

Basic Optics

1-convex and concave lenses:

A lens whose faces are curved so as to make the lens thicker near its center than near its edge is called a "converging lens." Rays of light entering such a lens are bent toward each other. If the rays are initially parallel to each other, they converge after passing through the lens. The point behind the lens where the transmitted rays cross is called the focus, and the distance of the focus from the middle of the lens is by definition the focal length of the lens. see fig.1a

Conversely, a lens which is thinnest near the center is called a "diverging lens," since it bends entering rays of light away from each other. If the incoming rays are parallel to each other, the direction of all transmitted rays can be extended backward to a common point in front of the lens. Since the rays do not actually pass through this point, it is called a virtual focus, and the negative of its distance from the center of the lens is by definition the focal length of a diverging lens. see fig.1b

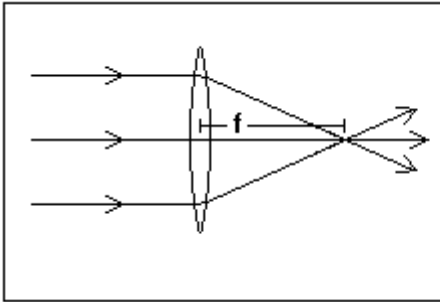


Fig.1a Focal length of a converging length

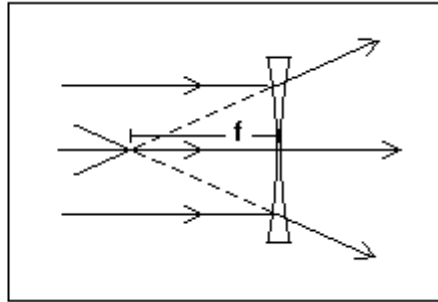


Fig.1b Focal length of a diverging length

1.2 Image of a distant object :

If the object is at infinity (distant object) like the sun or any distant object I.e a very large distant compared to the image distance. we can substitute $s=\infty$ in thin lens equation

$$\frac{1}{\infty} + \frac{1}{s} = \frac{1}{f}$$

The the focal length can be measured directly by $f= s$

1.3 The power of a lens:

The lens power is the inverse of the focal length in meters: the physical unit for lens power is 1/meter which is called diopter.

$$P = \frac{1}{f}$$

2-Mirrors and the law of reflection

When a ray of light strikes a plane mirror, the light ray reflects off the mirror. Reflection involves a change in direction of the light ray. The convention used to express the direction of a light ray is to indicate the angle which the light ray makes with a normal line drawn to the surface of the mirror. The angle of incidence is the angle between this normal line and the incident ray; the angle of reflection is the angle between this normal line and the reflected ray. According to the law of reflection, the angle of incidence

equals the angle of reflection. These concepts are illustrated in the figure 2 below.

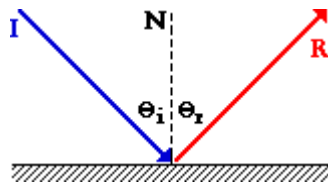


Figure 2:the law of reflection

3-Snell's law:

Snell's law gives the relationship between [angles of incidence](#) and [refraction](#) for a wave impinging on an interface between two media with different [indices of refraction](#). The law follows from the boundary condition that a wave be continuous across a boundary, which requires that the phase of the wave be constant on any given plane, resulting in

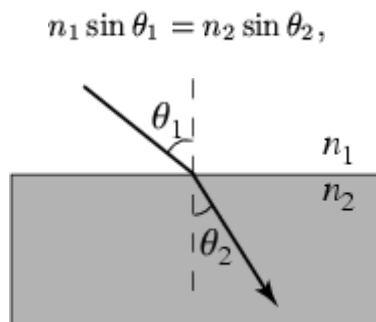


figure 3:snell's law

Where θ_1 and θ_2 are the angles from the *normal* of the incident and refracted waves, respectively.

The refraction of light when it passes from a medium with smaller n to a medium with higher n bends the light ray toward the normal to the boundary between the two media. The amount of bending depends on the [indices of refraction](#) of the two media

As the [speed of light](#) is reduced in the slower medium, the wavelength is shortened proportionately. The frequency is unchanged; it is a characteristic of the source of the light and unaffected by medium changes

The index of [refraction](#) is defined as the [speed of light](#) in vacuum (c) divided by the speed of light in the medium (v).

$$v = \frac{c}{n}$$

4: Total internal reflection

When light crosses an interface into a medium with a higher index of refraction, the light bends towards the normal. Conversely, light traveling across an interface from higher n to lower n will bend away from the normal. This has an interesting implication: at some angle, known as the critical angle, light travelling from a medium with higher n to a medium with lower n will be refracted at 90° ; in other words, refracted along the interface. If the light hits the interface at any angle larger than this critical angle, it will not pass through to the second medium at all. Instead, all of it will be reflected back into the first medium, a process known as total internal reflection.

