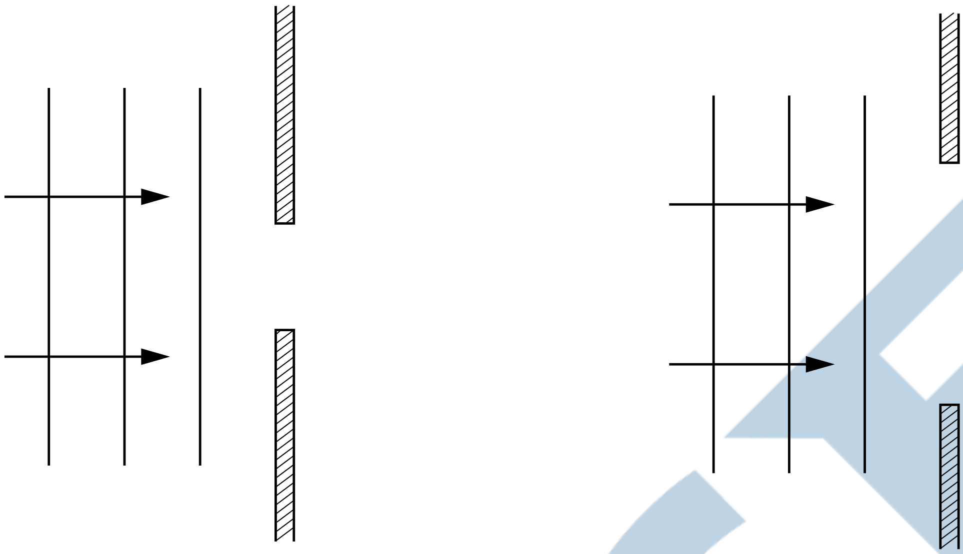
For Examiner's Use

1 **(a)** Figs. 7.1(a) and (b) show plane wavefronts approaching a narrow gap and a wide gap respectively.



(a) **(b)**

Fig. 7.1

On Figs. 7.1(a) and (b), draw three successive wavefronts to represent the wave after it has passed through each of the gaps. [5]

For Examiner's Use

(b) Light from a laser is directed normally at a diffraction grating, as illustrated in Fig. 7.2.

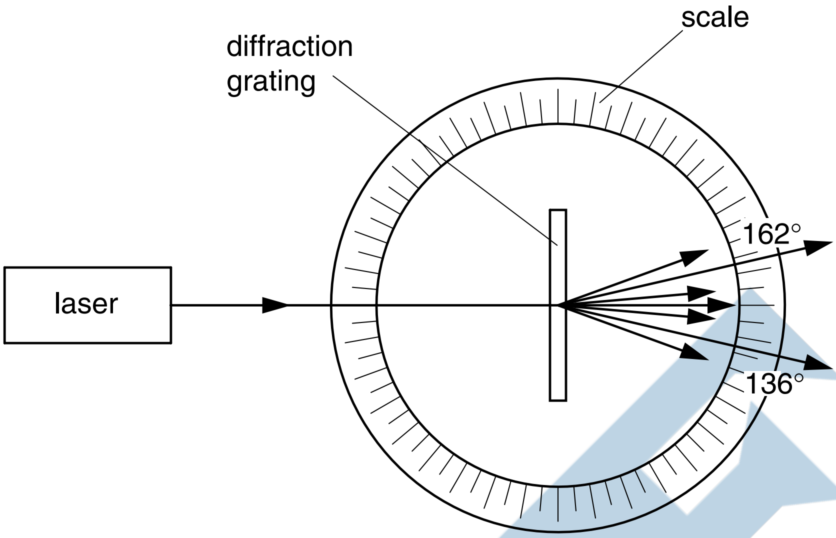


Fig. 7.2

The diffraction grating is situated at the centre of a circular scale, marked in degrees. The readings on the scale for the second order diffracted beams are 136° and 162°.

The wavelength of the laser light is 630 nm.

Calculate the spacing of the slits of the diffraction grating.

spacing = ... m [4]

(c) Suggest one reason why the fringe pattern produced by light passing through a diffraction grating is brighter than that produced from the same source with a double slit.

....

