Optics

(Lec-8)

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OUTLINES

- Resolving power of an optical instrument
- Theory of Plane Diffraction Grating
- Grating Constant

Resolving power of an optical instrument

The ability of an optical instrument, expressed in numerical measure, to distinguish between the images of two nearby objects is termed as its resolving power. In case of a diffraction grating, resolving power is referred to as its ability to resolve two spectral lines whose wavelengths are very close to each other so that these two lines can be viewed as separate lines.

Theory of Plane Diffraction Grating

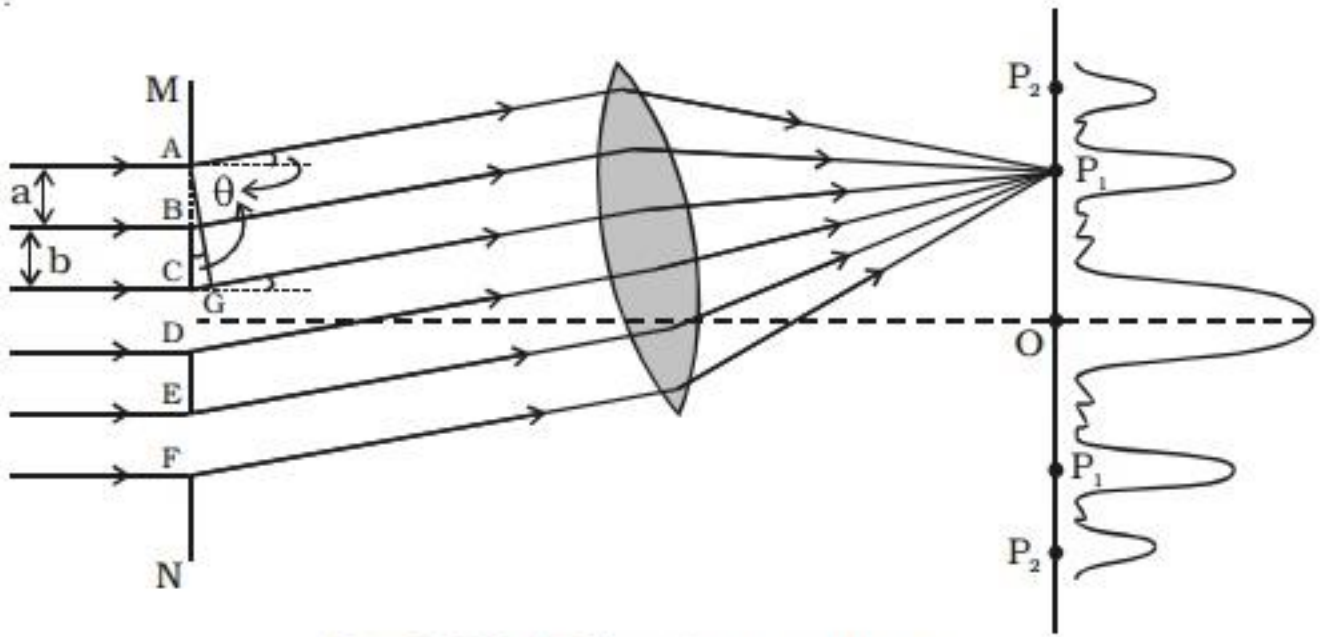
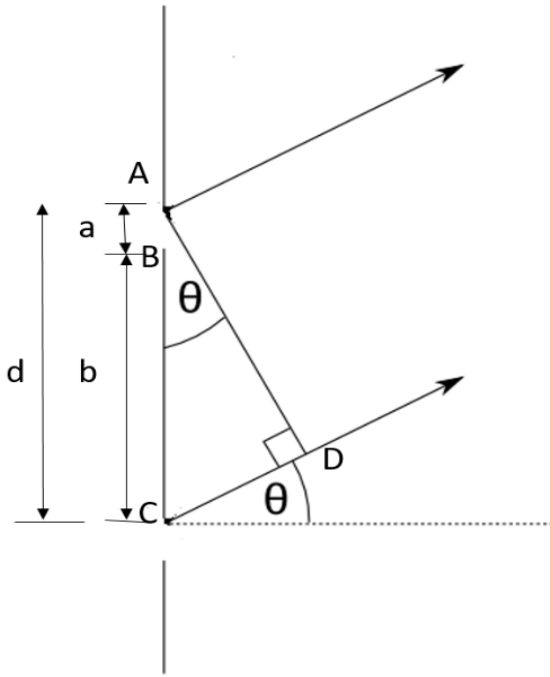


Fig 5.21 Diffraction grating

Parallel rays of a monochromatic light of wavelength λ are incident on a diffraction grating in which the slit separation is d. The width of each slit is a and the opaque spacing between any two consecutive slits is b.

The intensity at P_1 will depend on the path difference between the secondary waves originating from the corresponding points A and C of two neighboring slits.



From the figure,

$AB = a$, $BC = b$ and $AC = d = a + b$

The path difference between the secondary waves starting from A and C is CD.

From the triangle ΔACD,

Path difference, $CD = ACsin\theta$

$$= (AB + BC)sin\theta$$

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

The point P_1 will be of maximum intensity if this path difference is equal to the integral multiples of λ. In general,

$$(a+b)sin\theta_n = m\lambda \dots\dots\dots\dots (1)$$

$$or, d\ sin\theta_n = m\lambda$$

Where θ_n is the direction of the n^{th} principle maximum. Putting $m = 1,2,3 \dots\dots$ etc, the angles $\theta_1, \theta_2, \theta_3\ etc$ corresponding to the directions of the principle maxima can be obtained. Now, for the first order principle maxima

$$(a+b)sin\theta = \lambda$$

Grating Constant

The distance from the starting of a slit to the starting of the next slit is called the grating constant. If the grating has N lines per meter, the grating constant is given by:

$$d = (a + b) = \frac{1}{N}$$

Problem: A parallel beam of monochromatic source of light is allowed to incident normally on a plane transmission grating having 5000 lines per cm. A second order spectral line is found to be diffracted at an angle 30^0. Find the wavelength of the light.

Solution:

Here,

$$d = \frac{1}{N} = \frac{1}{5000}\ cm = 2 \times 10^{-4} cm = 2 \times 10^{-6} m$$

Now,

$$d sin\theta = m\lambda$$

$$\Rightarrow \lambda = \frac{d sin\theta}{m}$$

$$\Rightarrow \lambda = \frac{2 \times 10^{-6} \times sin30°}{2}$$

$$\therefore \lambda = 5 \times 10^{-7} m = 500\ nm$$

Differentiate between Interference and Diffraction

Interference:

(a) Interference is produced by light waves from two coherent sources super imposed at a point in a medium.
(b) Normally the width of the interference fringes is equal.
(c) Distance between the bright and dark band are always equal.
(d) No light is found in interference fringes. They are always dark. The region of the minimum intensity is perfectly dark.
(e) The intensity of the bright fringes is equal.

Diffraction:

(a) Diffraction is produced due to the interference of the secondary waves emitted from different parts of a wave front.
(b) Widths of the fringes in the diffraction pattern are never equal.
(c) In the case of diffraction pattern the distance between the bright and dark band are gradually decreases.
(d) In diffraction dark bands are not completely dark. Some light is observed there.
(e) The intensity in the bright diffracted band never remains same. The intensity is maximum in the central band and intensity gradually decreases on both sides of the central band.



