Interference

It is the process whereby two or more waves of the same frequency or wavelength combine to form a wave whose amplitude is the sum of the amplitudes of the interfering waves. The interfering waves can be electromagnetic, acoustic, or water waves.

Superposition of waves

Consider a region in space where two or more waves pass through at the same time. According to the super position principle, the net displacement is simply given by the vector or the algebraic sum of the individual displacements. Interference is the combination of two or more waves to form a composite wave.

Interference types:

1-Constructive interference: occurs when two waves are in phase. To be in phase, the points on the wave must have

$\Delta\emptyset = (2\pi)m$, where m is an integer.

Path difference $\Delta l = m\lambda$ where m: is an integer

2-Destructive interference: occurs when two waves are a half cycle out of phase. To be out of phase the points on the wave must have: $\Delta\emptyset = (2\pi)(m+1/2)$

Path difference: $\Delta l = (m + 1/2)\lambda$

Conditions of interference

The following four conditions must be turn in order for an interference pattern to be observed.

1-the source must be coherent (has a constant phase relationship).

2-wavelengths must be the same (monochromatic).

3-the principle of superposition must apply.

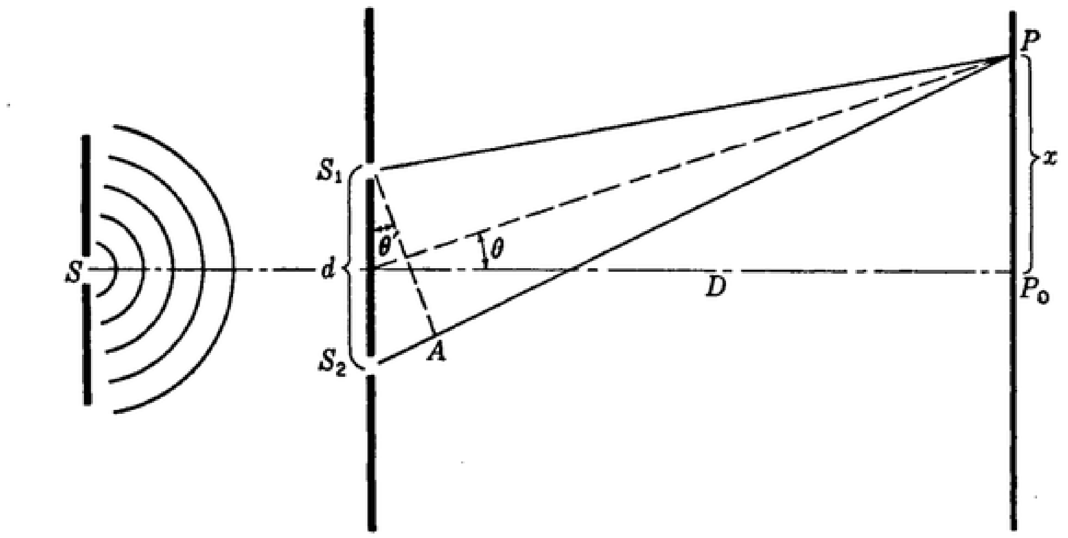
4-the wave have the same polarization state.

Huygen' s principle

Huygen 's proposed that :A wave front may be regarded as a new source of waves.

Young' s experiment(double-slit experiment)

In young's experiment of interference the light is passes through a pinhole (s_0) in the sheet (A), at a considerable distance away, through two pinhole (s_1) and (s_2) in sheet (B), combine in the region after the sheet (B), the interference phenomenon will be happened between the two transmitted waves from two pinholes, this phenomenon can be observed as a fringe mode on the sheet (c).



Path difference in Young's experiment.

Now, suppose that the light is monochromatic with a wavelength λ, the distance d between two pinholes smaller than the distance D between the two sheets C, B.

The condition for maximum intensity (**bright fringe)** in point (p) on sheet c is:

$$\boxed{d\sin\Theta = m\lambda} \quad ,m=0,1,2,3\ldots\ldots\ldots$$

And the condition for the minimum intensity (**dark fringe**) is:

$$\boxed{d\sin\Theta = (m+1/2)\lambda} \quad ,m=0,1,2,3\ldots\ldots\ldots$$

Interference fringes from a double slit

The geometry of the double slit interference is shown in fig.(1)

Consider a light that falls on the screen at a point p which it is at a distance (x_n) from the point 0 that lies on the screen, D is the perpendicular distance from the double slit system. The two slits are separated by a distance d.

Now we derive the fringe separation equation:-

At point 0, the path difference between the two waves:

$S_2 0 - S_1 0 = 0$ …………1)

At point p,the position of the nth order bright fringe (or maxima),the path difference between the two sources $S_1$and S_2 must differ by a whole number of wavelengths:

Path difference:$S_2 p - S_1 p = m\lambda$ …….2)

As a distance D is very much larger than d, the path difference ($S_2 p - S_1 p$) can be approximated by dropping a perpendicular line($S_1 N$) to $S_2 P$ such that $S_1 p$ –Np.

Path difference $S_2 P - S_1 p - S_2 N = m\lambda$ --------3)

And from geometry:

$S_2 N = d\sin\Theta$ ……….4)

Where d: is the distance between the centers of the two slits.

Equating eqns.(3,4) yields:

$d\sin\Theta = m\lambda$ …….5)

$\sin\Theta = m\lambda / d$ ……6)

but fom geometry: $\tan\Theta = X_n / D$ $X_{n:}$ is the distance of nth order fringe from the central axis.

Since Θ is usually very small, $\tan\Theta \sim \sin\Theta$

i.e $X_n / D = m\lambda / d$

or:

$\boxed{X_n = m\lambda D / d}$ …7 fringe separation between any bright fringe and the central fringe

Similarly, we can write for the dark fringe

$\boxed{X_n = (m+1/2)\lambda D/d}$ fringe separation between any dark fringe and the central fringe

Thus the separation between adjacent fringes is:

$$\Delta X = X_{n+1} - X_n = (m+1)\lambda D / d - m\lambda D / d$$

Fringe separation between two adjacent bright fringes:

$$\boxed{\mathbf{\Delta X = \lambda D / d}}$$