Studybeesofficial

Where Minds Pollinate

Class 12

Physics

Chapter 18

Handwritten Notes

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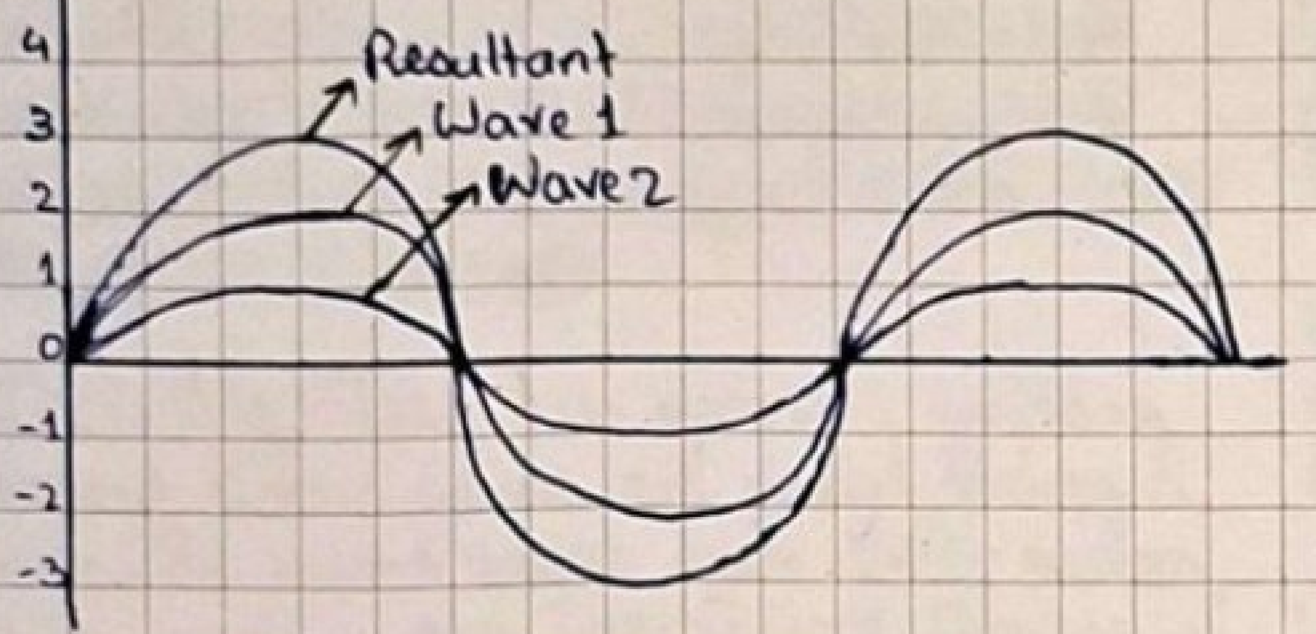
10 November 2025

Diffraction & Interference

Principle of Superposition

When two or more waves meet at a point, the resultant displacement is the vector sum of displacement due to each wave individually.



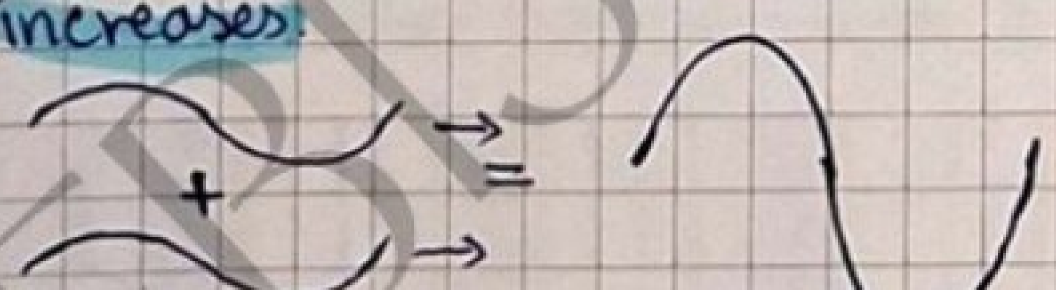
Interference

Interference is the phenomenon of superposition of two or more waves that results in the formation of new wave with amplitude increased, decreased or zero.

Conditions for Interference: Waves must be coherent. Must arrive at same time and at same place. Waves should travel in the same direction. Waves must be same type.

