# Engineering Optics

## Lecture 6

*by*

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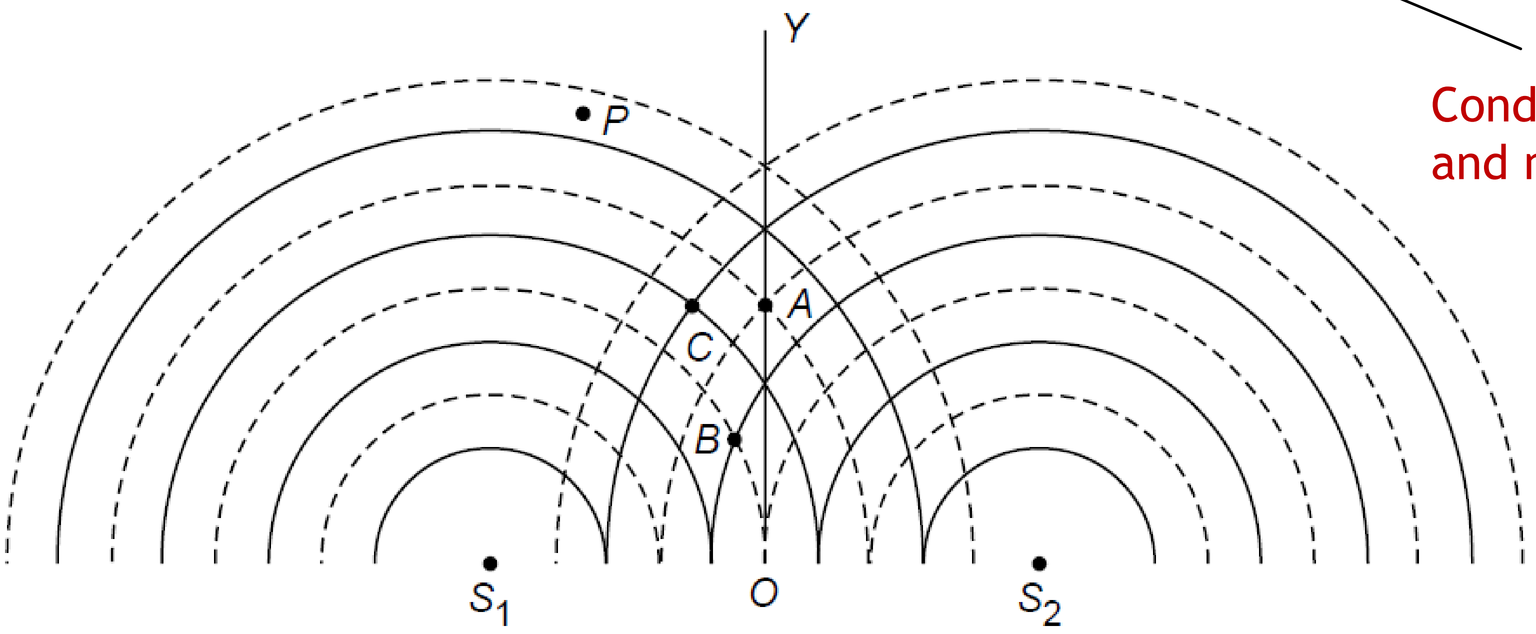
# Interference between two waves e.g. on *surface of water*

**Example-1:** when the sources are vibrating in phase

Refer. '14.2 INTERFERENCE PATTERN PRODUCED ON THE SURFACE OF WATER'

Conditions for maxima and minima?




Waves emanating from two point sources $S_1$ and $S_2$ vibrating in phase. The solid and the dashed curves represent the positions of the crests and troughs, respectively.

