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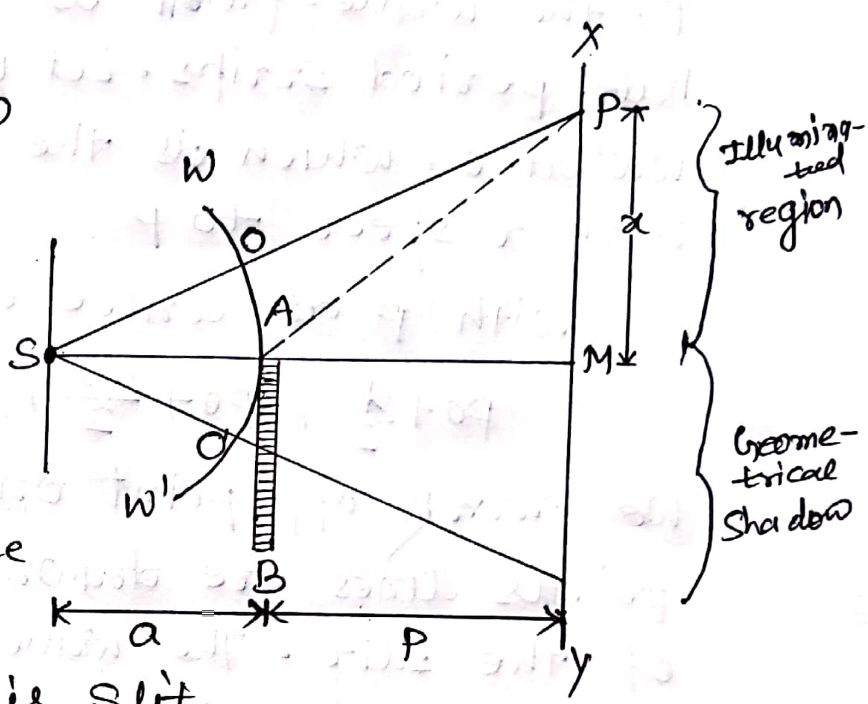
B.Sc (part-II) Hons

paper-III

Diffraction at a straight edge and Diffraction Bands.



Let S be a narrow slit perpendicular to the plane of paper and illuminated with monochromatic light of wavelength λ. Let AB be the straight edge of an opaque obstacle placed parallel to this slit.
Let xy be a Screen to AB. Let SA be joined and produce to meet the Screen in M.

If there were no diffraction of light at straight edge, we would have obtained uniform illumination above M and Complete darkness below it. But actually we observe a few unequally spaced bright and dark bands with poor Constrast and running parallel to the length of the slit in the illuminated region. In the Geometrical shadow the intensity falls rapidly and becomes zero at at a Small yet finite distance from M. This is the diffraction pattern of the Straight edge.

Explanation of Diffraction Bands :– Let ww' be the section of the cylindrical wave-front diverging from S, and P a point in the illuminated region. To find the intensity of light at P, the wave-front is to be divided in to half-period strips. Let us join PS. It intersects ww' at O, which is the pole of the wave-front with respect to P

with P as centre and radii equal to

$$PO+\frac{\lambda}{2},\ PO+\frac{2\lambda}{2},\ PO+\frac{3\lambda}{2},\ ---\ PO+\frac{n\lambda}{2}$$

we mark off point on ww'. Through these points lines are drawn parallel to the length of the slit. The wave-front is thus divided in to half-period strips. There are two similar halves of the wave-front namely Ow and Ow',

The point P receives light from the entire upper half of the wavefront and from those half-period strips of the lower half which are contained in OA. If OA contains one-half period strip then the amplitude at P will be

$$\frac{R_1}{2}+R_1$$

where $\frac{R_1}{2}$ is the amplitude due to the entire half wave-front Ow and R_1 is the amplitude due to the first half-period strip of the lower half Ow'.

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As P moves away from M, OA Contains more and more half-period Strips of the lower half wave-front. If OA Contains 2,3,4, ---- etc, half-period strips the respective amplitudes at P will be

$$\frac{R_1}{2} + R_1 - R_2 \quad \text{(1st minimum}$$

$$\frac{R_1}{2} + R_1 - R_2 + R_3 \quad \text{(2nd maximum)}$$

$$\frac{R_1}{2} + R_1 - R_2 + R_3 - R_4 \quad \text{(2nd minimum)}$$

as so on. Thus the point P is a maximum or a minimum accordings as OA Contains and odd or even number of half-period ~~strit~~ strips.

Clearly as we move away from M in illuminated region, maxima and minima are obtained alternately. The amplitude and hence the intensity of minima are comparable to those of maxima. Hence the bands have a poor Contrast.

When the point P is at a sufficient distance from M, the entire upper half wavefront and a large number of half period Strips of the lower half wave-front are unobstructed. The resultant amplitude at P is then

$$\frac{R_1}{2} + \frac{R_1}{2} = R_1$$

and the resultant is R_1^2. Hence at a sufficient distance from M the diffraction bands merge into uniform illumination.