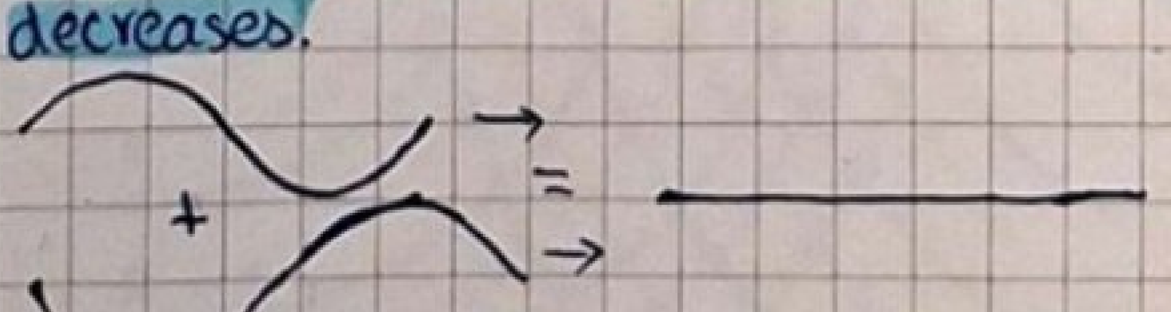
Types of Interference:

a) **Constructive:** In constructive intereference, crest of one wave overlape crest of other wave and amplitude of resultant wave increases.

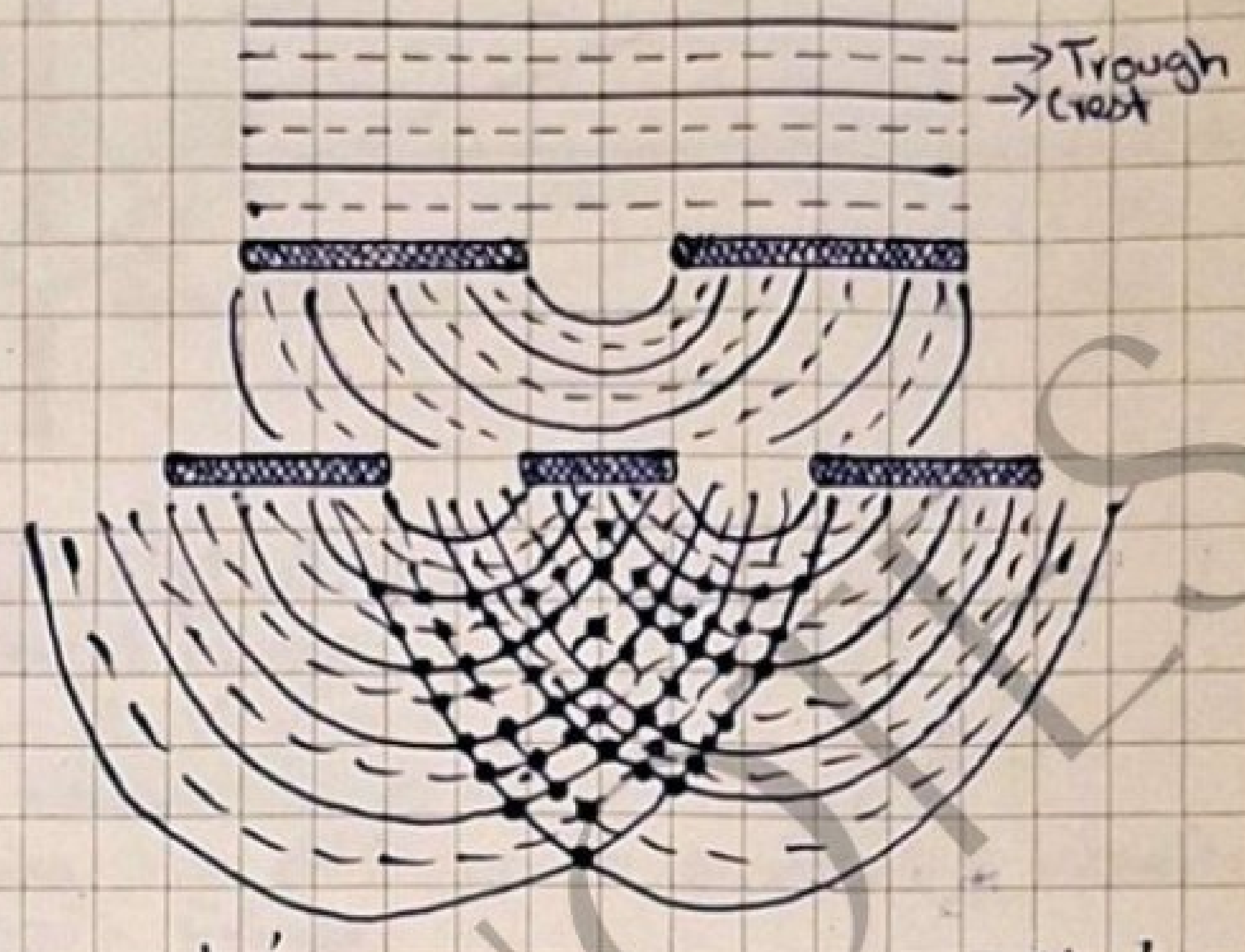


- Path difference $= n\lambda$ $\because n = 0, 1, 2, 3 \ldots$
- Waves should be in phase ($0°$).

b) **Destructive:** In destructive interference crest of one wave overlap trough of other wave and amplitude of resultant wave decreases.



