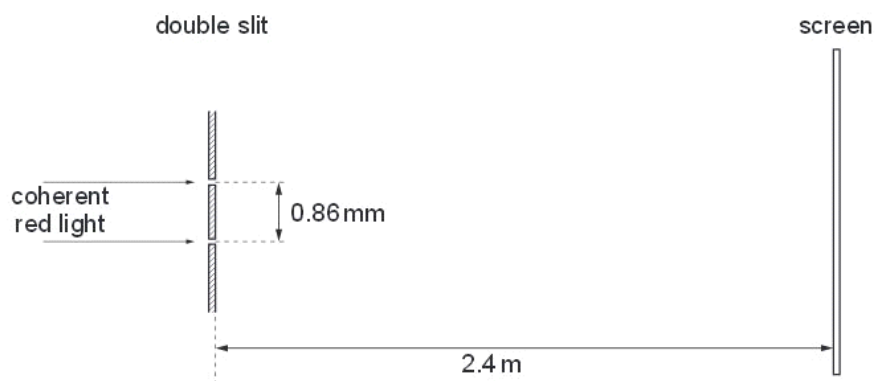


Fig. 5.1 (not to scale)

The separation of the slits is 0.86 mm.

The distance of the screen from the double slit is 2.4 m.

A series of light and dark fringes is observed on the screen.

- (a) State what is meant by *coherent* light.

.....
 [1]

- (b) Estimate the separation of the dark fringes on the screen.

separation = ... mm [3]

- (c) Initially, the light passing through each slit has the same intensity.
 The intensity of light passing through one slit is now reduced.
 Suggest and explain the effect, if any, on the dark fringes observed on the screen.

.....

 [2]

Q10.

- 4 (a) State what is meant by the *diffraction* of a wave.

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.....

 [2]

- (b) A laser produces a narrow beam of coherent light of wavelength 632 nm. The beam is incident normally on a diffraction grating, as shown in Fig. 4.1.

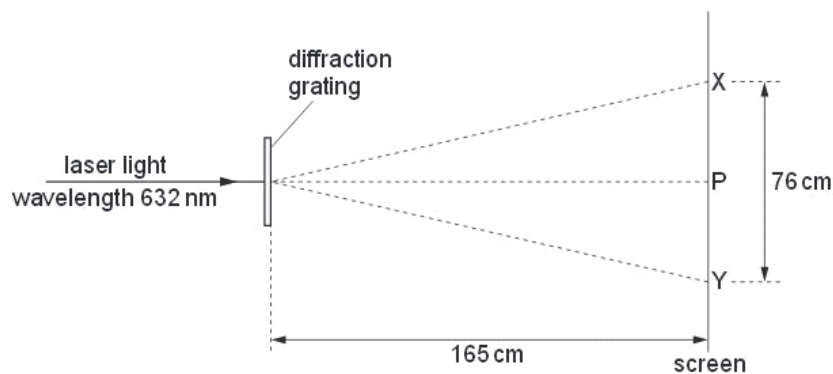


Fig. 4.1

Spots of light are observed on a screen placed parallel to the grating. The distance between the grating and the screen is 165 cm.

The brightest spot is P. The spots formed closest to P and on each side of P are X and Y.

X and Y are separated by a distance of 76 cm.

Calculate the number of lines per metre on the grating.

number per metre = ... [4]

- (c) The grating in (b) is now rotated about an axis parallel to the incident laser beam, as shown in Fig. 4.2.

Ex 4

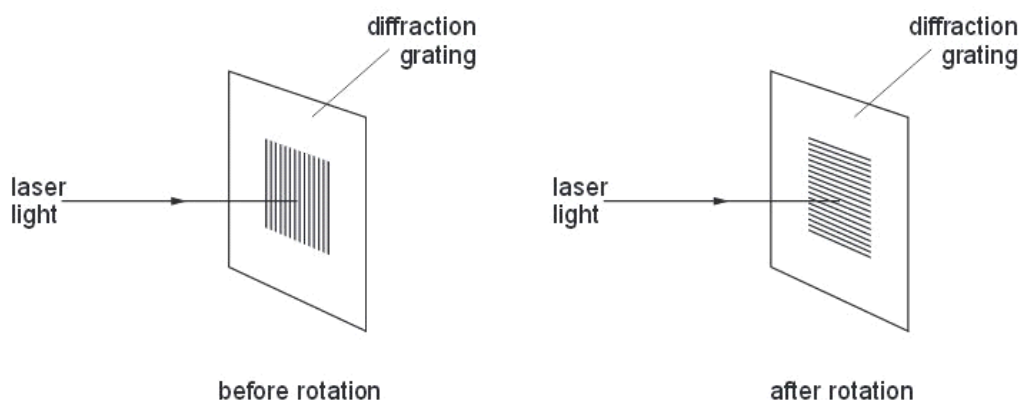


Fig. 4.2

State what effect, if any, this rotation will have on the positions of the spots P, X and Y.

.....

.....

.....

.....[2]

- (d) In another experiment using the apparatus in (b), a student notices that the distances XP and PY, as shown in Fig. 4.1, are not equal. Suggest a reason for this difference.

.....

.....[1]

Q11.

- 4 (a) State two features of a stationary wave that distinguish it from a progressive wave.

For
Examiner's
Use

1.

.....

2.

.....

[2]

- (b) A long tube is open at one end. It is closed at the other end by means of a piston that can be moved along the tube, as shown in Fig. 4.1.

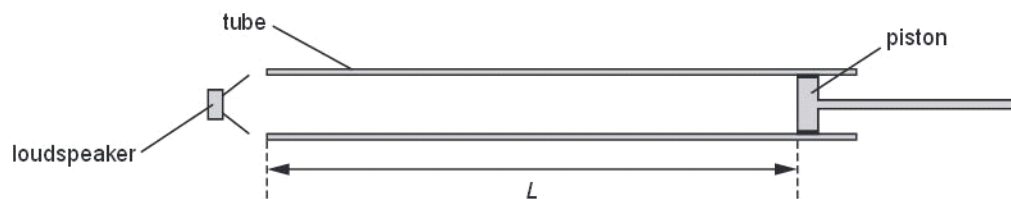


Fig. 4.1

A loudspeaker producing sound of frequency 550 Hz is held near the open end of the tube.

The piston is moved along the tube and a loud sound is heard when the distance L between the piston and the open end of the tube is 45 cm.

The speed of sound in the tube is 330 m s^{-1} .

- (i) Show that the wavelength of the sound in the tube is 60 cm.

[1]

- (ii) On Fig. 4.1, mark all the positions along the tube of

1. the displacement nodes (label these with the letter N),
2. the displacement antinodes (label these with the letter A).

[3]

- (c) The frequency of the sound produced by the loudspeaker in (b) is gradually reduced.

Determine the lowest frequency at which a loud sound will be produced in the tube of length $L = 45 \text{ cm}$.

Ex 4

frequency = ... Hz [3]

Q12.

- 5 (a) A source of sound has frequency f . Sound of wavelength λ is produced by the source.

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U

- (i) State

1. what is meant by the *frequency* of the source,

.....
.....[1]

2. the distance moved, in terms of λ , by a wavefront during n oscillations of the source.

distance = ...[1]

- (ii) Use your answers in (i) to deduce an expression for the speed v of the wave in terms of f and λ .

[2]

- (b) The waveform of a sound wave produced on the screen of a cathode-ray oscilloscope (c.r.o.) is shown in Fig. 5.1.

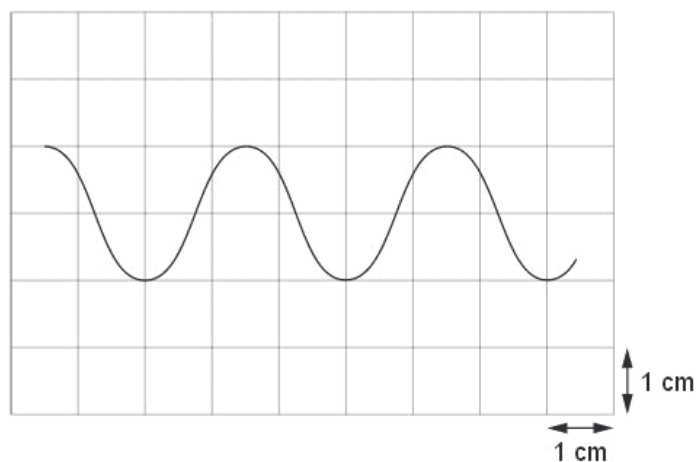


Fig. 5.1

The time-base setting of the c.r.o. is 2.0 ms cm^{-1} .

- (i) Determine the frequency of the sound wave.

frequency = ...Hz [2]

- (ii) A second sound wave has the same frequency as that calculated in (i). The amplitude of the two waves is the same but the phase difference between them is 90° .

On Fig. 5.1, draw the waveform of this second wave.

[1]

Q13.

7 (a) Explain the term *interference*.

E

.....

.....

..... [1]

(b) A ripple tank is used to demonstrate interference between water waves.

Describe

(i) the apparatus used to produce two sources of coherent waves that have circular wavefronts,

.....

.....

.....

..... [2]

(ii) how the pattern of interfering waves may be observed.

.....

.....

.....

..... [2]

(c) A wave pattern produced in (b) is shown in Fig. 7.1.

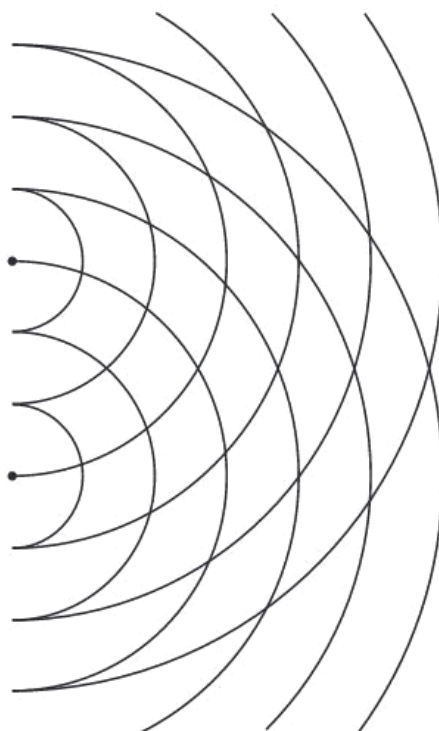


Fig. 7.1

Solid lines on Fig. 7.1 represent crests.

On Fig. 7.1,

- (i) draw two lines to show where maxima would be seen (label each of these lines with the letter X), [1]
- (ii) draw one line to show where minima would be seen (label this line with the letter N). [1]

Q14.

- 6 (a) Apparatus used to produce interference fringes is shown in Fig. 6.1. The apparatus is not drawn to scale.

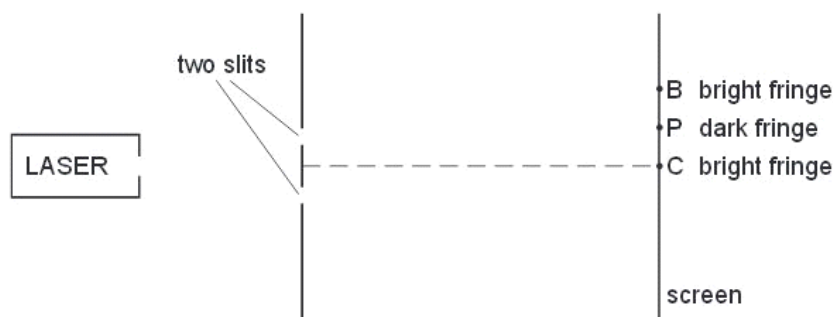


Fig. 6.1 (not to scale)

Laser light is incident on two slits. The laser provides light of a single wavelength. The light from the two slits produces a fringe pattern on the screen. A bright fringe is produced at C and the next bright fringe is at B. A dark fringe is produced at P.

- (i) Explain why one laser and two slits are used, instead of two lasers, to produce a visible fringe pattern on the screen.

.....
..... [1]

(ii) State the phase difference between the waves that meet at

1. B [1]

2. P [1]

(iii) 1. State the *principle of superposition*.

.....
.....
..... [2]

2. Use the principle of superposition to explain the dark fringe at P.

.....
..... [1]

(b) In Fig. 6.1 the distance from the two slits to the screen is 1.8m. The distance CP is 2.3mm and the distance between the slits is 0.25mm. Calculate the wavelength of the light provided by the laser.

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wavelength = ... nm [3]

Q15.

- 6 (a) A transverse progressive wave travels along a stretched string from left to right. The shape of part of the string at a particular instant is shown in Fig. 6.1.

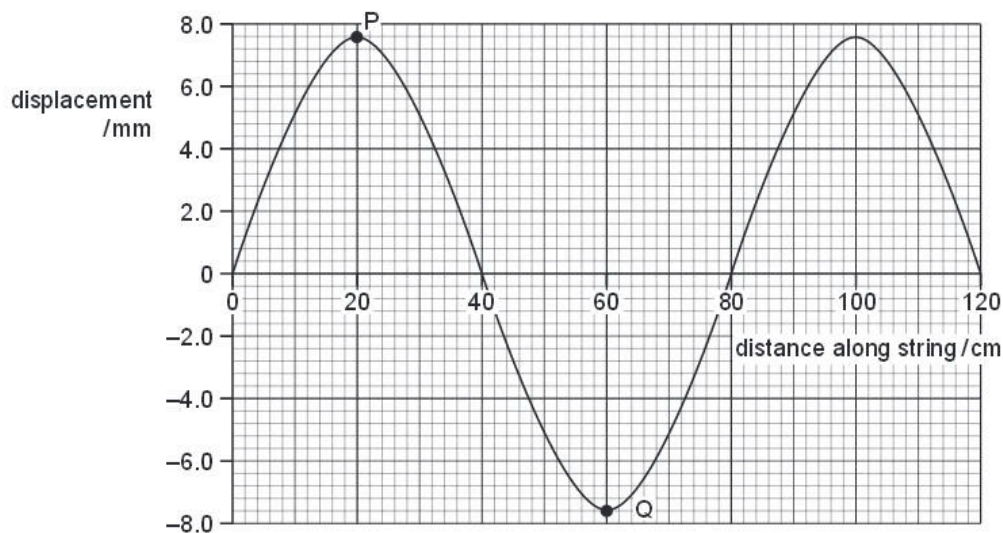


Fig. 6.1

The frequency of the wave is 15 Hz.
For this wave, use Fig. 6.1 to determine

- (i) the amplitude,

amplitude = ... mm [1]

- (ii) the phase difference between the points P and Q on the string,

phase difference = ... [1]

- (iii) the speed of the wave.

speed = ... m s^{-1} [2]

- (b) The period of vibration of the wave is T . The wave moves forward from the position shown in Fig 6.1 for a time $0.25 T$. On Fig. 6.1, sketch the new position of the wave. [2]

- (c) Another stretched string is used to form a stationary wave. Part of this wave, at a particular instant, is shown in Fig. 6.2.

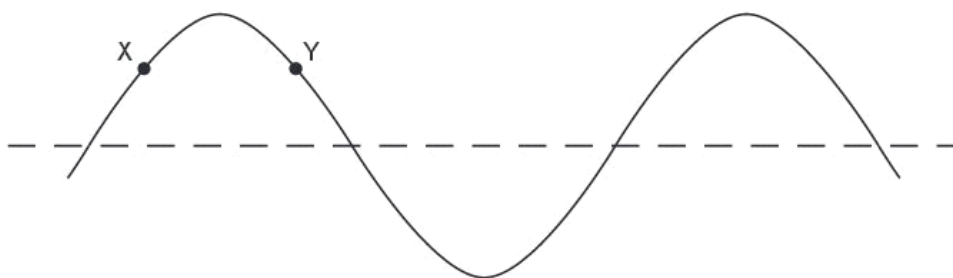


Fig. 6.2

The points on the string are at their maximum displacement.

- (i) State the phase difference between the particles labelled X and Y.

phase difference = ... [1]

- (ii) Explain the following terms used to describe stationary waves on a string:

antinode:

node:

[1]

- (iii) State the number of antinodes shown on Fig. 6.2 for this wave.

number of antinodes = ... [1]

- (iv) The period of vibration of this wave is τ . On Fig. 6.2, sketch the stationary wave 0.25τ after the instant shown in Fig. 6.2. [1]

Q16.

- 6 (a) A laser is used to produce an interference pattern on a screen, as shown in Fig. 6.1.

Exa
1

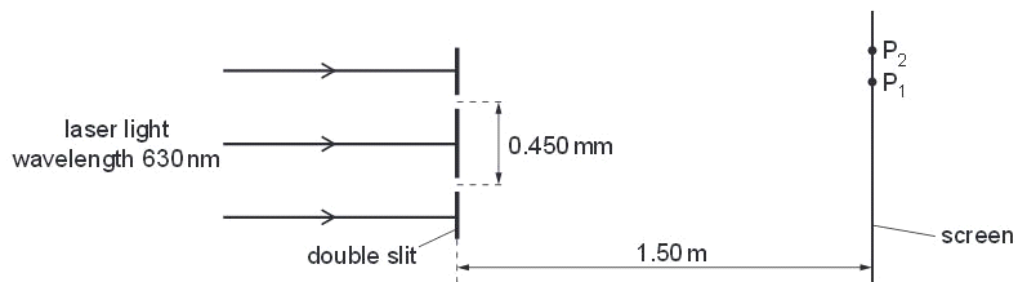


Fig. 6.1 (not to scale)

The laser emits light of wavelength 630 nm. The slit separation is 0.450 mm. The distance between the slits and the screen is 1.50 m. A maximum is formed at P₁ and a minimum is formed at P₂.
Interference fringes are observed only when the light from the slits is coherent.

- (i) Explain what is meant by *coherence*.

.....

 [2]

- (ii) Explain how an interference maximum is formed at P₁.

.....
 [1]

- (iii) Explain how an interference minimum is formed at P₂.

.....
 [1]

- (iv) Calculate the fringe separation.

fringe separation = ... m [3]

- (b)** State the effects, if any, on the fringes when the amplitude of the waves incident on the double slits is increased.

Ex

.....

.....

.....

..... [3]

Q17.

- 6 (a)** Use the principle of superposition to explain the formation of a stationary wave.

Ex

.....

.....

.....

.....

..... [3]

- (b)** Describe an experiment to determine the wavelength of sound in air using stationary waves. Include a diagram of the apparatus in your answer.

..... [3]

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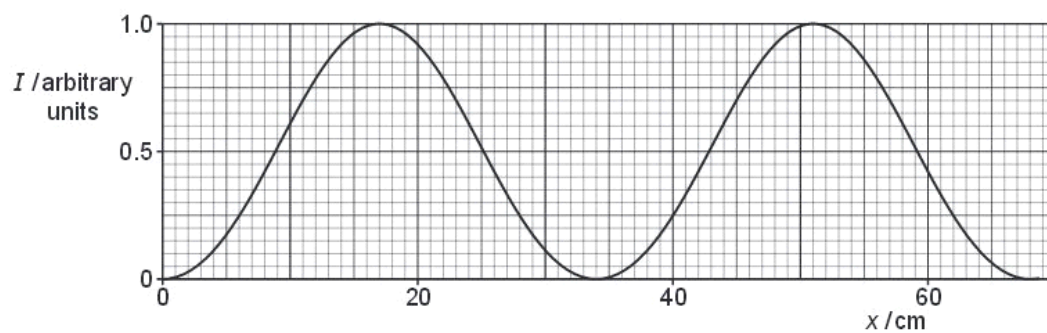


Fig. 6.1

- (i) On the x-axis of Fig. 6.1, indicate the positions of all the nodes and antinodes of the stationary wave. Label the nodes **N** and the antinodes **A**. [1]

- (ii) The speed of sound in air is 340 m s^{-1} .

Use Fig. 6.1 to determine the frequency of the sound wave.

frequency = ... Hz [3]

Q18.

- 6 (a) Monochromatic light is diffracted by a diffraction grating. By reference to this, explain what is meant by

- (i) diffraction,

.....
.....
..... [2]

- (ii) coherence,

.....
.....
..... [1]

- (iii) superposition.

.....
.....
..... [1]

Ex

- (b) A parallel beam of red light of wavelength 630 nm is incident normally on a diffraction grating of 450 lines per millimetre.

Calculate the number of diffraction orders produced.

number of orders = ... [3]

- (c) The red light in (b) is replaced with blue light. State and explain the effect on the diffraction pattern.

.....
.....
.....
.....
..... [3]

Q19.

- 5 (a) State three conditions required for maxima to be formed in an interference pattern produced by two sources of microwaves.

Ex 4

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

- (b) A microwave source M emits microwaves of frequency 12 GHz. Show that the wavelength of the microwaves is 0.025 m.

[3]

- (c) Two slits S_1 and S_2 are placed in front of the microwave source M described in (b), as shown in Fig 5.1.

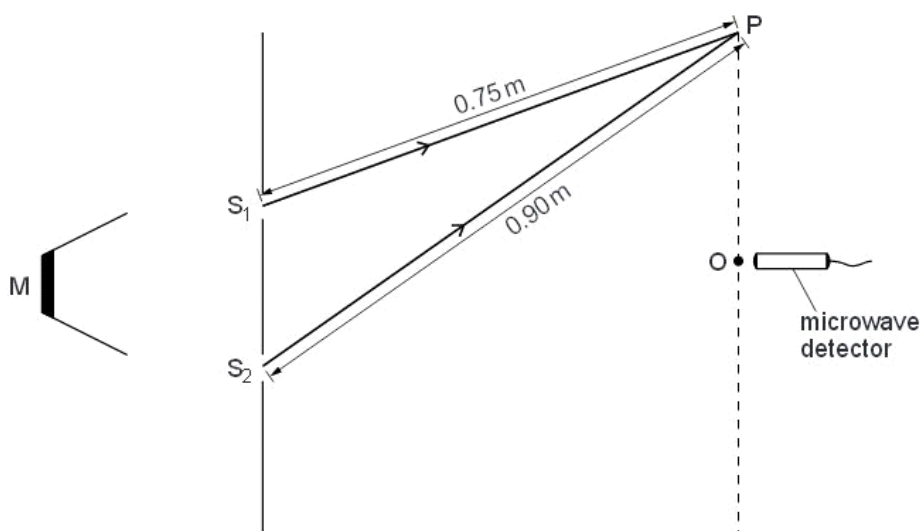


Fig. 5.1 (not to scale)

The distances S_1O and S_2O are equal. A microwave detector is moved from O to P. The distance S_1P is 0.75 m and the distance S_2P is 0.90 m.

The microwave detector gives a maximum reading at O.

State the variation in the readings on the microwave detector as it is moved slowly along the line from O to P.

.....

.....

.....

.....

..... [3]

(d) The microwave source M is replaced by a source of coherent light.

State two changes that must be made to the slits in Fig. 5.1 in order to observe an interference pattern.

1.

2.

[2]

Q20.

5 Fig. 5.1 shows a string stretched between two fixed points P and Q.



Fig. 5.1

A vibrator is attached near end P of the string. End Q is fixed to a wall. The vibrator has a frequency of 50 Hz and causes a transverse wave to travel along the string at a speed of 40 m s^{-1} .

(a) (i) Calculate the wavelength of the transverse wave on the string.

wavelength = ... m [2]

- (ii) Explain how this arrangement may produce a stationary wave on the string.

.....

[2]

- (b) The stationary wave produced on PQ at one instant of time t is shown on Fig. 5.2. Each point on the string is at its maximum displacement.

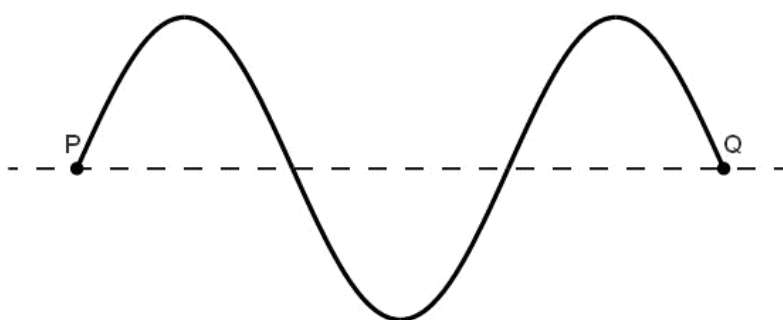


Fig. 5.2 (not to scale)

- (i) On Fig. 5.2, label all the nodes with the letter **N** and all the antinodes with the letter **A**. [2]

- (ii) Use your answer in (a)(i) to calculate the length of string PQ.

length = ... m [1]

- (iii) On Fig. 5.2, draw the stationary wave at time $(t + 5.0 \text{ ms})$. Explain your answer.

.....[3]

Q21.

- 5 (a) Explain the principle of superposition.

.....

[2]

- (b) Sound waves travel from a source S to a point X along two paths SX and SPX, as shown in Fig. 5.1.

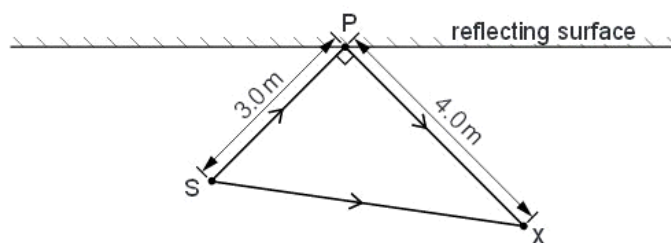


Fig. 5.1

- (i) State the phase difference between these waves at X for this to be the position of

1. a minimum,

phase difference = ... unit[1]

2. a maximum.

phase difference = ... unit[1]

- (ii) The frequency of the sound from S is 400 Hz and the speed of sound is 320 m s^{-1} . Calculate the wavelength of the sound waves.

wavelength = ... m [2]

- (iii) The distance SP is 3.0m and the distance PX is 4.0m. The angle SPX is 90° . Suggest whether a maximum or a minimum is detected at point X. Explain your answer.

.....
[2]

Q22.

- 5 The variation with time t of the displacement x of a point in a transverse wave T_1 is shown in Fig. 5.1.

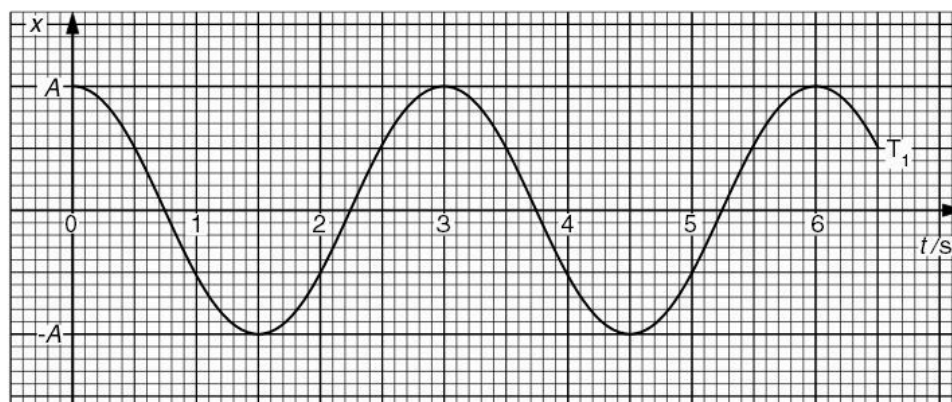


Fig. 5.1

- (a) By reference to displacement and direction of travel of wave energy, explain what is meant by a *transverse wave*.

