Huygen's Principle - used to find the shape and position of a wavefront at a later time from its shape and position at an earlier instant.

According to this principle:

(i) Each point on a given wavefront acts as a source of new disturbance, called secondary wavelets which also travel out in all directions with the same velocity as that of the original wavefront.

(ii) The new shape and position of the wavefront at any later instant, is given by the forward envelope of the secondary wavelets ie the surface tangential to all secondary wavelets at that instant.

[Let AB be a small section of a spherical wavefront at any instant from a source S. To find out the shape and position of the secondary wavefront after time τ, we can consider many points on the wave front and draw arc with radius, $r = v \times \tau$ where v is the velocity of the light in the medium. r is the distance travelled by the wave in time τ. By drawing tangents to all these arcs which are part of spherical wavelets, we get a new wavefront A'B'. We can also draw a ~~wavefront~~ wavefront by considering the backward direction but Huygen ruled out the existence of backward wavefront saying that amplitude of such wavelets are zero.] Refer diagram in NCERT TEXT

Laws of Reflection and Refraction using Huygens principle.

Laws of Reflection

Consider a plane wavefront AB incident on a reflecting surface as shown in fig (i)

According to Huygen's principle, each point on AB will act as the source of secondary wavelets. Let the secondary wavelet originating from A reach C in time t.

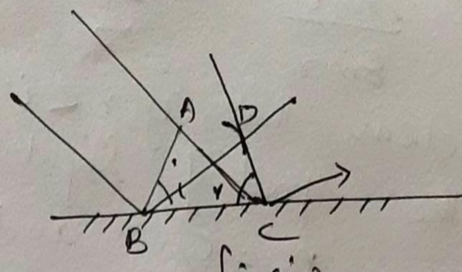


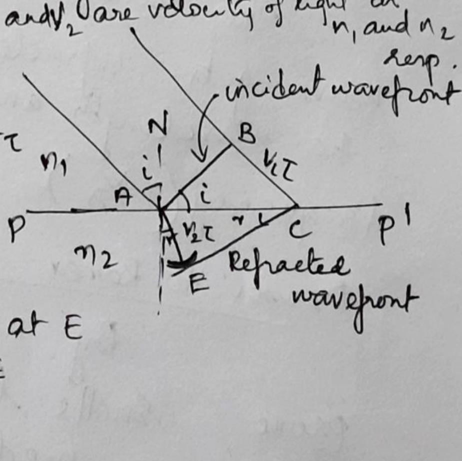
fig (i)

$AC = Vt$ where V is the velocity of the medium. Hence the secondary wavelet from B will cover same distance BD. Taking B as centre radius equal to AC, cut an arc at D. ~~Hence~~ ~~CD~~ By drawing tangent to this arc, we get the reflected wavefront CD. From fig, it is clear that Δ ABC and BCD are congruent, hence $\angle i = \angle r$. Thus law of reflection is verified.

Laws of Reflection (Rarer to denser)

Consider a plane wavefront AB incident at a refracting surface as shown in fig (ii). PP' is an interface separating two media of refractive indices n_1 and n_2 such that $n_2 > n_1$. V_1 and V_2 are velocity of light in n_1 and n_2 resp.

To determine the shape of the refracted wavefront at a later instant τ, draw a sphere of radius $V_2\tau$ from the point A in second medium. Draw a tangent to this surface at E to get the refracted wavefront CE



$AE = V_2\tau$ and $BC = V_1\tau$

Consider triangles ABC and AEC

$$\sin i = \frac{BC}{AC} = \frac{V_1\tau}{AC} \quad \text{and} \quad \sin r = \frac{AE}{AC} = \frac{V_2\tau}{AC}$$

where i and r are angles of incidence and refraction respectively.

$\therefore \dfrac{\sin i}{\sin r} = \dfrac{v_1}{v_2}$ From the above eqn, it is clear that if $r < i$, the $v_2 < v_1$. Also c is the speed of light in vacuum,

$n_1 = c/v_1$ and $n_2 = \dfrac{c}{v_2}$

$$\therefore \frac{n_2}{n_1} = \frac{v_1}{v_2} = \frac{\sin i}{\sin r}$$

$$n_1 \sin i = n_2 \sin r$$

This is snell's law of refraction.

If λ_1 and λ_2 denote wavelength of light in medium ① and ② resp. such that $BC = \lambda_1$ and $AE = \lambda_2$ then $\dfrac{\lambda_1}{\lambda_2} = \dfrac{v_1}{v_2}$

or $\dfrac{v_1}{\lambda_1} = \dfrac{v_2}{\lambda_2}$

The above equation implies that when a wave gets refracted into a denser medium $(v_1 > v_2)$ the wavelength and speed of propagation decrease but frequency $(\nu = v/\lambda)$ remains constant.

Denser to Rarer medium

By using the same approach we can prove snell's law when light travels from a denser medium to rarer medium.

Here $n_1 > n_2$

and $v_2 > v_1$

$BC < AE$