Waves: 13

TOPIC-Describing waves, Types, speed, Intensity and wave power,oscilloscope, Doppler effect, EMW and EMR

0 1 **(a)** State one property of electromagnetic waves that is **not** common to other transverse waves.

.... [1]

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

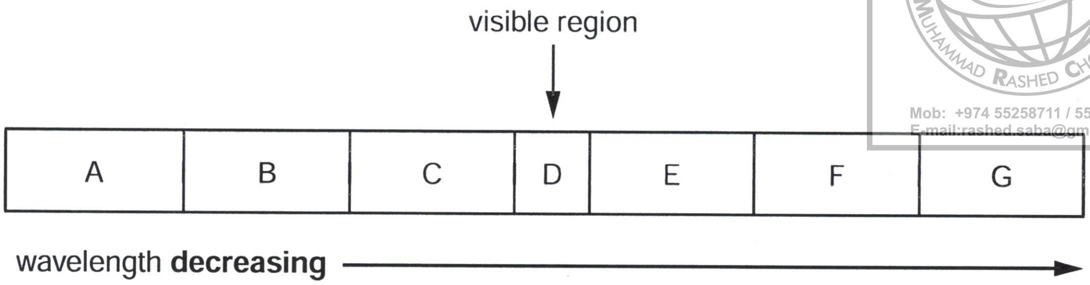

Fig. 5.1

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]

For Examiner's Use

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

For Examiner's Use

(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]

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

For Examiner's Use

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.

For Examiner's Use

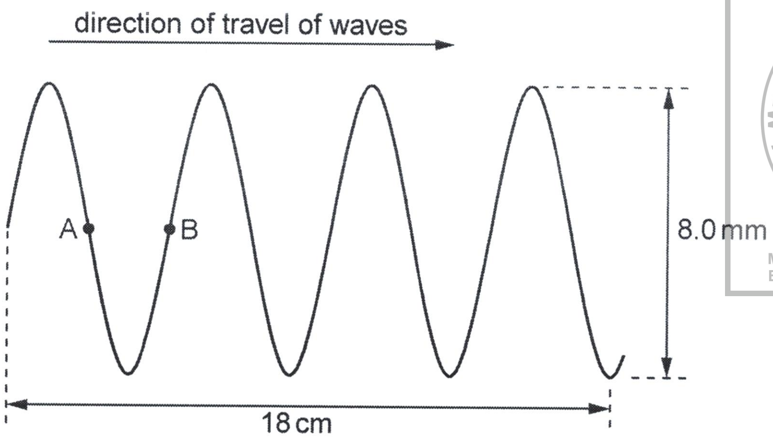

Fig. 5.1 (not to scale)

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.

For Examiner's Use

....

....

....

[2]

04 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 Examiner's Use

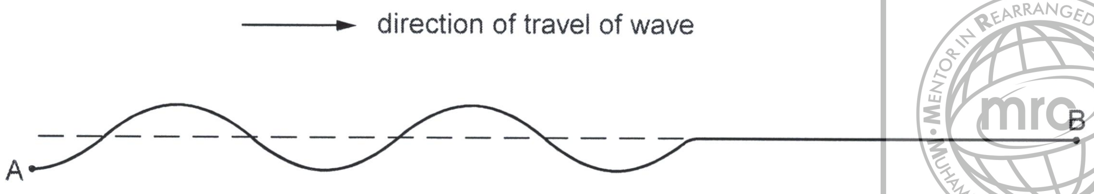

Fig. 5.1 (not to scale)

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]

For Examiner's Use

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.

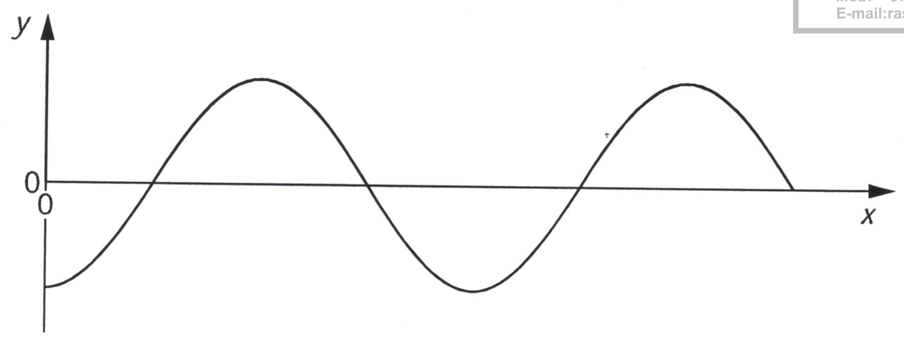

Fig. 5.1

(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]

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

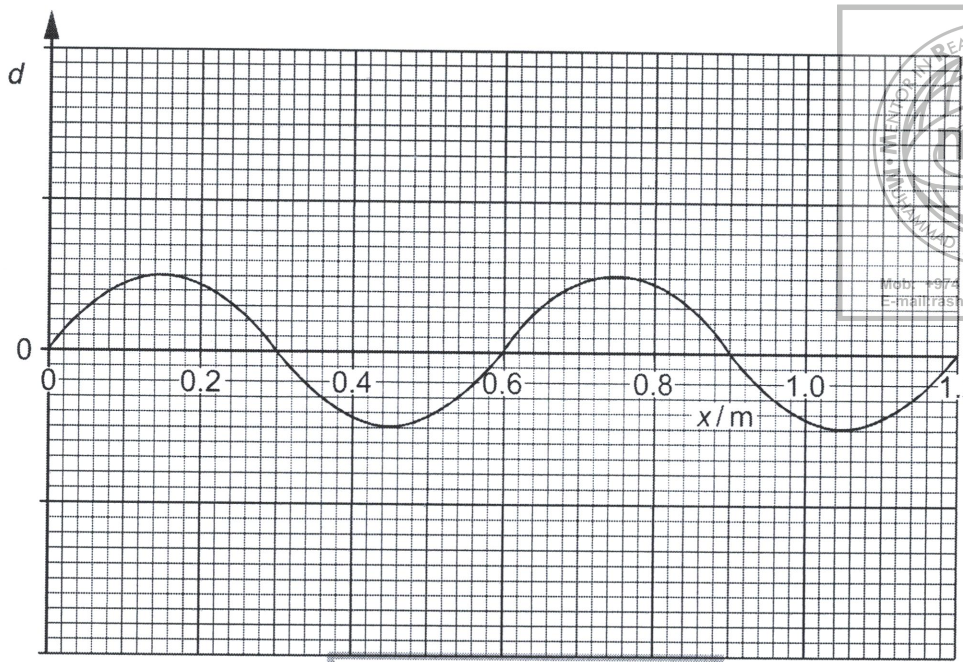

Fig. 2.1

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]

