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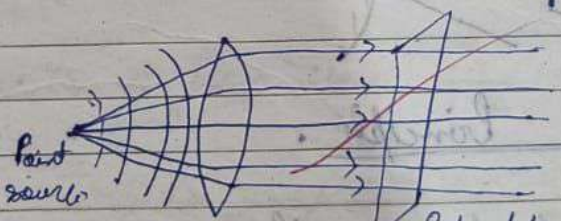
Wave optics

Wave front

Wave front is defined as surface of constant phase.

or.

Wave front is defined as locus of point is vibrating in same position.



Incident wave front spherical

Refracted wave front plane wave front

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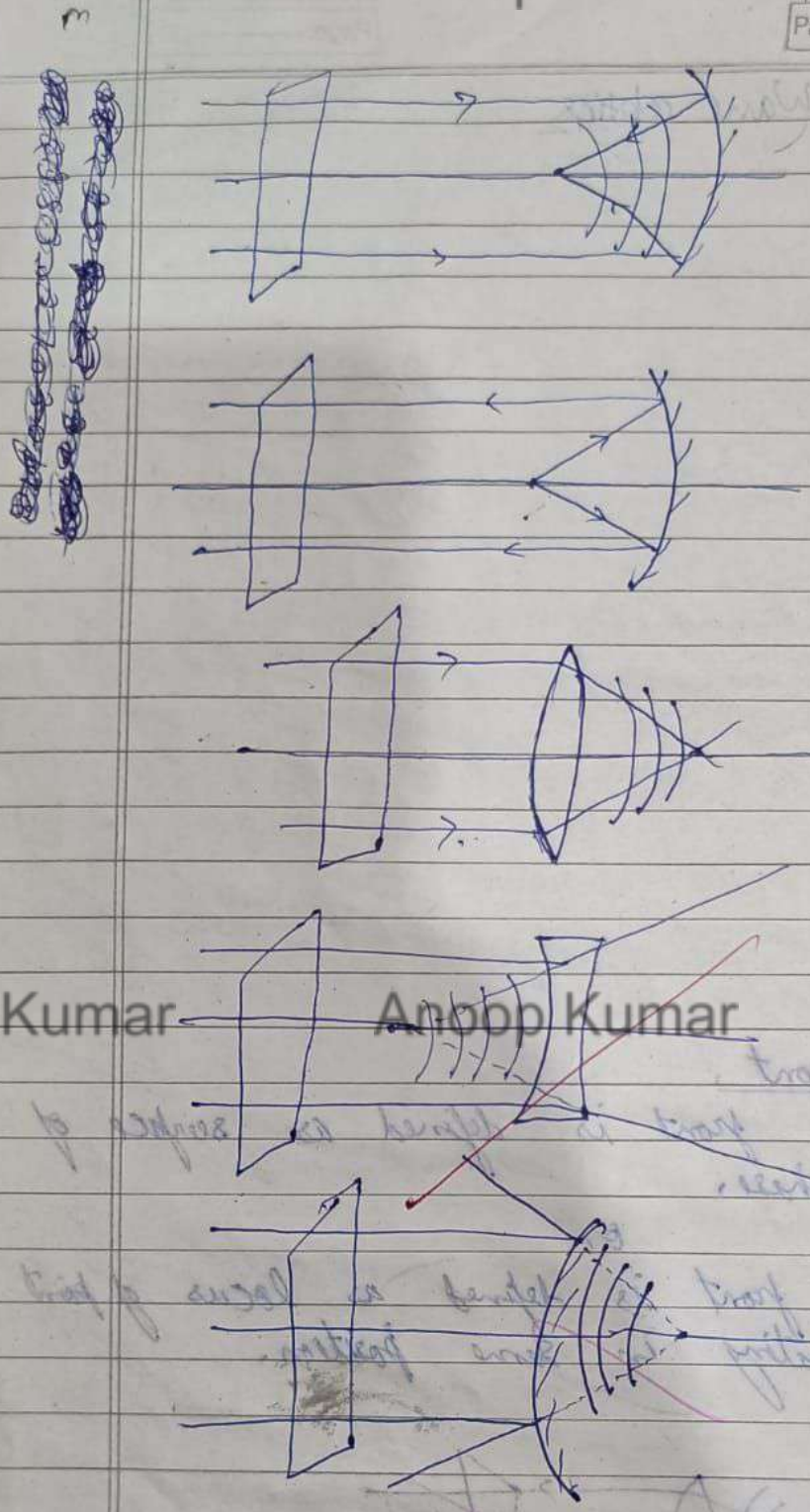

Huygens Principle.