.....
[1]

- (b) A second transverse wave T_2 , of amplitude A has the same waveform as wave T_1 but lags behind T_1 by a phase angle of 60° . The two waves T_1 and T_2 pass through the same point.

- (i) On Fig. 5.1, draw the variation with time t of the displacement x of the point in wave T_2 . [2]

- (ii) Explain what is meant by the *principle of superposition* of two waves.

.....

[2]

- (iii) For the time $t = 1.0$ s, use Fig. 5.1 to determine, in terms of A ,

1. the displacement due to wave T_1 alone,

displacement = ...

2. the displacement due to wave T_2 alone,

displacement = ...

3. the resultant displacement due to both waves.

displacement = ...

[3]

Q23.

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

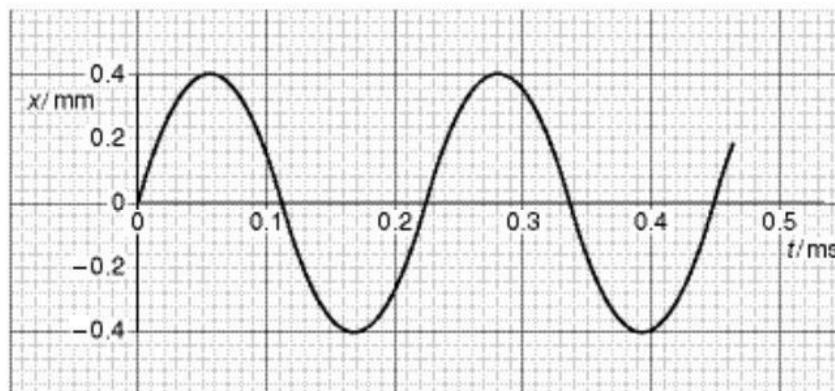


Fig. 4.1

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

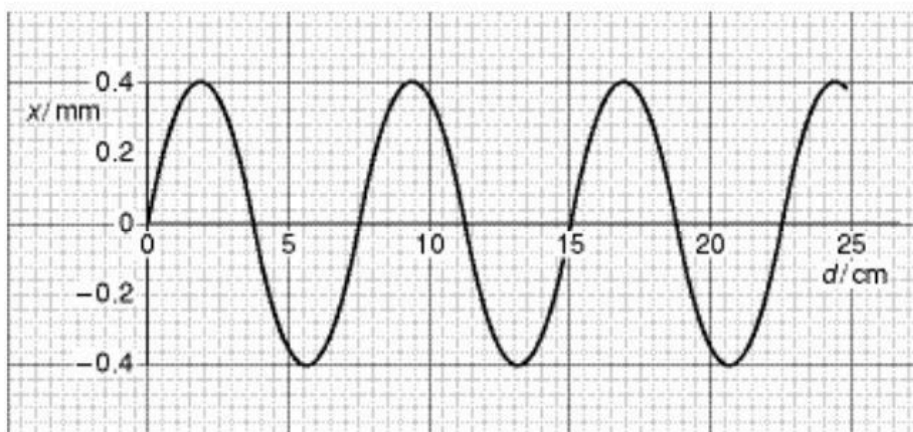


Fig. 4.2

- (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 = ... 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]

(b) Light of wavelength 590 nm is incident at right angles to a diffraction grating having 5.80×10^5 lines per metre, as illustrated in Fig. 4.3.

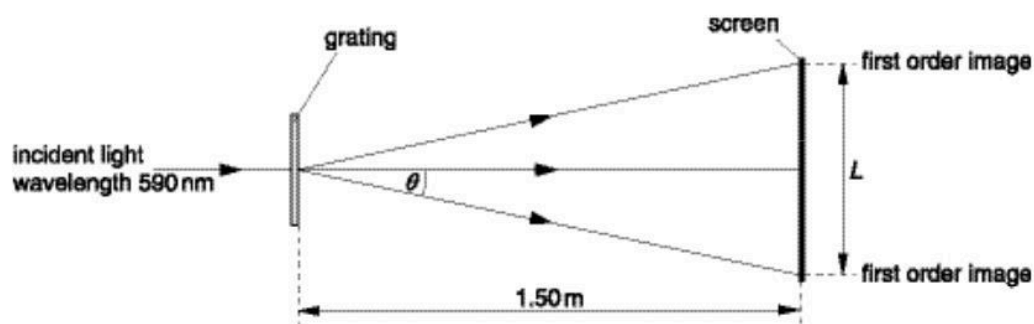


Fig. 4.3

A screen is placed parallel to and 1.50 m from the grating. Calculate

- (i) the spacing, in μm , of the lines of the grating,

spacing = ... μm

- (ii) the angle θ to the original direction of the light at which the first order diffracted image is seen,

angle = ... $^{\circ}$

- (iii) the minimum length L of the screen so that both first order diffracted images may be viewed at the same time on the screen.

length = ... m
[5]

Q24.

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

F
Exam
U

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

1.

2.

3. [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]

Q25.

- 4 A string is stretched between two fixed points. It is plucked at its centre and the string vibrates, forming a stationary wave as illustrated in Fig. 4.1.

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Use*

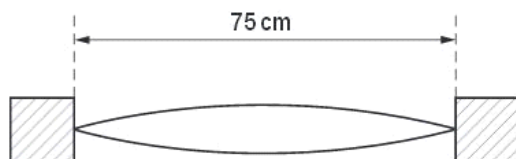


Fig. 4.1

The length of the string is 75 cm.

(a) State the wavelength of the wave.

wavelength = ... m [1]

- (b) The frequency of vibration of the string is 360 Hz. Calculate the speed of the wave on the string.

speed = ... m s^{-1} [2]

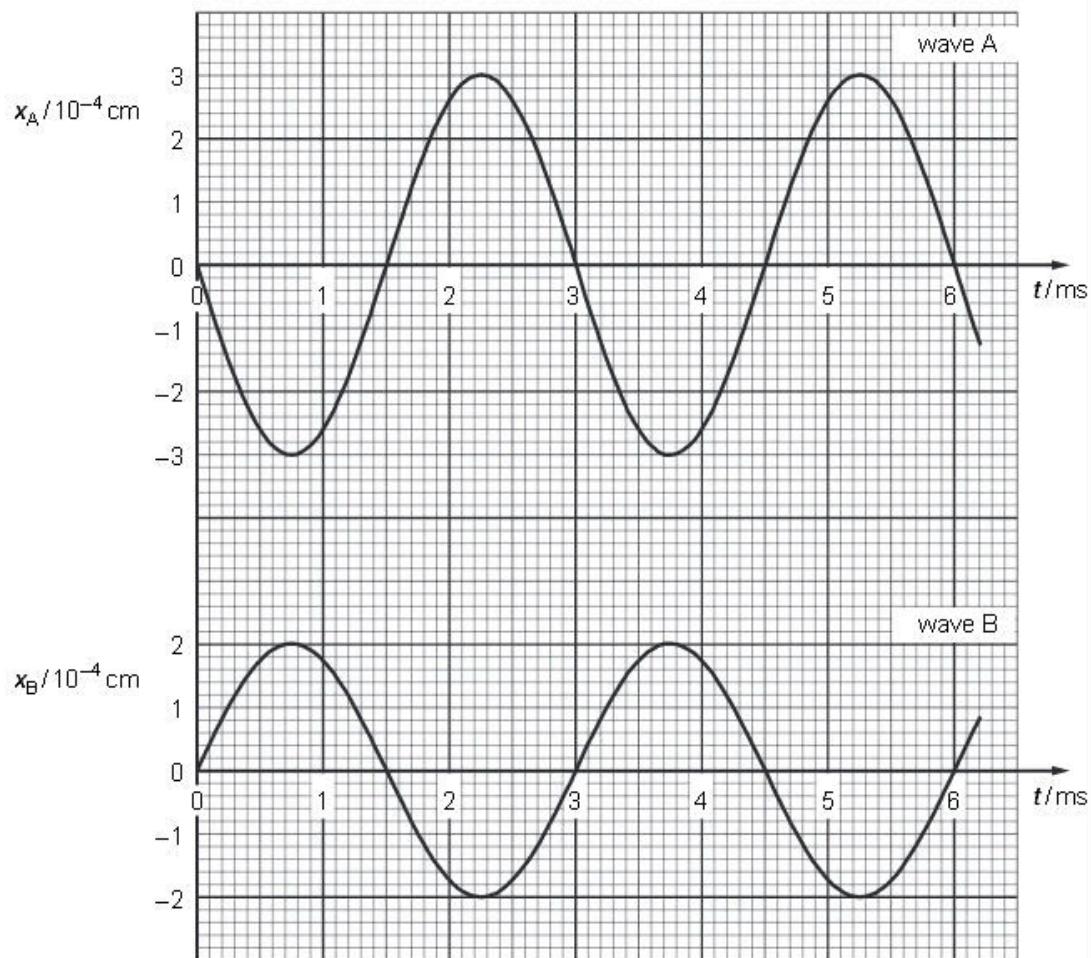
- (c) By reference to the formation of the stationary wave on the string, explain what is meant by the speed calculated in (b).

.....
.....
..... [3]

Q26.

- 5 Fig. 5.1 shows the variation with time t of the displacements x_A and x_B at a point P of two sound waves A and B.

Exa
.



- (a) By reference to Fig. 5.1, state one similarity and one difference between these two waves.

similarity:

difference: [2]

- (b) State, with a reason, whether the two waves are coherent.

.....

..... [1]

(c) The intensity of wave A alone at point P is I .

For
Examine
Use

(i) Show that the intensity of wave B alone at point P is $\frac{4}{9}I$.

[2]

(ii) Calculate the resultant intensity, in terms of I , of the two waves at point P.

resultant intensity = ... I [2]

(d) Determine the resultant displacement for the two waves at point P

(i) at time $t = 3.0$ ms,

resultant displacement = ... cm [1]

(ii) at time $t = 4.0$ ms.

resultant displacement = ... cm [2]

Q27.

- 4 (a) In order that interference between waves from two sources may be observed, the waves must be coherent.

Exa
1

Explain what is meant by

- (i) *interference*,

.....
.....
..... [2]

- (ii) *coherence*.

.....
..... [1]

- (b) Red light of wavelength 644 nm is incident normally on a diffraction grating having 550 lines per millimetre, as illustrated in Fig. 4.1.

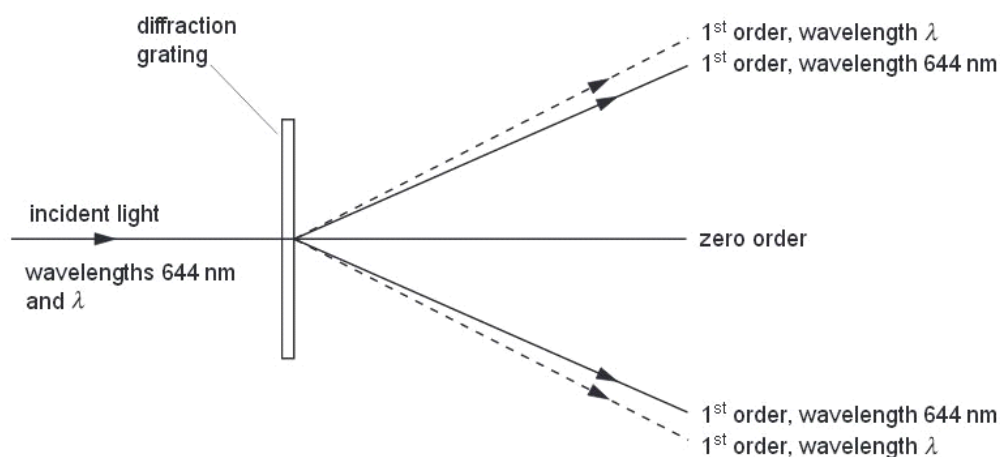


Fig. 4.1

Red light of wavelength λ is also incident normally on the grating. The first order diffracted light of both wavelengths is illustrated in Fig. 4.1.

- (i) Calculate the number of orders of diffracted light of wavelength 644 nm that are visible on each side of the zero order.

Ex.

number = ... [4]

- (ii) State and explain

1. whether λ is greater or smaller than 644 nm,

.....
..... [1]

2. in which order of diffracted light there is the greatest separation of the two wavelengths.

.....
.....
..... [2]

Q28.

- 5 (a) Fig. 5.1 shows the variation with time t of the displacement y of a wave W as it passes a point P. The wave has intensity I .

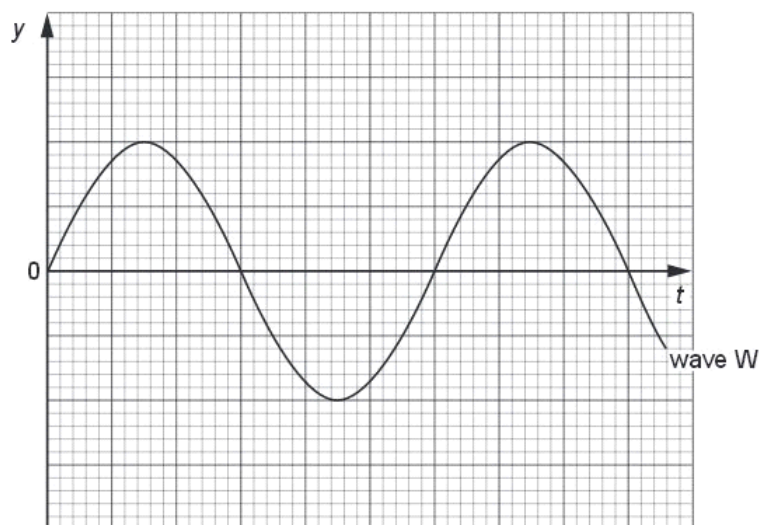


Fig. 5.1

A second wave X of the same frequency as wave W also passes point P. This wave has intensity $\frac{1}{2}I$. The phase difference between the two waves is 60° . On Fig. 5.1, sketch the variation with time t of the displacement y of wave X.

[3]

- (b) In a double-slit interference experiment using light of wavelength 540 nm, the separation of the slits is 0.700 mm. The fringes are viewed on a screen at a distance of 2.75 m from the double slit, as illustrated in Fig. 5.2 (not to scale).

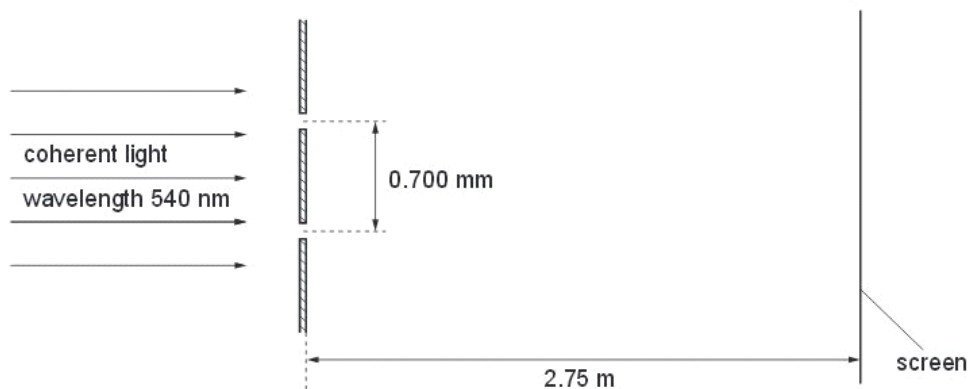


Fig. 5.2

Calculate the separation of the fringes observed on the screen.

separation = ... mm [3]

(c) State the effect, if any, on the appearance of the fringes observed on the screen when the following changes are made, separately, to the double-slit arrangement in (b).

(i) The width of each slit is increased but the separation remains constant.

.....
.....
.....
..... [3]

(ii) The separation of the slits is increased.

.....
.....
..... [2]

Q29.

6 (a) Explain what is meant by the *diffraction* of a wave.

.....
.....
..... [2]

- (b) (i) Outline briefly an experiment that may be used to demonstrate diffraction of a transverse wave.

.....
.....
..... [3]

- (ii) Suggest how your experiment in (i) may be changed to demonstrate the diffraction of a longitudinal wave.

.....
.....
..... [3]

Q30.

- 5 (a) State what is meant by a *progressive wave*.

.....

 [2]

- (b) The variation with distance x along a progressive wave of a quantity y , at a particular time, is shown in Fig. 5.1.

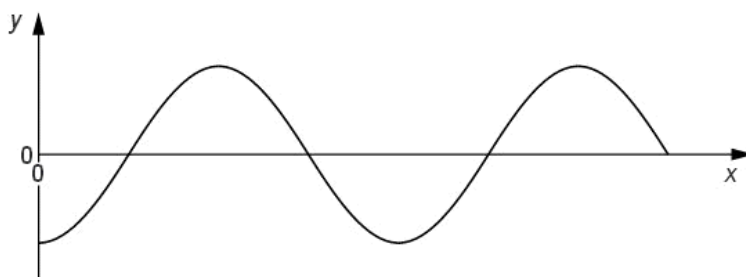


Fig. 5.1

- (i) State what the quantity y could represent.

.....
 [1]

- (ii) Distinguish between the quantity y for

1. a transverse wave,

.....
 [1]

2. a longitudinal wave.

.....
 [1]

- (c) The wave nature of light may be demonstrated using the phenomena of diffraction and interference.

E

Outline how diffraction and how interference may be demonstrated using light.
In each case, draw a fully labelled diagram of the apparatus that is used and describe what is observed.

diffraction

.....

.....

.....

interference

.....

.....

.....

[6]

Q31.

- 5 A uniform string is held between a fixed point P and a variable-frequency oscillator, as shown in Fig. 5.1.

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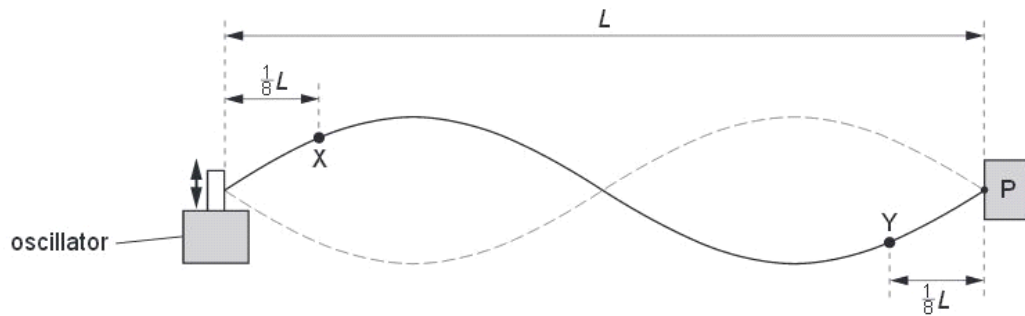


Fig. 5.1

The distance between point P and the oscillator is L .

The frequency of the oscillator is adjusted so that the stationary wave shown in Fig. 5.1 is formed.

Points X and Y are two points on the string.

Point X is a distance $\frac{1}{8}L$ from the end of the string attached to the oscillator. It vibrates with frequency f and amplitude A .

Point Y is a distance $\frac{1}{8}L$ from the end P of the string.

(a) For the vibrations of point Y, state

(i) the frequency (in terms of f),

frequency = ... [1]

(ii) the amplitude (in terms of A).

amplitude = ... [1]

(b) State the phase difference between the vibrations of point X and point Y.

phase difference = ... [1]

- (c) (i) State, in terms of f and L , the speed of the wave on the string.

speed = ... [1]

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- (ii) The wave on the string is a stationary wave.

Explain, by reference to the formation of a stationary wave, what is meant by the speed stated in (i).

.....

.....

.....

.....

..... [3]

Q32.

- 5 (a) State what is meant by the *diffraction* of a wave.

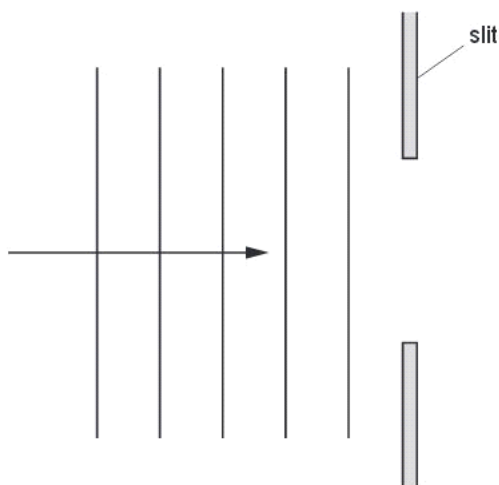
.....

.....

..... [2]

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- (b) Plane wavefronts are incident on a slit, as shown in Fig. 5.1.



Complete Fig. 5.1 to show four wavefronts that have emerged from the slit.

[2]

- (c) Monochromatic light is incident normally on a diffraction grating having 650 lines per millimetre, as shown in Fig. 5.2.

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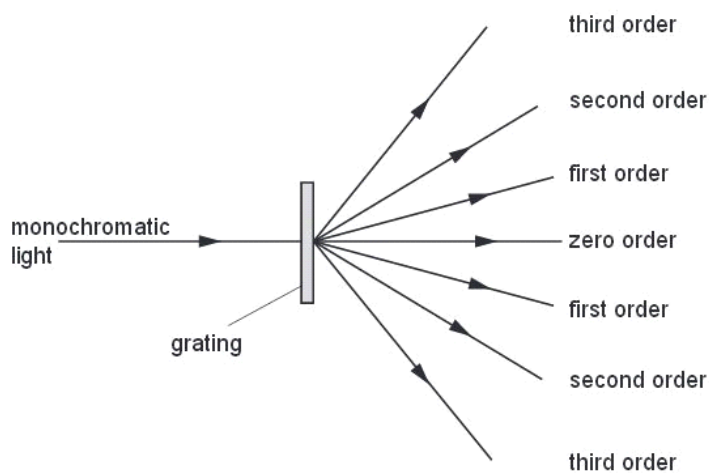


Fig. 5.2

An image (the zero order) is observed for light that has an angle of diffraction equal to zero.

For incident light of wavelength 590 nm, determine the number of orders of diffracted light that can be observed on each side of the zero order.

number = ... [3]

- (d) The images in Fig. 5.2 are viewed, starting with the zero order and then with increasing order number.
State how the appearance of the images changes as the order number increases.

.....
..... [1]

Q33.

- 5 A student is studying a water wave in which all the wavefronts are parallel to one another. The variation with time t of the displacement x of a particular particle in the wave is shown in Fig. 5.1.

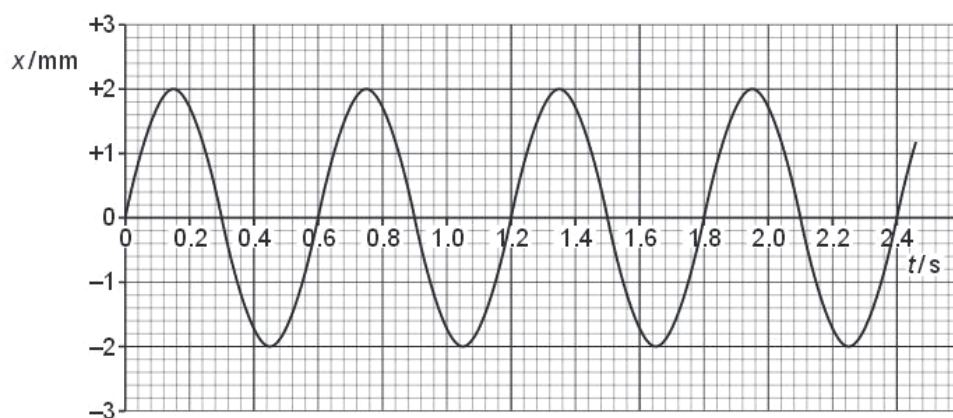


Fig. 5.1

The distance d of the oscillating particles from the source of the waves is measured. At a particular time, the variation of the displacement x with this distance d is shown in Fig. 5.2.

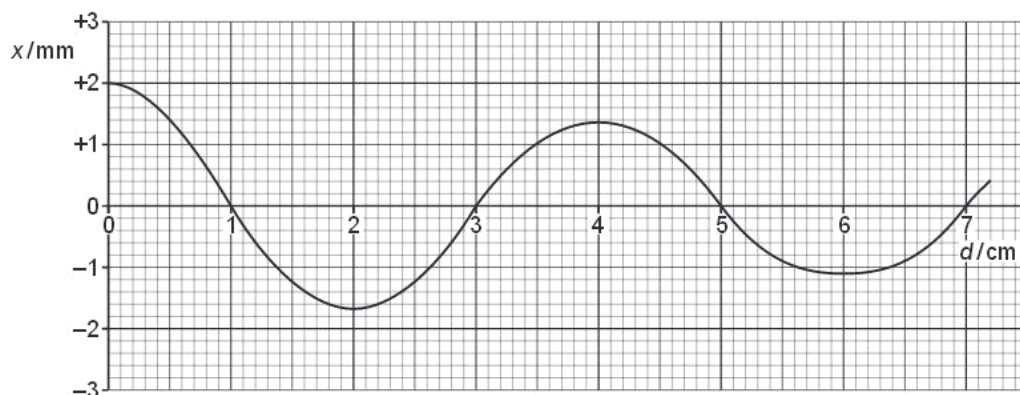


Fig. 5.2

(a) Define, for a wave, what is meant by

(i) *displacement*,

.....
[1]

(ii) *wavelength*.

.....
.....[1]

(b) Use Figs. 5.1 and 5.2 to determine, for the water wave,

(i) the period T of vibration,

$T = \dots\dots\dots \text{s}$ [1]

(ii) the wavelength λ ,

$\lambda = \dots\dots\dots \text{cm}$ [1]

(iii) the speed v .

$v = \dots\dots\dots \text{cm s}^{-1}$ [2]

- (c) (i) Use Figs. 5.1 and 5.2 to state and explain whether the wave is losing power as it moves away from the source.

.....
.....
..... [2]

- (ii) Determine the ratio

$$\frac{\text{intensity of wave at source}}{\text{intensity of wave 6.0 cm from source}}$$

ratio = ... [3]

Q34.

- 3 A loudspeaker produces a sound wave of constant frequency.

5

Outline how a cathode-ray oscilloscope (c.r.o.) may be used to determine this frequency.

.....

.....

.....

.....

..... [4]

Q35.

- 6 (a) State the principle of superposition.

Ex.

.....

 [2]

- (b) Coherent light of wavelength 590 nm is incident normally on a double slit, as shown in Fig. 6.1.

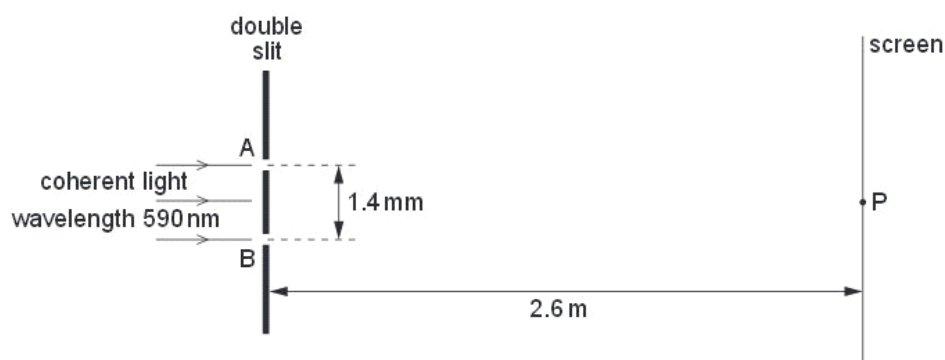


Fig. 6.1 (not to scale)

The separation of the slits A and B is 1.4 mm.