For Examiner's Use

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

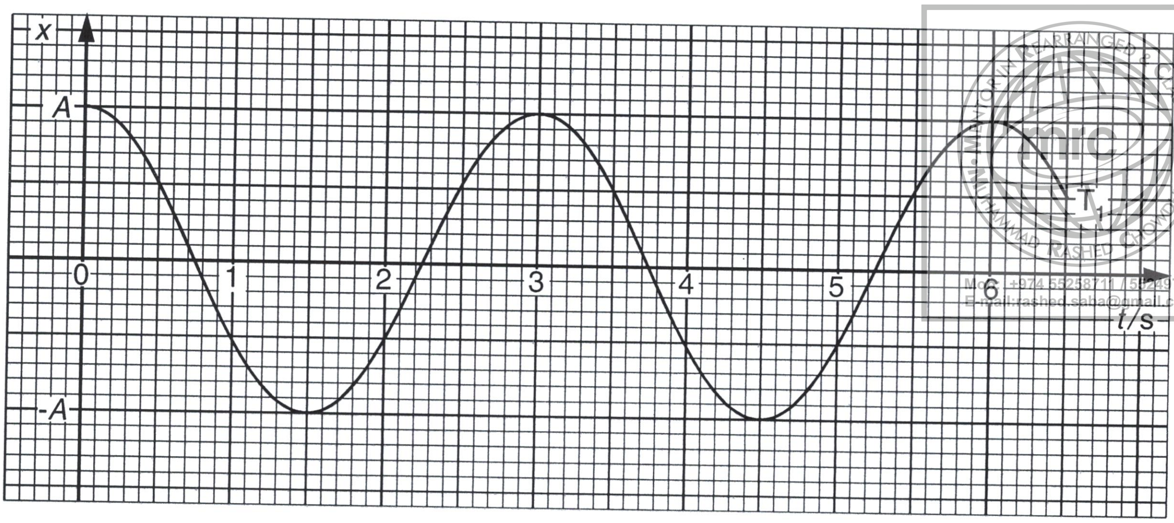

Fig. 5.1

(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]

08 **(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.

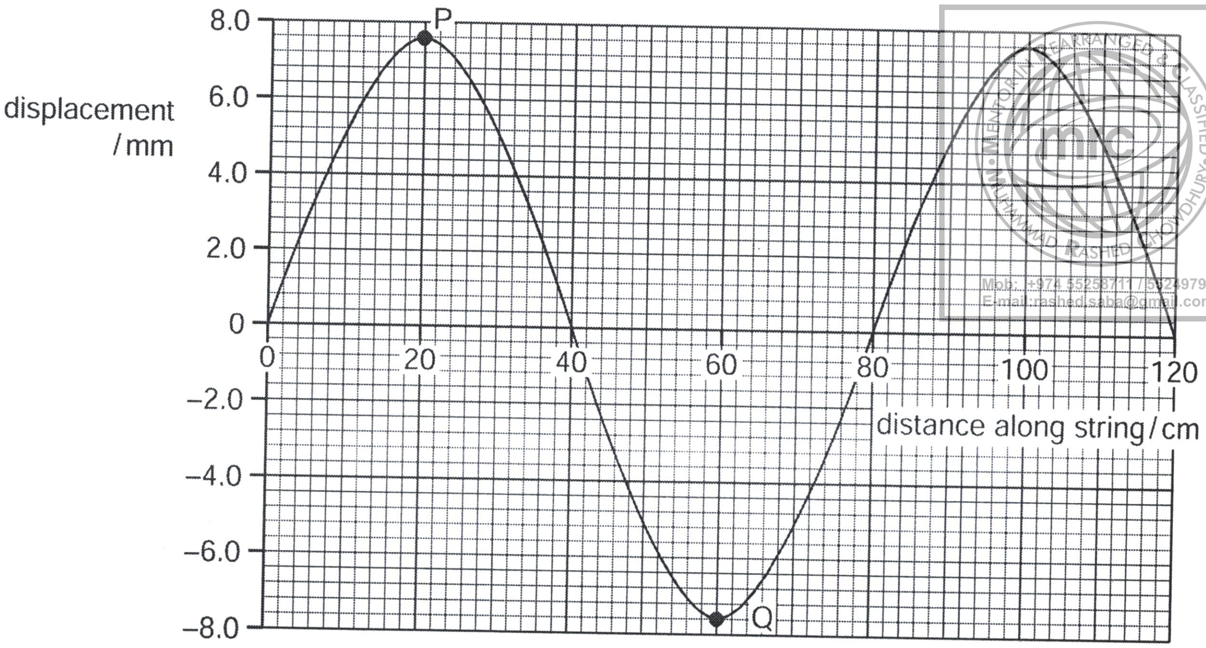

Fig. 6.1

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.

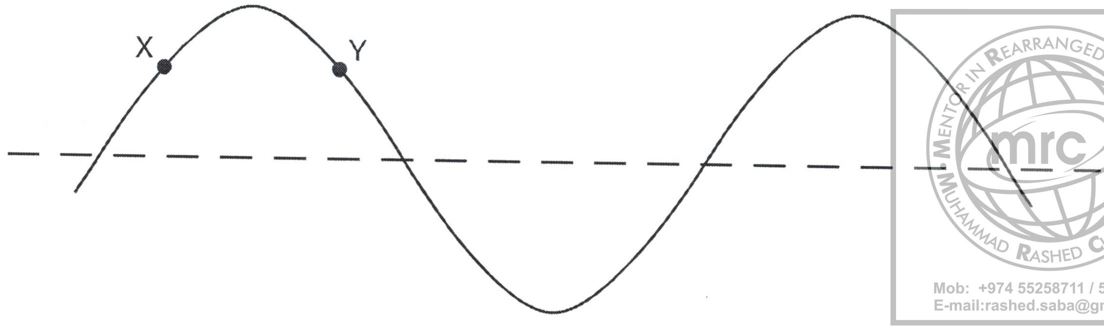

Fig. 6.2

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]

09 **(a)** **(i)** Explain what is meant by a *progressive transverse* wave.

progressive: ....

