8. Superposition

8.4 The diffraction grating

Paper 1

Question Paper

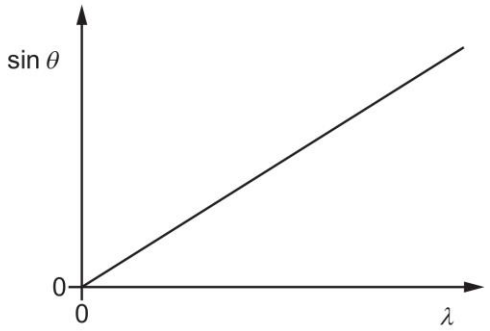
1 Light of frequency 6.7×10^{14} Hz in a vacuum is incident normally on a diffraction grating that contains 4.0×10^{5} lines m^{-1}.

What is the angle between the adjacent second and third order intensity maxima?

A 12° **B** 21° **C** 33° **D** 54°

2 A diffraction grating with N lines per metre is used to diffract light of various wavelengths λ.

The graph shows the relation between the diffraction angle θ and λ for different wavelengths in the n^{th} order interference pattern.



What is the gradient of the graph?

A Nn **B** $\frac{N}{n}$ **C** $\frac{n}{N}$ **D** $\frac{1}{Nn}$

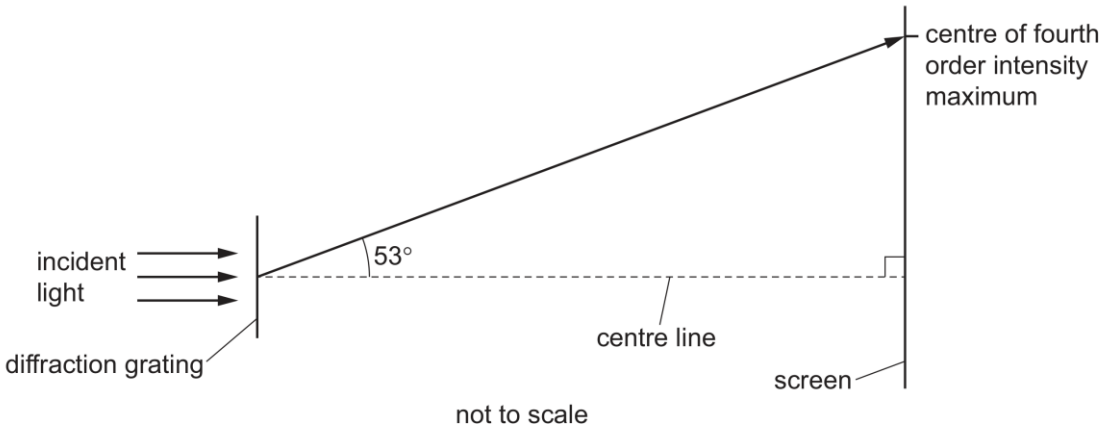
3 Light of wavelength λ is incident normally on a diffraction grating with a total number of N lines in width w.

A second order maximum is observed at an angle of diffraction θ.

What is N?

A $\frac{w\lambda}{\sin\theta}$ **B** $\frac{2w\lambda}{\sin\theta}$ **C** $\frac{w\sin\theta}{2\lambda}$ **D** $\frac{w\sin\theta}{\lambda}$

4 The diagram shows visible light incident normally on a diffraction grating.

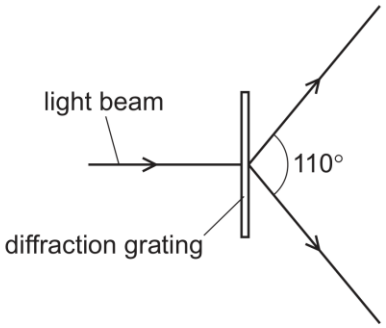


A pattern of intensity maxima forms on the screen. A line connecting the centre of the fourth order intensity maximum with the centre of the diffraction grating forms an angle of 53° with the centre line. The grating has a line spacing of 2.7×10^{-6} m.

What is the wavelength of the incident light?