....[1]

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

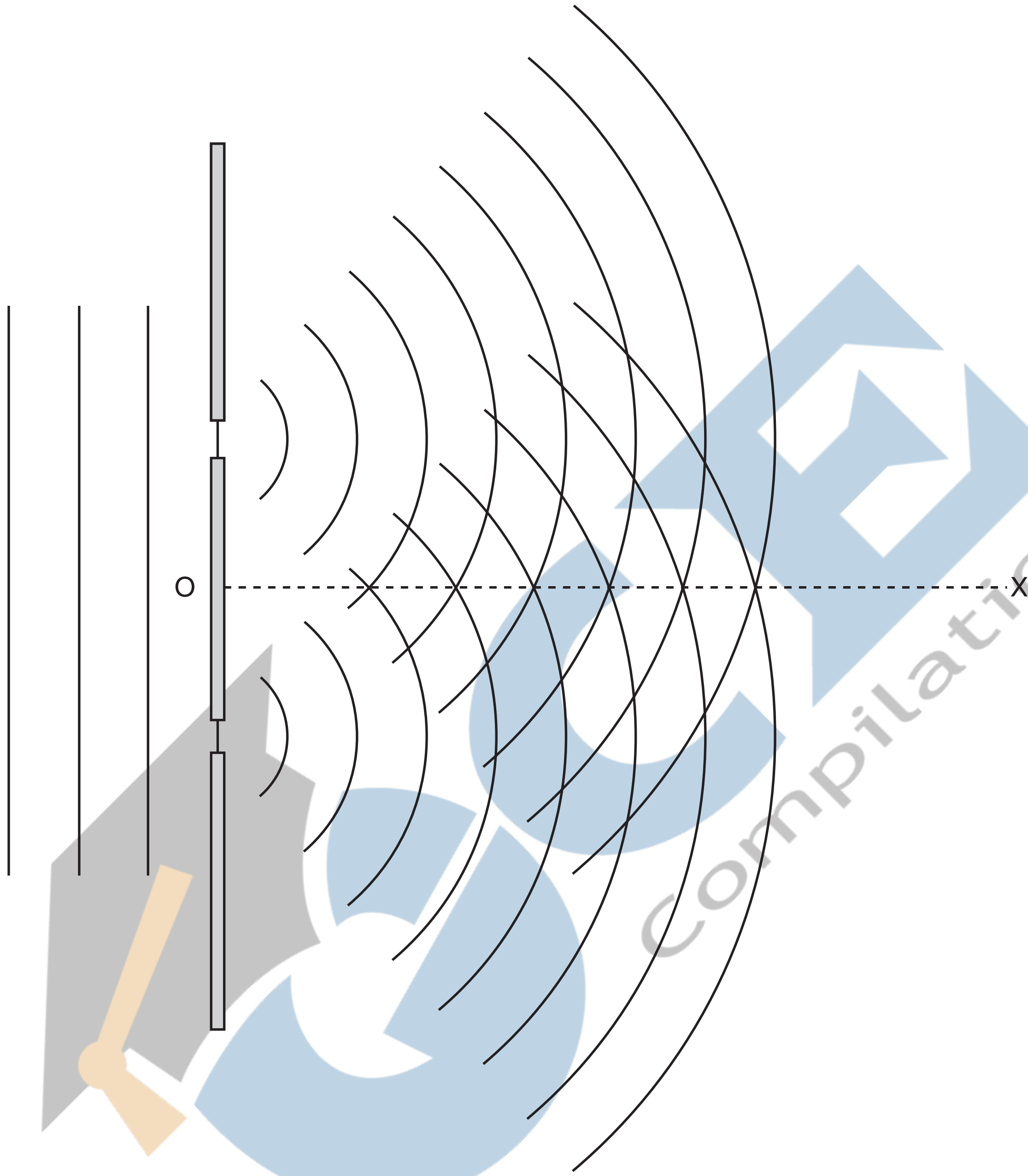


Fig. 6.1

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.