Interference fringes are observed on a screen placed parallel to the plane of the double slit.

The distance between the screen and the double slit is 2.6 m.

At point P on the screen, the path difference is zero for light arriving at P from the slits A and B.

- (i) Determine the separation of bright fringes on the screen near to point P.

separation = ... mm [3]

- (ii) The variation with time of the displacement x of the light wave arriving at point P on the screen from slit A and from slit B is shown in Fig. 6.2a and Fig. 6.2b respectively.

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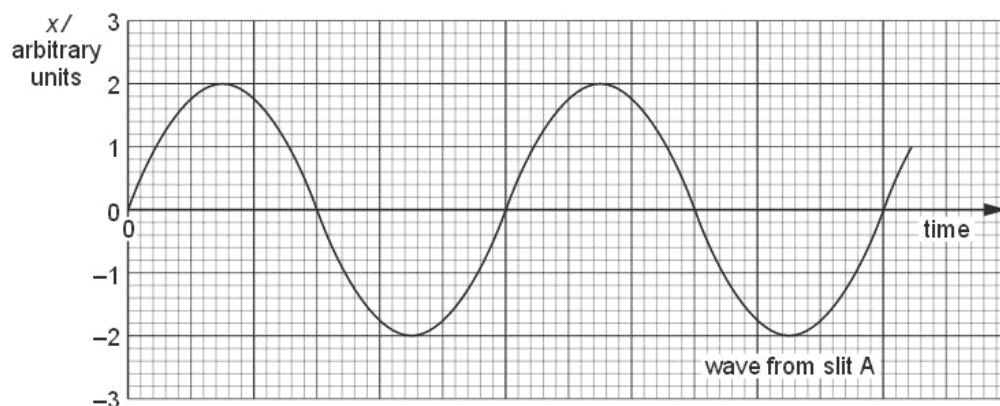


Fig. 6.2a

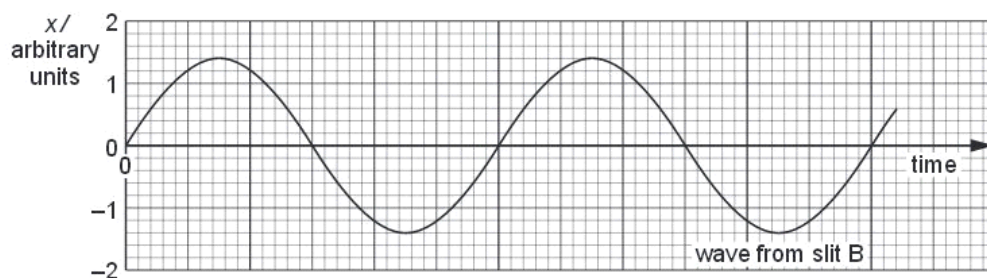


Fig. 6.2b

1. State the phase difference between waves forming the dark fringe on the screen that is next to point P.

phase difference = ... ° [1]

2. Determine the ratio

$$\frac{\text{intensity of light at a bright fringe}}{\text{intensity of light at a dark fringe}}$$

ratio = ... [3]

Q36.

6 (a) State the *principle of superposition*.

.....

 [2]

For
Examiner's
Use

(b) An arrangement that can be used to determine the speed of sound in air is shown in Fig. 6.1.

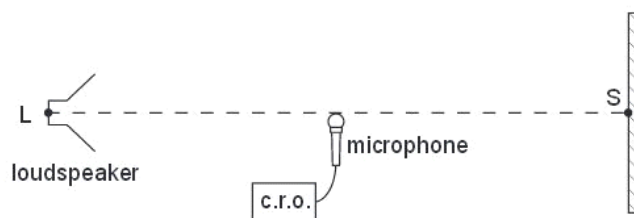


Fig. 6.1

Sound waves of constant frequency are emitted from the loudspeaker L and are reflected from a point S on a hard surface.
 The loudspeaker is moved away from S until a stationary wave is produced.

Explain how sound waves from L give rise to a stationary wave between L and S.

.....

 [2]

- (c) A microphone connected to a cathode ray oscilloscope (c.r.o.) is positioned between L and S as shown in Fig. 6.1. The trace obtained on the c.r.o. is shown in Fig. 6.2.

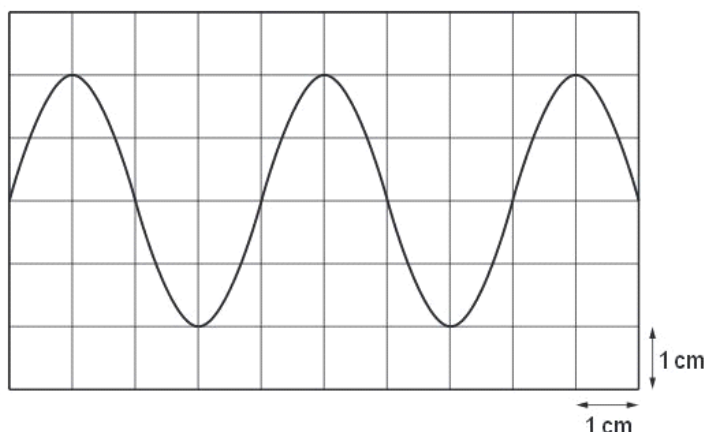


Fig. 6.2

The time-base setting on the c.r.o. is 0.10 ms cm^{-1} .

- (i) Calculate the frequency of the sound wave.

frequency = ... Hz [2]

- (ii) The microphone is now moved towards S along the line LS. When the microphone is moved 6.7 cm, the trace seen on the c.r.o. varies from a maximum amplitude to a minimum and then back to a maximum.

1. Use the properties of stationary waves to explain these changes in amplitude.

.....

 [1]

For
Examiner's
Use

2. Calculate the speed of sound.

speed of sound = ... m s^{-1} [3]

Q37.

- 5 (a) By reference to vibrations of the points on a wave and to its direction of energy transfer, distinguish between transverse waves and longitudinal waves.

For
Examine
Use

.....
.....
.....
..... [2]

- (b) Describe what is meant by a *polarised* wave.

.....
.....
..... [2]

- (c) The variation with distance x of the displacement y of a transverse wave is shown in Fig. 5.1.

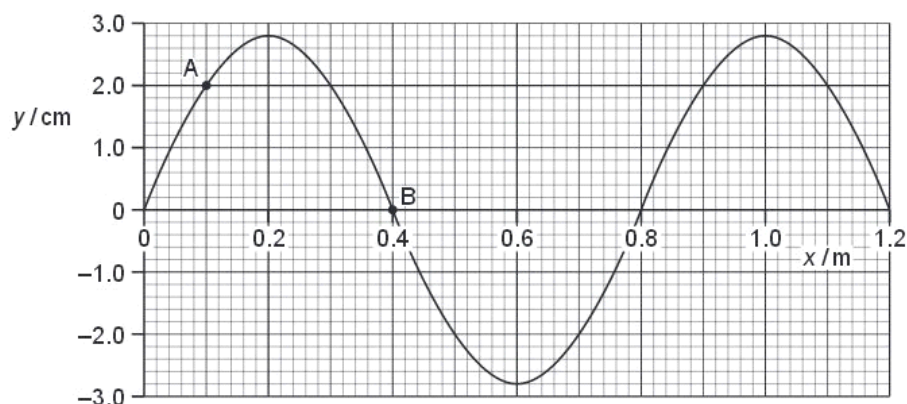


Fig. 5.1

- (i) Use Fig. 5.1 to determine

1. the amplitude of the wave,

amplitude = ... cm [1]

2. the phase difference between the points labelled A and B.

phase difference = ... [2]

- (ii) Determine the amplitude of a wave with twice the intensity of that shown in Fig. 5.1.

amplitude = ... cm [1]

For
Examin
Use

Q38.

- 4 (a) Describe the diffraction of monochromatic light as it passes through a diffraction grating.

Ex.

.....
.....
..... [2]

- (b) White light is incident on a diffraction grating, as shown in Fig. 4.1.

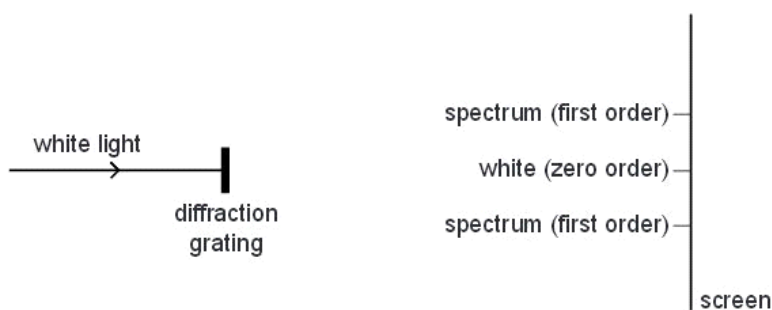


Fig. 4.1 (not to scale)

The diffraction pattern formed on the screen has white light, called zero order, and coloured spectra in other orders.

- (i) Describe how the principle of superposition is used to explain

1. white light at the zero order,

.....
.....
..... [2]

2. the difference in position of red and blue light in the first-order spectrum.

.....
.....
..... [2]

- (ii) Light of wavelength 625 nm produces a second-order maximum at an angle of 61.0° to the incident direction.
Determine the number of lines per metre of the diffraction grating.

For
Examiner's
Use

number of lines = ... m^{-1} [2]

- (iii) Calculate the wavelength of another part of the visible spectrum that gives a maximum for a different order at the same angle as in (ii).

wavelength = ...nm [2]

Q39.

- 4 Fig. 4.1 shows an arrangement for producing stationary waves in a tube that is closed at one end.

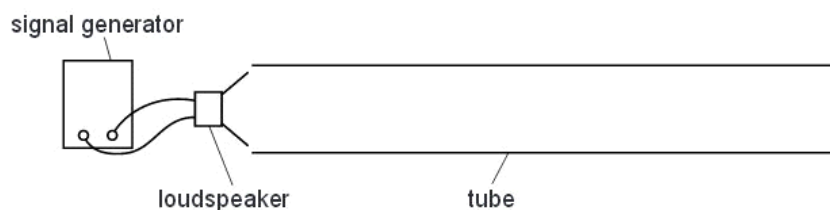


Fig. 4.1

- (a) Explain how waves from the loudspeaker produce stationary waves in the tube.

.....

[3]

- (b) One of the stationary waves that may be formed in the tube is represented in Fig. 4.2.



Fig. 4.2

- (i) Describe the motion of the air particles in the tube at

1. point P,

.....[1]

2. point S.

.....[1]

- (ii) The speed of sound in the tube is 330 m s^{-1} and the frequency of the waves from the loudspeaker is 880 Hz . Calculate the length of the tube.

length = ... m [3]

Q40.

- 5 (a) State one property of electromagnetic waves that is **not** common to other transverse waves.

Ex

..... [1]

- (b) The seven regions of the electromagnetic spectrum are represented by blocks labelled A to G in Fig. 5.1.

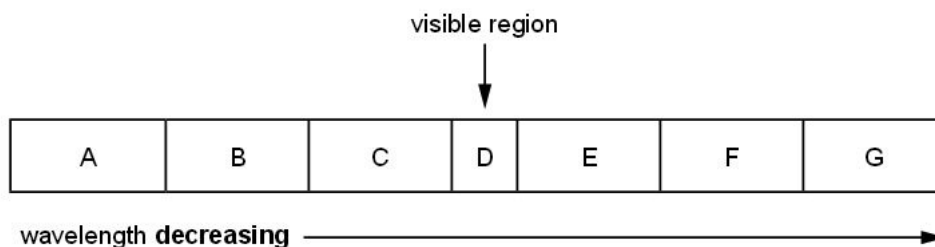


Fig. 5.1

A typical wavelength for the visible region D is 500 nm .

- (i) Name the principal radiations and give a typical wavelength for each of the regions B, E and F.

B: name: wavelength: m

E: name: wavelength: m

F: name: wavelength: m

[3]

- (ii) Calculate the frequency corresponding to a wavelength of 500 nm .

frequency = ... Hz [2]

- (c) All the waves in the spectrum shown in Fig. 5.1 can be polarised. Explain the meaning of the term *polarised*.

.....

.....

.....

..... [2]

Q41.

- 5 A long rope is held under tension between two points A and B. Point A is made to vibrate vertically and a wave is sent down the rope towards B as shown in Fig. 5.1.

For
Examin
Use

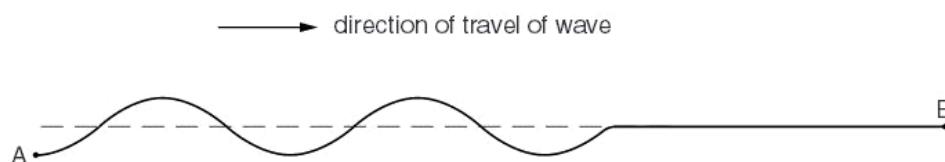


Fig. 5.1 (not to scale)

The time for one oscillation of point A on the rope is 0.20 s. The point A moves a distance of 80 mm during one oscillation. The wave on the rope has a wavelength of 1.5 m.

- (a) (i) Explain the term *displacement* for the wave on the rope.

.....

..... [1]

(ii) Calculate, for the wave on the rope,

1. the amplitude,

amplitude = ... mm [1]

2. the speed.

speed = ... m s⁻¹ [3]

(b) On Fig. 5.1, draw the wave pattern on the rope at a time 0.050 s later than that shown. [2]

(c) State and explain whether the waves on the rope are

(i) progressive or stationary,

.....
..... [1]

(ii) longitudinal or transverse.

.....
..... [1]

Q42.

5 (a) (i) Define, for a wave,

Ex

1. wavelength λ ,

.....
.....[1]

2. frequency f .

.....
.....[1]

(ii) Use your definitions to deduce the relationship between λ , f and the speed v of the wave.

[1]

- (b) Plane waves on the surface of water are represented by Fig. 5.1 at one particular instant of time.

E

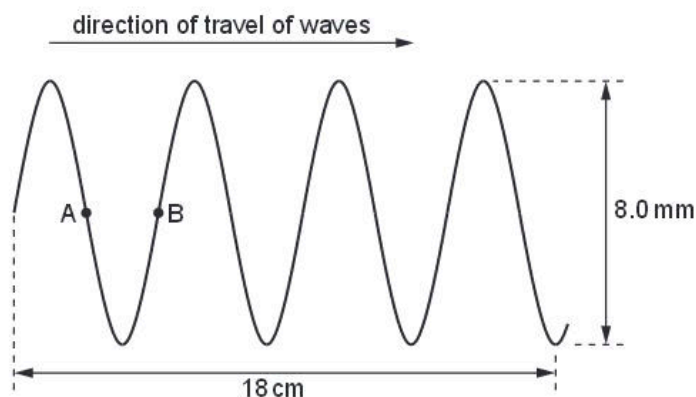


Fig. 5.1 (not to scale)

The waves have frequency 2.5 Hz.

Determine, for the waves,

- (i) the amplitude,

amplitude = ... mm [1]

- (ii) the speed,

speed = ... m s^{-1} [2]

- (iii) the phase difference between points A and B.

phase difference = ... unit [1]

- (c) The wave in (b) was produced in a ripple tank. Describe briefly, with the aid of a sketch diagram, how the wave may be observed.

E

.....

.....

.....

Q1.

4	(a)	e.g. both transverse/longitudinal/same type meet at a point, same direction of polarisation, etc..... 1 each, max 3 B3 (allow 1 mark for any condition for observable interference)	[3]
(b)	(i)1	allow 0.3 mm → 3 mm..... B1	
	(i)2	$\lambda = ax/D$ (allow any subject) B1	
	(ii)1	separation increased..... B1 less bright B1	
	(ii)2	separation increased..... B1 less bright B1	
	(ii)3	separation unchanged..... B1 fringes brighter..... B1 further detail, i.e quantitative aspect in (ii)1 or (ii)2 B1 (in (b), do not allow e.c.f. from (b)(i)2)	[7]

Q2.

2	(a)	(i) $\lambda = 0.6$ m (ii) frequency ($= v/\lambda$) = $330/0.60$ = 550 Hz (use of $c = 3 \times 10^8 \text{ ms}^{-1}$ scores no marks)	Total B1 C1 A1 [3]
	(b)	amplitude shown as greater than a but less than $2a$ and constant correct phase (wave to be at least three half-periods, otherwise -1 overall)	B1 B1 [2]
		Total	[5]

Q3.

6	(a)	When two (or more) waves meet (not 'superpose' or 'interfere') resultant displacement is the sum of individual (displacements)	Total B1 M1 A1 [3]
(b)	(i)	any correct line through points of intersection of crests	B1
	(ii)	any correct line through intersections of a crest and a trough	B1 [2]
(c)	(i)	$\lambda = ax/D$ OR $\lambda = a \sin \theta$ and $\theta = x/D$ $650 \times 10^{-9} = (a \times 0.70 \times 10^{-3})/1.2$ $a = 1.1 \times 10^{-3} \text{ m}$	C1 C1 A1 [3]
	(ii) 1	no change	B1
	2	brighter	B1
	3	no change (accept stay/remain dark)	B1 [3]
		Total	[11]

Q4.

5	(a)	When a wave (front) is incident on an edge or an obstacle/slit/gap Wave 'bends' into the geometrical shadow/changes direction/spreads	M1	
			A1	[2]
	(b) (i)	$d = 1/(750 \times 10^3)$ $= 1.33 \times 10^{-6} \text{ m}$	C1	
			A1	[2]
	(ii)	$1.33 \times 10^{-6} \times \sin 90^\circ = n \times 590 \times 10^{-9}$ $n = 2$ (must be an integer)	C1	
			A1	[2]
	(iii)	formula assumes no path difference of light before entering grating <u>or</u> there is a path difference before the grating	B1	[1]
	(c)	e.g. lines further apart in second order lines fainter in second order (allow any sensible difference: 1 each, max 2) (if differences stated but without reference to the orders, max 1 mark)	B2	[2]

Q5.

6	(a) (i)	correct shape drawn	B1	[1]
	(ii)	two nodes marked correctly	B1	[1]
	(b)	$\frac{1}{2}\lambda = 0.324 \text{ m}$	C1	
		$v = f\lambda$	C1	
		$= 512 \times 2 \times 0.324$ $= 332 \text{ m s}^{-1}$	A1	[3]
	(c)	$\frac{1}{4}\lambda = 16.2 \text{ cm}$	C1	
		either antinode is 0.5 cm above top of tube or antinode is 16.2 cm above water surface	A1	[2]

Q6.

5	(a)	(i)	vibrations (in plane) <u>normal</u> to direction of energy propagation	B1	[1]
		(ii)	vibrations in <u>one</u> direction (normal to direction of propagation)	B1	[1]
	(b)	(i)	at (displacement) antinodes / where there are no heaps, wave has maximum amplitude (of vibration)	B1	
			at (displacement) nodes/where there are heaps, amplitude of vibration is zero/minimum	B1	
			dust is pushed to / settles at (displacement) nodes	B1	[3]
		(ii)	$2.5\lambda = 39 \text{ cm}$	C1	
			$v = f\lambda$	C1	
			$v = 2.14 \times 10^3 \times 15.6 \times 10^{-2}$		
			$= 334 \text{ m s}^{-1}$ (allow 330, not 340)	A1	[3]
	(c)		Stationary wave formed by interference / superposition / overlap of <i>either</i> wave travelling down tube and its reflection	B1	
			<i>or</i> two waves of same (type and) frequency travelling in opposite directions	B1	
			speed is the speed of the incident / reflected waves	B1	[3]

Q7.

5	(a)	(i)	frequency: number of oscillations <u>per</u> unit time of the source / of a point on the wave	M1 A1	[2]
		(ii)	speed: speed at which energy is transferred / speed of wave <u>front</u>	B1	[1]
	(b)	(i)	does not transfer energy (along the wave)	B1	[1]
		(ii)	position (along wave) where amplitude of vibration is a maximum	B1	[1]
		(iii)	all three positions marked	B1	[1]
	(c)		wavelength = $2 \times 17.8 = 35.6 \text{ cm}$	C1	
			$v = f\lambda$	C1	
			$v = 125 \times 0.356$		
			$= 44.5 \text{ m s}^{-1}$	C1	
			$44.5^2 = 4.00 / m$	C1	
			$m = 2.0 \times 10^{-3} \text{ kg m}^{-1}$	A1	[5]

Q8.

5	(a)	<i>either</i> phase difference is $\pi \text{ rad} / 180^\circ$ <i>or</i> path difference (between waves from S_1 and S_2) is $\frac{1}{2}\lambda / (n + \frac{1}{2})\lambda$.	B1	
		<i>either</i> same amplitude / intensity at M <i>or</i> ratio of amplitudes is 1.28 / ratio of intensities is 1.28^2	B1	[2]
	(b)	path difference between waves from S_1 and $S_2 = 28 \text{ cm}$	B1	
		wavelength changes from 33 cm to 8.25 cm	B1	
		minimum when $\lambda = (56 \text{ cm,}) 18.7 \text{ cm, } 11.2 \text{ cm, } (8.0 \text{ cm})$	B1	
		so two minima	B1	[4]

Q9.

- 5 (a) constant phase difference B1 [1]
- (b) allow wavelength estimate 750 nm → 550 nm C1
 separation = $\lambda D / x$ C1
 $= (650 \times 10^{-9} \times 2.4) / (0.86 \times 10^{-3})$
 $= 1.8 \text{ mm}$ A1 [3]
(allow 2 marks from inappropriate estimate if answer is in range 10 cm → 0.1 mm)
- (c) no longer complete destructive interference /
 amplitudes no longer completely cancel M1
 so dark fringes are lighter A1 [2]

Q10.

- 4 (a) when a wave (front) passes by/incident on an edge/slit M1
 wave bends/spreads (into the geometrical shadow) A1 [2]
- (b) $\tan \theta = \frac{38}{165}$
 $\theta = 13^\circ$ C1
 $d \sin \theta = n\lambda$ C1
 $d = 2.82 \times 10^{-6}$ C1
 number = $(1/d) = 3.6 \times 10^5$ A1 [4]
- (c) P remains in same position B1
 X and Y rotate through 90° B1 [2]
- (d) *either* screen not parallel to grating
or grating not normal to (incident) light B1 [1]

Q11.

- 4 (a) e.g. no energy transfer
 amplitude varies along its length/nodes and antinodes
 neighbouring points (in inter-nodal loop) vibrate in phase, etc.
(any two, 1 mark each to max 2) B2 [2]

(b) (i)	$\lambda = (330 \times 10^2)/550$	M1	
	$\lambda = 60 \text{ cm}$	A0	[1]
(ii)	node labelled at piston	B1	
	antinode labelled at open end of tube	B1	
	additional node and antinode in correct positions along tube	B1	[3]
(c)	at lowest frequency, length = $\lambda/4$	C1	
	$\lambda = 1.8 \text{ m}$		
	frequency = $330/1.8$	C1	
	= 180 Hz	A1	[3]

Q12.

5 (a) (i)	1 number of oscillations per unit time (not per second)	B1	[1]
	2 $n\lambda$	A1	[1]
(ii)	$v = \text{distance} / \text{time} = n\lambda/t$	M1	
	$n/t = f$ hence $v = f\lambda$	A1	
	or f oscillations per unit time so $f\lambda$ is distance per unit time	M1	
	distance per unit time is v so $v = f\lambda$	A1	[2]
(b) (i)	1.0 period is $3 \times 2 = 6.0 \text{ ms}$	C1	
	frequency = $1/(6 \times 10^{-3}) = 170 \text{ Hz}$	A1	[2]
(ii)	wave (with approx. same amplitude and) with correct phase difference	B1	[1]

Q13.

7 (a)	when waves overlap / meet, (resultant) displacement is the sum of the individual displacements	B1	[1]
(b) (i)	two (ball-type) dippers	(M1)	
	connected to the same vibrating source /motor	(A1)	
	or		
	one wave source described with two slits	(M1) (A1)	[2]
(ii)	lamp with viewing screen on opposite side of tank	B1	
	means of freezing picture e.g. strobe	B1	[2]
(c) (i)	two correct lines labelled X	B1	[1]
	(ii) correct line labelled N	B1	[1]

Q14.

6 (a) (i)	to produce coherent sources or constant phase difference	B1	[1]
(ii) 1.	$360^\circ / 2\pi$ rad allow $n \times 360^\circ$ or $n \times 2\pi$ (unit missing –1)	B1	[1]
2.	$180^\circ / \pi$ rad allow $(n \times 360^\circ) - 180^\circ$ or $(n \times 2\pi) - \pi$	B1	[1]
(iii) 1.	waves overlap / meet	B1	
	(resultant) displacement is sum of displacements of each wave	B1	[2]
2.	at P crest on trough (OWTTE)	B1	[1]
(b)	$\lambda = ax / D$	C1	
	$= 2 \times 2.3 \times 10^{-3} \times 0.25 \times 10^{-3} / 1.8$	C1	
	$= 639 \text{ nm}$	A1	[3]

Q15.

6 (a) (i)	amplitude = 7.6 mm allow 7.5 mm	A1	[1]
(ii)	$180^\circ / \pi$ rad	A1	[1]
(iii)	$v = f \times \lambda$	C1	
	$= 15 \times 0.8$	A1	[2]
	$= 12 \text{ ms}^{-1}$		
(b)	correct sketch with peak moved to the right	B1	
	curve moved by the correct phase angle / time period of $0.25 T$	B1	[2]
(c) (i)	zero (rad)	A1	[1]
(ii)	antinode maximum amplitude, node zero amplitude / displacement	A1	[1]
(iii)	3	A1	[1]
(iv)	horizontal line through central section of wave	B1	[1]

Q16.

6 (a) (i)	coherence: constant phase difference between (two) waves	M1	
		A1	[2]
(ii)	path difference is <i>either</i> λ or $n\lambda$ or phase difference is 360° or $n \times 360^\circ$ or $n2\pi$ rad	B1	[1]

- (iii) path difference is *either* $\lambda/2$ or $(n + \frac{1}{2}) \lambda$
or phase difference is odd multiple of *either* 180° or π rad B1 [1]
- (iv) $w = \lambda D / a$ C1
 $= [630 \times 10^{-9} \times 1.5] / 0.45 \times 10^{-3}$ C1
 $= 2.1 \times 10^{-3} \text{m}$ A1 [3]
- (b) no change to dark fringes B1
no change to separation/fringe width B1
bright fringes are brighter/lighter/more intense B1 [3]

Q17.

- 6 (a) two waves travelling (along the same line) in opposite directions overlap/meet M1
same frequency / wavelength A1
resultant displacement is the sum of displacements of each wave /
produces nodes and antinodes B1 [3]
- (b) apparatus: source of sound + detector + reflection system B1
adjustment to apparatus to set up standing waves – how recognised B1
measurements made to obtain wavelength B1 [3]
- (c) (i) at least two nodes and two antinodes A1 [1]
- (ii) node to node $= \lambda / 2 = 34 \text{ cm}$ (allow 33 to 35 cm) C1
 $c = f\lambda$ C1
 $f = 340 / 0.68 = 500$ (490 to 520) Hz A1 [3]

Q18.