....

transverse: ....

.... [2]

(ii) Define frequency.

....

....[1]

(b) The variation with distance *x* of displacement *y* for a transverse wave is shown in Fig. 7.1.

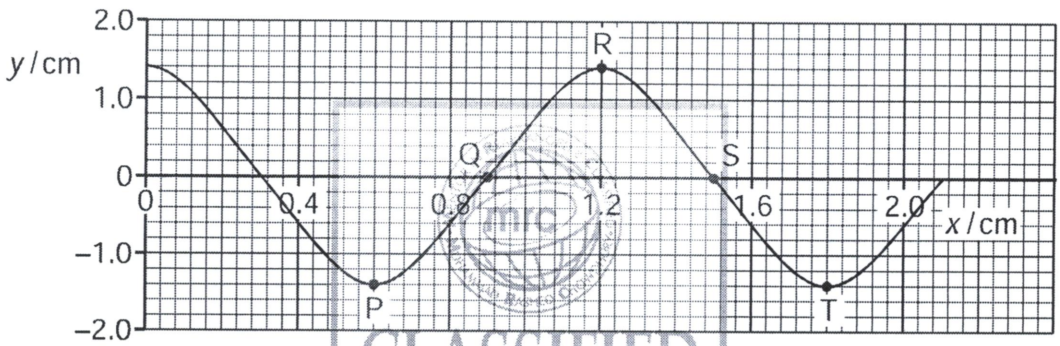

Fig. 7.1

On Fig. 7.1, five points are labelled.

Use Fig. 7.1 to state any two points having a phase difference of

(i) zero,

....[1]

(ii) 270°.

....[1]

(c) The frequency of the wave in **(b)** is 15 Hz.

Calculate the speed of the wave in **(b)**.

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

(d) Two waves of the same frequency have amplitudes 1.4 cm and 2.1 cm.

Calculate the ratio

$$\frac{\text{intensity of wave of amplitude 1.4 cm}}{\text{intensity of wave of amplitude 2.1 cm}}.$$

ratio = ... [2]

10 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.

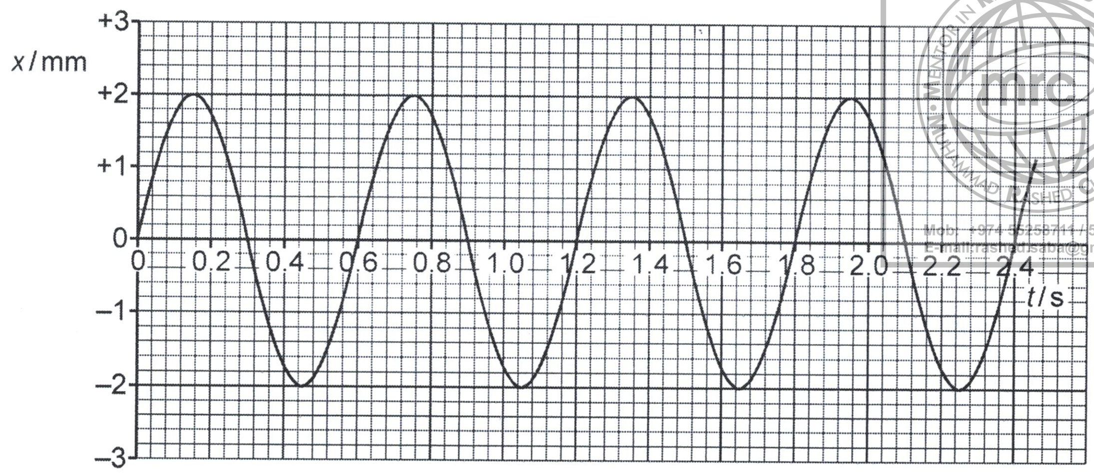

Fig. 5.1

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.

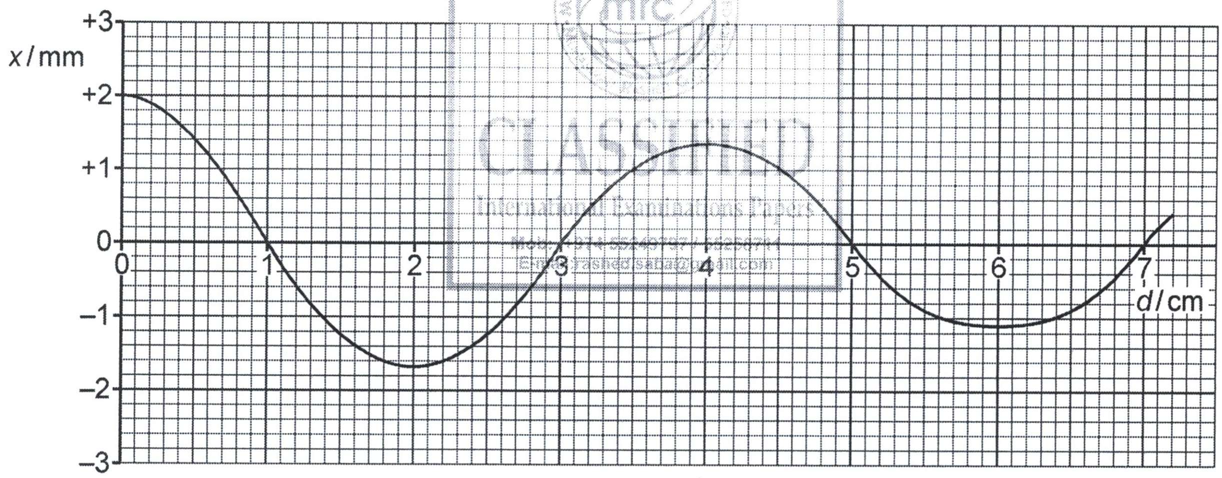

Fig. 5.2

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

(i) *displacement*,

....

....[1]

(ii) *wavelength*.

....

