# Wave Optics

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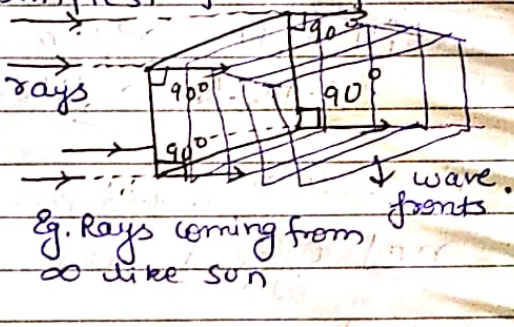
**Wave front :—** It is defined as the continous locus of all such particles of the medium which are vibrating in the same phase of oscillation at any time.

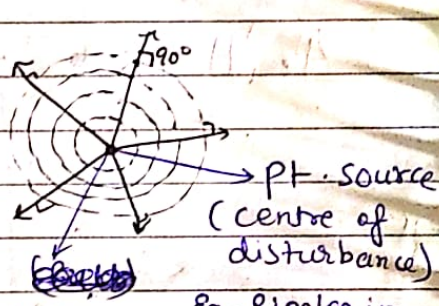
Depending upon the shape of the source of light, wavefront are of different shapes :—

**1) Plane Wavefront :—** The simplest form of wavefront is the plane wave, where rays are ∥ to one another. Rays are making 90° with all wave fronts.



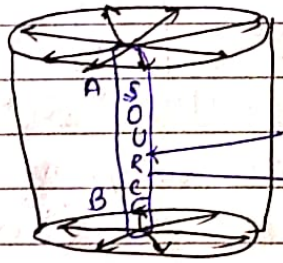

Eg. Rays coming from ∞ like sun

**2) Spherical Wavefront :—** It is a source of disturbance is a point source then the wave front is spherical. A pt. source of light emits waves which spreads outward in all directions.




Eg. Ripples in water are in concentric circles

**3) Cylindrical Wavefront :—** If the source of disturbance is a linear slit (AB) then the wavefront is cylindrical bcz all the points equidistant from the line source lie on the surface of the cylinder.




