CLASSIFIED

International Examinations Papers

Mob: +974 55249797 / 55258711
E-mail:rashed.saba@gmail.com

Superposition of waves: 14

TOPIC-Diffraction of waves, principle, interference, Young experiment, gratings

Superposition of waves: 14

TOPIC- principle of superposition

0 1 (a) Explain the principle of superposition.

For Examiner's Use

....

....

.... [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.

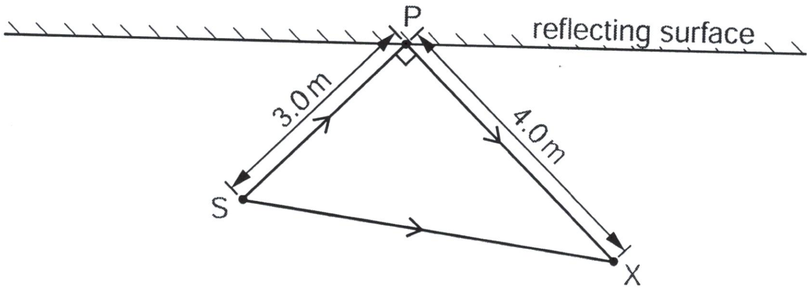

Fig. 5.1

(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 $320\,\text{m}\,\text{s}^{-1}$. Calculate the wavelength of the sound waves.

wavelength = ... m [2]

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

....

.... [2]

0 2 **(a)** **(i)** By reference to the direction of propagation of energy, state what is meant by a *transverse* wave.

....

.... [1]

(ii) State the principle of superposition.

....

....

.... [2]

(b) Circular water waves may be produced by vibrating dippers at points P and Q, as illustrated in Fig. 4.1.

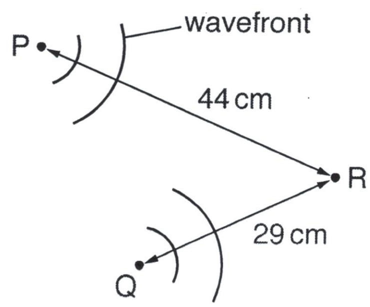

Fig. 4.1 (not to scale)

The waves from P alone have the same amplitude at point R as the waves from Q alone. Distance PR is 44 cm and distance QR is 29 cm.

The dippers vibrate in phase with a period of 1.5 s to produce waves of speed $4.0\,cm\,s^{-1}$.

(i) Determine the wavelength of the waves.

wavelength = ... cm [2]

(ii) By reference to the distances PR and QR, explain why the water particles are at rest at point R.

....

....

....

....

.... [3]

(c) A wave is produced on the surface of a different liquid. At one particular time, the variation of the vertical displacement *y* with distance *x* along the surface of the liquid is shown in Fig. 4.2.

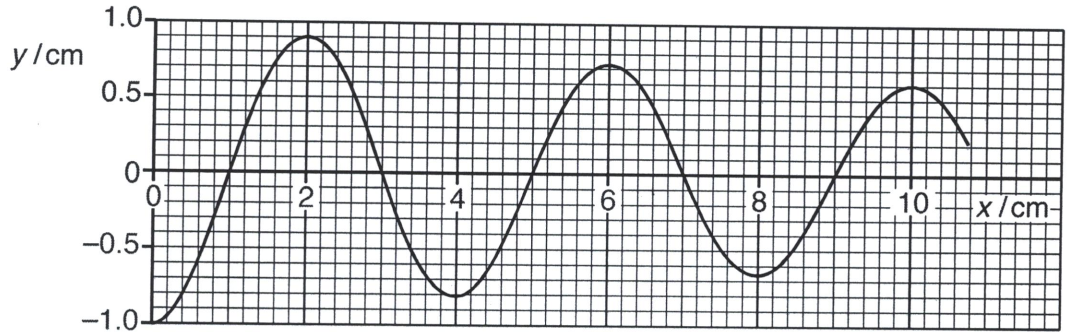

Fig. 4.2

(i) The wave has intensity I_1 at distance x = 2.0 cm and intensity I_2 at x = 10.0 cm.

Determine the ratio

$$\frac{\text{intensity } I_2}{\text{intensity } I_1}.$$

ratio = ... [2]

(ii) State the phase difference, with its unit, between the oscillations of the liquid particles at distances x = 3.0 cm and x = 4.0 cm.

phase difference = ... [1]

[Total: 11]

0 3 An arrangement that is used to demonstrate interference with waves on the surface of water is shown in Fig. 7.1.

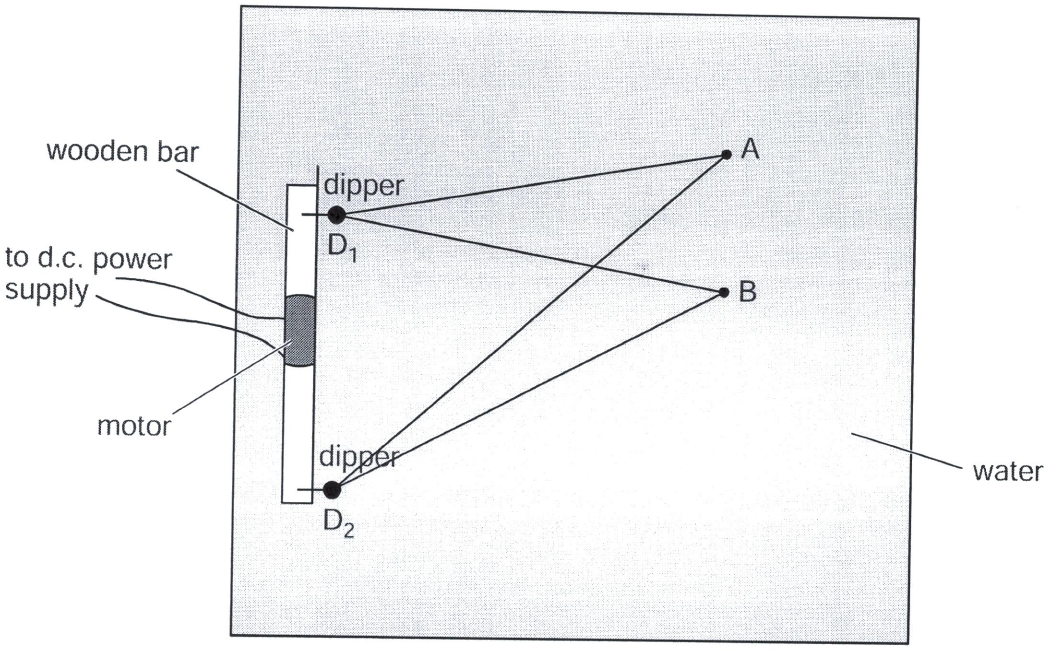

Fig. 7.1 (view from above)

(a) Two dippers D_1 and D_2 are connected to a motor and a d.c. power supply. Initially only D_1 vibrates on the water surface to produce waves.
The variation with distance x from D_1 of the displacement y of the water at one instant of time is shown in Fig. 7.2.

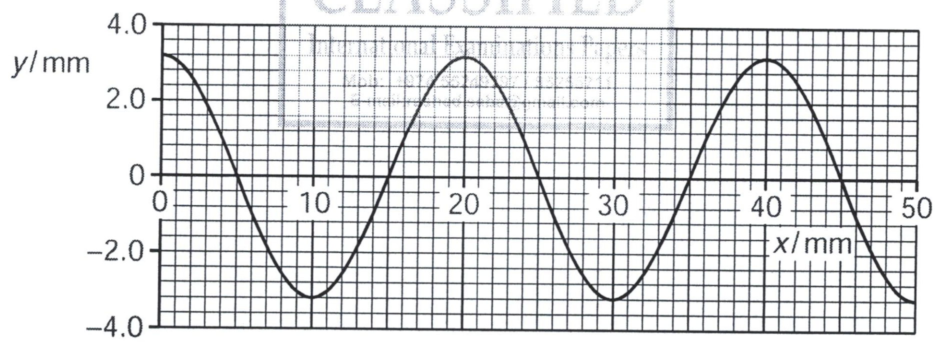

Fig. 7.2

Using Fig. 7.2, determine

(i) the amplitude of the wave,

amplitude = ... mm [1]

(ii) the wavelength of the wave.

wavelength = ... mm [1]

(b) The two dippers D_1 and D_2 are made to vibrate and waves are produced by both dippers on the water surface.

(i) State and explain whether these waves are stationary or progressive.

....

....[1]

(ii) Explain why D_1 and D_2 are connected to the same motor.

....

....[1]

(c) The points A and B on Fig. 7.1 are at the distances from D_1 and D_2 shown in Fig. 7.3.

D_1A	D_2A	D_1B	D_2B
5.0 cm	7.0 cm	5.0 cm	6.0 cm

Fig. 7.3

State and explain the variation with time of the displacement of the water on the surface at

(i) A,

....

....

....

....[2]

(ii) B.

....

....

....[1]

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

For Examiner's Use

....

....

.... [2]

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

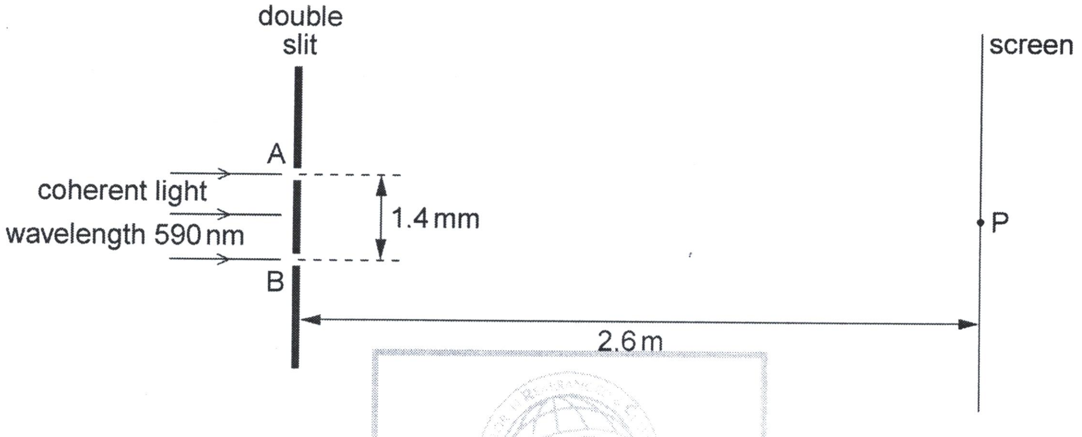

Fig. 6.1 (not to scale)

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.