....[1]

For Examiner's Use

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

(i) the period T of vibration,

T = ... s [1]

(ii) the wavelength λ,

λ = ... cm [1]

(iii) the speed v.

v = ... 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]

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

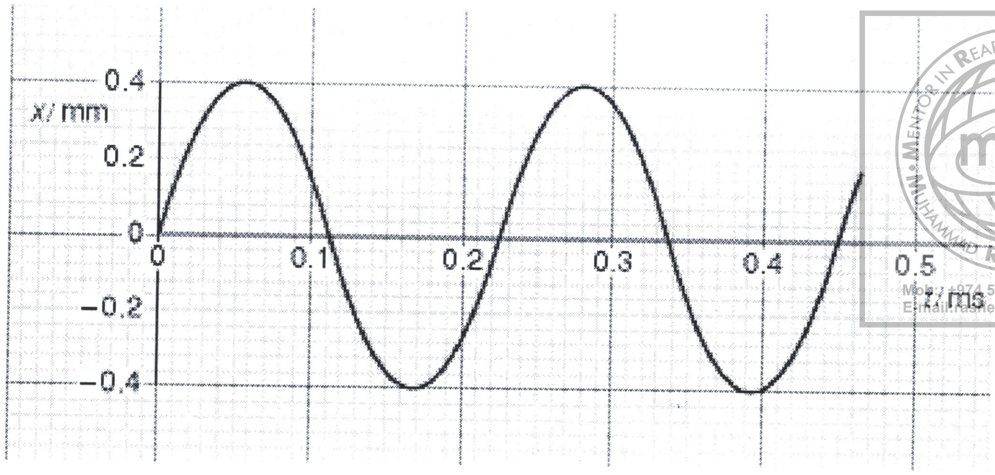

Fig. 4.1

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

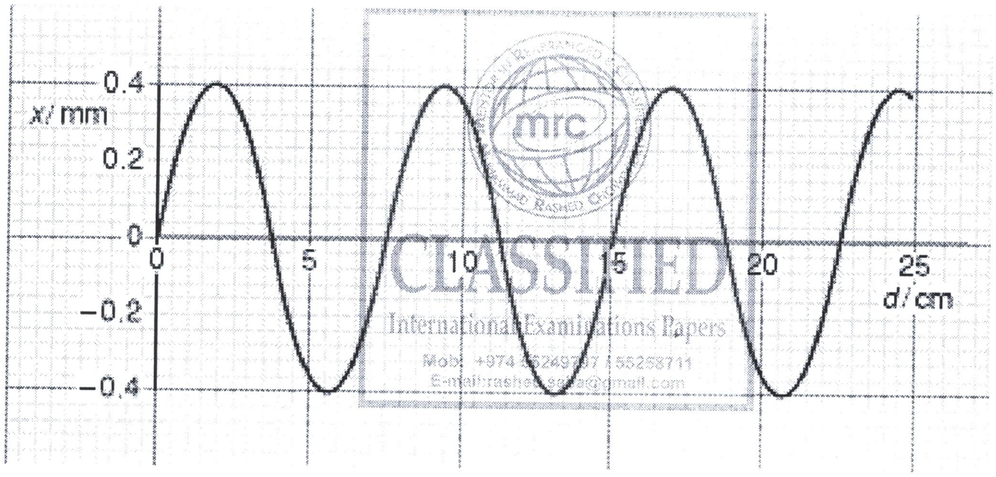

Fig. 4.2

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

1. the amplitude,

amplitude = ... mm

2. the wavelength,

wavelength = ... m

For Examiner's Use

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]

12 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.

