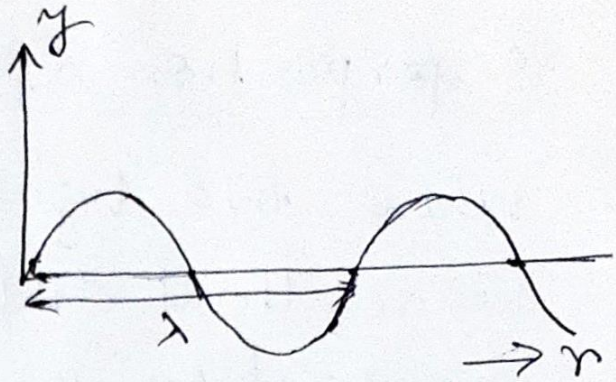
Superposition of waves: Interference

When two light waves superimpose, then the resultant amplitude in the region of superposition is different than the individual ones. This modification of amplitude or intensity of wave in the region of superposition is called interference of light. There are two types of interference of light, constructive and destructive interference. Constructive interference takes place in the region of superposition when individual displacement of waves are directed in the same direction as $y = y_1 + y_2$. Destructive interference takes place in the region of superposition when individual displacement of waves are directed in opposite direction as $y = y_1 - y_2$.

Relation between phase difference and path difference

Let us consider a particle at the origion executing SHM and creating a wave with an amplitude 'a' and time period $T = \frac{2\pi}{\omega}$. The displacement y of the particle at time t is $y = a \sin \omega t$, where ω is the angular frequency and ωt is the phase of the particle.



In case of progressive wave in +ve direction of origin, the phase of the particle decreases regularly and after a certain distance λ (wavelength) the phase decreases by 2π. Thus for an advancement of distance r the phase decreases by $\frac{2\pi r}{\lambda}$. Hence phase of the particle at a distance r from the origin and at a time t becomes $\left(\omega t - \frac{2\pi r}{\lambda}\right)$.

Thus the displacement at that point is given by $y = a \sin\left(\omega t - \frac{2\pi r}{\lambda}\right) = a \sin\left(\frac{2\pi}{T} t - \frac{2\pi r}{\lambda}\right)$

$\therefore y = a \sin \frac{2\pi}{\lambda}\left(\frac{\lambda t}{T} - r\right)$ as velocity of wave is $v = \lambda / T$ then $y = a \sin \frac{2\pi}{\lambda}(vt - r)$

If we take two particles at a distance r_1 and r_2 from the origin, then corresponding displacements are

$y_1 = a \sin \frac{2\pi}{\lambda}(vt - r_1)$ and $y_2 = a \sin \frac{2\pi}{\lambda}(vt - r_2)$

Therefore phase difference between two particles on the wave is

$$\delta = \frac{2\pi}{\lambda}(vt - r_1) - \frac{2\pi}{\lambda}(vt - r_2) = \frac{2\pi}{\lambda}(r_2 - r_1)$$

Now $r_2 - r_1$ is path difference between two particles. So $\boxed{\text{phase difference} = \frac{2\pi}{\lambda} \times \text{path difference}}$