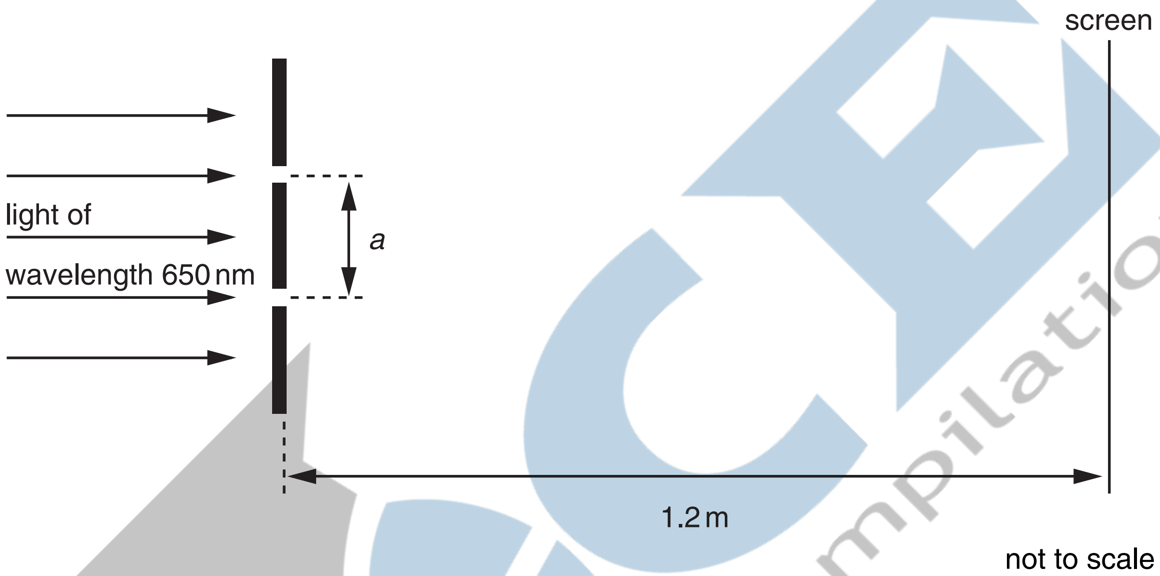


Fig. 6.2

The fringe separation is 0.70 mm.

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

separation = ... m [3]

(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]

For Examiner's Use

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

....

....

....[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.

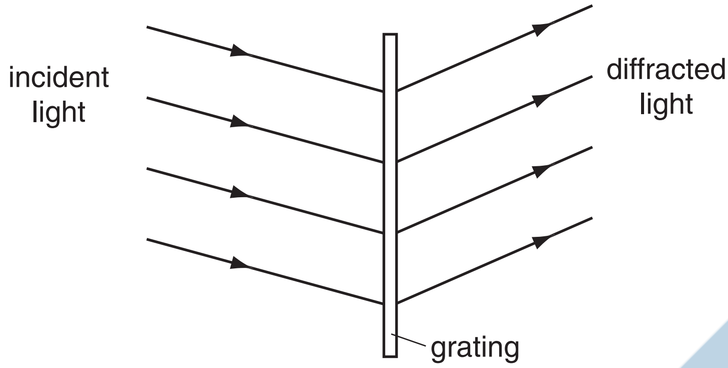


Fig. 5.1

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]

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

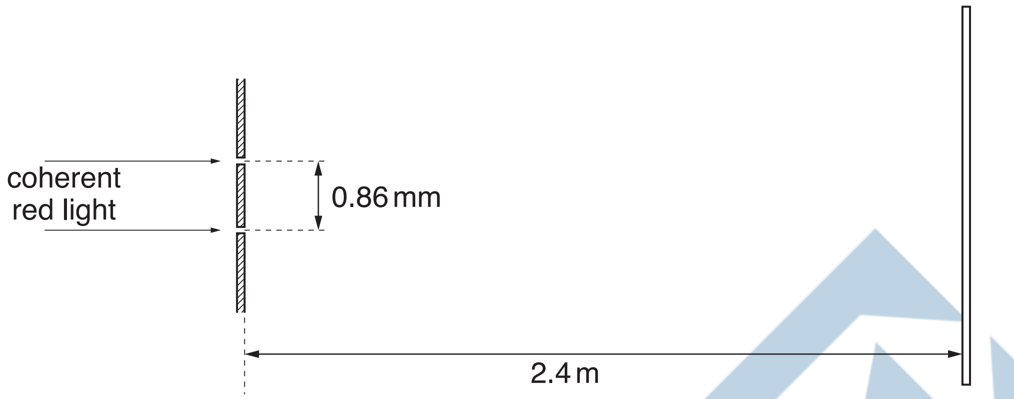


Fig. 5.1 (not to scale)

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]

For Examiner's Use

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

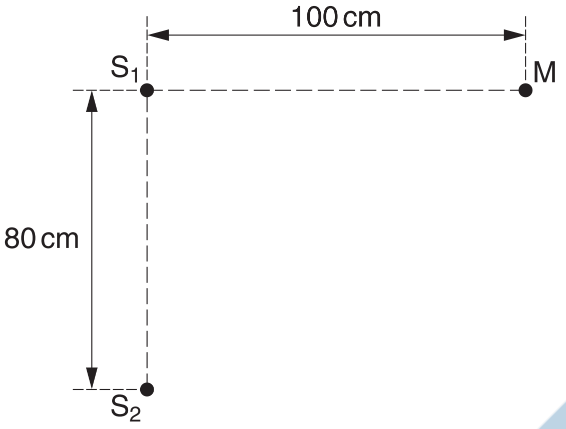


Fig. 5.1

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]