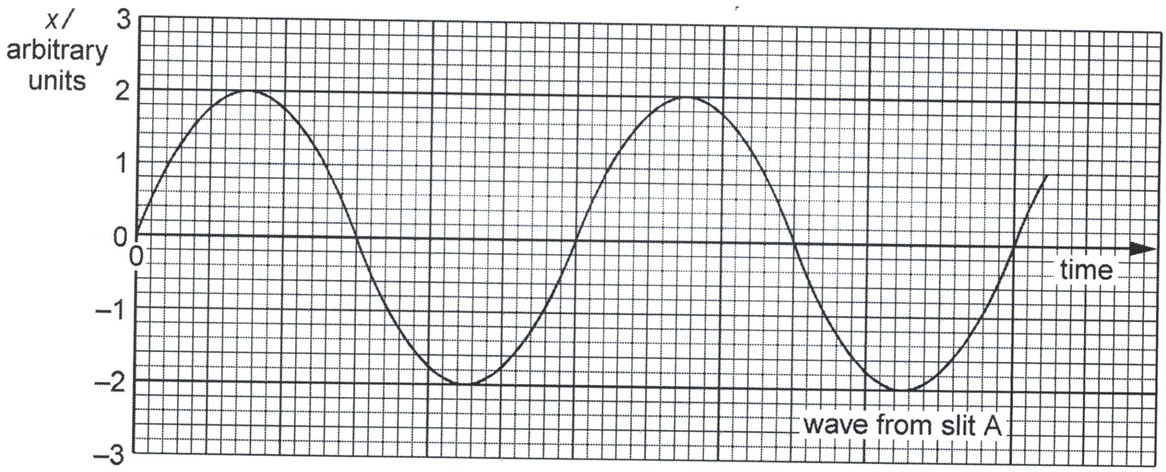

Fig. 6.2a

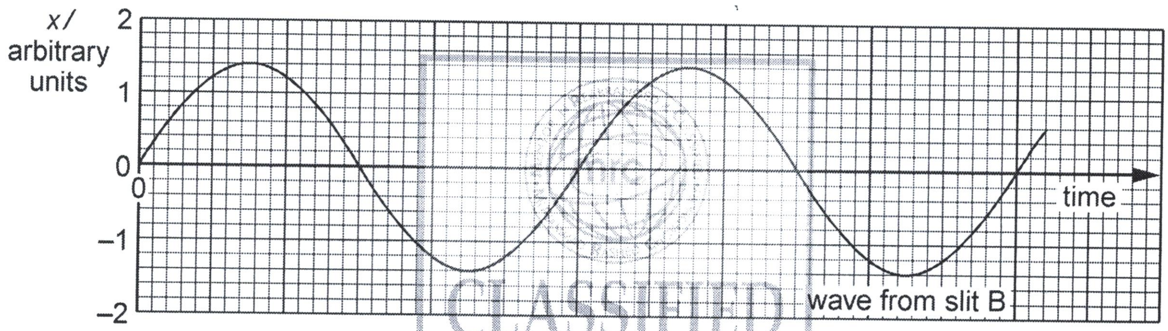

Fig. 6.2b

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]

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

For Examiner's Use

....

....

.... [2]

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

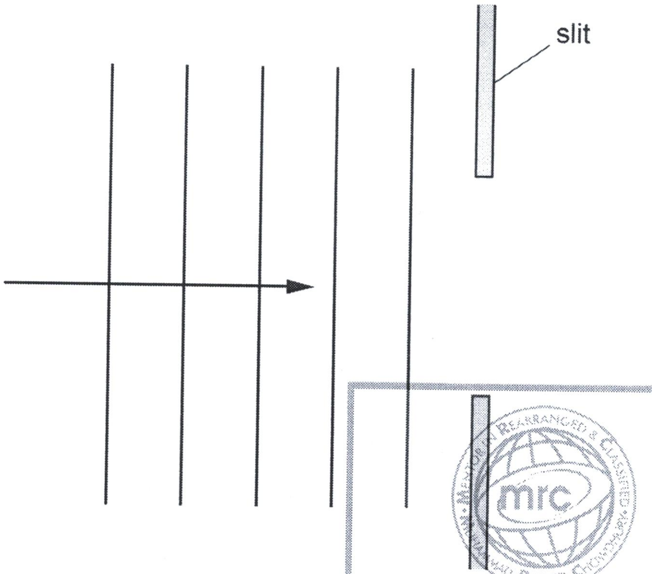

Fig. 5.1

Complete Fig. 5.1 to show four wavefronts that have emerged from the slit. [2]

For Examiner's Use

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

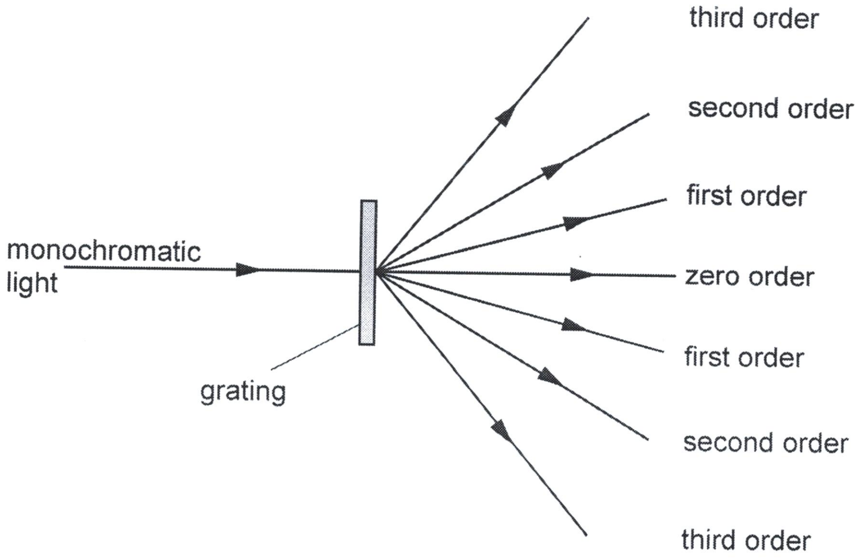

Fig. 5.2

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]

Superposition of waves: 14

TOPIC- Interference & Young's double slit experiment

For Examiner's Use

0 1 Fig. 6.1 shows wavefronts incident on, and emerging from, a double slit arrangement.

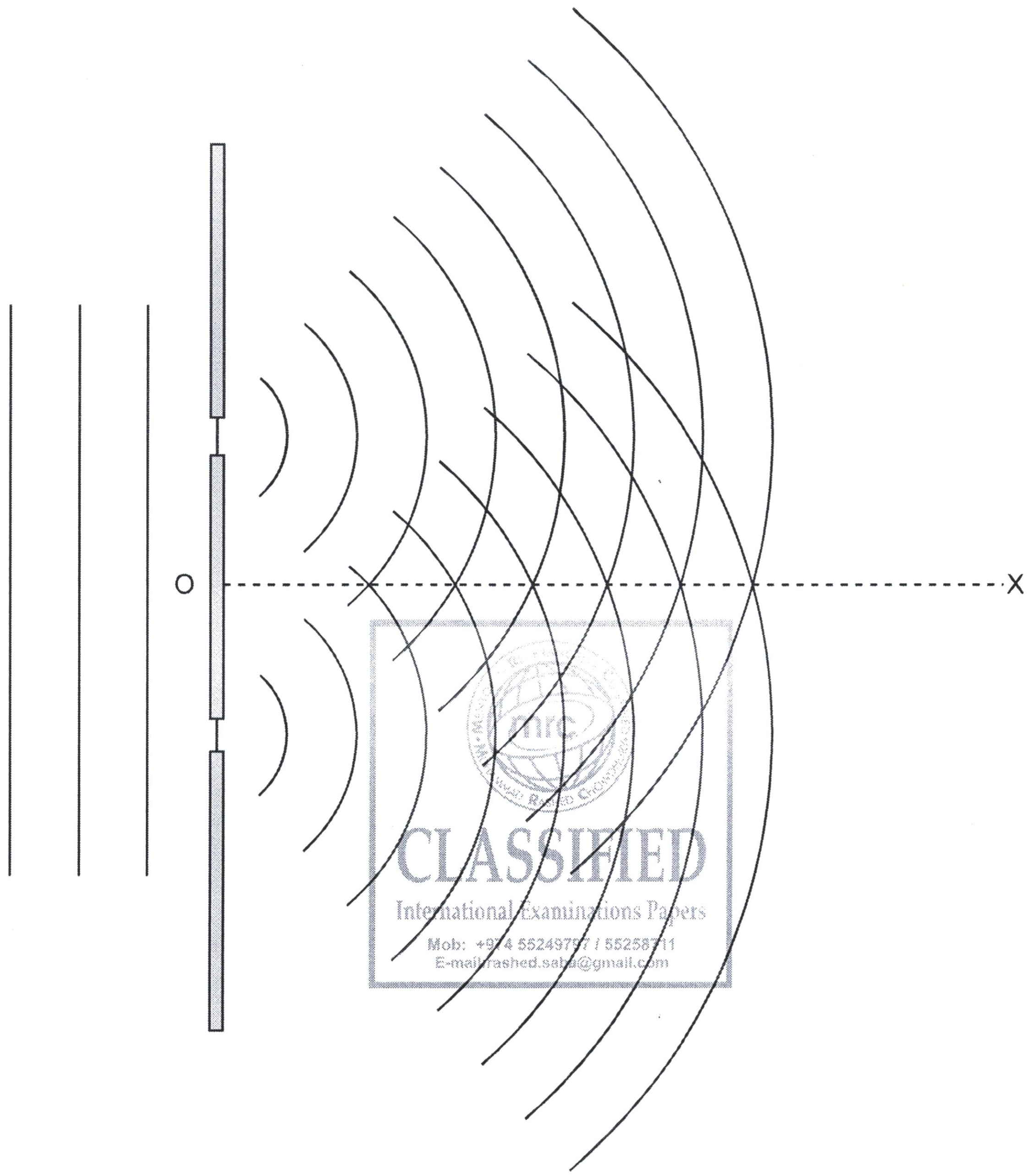

Fig. 6.1

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]

For Examiner's Use

(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.