- Path Difference $= (n + 1/2\ \lambda)$ $\because n = 1, 2 \ldots$
- Waves should be out of phase ($180°$)



Where it is D·I and Where it is C·I.

Conditions To Observe: Two source emitting waves must be coherent. Slits must be narrow and close as compare to the wavelength. Source should have only a single wavelength. Experimentl setup must be free from disturbance.

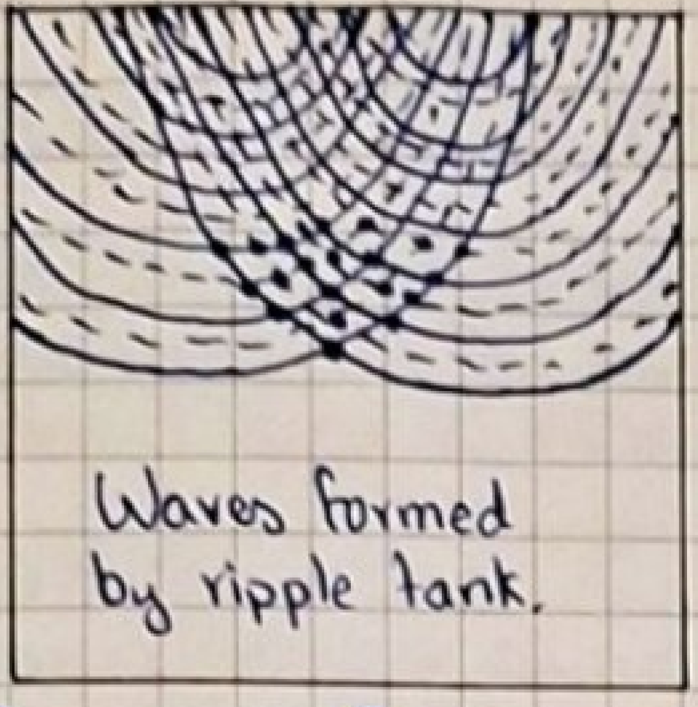
Interference of Water Waves

Interference can be demonstrated in a ripple tank by using two point source of vibration. These coherent source of vibrations produce circular waves in water. Light bulb is used to illuminate the tank.

Intereference: Circular waves from both sources meet and produce intereferance. There are two types of intereference, constructive and destructive.

Constructive: Region where the waves reinforce each other and produce large amplitude is called constructive intereference region. If two waves arrive in phase ($0°$), they will interfere constructively. Resultant wave produces much higher crest as compared to individual waves and much deeper trough.

Destructive: There are regions where waves cancel the effect of each other due to destructive interference. If two wave arrive in such a way that these are out of phase ($180°$), they will produce destructive Intereference. The resultant wave will have smaller or zero amplitude.



Waves formed by ripple tank.

Interference of Sound Waves

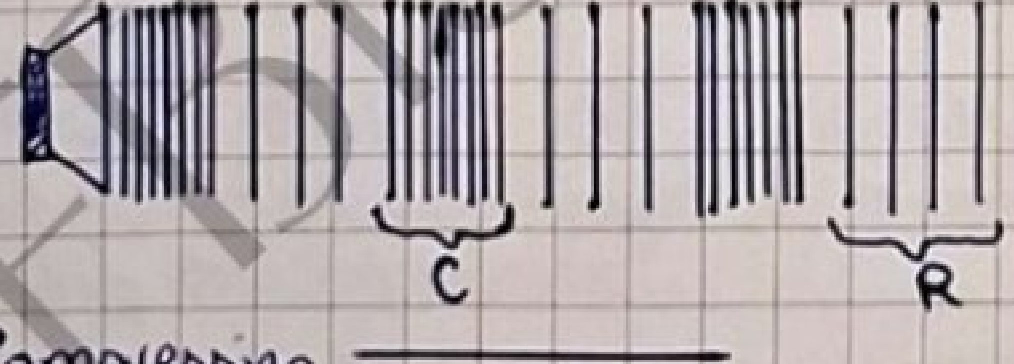
The effect produced by superposition of sound waves from two coherent sources, passing through same region is known as intereference of sound.

Activity: Take two speakers emitting coherent sound waves are placed facing a screen. The sound waves from both sources overlap and produce intereference. Regions of constructive and destructive interference formed. This interference pattern can be observed by using microphone or detectors to measure intensity of sound at various points on screen.

