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PROBLEMS

Q 1. A diffraction grating has 5000 lines/cm. Calculate the second order angle if a wavelength of 650 nm is used as a light source.

$$d \sin\theta = n\lambda$$

here, $d = \frac{1}{N}$ and $N =$ No of lines/m

$$= \frac{5000 \text{ lines}}{\text{cm}}$$

$$= \frac{5000 \text{ lines}}{\text{cm}} \times \frac{100 \text{ cm}}{1 \text{ m}}$$

$$= 5 \times 10^{5} \text{ lines/m}$$

so. $d = \frac{1}{5 \times 10^{5} \text{ lines/m}}$

$d = 2 \times 10^{-6}$ m/lines

hence,

$\lambda = 650$ nm $= 650 \times 10^{-9}$ m

$n = 2$

$$d \sin\theta = n\lambda$$

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

$$\theta = \sin^{-1}\left(\frac{2 \times 650 \times 10^{-9}}{2 \times 10^{-6}}\right)$$

$$\theta = 40.5^{\circ}$$

Q 2. A diffraction grating has 10,000 lines/cm. If the third order bright fringe has an angle of 25°, what is the wavelength of the light source?

$d\sin\theta = n\lambda$

$N =$ No. of lines/m

$= 10000$ lines/cm

$= \dfrac{10000 \text{ lines}}{\text{cm}} \times \dfrac{100 \text{ cm}}{1 \text{ m}}$

$N = 1 \times 10^{6}$ lines/m

$d =$ spacing between slits.

$= \dfrac{1}{N} = \dfrac{1}{1 \times 10^{6} \text{ lines/m}}$

$d = 1 \times 10^{-6}$ m/lines

$\theta_3 = 25°$ $\lambda = ?$

$n = 3$

Now $d\sin\theta = n\lambda$

$\lambda = \dfrac{d\sin\theta}{n} = \dfrac{1 \times 10^{-6} \times \sin 25}{3}$

$\lambda = 1.41 \times 10^{-7}$ m

$= 141 \times 10^{-7}$ m $\times \dfrac{1 \text{ nm}}{10^{-9} \text{ m}}$

$\lambda = 141$ nm.

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Q. 3. The second order bright fringe has an angle of 18° using a light source with a wavelength of 540 nm. How many lines per centimeter does the diffraction grating have?

$$d \sin\theta = n\lambda$$

here

$N = ?$

$\theta_2 = 18^\circ$

$n = 2$

$\lambda = 540\ nm = 540 \times 10^{-9}\ m$

Now

$$d \sin\theta = n\lambda$$

$$d = \frac{n\lambda}{\sin\theta} = \frac{2 \times 540 \times 10^{-9}}{\sin 18}$$

$$d = 3.495 \times 10^{-6}\ m/line$$

But

$$d = \frac{1}{N}$$

$$N = \frac{1}{d} = \frac{1}{3.495 \times 10^{-6}\ m/line}$$

$$N = 286127\ lines/m$$

$$= \frac{286127\ lines}{m} \times \frac{1\ m}{100\ cm}$$

$$= 2861\ lines/cm.$$

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Q. 4. Find the angle at which the first order maximum is observed when a diffraction grating with 500 lines per mm is illuminated with a laser of wavelength 720 nm.

500 lines per mm => 500000 lines per m

Line spacing, $d = \frac{1}{50\ 0000} = 2.0 \times 10^{-6}$ m

For first order, using $\frac{\lambda}{d} = d\sin\theta$ with n = 1:

$$\sin\theta = \frac{\lambda}{d} = \frac{7.2 \times 10^{-7}}{2.0 \times 10^{-6}} = 3.6 \times 10^{-1}$$

$$\theta = 21° \text{ (2 s.f.)}$$

For the same grating illuminated as in the above question, how many bright spots would be visible on a distant screen?

$$\sin\theta < 1$$

so $n < \frac{d}{\lambda}$ for any diffraction grating

$n < \frac{2.0 \times 10^{-6}}{7.2 \times 10^{-7}}$ in this case

< 2.78

Two spots visible on each side of the central maximum therefore a total of **5 spots** are visible on the screen.

Student Practice Task 1.

A laser of wavelength 640 nm illuminates a diffraction grating with 300 lines per mm.

Explain what is meant by the term coherent.

Find the angle of the second order bright spot produced by the grating.

Show that the maximum number of spots visible is 11.

Explain how the pattern would change if a laser producing light of higher frequency were used.

2. Find the angle of the fifth order maxima when a ray of light of wavelength 590 nm passes through a grating with 2000 lines per meter.

Ans: 0.338°