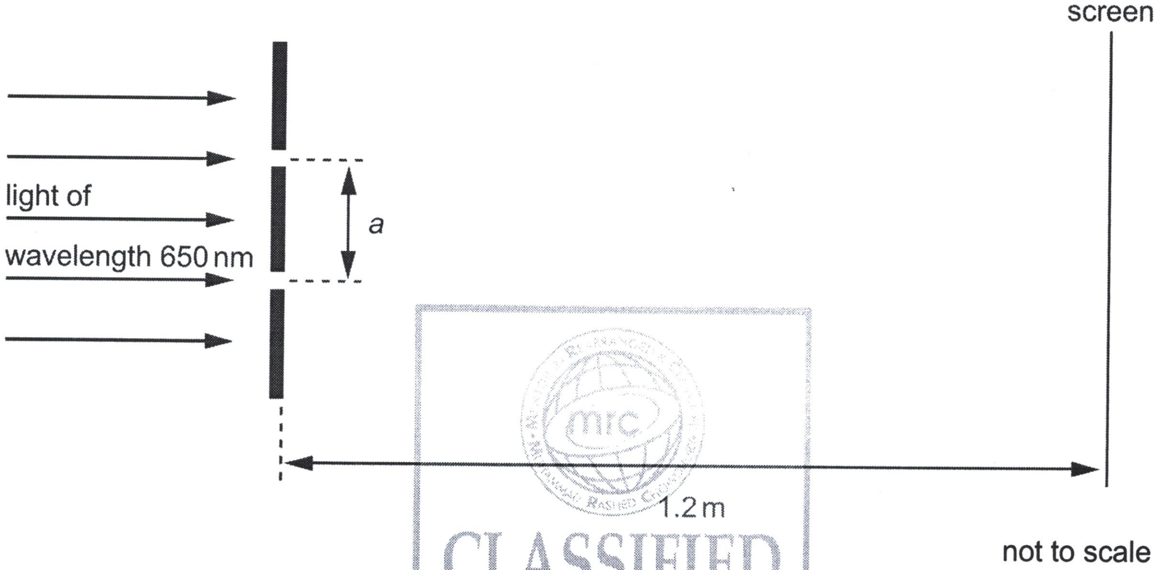

Fig. 6.2

The fringe separation is 0.70 mm.

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

separation = ... m [3]

For Examiner's Use

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

1. the separation of the fringes,

....

2. the brightness of the light fringes,

....

3. the brightness of the dark fringes.

....

[3]

0 2 **(a)** Explain the term *interference*.

For Examiner's Use

....

....

.... [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.

For Examiner's Use

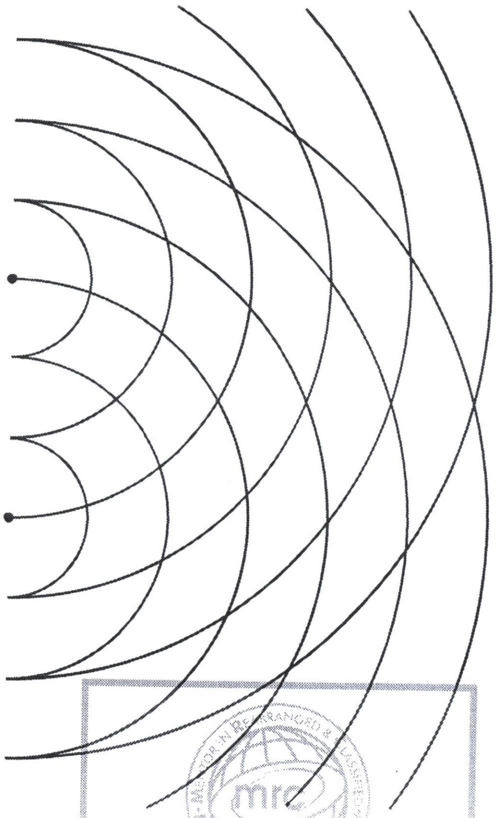

Fig. 7.1

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]

0 3 **(a)** Two overlapping waves of the same type travel in the same direction. The variation with distance x of the displacement y of each wave is shown in Fig. 6.1.

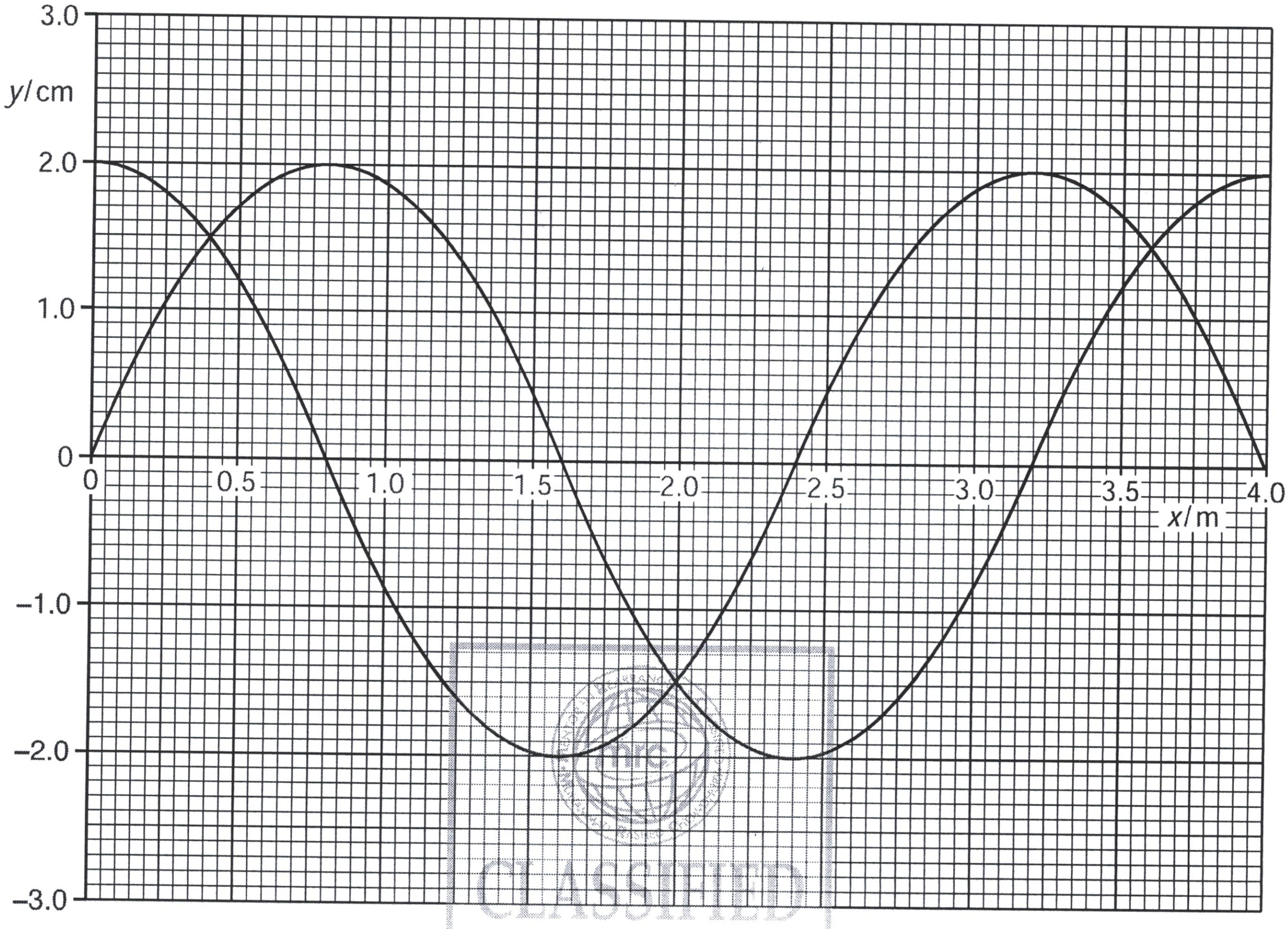

Fig. 6.1

The speed of the waves is $240\,\mathrm{m\,s^{-1}}$. The waves are coherent and produce an interference pattern.

(i) Explain the meaning of *coherence* and *interference*.

coherence: ....

....

interference: ....

....
[2]

(ii) Use Fig. 6.1 to determine the frequency of the waves.

frequency = ... Hz [2]

(iii) State the phase difference between the waves.

phase difference = ... ° [1]

(iv) Use the principle of superposition to sketch, on Fig. 6.1, the resultant wave. [2]

(b) An interference pattern is produced with the arrangement shown in Fig. 6.2.