6 Light of frequency 4.8×10^{14} Hz is incident normally on a double slit, as illustrated in Fig. 6.1.

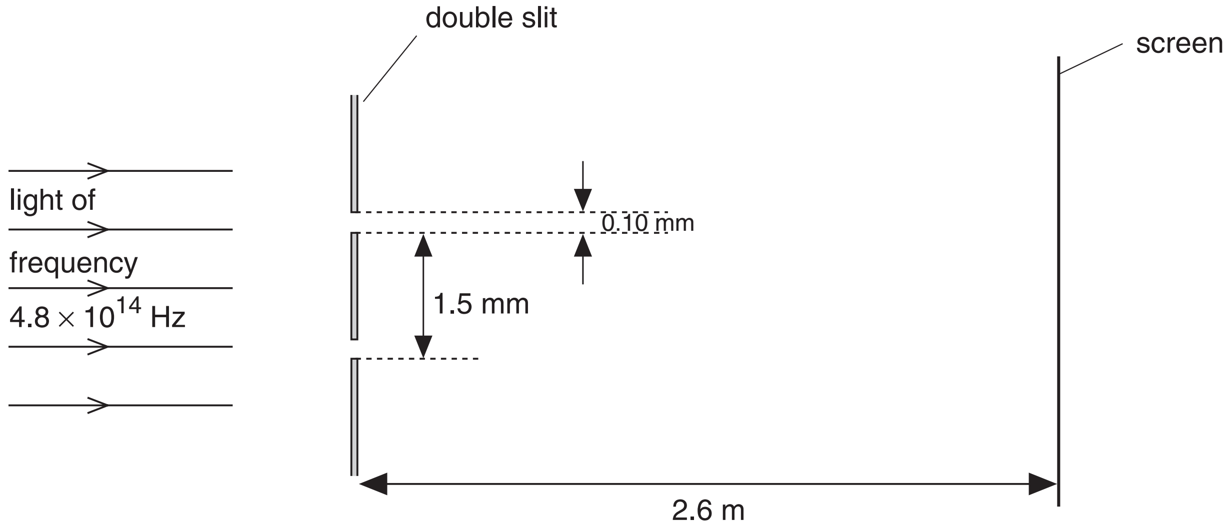


Fig. 6.1 (not to scale)

Each slit of the double slit arrangement is 0.10 mm wide and the slits are separated by 1.5 mm. The pattern of fringes produced is observed on a screen at a distance 2.6 m from the double slit.

(a) **(i)** Show that the width of each slit is approximately 160 times the wavelength of the incident light.

[3]

(ii) Hence explain why the pattern of fringes on the screen is seen over a *limited* area of the screen.

....

....

....

....[3]

For Examiner's Use

(b) Calculate the separation of the fringes observed on the screen.

separation = ... mm [3]

(c) The intensity of the light incident on the double slit is increased. State the effect, if any, on the separation and on the appearance of the fringes.

....

....

....

....

....[3]

7 **(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.

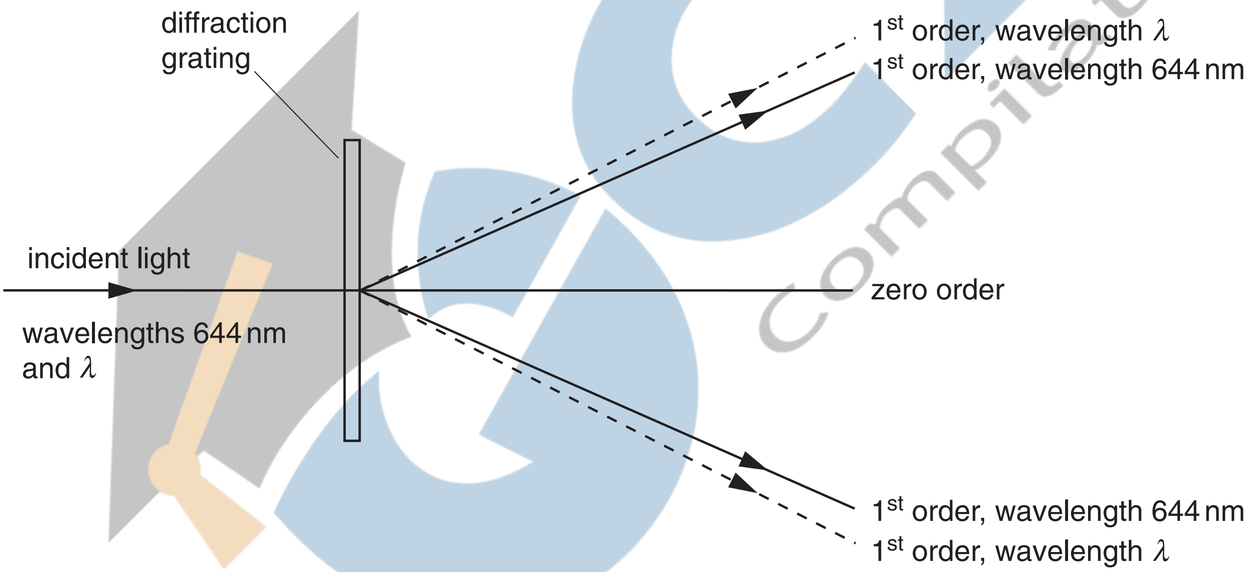


Fig. 4.1

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]

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.