- 6 (a) (i) diffraction bending/spreading of light at edge/slit B1
this occurs at each slit B1 [2]
- (ii) constant phase difference between each of the waves B1 [1]
- (iii) (when the waves meet) the resultant displacement is the sum of the
displacements of each wave B1 [1]
- (b) $d \sin \theta = n\lambda$
 $n = d / \lambda = 1 / 450 \times 103 \times 630 \times 10^{-9}$ C1
 $n = 3.52$ M1
hence number of orders = 3 A1 [3]
- (c) λ blue is less than λ red M1
more orders seen A1
each order is at a smaller angle than for the equivalent red A1 [3]

Q19.

- 5 (a) waves overlap / meet / superpose (B1)
 coherence / constant phase difference (*not constant λ or frequency*) (B1)
 path difference = 0, λ , 2λ or phase difference = 0, 2π , 4π (B1)
 same direction of polarisation/unpolarised (B1)
 max. 3 [3]
- (b) $\lambda = v / f$ C1
 $f = 12 \times 10^9 \text{ Hz}$ C1
 $\lambda = 3 \times 10^8 / 12 \times 10^9$ (any subject) M1
 $= 0.025 \text{ m}$ A0 [3]
- (c) maximum at P B1
several minima or maxima between O and P B1
 5 maxima / 6 minima between O and P
 or 7 maxima / 6 minima including O and P B1 [3]
- (d) slits made narrower B1
 slits put closer together B1 [2]
 (*not just 'make slits smaller'*)
 Allow tilting the slits M1 and explanation of axes of rotation A1

Q20.

- 5 (a) (i) $v = f\lambda$ C1
 $\lambda = 40 / 50 = 0.8(0) \text{ m}$ A1 [2]
- (ii) waves (travel along string and) reflect at Q / wall / fixed end B1
 incident and reflected waves interfere / superpose B1 [2]
- (b) (i) nodes labelled at P, Q and the two points at zero displacement B1
 antinodes labelled at the three points of maximum displacement B1 [2]
- (ii) $(1.5\lambda \text{ for PQ hence } PQ = 0.8 \times 1.5) = 1.2 \text{ m}$ A1 [1]
- (iii) $T = 1 / f = 1/50 = 20 \text{ ms}$ C1
 5 ms is $\frac{1}{4}$ of cycle A1
 horizontal line through PQ drawn on Fig. 5.2 B1 [3]

Q21.

- 5 (a) when waves overlap / meet B1
the resultant displacement is the sum of the individual displacements of the waves B1 [2]
- (b) (i) 1. phase difference = $180^\circ / (n + \frac{1}{2}) 360^\circ$ (allow in rad) B1 [1]
2. phase difference = $0 / 360^\circ / (n360^\circ)$ (allow in rad) B1 [1]
- (ii) $v = f\lambda$ C1
 $\lambda = 320 / 400 = 0.80 \text{ m}$ A1 [2]
- (iii) path difference = $7 - 5 = 2 \text{ (m)}$
 $= 2.5\lambda$ M1
hence minimum
or maximum if phase change at P is suggested A1 [2]

Q22.

- 5 (a) displacement & direction of energy travel normal to one another ... B1 [1]
- (b) (i) phase angle of 60° correct .. (need to see $1\frac{1}{2}$ wavelengths) B1
lags behind T_1 B1 [2]
- (ii) waves must be in same place (at same time) B1
resultant displacement = sum of individual displacements B1 [2]
- (iii) 1. $-\frac{1}{2}A$ B1
2. $\frac{1}{2}A$ (allow e.c.f.) B1
3. zero (allow e.c.f.) B1 [3]

Q23.

- 4 (a) (i)1 amplitude = $0.4(0) \text{ mm}$ A1
- (i)2 wavelength = $7.5 \times 10^{-2} \text{ m}$
(1 sig. fig. -1 unless already penalised) A1
- (i)3 period = 0.225 ms C1
frequency = $1/T = 4400 \text{ Hz}$ A1
- (i)4 $v = f\lambda$
 $= 4400 \times 7.5 \times 10^{-2}$ C1
 $= 330 \text{ m s}^{-1}$ A1 [6]

(a)	(ii)	reasonable shape, same amplitude and wavelength doubled	B1	[1]
(b)	(i)	$1.7(2) \mu\text{m}$	A1	
	(ii)	$d \sin 2 = n\lambda$ (double slit formula scores 0/2)		
		$1.72 \times 10^{-6} \times \sin 2 = 590 \times 10^{-9}$	C1	
		$2 = 20.1^\circ$ (allow 20°)	A1	
	(iii)	$\frac{1}{2}L = 1.5 \tan 20.1$	C1	
		$L = 1.1 \text{ m}$	A1	[5]

Q24.

2	(a)	all same speed in a vacuum (allow medium)/all travel in a vacuum	(1)	
		transverse/can be polarised	(1)	
		undergo diffraction/interference/superposition	(1)	
		can be reflected/refracted	(1)	
		show properties of particles	(1)	
		oscillating electric and magnetic fields	(1)	
		transfer energy/progressive	(1)	
		not affected by electric and magnetic fields	(1)	
		(allow any three, 1 each)		B3 [3]
	(b)	$495 \text{ nm} = 495 \times 10^{-9} \text{ m}$		C1
		number = $1/(495 \times 10^{-9}) = 2.02 \times 10^6$		A1 [2]
		(allow 2 or more significant figures)		
	(c)	(i) allow $10^{-7} \rightarrow 10^{-11} \text{ m}$		B1
		(ii) allow $10^{-3} \rightarrow 10^{-6} \text{ m}$		B1 [2]

Q25.

- 4 (a) wavelength = 1.50 m B1 [1]
- (b) $v = f \lambda$ C1
- speed = 540 m s⁻¹ A1 [2]
- (c) (progressive) wave reflected at the (fixed) ends B1
- wave is formed by superposition of (two travelling) waves B1
- this quantity is the speed of the travelling wave B1 [3]

Q26.

- 5 (a) similarity: e.g. same wavelength/frequency/period, constant phase difference B1
- difference: e.g. different amplitude/phase (do not allow a reference to phase for both similarity and difference) B1 [2]
- (b) constant phase difference so coherent B1 [1]
- (c) (i) $intensity \propto amplitude^2$ C1
- $I \propto 3^2$ and $I_B \propto 2^2$ leading to M1
- $I_B = \frac{4}{9} I$ A0 [2]
- (ii) resultant amplitude = 1.0×10^{-4} cm C1
- resultant intensity = $\frac{1}{9} I$ A1 [2]
- (d) (i) displacement = 0 B1 [1]
- (ii) $x_A = -2.6 \times 10^{-4}$ cm and $x_B = +1.7 \times 10^{-4}$ cm C1
- allow $\pm 0.5 \times 10^{-4}$ cm
- resultant displacement = (-) 0.9×10^{-4} cm A1 [2]

Q27.

- 4 (a) (i) when two (or more) waves meet (at a point) M1
- there is a change in overall intensity / displacement A1
- (ii) constant phase difference (between waves) B1 [3]
- (b) (i) $d \sin \theta = n \lambda$ B1
- $(10^{-3} / 550) \sin 90 = n \times 644 \times 10^{-9}$ C1
- $n = 2.8$ C1
- so two orders A1 [4]
- (power-of-ten error giving 2800 orders, allow 1/3 only for calculation of n)
- (ii) 1. $d \sin \theta = n \lambda$ (either here or in (i) – not both) B1 [1]
- θ is greater so λ is greater
2. when n is larger, $\Delta \theta$ is larger M1
- so greater in second order A1 [2]

Q28.

- 5 (a) amplitude between 6.5 squares and 7.5 squares on 3 peaks
(allow 1 mark if outside this range but between 6.0 and 8.0 squares)
correct phase (ignore lead/lag, look at x-axis only and allow $\pm\frac{1}{2}$ square) B2
B1 [3]
- (b) $\lambda = ax / D$ C1
 $540 \times 10^{-9} = (0.700 \times 10^{-3} x) / 2.75$ C1
 $x = 2.12 \text{ mm}$ A1 [3]
- (c) (i) same separation B1
bright areas brighter (1)
dark areas, no change (1)
(allow 'contrast greater' for 1 mark if dark/light areas not discussed)
fewer fringes observed (1) any two, 1 each B2 [3]
- (ii) smaller separation of fringes B1
no change in brightness B1 [2]

Q29.

- 6 (a) wave incident at an edge / aperture / slit / (edge of) obstacle M1
bending / spreading of wave (into geometrical shadow) A1 [2]
(award 0/2 for bending at a boundary)
- (b) (i) apparatus e.g. laser & slit / point source & slit / lamp and slit & slit
microwave source & slit B1
water / ripple tank, source & barrier
detector e.g. screen
aerial / microwave probe B1
strobe / lamp B1 [3]
what is observed B1
- (ii) apparatus e.g. loudspeaker, and slit / edge B1
detector e.g. microphone & c.r.o. / ear B1
what is observed B1 [3]

Q30.

5	(a)	transfer / propagation of energy	M1	
		as a result of oscillations / vibrations	A1	[2]
	(b)	(i) displacement / velocity / acceleration (of particles in the wave)	B1	[1]
		(ii) displacement etc. is normal to direction of energy transfer / travel of wave / propagation of wave(not 'wave motion')	B1	[1]
		(iii) displacement etc. along / same direction of energy transfer / travel of wave / propagation of wave(not 'wave motion')	B1	[1]
	(c)	diffraction: suitable object, means of observation	M1	
		either laser or lamp and aperture		
		or distant source	M1	
		light region where darkness expected	A1	
		interference: suitable object, means of observation and illumination	B1	
		light and dark fringes observed	B1	
		appropriate reference to a dimension for diffraction or for interference	B1	[6]
				[Total: 11]

Q31.

5	(a)	(i) frequency f	B1	[1]
		(ii) amplitude A	B1	[1]
	(b)	π rad or 180°(unit necessary)	B1	[1]
	(c)	(i) speed = $f \times L$	B1	[1]
		(ii) wave is reflected at end / at P	B1	
		either incident and reflected waves interfere		
		or two waves travelling in opposite directions interfere	M1	
		speed is the speed of incident or reflected wave / one of these waves	A1	[3]
				[Total: 7]

Q32.

- 5 (a) when a wave passes through a slit / by an edge
the wave spreads out / changes direction M1
A1 [2]
- (b) diagram: wavelength unchanged M1
wavefront flat at centre, curving into geometrical shadow A1 [2]
- (c) $d \sin \theta = n\lambda$ C1
for $\theta = 90^\circ$
 $1 / (650 \times 10^3) = n \times 590 \times 10^{-9}$ M1
 $n = 2.6$
number of orders is 2 A1 [3]
- (d) intensity / brightness decreases (as order increases) B1 [1]

Q33.

- 5 (a) (i) distance (of point on wave) from rest / equilibrium position B1 [1]
- (ii) distance moved by wave energy / wavefront during one cycle of the source
or minimum distance between two points with the same phase or between
adjacent crests or troughs B1 [1]
- (b) (i) $T = 0.60\text{ s}$ B1 [1]
- (ii) $\lambda = 4.0\text{ cm}$ B1 [1]
- (iii) either $v = \lambda/T$ or $v = f\lambda$ and $f = 1/T$ C1
 $v = 6.7\text{ cm s}^{-1}$ A1 [2]
- (c) (i) amplitude is decreasing
so, it is losing power M1
A1 [2]
- (ii) $\text{intensity} \sim (\text{amplitude})^2$ C1
ratio = $2.0^2 / 1.1^2$ C1
= 3.3 A1 [3]

Q34.

- 3 connect microphone / (terminals of) loudspeaker to Y-plates of c.r.o. B1
adjust c.r.o. to produce steady wave of 1 (or 2) cycles / wavelengths on screen B1
measure length of cycle / wavelength λ and note time-base b M1
frequency = $1 / \lambda b$ A1 [4]
(assume b is measured as s cm^{-1} , unless otherwise stated)
- (if statement is 'measure T , $f = 1/T$ ' then last two marks are lost)

Q35.

- 6 (a) when two (or more) waves meet (at a point)
(resultant) displacement is (vector) sum of individual displacements B1
B1 [2]
- (b) (i) $\lambda = ax / D$ (if no formula given and substitution is incorrect then 0/3) C1
 $590 \times 10^{-9} = (1.4 \times 10^{-3} \times x) / 2.6$ C1
 $x = 1.1 \text{ mm}$ A1 [3]
- (ii) 1. 180° (allow π if rad stated) A1 [1]
2. at maximum, amplitude is 3.4 units and at minimum, 0.6 units C1
intensity $\sim$ *amplitude*² allow $I \sim a^2$ C1
ratio = $3.4^2 / 0.6^2$
= 32 A1 [3]

Q36.

- 6 (a) waves overlap B1
(resultant) displacement is the sum of the displacements of each of the waves B1 [2]
- (b) waves travelling in opposite directions overlap / incident and reflected waves overlap B1
(allow superpose or interfere for overlap here) B1 [2]
waves have the same speed and frequency
- (c) (i) time period = $4 \times 0.1 \text{ (ms)}$ C1
 $f = 1 / T = 1 / 4 \times 10^{-4} = 2500 \text{ Hz}$ A1 [2]
- (ii) 1. the microphone is at an antinode and goes to a node and then an antinode / maximum amplitude at antinode and minimum amplitude at node B1 [1]
2. $\lambda / 2 = 6.7 \text{ (cm)}$ C1
 $v = f\lambda$ C1
 $v = 2500 \times 13.4 \times 10^{-2} = 335 \text{ ms}^{-1}$ A1 [3]
- incorrect λ then can only score second mark

Q37.

- 5 (a) transverse waves have vibrations that are perpendicular / normal to the direction of energy travel B1
longitudinal waves have vibrations that are parallel to the direction of energy travel B1 [2]
- (b) vibrations are in a single direction M1
either applies to transverse waves
or normal to direction of wave energy travel A1 [2]
or normal to direction of wave propagation
- (c) (i) 1. amplitude = 2.8 cm B1 [1]
2. phase difference = 135° or 0.75π rad or $\frac{3}{4}\pi$ rad or 2.36 radians (three sf needed) M1
numerical value A1 [2]
unit
- (ii) amplitude = 3.96 cm (4.0 cm) A1 [1]

Q38.

- 4 (a) waves pass through the elements / gaps / slits in the grating spread into geometric shadow M1
A1 [2]
- (b) (i) 1. displacements add to give resultant displacement B1
each wavelength travels the same path difference or are in phase B1
hence produce a maximum A0 [2]
2. to obtain a maximum the path difference must be λ or phase difference $360^\circ / 2\pi$ rad B1
 λ of red and blue are different B1
hence maxima at different angles / positions A0 [2]
- (ii) $n\lambda = d \sin \theta$ C1
 $N = \sin 61^\circ / (2 \times 625 \times 10^{-9}) = 7.0 \times 10^5$ A1 [2]
- (iii) $n\lambda = 2 \times 625$ is a constant (1250) C1
 $n = 1 \rightarrow \lambda = 1250$ outside visible
 $n = 3 \rightarrow \lambda = 417$ in visible
 $n = 4 \rightarrow \lambda = 312.5$ outside visible
 $\lambda = 420$ nm A1 [2]

Q39.

- 4 (a) waves (travels along tube) reflect at closed end / end of tube
incident and reflected waves or these two waves are in opposite directions
interfere or stationary wave formed if tube length equivalent to
 $\lambda / 4, 3\lambda / 4$, etc. B1
M1
A1 [3]
- (b) (i) 1. no motion (as node) / zero amplitude B1 [1]
2. vibration backwards and forwards / maximum amplitude
along length B1 [1]
- (ii) $\lambda = 330 / 880 (= 0.375 \text{ m})$ C1
 $L = 3\lambda / 4$ C1
 $L = 3 / 4 \times (0.375) = 0.28 (0.281) \text{ m}$ A1 [3]

Q40.

- 5 (a) travel through a vacuum / free space B1 [1]
- (b) (i) B : name: **microwaves** wavelength: 10^{-4} to 10^{-1} m B1
C : name: **ultra-violet / UV** wavelength: 10^{-7} to 10^{-9} m B1
F : name: **X-rays** wavelength: 10^{-9} to 10^{-12} m B1 [3]
- (ii) $f = \frac{3 \times 10^8}{500 \times 10^{-9}}$ C1
 $f = 6(.0) \times 10^{14} \text{ Hz}$ A1 [2]
- (c) vibrations are in one direction M1
perpendicular to direction of propagation / energy transfer
or good sketch showing this A1 [2]

Q41.

- 5 (a) (i) displacement is the distance the rope / particles are (above or below) from the equilibrium / mean / rest / undisturbed position (not 'distance moved') B1 [1]
- (ii) 1. amplitude ($= 80 / 4$) = 20 mm B1 [1]
2. $v = f\lambda$ or $v = \lambda / T$ C1
 $f = 1 / T = 1 / 0.2$ (5 Hz) C1
 $v = 5 \times 1.5 = 7.5 \text{ ms}^{-1}$ A1 [3]
- (b) point A of rope shown at equilibrium position B1
same wavelength, shape, peaks / wave moved $\frac{1}{4}\lambda$ to right B1 [2]
- (c) (i) progressive as energy OR peaks OR troughs is/are transferred/moved /propagated (by the waves) B1 [1]
- (ii) transverse as particles/rope movement is perpendicular to direction of travel /propagation of the energy/wave velocity B1 [1]

Q42.

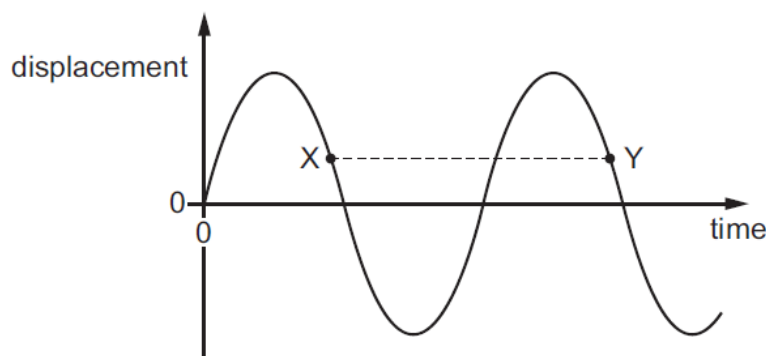
- 5 (a) (i) 1. wavelength: minimum distance between two points moving in phase OR distance between neighbouring or consecutive peaks or troughs OR wavelength is the distance moved by a wavefront in time T or one oscillation/cycle or period (of source) B1 [1]
2. frequency: number of wavefronts / (unit) time OR number of oscillations per unit time or oscillations/time B1 [1]
- (ii) speed = $\frac{\text{distance}}{\text{time}} = \frac{\text{wavelength}}{\text{time period}}$ M1
 $= \lambda / T = \lambda f$ A0 [1]
- (b) (i) amplitude = 4.0 mm (allow 1 s.f.) A1 [1]
- (ii) wavelength = $18 / 3.75$ (= 4.8) C1
speed = $2.5 \times 4.8 \times 10^{-2} = 12 \times 10^{-2} \text{ ms}^{-1}$ unit consistent with numerical answer, e.g. in cm s^{-1} if cm used for λ and unit changed on answer line [if $18 \text{ cm} = 3.5\lambda$ used giving speed 13 (12.9) cm s^{-1} allow max. 1]. A1 [2]
- (iii) 180° or π rad A1 [1]
- (c) light and screen and correct positions above and below ripple tank B1
strobe or video camera B1 [2]

Waves - 2018

1. 9702/11/M/J/18/No.20

A transverse progressive wave is set up on a string.

The graph shows the variation with time of displacement for a point on this string.



The separation XY on the graph represents the 1..... of the wave.

X and Y have equal 2..... .

Which words correctly complete gaps 1 and 2?

	1	2
A	time period	amplitudes
B	time period	displacements
C	wavelength	amplitudes
D	wavelength	displacements

2. 9702/11/M/J/18/No.21

Which region of the electromagnetic spectrum includes waves with a frequency of 10^7 MHz?

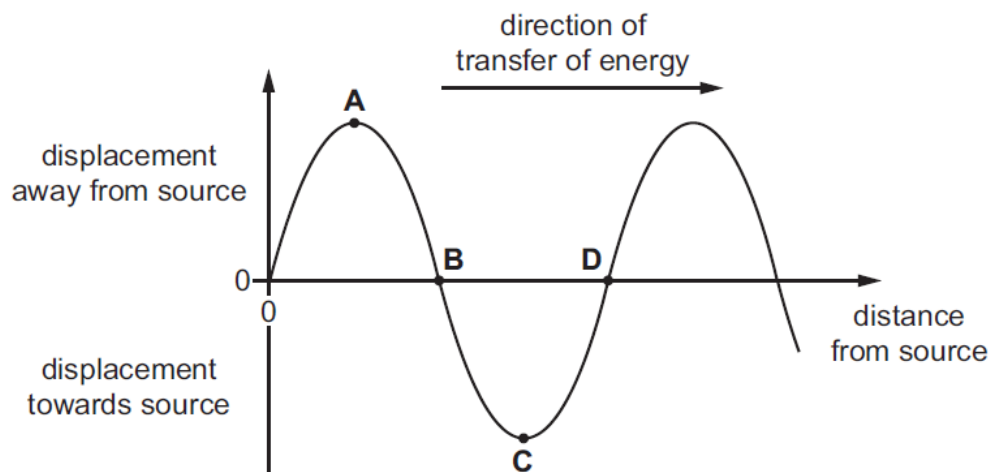
- A** infra-red waves
- B** radio waves
- C** ultraviolet waves
- D** X-rays

3. 9702/11/M/J/18/No.22

A longitudinal wave has vibrations parallel to the direction of transfer of energy by the wave.

The wave can be represented on a graph showing the variation of the displacement of the particles with distance from the source.

Which point on the graph is the centre of a compression?



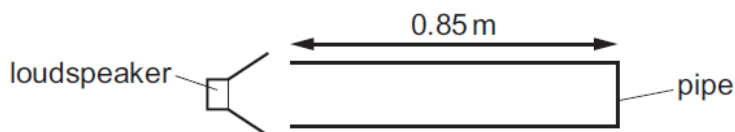
4. 9702/11/M/J/18/No.23

What can be deduced from a table of wavelengths of the waves in the electromagnetic spectrum?

- A Green light has a shorter wavelength than X-rays.
- B Red light has a shorter wavelength than green light.
- C The wavelength range for radio waves is less than that for infra-red waves.
- D The wavelength range for X-rays is less than that for radio waves.

5. 9702/11/M/J/18/No.27

A pipe, closed at one end, has a loudspeaker at the open end. A stationary sound wave is formed in the air within the pipe with an antinode at the open end of the pipe.



The length of the pipe is 0.85 m.

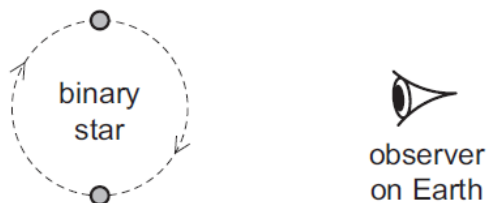
The speed of sound in air is 340 m s^{-1} .

Which frequency of sound from the loudspeaker would **not** produce a stationary wave?

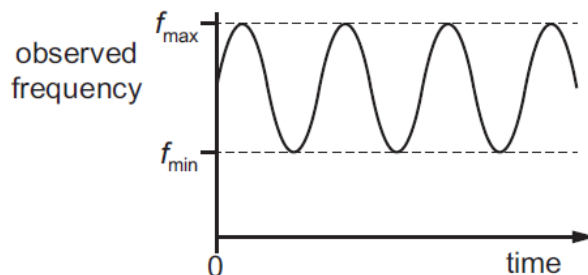
- A 100 Hz
- B 200 Hz
- C 300 Hz
- D 500 Hz

6. 9702/11/M/J/18/No.24

A binary star consists of two stars rotating around a common centre. Light from one of the stars is observed on the Earth.



The observed frequency of the light varies between a minimum frequency $f_{\min}$ and a maximum frequency $f_{\max}$, as shown.



The rate of rotation of the binary star increases.

What is the change to $f_{\max}$ and the change to $f_{\min}$?

	$f_{\max}$	$f_{\min}$
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

7. 9702/12/M/J/18/No.22

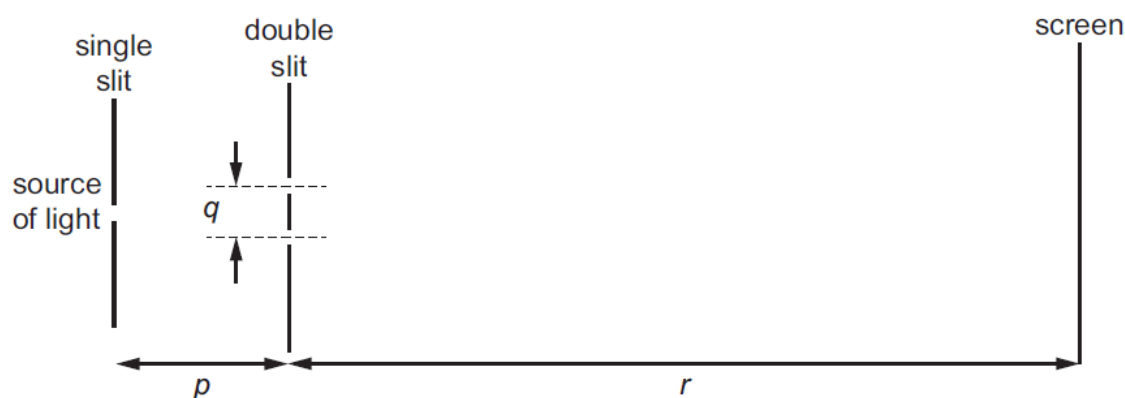
Two lasers emit light in a vacuum. One laser emits red light and the other emits green light.

Which property of the two laser beams **must** be different?

- A** amplitude
- B** frequency
- C** intensity
- D** speed

8. 9702/11/M/J/18/No.25

A teacher sets up the apparatus shown to demonstrate a double-slit interference pattern on the screen.

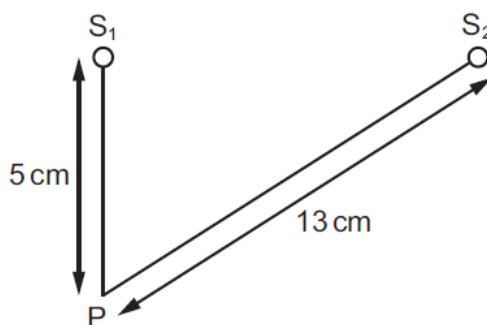


Which change to the apparatus will increase the fringe spacing?

- A decreasing the distance p
- B decreasing the distance q
- C decreasing the distance r
- D decreasing the wavelength of the light

9. 9702/11/M/J/18/No.26

The diagram shows two sources of waves S_1 and S_2 . The sources oscillate with a phase difference of 180° .