Optics, Ghatak

# Answer

at $A$

$y = y_1 + y_2$

$= 2a \cos \omega t$

$S_2C - S_1C = \lambda$

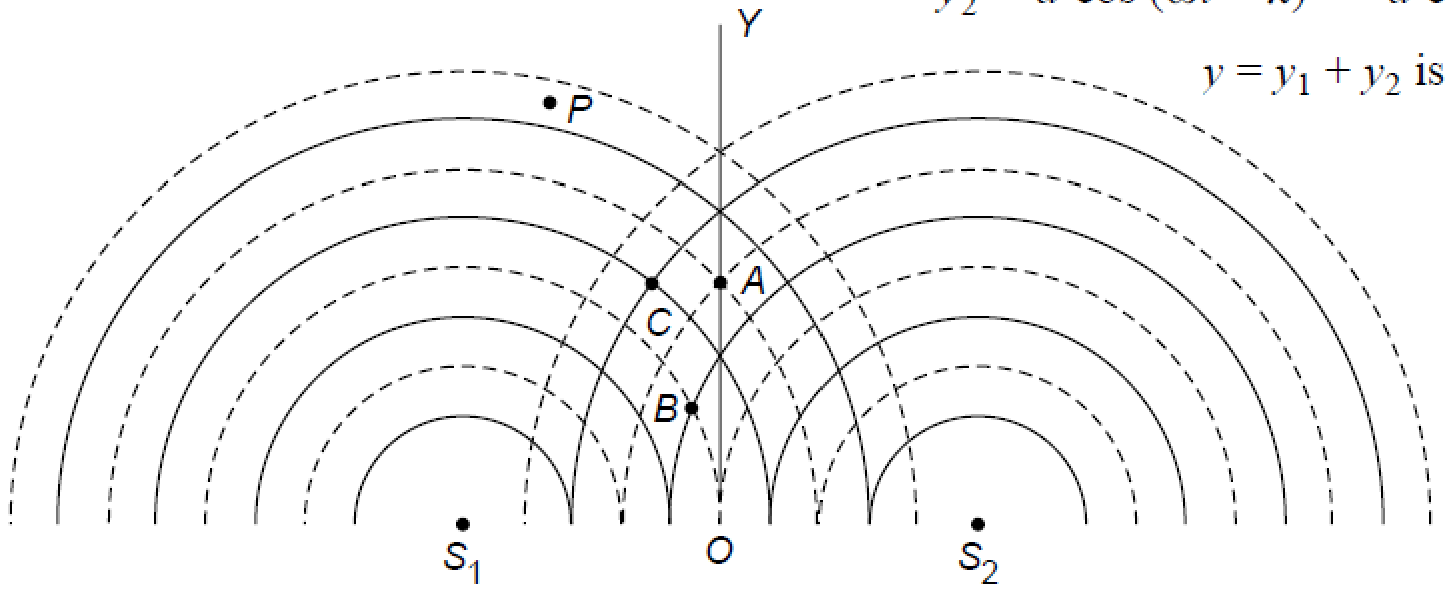
$S_2P \sim S_1P = n\lambda$ (maxima)

$S_2B - S_1B = \lambda/2$

$y_1 = a \cos \omega t$

$y_2 = a \cos (\omega t - \pi) = -a \cos \omega t$

$y = y_1 + y_2$ is zero at all times.