For Examiner's Use

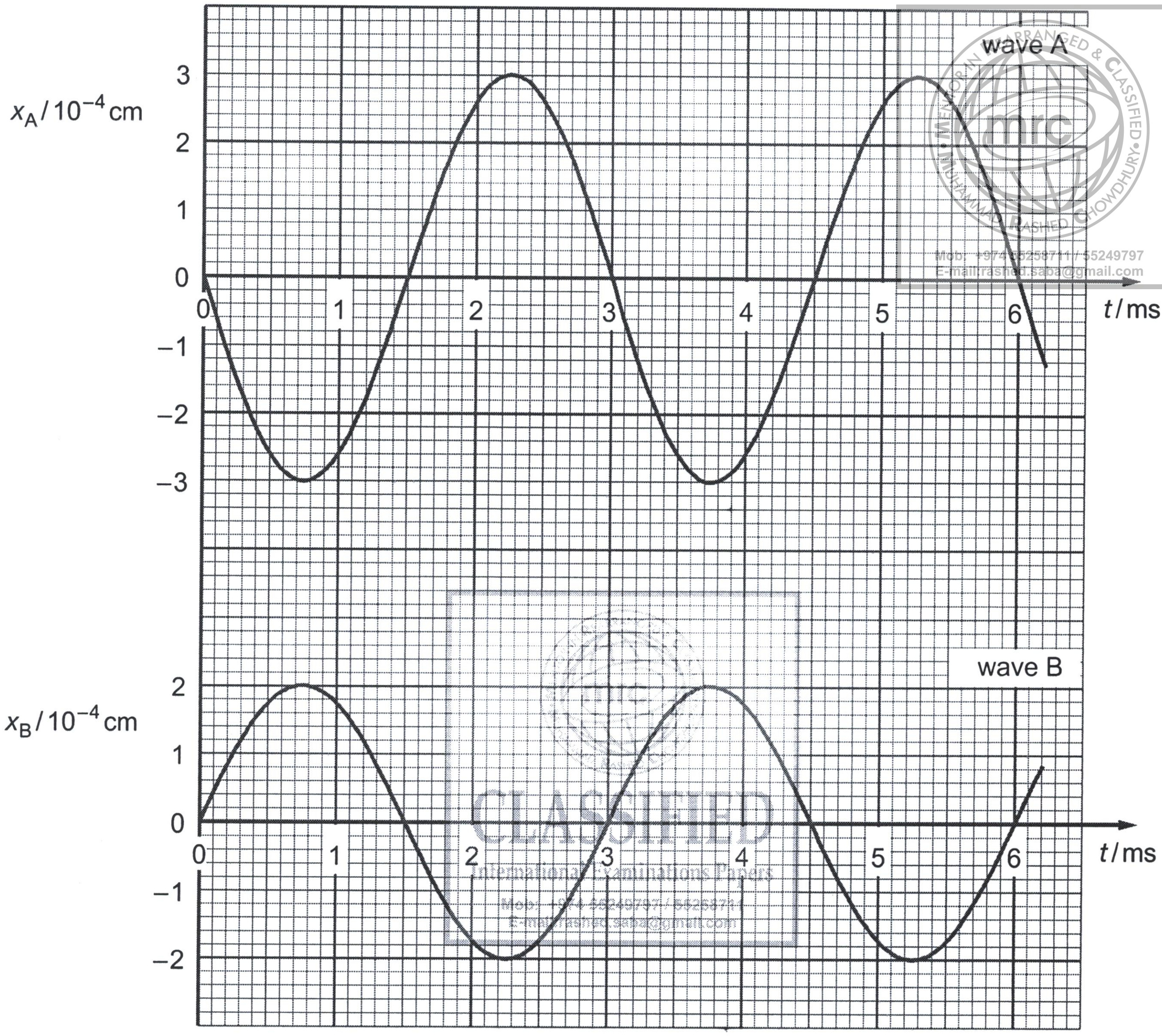

Fig. 5.1

(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 Examiner's 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]

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

For Examiner's Use

....

....

.... [2]

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

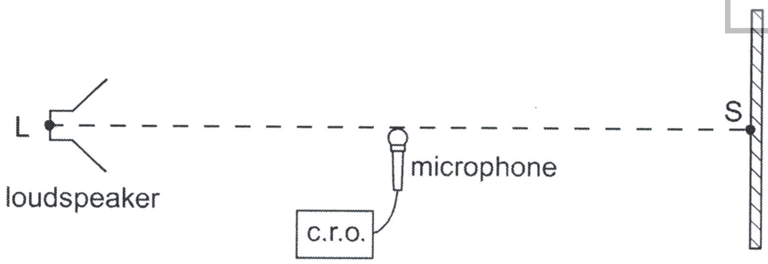

Fig. 6.1

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.

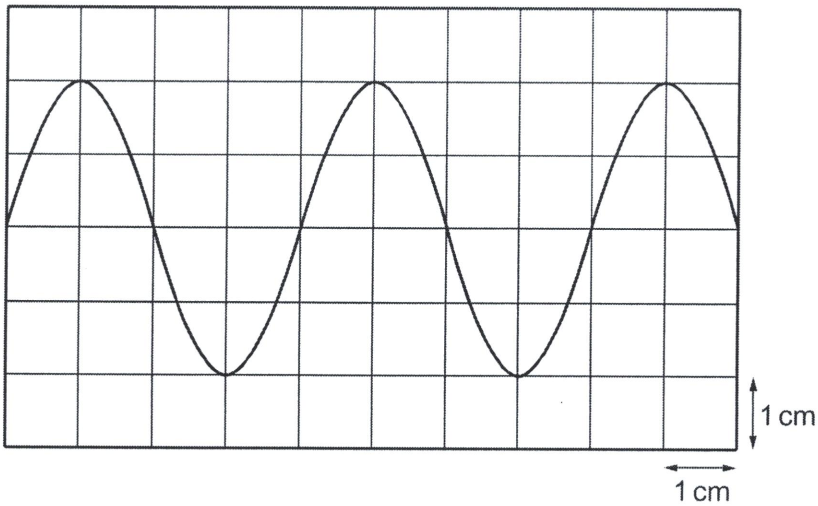

Fig. 6.2

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

(i) Calculate the frequency of the sound wave.

For Examiner's Use

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]

2. Calculate the speed of sound.

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

Please turn over for Question 7.

14 A loudspeaker produces a sound wave of constant frequency.

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

For Examiner's Use

....

....

....

....

.... [4]

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

(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.

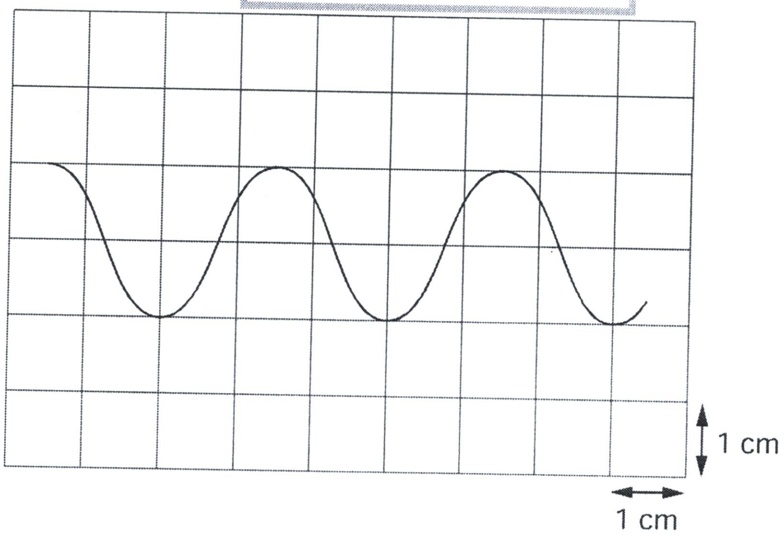

Fig. 5.1

For Examiner's Use

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

For Examiner's Use

(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]

16 **(a)** State Newton's first law of motion.

....

....[1]

(b) An object A of mass 100 g is moving in a straight line with a velocity of $0.60\,\mathrm{m\,s^{-1}}$ to the right. An object B of mass 200 g is moving in the same straight line as object A with a velocity of $0.80\,\mathrm{m\,s^{-1}}$ to the left, as shown in Fig. 4.1.

Fig. 4.1

Objects A and B collide. Object A then moves with a velocity of $0.40\,\mathrm{m\,s^{-1}}$ to the left.

(i) Calculate the magnitude of the velocity of B after the collision.

magnitude of velocity = ... $\mathrm{m\,s^{-1}}$ [2]

(ii) The collision between A and B is inelastic.

Explain how the collision is inelastic and still obeys the law of conservation of energy.

....

....

....[1]

[Total: 4]

5 **(a)** Define the *frequency* of a sound wave.

....

....[1]

(b) A sound wave travels through air. Describe the motion of the air particles relative to the direction of travel of the sound wave.

....

....[1]

(c) The sound wave emitted from the horn of a stationary car is detected with a microphone and displayed on a cathode-ray oscilloscope (c.r.o.), as shown in Fig. 5.1.