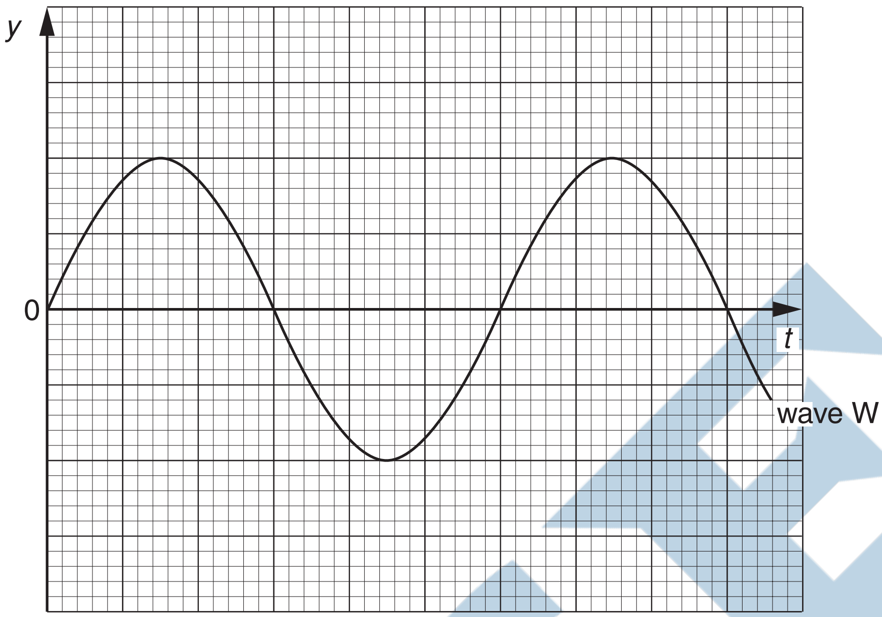


Fig. 5.1

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).

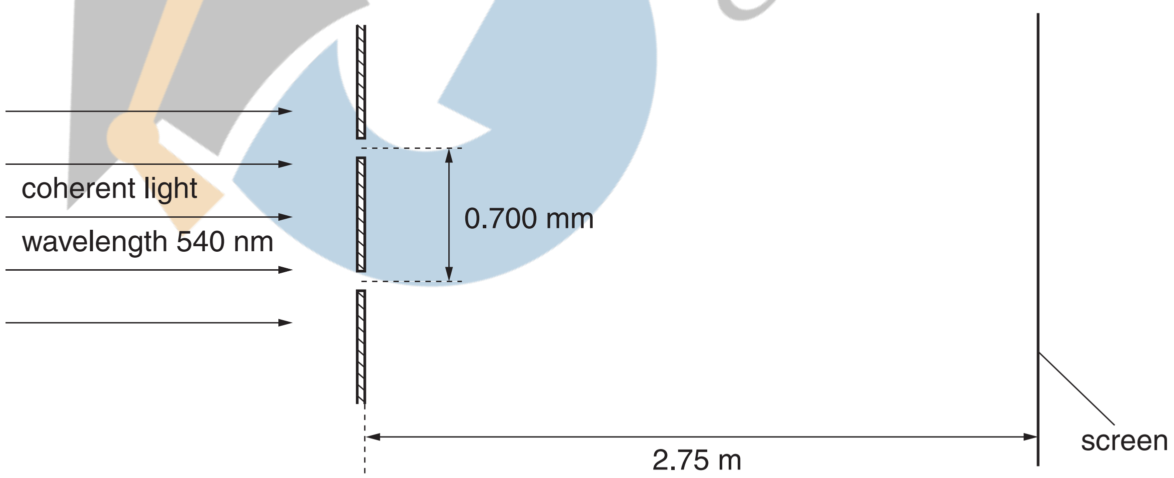


Fig. 5.2

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]

9 **(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]

10 **(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.

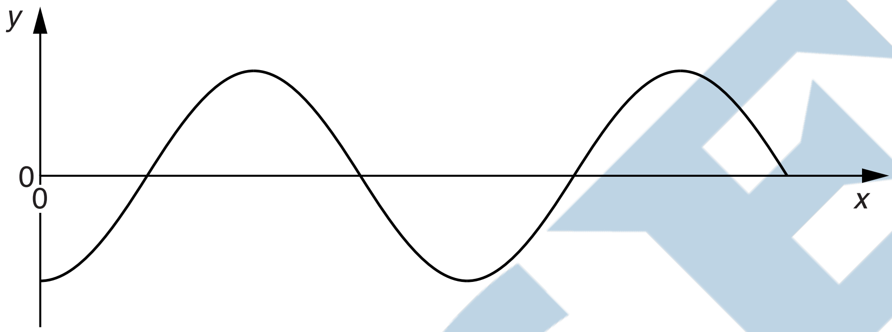


Fig. 5.1

(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]

For Examiner's Use

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

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]

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

....