A 4.1×10^{-7} m **B** 5.4×10^{-7} m **C** 1.6×10^{-6} m **D** 2.2×10^{-6} m

5 A beam of light from a laser is incident normally on a diffraction grating.



The diagram shows only the **second**-order maxima that are produced.

The grating has a line spacing of 1.0×10^{-6} m. The angle between the two second-order maxima is 110°.

What is the wavelength of the light?

A 4.1×10^{-7} m

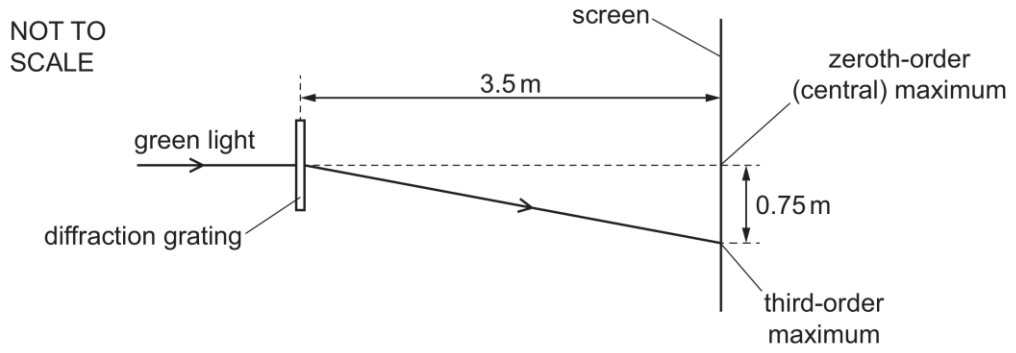
B 4.7×10^{-7} m

C 8.2×10^{-7} m

D 9.4×10^{-7} m

6 Green light of wavelength 550 nm is incident normally on a diffraction grating and produces a diffraction pattern on a screen placed 3.5 m from the diffraction grating.

The **third**-order maximum on the screen is a distance of 0.75 m from the zeroth-order (central) maximum.



What is the distance between two adjacent slits in the diffraction grating?

A 2.6×10^{-6} m

B 7.7×10^{-6} m

C 7.9×10^{-6} m

D 1.0×10^{-5} m

7 A beam of red light of wavelength 720 nm is incident normally on a diffraction grating and produces a diffraction pattern on a screen placed parallel to the grating.

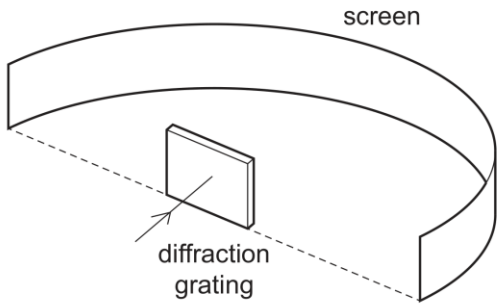
The beam of red light is replaced with a beam of electromagnetic radiation of wavelength *X*, which is incident normally on the same diffraction grating.

The third-order maximum for the electromagnetic radiation of wavelength *X* is at the same position on the screen as the second-order maximum for the red light.

What is wavelength *X*?

A 480 nm **B** 540 nm **C** 960 nm **D** 1100 nm

8 Light of wavelength 690 nm passes through a diffraction grating with 300 lines per mm, producing a series of bright spots (maxima) on a screen.

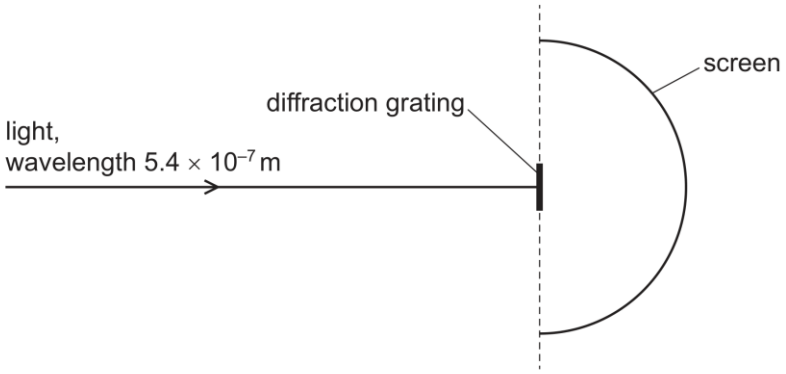


What is the total number of bright spots that are produced?