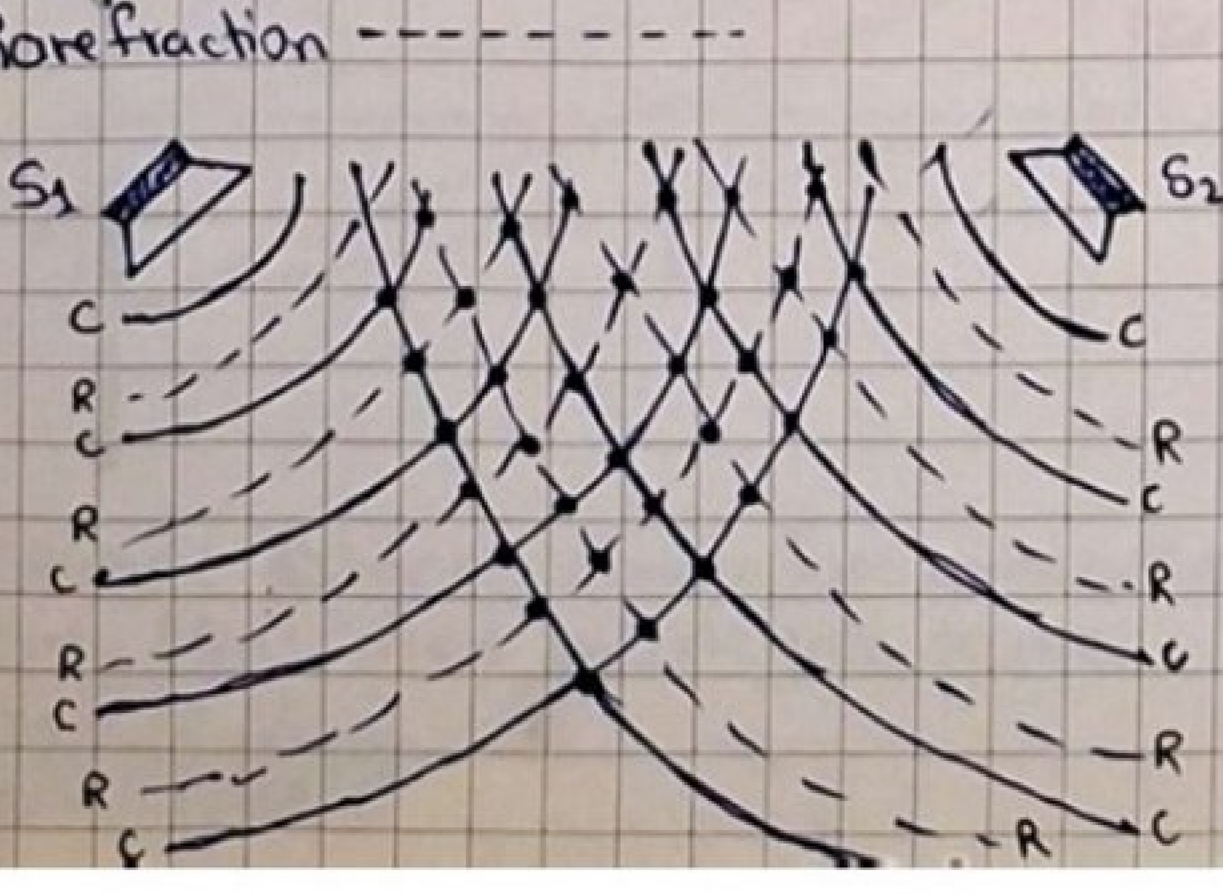
Explanation: Consider two load speakers are connected at the same signal generator and amplifier producing notes of same frequency. Sound waves consists of compressions and rarefractions.

Constructive Interference: A point where compression align with compression and rarefraction align with rarefraction, constructive intereference is produced.

