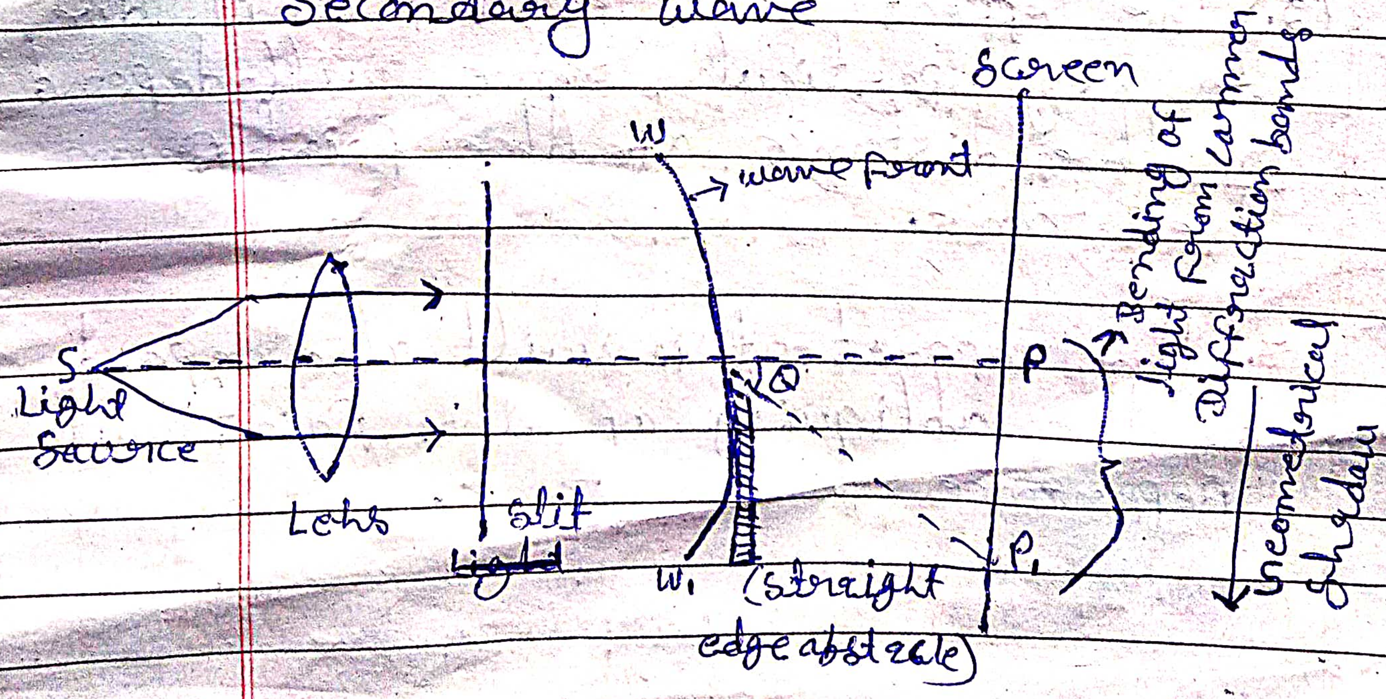
Fresnel's diffraction :→

The bending of light round the Edge of an obstacle or encroachment of light within the geometrical shadow is called diffraction of light. Fresnel tried to explain the phenomenon of diffraction on the basis of Interference of secondary wavelets originating from various points of wave front which are Not blocked off by an obstacle (i.e. upper part AW of wave front WW1). He applied huygen's Principle of Secondary wave



Lets in conjuction with the principle of Interference and calculated the positing of fringes. According to Fresnal —