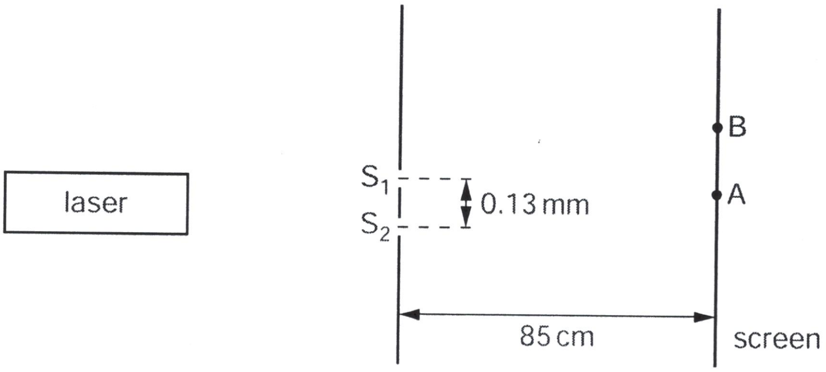

Fig. 6.2 (not to scale)

Laser light of wavelength λ of 546 nm is incident on the slits S_1 and S_2. The slits are a distance 0.13 mm apart. The distance between the slits and the screen is 85 cm.

Two points on the screen are labelled A and B. The path difference between S_1A and S_2A is zero. The path difference between S_1B and S_2B is 2.5λ. Maxima and minima of intensity of light are produced on the screen.

(i) Calculate the distance AB.

distance = ... m [3]

(ii) The laser is replaced by a laser emitting blue light. State and explain the change in the distance between the maxima observed on the screen.

....

....

....[1]

0:4 **(a)** Interference fringes may be observed using a light-emitting laser to illuminate a double slit. The double slit acts as two sources of light.

Explain

(i) the part played by diffraction in the production of the fringes,

....

....

....[2]

(ii) the reason why a double slit is used rather than two separate sources of light.

....

....

....[1]

(b) A laser emitting light of a single wavelength is used to illuminate slits S_1 and S_2, as shown in Fig. 6.1.

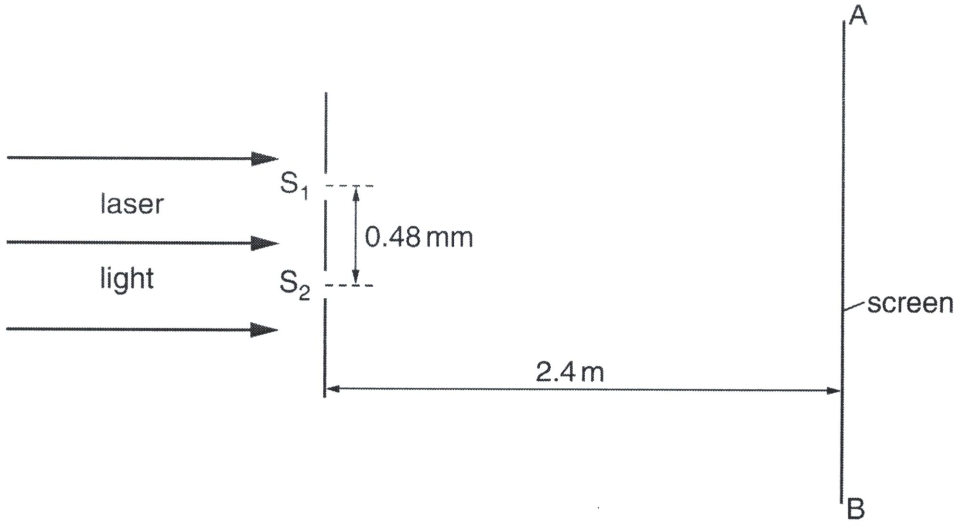

Fig. 6.1 (not to scale)

An interference pattern is observed on the screen AB. The separation of the slits is 0.48 mm. The slits are 2.4 m from AB. The distance on the screen across 16 fringes is 36 mm, as illustrated in Fig. 6.2.

Fig. 6.2

Calculate the wavelength of the light emitted by the laser.

wavelength = ...m [3]

(c) Two dippers D_1 and D_2 are used to produce identical waves on the surface of water, as illustrated in Fig. 6.3.

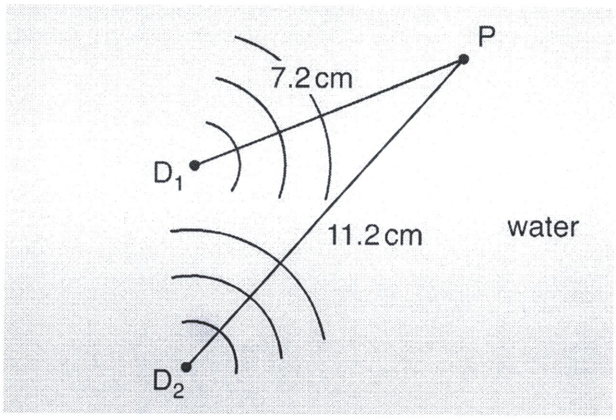

Fig. 6.3 (not to scale)

Point P is 7.2 cm from D_1 and 11.2 cm from D_2.

The wavelength of the waves is 1.6 cm. The phase difference between the waves produced at D_1 and D_2 is zero.

(i) State and explain what is observed at P.

....

....

.... [2]

(ii) State and explain the effect on the answer to **(c)(i)** if the apparatus is changed so that, separately,

1. the phase difference between the waves at D_1 and at D_2 is 180°,

....

....

....

2. the intensity of the wave from D_1 is less than the intensity of that from D_2.

....

....

....

[2]

[Total: 10]

05 **(a)** State one difference and one similarity between longitudinal and transverse waves.

difference: ....

....

similarity: ....

.... [2]

(b) A laser is placed in front of two slits as shown in Fig. 6.1.

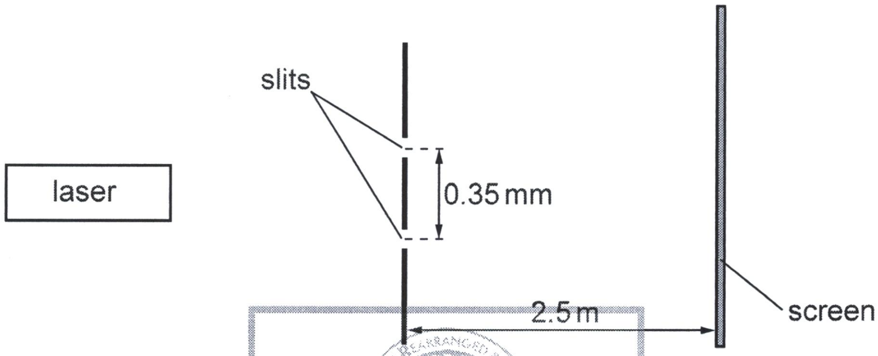

Fig. 6.1 (not to scale)

The laser emits light of wavelength 6.3×10^{-7} m.
The distance from the slits to the screen is 2.5 m. The separation of the slits is 0.35 mm.
An interference pattern of maxima and minima is observed on the screen.

(i) Explain why an interference pattern is observed on the screen.

....

....

....

.... [2]

(ii) Calculate the distance between adjacent maxima.

distance = ... m [2]

(c) State and explain the effect, if any, on the distance between adjacent maxima when the laser is replaced by another laser emitting ultra-violet radiation.

....

.... [1]

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

....

.... [2]

(b) An arrangement for demonstrating the interference of light is shown in Fig. 4.1.

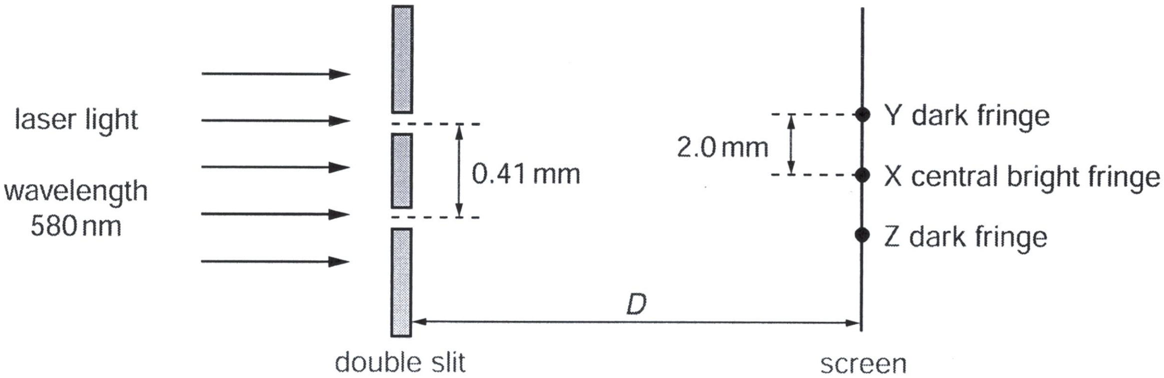

Fig. 4.1 (not to scale)

The wavelength of the light from the laser is 580 nm. The separation of the slits is 0.41 mm. The perpendicular distance between the double slit and the screen is *D*.

Coherent light emerges from the slits and an interference pattern is observed on the screen. The central bright fringe is produced at point X. The closest dark fringes to point X are produced at points Y and Z. The distance XY is 2.0 mm.

(i) Explain why a bright fringe is produced at point X.

....

....

....

.... [2]

(ii) State the difference in the distances, in nm, from each slit to point Y.

distance = ... nm [1]

(iii) Calculate the distance *D*.

D = ... m [3]

(iv) The intensity of the light passing through the two slits was initially the same. The intensity of the light through **one** of the slits is now reduced. Compare the appearance of the fringes before and after the change of intensity.

....

....

....

....[2]

[Total: 10]

07 A signal generator is connected to two loudspeakers L_1 and L_2, as shown in Fig. 2.1.

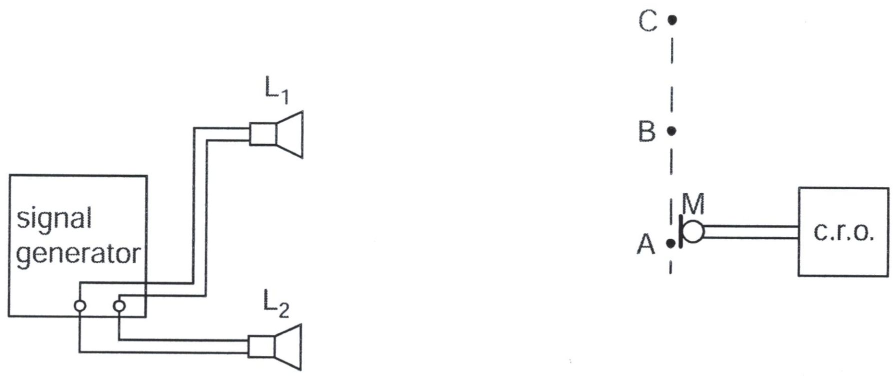

Fig. 2.1

A microphone M, connected to the Y-plates of a cathode-ray oscilloscope (c.r.o.), detects the intensity of sound along the line ABC.
The distances L_1A and L_2A are equal.
The time-base of the c.r.o. is switched off.

