PHS 245 LECTURE NOTES

BASIC PHYSICS FOR ENGINEERING APPLICATIONS

(Part I)

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Course contents

Elements of geometrical optics; velocity of light, microscope and telescope; lens equation. Abberation and correction.

Suggested references:

1. Modern optics by R. Guenther
2. Optics by Eutchene Hetch
3. Advance level Physics by Nelkon and Parker
4. Basics of Physics by A.E. Ekpeyong
5. Lecture notes in modern optics by L. Solymer

PROPAGATION OF LIGHT USING GEOMETRY

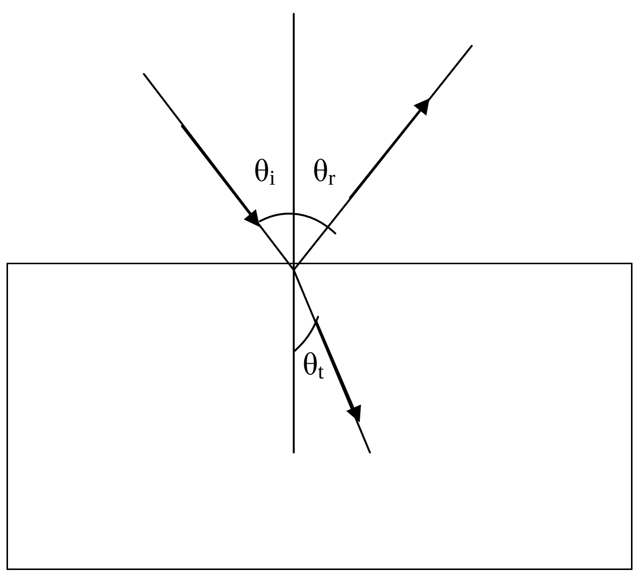
Geometrical optics is an idealized optics that essentially ignores the wave nature of light. It is optics for negligible wavelength (i.e. $\lambda \rightarrow 0$) in comparison to the object encountered. It neglects interference, diffraction effects and polarization and uses rays to the path of light through reflecting and refracting bodies.

Within the approximation represented by geometrical optics, light is understood to travel out from its source along straight lines or **rays.** The laws of geometrical optics that describe the subsequent direction of the rays are law of reflection and law of refraction.

Law of reflection: When a ray of light is reflected at an interface dividing two uniform media, the reflected ray remains within the **plane of incidence**, and the angle of reflection equals the angle of incidence. The plane of incidence includes the the incidence ray and the normal to the point of incidence.

Law of refraction (Snell's law): When a ray of light is refracted at an interface dividing two uniform media, the transmitted ray remains within the plane of incidence and the sine of angle of refraction is directly proportional to the sine of angle of incidence.

These laws can be visually seen in the following figure



$\theta_i = \theta_r$

$$\frac{\sin\theta_i}{\sin\theta_t} = cons\tan t$$

Huygens' Principle

The Dutch Physicist, Christian Huygens imagined each poit of a propagating disturbance as capable of originating new pulses that contributed to the disturbance an instant later. To show how his model of light propagation implied laws of geometrical optics, he formulated a principle which states that "each point on the leading surface of a wave disturbance may be regarded as a secondary source of spherical waves, which themselves progress with the speed of light in the medium and whose envelopes at later times constitutes the new wavefront. This principle is useful for obtaining the two laws of geometrical optics.

Fermat's Principle

This is another law of geometrical optics which states that nature is economical, and thus requires that the time required for light to travel from point A to point B is the minimum time required. This law can be used to prove both the law of reflection and refraction.

Optical Path Length (OPL)

OPL is the distance light would have travelled if it were in vacuum instead of some some optical media for the same amount of time. Suppose that we have some stratified material composed of m layers, each having a different index of refraction. The transit time across the layers will then be

$$t = \frac{s_1}{v_1} + \frac{s_2}{v_2} + ...+ \frac{s_m}{v_m}$$

$$= \sum_{i-1}^{m} \frac{s_i}{v_i} \qquad \text{-------------------------------------1.1}$$

$$= \frac{1}{c}\sum_{i=1}^{m} n_i s_i$$

Where the summation is called the **optical path length** traversed by the ray.

Optical Reversibility

Consider applying Fermat's principle to an optical system. Since the time must be minimized, we see that the same path is predicted regardless of whether we start at A and travel to B, or start at B and travel to A. Generally, any actual ray of light in an optical system, if reversed in direction, will retrace the same path backward

SPHERICAL MIRRORS

Spherical mirrors may be either concave or convex relative to an object point O, depending on whether the center of curvature is on the same or opposite side of the surface.