DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY
SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

18PYB101J - Electromagnetic Theory, Quantum Mechanics, Waves and Optics

Module-IV (Waves and Optics) Lecture-10

Problem Solving

Problem 1. A monochromatic light with wavelength of 500 nm strikes a grating and produces the fourth-order bright line at an 30° angle. Determine the number of slits per centimeter.

Given data :

Wavelength (λ) = 500×10^{-9} m = 5×10^{-7} m, $\theta = 30^{o}$, n = 4

Solution :

Distance between slits: $a \sin\theta = n\lambda$

$a (\sin 30^{o}) = 4 \times 5 \times 10^{-7}$

$a (0.5) = 20 \times 10^{-7}$

$a = (20 \times 10^{-7}) / 0.5$

$a = 4 \times 10^{-6}$ m

Number of slits per centimeter :

$x = 1 / 4 \times 10^{-6}$ m

$x = 0.25 \times 10^{6}$ / m

$x = 0.25 \times 10^{6} / 10^{2}$ cm

$x = 0.25 \times 10^{4}$ / cm

$x = 2500$ / cm

Problem 2. A grating containing 4000 slits per centimeter is illuminated with a monochromatic light and produces the second-order bright line at a 30° angle. What is the wavelength of the light used?

Data:

The distance between the slits (a) = 1 / (4000 slits / cm) = 0.00025 cm = 2.5 x 10^{-4} cm = 2.5 x 10^{-6} meters

Order (n) = 2, Sin 30° = 0.5

Solution :

$a \sin\theta = n\lambda$

$\lambda = a \sin\theta / n$

$= 2.5 \times 10^{-6} \times \sin 30/2$

$= 2.5 \times 10^{-6} \times 0.5/2$

$= 6250 \times 10^{-10}$ m

Problem. 3 The refractive index of a polarizer is 1.9218. What will be the polarization angle and angle of refraction?

Data: $\mu = 1.9218$.
From Brewster's law:
$\mu = \tan i_p$
$i_p = \tan^{-1}(1.9128)$
$i_p = 62^0\ 24'$

Now we will see that our angle of refraction:

It is specified that $i_p + i_r = 90$ degrees

Thus, angle of refraction or $i_r = 90 - 62^0\ 24'$
$i_r = 27^0\ 6'$

4. A parallel beam of monochromatic light is allowed to incident normally on a plane transmission grating having 5000 lines per cm and second order spectral line is found to be diffracted through 30°. Calculate the wavelength of light.

SOLUTION Given $N = 5000$ lines per cm, $\theta = 30°$ and $n = 2$.

$$(b + d) = \frac{1}{N} = \frac{1}{5000} = 2.0 \times 10^{-4} \text{ cm}$$

Formula used is $(b = d) \sin\theta = n\lambda$ or $\lambda = \dfrac{(b + d)\sin\theta}{n}$

or $$\lambda = \frac{2.0 \times 10^{-4} \times \sin 30°}{2} = 5000 \times 10^{-8} \text{ cm}$$

$$\lambda = 5000 \text{ Å}$$

5. In a plane transmission grating the angle of diffraction for second order maxima for wavelength 5 x 10^{-5} cm is 30°. Calculate the number of lines in one cm of the grating surface.

Solution Given $\lambda = 5 \times 10^{-5}$ cm, $\theta = 30°$ and $N = ?$, $n = 2$.

$$(b + d) \sin \theta = n\lambda$$

$$(b+d) = \frac{n\lambda}{\sin\theta} = \frac{2 \times 5 \times 10^{-5}}{\sin 30°} = \frac{10 \times 10^{-5}}{0.5}$$

$$= 2.0 \times 10^{-4} \text{ cm.}$$

The number of lines are

$$N = \frac{1}{(b+d)} = \frac{1}{2.0 \times 10^{-4}} = \frac{10^4}{2} \text{ per cm}$$

$$= \mathbf{5000 \text{ lines/cm}}$$

6. How many orders will be visible if the wavelength of the incident radiation is 5000 x 10^{-10} m and the number of lines on the grating is 2620 in one inch.

SOLUTION Given $N = 2620$ lines per inch and $\lambda = 5000 \times 10^{-8}$ cm.

$$b + d = \frac{1}{N} = 1 \text{ inch} = 2.54 \text{ cm} = 9.695 \times 10^{-4} \text{ cm}$$

Formula used is $(b + d) \sin\theta = n\lambda$

For maximum possible value $\sin\theta = 1$, then

$$\text{Order of spectrum } (n) = \frac{(b+d)}{\lambda} = \frac{9.695 \times 10^{-4}}{5.0 \times 10^{-5} \text{ cm}}$$

$= 19.38$

$= \mathbf{19}$

That is 19^{th} order will be visible.

Exercise Problems:

1. A plane transmission grating has 5000 lines / cm. Calculate the angular separation in second order spectrum of red line 7070 Å and blue line 5000 Å. (Answer: 15°)

2. The refractive index of the medium is √3 . Calculate the angle of refraction if the unpolarised light is incident on it at the polarizing angle of the medium. (Answer: 30°)