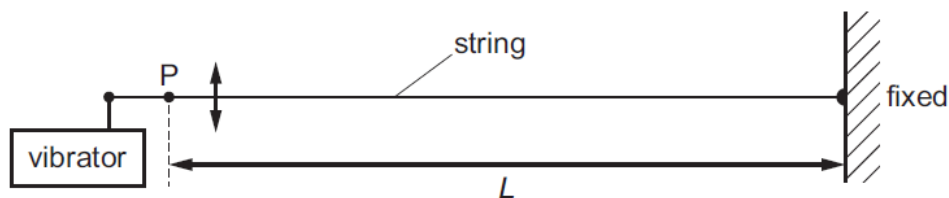
The sources each generate a wave of wavelength 2.0 cm. Each source produces a wave that has amplitude x_0 when it reaches point P .

What is the amplitude of the oscillation at P ?

- A 0
- B $\frac{x_0}{2}$
- C x_0
- D $2x_0$

10. 9702/12/M/J/18/No.24

A string is fixed at one end and the other end is attached to a vibrator. The frequency of the vibrator is slowly increased from zero. A series of stationary waves is formed. Assume that for a stationary wave there is a node at point P.



What are the first five wavelengths of the stationary waves that could be formed?

A $2\frac{L}{1}, 2\frac{L}{2}, 2\frac{L}{3}, 2\frac{L}{4}, 2\frac{L}{5}$

B $2\frac{L}{2}, 2\frac{L}{3}, 2\frac{L}{4}, 2\frac{L}{5}, 2\frac{L}{6}$

C $4\frac{L}{1}, 4\frac{L}{2}, 4\frac{L}{3}, 4\frac{L}{4}, 4\frac{L}{5}$

D $4\frac{L}{1}, 4\frac{L}{3}, 4\frac{L}{5}, 4\frac{L}{7}, 4\frac{L}{9}$

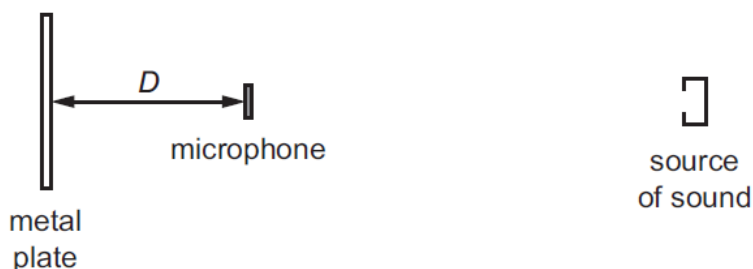
11. 9702/12/M/J/18/No.25

Which region of the electromagnetic spectrum has waves of wavelength 1000 times smaller than the wavelength of visible light?

- A infra-red
- B microwaves
- C ultraviolet
- D X-rays

12. 9702/12/M/J/18/No.26

The diagram shows apparatus for the measurement of the frequency of a sound wave.



Sound of the unknown frequency is reflected back from a metal plate. A microphone placed at a distance D from the metal plate detects the sound intensity. A minimum intensity is detected with $D = 12.0$ cm. The plate is moved further away from the microphone until the next minimum is detected with $D = 15.0$ cm.

The speed of sound in air is 336 ms^{-1} .

What is the frequency of the sound?

- A** 56 Hz **B** 112 Hz **C** 5600 Hz **D** 11 200 Hz

13. 9702/12/M/J/18/No.27

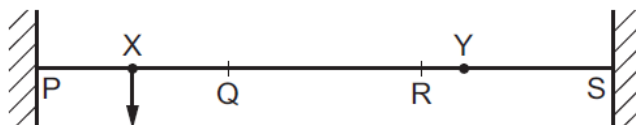
An astronomer observes the light from a star that is moving away from the Earth.

For the observed light, what has been increased due to the star's motion?

- A** amplitude
B frequency
C speed
D wavelength

14. 9702/12/M/J/18/No.28

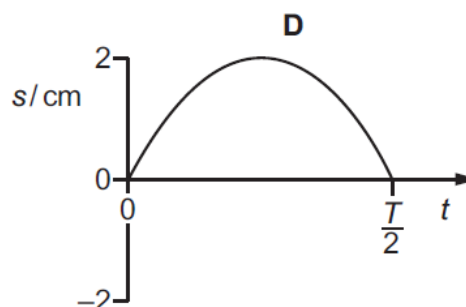
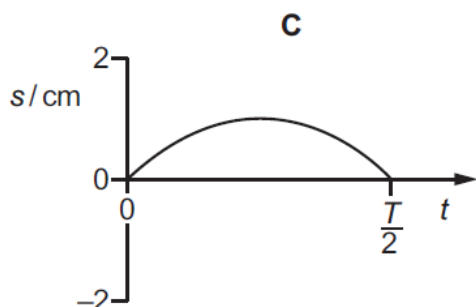
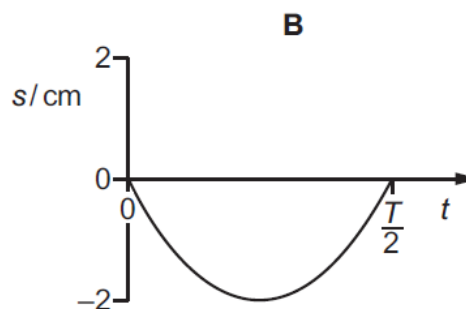
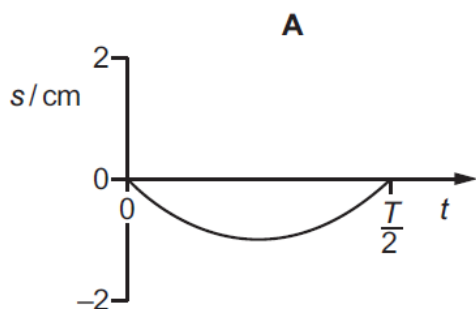
The diagram shows a stationary wave, at time $t = 0$, that has been set up on a string fixed between points P and S.



The nodes of the stationary wave occur on the string at P, Q, R and S. Point X is moving down at time $t = 0$. The points on the string vibrate with time period T and maximum amplitude 2 cm.

The displacement s is positive in the upward direction.

Which graph best shows the variation with t of the displacement s of point Y on the string?



15. 9702/13/M/J/18/No.23

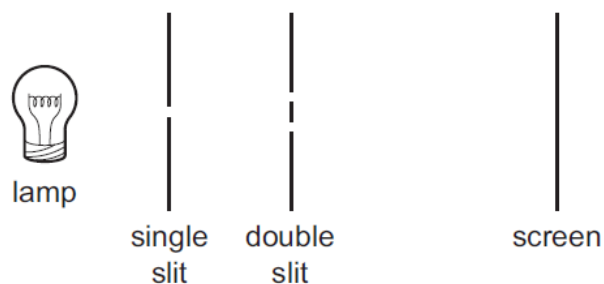
A police car travels at a velocity of 30.0 m s^{-1} directly towards a stationary observer. The horn of the car emits sound of frequency 2000 Hz . The speed of sound is 340 m s^{-1} .

What is the frequency of the sound heard by the observer?

- A** 1840 Hz **B** 2000 Hz **C** 2180 Hz **D** 2190 Hz

16. 9702/12/M/J/18/No.29

A two-source interference experiment uses the apparatus shown.

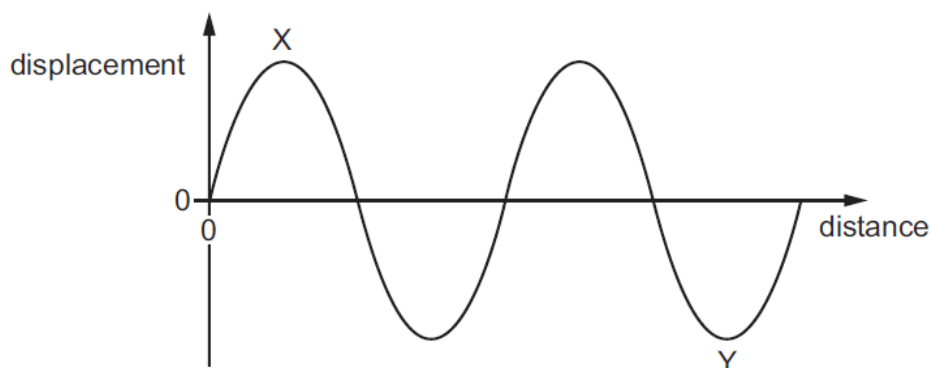


What is the main purpose of the single slit?

- A to make a narrow beam of light
- B to make the same amplitude of light incident on each slit
- C to provide coherent light
- D to provide monochromatic light

17. 9702/13/M/J/18/No.20

The displacement-distance graph for a transverse progressive wave is shown.



The phase difference between points X and Y can be expressed as $(180n)^\circ$.

What is the value of n ?

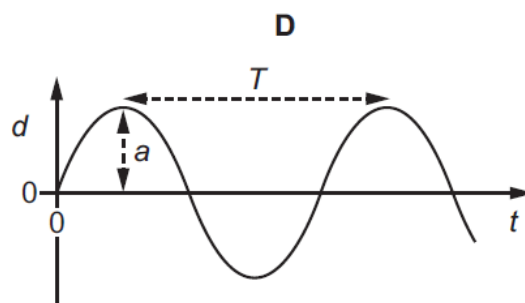
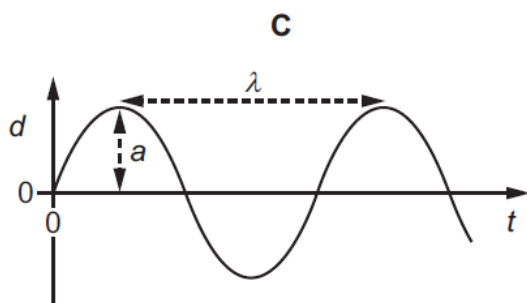
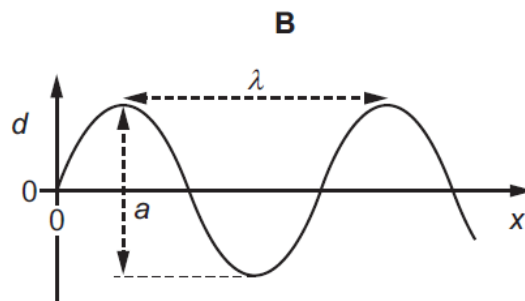
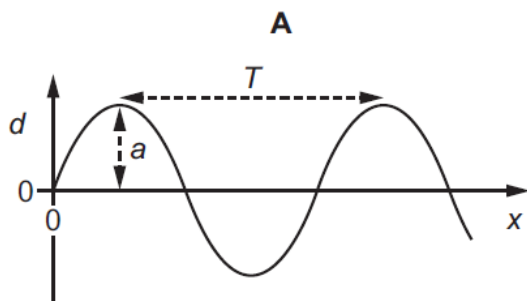
- A 1.5
- B 2.5
- C 3.0
- D 6.0

18. 9702/13/M/J/18/No.21

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 λ , the period T and the amplitude a of the wave, but only one graph is correctly labelled.

Which graph is correctly labelled?



19. 9702/13/M/J/18/No.25

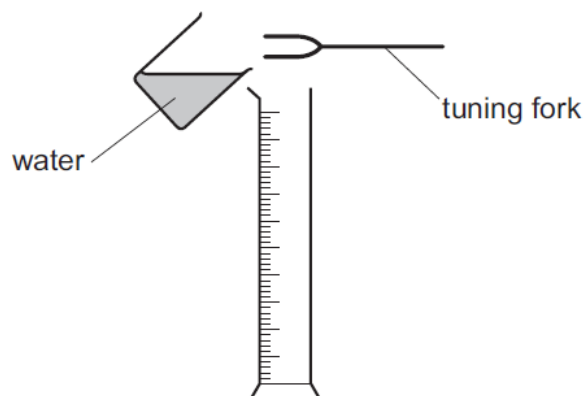
A water wave in a ripple tank is diffracted as it passes through a gap in a barrier.

Which two factors affect the angle of diffraction of the wave?

- A** the amplitude and frequency of the incident wave
- B** the amplitude of the incident wave and the width of the gap
- C** the wavelength and amplitude of the incident wave
- D** the wavelength of the incident wave and the width of the gap

20. 9702/13/M/J/18/No.24

A vibrating tuning fork is held over a measuring cylinder, as shown.



Water is then gradually poured into the measuring cylinder. A much louder sound is first heard when the water level is 2.9 cm above the base of the measuring cylinder. A second much louder sound is heard when the water level reaches a height of 67.3 cm above the base.

The speed of sound in air is 330 m s^{-1} .

What is the frequency of the tuning fork?

- A** 128 Hz **B** 256 Hz **C** 512 Hz **D** 1024 Hz

21. 9702/13/M/J/18/No.26

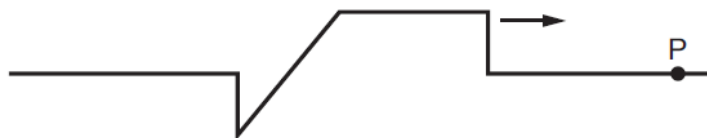
A double-slit interference pattern using red light of wavelength $7.0 \times 10^{-7} \text{ m}$ has a fringe spacing of 3.5 mm.

Which fringe spacing would be observed for the same arrangement of apparatus but using blue light of wavelength $4.5 \times 10^{-7} \text{ m}$?

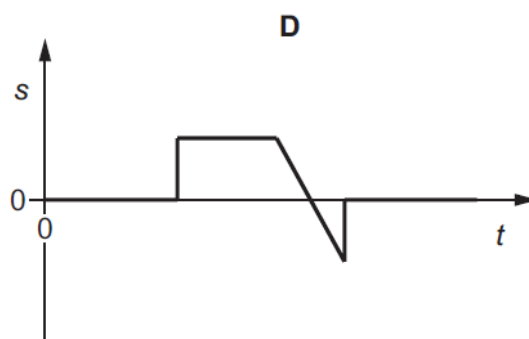
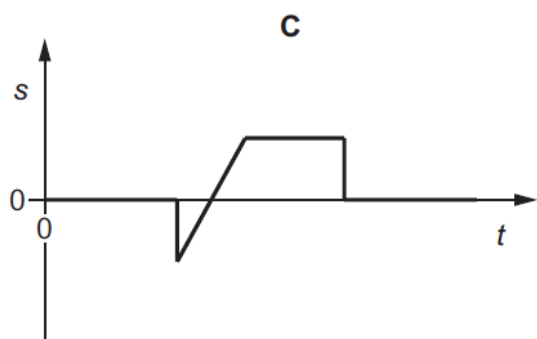
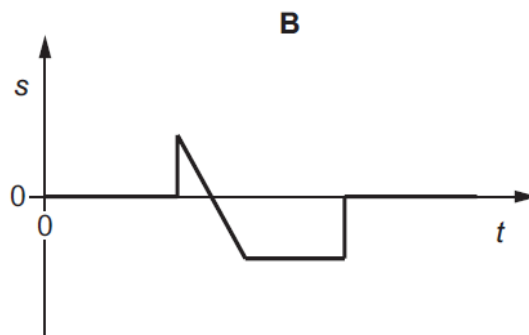
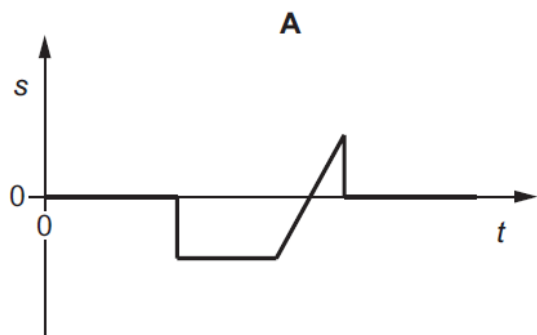
- A** 2.3 mm **B** 3.5 mm **C** 5.4 mm **D** 9.0 mm

22. 9702/12/F/M/18/No.21

A wave pulse moves along a stretched rope in the direction shown.



Which diagram shows the variation with time t of the displacement s of the particle P in the rope?



23. 9702/12/F/M/18/No.23

The table lists possible orders of magnitude of the wavelengths of some of the principal radiations of the electromagnetic spectrum.

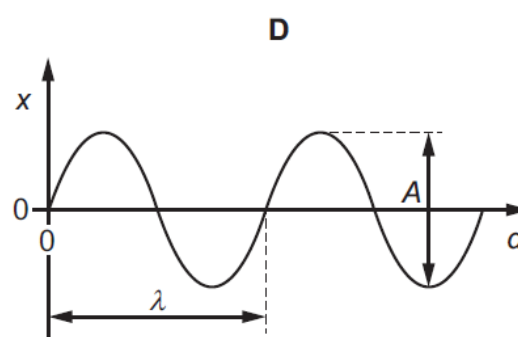
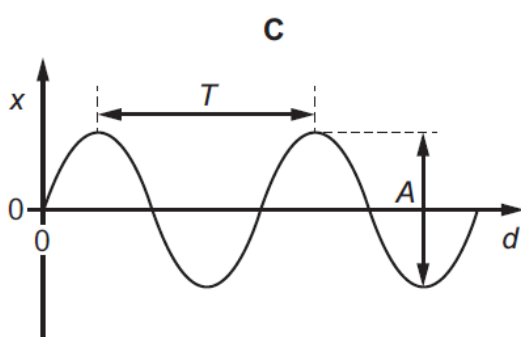
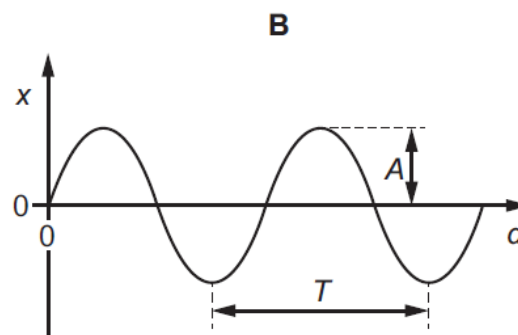
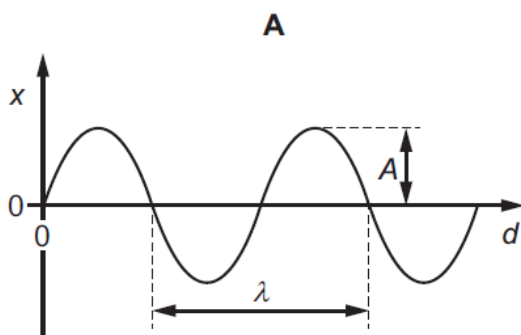
Which row shows the correct orders of magnitude of the wavelengths?

	wavelength / m			
	microwaves	infra-red	ultraviolet	X-rays
A	10^{-6}	10^{-10}	10^{-12}	10^{-14}
B	10^{-4}	10^{-8}	10^{-10}	10^{-12}
C	10^{-2}	10^{-6}	10^{-8}	10^{-10}
D	10^2	10^{-4}	10^{-6}	10^{-8}

24. 9702/12/F/M /18/No.22

A wave has period T , wavelength λ and amplitude A . The wave is shown on a graph of displacement x against distance d .

Which graph is correctly labelled?



25. 9702/12/F/M /18/No.24

A vehicle carries a microwave transmitter that emits microwaves of a constant frequency. A stationary observer has a microwave receiver.

The vehicle moves directly towards the observer at constant speed. The observer detects microwaves of frequency F_o .

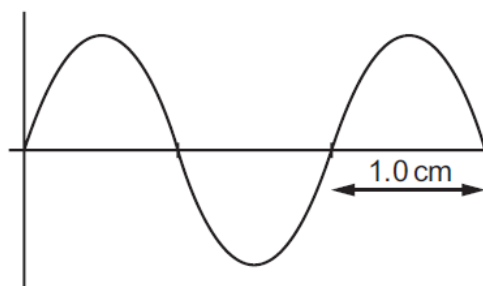
The vehicle then accelerates, still moving towards the observer, travels at higher steady speed for a time and then decelerates until it stops.

What is the variation in the frequency of the microwaves that are detected by the observer?

- A** The observed frequency will fall, then remain steady then return to the frequency F_o .
- B** The observed frequency will fall, then remain steady then rise to a higher frequency than F_o .
- C** The observed frequency will rise, then remain steady then fall to a lower frequency than F_o .
- D** The observed frequency will rise, then remain steady then return to the frequency F_o .

26. 9702/12/F/M /18/No.25

The diagram shows a cathode-ray oscilloscope display of an electromagnetic wave.



The time base setting is $0.20 \mu\text{s cm}^{-1}$.

Which statement is correct?

- A The frequency of the wave is 2.5 MHz and it lies in the microwave region of the electromagnetic spectrum.
- B The frequency of the wave is 2.5 MHz and it lies in the radio-wave region of the electromagnetic spectrum.
- C The frequency of the wave is 5.0 MHz and it lies in the microwave region of the electromagnetic spectrum.
- D The frequency of the wave is 5.0 MHz and it lies in the radio-wave region of the electromagnetic spectrum.

27. 9702/12/F/M /18/No.26

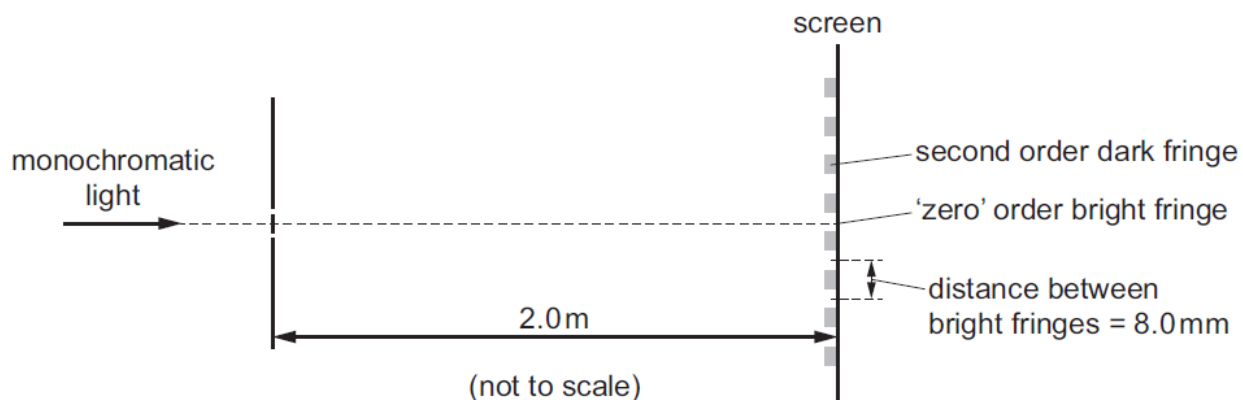
In a double-slit interference experiment, light of frequency $6.0 \times 10^{14} \text{ Hz}$ is incident on a pair of slits. Bright fringes that are 3.0 mm apart are observed on a screen some distance away.

What is the separation of the bright fringes when the frequency of the light is changed to $5.0 \times 10^{14} \text{ Hz}$?

- A 1.8 mm B 2.5 mm C 3.0 mm D 3.6 mm

28. 9702/12/F/M /18/No.27

Monochromatic light is incident on a pair of narrow slits a distance of 0.1 mm apart. A series of bright and dark fringes are observed on a screen a distance of 2.0 m away. The distance between adjacent bright fringes is 8.0 mm.



What is the path difference between the light waves from the two slits that meet at the second order dark fringe?

- A $2.0 \times 10^{-7} \text{ m}$
- B $4.0 \times 10^{-7} \text{ m}$
- C $6.0 \times 10^{-7} \text{ m}$
- D $8.0 \times 10^{-7} \text{ m}$

29. 9702/12/F/M /18/No.29

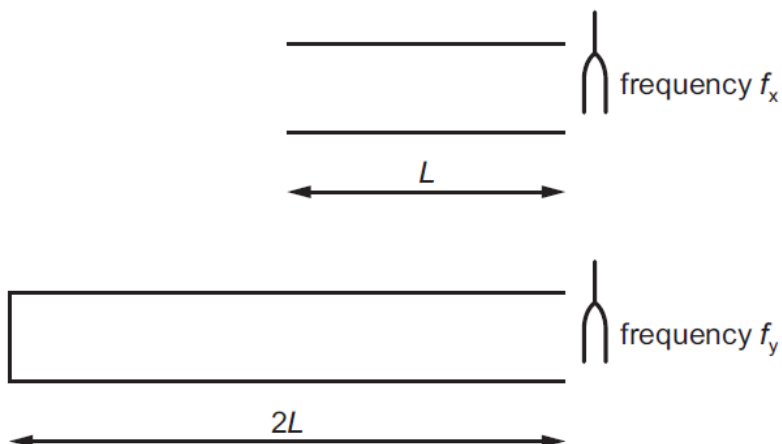
Which statement gives a condition that enables diffraction to occur?

- A A source of waves moves towards a stationary observer.
- B A wave is partially blocked by an obstacle.
- C Two coherent waves are superposed.
- D Two waves of equal speed and frequency are travelling through the same part of a medium in opposite directions.

30. 9702/12/F/M /18/No.28

A tube of length L is open at both ends. A stationary wave is set up in this tube when a tuning fork vibrating with frequency f_x is held at one end. This is the lowest frequency of stationary wave that can be formed in this tube.

Another tube of length $2L$ is closed at one end. A stationary wave is set up in this tube when a tuning fork vibrating with frequency f_y is held at the open end. This is the lowest frequency of stationary wave that can be formed in this tube.



Assume the end correction for each tube is negligible.

Which equation is correct?

A $f_x = \frac{f_y}{4}$

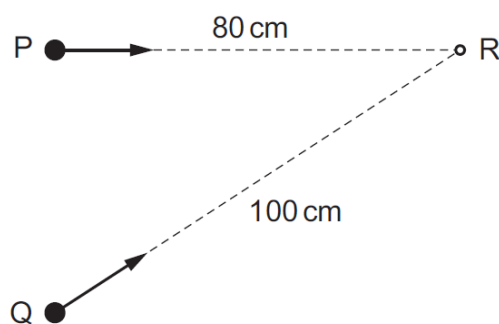
B $f_x = \frac{f_y}{2}$

C $f_x = 2f_y$

D $f_x = 4f_y$

1. June/2021/Paper_11/No.21

Two identical waves are produced by sources at points P and Q. The waves travel along different paths to reach point R, as shown.



Both waves have a wavelength of 6.0 cm. The waves are in phase at point R.

What is the phase difference between the waves as they leave points P and Q?

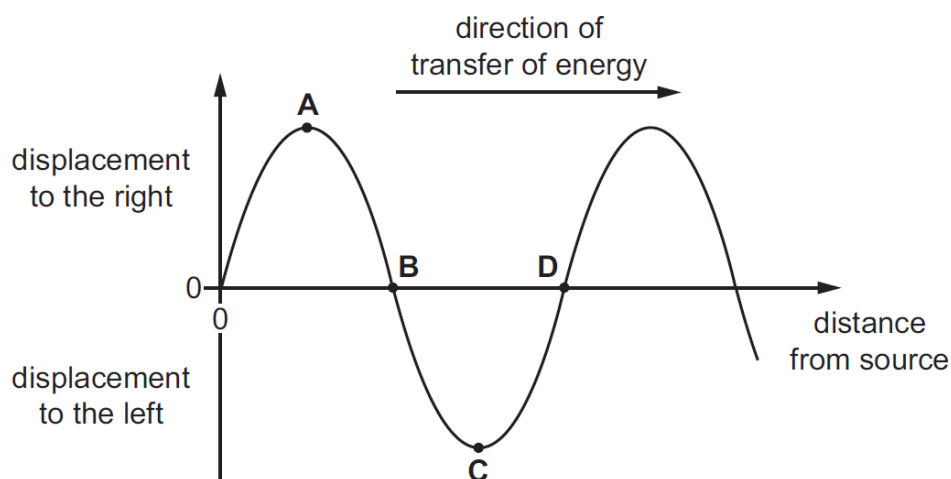
- A** 0° **B** 60° **C** 90° **D** 120°

2. June/2021/Paper_11/No.22

A longitudinal wave travelling from left to right has vibrations parallel to the direction of transfer of energy by the wave.

