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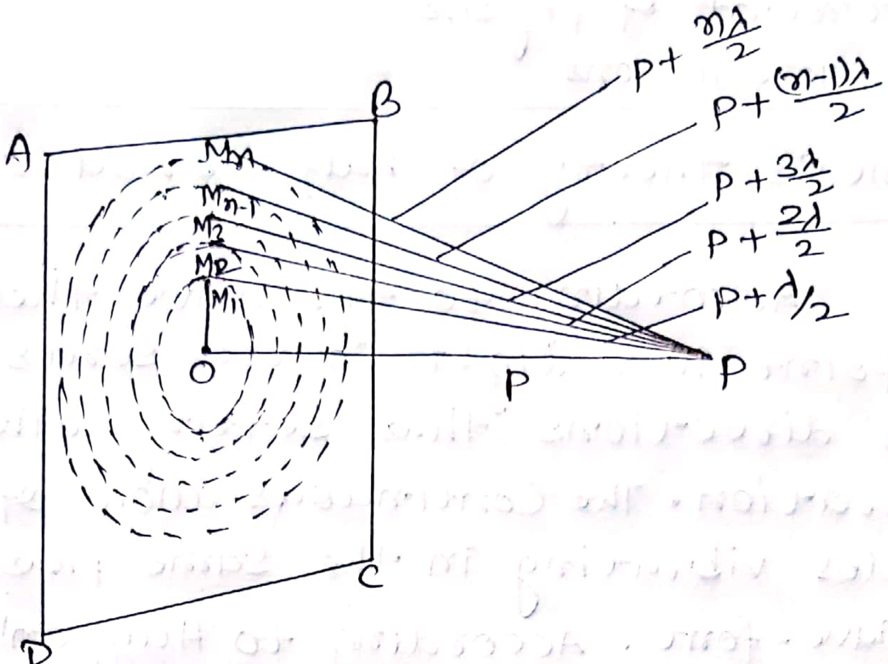
B.Sc (Part-II) Hons Paper-III

Fresnel's theory of half period zones.

According to the wave theory of light, each point in a light source sends out waves in all directions, thus setting ether particles in vibration. The continuous locus of all ether particles vibrating in the same phase is called the wave-front. According to Huygen's principle, each point on wave front sends out secondary wavelets. Fresnel assumed that these wavelets are in a position to interfere and the resultant intensity of light at any point is the result of interference of these wavelets. In order to calculate the resultant intensity at a point due to a wave front, Fresnel divided the wave front, in to a number of zones called Fresnel's half period zones.

Half-period zones:— Let ABCD be a plane wave-front of monochromatic light of wavelength λ, travelling from left to right. Let P be an external point at which the effect of ~~light~~ entire wave-front is to be found. Let us draw from the point P a perpendicular PO to the wave-front. Let PO = P. The point O is called pole of the wave-front corresponding to p.



Let us draw, with P as centre and radii $p+\lambda/2$, $p+2\lambda/2$, $p+3\lambda/2$ ---- etc, a series of spheres. The section of these spheres by the plane wave-front are concentric circles about the common centre O. The area of the first circle is called the first half-period zone, the angular area between the first circle and the second circle is called the second half-period zone, and so on. Thus the annular area between $(n-1)$th circle and the nth circle is the nth half-period zone.

Area of zone:- The area of the nth zone

$$= \pi (OM_n)^2 - \pi (OM_{n-1})^2$$

$$= \pi\left[(PM_n)^2 - (PO)^2\right] - \pi\left[(PM_{n-1})^2 - (PO)^2\right]$$

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

$$= \pi \left[p n\lambda + \frac{n^2\lambda^2}{4} - p(n-1)\lambda - (n-1)^2\frac{\lambda^2}{4} \right]$$

$$= \pi \left[p n\lambda + \frac{n^2\lambda^2}{4} - p n\lambda + p\lambda - (n-1)^2\frac{\lambda^2}{4} \right]$$

$$= \pi \left[p\lambda + \frac{\lambda^2}{4} \left\{ n^2 - (n-1)^2 \right\} \right]$$

$$= \pi \left[p\lambda + \frac{\lambda^2}{4}(2n-1) \right] \quad \text{——— (1)}$$

Since $p >> \lambda$ then λ^2 term can be ignored as compared to $p\lambda$ in above. Then area of the zone is $\pi p\lambda$ approximately. That is the area of each zone is approximately same, while more accurately it increases slightly with n.

Further, the average distance of the nth zone from P is

$$= \frac{\left\{ p + \frac{n\lambda}{2} \right\} + \left\{ p + (n-1)\frac{\lambda}{2} \right\}}{2}$$

$$= p + (2n-1)\frac{\lambda}{4} \quad \text{——— (2)}$$

Amplitude due to a zone! — The amplitude of the disturbance at P due to a zone is

(i) Directly proportional to the area of the zone.

(ii) Inversely proportional to the average distance of the zone from P. and

(iii) Directly proportional to the obliquity factor $(1+\cos\theta)$, where θ is the tangent between the normal to the zone and the line joining the zone to p.

$\therefore$ Amplitude due to the nth zone

$$R_n \propto \frac{\pi\left[p\lambda + \frac{\lambda^2}{4}(2n-1)\right]}{p+(2n-1)\lambda/4}(1+\cos\theta_n)$$

$$\propto \pi\lambda(1+\cos\theta_n)$$

Now as the order of the zone, n increases θ_n and $\cos\theta_n$ decreases. Therefore the amplitude of the wave at p due to a zone decreases as the order of the zone increases.