Kirkuk University

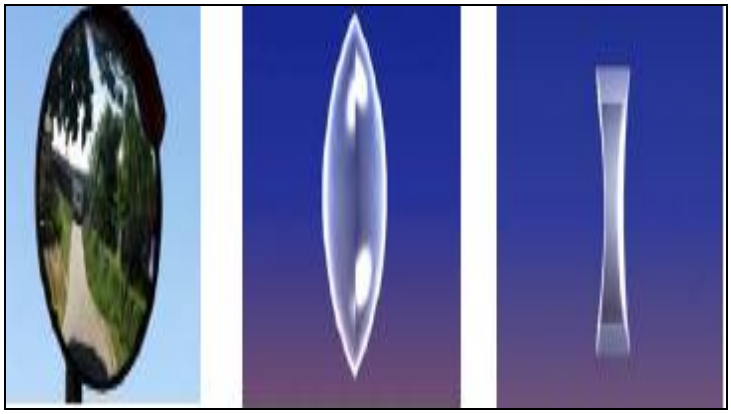
Science College

Physics Department

Lectures of

GEOMETRIC OPTICS

Lecture – 1 –



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Lecture 1: Reflection and Plane Mirrors

1 – 1 The Law of Reflection

- The Fig.(**1-1**) below illustrates the law of reflection**.**

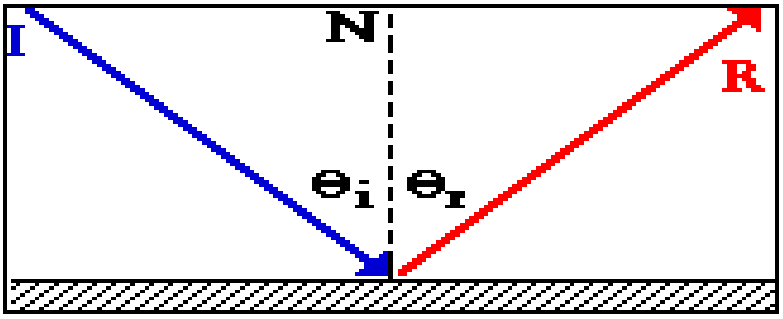


Fig.(1-1) : The law of reflection

- In the diagram, the ray of light approaching the mirror is known as the **incident ray** (labeled **I** in the diagram)**.**
- The ray of light that leaves the mirror is known as the **reflected ray** (labeled **R** in the diagram)**.**
- At the point of incidence where the ray strikes the mirror, a line can be drawn perpendicular to the surface of the mirror**.**
- This line is known as a **normal line** (labeled **N** in the diagram)**.**
- The normal line divides the angle between the incident ray and the reflected ray into two equal angles**.**
- The angle between the incident ray and the normal is known as the **angle of incidence.**

- The angle between the reflected ray and the normal is known as the **angle of reflection.**
- (These two angles are labeled with the Greek letter "theta" accompanied by a subscript; read as "theta-i" for angle of incidence and "theta-r" for angle of reflection)**.**
- The two laws of reflection are **:-**

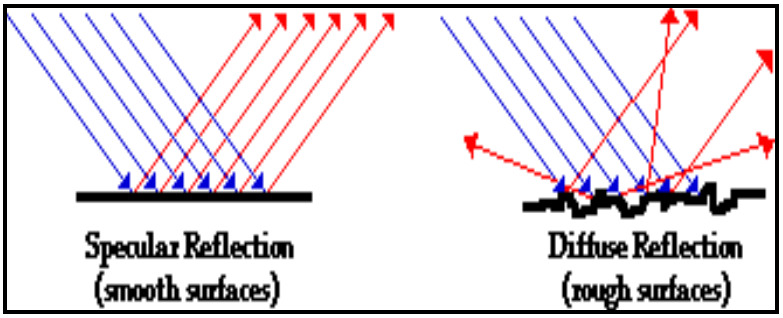
1- The incident and reflected rays and the normal to the surface all lie in the same plane **.**

2- The angle of reflection (θ_r) is equal to the angle of incidence (θ_i) for all wavelengths , as represented in Equ.(**1-1**) **:**

$$\boxed{\theta_r = \theta_i ...(1-1)}$$

1 – 2 Specular vs. Diffuse Reflection

- Reflection off of smooth surfaces such as mirrors or a calm body of water leads to a type of reflection known as **specular reflection.**
- Reflection off of rough surfaces such as clothing, or the asphalt roadway leads to a type of reflection known as **diffuse reflection.**
- Whether the surface is microscopically rough or smooth has a tremendous impact upon the subsequent reflection of a beam of light**.**
- The Fig.(**1-2**) below depicts two beams of light incident upon a rough and a smooth surface**.**



Fig(1-2) :Two beams of light incident upon a rough and a smooth surface

- A light beam can be thought of as a bundle of individual light rays which are traveling parallel to each other**.**
- Each individual light ray of the bundle follows the law of reflection**.**
- If the bundle of light rays is incident upon a smooth surface, then the light rays reflect and remain concentrated in a bundle upon leaving the surface**.**
- On the other hand, if the surface is microscopically rough, the light rays will reflect and diffuse in many different directions**.**

1 – 3 Why Does a Rough Surface Diffuses a Beam of Light?