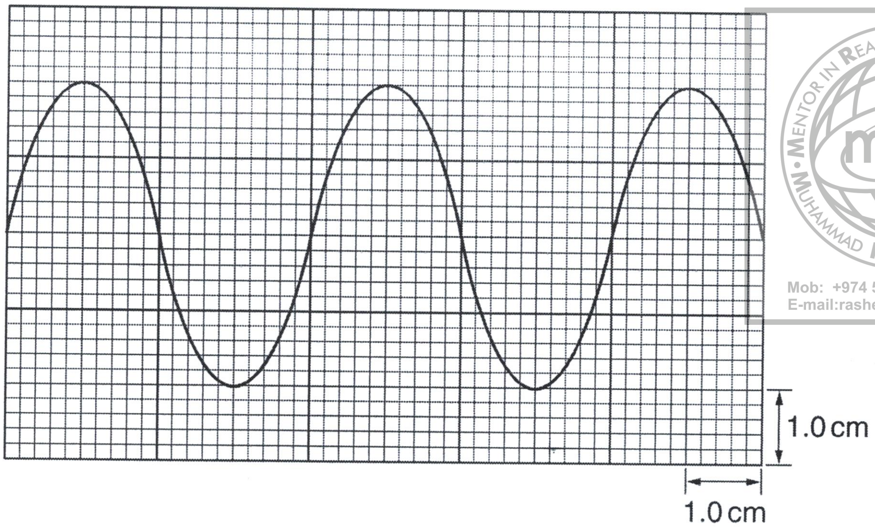

Fig. 5.1

The y-axis setting is $5.0\,\text{mV}\,\text{cm}^{-1}$.
The time-base setting is $0.50\,\text{ms}\,\text{cm}^{-1}$.

(i) Use Fig. 5.1 to determine the frequency of the sound wave.

frequency = ... Hz [2]

(ii) The horn of the car sounds continuously. Describe the changes to the trace seen on the c.r.o. as the car travels at constant speed

1. directly towards the stationary microphone,

....

....

2. directly away from the stationary microphone.

....

....

[3]

[Total: 7]

17 (a) Describe the Doppler effect.

....

....

....[1]

(b) A car travels with a constant velocity along a straight road. The car horn with a frequency of 400 Hz is sounded continuously. A stationary observer on the roadside hears the sound from the horn at a frequency of 360 Hz.
The speed of sound is $340\,m\,s^{-1}$.

Determine the magnitude *v*, and the direction, of the velocity of the car relative to the observer.

v = ... $m\,s^{-1}$

direction ....

[3]

[Total: 4]

18 **(a)** State what is meant by the *Doppler effect*.

....

....

.... [2]

(b) A child sits on a rotating horizontal platform in a playground. The child moves with a constant speed along a circular path, as illustrated in Fig. 4.1.

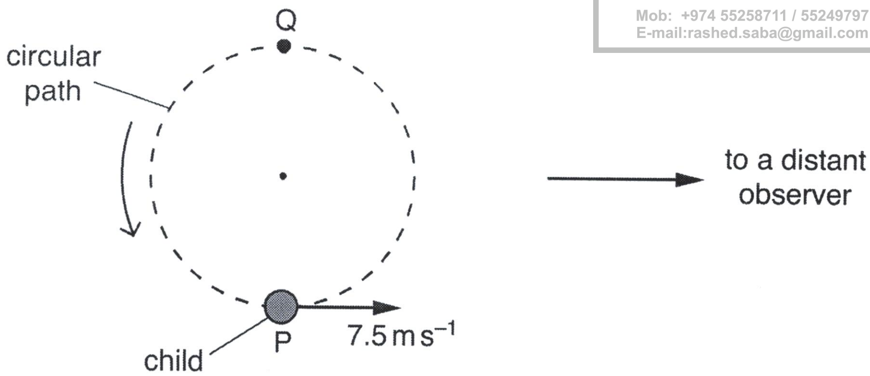

Fig. 4.1

An observer is standing a long distance away from the child. During one particular revolution, the child, moving at a speed of $7.5\,\mathrm{m\,s^{-1}}$, starts blowing a whistle at point P and stops blowing it at point Q on the circular path.

The whistle emits sound of frequency 950 Hz. The speed of sound in air is $330\,\mathrm{m\,s^{-1}}$.

(i) Determine the maximum frequency of the sound heard by the distant observer.

maximum frequency = ... Hz [2]

(ii) Describe the variation in the frequency of the sound heard by the distant observer.

....

....

....

.... [2]

[Total: 6]

19 The signal from a microwave detector is recorded on a cathode-ray oscilloscope (c.r.o.), as shown in Fig. 2.1.

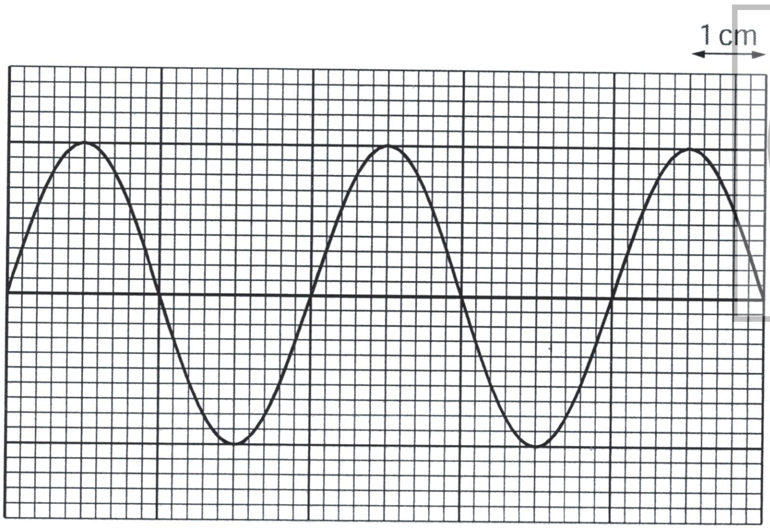

Fig. 2.1

The time-base setting on the c.r.o. is $50\,ps\,cm^{-1}$.

(a) Using Fig. 2.1, determine the wavelength of the microwaves.

wavelength = ... m [4]

(b) The signal from a radio wave detector is recorded on the same c.r.o.
The wavelength of the radio waves is 1.5×10^3 m.