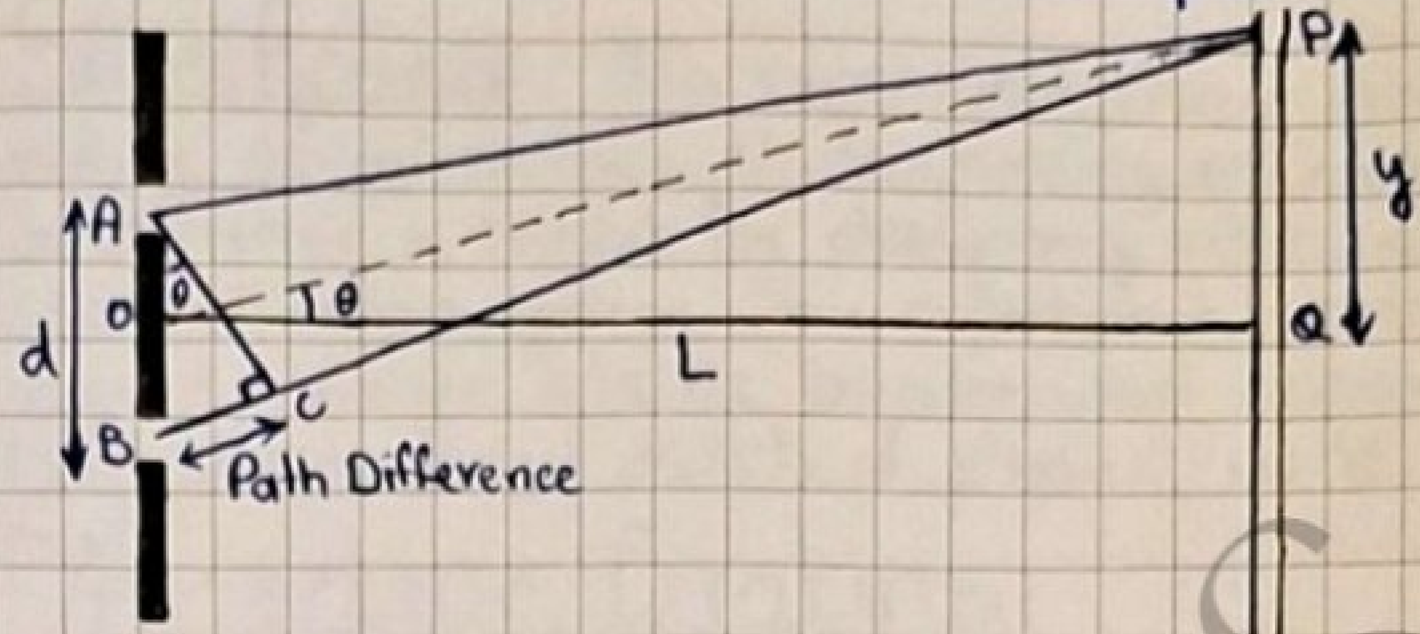
Destructive Intereference: A point where compression align with rarefraction, destructive intereference takes place.



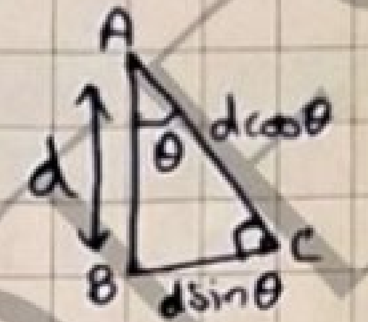
Compression ————
Rarefraction - - - - - - - -



Young's Double Slit Experiment



Conditions:



- **Bright Fringe:**

$\overline{BC} = d\sin\theta = n\lambda$

$= d\sin\theta = n\lambda$ — (i)

Using path difference of constructive intereference.

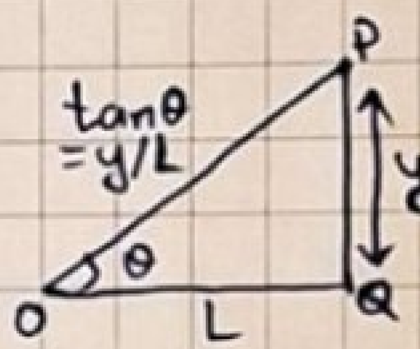
- **Dark Fringe:**

$\overline{BC} = d\sin\theta = [n + 1/2]\lambda$

$= d\sin\theta = [n + 1/2]\lambda$ — (ii)

Using path difference of destructive intereference.

Positions:



- **Bright Fringe:**

$y = L\tan\theta$ — (iii)

$\because \tan\theta \approx \sin\theta$

$y = L\sin\theta$ — (iv)

Using equation (i)

$d\sin\theta = n\lambda$

$\sin\theta = n\lambda/d$

Putting the value in equation (iv)

$y = Ln\lambda/d$

- **Dark Fringe:**

Using equation (ii)

$d\sin\theta = [n+1/2]\lambda$

$\sin\theta = [n+1/2]\lambda/d$

Putting the value in equation (iv)

$y = L[n+1/2]\lambda/d$

$y = [n+1/2]\lambda L/d$

Spacing:

- **Bright Fringe:**

$y_n = n\lambda L/d$ — (v)

$y_{n+1} = (n+1)\lambda L/d = n\lambda L/d + \lambda L/d$ — (vi)

Subtracting equation (v) from equation (vi)