Cylindrical

Converging  Diverging

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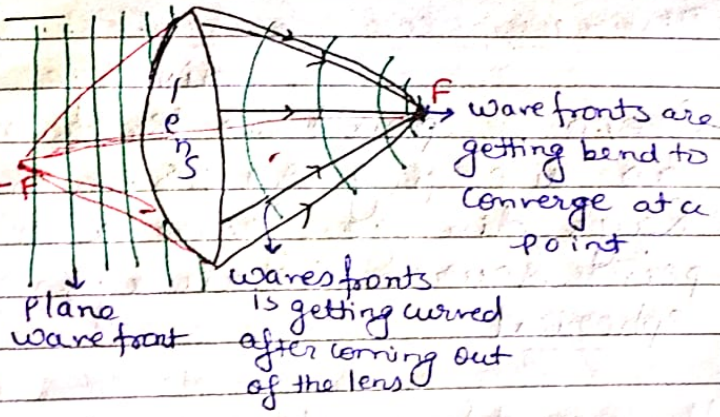
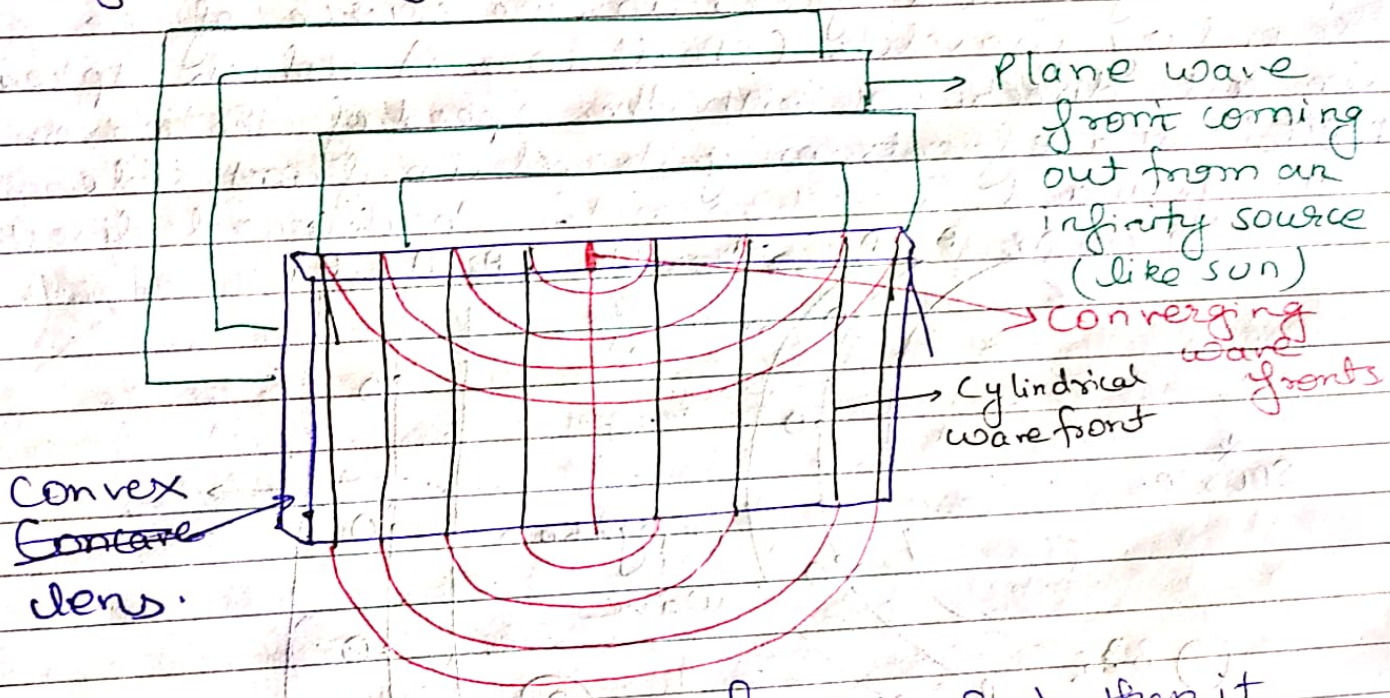
## a) Converging Wave front :-

The waves are bending and converging at a point so the shape of the wavefront is in the form of cylinder.

~~Many~~ When rays of light fall on a lens after coming out of lens, they will converge at a point.




NOTE:- If we see the wave front in 2-d. then it will be spherical (as shown in above diag). But if see in 3-D, then it will be cylindrical (as shown in below diag.).