A 4 **B** 5 **C** 8 **D** 9

9 Light of wavelength 5.4×10^{-7} m is incident normally on a diffraction grating.

The separation between adjacent lines in the grating is 2.0×10^{-6} m. The light that emerges from the grating falls on a semicircular screen, as shown in the view from above.



VIEW FROM ABOVE

The grating is at the centre of the semicircle, and the lines of the grating are vertical.

How many bright dots are formed on the screen?

A 3 **B** 4 **C** 6 **D** 7

10 The equation

$$\lambda = \frac{d \sin\theta}{n}$$

is used to calculate the wavelength λ of light in an experiment that uses a diffraction grating. The light from the diffraction grating is displayed on a screen.

What do the symbols *n* and *d* represent?

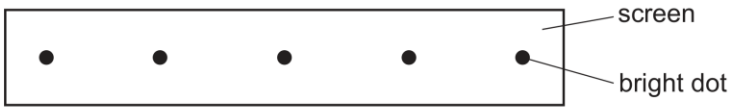
	n	*d*
A	number of slits in the grating	distance between adjacent slits in the grating
B	number of slits in the grating	distance from grating to screen
C	order of intensity maximum	distance between adjacent slits in the grating
D	order of intensity maximum	distance from grating to screen

11 A diffraction grating has 4.00×10^5 lines per metre. A beam of light of wavelength 589×10^{-9} m is incident normally on the diffraction grating.

What is the angle between the second-order maximum and the direction of the incident beam of light?

A 13.6° **B** 27.3° **C** 28.1° **D** 56.2°

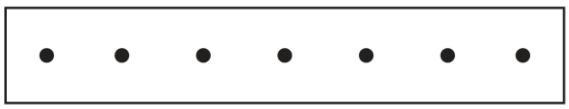
12 Red light of a single wavelength passes through a diffraction grating. Bright dots are formed on a screen, as shown.



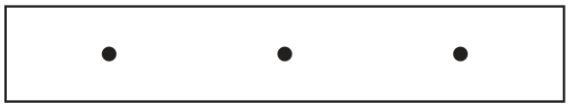
The red light is replaced with white light.

Which diagram, drawn to the same scale, shows a possible pattern of bright light on the screen?

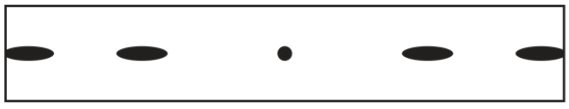
A



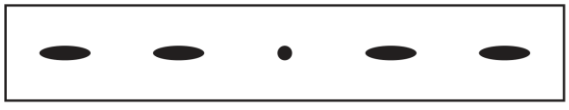
B



C



D



13 Light of a single unknown wavelength and blue light of a single wavelength are both incident normally on a diffraction grating. Two diffraction patterns are produced, one for each wavelength of light.

The third-order maximum for the blue light occurs at the same angle as the second-order maximum for the light of unknown wavelength. The wavelength of the blue light is 480 nm.

What is the unknown wavelength?

A 320 nm **B** 720 nm **C** 960 nm **D** 1440 nm

14 A parallel beam of light consists of light of wavelength 420 nm and light of wavelength 630 nm.

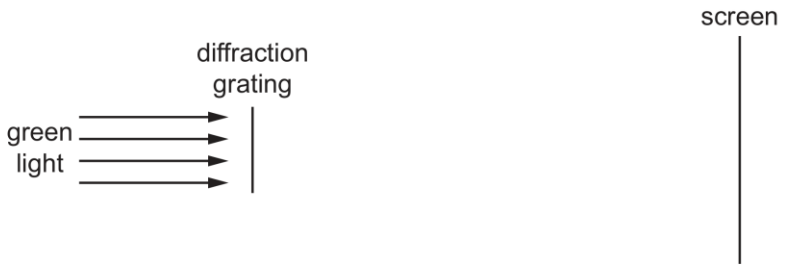
The light is incident normally on a diffraction grating.