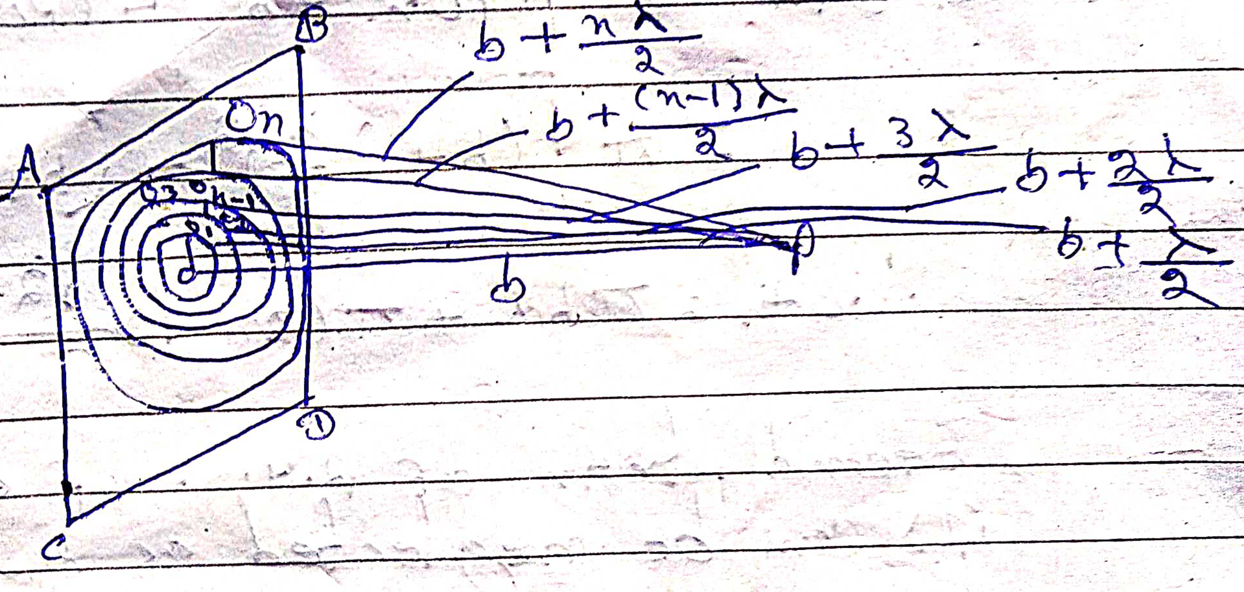
(1.) Each element of surface AW sends out continuous train of waves. The wave front is divided into large number of Fresnel's zones of small area and the resultant effect at any point will depend on the combined effect of all secondary waves originating from various zones.

(2.) The effect at a point P or P_1 due to any particular zone will depend on the distance of the point from the zone.

(3.) The effect at P_1 will also depend on the obliquity of the point with reference to the zone.

Fresnel's half period zones:— Here ABCD is a plane wave front of monochromatic light of wavelength λ. we are to find the resultant Inten-sity at P due to all wavelets

Now the whole wavefront is divided Into a number of Fresnel half period zones in the fol-lowing way:



From P, a perpendicular PO(=b) is drawn on ABCD. O is called pole with P as centre and radii $(b+\frac{\lambda}{2})$, $(b+\frac{3\lambda}{2})$, $(b+\frac{3\lambda}{2})$ etc. spheres are drawn the sections of which on wavefront are concentric circles O_1, O_2 .....

The area of first circle O_1 is called first half period zone. The annular zone between circles O_1 and O_2 is called second half period zone and so on.

Thus area of nth zone,

$$A_n = \pi (OO_n)^2 - \pi (OO_{n-1})^2$$

$$\text{or, } A_n = \pi \{ (PO_n^2 - b^2) - (PO^2_{n-1} - b) \}$$

$$= \pi \left[\left(b + \frac{n\lambda}{2}\right)^2 - \left\{ b + (n-1)\frac{\lambda}{2} \right\}^2 \right]$$

$$\therefore A_n = \pi b \lambda + \pi (2n-1) \frac{\lambda^2}{4}$$

Second term of R.H.S. of equation (1) can be neglected as b is very large in comparison to λ.

$$\therefore A_n = \pi b \lambda$$

Equation (2) shows that all zones are approximately equal in area. Infact, the area will increase with order of n of zone according to equation (1.)

Intensity calculation at P:

Let $R_1, R_2, \ldots R_n$ be the resultant displacements at P due to all wavelets coming from first, second ... n^{th} zone respectively. hence resultant displacement at P due to all zones.

$$R = R_1 + R_2 + \ldots + R_n$$

Now displacement at P due to any zone (iii) obliquity of the zone.

Thus $R \propto \pi b_n \lambda$ [b_n = distance of the zone from P.]

$$\propto \frac{1}{b_n}$$

$\therefore R \propto \pi \lambda$ (which is constant)

Now as the obliquity of a zone Increases with the increase of Its order number n, we conclude that $R_1, R_2 \ldots R_n$ are in descending order of magnitude.

If phase of wavelet coming from O is zero then that of the wavelet from O_1 would be π. hence average phase of all wavelets coming from the first half period zone is $\frac{\pi}{2}$. Similarly the average phase of the wavelets from second half period zone is $\frac{3\pi}{2}$ which is opposite to the first zone.

~~from second half period zone is $\frac{3\pi}{}$~~

Thus displacements from alternate zones will have opposite phases.

hence $R = R_1 - R_2 + R_3 - R_4 + \ldots + (-1)^{n-1} R_n$

$$\text{or, } R = \frac{R_1}{2} + \left(\frac{R_1 + R_3}{2} - R_2\right) + \left(\frac{R_3 + R_5}{2} - R_4\right) + \ldots + \frac{R_n}{2}$$

As R_1, R_2 .... are in descending order $\frac{R_1 + R_3}{2}$ is approximately equal to R_2 and so on.

$\therefore R = \frac{R_1}{2} + \frac{R_n}{2}$. If n is very large then R_n is ~~is~~ zero.

$\therefore R = \frac{R_1}{2}$

Thus resultant displacement P due to whole wavefront is equal to half the displacement of the secondary waves from the first half - period zone.