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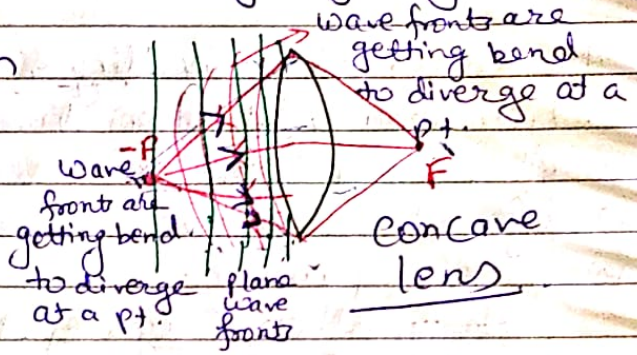
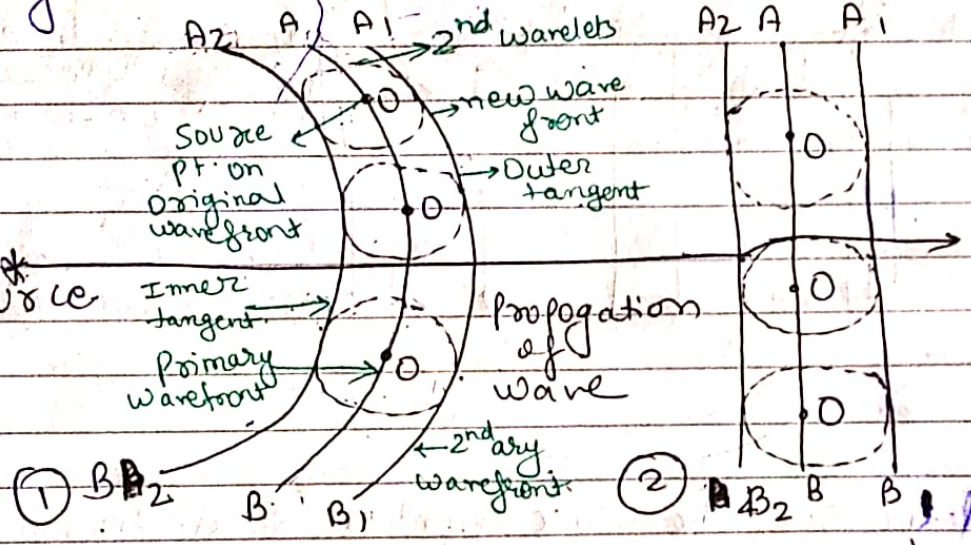
**Diverging Wavefront :—** When rays of light diverge from a point is known as diverging rays. Rays diverge from a point source is always spherical




**Huygens Principle :—**

This principle states that each point of a wavefront is the source of secondary wavelets (small waves) which spread in all directions with the speed of the wave.

**NOTE:—** Wavefronts only travel in front side i.e. forward direction not in backward direction.




* $A_2B_2$ is the wavefront (1st Circular, 2nd Plane) at time $t=0$
* $A_1B_1$ " " " " " " " " " " " " $t=\tau$
* $A_1B_1$ → Envelope of 2nd wavelets arising from $A_2B_2$ produces wavefront in forward direction.
* AB is a wavefront (① Spherical, ② Plane) with O center at $t=0$
* Now, $A_2B_2$ doesn't exist.

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For eg If a stone is thrown in the river, waves will be formed surrounding that point. These waves look like concentric circles and they are known as wavefronts. The wavefronts gradually spread in all the directions When the locus of all the waves is joined which are in the same phase, it will be the same as a sphere are known as Primary wavefront. Secondary wavefront are formed from each point on the Primary wavefront. The common tangential line that envelopes these secondary wavefronts will further give rise to other secondary wavefronts. All wavefronts will gradually fade after some time. According to Huygens principle, every point on a wavefront give rise to secondary wavelets which spread out in all directions with the speed of a wave.

Using Huygens principle we can determine the new position of the wavefront after time t. Mathematically, to calculate the new position of the wavefront after time t.

- Let the initial time $t_i = 0$
- Each wave will travel $= vt$ where v is the speed of wave
- Distance travelled by each wave is equal to the radius of the sphere.
- Therefore radius of the sphere $= vt$
- Common tangent joining all the spheres will give the position of the new wavefront at time $t = t_1$
- ∴ 2 possibilities :- Outer tangent & inner tangent
- Amplitude of the back wave is 0. ∴ the back wave is neglected & the forward wave was considered.

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↳ New wave front will arise from each pt. on the outer wavefront.
↳ ∴ The distance covered by these wavefronts = $Vt_2$
↳ Again spheres will be obtained & by drawing common tangent will tell the position of all the new wavefront after time $t_2$.
↳ Again back wave is neglected & forward wavefront is considered.
↳ This shows the wavefront keep on spreading with time.