Each point of the wave front is source of secondary disturbance. And secondary wavelets emanating from these points spread

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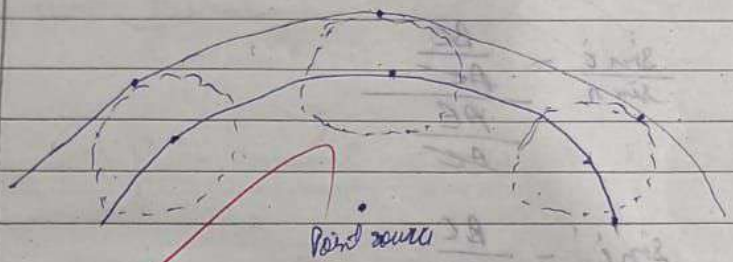
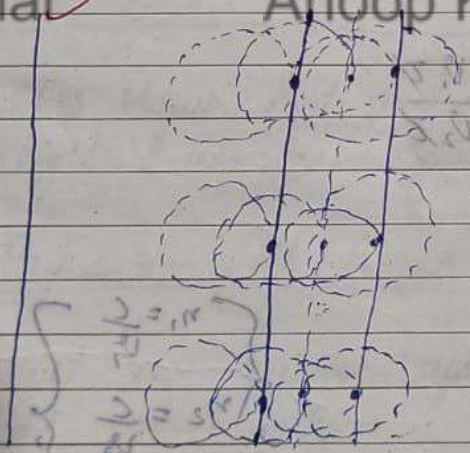
Out in all the directions with speed of light wave

Secondary wave front

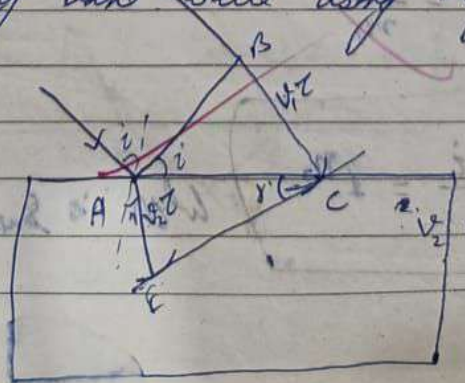
The wavelets emanating from the wave front are usually referred as secondary wavelets. If we draw a common tangent from all these spheres we obtain new position of wavefront at later time.





Refraction of plane wave using Huygen's principle

v_1 = speed of light



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Wave front AB is incident on the surface PP' Let v_1 is speed of light is first medium and v_2 is in second medium. At point A secondary wavelets emitted from second medium. Wave travells from A to E in same time as from B to C. So, spherical wavefront are drawn with radius of $v_1 t$ and $v_2 t$ for for first medium and second medium respectively. So, $BC = v_1 t$

$AE = v_2 t$

$$\frac{\sin i}{\sin r} = \frac{\frac{BC}{AC}}{\frac{AE}{AC}}$$

$$\frac{\sin i}{\sin r} = \frac{BC}{AE}$$

$$= \frac{v_1 t}{v_2 t}$$

$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2}$$

$$\frac{\sin i}{\sin r} = \frac{\frac{c}{n_1}}{\frac{c}{n_2}}$$

$$\left\{ n_1 = \frac{c}{v_1}, \quad n_2 = \frac{c}{v_2} \right\}$$

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$$

$$\boxed{\frac{\sin i}{\sin r} = {}_1 n_2}$$ which is Snell's law

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Let λ_1 is wavelength of light in medium first and λ_2 is wavelength of light in medium second

$$\frac{BC}{AE} = \frac{v_1 t}{v_2 t}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{v_1 t}{v_2 t}$$

$$\frac{v_1}{\lambda_1} = \frac{v_2}{\lambda_2}$$

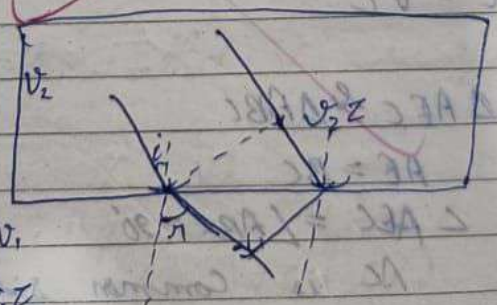
$$\frac{v}{\lambda} = \text{constant}$$

frequency = constant

This shows that during refraction frequency of light remains constant.

Refraction At Rarer Medium

Let us consider refraction of plane wave at rarer medium



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$$\frac{\sin i}{\sin r} = {}^{2}n_{1}$$

$$\frac{\sin i_c}{\sin 90^\circ} = {}^{2}n_{1}$$

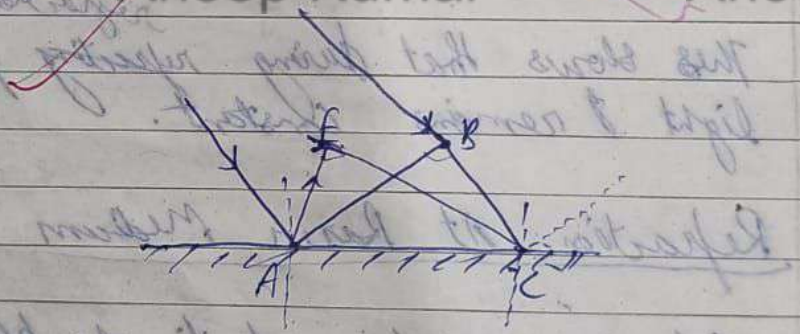
$$\sin i_c = {}^{2}n_{1}$$

$$\boxed{\sin i_c = \frac{1}{{}^{1}n_{2}}}$$

This shows that for angle $i > i_c$ the wavefront is reflected back in the same medium.

Reflection of plane wave by plane surface

Laws of reflection using Huygens wave theory.



Here $AE = vt$

$BC = vt$

In ΔAEC & ΔABC

$AE = BC$

$\angle AEC = \angle ABC = 90^\circ$

AC is common side

So, $\Delta AEC \cong \Delta ABC$