The wave can be represented on a graph showing the variation with distance of the displacement of the particles from their equilibrium positions at one instant.

Which point on the graph is the centre of a compression?



3. June/2021/Paper_11/No.24

An ambulance has a siren that emits sound of a constant frequency. The ambulance is moving directly towards a stationary observer.

The ambulance decelerates as it is approaching the observer and then accelerates after it has passed the observer.

How does the frequency of the sound heard by the observer change as the ambulance is approaching and as it is moving away from the observer?

	approaching observer	moving away from observer
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

4. June/2021/Paper_11/No.25

Microwaves in a vacuum travel at speed X and have wavelength of order of magnitude Y .

What are the speed and a possible order of magnitude of wavelength of X-rays in a vacuum?

	speed	wavelength
A	X	$10^{-8} Y$
B	X	$10^{-4} Y$
C	$10^4 X$	Y
D	$10^8 X$	Y

5. June/2021/Paper_12/No.21

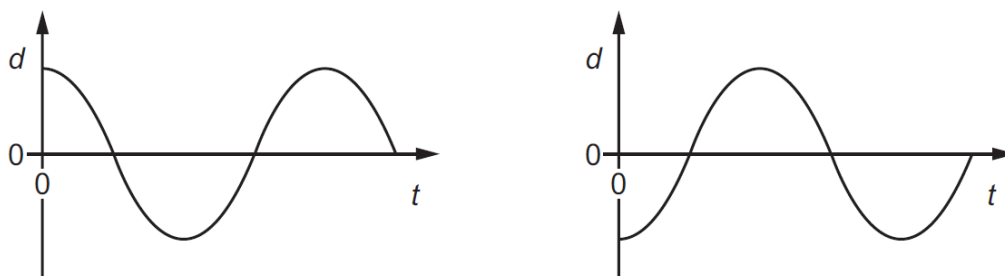
Two lasers emit light in a vacuum. One laser emits red light and the other emits green light.

Which property of the light from the two lasers **must** be different?

- A amplitude
- B frequency
- C intensity
- D speed

6. June/2021/Paper_12/No.22

Two particles in a progressive wave are a distance 10 cm apart. The two graphs show the variation with time t of the displacement d of the two particles.



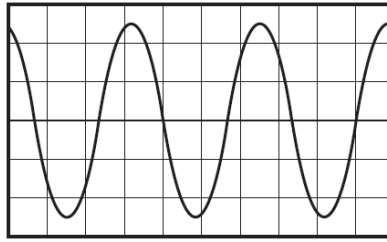
What could be represented by the two graphs?

- A particles in a longitudinal wave with a compression and the nearest rarefaction separated by 10 cm
- B particles in a longitudinal wave with a compression and the nearest rarefaction separated by 20 cm
- C particles in a transverse wave with a peak and the nearest trough separated by 20 cm
- D particles in a transverse wave with two adjacent peaks separated by 10 cm

7. **June/2021/Paper_12/No.23**

A sound wave is detected by a microphone that is connected to a cathode-ray oscilloscope (CRO).

The screen of the CRO displays a waveform, as shown.



The time-base is set to $20\ \mu\text{s div}^{-1}$.

What is the frequency of the sound wave?

- A** 15 Hz **B** 15 000 Hz **C** 20 000 Hz **D** 30 000 Hz

8. **June/2021/Paper_12/No.24**

A person stands at the side of a straight railway track. A train moves towards the person and emits sound from its whistle. The person hears a sound of frequency 1690 Hz as the train approaches him.

The person then hears sound of frequency 1500 Hz as the train moves away from him. The speed of sound in air is $340\ \text{m s}^{-1}$.

What is the speed of the train?

- A** $20\ \text{m s}^{-1}$ **B** $38\ \text{m s}^{-1}$ **C** $41\ \text{m s}^{-1}$ **D** $43\ \text{m s}^{-1}$

9. **June/2021/Paper_12/No.25**

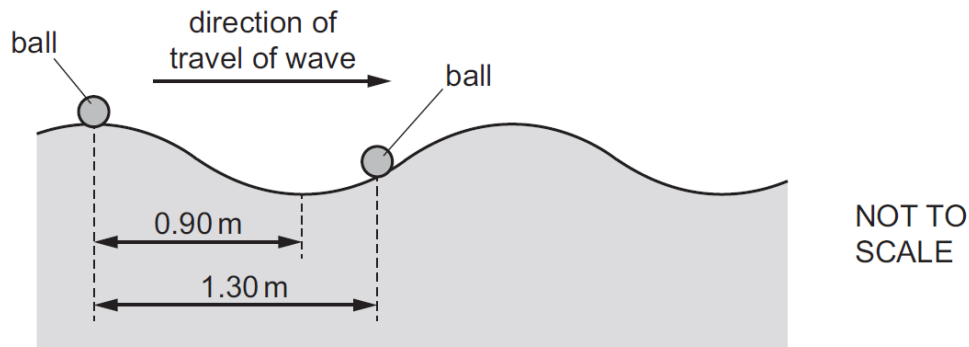
Which list shows electromagnetic waves in order of decreasing frequency?

- A** gamma-rays $\rightarrow$ infrared $\rightarrow$ ultraviolet $\rightarrow$ radio waves
B gamma-rays $\rightarrow$ ultraviolet $\rightarrow$ infrared $\rightarrow$ radio waves
C radio waves $\rightarrow$ infrared $\rightarrow$ ultraviolet $\rightarrow$ gamma-rays
D radio waves $\rightarrow$ ultraviolet $\rightarrow$ infrared $\rightarrow$ gamma-rays

10. Nov/2021/Paper_11/No.21

Two balls float on the surface of the sea. The balls are separated by a distance of 1.30 m.

A wave travels on the surface of the sea so that the balls move vertically up and down.



The distance between a crest and an adjacent trough of the wave is 0.90 m.

What is the phase difference between the two balls?

- A 55° B 110° C 160° D 260°

11. Nov/2021/Paper_11/No.22

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

- A Longitudinal waves can be used to demonstrate diffraction.
- B Longitudinal waves can travel in a vacuum.
- C Transverse waves can form stationary waves.
- D Transverse waves can transfer energy.

12. Nov/2021/Paper_11/No.24

With which waves can the Doppler effect be observed?

- A all waves including sound and light
- B light waves only
- C sound and light waves only
- D sound waves only

13. Nov/2021/Paper_11/No.25

Which radiation could consist of waves of wavelength 0.5 nm?

- A γ -rays
- B ultraviolet
- C visible light
- D X-rays

14. Nov/2021/Paper_12/No.23

The table contains descriptions and examples of waves.

Which row is correct?

	description of wave	example
A	oscillations are parallel to the direction of energy transfer	gamma-rays
B	oscillations are parallel to the direction of energy transfer	ultraviolet waves
C	oscillations are perpendicular to the direction of energy transfer	sound waves
D	oscillations are perpendicular to the direction of energy transfer	X-rays

15. Nov/2021/Paper_12/No.25

A train travels in a straight line at a constant speed of 30 ms^{-1} . The train's horn continuously emits sound of frequency 2400 Hz.

A stationary observer stands next to the train track. The train approaches the stationary observer, passes him and then moves away.

The speed of sound is 340 ms^{-1} .

What is the maximum difference in the frequencies of the sound heard by the stationary observer?

- A 190 Hz B 230 Hz C 430 Hz D 460 Hz

16. Nov/2021/Paper_12/No.26

Electromagnetic waves of frequency 30 THz are in a vacuum.

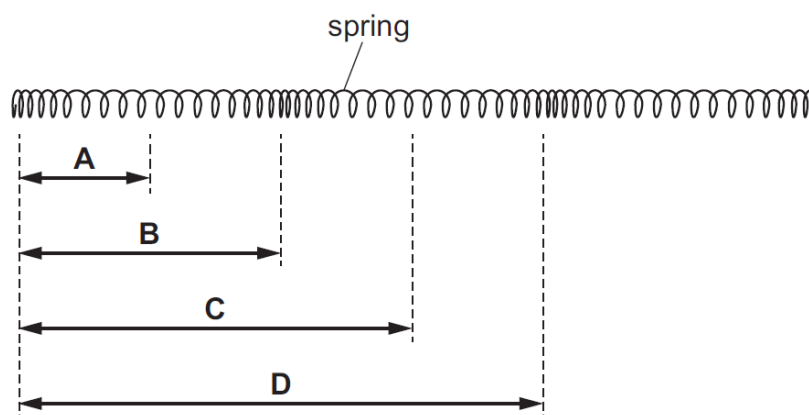
In which region of the electromagnetic spectrum are the waves?

- A infrared
- B microwave
- C ultraviolet
- D visible light

17. Nov/2021/Paper_13/No.22

A longitudinal wave travels through a long spring. The spring is shown at one instant.

What is the wavelength of the wave?



18. Nov/2021/Paper_13/No.23

Which statement about waves is correct?

- A Both longitudinal and transverse waves can travel through a vacuum.
- B Both longitudinal and transverse waves transfer matter.
- C Longitudinal progressive waves consist of alternate nodes and antinodes.
- D The particles of a transverse wave vibrate perpendicular to the direction of energy propagation.

19. Nov/2021/Paper_13/No.25

A train travels at constant speed along a straight track. The train's horn emits sound of frequency 500 Hz.

A person standing by the side of the track hears sound of frequency 450 Hz.

The speed of sound in air is 340 m s^{-1} .

What is the speed of the train and in which direction is it travelling relative to the person?

	speed / m s^{-1}	direction
A	34	away from the person
B	34	towards the person
C	38	away from the person
D	38	towards the person

20. Nov/2021/Paper_13/No.26

A smooth surface has bumps on the surface that are smaller than the wavelength of visible light.

What is the approximate maximum size of the largest bumps on the surface?

- A** 20 nm **B** 350 nm **C** 720 nm **D** $5.0 \mu\text{m}$

(a) By reference to the direction of transfer of energy, state what is meant by a *longitudinal* wave.

.....
 [1]

(b) A vehicle travels at constant speed around a wide circular track. It continuously sounds its horn, which emits a single note of frequency 1.2 kHz. An observer is a large distance away from the track, as shown in the view from above in Fig. 4.1.

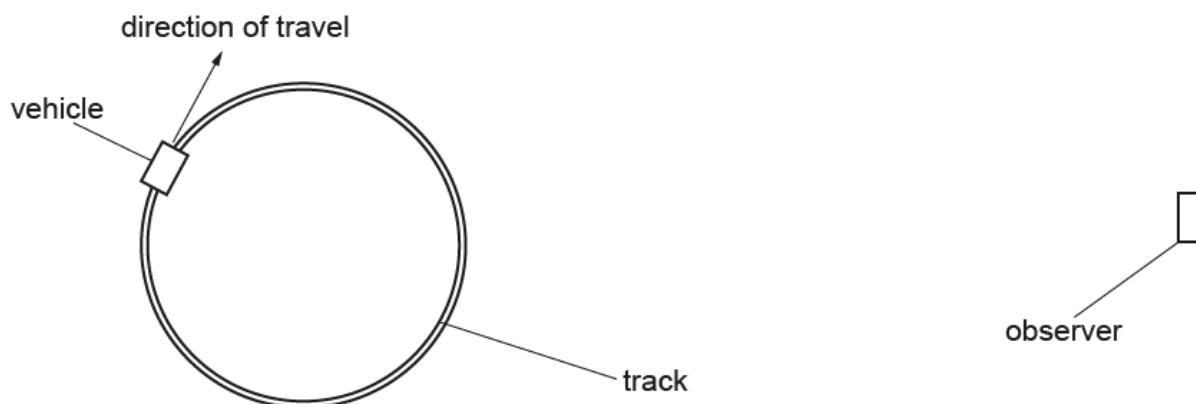


Fig. 4.1 (not to scale)

Fig. 4.2 shows the variation with time of the frequency f of the sound of the horn that is detected by the observer. The time taken for the vehicle to travel once around the track is T .

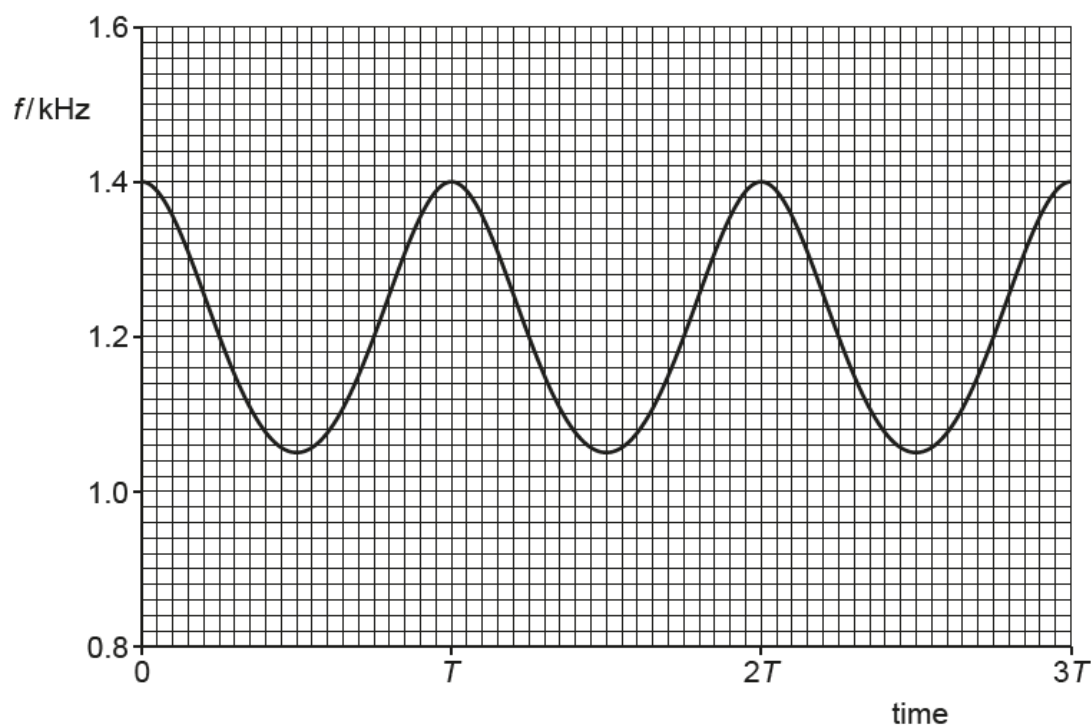


Fig. 4.2

- (i) Explain why the frequency of the sound detected by the observer is sometimes above and sometimes below 1.2 kHz.

.....

.....

.....

..... [2]

- (ii) State the name of the phenomenon in (b)(i).

..... [1]

- (iii) On Fig. 4.1, mark with a letter X the position of the vehicle when it emitted the sound that is detected at time T . [1]

- (iv) On Fig. 4.1, mark with a letter Y the position of the vehicle when it emitted the sound that is detected at time $\frac{9T}{4}$. [1]

- (c) The speed of the sound in the air is 320 m s^{-1} .

Use Fig. 4.2 to determine the speed of the vehicle in (b).

speed = ... m s^{-1} [3]

[Total: 9]

A child sits on the ground next to a remote-controlled toy car. At time $t = 0$, the car begins to move in a straight line directly away from the child. The variation with time t of the velocity of the car along this line is shown in Fig. 4.1.

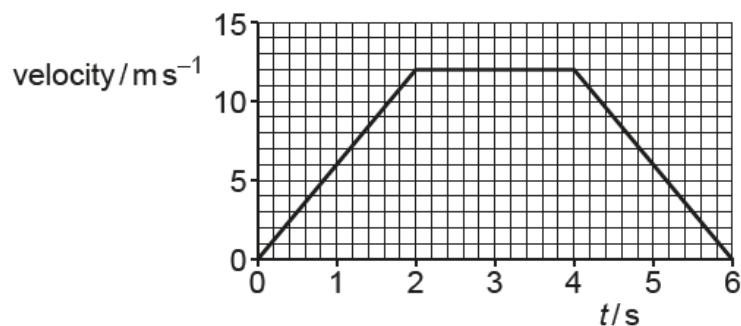


Fig. 4.1

The car's horn continually emits sound of frequency 925 Hz between time $t = 0$ and time $t = 6.0$ s. The speed of the sound in the air is 338 m s^{-1} .

- (a) Describe qualitatively the variation, if any, in the frequency of the sound heard, by the child, that was emitted from the car horn:

- (i) from time $t = 0$ to time $t = 2.0$ s

..... [1]

- (ii) from time $t = 4.0$ s to time $t = 6.0$ s.

..... [1]

- (b) Determine the frequency, to three significant figures, of the sound heard, by the child, that was emitted from the car horn at time $t = 3.0$ s.

frequency = ... Hz [2]

(c) Determine the time taken for the sound emitted at time $t = 4.0$ s to travel to the child.

time taken = ... s [2]

[Total: 6]

- (d) The aircraft in (c) travels from X to Y in a time of 14 s. Fig. 3.3 shows that, as the aircraft travels from X to Y, it moves directly towards an observer who is standing on the ground.

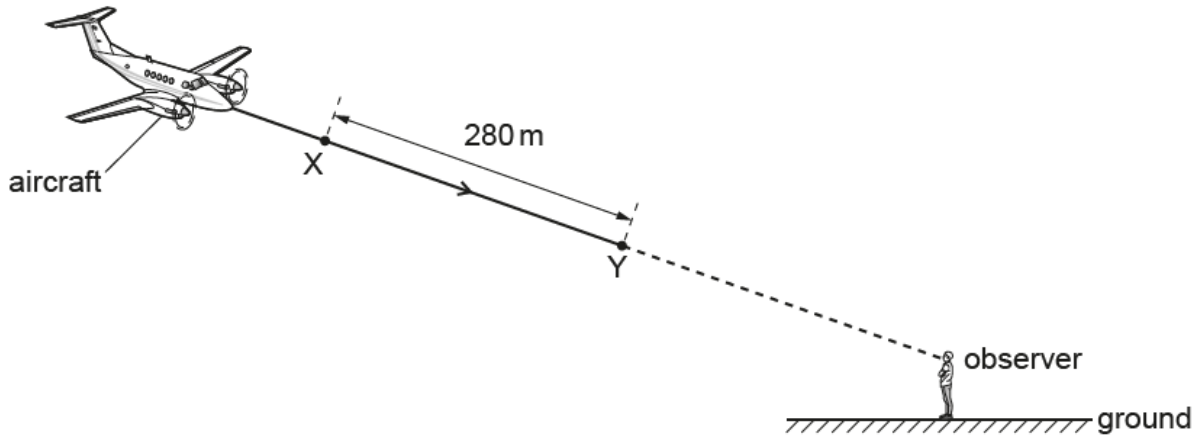


Fig. 3.3 (not to scale)

The aircraft emits sound as it travels from X to Y. The observer hears sound of frequency 450 Hz. The speed of the sound in the air is 340 m s^{-1} .

Calculate the frequency of the sound that is emitted by the aircraft.

frequency = ... Hz [3]

[Total: 11]

(a) For a progressive wave on a stretched string, state what is meant by *amplitude*.

.....
 [1]

(b) Light from a laser has a wavelength of 690 nm in a vacuum.

Calculate the period of the light wave.

period = ... s [3]

(c) A two-source interference experiment uses the arrangement shown in Fig. 5.1.

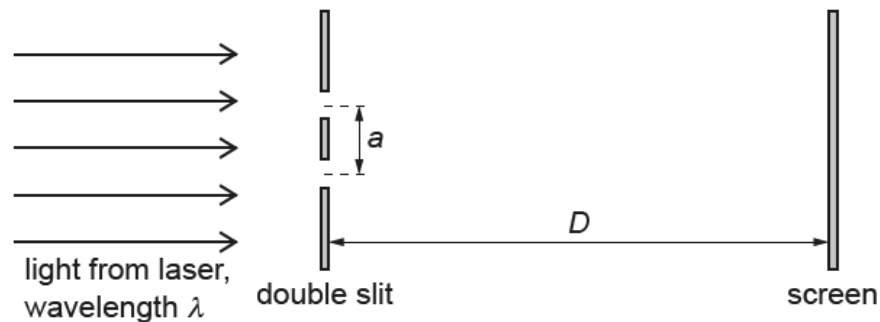


Fig. 5.1 (not to scale)

Light from a laser is incident normally on a double slit. A screen is parallel to the double slit.

Interference fringes are seen on the screen at distance D from the double slit. The separation of the centres of the slits is a . The light has wavelength λ .

The separation x of the centres of adjacent bright fringes is measured for different values of distance D .

The variation with D of x is shown in Fig. 5.2.

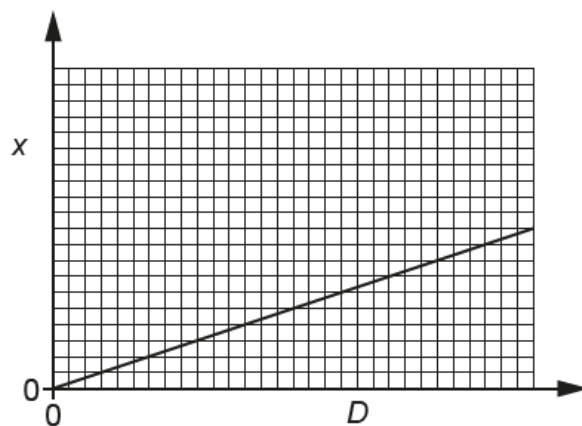


Fig. 5.2

The gradient of the graph is G .

- (i) Determine an expression, in terms of G and λ , for the separation a of the slits.

$$a = \dots\dots\dots [2]$$

- (ii) The experiment is repeated with slits of separation $2a$. The wavelength of the light is unchanged.

On Fig. 5.2, sketch a graph to show the results of this experiment. [2]

[Total: 8]

5. March/2021/Paper_22/No.5

A source of sound is attached to a rope and then swung at a constant speed in a horizontal circle, as illustrated in Fig. 5.1.

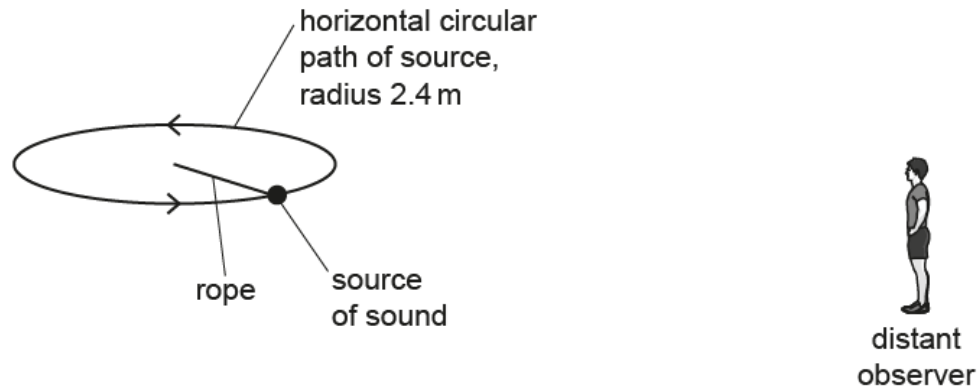


Fig. 5.1 (not to scale)

The source moves with a speed of 12.0 m s^{-1} and emits sound of frequency 951 Hz . The speed of the sound in the air is 330 m s^{-1} . An observer, standing a very long distance away from the source, hears the sound.

- (a) Calculate the minimum frequency, to three significant figures, of the sound heard by the observer.

minimum frequency = ... Hz [2]

- (b) The circular path of the source has a radius of 2.4 m .

Determine the shortest time interval between the observer hearing sound of minimum frequency and the observer hearing sound of maximum frequency.

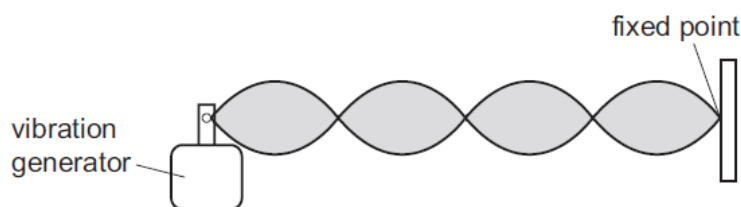
time interval = ... s [2]

[Total: 4]

1. June/2023/Paper_9702/11/No.26

A string is stretched between a vibration generator and a fixed point.

When the vibration generator is vibrating at a frequency f , a stationary wave with five nodes is created on the stretched string, as shown. There is a node at the end of the string that is attached to the vibration generator.



The frequency of vibration of the vibration generator is slowly increased.

What is the next frequency that produces a stationary wave on the string?

- A** $1.25f$ **B** $1.50f$ **C** $1.75f$ **D** $2.00f$

2. June/2023/Paper_9702/12/No.25

A stationary wave is formed by two progressive waves travelling in opposite directions along the same line of travel.

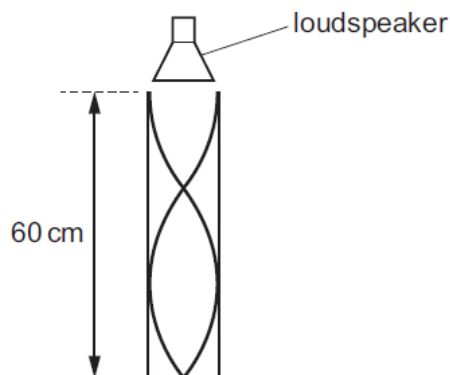
Which statement about the two progressive waves is **not** correct?

- A** They must have a constant phase difference.
B They must have the same frequency.
C They must have the same wavelength.
D They must travel at the same speed.

3. June/2023/Paper_ 9702/12/No.26

The sound from a loudspeaker placed above a tube causes resonance of the air in the tube.

A stationary wave is formed with two nodes and two antinodes, as shown.



The tube has height 60 cm.

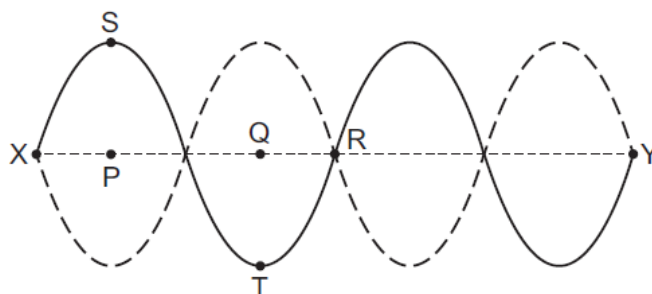
The speed of sound in the air is 340 m s^{-1} .

What is the frequency of the sound?