....

.... [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.

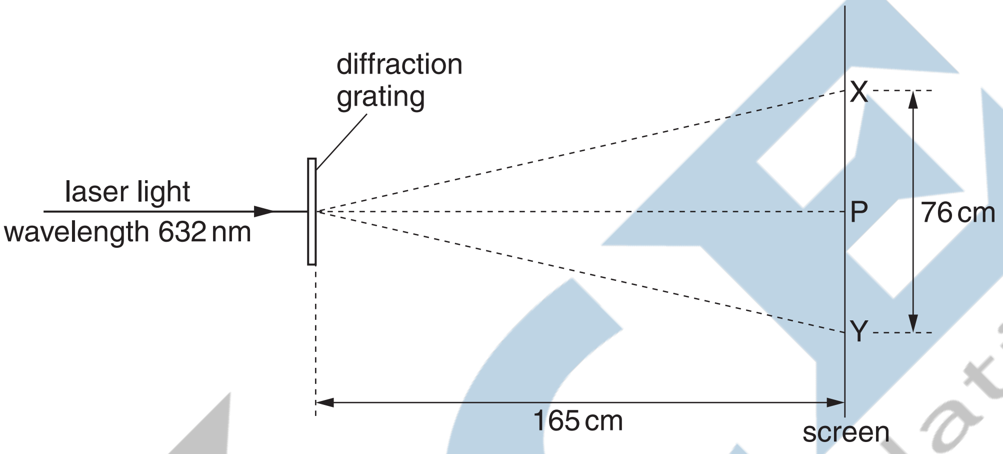


Fig. 4.1

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.

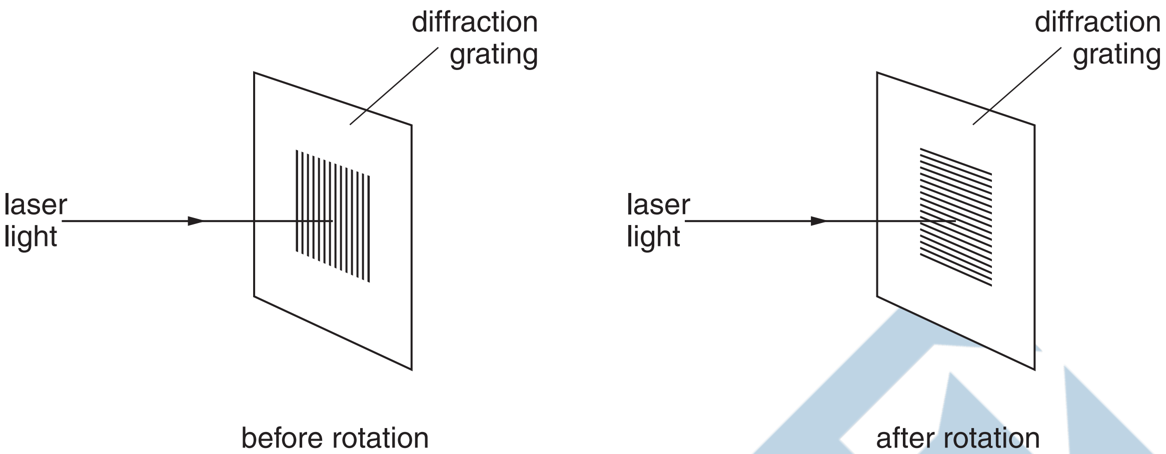


Fig. 4.2

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]

For Examiner's Use

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

....

....

.... [2]