$y_{n+1} - y_n = \cancel{n\lambda L/d} + \lambda L/d - \cancel{n\lambda L/d}$

$y_{n+1} - y_n = \lambda L/d$

- **Dark Fringe:**

$y_n = [n+1/2]\lambda L/d = n\lambda L/d + \lambda L/2d$ — (vii)

$y_{n+1} = [n+1+1/2]\lambda L/d = [n+3/2]\lambda L/d$

$= n\lambda L/d + 3/2\,\lambda L/d$ — (viii)

Subtracting equation (vii) from equation (viii)

$y_{n+1} - y_n = \cancel{n\lambda L/d} + 3/2\,\lambda L/d - \cancel{n\lambda L/d} - \lambda L/2d$

$y_{n+1} - y_n = 3\lambda L/2d - \lambda L/2d$

$= \dfrac{3\lambda L - \lambda L}{2d}$

$y_{n+1} - y_n = \lambda L/d$

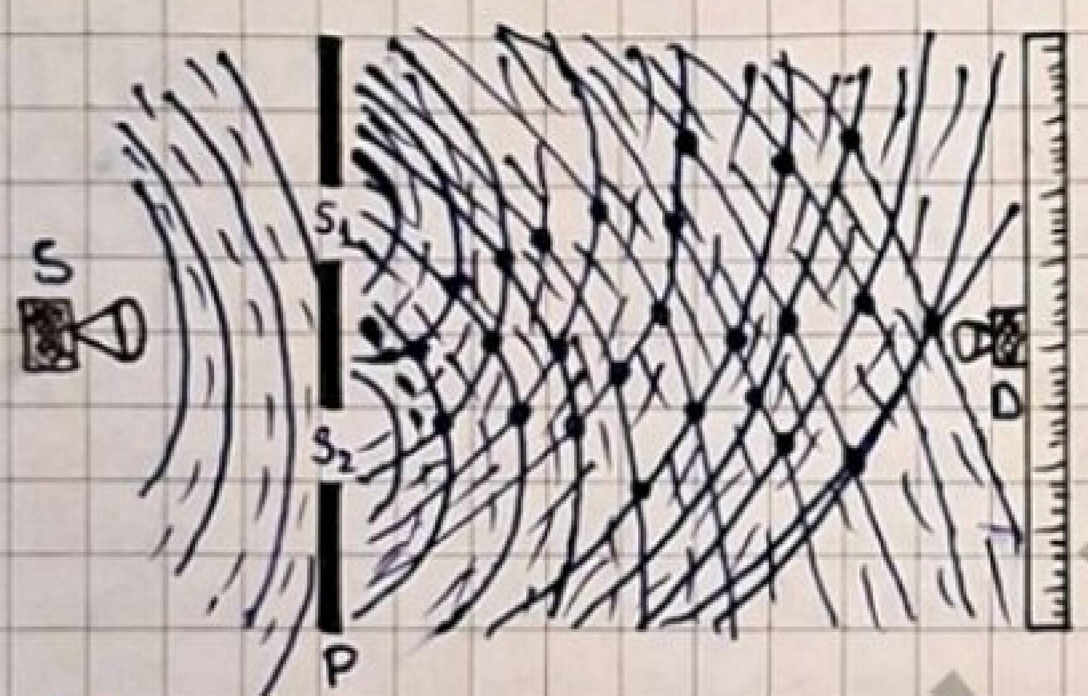
Inference of Microwaves

Microwaves can be used to demonstrate two source interference. In this experiment we use two coherent source of microwaves.

Experiment:

Apparatus: • Microwave source (S)
• Microwave detector (D)
• Metal plates with two slits (P)

Procedure: Place metal plates with two slits in front of microwave transmitter and microwave detector behind plates. Transmitter emitts microwaves towards slits which acts as new coherent sources. Waves coming from these coherent sources overlap and intereference produced. Place receiver at different positions on screen. At some positions detector produces loud sound and at some positions no sound is produced.