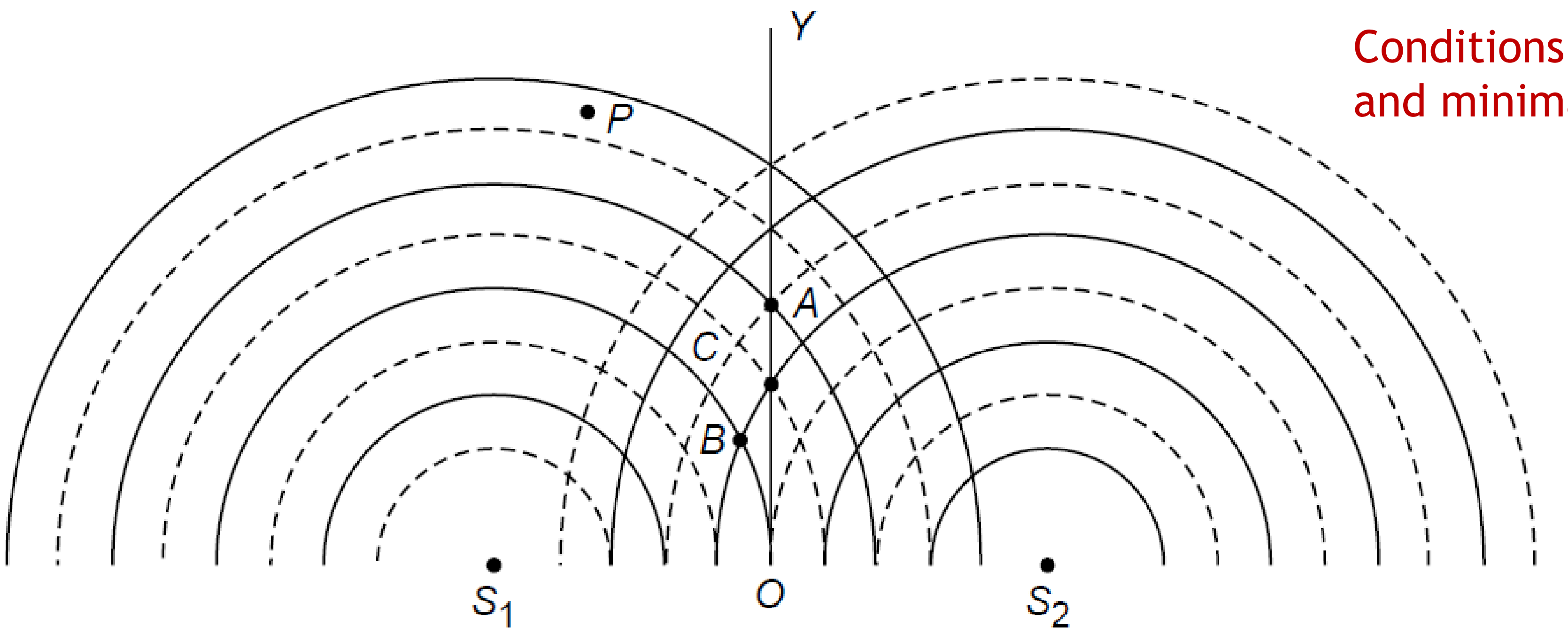



$\boxed{S_2P \sim S_1P = n\lambda \qquad \text{(maxima)}}$

$\boxed{S_2P \sim S_1P = \left(n + \frac{1}{2}\right)\lambda \qquad \text{(minima)}}$

# Interference between two waves

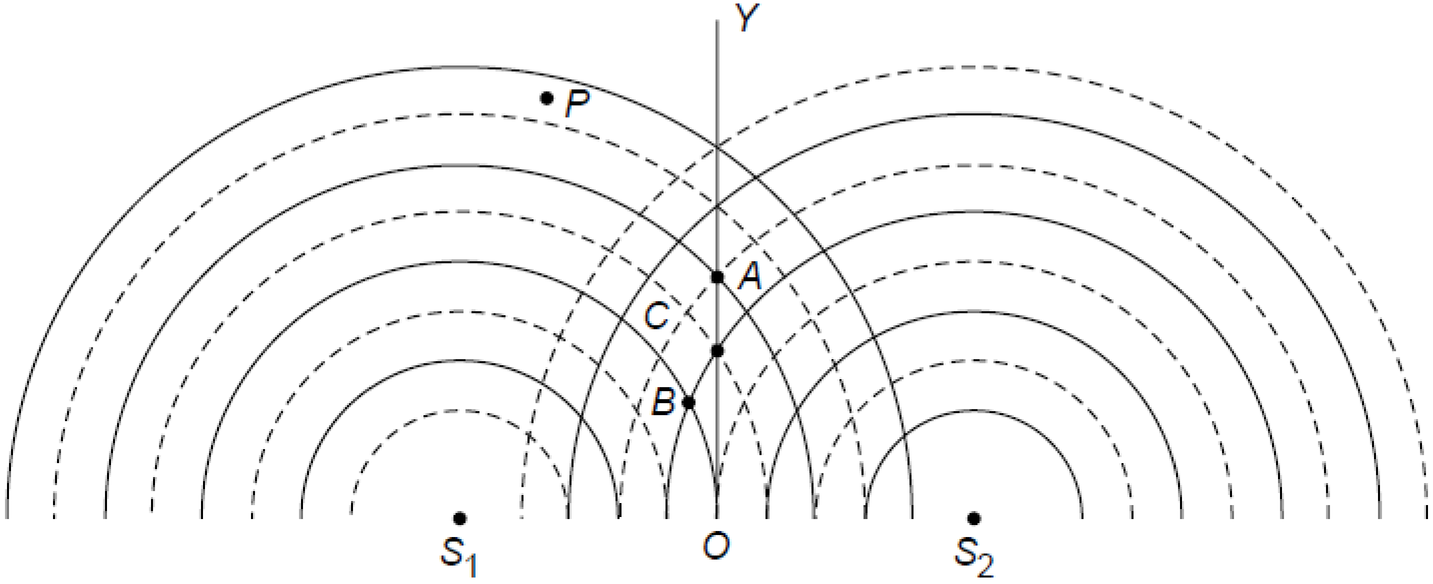
- Example-2: when the sources are vibrating out of phase
- Refer. ‘14.2 INTERFERENCE PATTERN PRODUCED ON THE SURFACE OF WATER’




Waves emanating from two point sources $S_1$ and $S_2$ vibrating out of phase.