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

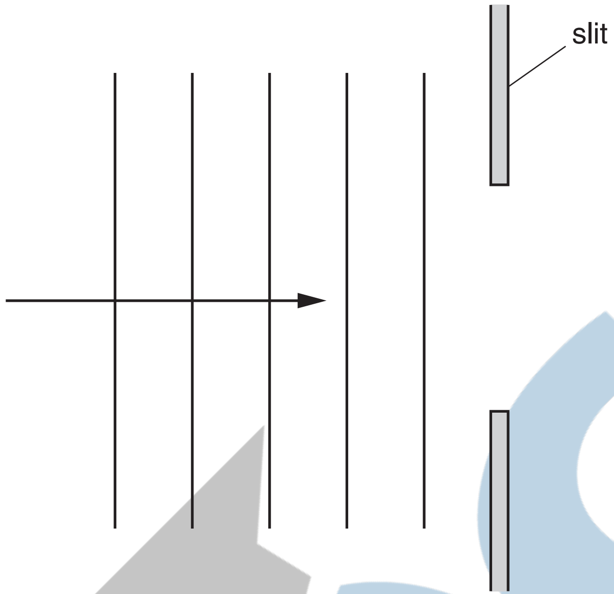


Fig. 5.1

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

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

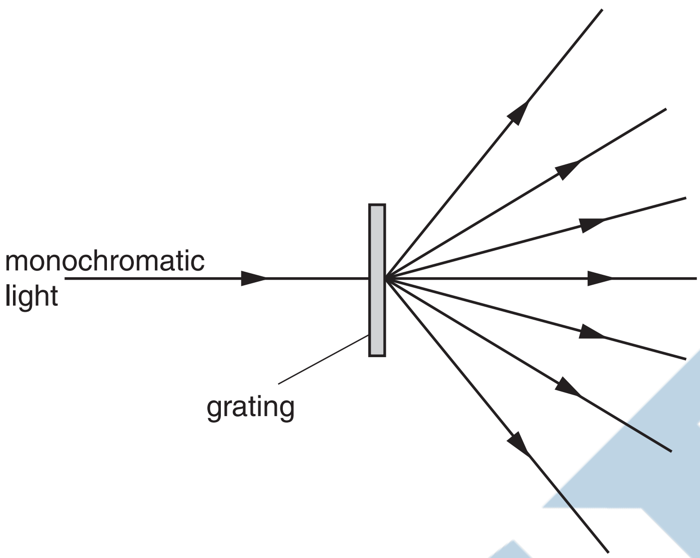


Fig. 5.2

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]

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

....

....

.... [2]

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

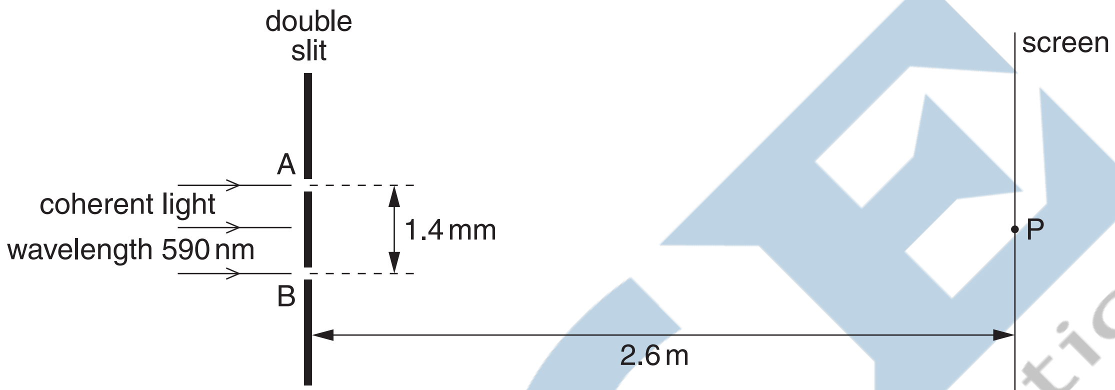


Fig. 6.1 (not to scale)

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]

For Examiner's Use

(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.

