Problem 2 ✓

In a plane transmission grating, the angle of diffraction for second order principal maximum for the wavelength 5×10^{-5} cm is $30°$. Calculate the number of lines / cm on the grating surface. *(M.U. May 2013) (3 m)*

Solution :

Data : $\theta = 30°$, $\lambda = 5 \times 10^{-5}$ cm, $n = 2$.

Formula : $(a + b) \sin\theta = n\lambda$, $\quad n = 1, 2, 3, ...$

$$a + b = \frac{1}{\text{No. of lines/cm}}$$

Calculation : $(a + b) = \dfrac{n\lambda}{\sin\theta}$

$\therefore \qquad (a + b) = \dfrac{2 \times 5 \times 10^{-5}}{\sin 30°} = 20 \times 10^{-5}$ cm

$$\text{No. of lines/cm} = \frac{1}{20 \times 10^{-5}} = 5000$$

Result : No. of lines/cm = 5000.

Problem 3

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Result : Number of lines/cm = 5735

Problem 5

Calculate the highest order spectrum that can be obtained by a monochrom of wavelength 6000 A° by a grating with 6000 lines/cm.

Solution :

Data : $\lambda = 6000$ A° $= 6000 \times 10^{-8}$ cm,

No. of lines/cm = 6000.

Formula : $(a + b) \sin \theta = n\lambda$, $\quad n = 1, 2, 3, \ldots$

$$a + b = \frac{1}{\text{No. of lines / cm}}$$

Calculation : For given $(a + b)$ and λ

$$\sin \theta \propto n$$

$$(a + b) \sin \theta_{max} = n_{max} \lambda$$

$$\sin \theta_{max} = 1$$

$$(a + b) = n_{max} \lambda$$

$$n_{max} = \frac{a + b}{\lambda} = \frac{1}{6000 \times 6000 \times 10^{-8}}$$

$\therefore$ $n_{max} = 2.7$

As $n_{max} = 2.7 < 3$, 3rd order is not visible.

$n_{max} = 2.$

Result : As $n_{max} = 2$.

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is used to obtain a spect

Calculation :

$$(a + b) \sin \theta = n \lambda_1$$

$$(a + b) \sin \lambda = (n + 1) \lambda_2 \left.\right\} \text{ since } n \propto \dfrac{1}{\lambda} \text{ for constant } (a + b) \text{ and } \theta$$

$$n \lambda_1 = (n + 1) \lambda_2$$

$$n = \frac{\lambda_2}{\lambda_1 - \lambda_2}$$

$$\therefore \quad n = \frac{4050 \times 10^{-8}}{(5400 - 4050) \times 10^{-8}} = 3$$

$$(a + b) \sin \theta = n \lambda_1$$

$$(a + b) = \frac{n \lambda_1}{\sin \theta} = \frac{3 \times 5400 \times 10^{-8}}{\sin 30^\circ}$$

$$= 3.24 \times 10^{-4}$$

$$\text{No. of lines / cm} = \frac{1}{a + b} = 3086$$

Result : No. of lines / cm = 3086.

Problem 11

In an experiment with grating, third order spectral line of some wavelength coincides with the fourth order spectral line of wavelength 4992 A°. Calculate the value of the wavelength.

(M.U. Dec. 2011) (7 m)

Solution :

Data :   Let the unknown wavelength be λ_1.

$n_1 = 3$ for λ_1, $n_2 = 4$ for $\lambda_2 = 4992$ A°.

$\lambda_2 = 4992 \times 10^{-8}$ cm.

Formula : $(a + b) \sin \theta = n \lambda$, $n = 1, 2, 3, ...$

Calculations :

$$(a + b) \sin \theta = n_1 \lambda_1$$

$$(a + b) \sin \theta = n_2 \lambda_2$$

$$n_1 \lambda_1 = n_2 \lambda_2$$

$$\therefore \qquad \lambda_1 = \frac{n_2 \lambda_2}{n_1} = \frac{4 \times 4992 \times 10^{-8}}{3}$$

$$= 6656 \times 10^{-8} \text{ cm.}$$

Result : Unknown wavelength $= 6656$ A°.

Since $n_{max} = 3$, absent order $= 3$ only.

Result : (i) Maximum visible order, $n_{max} = 3$

(ii) Absent order, $m_{max} = 3$.

Problem 15

A grating has 620 rulings/mm and is 0.5 mm wide. What is the smallest wavelength-interval that can be resolved in the third order at $l = 481$ nm?

(M.U. May 2016, 17) (3 m)

Solution :

Data : $N = 620 \times 0.5 = 310$, $\lambda = 481 \times 10^{-9}$ m, $m = 3$.

Formula :
$$\frac{\lambda}{d\lambda} = mN$$

Calculations : $d\lambda = \dfrac{\lambda}{mN} = \dfrac{481 \times 10^{-9}}{3 \times 310} = 0.5172 \times 10^{-9}$ m

Result : $d\lambda = 0.5172$ A°

Result : The 6th, 12th, 18th, ... etc. orders will be absent.

Problem 21

Find the maximum resolving power of a grating 2 cm wide with 6000 lines / cm illuminated by a light of wavelength 5890 A°.

Solution :

Data : Width of grating surface = 2 cm

$$a + b = \frac{1}{6000} \text{ cm}, \quad \lambda = 5890 \text{ A}° = 5890 \times 10^{-8} \text{ cm}.$$

Formula : $RP = mN$, $(a + b) \sin \theta = m\lambda$, $m = 1, 2, 3, ...$

Calculations :

$$(RP)_{max} = m_{max} \cdot N$$

$$m_{max} = \frac{a + b}{\lambda}, \quad \text{since } \theta_{max} = 1$$

$$\therefore \quad m_{max} = \frac{1}{6000 \times 5890 \times 10^{-8}} = 2.8$$

Here, $2 < m_{max} < 3$.

Hence, $m_{max} = 2$.

$$\therefore \quad N = 6000 \text{ lines / cm} \times 2 \text{ cm} = 12000 \text{ lines}$$

$$RP_{max} = 2 \times 12000 = 24000$$

Rsult : Maximum resolving power = 24000.