Solved Examples (Diffraction)

Ex. 1 Calculate the angle at which the first dark band and the next bright band are formed in the Fraunhofer diffraction pattern of a slit of width 0.2 mm. Given $\lambda = 5890\ A^0$

Soln :

Given data : a = 0.2 mm

$\lambda = 5890\ A^0$

Formulae :

A sin $\Theta = n\lambda$ and A sin $\Theta' =$

i) For first dark band n = 1

Sin $\Theta =$

$\Theta =$

Or Θ = 10.12’

ii) **For next bright band,**

A sin $\Theta' =$

Or, sin $\Theta' =$

=

$\Theta' =$

Or $\Theta' =$

Ex. 2 How many lines per centimeter are there in a plane transmission grating which gives 1st order of light of wavelength 6000 A^0 at angle of diffraction 30^0 ?

Soln :

Given data : $\Theta = 30^0$, m = 1, $\lambda = 6000 \times 10^{-8}$ cm

Formulae :

(a + b)sin$\Theta = m\lambda$, or (a + b) =

Grating element (a + b) =

Or (a + b) = 12×10^{-5} cm

So, the number of lines per cm

N =

=

N = 8333 lines/cm

Ex. 3 Monochromatic light of wavelength 6500 A^0 falls normally on a grating 2 cm wide. The first order spectrum is produced at an angle 15^0 from the normal. What is the total numbers of lines on the grating ?

Soln :

Given data : m = 1, $\lambda = 6500 \times 10^{-8}$ cm, width of grating = 2 cm

Formulae :

(a + b) sin$\Theta = m\lambda$

So, grating element (a + b) =

Or, (a + b) = 2.5115×10^{-4}

Hence, Number of lines per cm

N =

Or, N = 3981 lines/cm

Total number of lines on grating is 3981 × 2

N = 7968

Ex. 4 What is the longest wavelength that can be observed in the fourth order for a transmission grating having 5000 lines per cm ?

Soln :

Given : m = 4, (a + b) = 1/5000 cm.
To find $(\lambda)max$ = ?
Formula : $(a + b)\sin \Theta = m\lambda$
For the longest wavelength, $\sin \Theta = 1$
Hence,
Hence, The longest wavelength **= 5000 A^0**

Ex. 5 A slit of width 'a' is illuminated by white light. For what value of 'a' will the first minimum for red light fall at an angle 30^0 ? Wavelength of red light is 6500 A^0.

Soln :

Given : $\Theta = 30^0$, m = 1, $\lambda = 6500 \times 10^{-8}$ cm
To find : a = ?
Formula : For minima in single slit diffraction pattern.
$A \sin \Theta = m\lambda$
For first minimum, m = 1
Hence, a =
Hence, $a = 1.3 \times 10^4 \times 10^{-8}$ cm = **1.3×10^{-4} cm.**

Ex. 6 The wavelength of visible spectrum are approximately 4000 A^0 to 7000 A^0 find the angular breadth of the first order visible spectrum produced by a plane grating having 6000 lines per cm, when light is incident normally on the grating.

Soln :

Given : $\lambda_1 = 4000\ A^0 = 4000 \times 10^{-10}$ m, $\lambda_2 = 7000\ A^0 = 7000 \times 10^{-10}$ m,
A + b =
Formula : $(a + b) \sin\Theta = m\lambda$
Hence, for λ, we have
$\sin\Theta_1$ =
Hence, Θ_1 =

for $\lambda 2$, we have $\sin\Theta_2$ =
Hence, Θ_2 =
Angular breadth of the first order visible spectrum
$= \Theta 2 - \Theta 1 =$

Ex. 7 A plane transmission grating has 5000 lines/cm. Find out the highest order of spectrum observed if incident light has $\lambda = 6000\ A^0$

Soln :

Given : (a + b) =
Formula : $(a + b) \sin\Theta = m\lambda$, $\lambda = 6000\ A^0 = 6000 \times 10^{-10}$ m
Maximum value of $\sin\Theta = 1$
Hence $(m)_{max}$
Hence, **Third order is the highest order visible.**

Ex. 8 Find the half angular width of the central maximum in the Fraunhofer diffraction pattern of a slit of width 12×10^{-5} cm, when illuminated by light of wavelength 6000 A^0.

Soln :

Given : $a = 12 \times 10^{-5}$ cm, $\lambda = 6000\ A^0 = 6000 \times 10^{-8}$ cm

Formula : Half angular width of the first maxima is the angle made by the first minima with the normal to the slit.

Hence, $a \sin\Theta = m\lambda$ $\quad m = 1$

$\sin\Theta =$

Θ

Ex. 9 A single slit is illuminated by light composed of two wavelength λ_1 & λ_2 . One observes that due to Fraunhofer diffraction the first minima obtained for λ_1 coincides with the second diffraction minima of λ_2. What is the relation between λ_1 and λ_2.

Soln :

We have the angular position of minima is,

$$a \sin\Theta = n\lambda$$

For λ_1, we can write,

$$a \sin\Theta_1 = 1 \times \lambda_1 \quad \text{…………(1)}$$

For λ_2,

$$a \sin\Theta_2 = 2 \times \lambda_2 \quad \text{…………(2)}$$

Given that, $\Theta_1 = \Theta_2$

By comparing, Equation (1) and (2), we can write,

$\lambda_1 = 2\ \lambda_2$ This is the required relation