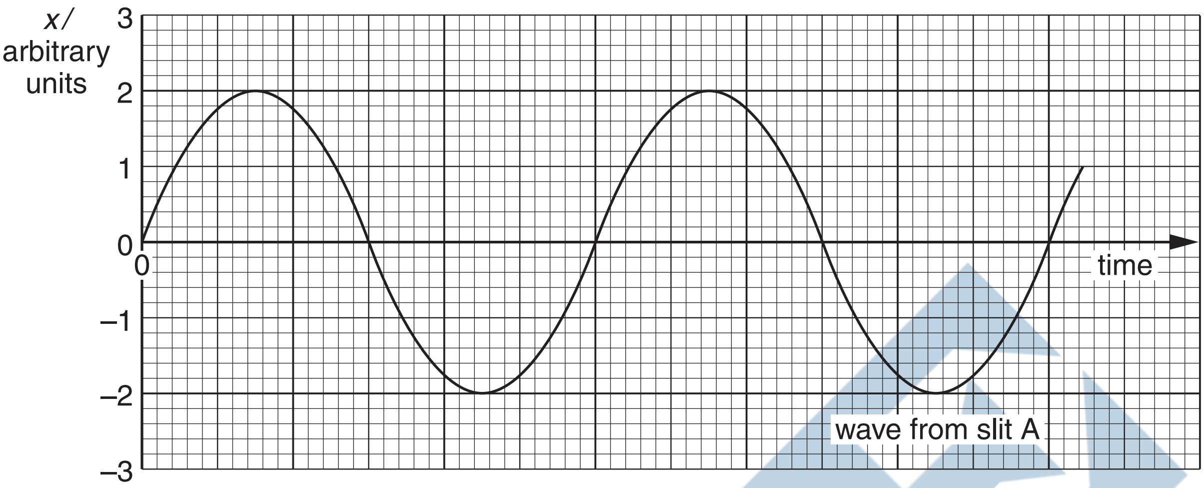


Fig. 6.2a

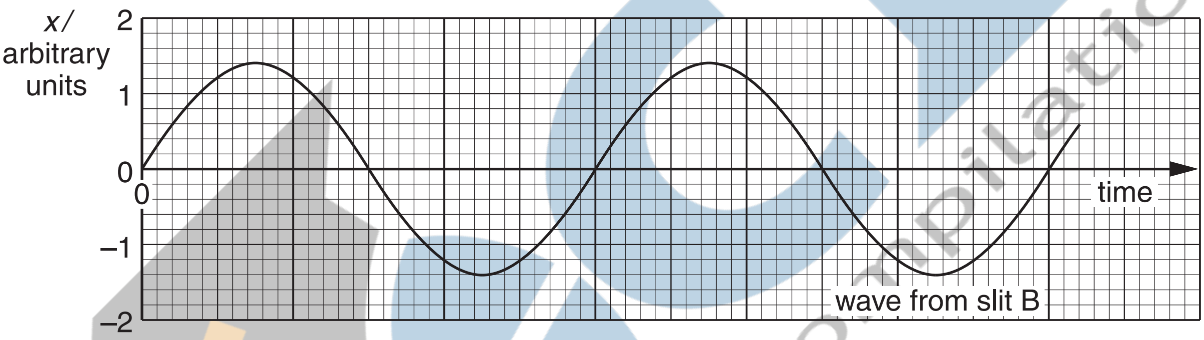


Fig. 6.2b

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]

For Examiner's Use

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

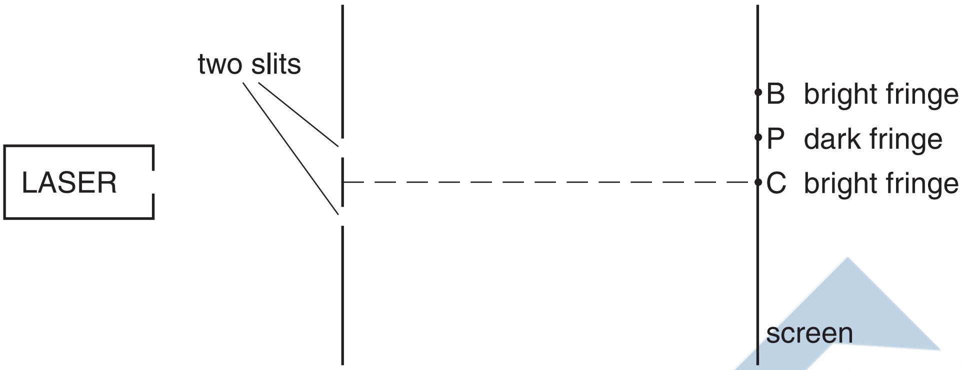


Fig. 6.1 (not to scale)

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]

For Examiner's Use

(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.

wavelength = ... nm [3]

For Examiner's Use

7 **(a)** Explain the term *interference*.

....

....

.... [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

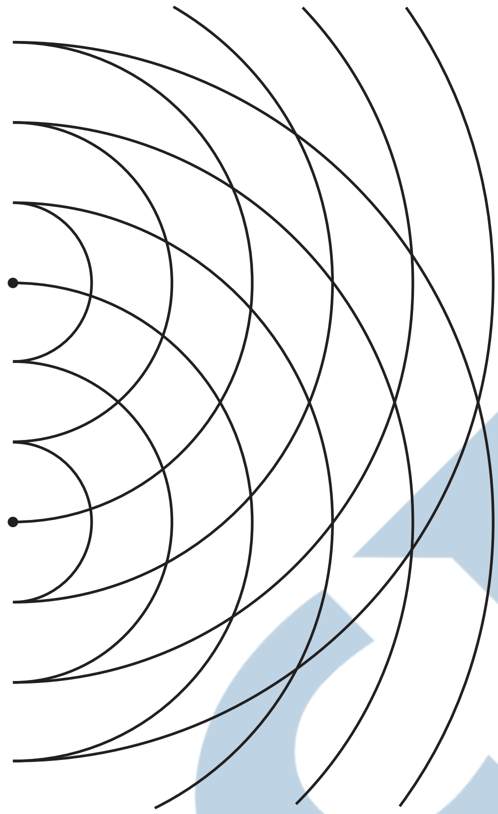


Fig. 7.1

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]