WAVE THEORY

Huygens Wave Theory of Light

- Light travels in the form of longitudinal waves which travel with uniform velocity in homogeneous medium
- Different colours are due to the different wavelengths.
- When light enters our eyes, we get sensation of light
- A material medium is necessary for propagation of longitudinal waves.

To explain propagation of light through vacuum, Huygens suggested the existence of an hypothetical medium called 'Luminiferous Ether' which is supposed to be present everywhere in space.

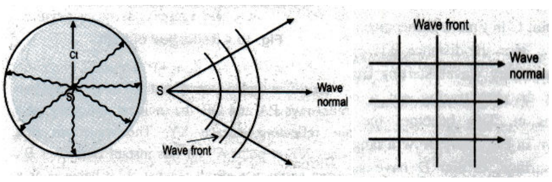
Success:

- Could explain laws of refection, refraction, interference, diffraction, etc.
- Speed of light in the denser medium is less than that in the an optically rarer medium.

Drawbacks:

- Could not explain rectilinear propagation of light
- Couldn't explain polarization of light,Compton effect,photoelectric effect
- Experiments concluded there is no ether drag when earth moves.

Wave Front and Wave Normal:



A locus of all the points of medium to which waves reach simultaneously so that all the points are in the same phase at a given instant is called ***wavefront***.

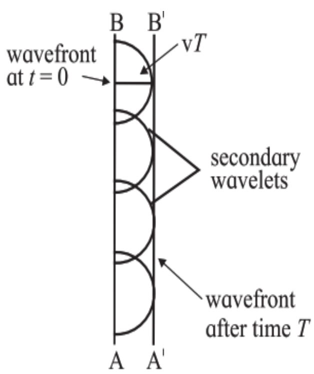
A perpendicular drawn to the surface of a wavefront at any point of a wavefront in the direction of propagation of light, is called a ***wave normal*** *(or ray of light)*.

NOTE: *Primary Sources* are sources that emit their own light like sun, stars, TV, tube lights, firecrackers, nuclear energy generations)
Secondary Sources are those which do not produce their own light but receive it from other source and they reflect and/or scatter that light e.g. moon, planets, plants, humans, animals

Huygens' Principle:

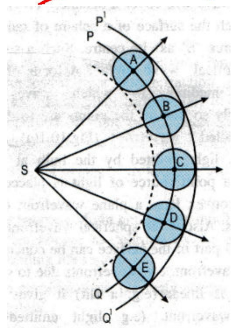
>> Every point on a wavefront behaves as if it is a secondary source of light sending secondary waves (wavelets) in all possible directions.
>> The new secondary wavelets are more effective in the forward direction only (backward direction are ineffective)
>> The resultant wavefront at any position is given by the tangent to all the secondary wavelets at that instant.

Construction of plane wavefront:



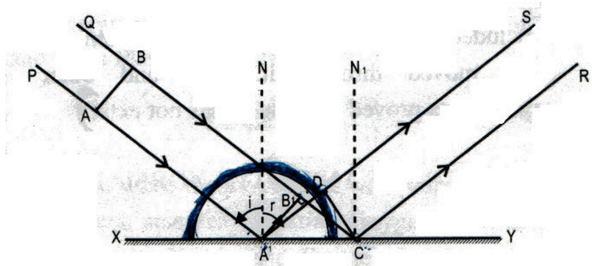
Let AB be a plane wavefront perpendicular to the plane of the paper, due to the source (S), at any instant and at very large distance. This is the primary wavefront. Now consider points P,Q,R,S on AB. They act as secondary wavelets as per Huygens' principle. Each wave will describe a distance 'vT', where 'v' is the speed of light and 'T' the time. With P,Q,R,S as centers, hemispheres each of radius 'vT' will be traced. Each hemisphere represents a secondary wavefront. The common tangential surface (envelope) i.e. A'B' drawn to these secondary wavefronts represents the new position for the wavefront after time 'T'. The secondary waves moving in the backward direction do not exist

Construction of Spherical Wavefront :



Let PQ be a cross-section of a spherical wavefront due to a point source (S) , at any instant. This is called as primary wavefront. Now consider points A, B, C, D, E on PQ. They act as secondary sources and send out secondary wavelets as per Huygens' principle. Each wave will describe a distance 'vT', where 'v' is the speed of light and 'T' the time. With A,B,C,D,E as centers, spheres each of radius 'vT' will be traced. Each sphere represents a secondary wavefront. The common tangential surface (envelope) i.e. P'Q' drawn to these secondary wavefronts represents the new position for the wavefront after time 't'. The secondary waves moving in the backward direction do not exist.

Reflection at a Plane Surface :



Consider a plane wavefront AB bounded by two parallel rays PA and QB, incident obliquely on a plane reflecting surface XY. The wavefront first reaches at A'. At this instant B reaches B'. As soon as the wavefront reaches A' it behaves as a secondary source and begins to emit secondary waves in the same medium. Let the wavefront at B' move to C in time T. Is speed of light in medium is 'c' then the distance B'C=cT. During this time the secondary waves starting from A' will cover an equal distance tracing out a hemisphere of radius cT. Then draw a tangent CD. C and D have the same phase. Thus CD represents the reflected wavefront

ΔA'B'C congruent ΔCDA' (B'C=AD ; 90⁰ at B' and D, and A'C common side)

Thus, /_B'A'C = /_DCA' ..... (i)

/_NA'B' = 90 – i   therefore, /_ B'A'C = 90 – /_NA'B' = 90 – (90 – i) = i ..(ii)

/_NA'D = r   Thus, /_DA'C = 90 - /_NA'D = 90 – r

In ΔCDA', /_DCA' = 180 - /_CDA' - /_DA'C = 180 – 90 – (90 – r) = r .... (iii)

From (i) , (ii) and (iii) we can conclude i = r

Also the incident ray, reflected ray and normal lie in the same plane. Thus laws of reflection can be proved using Huygens' wave theory.

NOTE: Width of object = Width of image and lateral inversion is also visible from the above diagram

Refraction of a Plane Wavefront (Excluded from 2021 exam):

POLARISATION(Excluded from 2021 exam):

BREWSTER'S LAW (Excluded from 2021 exam):

POLAROIDS (Excluded from 2021 exam):