The traces on the c.r.o. when M is at A, then at B and then at C are shown on Fig. 2.2, Fig. 2.3 and Fig. 2.4 respectively.

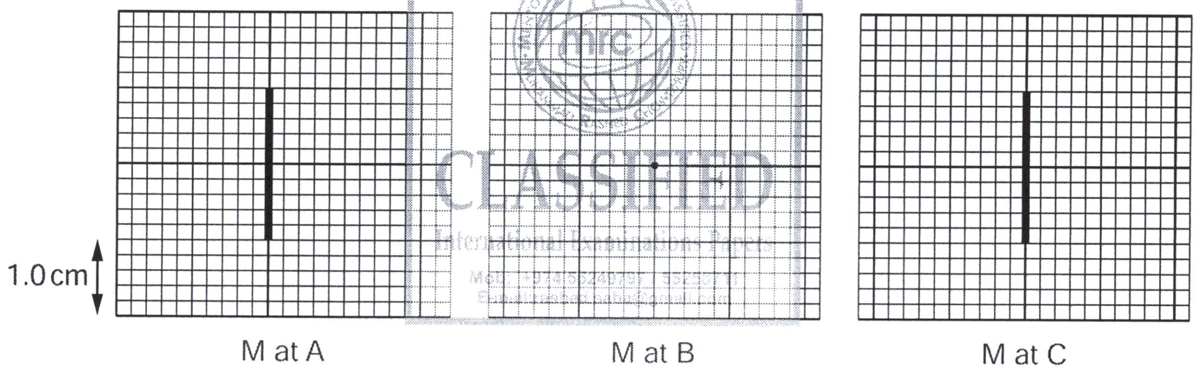

Fig. 2.2 **Fig. 2.3** **Fig. 2.4**

For these traces, 1.0 cm represents 5.0 mV on the vertical scale.

(a) **(i)** Explain why coherent waves are produced by the loudspeakers.

....

....

....[1]

(ii) Use the principle of superposition to explain the traces shown with M at

1. A,

....

....

....[1]

2. B,

....

....

....[1]

3. C.

....

....

....[1]

(b) The sound emitted from L_1 and L_2 has frequency 500 Hz. The time-base on the c.r.o. is switched on.

The microphone M is placed at A.

On Fig. 2.5, draw the trace seen on the c.r.o.

On the vertical scale, 1.0 cm represents 5.0 mV. On the horizontal scale, 1.0 cm represents 0.10 ms.

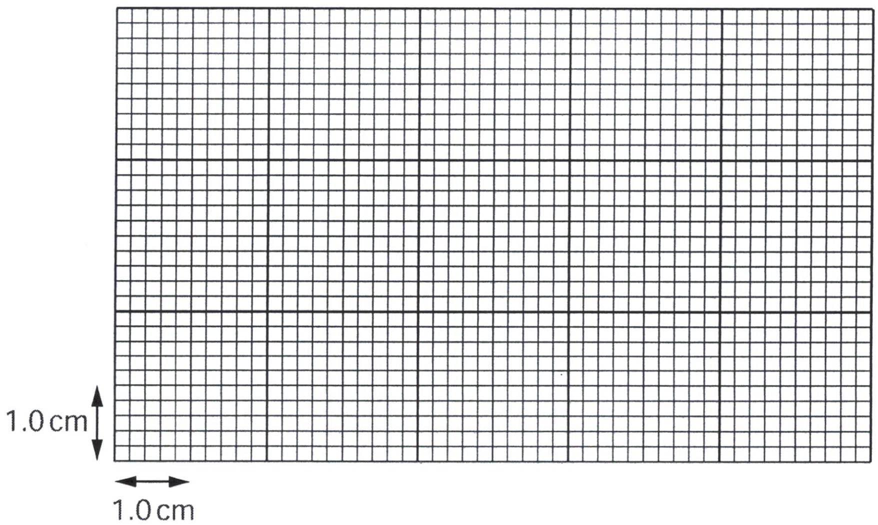

Fig. 2.5

[3]

For Examiner's Use

0·8 **(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.

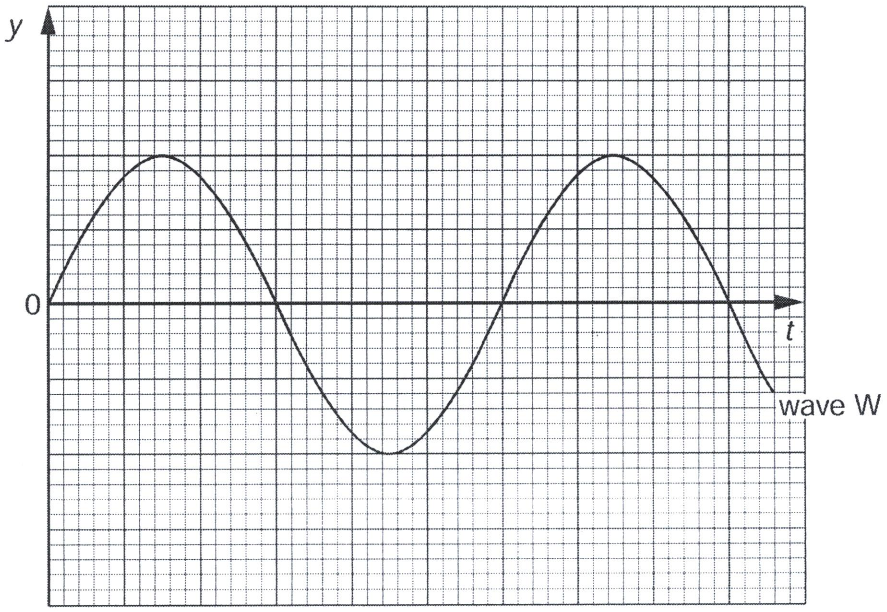

Fig. 5.1

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).

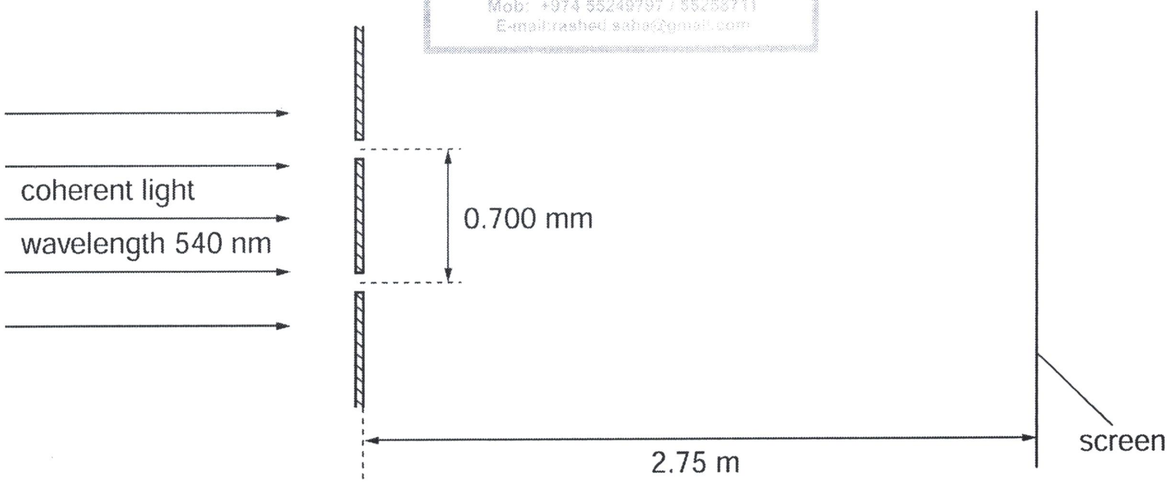

Fig. 5.2

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]

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

For Examiner's Use

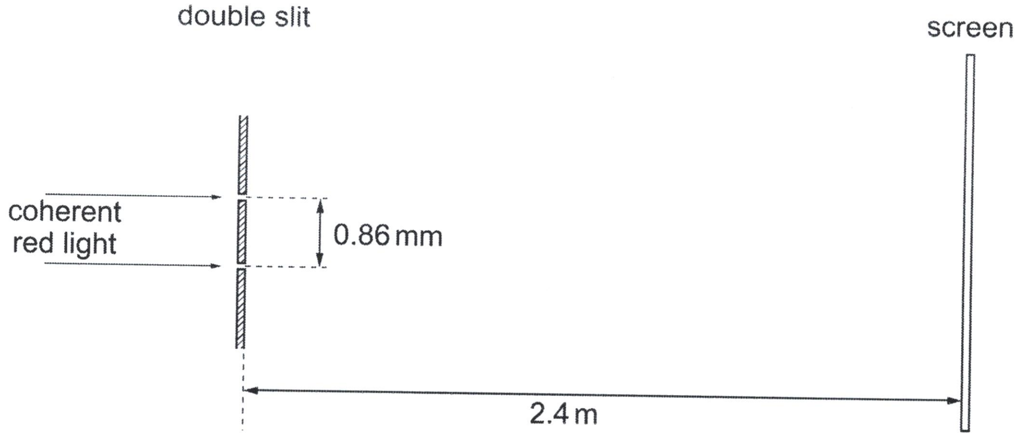

Fig. 5.1 (not to scale)

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]