- For each type of reflection, each individual ray follows the law of reflection**.**
- However, the roughness of the material means that each individual ray meets a surface which has a different orientation**.**
- The normal line at the point of incidence is different for different rays**.**
- Subsequently, when the individual rays reflect off the rough surface according to the law of reflection, they scatter in different directions**.**
- The result is that the rays of light are incident upon the surface in a concentrated bundle and are diffused upon reflection**.**
- The Fig.(**1-3**) below depicts this principle**.**

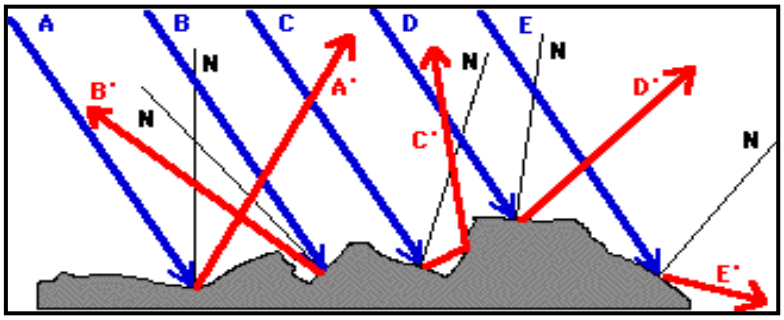


Fig.(1-3) : Rough Surface Diffuses a Beam of Light

- Five incident rays (labeled **A**, **B**, **C**, **D**, and **E**) approach a surface**.**
- The normal line (approximated) at each point of incidence is shown in labeled with an **N.**
- In each case, the law of reflection is followed, resulting in five reflected rays (labeled **A**', **B**', **C**', **D**', and **E**')**.**

1 – 4 Image Characteristics for Plane Mirrors

- In the case of plane mirrors, the image is said to be a **virtual image.**
- Virtual images are images that are formed in locations where light does not actually reach**.**
- Whenever a mirror (whether a plane mirror or otherwise) creates an image that is virtual, it will be located behind the mirror where light does not really come from**.**
- Later , we will study instances in which **real images** are formed by curved mirrors**.**
- Such images are formed on the same side of the mirror as the object and light passes through the actual image location**.**
- Besides the fact that plane mirror images are virtual, there are several other characteristics that are worth noting**.**
- The second characteristic has to do with the orientation of the image**.**
- If you raise your right hand, the image raises what would seem to be its left hand**.**
- This is often termed **left-right reversal.**
- If you *stand on your feet* in front of a plane mirror, the image does not *stand on its head***.**
- Similarly, the *ceiling* does not become the *floor***.**
- The image is said to be **upright**, as opposed to **inverted.**
- A third characteristic of plane mirror images pertains to the relationship between the object's distance to the mirror and the image's distance to the mirror**.**
- For plane mirrors, the object distance (often represented by the symbol $\mathbf{d_o}$, $\mathbf{s_o}$, **O**) is equal to the image distance (often represented by the symbol $\mathbf{d_i}$, $\mathbf{s_i}$, **I**)**.**

- That is the image is the same distance behind the mirror as the object is in front of the mirror**.**
- A fourth and final characteristic of plane mirror images is that the dimensions of the image are the same as the dimensions of the object**.**
- The ratio of the image dimensions to the object dimensions is termed the **magnification.**
- Plane mirrors produce images that have a magnification of **1.**
- In conclusion, plane mirrors produce images with a number of distinguishable characteristics**.**
- Images formed by plane mirrors are virtual, upright, left-right reversed, the same distance from the mirror as the object's distance, and the same size as the object, as shown in Fig. (**1-4**).

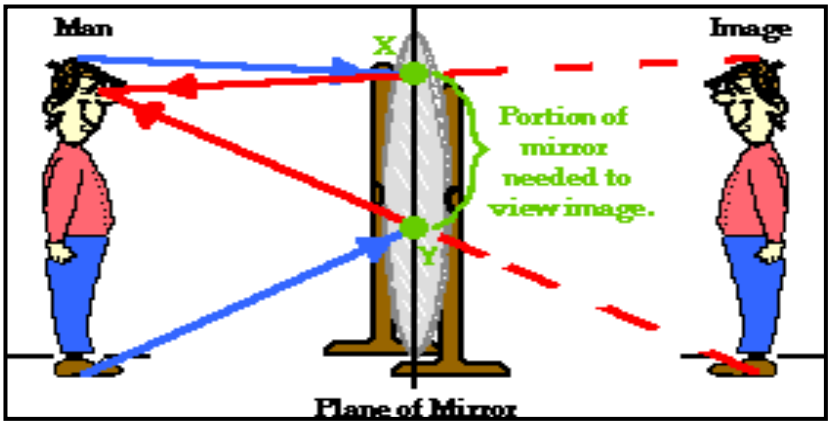


Fig.(1-4) : Plane Mirror