Conditions for maxima and minima?

Optics, Ghatak




Waves emanating from two point sources $S_1$ and $S_2$ vibrating out of phase.

$$S_2B - S_1B = \lambda/2$$

$$S_2P \sim S_1P = \left(n + \frac{1}{2}\right)\lambda \qquad \text{(maxima)}$$

$$S_2P \sim S_1P = n\lambda \qquad \text{(minima)}$$

# Coherence: constant phase relationship

- Whenever the phase difference is constant, a stationary interference pattern is produced.
- The positions of the maxima and minima → depend on the phase difference
- Two sources which vibrate with a fixed phase difference between them are said to be **coherent**.'

# Constantly changing phase

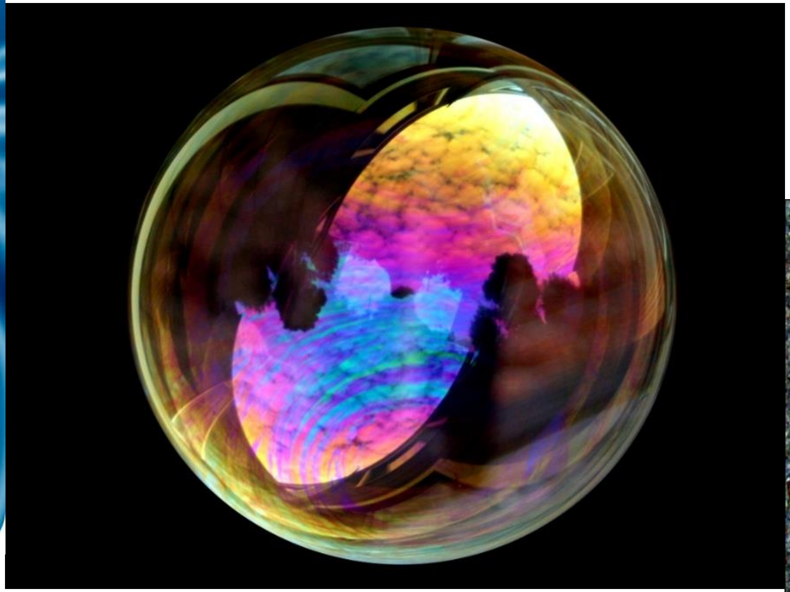
- Changing phase difference → sometimes in phase, sometimes out of phase,
- No stationary interference can be observed,
- sources are said to be **incoherent**

Optics, Hecht

# Interference

**Superposition of waves→ resultant wave**

https://flexbooks.ck12.org/cbook/
ck-12-physics-flexbook-2.0/section
/11.5/primary/lesson/wave-interference-ms-ps



Soap bubble

https://simple.wikipedia.org/wiki/Interference#/media/
File:Soap_bubble_sky.jpg

Oil on water

https://simple.wikipedia.org/wiki/Interference#/media/
File:Soap_bubble_sky.jpg

# Few points to note

- The wave theory for EM nature of light provides a natural basis from which to proceed.
- As we have seen, it obeys the important Superposition Principle.
- The resultant electric-field intensity **E**, at a point in space where two or more lightwaves overlap, is equal to the vector sum of the individual constituent disturbances.
- Optical interference corresponds to the interaction of two or more lightwaves yielding a resultant irradiance that deviates from the sum of the component irradiances.
- After being superimposed, the individual waves separate and continue on, completely unaffected by their previous encounter.

# Question:

- If you use two conventional light sources (such as two sodium lamps) illuminating two pinholes, will you observe interference pattern on the screen?

- Each atom emitting light for about $10^{-10}$ s, i.e., light emitted by an atom is essentially a pulse lasting for only $10^{-10}$ s.
- such a short pulse consists of about 1 million oscillations;
- Even if the atoms were emitting under similar conditions, waves from different atoms would differ in their initial phases.
- Consequently, light coming out from S1 and S2 will have a fixed phase relationship for about 10–10 s, if any
- Interference pattern will keep on changing every billionth of a second.
- The eye can notice intensity changes which last at least for 0.1 s, and hence we will observe a uniform intensity.
- If we have a camera whose time of shutter opening can be made less than $10^{-10}$ s, then the film will record an interference pattern.
- light beams from two independent sources do not have any fixed relationship, as such, they do not produce any stationary interference pattern.

# Thank You