LECTURE 7

Fundamentals of ray optics
The laws of ray optics

- **Geometrical optics**, or **ray optics**, describes light propagation in terms of rays. The ray in geometric optics is an abstraction, or instrument, useful in approximating the paths along which light propagates in certain classes of circumstances.
- The assigned in practice the content of the laws of beam optics:

  1. The straight line of light propagation law.

  The light beams propagate along a straight line in a homogeneous medium. This law can be used only in cases not accounted for only diffraction phenomena.

- *2. The independence law of the light beams.*

The effect of a bunch does not depend of other beams of light effects that is, the light beams does not affect to each other.

3. The laws of light reflection:

a) The incident beam to the surface , the reflecting beam from surface and and the normal to the interface, all lie in the *same plane*.

a) Incidence angle (i') and reflection angle (i) are equal to each other.

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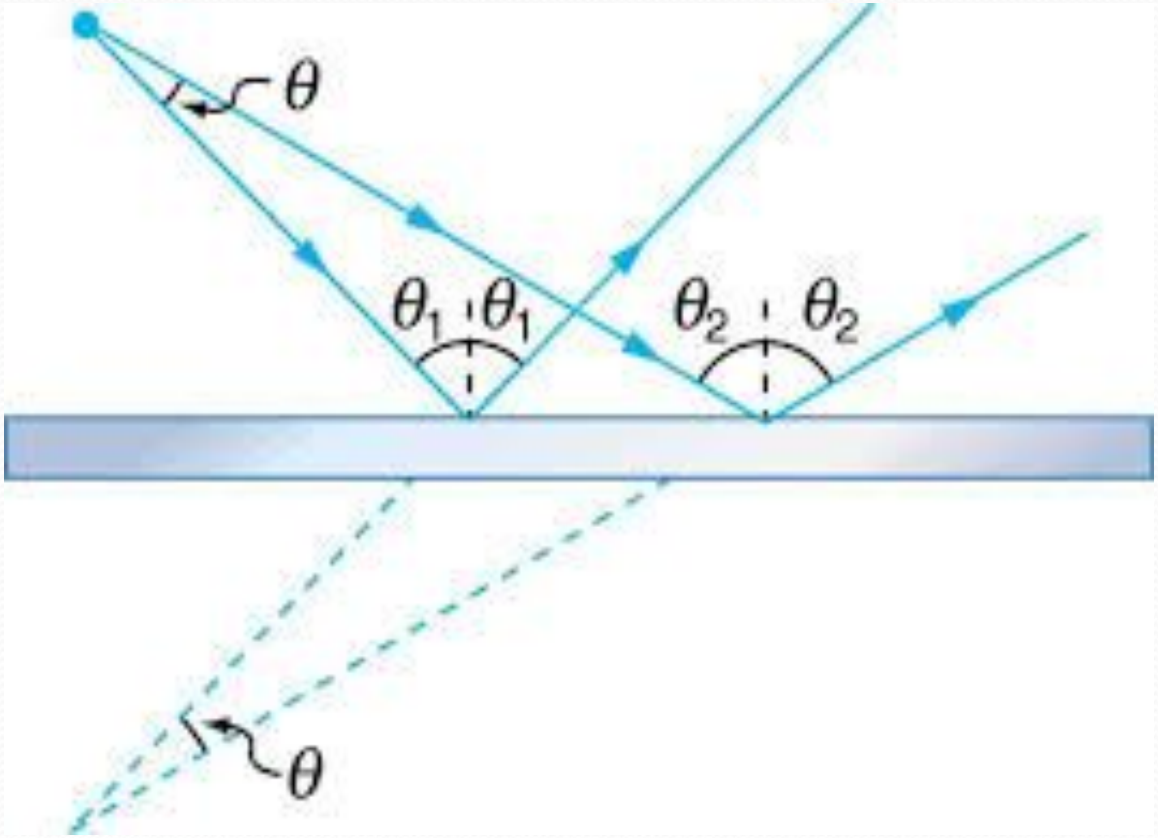
Refraction and reflection of light on a flat surface

- *1)The reflection of light on a flat mirror*

- The reflection of light from a plane mirror can be summarised by the following laws:
  1. The angle of incidence (i) is equal to the angle of reflection (r)
  2. The incident ray, reflected ray and the normal to the surface at the point of incidence all lie in the same plane.

- Remember that with a glass mirror the reflecting surface (usually a thin layer of aluminum or silver) is placed on the back of the mirror and then covered with a protective layer. This means that although the main reflected image comes form this surface light will also reflect from the front surface of the glass. This will give a secondary image which is much weaker that the main image. This is usually invisible in every day life but would create severe problems in astronomy. For this reason all astronomical mirrors have their reflecting surface formed on the front of the glass.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The phenomenon of total internal reflection

- **Total internal reflection** is a phenomenon which occurs when a propagating wave strikes a medium boundary at an angle larger than a particular critical angle with respect to the normal to the surface. If the refractive index is lower on the other side of the boundary and the incident angle is greater than the critical angle, the wave cannot pass through and is entirely reflected. The **critical angle** is the angle of incidence above which the total internal reflection occurs.

- When a wave reaches a boundary between different materials with different refractive indices, the wave will in general be partially refracted at the boundary surface, and partially reflected. However, if the angle of incidence is greater (i.e. the direction of propagation is closer to being parallel to the boundary) than the critical angle – the angle of incidence at which light is refracted such that it travels along the boundary – then the wave will not cross the boundary, but will instead be totally reflected back internally. This can only occur when the wave in a medium with a higher refractive index (n_1) reaches a boundary with a medium of lower refractive index (n_2). For example, it will occur with light reaching air from glass, but not when reaching glass from air.

- Total internal reflection of light can be demonstrated using a semi-circular block of glass or plastic. A "ray box" shines a narrow beam of light (a "ray") onto the glass medium. The semi-circular shape ensures that a ray pointing towards the centre of the flat face will hit the curved surface at a right angle; this will prevent refraction at the air/glass boundary of the curved surface. At the glass/air boundary of the flat surface, what happens will depend on the angle.

- Where θ_c is the critical angle measurement which is caused by the **sun** or a **light source**(measured normal to the surface):
- If $\theta < \theta_c$, the ray will split. Some of the ray will reflect off the boundary, and some will refract as it passes through. This is not total internal reflection.
- If $\theta > \theta_c$, the entire ray reflects from the boundary. None passes through. This is called total internal reflection.
- This physical property makes optical fibers useful and prismatic binoculars possible. It is also what gives diamonds their distinctive sparkle, as diamond has an unusually high refractive index.

Refraction and reflection of light on a spherical surface