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

For Examiner's Use

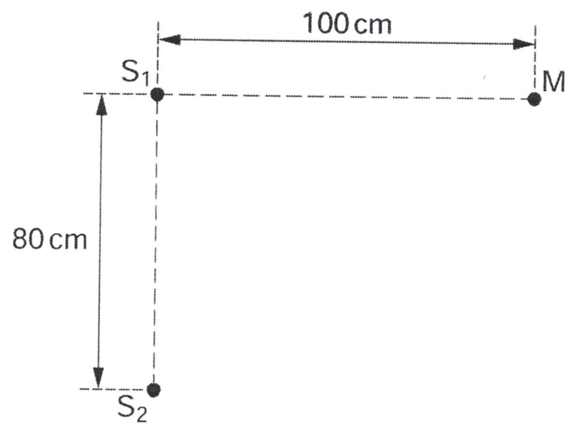

Fig. 5.1

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]

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

For Examiner's Use

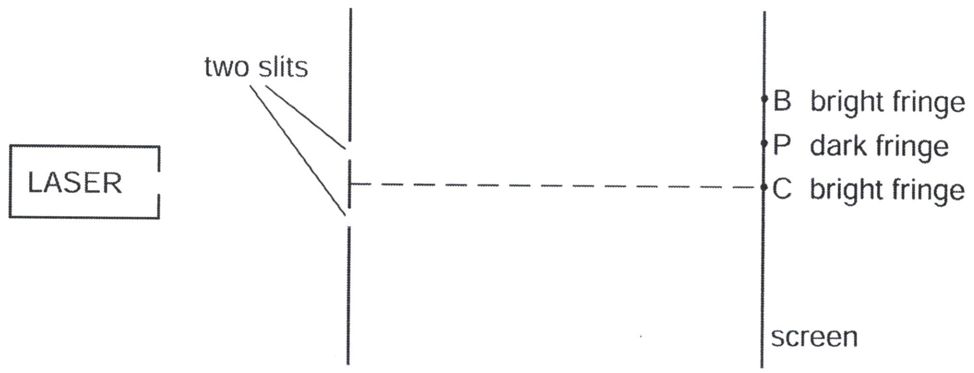

Fig. 6.1 (not to scale)

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 1.8 m. The distance CP is 2.3 mm and the distance between the slits is 0.25 mm.
Calculate the wavelength of the light provided by the laser.

For Examiner's Use

wavelength = ... nm [3]

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

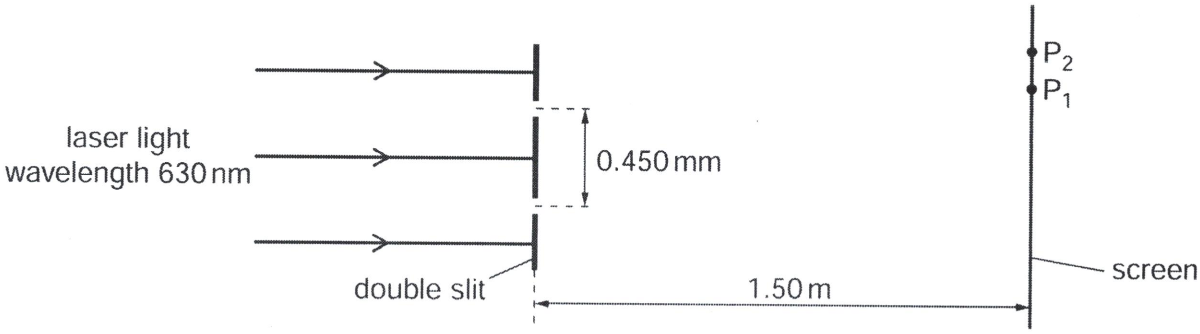

Fig. 6.1 (not to scale)

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 P_1 and a minimum is formed at P_2.
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 P_1.

....

.... [1]

(iii) Explain how an interference minimum is formed at P_2.

....

.... [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.

For Examiner's Use

....

....

....

....[3]

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

1. ....

....

2. ....

....

3. ....

....
[3]

For Examiner's Use

(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.

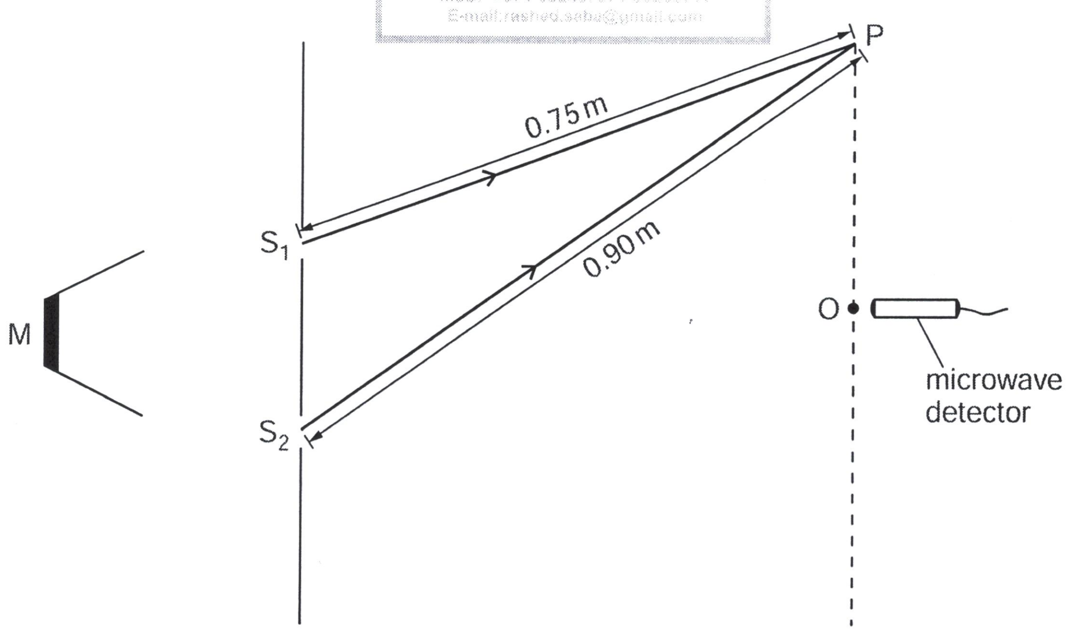

Fig. 5.1 (not to scale)

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.

For Examiner's Use

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]

14 A laser is placed in front of a double slit, as shown in Fig. 7.1.

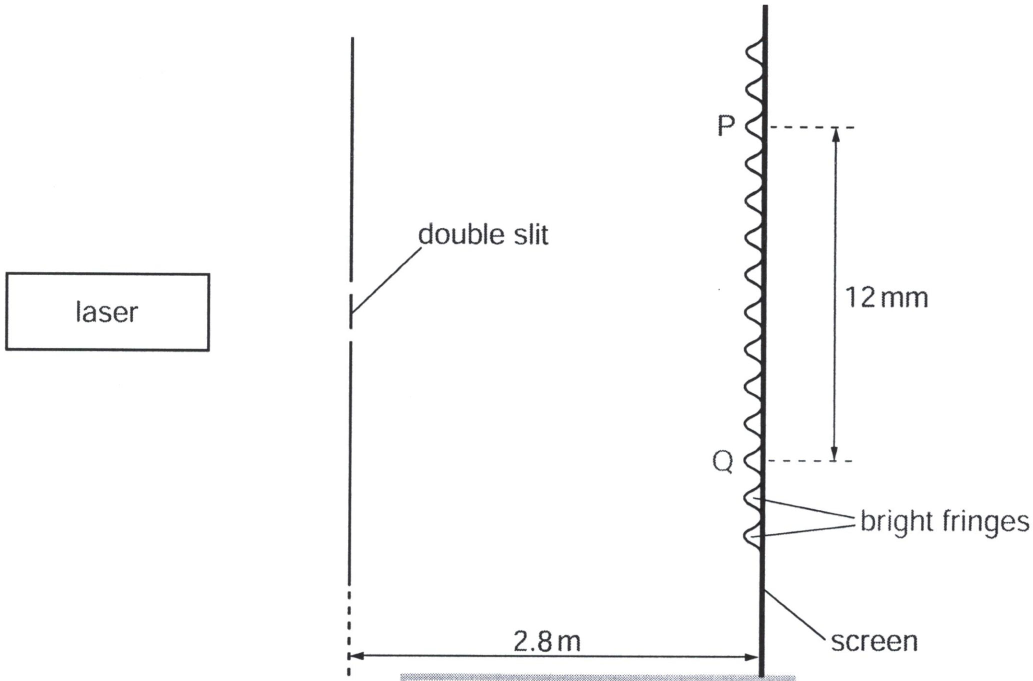

Fig. 7.1 (not to scale)

The laser emits light of frequency 670 THz. Interference fringes are observed on the screen.

(a) Explain how the interference fringes are formed.

....

....

....

....

....

.... [3]

(b) Show that the wavelength of the light is 450 nm.

[2]

(c) The separation of the maxima P and Q observed on the screen is 12 mm. The distance between the double slit and the screen is 2.8 m.

Calculate the separation of the two slits.

separation = ... m [3]

(d) The laser is replaced by a laser emitting red light. State and explain the effect on the interference fringes seen on the screen.

....

....

....