- A 430 Hz B 570 Hz C 850 Hz D 1700 Hz

4. June/2023/Paper_ 9702/13/No.25

The diagram shows a string stretched between fixed points X and Y. There is a stationary wave on the string.



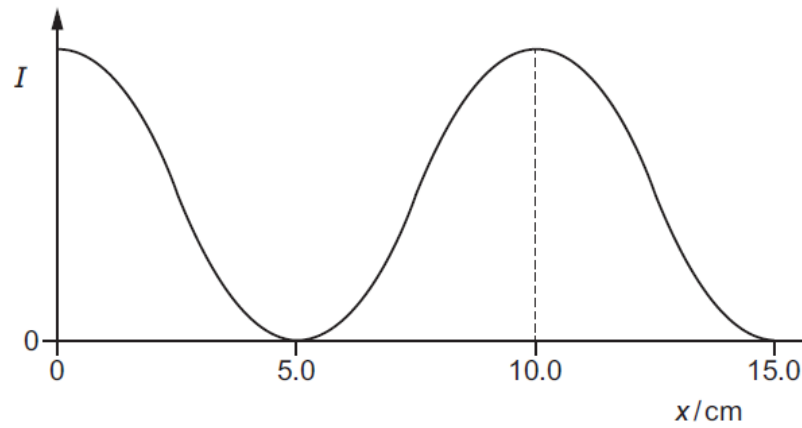
The solid curve shows the string at a position of maximum displacement at time t_0 . The dashed curve shows the other position of maximum displacement. The straight central dashed line shows the mean position of the string.

Point S on the string is directly above point P. Point T on the string is directly below point Q.

Which statement is correct?

- A A short time after t_0 , point R on the string will be displaced.
 B A short time after t_0 , points S and T on the string move in opposite directions.
 C The distance between P and Q is one wavelength.
 D Two moving points on the string that are equal distances from point R vibrate in phase.

The variation with distance x of the intensity I along a stationary sound wave in air is shown.



The speed of sound in air is 340 m s^{-1} .

What is the frequency of the sound wave?

- A** 1700 Hz **B** 2300 Hz **C** 3400 Hz **D** 6800 Hz

- (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.

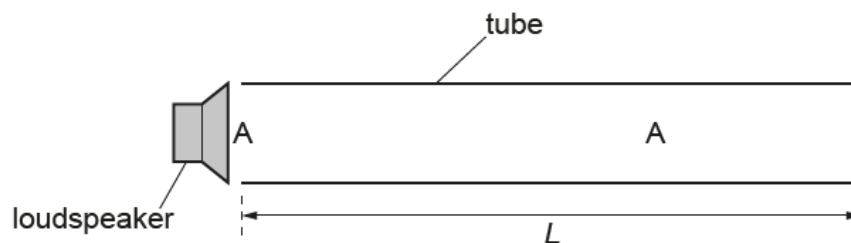


Fig. 5.1 (not to scale)

The loudspeaker emits sound of frequency 1.7 kHz . The speed of sound in the air in the tube is 340 ms^{-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

wavelength = ... m [2]

- (ii) the length L of the tube

$L =$ m [1]

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

maximum wavelength = ... m [1]

(d) A metal sheet is now placed in front of the loudspeaker in (b), as shown in Fig. 4.3.

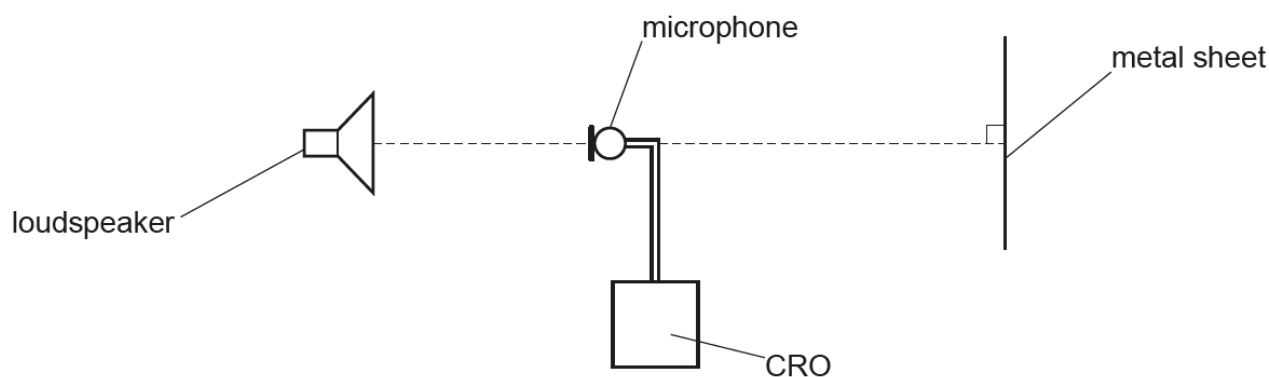


Fig. 4.3

A stationary wave is formed between the loudspeaker and the metal sheet.

(i) State the principle of superposition.

.....

 [2]

(ii) The initial position of the microphone is such that the trace on the CRO has an amplitude minimum. It is now moved a distance of 1.05 m away from the loudspeaker along the line joining the loudspeaker and metal sheet.

As the microphone moves, it passes through three positions where the trace has an amplitude maximum before ending at a position where the trace has an amplitude minimum.

Determine the wavelength of the sound wave.

wavelength = ... m [2]

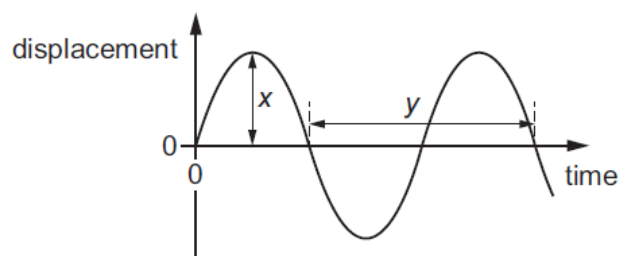
(iii) Use your answers in **(b)(i)** and **(d)(ii)** to determine the speed of the sound in the air.

speed = ... ms^{-1} [2]

[Total: 13]

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.



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

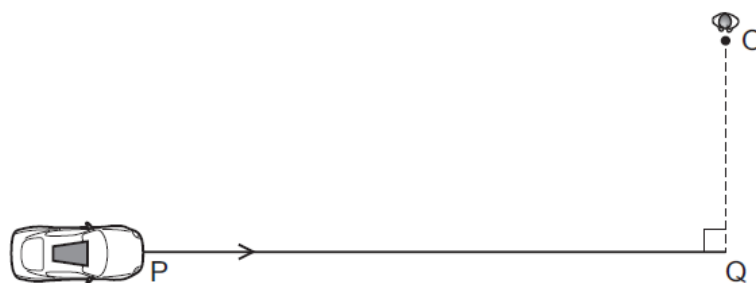
What do x and y represent?

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

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.



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.

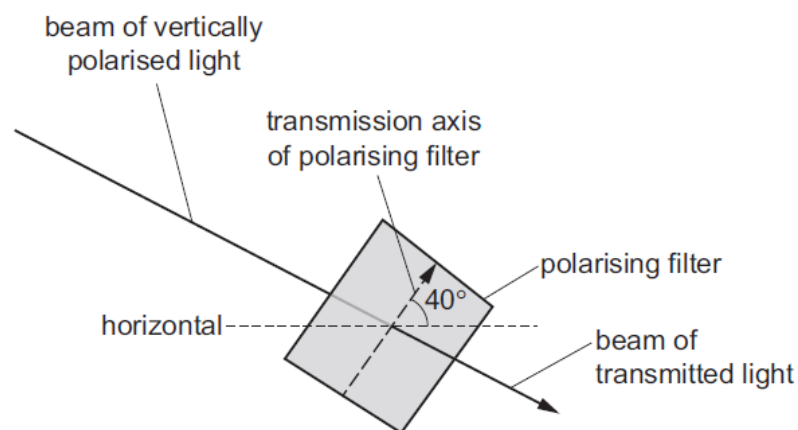
- 1 a radio wave transmitter
- 2 a source of X-rays
- 3 a 30 mm wavelength radar transmitter
- 4 a light-emitting diode that emits red light

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.



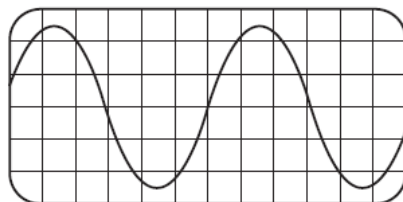
What is the ratio $\frac{\text{amplitude of transmitted beam}}{\text{amplitude of incident beam}}$?

- 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?

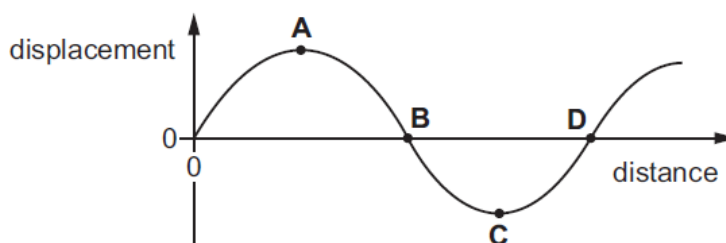
- A amplitude
- B frequency
- C speed
- D wavelength

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?

- 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.

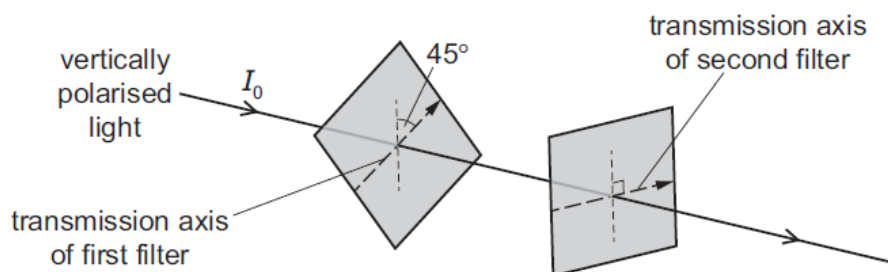
What could be the frequency of the light?

- A $5.0 \times 10^5 \text{ Hz}$ B $5.0 \times 10^8 \text{ Hz}$ C $5.0 \times 10^{11} \text{ Hz}$ D $5.0 \times 10^{14} \text{ Hz}$

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.



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} .

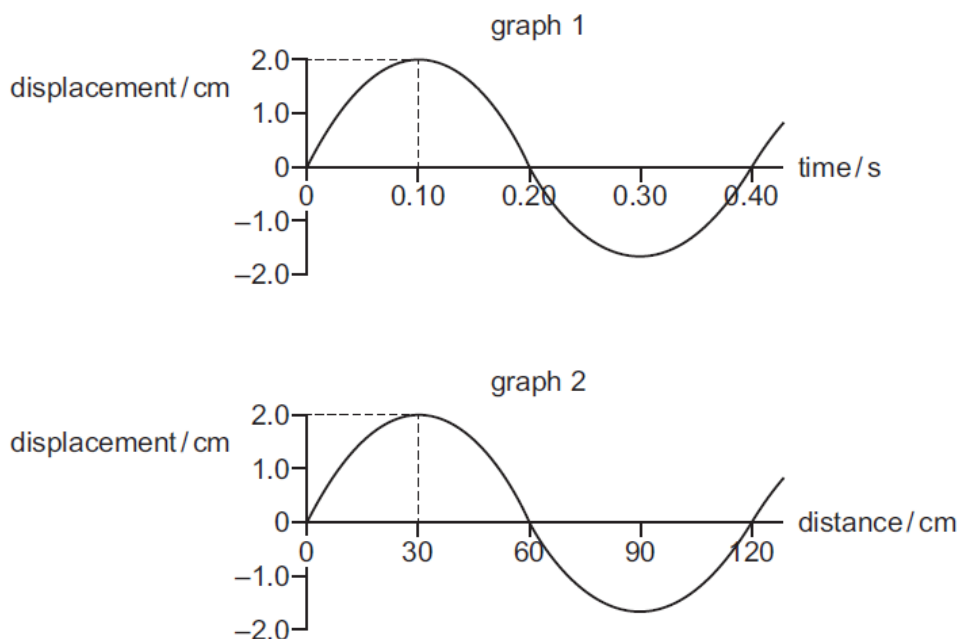
What is the minimum distance between two points on the wave that have a phase difference of 70° ?

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

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.



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

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

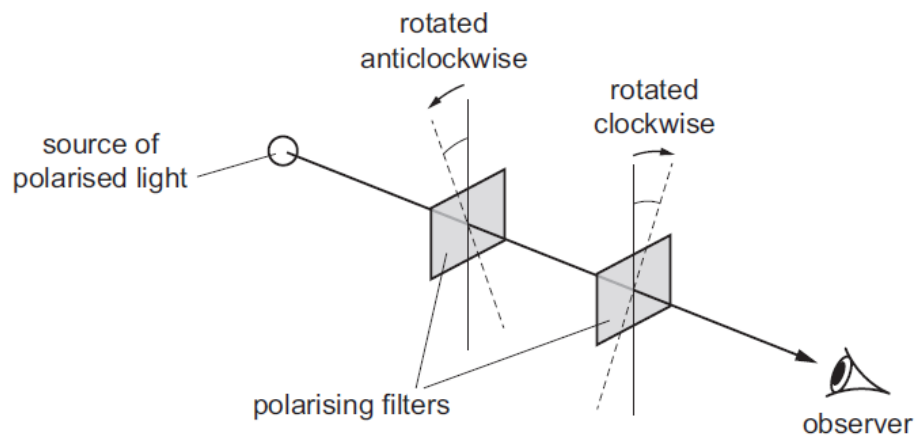
13. June/2023/Paper_9702/13/No.23

An electromagnetic wave has a wavelength of 2.1 cm in a vacuum.

Which region of the electromagnetic spectrum contains this wave?

- A** infrared
B microwave
C radio wave
D visible light

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

15. June/2023/Paper_9702/21/No.5(a)

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

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

..... [1]

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

frequency = ... THz [2]

- (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

..... [1]

- (ii) a longitudinal wave.

..... [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.

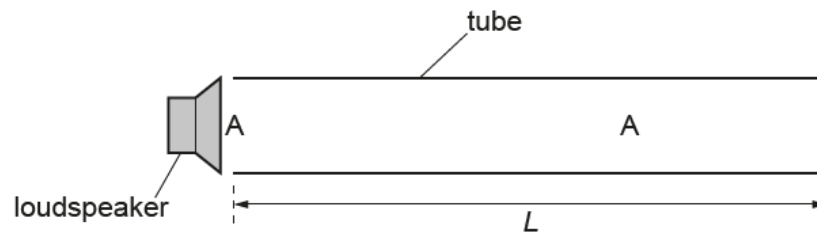


Fig. 5.1 (not to scale)

The loudspeaker emits sound of frequency 1.7 kHz . The speed of sound in the air in the tube is 340 ms^{-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

wavelength = ... m [2]

- (ii) the length L of the tube

$L =$ m [1]

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

maximum wavelength = ...m [1]

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

.....
 [1]

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

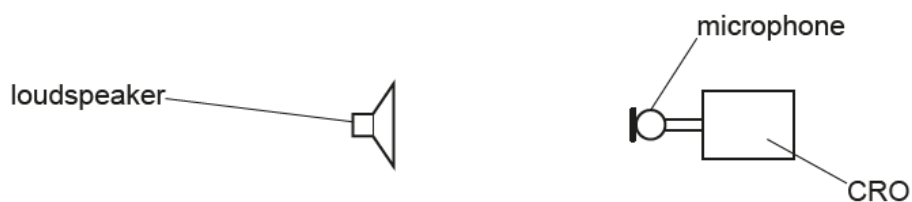


Fig. 4.1

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

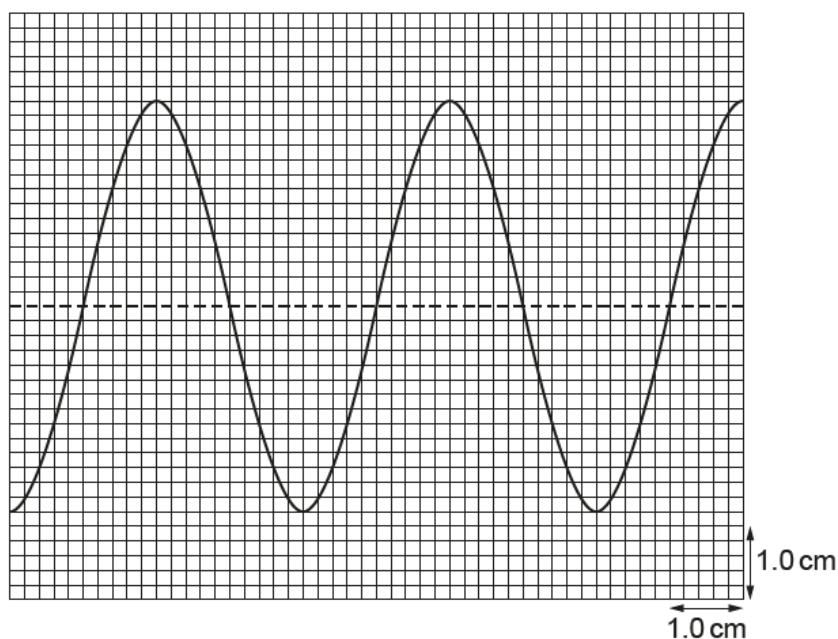


Fig. 4.2

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

frequency = ... Hz [2]

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

amplitude = ... V [1]

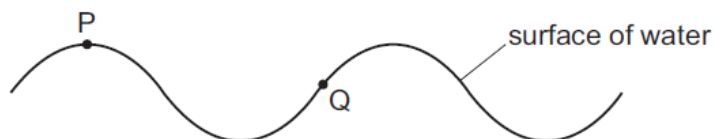
- (c) The intensity of the sound wave in (b) is reduced to a quarter of its original intensity without a change in frequency. Assume that the amplitude of the signal received by the CRO is proportional to the amplitude of the sound wave.

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

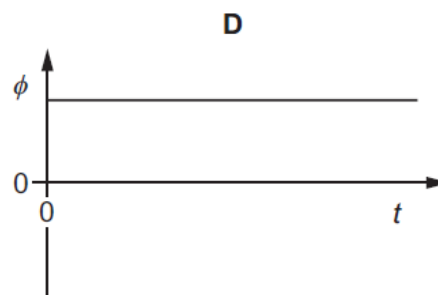
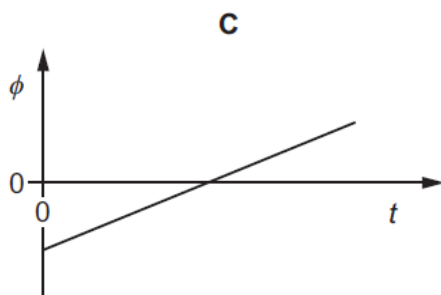
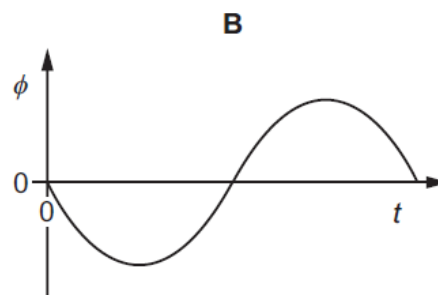
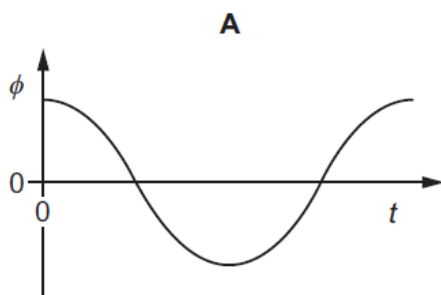
18. March/2023/Paper_9702/12/No.20

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?



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.
- 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?

- 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.

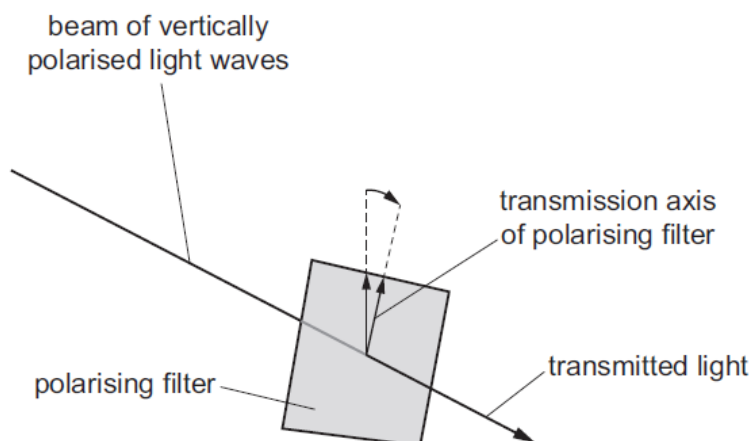
21. March/2023/Paper_9702/12/No.23

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

- A (430–750) kHz
- B (430–750) MHz
- C (430–750) GHz
- D (430–750) THz

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.



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 $0.87 I_{30}$

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



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.

- (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.

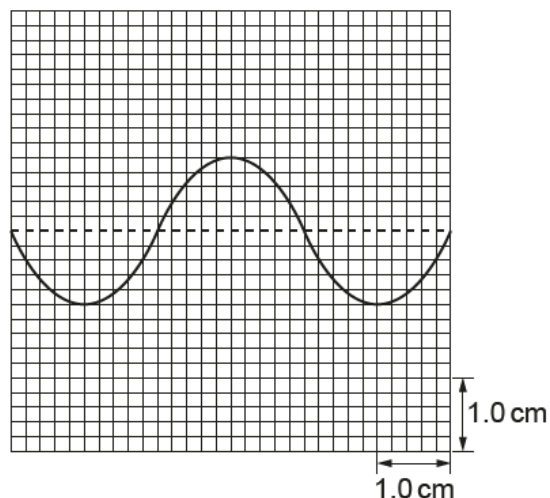


Fig. 5.1

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

time-base setting = ... 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]

1. Nov/2023/Paper_ 9702/11/No.25

In an experiment, a stationary wave is formed on a string stretched horizontally between two fixed points.

Which statement about the experiment is correct?

- A** At certain times, the string between two nodes is horizontal with all points having zero displacement.
- B** Each point on the string between two antinodes has an oscillation of the same amplitude.
- C** The number of nodes is equal to the number of antinodes.
- D** Two adjacent antinodes oscillate in phase.

2. Nov/2023/Paper_ 9702/11/No.26

A musical organ produces notes by blowing air into a set of pipes that are open at one end and closed at the other.

The speed of sound in the air in the pipes is 320 m s^{-1} .

What is the lowest frequency of sound produced by a pipe of length 10 m?

- A** 4 Hz **B** 8 Hz **C** 16 Hz **D** 32 Hz

3. Nov/2023/Paper_ 9702/12/No.25

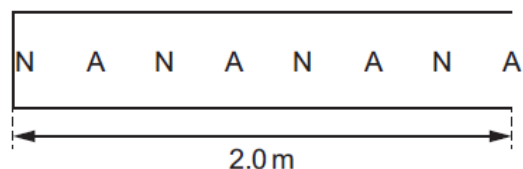
What can explain how stationary waves are formed from progressive waves?

- A** diffraction
- B** polarisation
- C** superposition
- D** the Doppler effect

4. Nov/2023/Paper_ 9702/12/No.26

A pipe has a length of 2.0 m. It is open at one end and closed at the other end.

A stationary sound wave is set up within the pipe. There are four nodes (N) and four antinodes (A) within the length of the pipe.



What is the wavelength of the sound wave?

- A** 0.57 m **B** 1.1 m **C** 1.3 m **D** 1.6 m

5. Nov/2023/Paper_ 9702/13/No.25

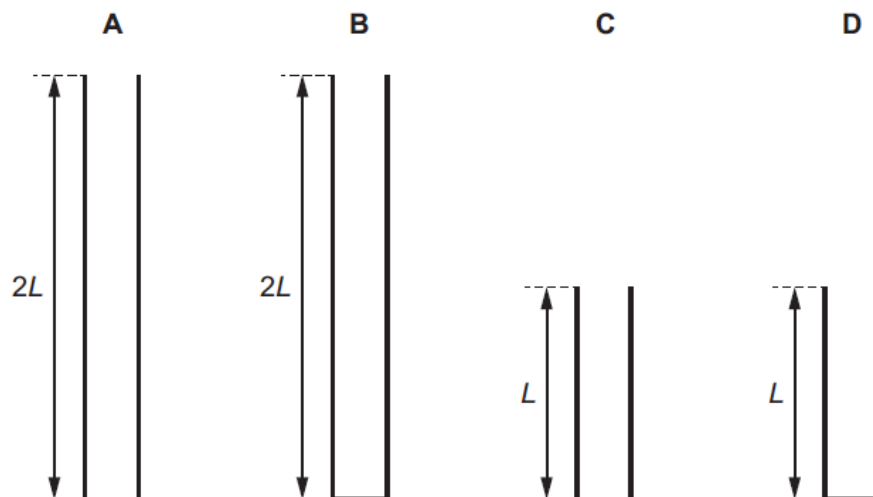
Which statement concerning a stationary wave is correct?

- A All the particles between two adjacent nodes oscillate in phase.
- B The amplitude of the stationary wave is equal to the amplitude of one of the waves creating it.
- C The wavelength of the stationary wave is equal to the separation of two adjacent nodes.
- D There is no displacement of a particle at an antinode at any time.

6. Nov/2023/Paper_ 9702/13/No.26

Stationary sound waves can be formed in the air columns of pipes. One type of pipe is closed at one end and open at the other end. Another type of pipe is open at both ends.

Which pipe can form a stationary sound wave with the lowest frequency?



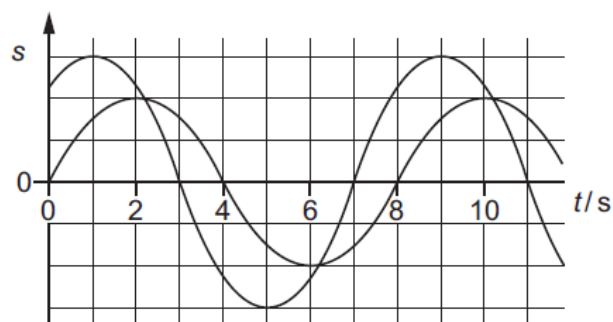
1. Nov/2023/Paper_ 9702/11/No.21

Which row is correct for both progressive transverse waves and progressive longitudinal waves?

	transverse waves	longitudinal waves
A	contain compressions and rarefactions	some can travel in a vacuum
B	can be polarised	contain compressions and rarefactions
C	vibrations are perpendicular to the direction of travel of the wave energy	can be polarised
D	some can travel in a vacuum	vibrations are perpendicular to the direction of travel of the wave energy

2. Nov/2023/Paper_ 9702/11/No.20

Two waves pass through a point P. The graph shows the variation with time t of the displacement s of the two waves at point P.