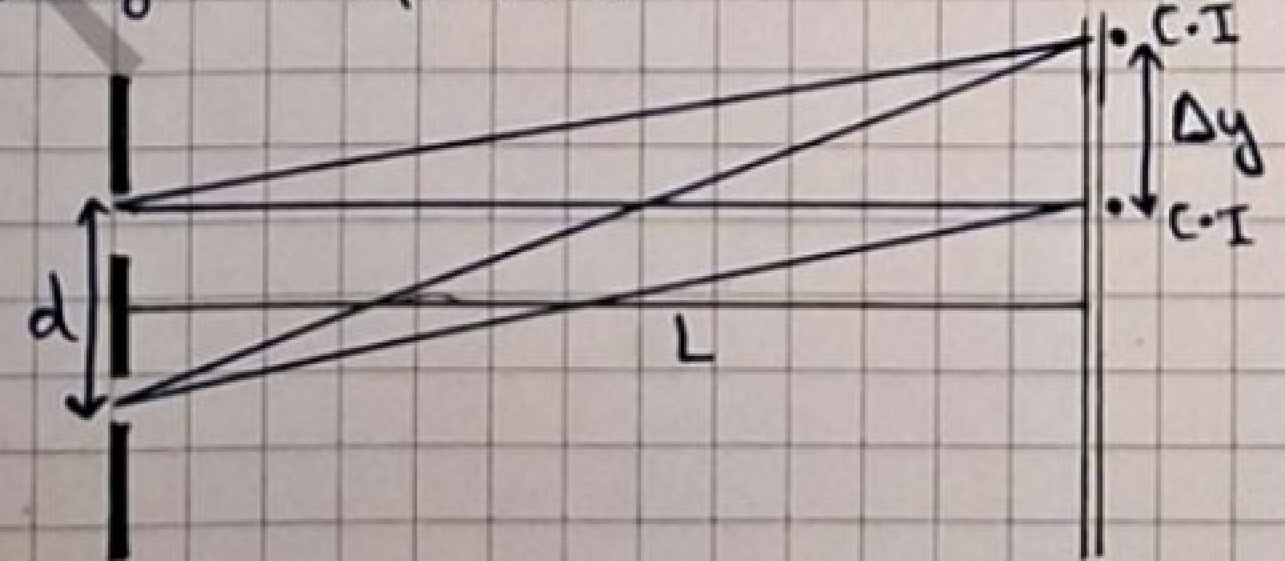
Observation:

Constructive Intereference: A point at which detector produces loud sound, constructive intereference is produced. Path difference = $n\lambda$, where $n = 0, 1, 2, 3, 4$ ......

Destructive Intereference: A point where detector produce low sound or no sound at all, destructive intereference produced. Path difference = $\{n + 1/2\}\lambda$, where $n = 0, 1, 2, 3$...

Wavelength of Microwave:

We can find wavelength of microwave using this experiment.



Measure distance between two consecutive points (Δy), where intereference occure.

$\Delta y = \lambda L/d$

$\lambda = \Delta y d/L$

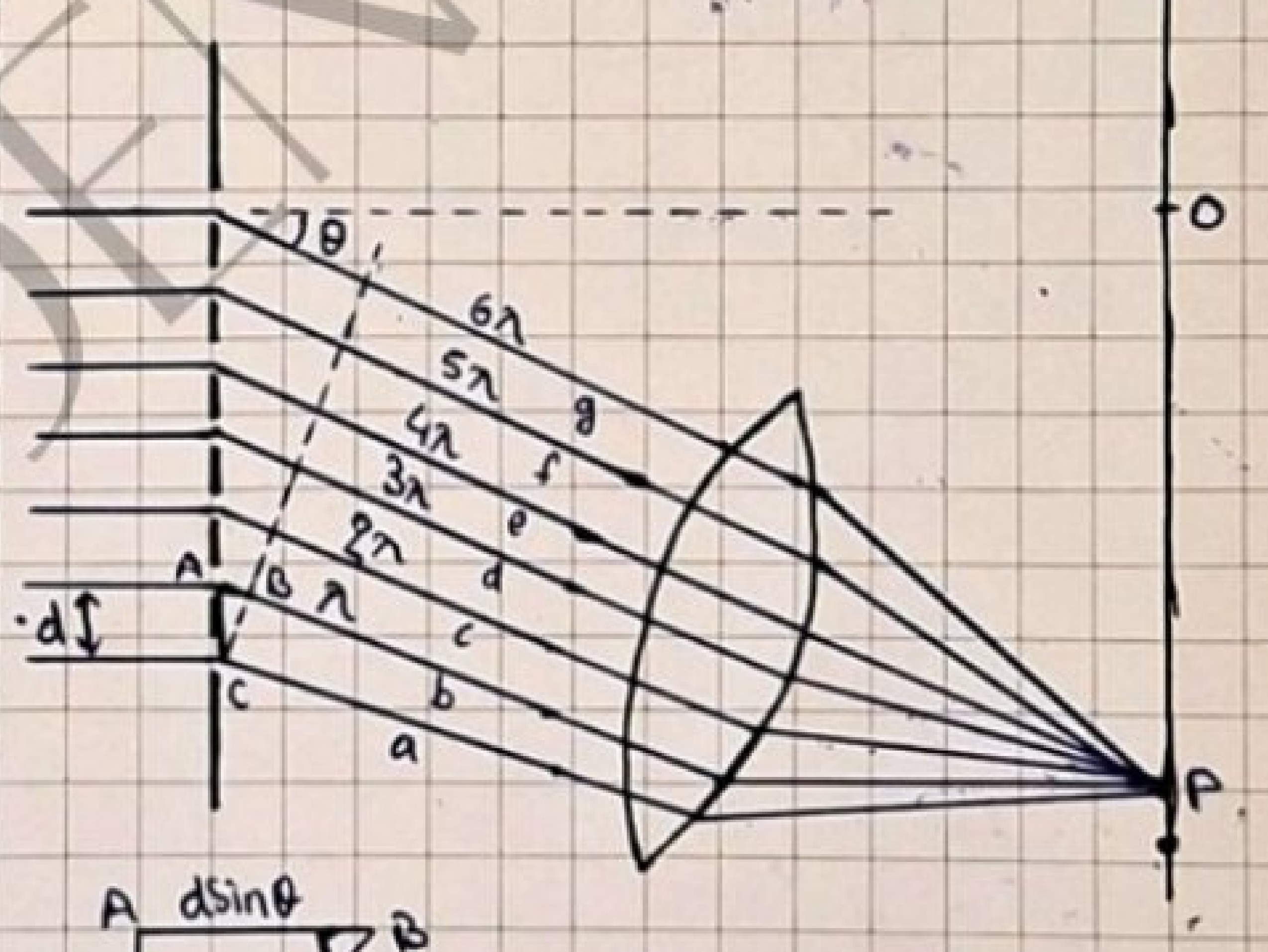
'L' is the distance from screen and "d" is space between slits.