Determine the time-base setting required to display the same number of oscillations on the c.r.o. as shown in Fig. 2.1.

time-base setting = ... unit........................ [2]

2 A microphone detects a musical note of frequency *f*. The microphone is connected to a cathode-ray oscilloscope (c.r.o.). The signal from the microphone is observed on the c.r.o. as illustrated in Fig. 2.1.

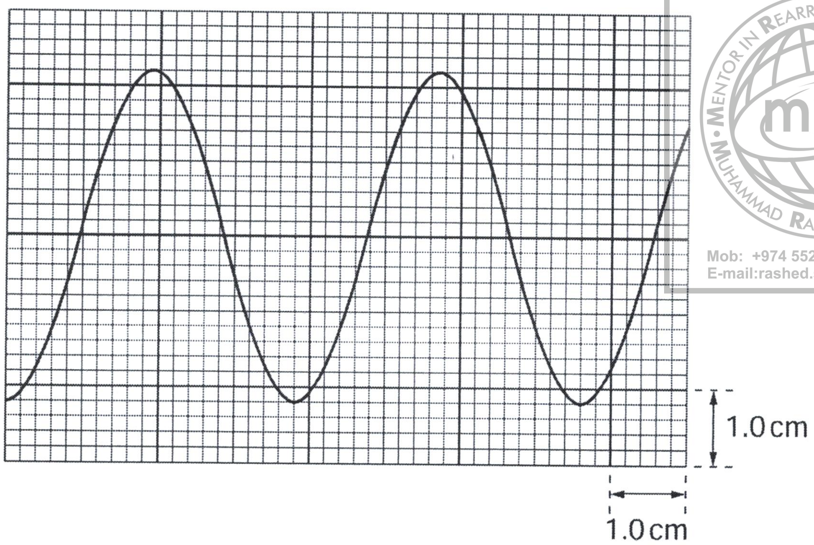

Fig. 2.1

The time-base setting of the c.r.o. is 0.50 $ms\,cm^{-1}$. The Y-plate setting is 2.5 $mV\,cm^{-1}$.

(a) Use Fig. 2.1 to determine

(i) the amplitude of the signal,

amplitude = ... mV [2]

(ii) the frequency *f*,

f = ... Hz [3]

(iii) the actual uncertainty in *f* caused by reading the scale on the c.r.o.

actual uncertainty = ... Hz [2]

(b) State *f* with its actual uncertainty.

f = ... ± .... Hz [1]

2 1 (a) Explain how stationary waves are formed.

....

....

.... [2]

(b) The arrangement of apparatus used to determine the wavelength of a sound wave is shown in Fig. 8.1.

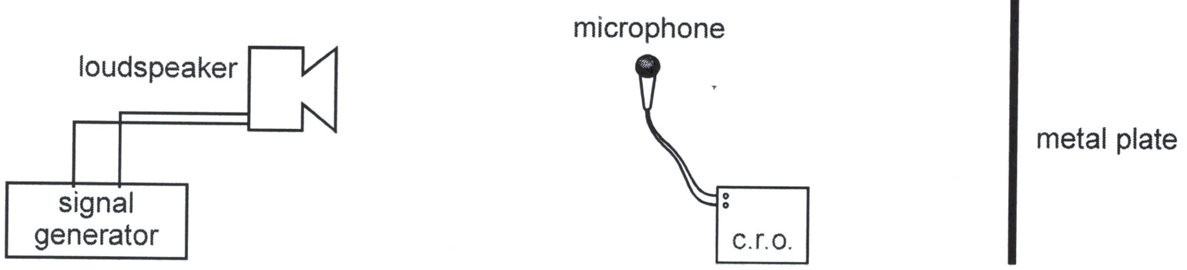

Fig. 8.1

The loudspeaker emits sound of one frequency. The microphone is connected to a cathode-ray oscilloscope (c.r.o.).
The waveform obtained on the c.r.o. for one position of the microphone is shown in Fig. 8.2.

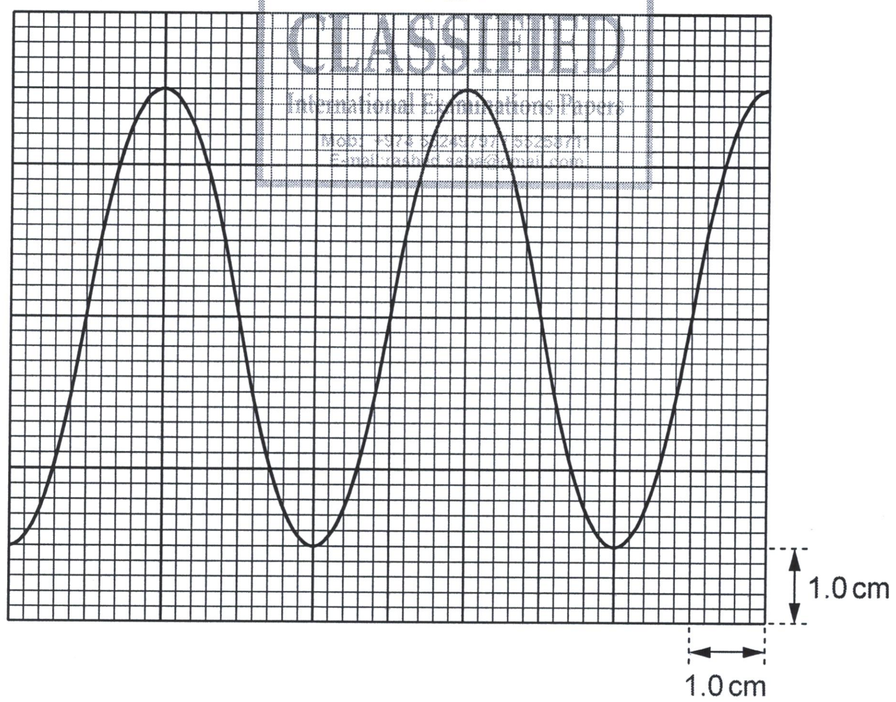

Fig. 8.2

The time-base setting of the c.r.o. is $0.20\,\text{ms}\,\text{cm}^{-1}$.

(i) Use Fig. 8.2 to show that the frequency of the sound is approximately 1300 Hz.