The diffraction maxima for the two wavelengths overlap only at an angle of 31° from the direction of the incident light beam.

What could be the line spacing of the diffraction grating?

A 1.2 μm **B** 1.6 μm **C** 2.4 μm **D** 3.7 μm

15 Green light is incident normally on a diffraction grating and forms a diffraction pattern on a distant screen.



Which change, on its own, would **decrease** the separation of the diffraction maxima on the screen?

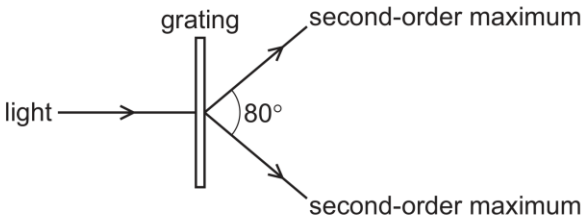
A Increase the distance between the screen and the diffraction grating.

B Replace the diffraction grating with a grating that has a smaller separation between the slits.

C Replace the diffraction grating with a grating that has fewer slits per unit length.

D Replace the green light with red light.

16 Light of wavelength 5.5×10^{-7} m is incident normally on a diffraction grating.



The angle between the second-order diffraction maxima is 80°, as shown.

What is the number of lines per metre of the diffraction grating?

A 5.8×10^5 lines per metre

B 9.0×10^5 lines per metre

C 1.2×10^6 lines per metre

D 2.3×10^6 lines per metre

17 A diffraction grating and a screen are used to determine the single wavelength λ of the light from a source.

What is an essential feature of this experiment?

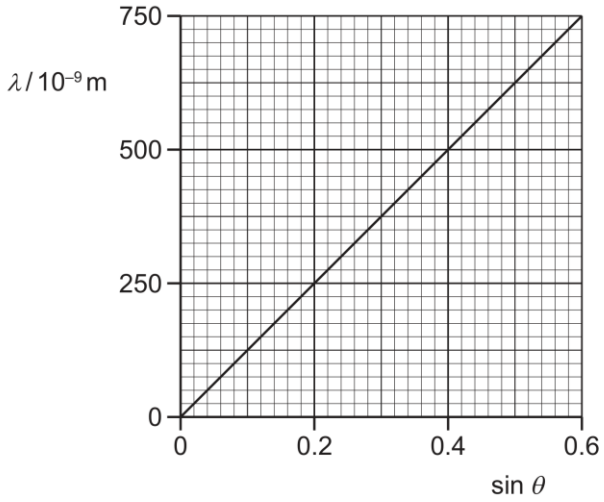
A A curved screen must be used.

B The diffraction angle θ must be measured for at least two interference maxima.

C The light waves incident on the grating must be coherent.

D The third order intensity maximum must be produced.

18 Light of wavelength λ is incident normally on a diffraction grating. The angle between the **second**-order maximum and the normal to the grating is θ. The variation with sin θ of λ is shown on the graph.



How many lines per millimetre are on the diffraction grating?

A 400 mm^{-1} **B** 625 mm^{-1} **C** 800 mm^{-1} **D** 1250 mm^{-1}

19 A parallel beam of white light passes through a diffraction grating. Orange light of wavelength 600 nm in the fourth-order diffraction maximum coincides with blue light in the fifth-order diffraction maximum.

What is the wavelength of the blue light?

A 450 nm **B** 480 nm **C** 500 nm **D** 750 nm

20 Light of a single frequency is incident on a diffraction grating. Seven bright spots are observed on a screen.

Which change will result in an increase in the number of bright spots observed?

A Increase the distance between the grating and the screen.

B Increase the frequency of the incident light.

C Increase the intensity of the incident light.

D Increase the number of lines per metre in the grating.

21 The interference patterns from a diffraction grating and a double slit are compared.

Using the diffraction grating, yellow light of the first order is seen at 30° to the normal to the grating.

The same light produces interference fringes on a screen 1.0 m from the double slit. The slit separation is 500 times greater than the line spacing of the grating.

What is the fringe separation on the screen?