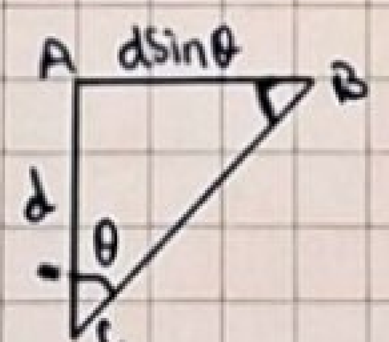
Significance: This experiment shows wave nature of microwaves. Understanding microwave intereference is crucial for designing microwave communication system. This experiment provides valuable insight into the broader wave phenomenon that govern various aspects of physical world.

Diffraction Grating:

A diffraction grating is a device that can separate a beam of light into constituent colors. A glass plate having large number of close parallel equidistant slits mechanically ruled on it is called diffraction grating.

Grating element: The spacing "d" between centers of opaque lines is called grating element. It depends upon wavelength of light used. Wavelength of light 400nm to 700nm, 4000to 6000 lines/cm.





Path difference between "a" and "b" = λ. So,
$\overline{AB} = \lambda$ — (i)
From ΔABC, $\overline{AB} = d\sin\theta$ — (ii)
Comparing equation (i) and equation (ii)

$d\sin\theta = \lambda$

Where "d" is separation of slits.

$$d = \frac{\text{Unit length of grating}}{\text{Total no. of lines ruled on it}}$$

$$d = \frac{1\,cm}{N}$$

Zero order image at $\theta = 0°$, Path D. $= 0\lambda$, $d\sin\theta = 0\lambda$
1st order image, Path D. $= 1\lambda$, $d\sin\theta = 1\lambda$
2nd order image, Path D. $= 2\lambda$, $d\sin\theta = 2\lambda$
3rd order image, Path D. $= 3\lambda$, $d\sin\theta = 3\lambda$
nth order image Path D. $= n\lambda$, $d\sin\theta = n\lambda$
When $n = 1$, $\lambda = d\sin\theta$

Electron Double Slit Experiment

It's purpose is to show wave-particle duality, electrons act like both particles and waves. Setup includes electron gun emits electrons toward two slits. Electrons hit a screen behind the slits. Observations were if electrons were practicles, two bands should appear. But actually, intereference pattern (many bright and dark fringes) appears. Which means electrons behave like waves when not observed. Main idea is electrons (and all quantum particles) show dual nature:

- Wave-like when unobserved.
- Particle-like when measured or observed.

Interpretations of Quantum Mechanics:

Coponhagen Interpretations (Niels Bohr and Werner Heisenberg): Before measurement, electron in superposition (goes through both slits). When observed, wave function collapses, electron shows particle behaviour. Bright/Dark fringes = regions of high/low probability of finding the electron.
Criticism: Collapse seems random and unexplained.

Many Worlds Interpretation (Hugh Evertt, 1957): Every quantum event creates many parallel universes. In each universe, the electron takes one path. Intereference pattern = combined result from all universes.
Criticism: Multi-universe idea cant be tested.

Conclusion: The experiment proves quantum behaviour cant be explained by classical physics. Both interpratations try to explain how measurement affects reality but no single answer is universally accepted.