[2]

(ii) Explain how the apparatus is used to determine the wavelength of the sound.

....

....

....

.... [2]

(iii) The wavelength of the sound wave is 0.26 m. Calculate the speed of sound in this experiment.

speed = ... $\text{m}\,\text{s}^{-1}$ [2]

2 A source of radio waves sends a pulse towards a reflector. The pulse returns from the reflector and is detected at the same point as the source. The emitted and reflected pulses are recorded on a cathode-ray oscilloscope (c.r.o.) as shown in Fig. 2.1.

For Examiner's Use

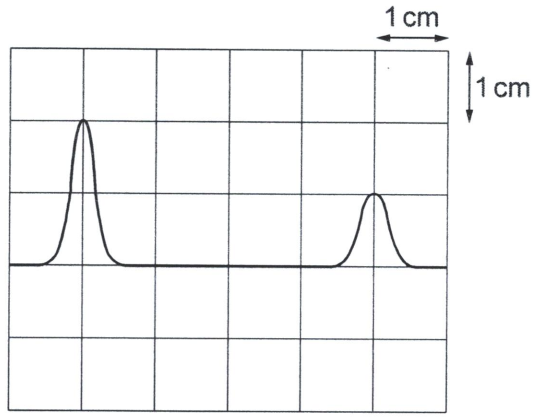

Fig. 2.1

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

(a) Using Fig. 2.1, determine the distance between the source and the reflector.

distance = ... m [4]

(b) Determine the time-base setting required to produce the same separation of pulses on the c.r.o. when sound waves are used instead of radio waves.
The speed of sound is $300\,m\,s^{-1}$.

....

....

....[3]

23 **(a)** Explain what is meant by the following quantities for a wave on the surface of water:

(i) displacement and amplitude,

displacement ....

amplitude .... [2]

(ii) frequency and time period.

frequency ....

time period .... [2]

(b) Fig. 5.1 represents waves on the surface of water in a ripple tank at one particular instant of time.

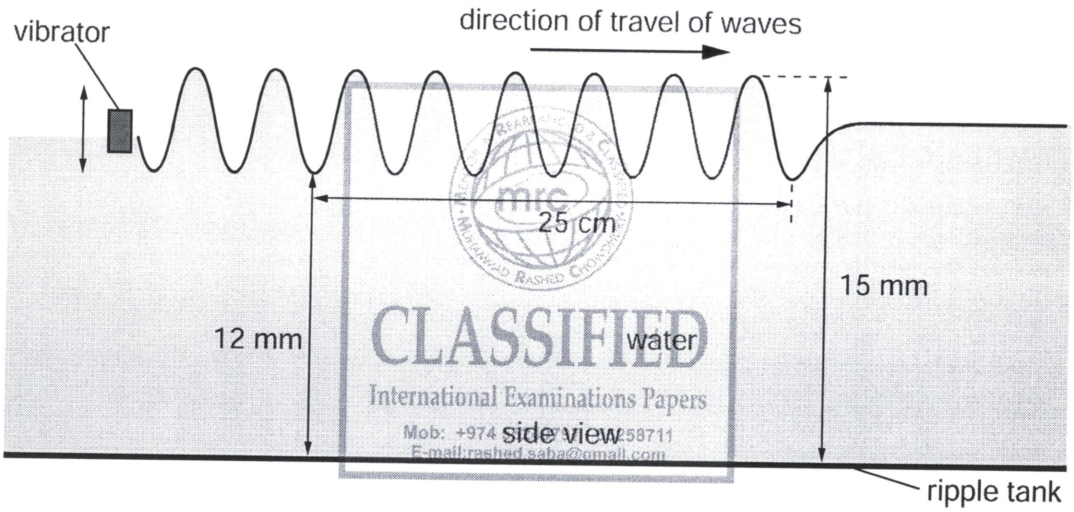

Fig. 5.1 (not to scale)

A vibrator moves the surface of the water to produce the waves of frequency *f*. The speed of the waves is $7.5\,\text{cm}\,\text{s}^{-1}$. Where the waves travel on the water surface, the maximum depth of the water is 15 mm and the minimum depth is 12 mm.

(i) Calculate, for the waves,

1. the amplitude,

amplitude = ... mm [1]

2. the wavelength.

wavelength = ... m [2]

(ii) Calculate the time period of the oscillations of the vibrator.

time period = ... s [2]

(c) State and explain whether the waves on the surface of the water shown in Fig. 5.1 are

(i) progressive or stationary,

....

.... [1]

(ii) transverse or longitudinal.

....

.... [1]

24 **(a)** State what is meant by the *frequency* of a progressive wave.

....

....

.... [2]

(b) A cathode-ray oscilloscope (c.r.o.) is used to determine the frequency of the sound emitted by a loudspeaker. The trace produced on the screen of the c.r.o. is shown in Fig. 4.1.

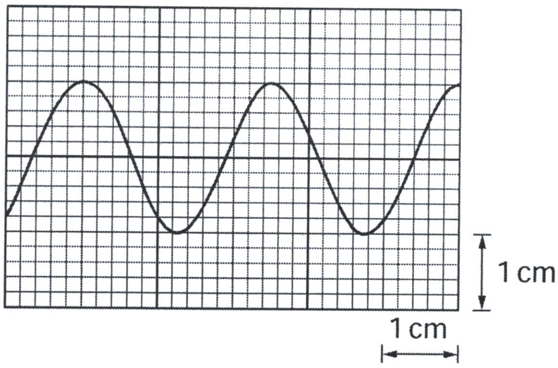

Fig. 4.1

The time-base setting of the c.r.o. is $250\,\mu s\,cm^{-1}$.

Show that the frequency of the sound wave is 1600 Hz.

[2]

(c) The loudspeaker in **(b)** emits the sound in all directions. A person attaches the loudspeaker to a string and then swings the loudspeaker at a constant speed in a horizontal circle above his head.

An observer, standing a large distance away from the loudspeaker, hears sound of maximum frequency 1640 Hz. The speed of sound in air is $330\,m\,s^{-1}$.

(i) Determine the speed of the loudspeaker.

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

(ii) Describe and explain, qualitatively, the variation in the frequency of the sound heard by the observer.

....

....

....

....

....[2]

[Total: 8]