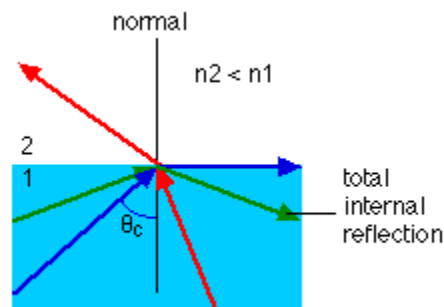


Figure 4: total internal reflection

procedure

1: convex and concave lenses:

- 1- Place the ray box on a white piece of paper.
- 2- Using five white rays from the ray box shine the rays straight into the convex lens.
- 3- Indicate the incoming and the outgoing rays with arrows in the appropriate directions.
- 4- The place where the five refracted rays cross each other is the focal point of the lens.

- 5-Measure the focal length from the center of the convex lens to the focal point.
- 6-measure the focal length using spherometer.
- 7-Repeat the procedure for the concave lens. Note that in Step 3, the rays leaving the lens are diverging and they will not cross. Use a rule to extend the outgoing rays straight back through the lens. The focal point is where these extended rays cross.
- 8-Use the laboratory lamp in as the distant object and try to find its image on the bench using the convex lens. measure δ .

2-Mirrors and the law of reflection:

- 1-Place the mirror on the table and position the plane surface of the mirror at an angle to the ray so that the both the incident and reflected rays are clearly seen.
- 2- Mark the position of the surface of the plane mirror and trace the incident and reflected rays.
- 3-Indicate the incoming and the outgoing rays with arrows in the appropriate directions.
- 4-Draw the normal to the surface and measure the incident and reflected angles.

3-Snell's law:

- 1-Place the rhombus on the table and position it so the ray passes through the parallel sides as shown in Figure .
- 2- Mark the position of the parallel surfaces of the rhombus and trace the incident and transmitted rays. Indicate the incoming and the outgoing rays with arrows in the appropriate directions. Mark carefully where the ray enters and leaves the rhombus.
- 3- Remove the rhombus and on the paper draw a line connecting the points where the ray entered and left the rhombus.
- 4draw the normal to the surface at the point where the ray enters the rhombus and at the point where the ray leaves the rhombus.
- 5-At these points measure the angle of incidence and the angle of refraction with a protractor.

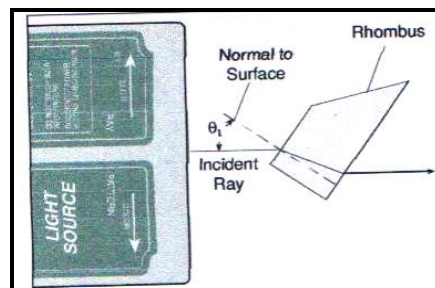


Figure5

4:total internal reflection

- 1-Position the rhombus as shown in figure .
- 2-Rotate the rhombus until the emerging ray just barely disappears. Just as it disappears, the ray

separates into colors. The rhombus is correctly positioned if the red has just disappeared.
 3-Mark the surfaces of the rhombus. Mark exactly the point on the surface where the ray is internally reflected. Also mark the entrance point of the incident ray and mark the exit point of the reflected ray.

4-Remove the rhombus and draw the rays that are incident upon and that reflect off the inside surface of the rhombus. See Figure

5- Measure the total angle between these rays using a protractor.

Note that this total angle is twice the critical angle because the angle of incidence equals the angle of reflection. Record the critical angle .

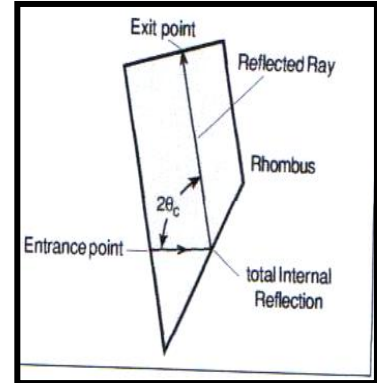


Figure6

Measurements and results:

1:convex and concave lenses:

a- f_{convex} (using spherometer)=

b- f_{convex} (direct measurement using the ray box)=

c-distant object: $f_{convex} = \dot{s} =$

F_{convex} (average)=

$$P_{convex} = \frac{1}{f_{convex}}$$

d- $f_{concave}$ (direct measurement using the ray box)=

$$P_{concave} = \frac{1}{f_{concave}}$$

2-Mirrors and the reflection law:

The incident angle $\theta_i =$

The reflected angle $\theta_r =$

3-Snell's law

For interface 1:

n_1 (air)=1

n_2 (rhombus)

θ_1 (incidence angle)=

θ_2 (refraction angle)=

$$n_2 = n_1 \frac{\sin \theta_1}{\sin \theta_2}$$

For interface :

n_2 (air)=1

n_1 (rhombus)

θ_1 (incidence angle)=

θ_2 (refraction angle)=

$$n_1 = n_2 \frac{\sin \theta_2}{\sin \theta_1}$$

n_{rhombus} (average)=

$$v = \frac{c}{n} =$$

$$c = 3 \times 10^8 \text{ m/s}$$

4-Total internal reflection:

$$2\theta_c =$$

$$\theta_c =$$