.... [2]

15 The variation with time t of the displacement y of a wave X, as it passes a point P, is shown in Fig. 5.1.

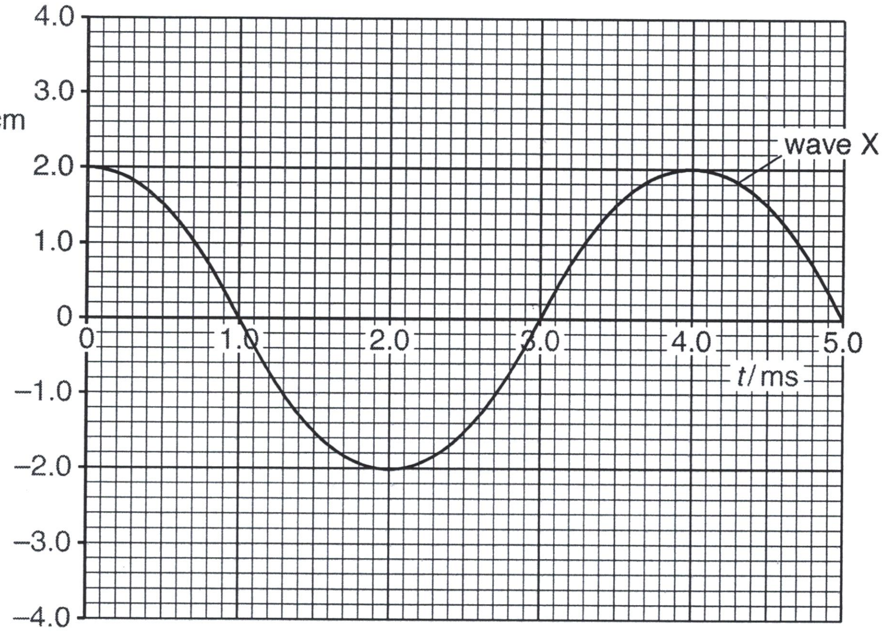

Fig. 5.1

The intensity of wave X is I.

(a) Use Fig. 5.1 to determine the frequency of wave X.

frequency = ... Hz [2]

(b) A second wave Z with the same frequency as wave X also passes point P. Wave Z has intensity $2I$. The phase difference between the two waves is 90°.

On Fig. 5.1, sketch the variation with time t of the displacement y of wave Z.

Show your working.

[3]

(c) A double-slit interference experiment is used to determine the wavelength of light emitted from a laser, as shown in Fig. 5.2.

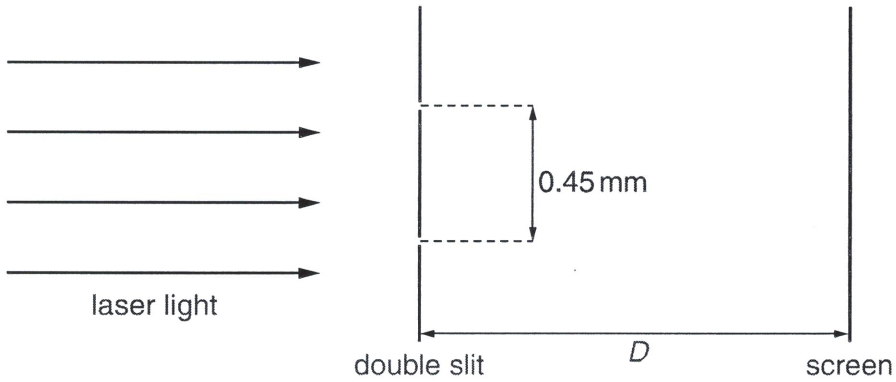

Fig. 5.2 (not to scale)

The separation of the slits is 0.45 mm. The fringes are viewed on a screen at a distance D from the double slit.

The fringe width x is measured for different distances D. The variation with D of x is shown in Fig. 5.3.

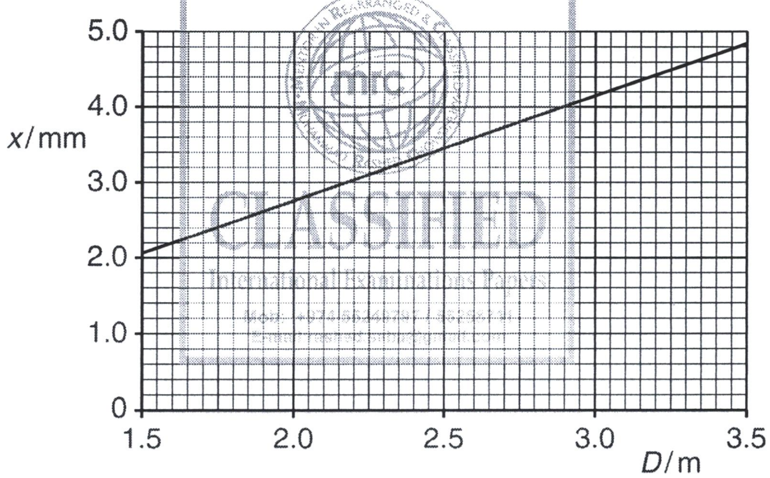

Fig. 5.3

(i) Use the gradient of the line in Fig. 5.3 to determine the wavelength, in nm, of the laser light.

wavelength = ... nm [4]

(ii) The separation of the slits is increased. State and explain the effects, if any, on the graph of Fig. 5.3.

....

....

....[2]

[Total: 11]

CLASSIFIED

International Examinations Papers

Mob: +974 55249797 / 55258711
E-mail:rashed.saba@gmail.com

Superposition of waves: 14

TOPIC-Diffraction of waves & diffracting gratings

01 The wave nature of light may be demonstrated using the phenomena of diffraction and interference.

For Examiner's Use

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]

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

....

....

....

....

....[2]

[Total: 8]

0 2 **(a)** State what is meant by the *diffraction* of a wave.

....

....[2]

(b) Laser light of wavelength 500 nm is incident normally on a diffraction grating. The resulting diffraction pattern has diffraction maxima up to and including the fourth-order maximum.

Calculate, for the diffraction grating, the minimum possible line spacing.

line spacing = ... m [3]

(c) The light in **(b)** is now replaced with red light. State and explain whether this is likely to result in the formation of a fifth-order diffraction maximum.

....

....

....

....[2]

[Total: 7]

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

For Examiner's Use

....

....

.... [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]

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

For Examiner's Use

....

....

.... [2]

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

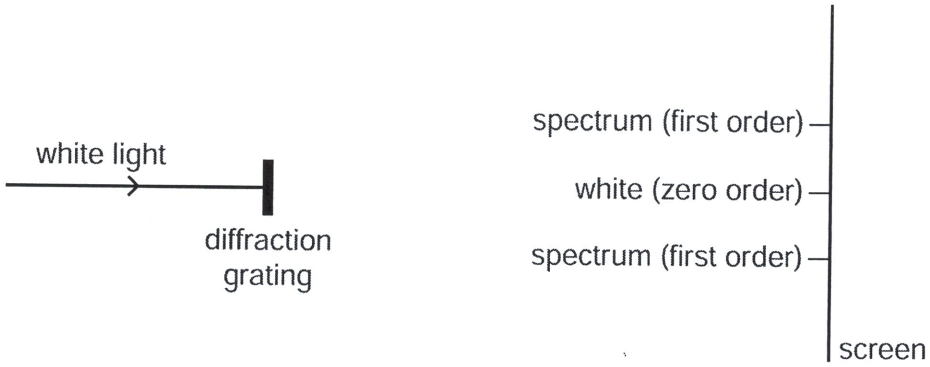

Fig. 4.1 (not to scale)

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]

For Examiner's Use

(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.

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]

For Examiner's Use

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

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.

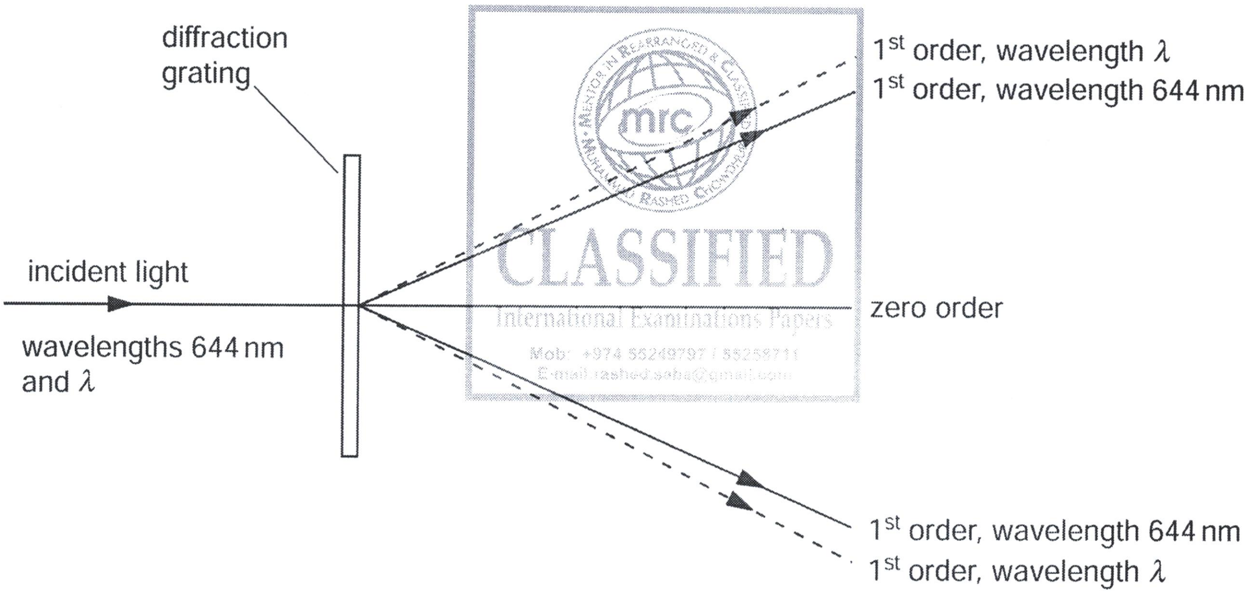

Fig. 4.1

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.

For Examiner's Use

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

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]

(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.

