8. Superposition

8.4 The diffraction grating

Paper 2

Question Paper

1 Light of a single frequency is incident normally on a diffraction grating. An interference pattern of bright and dark fringes forms on the semicircular screen shown in Fig. 6.1.

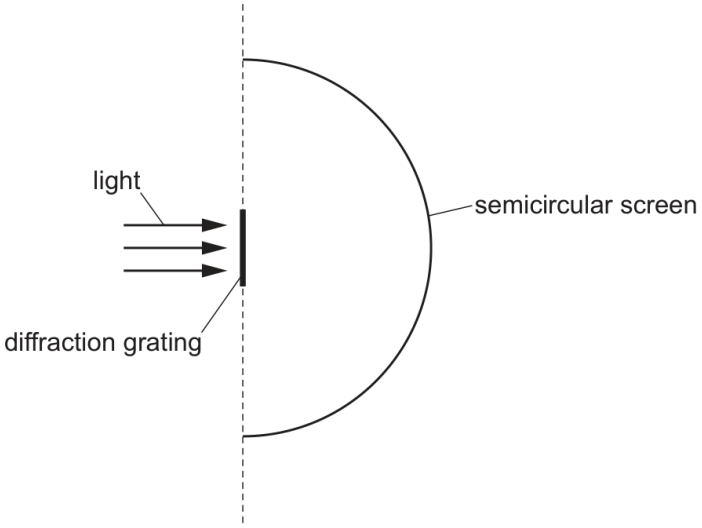


Fig. 6.1 (not to scale)

The light has wavelength 520 nm.
The separation of the lines in the grating is 3.8×10^{-6} m.

(a) Determine the total number of bright fringes formed on the screen.

number of bright fringes = ... [3]

(b) The light is replaced with red light of a single frequency.

(ii) State and explain the effect of this change on the number of bright fringes formed on the screen. A calculation is not required.

.....

.....

.....

..... [2]

2 **(c)** A beam of light of wavelength 4.3×10^{-7} m is incident normally on a diffraction grating in air, as shown in Fig. 5.3.

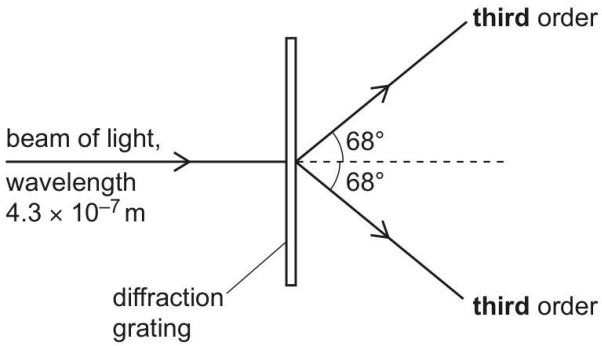


Fig. 5.3 (not to scale)

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 = ... m [2]

(ii) Determine a different wavelength of **visible** light that will also produce a diffraction maximum at an angle of 68°.

wavelength = ... m [2]

3 **(d)** A diffraction grating is used with different wavelengths of visible light. The angle θ of the **fourth**-order maximum from the zero-order (central) maximum is measured for each wavelength. The variation with wavelength λ of $\sin\theta$ is shown in Fig. 4.1.

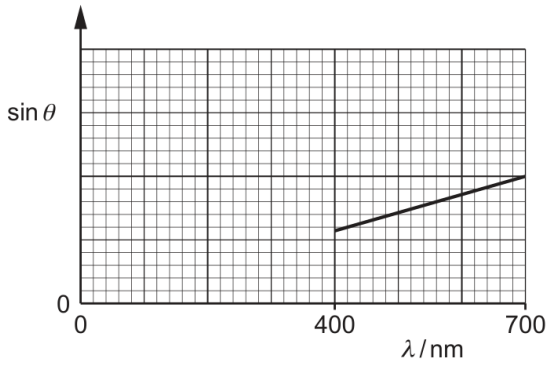


Fig. 4.1

(i) The gradient of the graph is *G*.

Determine an expression, in terms of *G*, for the distance *d* between the centres of two adjacent slits in the diffraction grating.

d = ... [2]

(ii) On Fig. 4.1, sketch a graph to show the results that would be obtained for the **second**-order maxima. [2]

4 **(c)** **(ii)** A parallel beam of light consists of two wavelengths 540 nm and 630 nm. The light is incident normally on a diffraction grating. Third-order diffraction maxima are produced for each of the two wavelengths. No higher orders are produced for either wavelength.

Determine the smallest possible line spacing d of the diffraction grating.

d = ... m [3]

(iii) The beam of light in **(c)(ii)** is replaced by a beam of blue light incident on the same diffraction grating.

State and explain whether a third-order diffraction maximum is produced for this blue light.

.....

.....

.....[2]

5 **(b)** Light consisting of only two wavelengths λ_1 and λ_2 is incident normally on a diffraction grating.

The third order diffraction maximum of the light of wavelength λ_1 and the fourth order diffraction maximum of the light of wavelength λ_2 are at the same angle θ to the direction of the incident light.

(i) Show that the ratio $\frac{\lambda_2}{\lambda_1}$ is 0.75.

Explain your working.

[2]

(ii) The difference between the two wavelengths is 170 nm.

Determine wavelength λ_1.

λ_1 = ... nm [1]

6 Red light of wavelength 640 nm is incident normally on a diffraction grating having a line spacing of 1.7×10^{-6} m, as shown in Fig. 5.1.

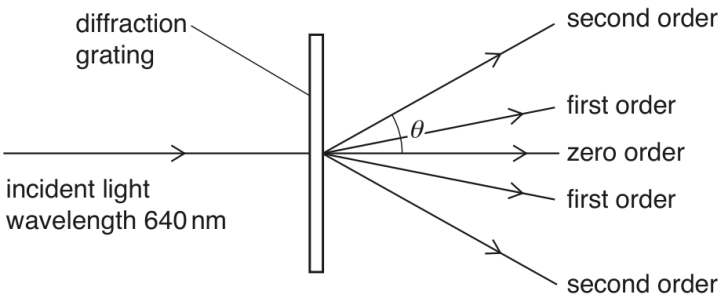


Fig. 5.1 (not to scale)

The second order diffraction maximum of the light is at an angle θ to the direction of the incident light.

(a) Show that angle θ is 49°.

[3]

(b) Determine a different wavelength of **visible** light that will also produce a diffraction maximum at an angle of 49°.

wavelength = ... m [2]