A 2.5×10^{-7} m

B 1.0×10^{-5} m

C 1.0×10^{-3} m

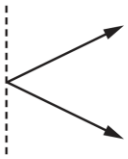
D 1.0×10^{-1} m

22 Monochromatic light is directed at a diffraction grating, as shown.

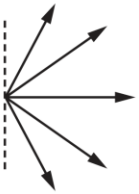


Which diagram could show all the possible directions of the light, after passing through the grating, that give maximum intensity?

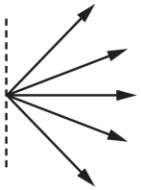
A



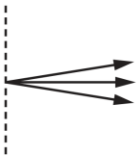
B



C



D



23 Light of wavelength 720 nm from a laser X is incident normally on a diffraction grating and a diffraction pattern is observed. Light from a laser Y is then also incident normally on the same grating. The third-order maximum due to laser Y is seen at the same place as the second-order maximum due to laser X.

What is the wavelength of the light from laser Y?

A 480 nm **B** 540 nm **C** 720 nm **D** 1080 nm

24 Monochromatic light of frequency f is incident on a diffraction grating of line spacing d. The speed of light is c.

Which expression can be used to determine the highest order of intensity maximum produced by the grating?

A $n = \frac{d}{cf}$ **B** $n = \frac{df}{c}$ **C** $n = \frac{dc}{f}$ **D** $n = \frac{c}{df}$

25 An electromagnetic wave is incident normally on a diffraction grating.

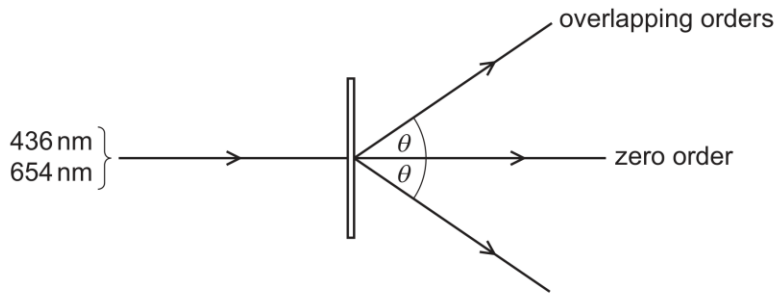
A second-order maximum is produced at an angle of 30° to a normal to the grating.

The grating has 5000 lines per cm.

What is the wavelength of the wave?

A 2.5×10^{-7} m **B** 5.0×10^{-7} m **C** 1.0×10^{-6} m **D** 5.0×10^{-5} m

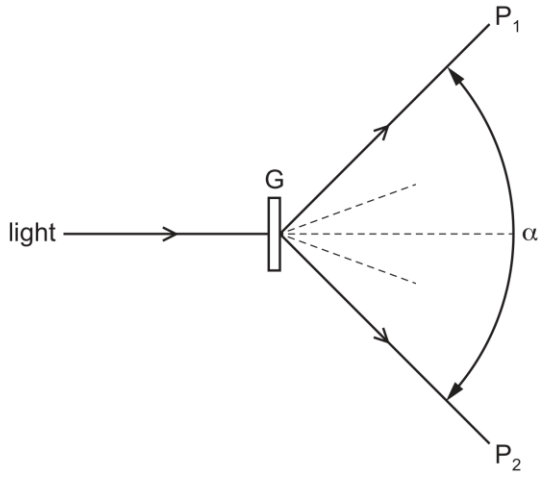
26 A beam of light consists of two wavelengths of 436 nm and 654 nm. A diffraction grating of 5.00×10^5 lines m^{-1} produces a diffraction pattern in which the second order of one of these wavelengths occurs at the same angle θ as the third order of the other wavelength.



What is the angle θ?

A 19.1° **B** 25.8° **C** 40.8° **D** 78.8°

27 A parallel beam of monochromatic light of wavelength λ is incident normally on a diffraction grating G. The angle between the directions of the two second-order diffracted beams at P_1 and at P_2 is α, as shown.



What is the spacing of the lines on the grating?

A $\frac{2\lambda}{\sin\alpha}$ **B** $\frac{\lambda}{\sin\alpha}$ **C** $\frac{2\lambda}{\sin(\alpha/2)}$ **D** $\frac{\lambda}{\sin(\alpha/2)}$