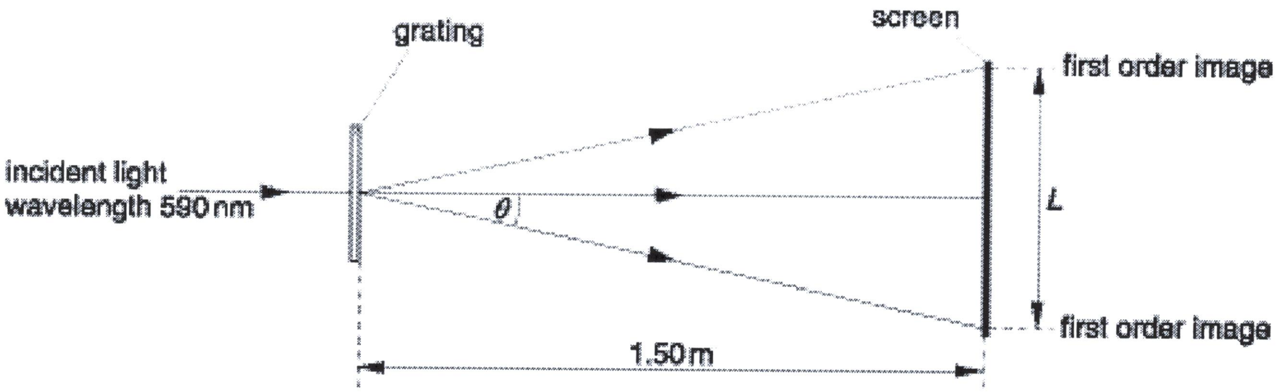

Fig. 4.3

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 = ... °

(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]

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

For Examiner's Use

....

....

....[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.

For Examiner's Use

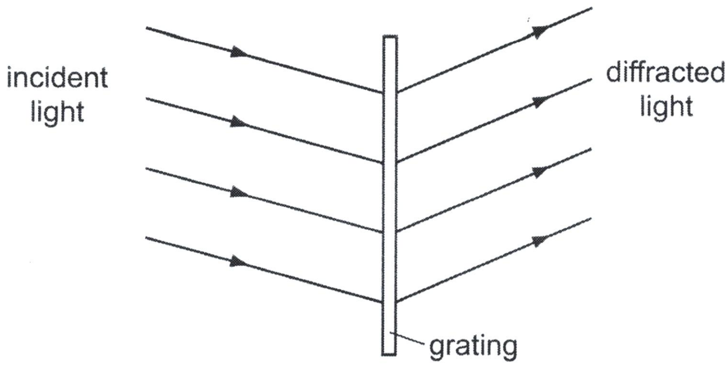

Fig. 5.1

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]

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

For Examiner's Use

....

....

.... [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.

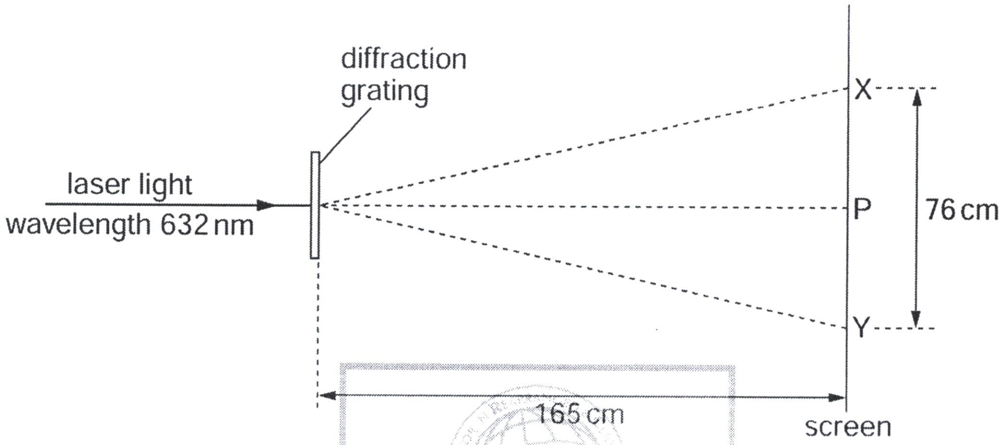

Fig. 4.1

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.

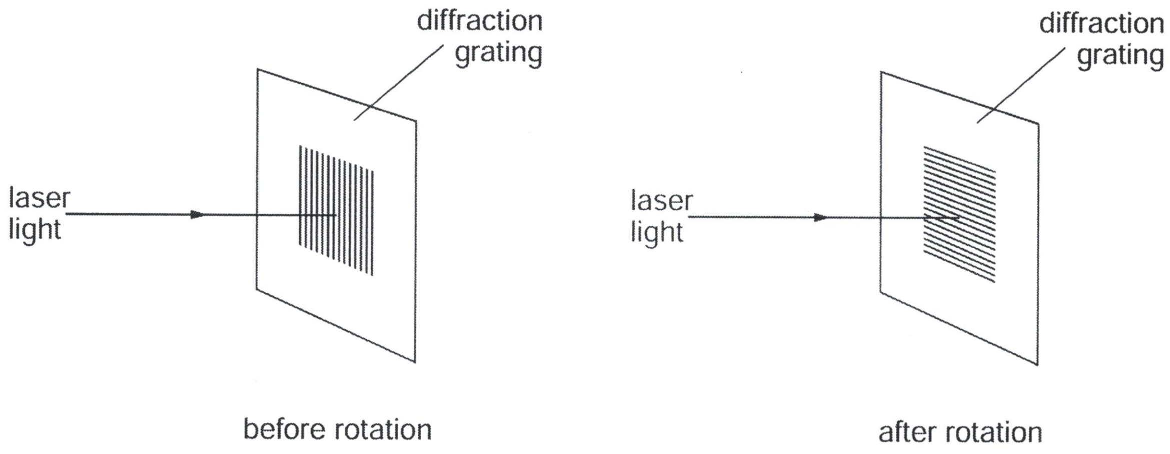

Fig. 4.2

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]

08 **(a)** State what is meant by *diffraction* and by *interference*.

diffraction: ....

....

interference: ....

.... [3]

(b) Light from a source S_1 is incident on a diffraction grating, as illustrated in Fig. 6.1.

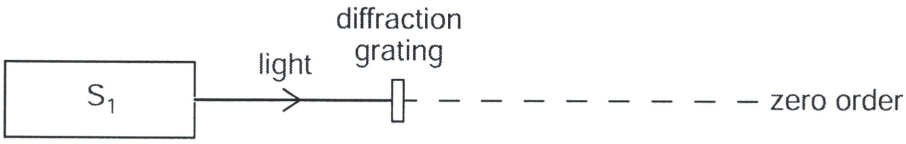

Fig. 6.1 (not to scale)

The light has a single frequency of 7.06×10^{14} Hz. The diffraction grating has 650 lines per millimetre.

Calculate the number of orders of diffracted light produced by the grating. Do not include the zero order.
Show your working.

number = ... [3]

(c) A second source S_2 is used in place of S_1. The light from S_2 has a single frequency lower than that of the light from S_1.

State and explain whether more orders are seen with the light from S_2.

....

.... [1]

09 **(a)** A diffraction grating is used to determine the wavelength of light.

(i) Describe the diffraction of light at a diffraction grating.

....

....

....[2]

(ii) By reference to interference, explain

1. the zero order maximum,

....

....

....

2. the first order maximum.

....

....

[3]

(b) A diffraction grating is used with different wavelengths of light. The angle θ of the second order maximum is measured for each wavelength. The variation with wavelength λ of $\sin\theta$ is shown in Fig. 5.1.

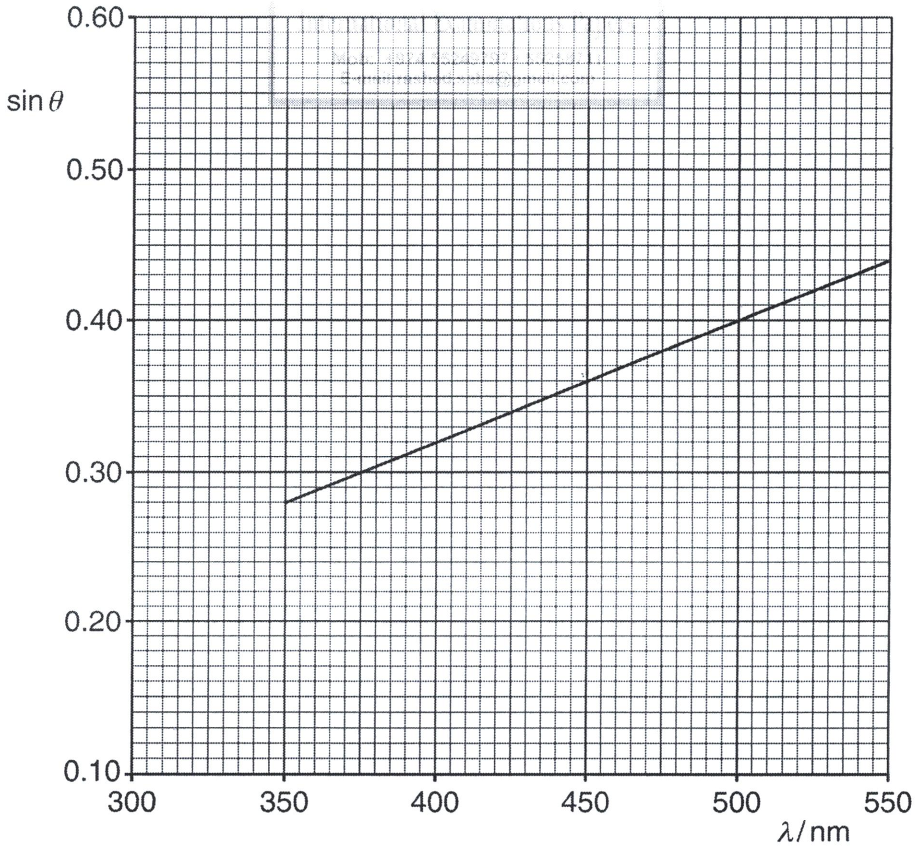

Fig. 5.1

(i) Determine the gradient of the line shown in Fig. 5.1.

gradient = ... [2]

(ii) Use the gradient determined in **(i)** to calculate the slit separation d of the diffraction grating.

d = ... m [2]

(iii) On Fig. 5.1, sketch a line to show the results that would be obtained for the first order maxima. [1]

[Total: 10]