**Huygens Theory :—** According to Huygens light can be of wave nature. He got this idea from the simple observation :—

↳ In an experiment conducted by Newton and Huygens, two rooms were considered with an obstruction in the middle. Newton considered a boundary and Huygens considered a door as the obstacle between rooms. In this experiment, the light was switched on in one room. According to Newton if light travels in straight lines then first room will be bright and some portions of the second room will become bright and the rest of the room will be dark. Huygens observed that the first room became bright and the light spread in the second room as well, but it was not as bright as the first room. Therefore, Huygen's proposed that light might be of a wave in nature.

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↳ As the wavelength of light is so small therefore the wave nature of light cannot be seen. If the light is made to pass through a small portion which is comparable to the wavelength of light, then the wave nature of the light can be observed.
According to Huygens, Newton's theory was not fully correct. Therefore he gave an idea that the light is of wave nature.
↳ For eg:- If a light is made to pass through a big window then the light will appear as ray and not the wave.
↳ But if the light is made to pass through a very small hole then the wave nature can be observed.
↳ Huygen's idea was not accepted because of the following reasons:—
↳ As there was no experimental proof of what Huygens proposed.
↳ There was Newton's authority at that time.
↳ Wave always needs a medium for propogation. This means light cannot propogate in vaccum. But sunlight is able to reach earth surface.
↳ Conclusion given by Huygens formed the basis of wave nature of light.
↳ Many other scientists came after Huygens to prove light is of wave nature :—
a) Thomsas Young (1800) :— Young performed very imp. experiment known as Young's double-slit experiment. He proves wave nature of light.

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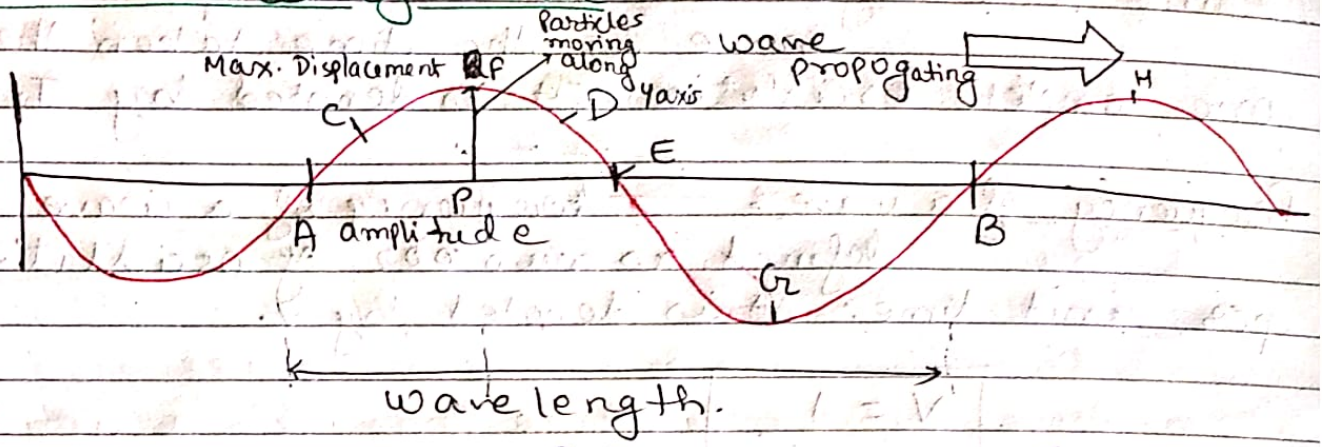
## Characteristics of wave :—




Consider two pts. A & B on a wave. Their positions as well as their behaviour are same. Therefore points A & B are in phase.
Consider the points F and G their positions are same but the behaviour is totally opposite. So F and G are out of phase.

**Amplitude :—** Amplitude is the maximum displacement of the elements of the medium from their equilibrium positions as wave passes through them. It is denoted by A.

**Phase :—** Phase of a wave describes the state of motion as the wave sweeps through an element at a particular position

**Wavelength :—** Wavelength is defined as the minimum distance b/w two consecutive crests or two consecutive troughs when in the same phase. It is denoted by $\lambda$.