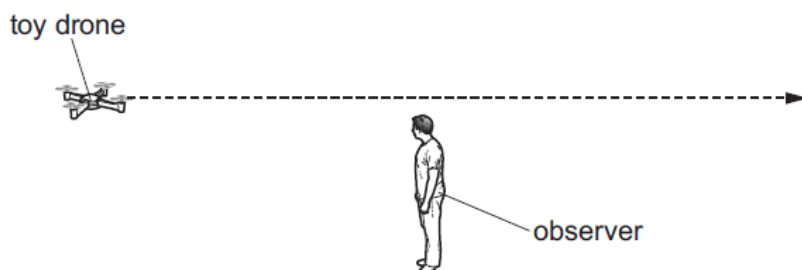
What is the phase difference between the two waves at point P?

- A** 0° **B** 45° **C** 90° **D** 180°

3. Nov/2023/Paper_ 9702/11/No.22

A toy drone emits a sound of constant frequency 800 Hz. The speed of the sound in the air is 330 m s^{-1} .

The drone moves along a straight path directly towards an observer and then continues in a straight line directly away from the observer. The speed of the drone is constant.



What is the velocity of the drone when the frequency of the sound heard by the observer is 850 Hz?

	magnitude of velocity / m s^{-1}	direction of velocity
A	19	away from the observer
B	21	away from the observer
C	19	towards the observer
D	21	towards the observer

4. Nov/2023/Paper_ 9702/11/No.23

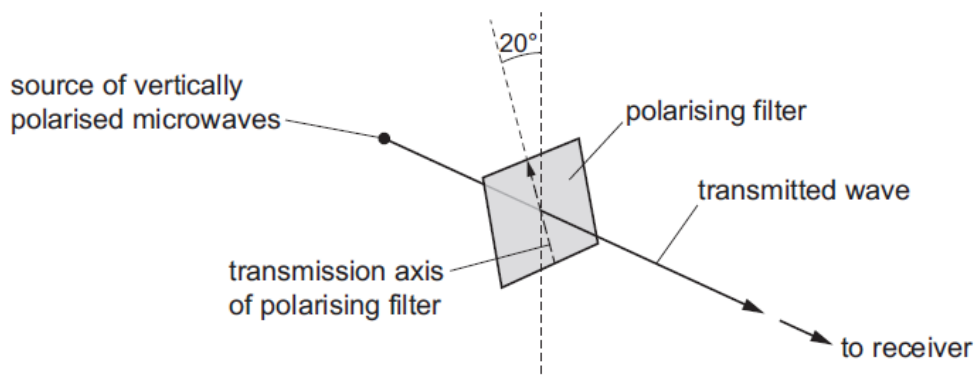
Which statement about electromagnetic waves in a vacuum is correct?

- A** Infrared waves have shorter wavelengths than visible light waves.
- B** Microwaves have longer wavelengths than radio waves.
- C** Ultraviolet waves have higher frequencies than visible light waves.
- D** γ -rays have lower frequencies than X-rays.

5. Nov/2023/Paper_ 9702/11/No.24

Vertically polarised microwaves are emitted from a source. The microwaves are detected by a receiver that is connected to a cathode-ray oscilloscope (CRO). The waveform displayed on the screen of the CRO has an amplitude of 2.6 cm.

A metal wire grid that acts as a polarising filter is now placed between the source and the receiver. The filter is orientated so that the plane of polarisation of the transmitted wave is at an angle of 20° to the vertical.



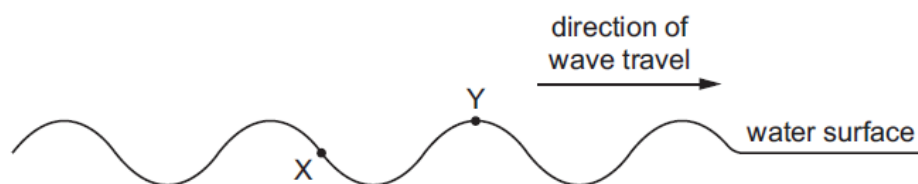
The distance between the source and receiver is unchanged. The settings on the CRO are also unchanged.

What is now the amplitude of the waveform displayed on the screen of the CRO?

- A 0.30 cm B 0.89 cm C 2.3 cm D 2.4 cm

6. Nov/2023/Paper_ 9702/12/No.20

X and Y are two points on the surface of water in a ripple tank. A source of constant frequency generates a wave which travels past X and Y, causing them to oscillate vertically.



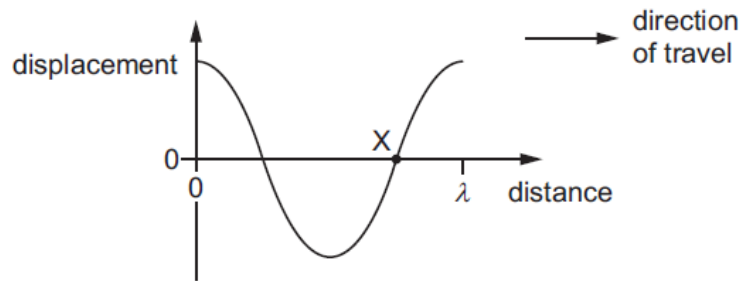
What is the phase difference between X and Y?

- A 45° B 135° C 180° D 270°

7. Nov/2023/Paper_ 9702/12/No.21

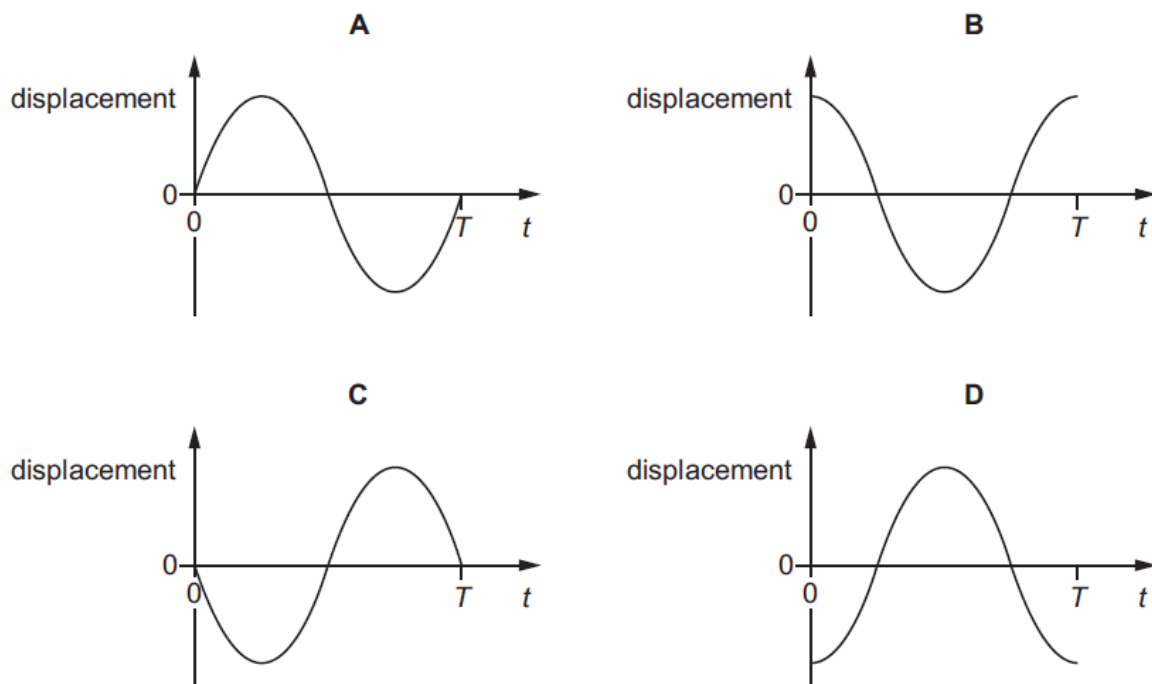
A transverse wave on a rope has wavelength λ and period T .

The graph shows the variation of the displacement of the particles of the rope with distance in the direction of travel of the wave at time $t = 0$.



A particle X is labelled.

Which graph shows the variation of the displacement of particle X with time t ?



8. Nov/2023/Paper_ 9702/12/No.22

A source of sound waves is moving at a constant speed directly towards a stationary observer.

The sound waves have a speed of 340 ms^{-1} and a frequency of 480 Hz . The observer hears sound waves of frequency 650 Hz .

What is the speed of the source?

- A** 89 ms^{-1} **B** 120 ms^{-1} **C** 250 ms^{-1} **D** 340 ms^{-1}

9. Nov/2023/Paper_ 9702/12/No.23

A student is investigating two electromagnetic waves, X and Y, in a vacuum.

Wave X has a wavelength of 5.2×10^{-7} m. Wave Y has a frequency of 9.4 GHz.

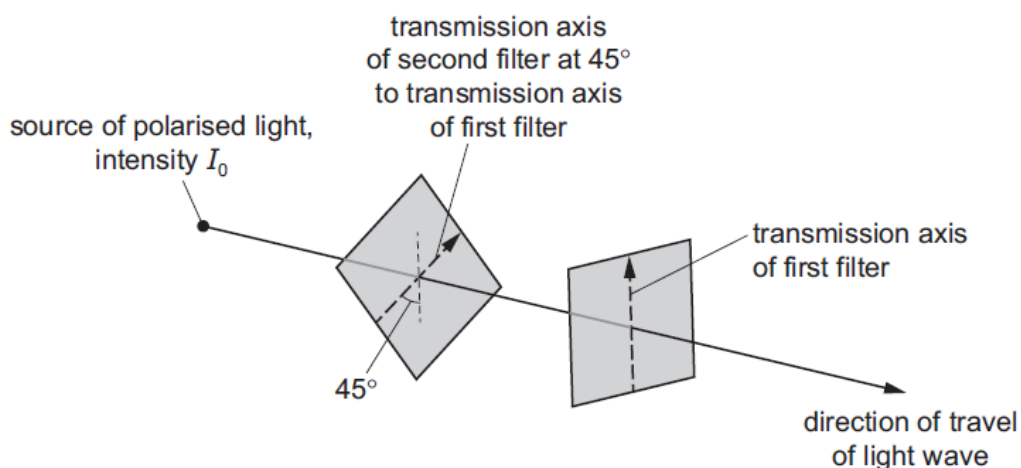
Which principal regions of the electromagnetic spectrum contain waves X and Y?

	X	Y
A	radio wave	ultraviolet
B	ultraviolet	visible
C	visible	microwave
D	microwave	radio wave

10. Nov/2023/Paper_ 9702/12/No.24

A plane polarised light wave of intensity I_0 is incident normally on a polarising filter. The initial intensity of the transmitted wave is 0.

A second polarising filter is then inserted between the source and the first filter. Its transmission axis is at 45° to the transmission axis of the first filter, as shown.



What is the intensity of the transmitted wave from the filter combination?

- A 0 B $\frac{I_0}{8}$ C $\frac{I_0}{4}$ D $\frac{I_0}{2}$

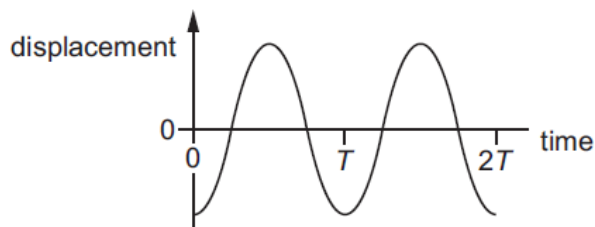
11. Nov/2023/Paper_ 9702/13/No.1

What is the best estimate of the wavelength of green light?

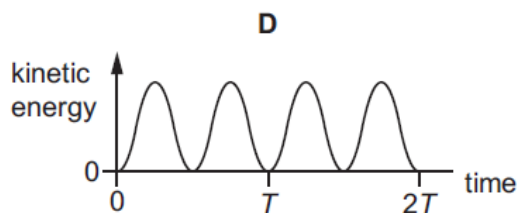
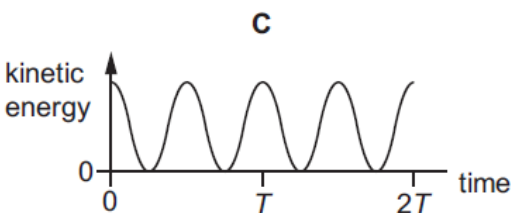
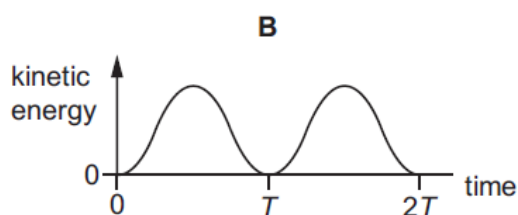
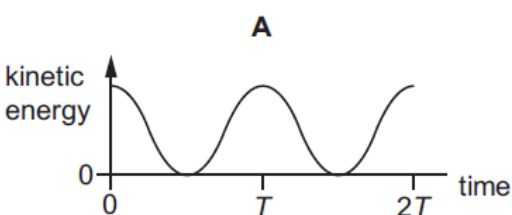
- A 260 nm B 540 nm C 780 nm D 920 nm

12. Nov/2023/Paper_ 9702/13/No.20

When sound travels through air, the air particles vibrate. A graph of displacement against time for a single air particle is shown.



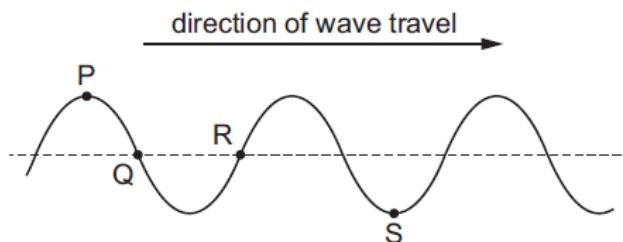
Which graph shows how the kinetic energy of the air particle varies with time?



13. Nov/2023/Paper_ 9702/13/No.21

A wave travels on the surface of water. P, Q, R and S are four particles of water on the surface.

The diagram shows the positions of the particles at one instant. The direction of travel of the wave is from left to right.



Which two particles are about to move upwards?

- A P and R B P and S C R and S D Q and S

14. Nov/2023/Paper_ 9702/13/No.22

A loudspeaker emits sound of frequency f_s . The loudspeaker is attached to a car that moves with increasing speed directly towards a stationary observer.

Which statement describes the frequency of the sound heard by the observer?

- A a frequency greater than f_s and increasing
- B a frequency greater than f_s but decreasing
- C a frequency less than f_s and decreasing
- D a frequency less than f_s but increasing

15. Nov/2023/Paper_ 9702/13/No.23

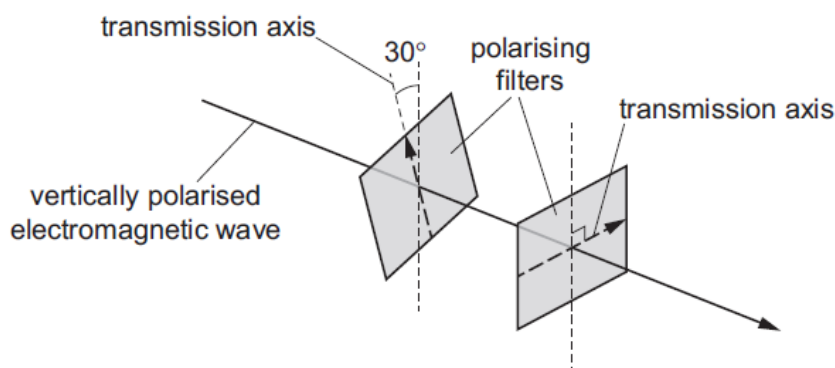
Which statement about electromagnetic waves in a vacuum is correct?

- A Amplitude is inversely proportional to velocity.
- B Frequency is inversely proportional to wavelength.
- C Intensity is proportional to amplitude.
- D Velocity is proportional to wavelength.

16. Nov/2023/Paper_ 9702/13/No.24

A vertically polarised electromagnetic wave of intensity I_0 is incident normally on a polarising filter. The transmission axis of the filter is at an angle of 30° to the vertical.

The transmitted wave from the first filter is then incident normally on a second polarising filter. The transmission axis of this filter is at an angle of 90° to the vertical.



What is the intensity of the wave after passing through the second filter?

- A 0
- B $0.063 I_0$
- C $0.19 I_0$
- D $0.56 I_0$

(a) State the principle of superposition.

.....

.....

..... [2]

(b) Coherent light is incident normally on two identical slits X and Y. The diffracted light emerging from the slits superposes to produce an interference pattern on a screen positioned at a distance of 1.9 m from the slits.

Fig. 4.1 shows the arrangement and the central part of the interference pattern of bright and dark fringes formed on the screen.

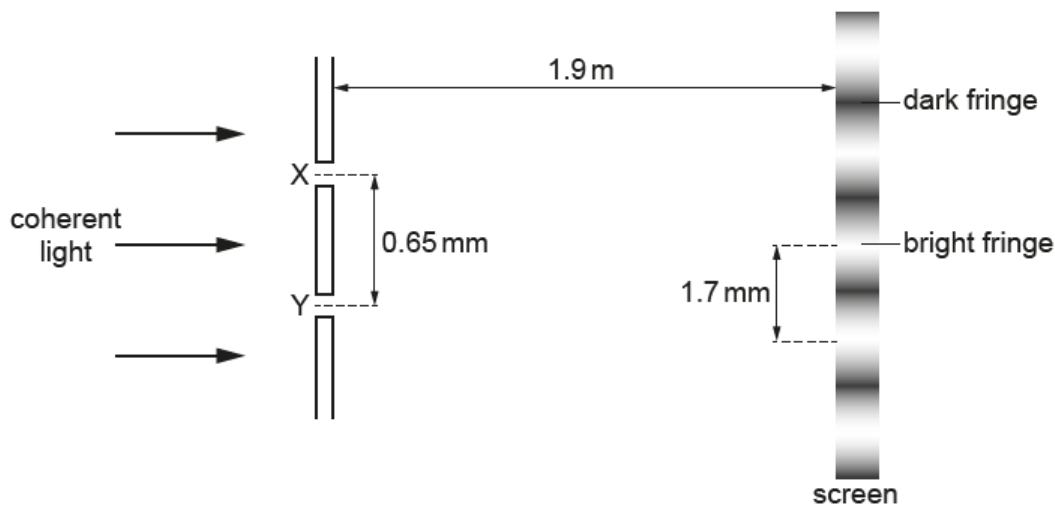


Fig. 4.1 (not to scale)

The separation of the slits is 0.65 mm. The distance between the centres of adjacent bright fringes is 1.7 mm.

Calculate the wavelength λ of the light.

$$\lambda = \text{..... m [3]}$$

- (c) Light waves from slits X and Y in (b) arrive at a point between adjacent bright fringes on the screen. Fig. 4.2 shows the variation of displacement with time for the waves arriving at the point where they meet.

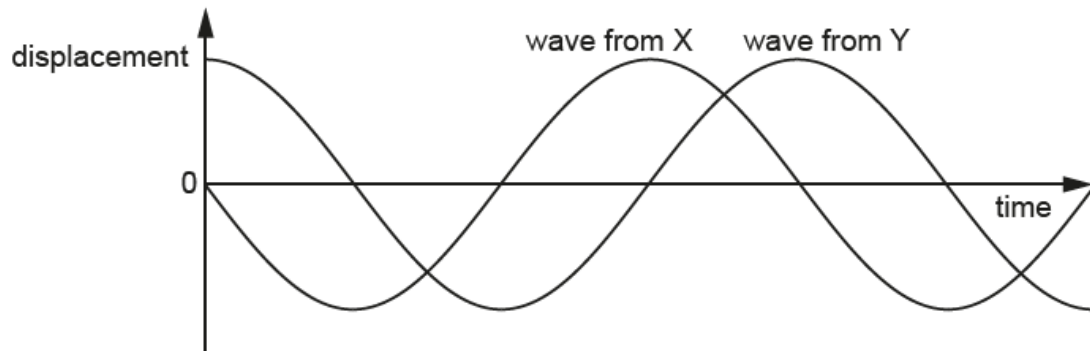


Fig. 4.2

A student makes two statements about the waves at this point:

Statement 1: 'The phase difference between the waves is 90° .'

Statement 2: 'The amplitude of the resultant wave is zero.'

- (i) Explain how statement 1 is correct.

.....
.....
..... [1]

- (ii) State and explain whether statement 2 is correct.

.....
.....
..... [1]

- (d) The width of each slit in (b) is decreased by the same amount. There is no change to the separation of the slits.

Describe and explain the effect, if any, of this change on the appearance of the interference pattern.

.....
.....
..... [2]

[Total: 9]

18. Nov/2023/Paper_ 9702/22/No.5(b, c)

(b) State what is meant by the diffraction of a wave.

.....

.....

..... [2]

- (c) A beam of light of wavelength $4.3 \times 10^{-7} \text{ m}$ is incident normally on a diffraction grating in air, as shown in Fig. 5.3.

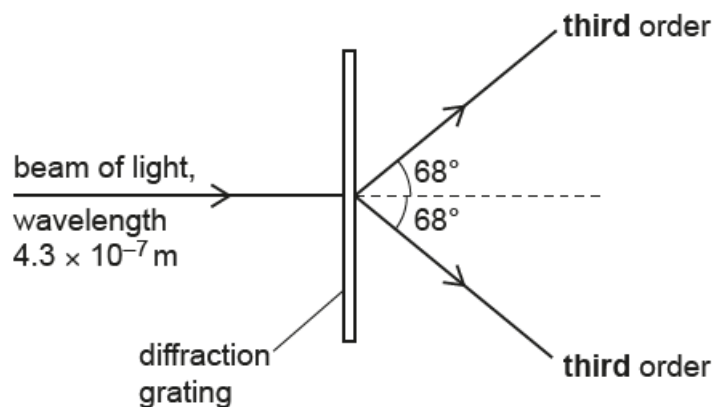


Fig. 5.3 (not to scale)

The **third**-order diffraction maximum of the light is at an angle of 68° to the direction of the incident light beam.

- (i) Calculate the line spacing d of the diffraction grating.

$d = \dots\dots\dots \text{m}$ [2]

- (ii) Determine a different wavelength of **visible** light that will also produce a diffraction maximum at an angle of 68° .

wavelength = $\dots\dots\dots \text{m}$ [2]

A train travels at constant speed along a straight horizontal track towards an observer standing adjacent to the track, as shown in Fig. 6.1.

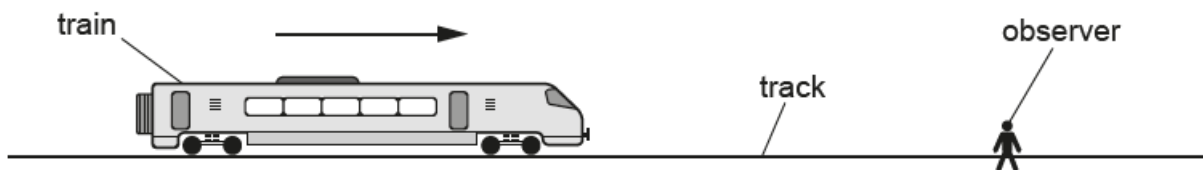


Fig. 6.1

The train sounds its horn continuously as it approaches the observer. The horn emits a sound of constant frequency 251 Hz. The frequency of sound heard by the observer is 291 Hz. The speed of sound in air is 340 ms^{-1} .

(a) Calculate the speed of the train.

speed = ... ms^{-1} [2]

- (b) The train approaches and then passes the observer. The intensity I of the sound heard by the observer varies with the distance d of the horn from the observer.

When the horn is at a distance x_0 from the observer, the intensity I of the sound heard is I_0 and the amplitude A of the sound wave at the observer is A_0 .

Fig. 6.2 shows the variation with d/x_0 of I/I_0 as the train moves away from the observer.

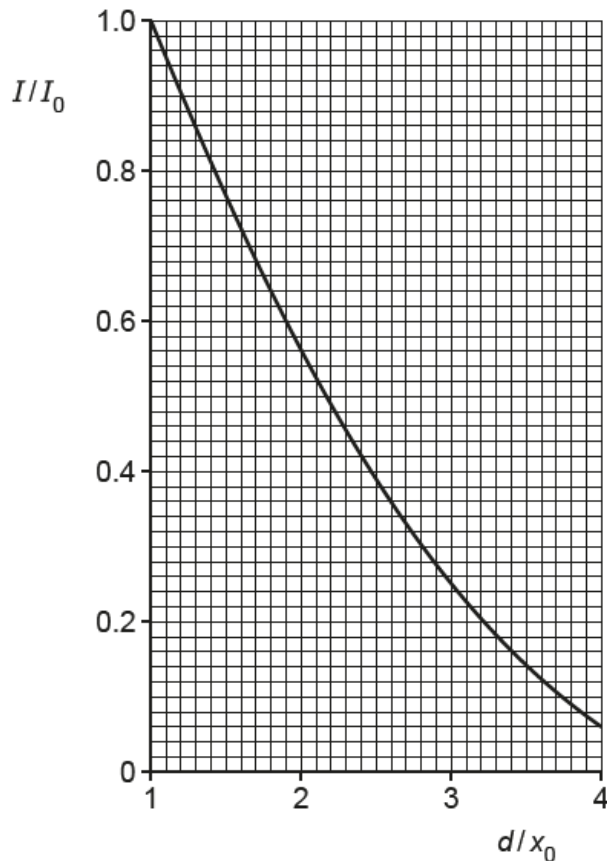


Fig. 6.2

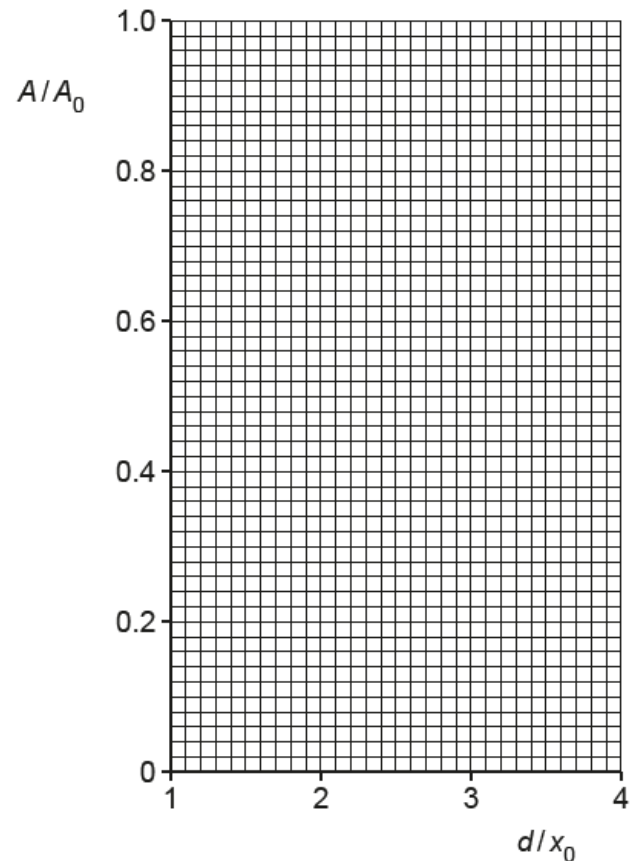


Fig. 6.3

- (i) State the relationship between amplitude A and intensity I for a progressive wave.

..... [1]

- (ii) On Fig. 6.3, sketch the variation with d/x_0 of A/A_0 . [2]

[Total: 5]

- (ii) State the principal region of the electromagnetic spectrum to which the waves belong.

..... [1]

[Total: 6]