جامعة الفرات الاوسط
المعهد التقني / النجف
قسم تقنيات فحص البصر

اسم المادة / الفيزياء البصرية

(Opticalphysics)

المحاضرة الخامسة / الانعكاس الكلي التام

(Total internal reflection)

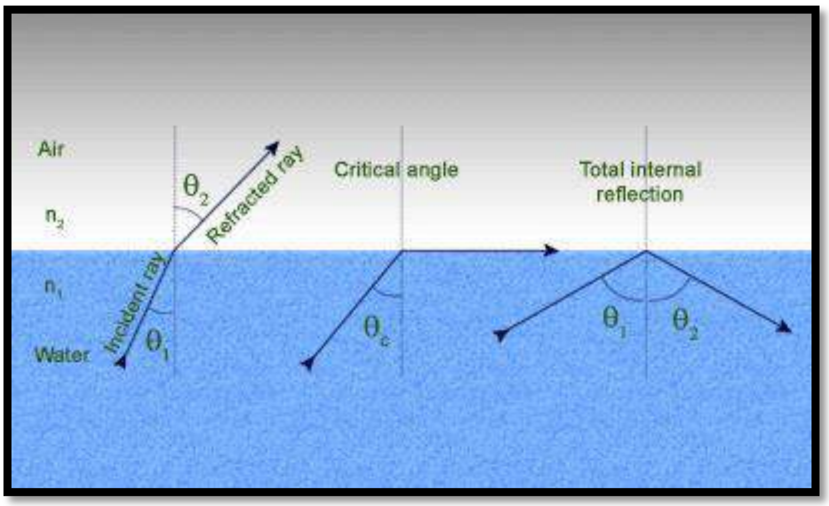
المرحلة / الاولى

اعداد / د. رنيم محمد عباس

Total internal reflection :

The phenomenon which occurs when the light rays travel from a more optically denser medium to a less optically denser medium.

A ray of light passes from a medium of water to that of air. Light ray will be refracted at the junction separating the two media. Since it passes from a medium of a higher refractive index to that having a lower refractive index, the refracted light ray bends away from the normal. At a specific angle of incidence, the incident ray of light is refracted in such a way that it passes along the surface of the water. This particular angle of incidence is called the critical angle. Here the angle of refraction is 90 degrees. When the angle of incidence is greater than the critical angle, the incident ray is reflected back to the medium. We call this phenomenon total internal reflection.



Figure(1) : Total internal reflection

Formula of Total Internal Reflection :

$$\frac{n_1}{n_2} = \frac{sinr}{sini}$$

Where :

- r is the angle of refraction
- i is the angle of incidence
- n_1 is the refractive index in medium 1
- n_2 is the refractive index in medium 2

Examples of Total Internal Reflection

Following are the examples of total internal reflection:

Diamond:

When the incident ray falls on every face of the diamond such that the angle formed, the ray is greater than the critical angle. The critical value of the diamond is 23°. This condition is responsible for the total internal reflection in a diamond which makes it shine.

Optical fibre:

When the incident ray falls on the cladding, it suffers total internal reflection as the angle formed by the ray is greater than the critical angle. Optical fibers transmit signals, not only across cities but across countries and continents making telecommunication one of the fastest modes of information transfer. Optical fibers are also used in endoscopy.

Critical angle :

The critical angle is defined as the angle of incidence that provides an angle of refraction of 90-degrees.

$\Theta_{crit} = \sin^{-1}(n_2/n_1)$

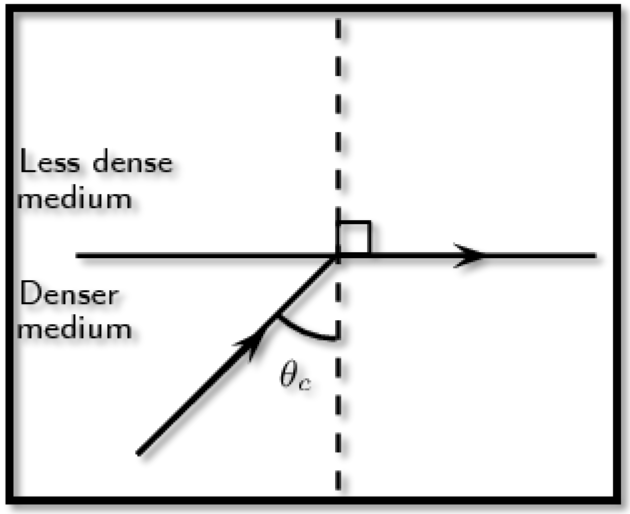


Figure (2) : critical angle

Solved Problems:

1- Calculate the critical angle for the diamond-air boundary?

$\Theta crit = \sin^{-1} (n_2/n_1)$

$\Theta crit = \sin^{-1} (1.000/2.42) = 24.4$ degrees

2- Calculate the critical angle for the glass-air boundary ?

$\Theta crit = \sin^{-1} (n_2/n_1)$

$\Theta crit = \sin^{-1} (1.000/1.5) = 41.1$ degrees

3- A ring is placed in a container full of glycerin. If the critical angle is found to be 37.4° and the refractive index of glycerin is given to be 1.47 find the refractive index of ring.

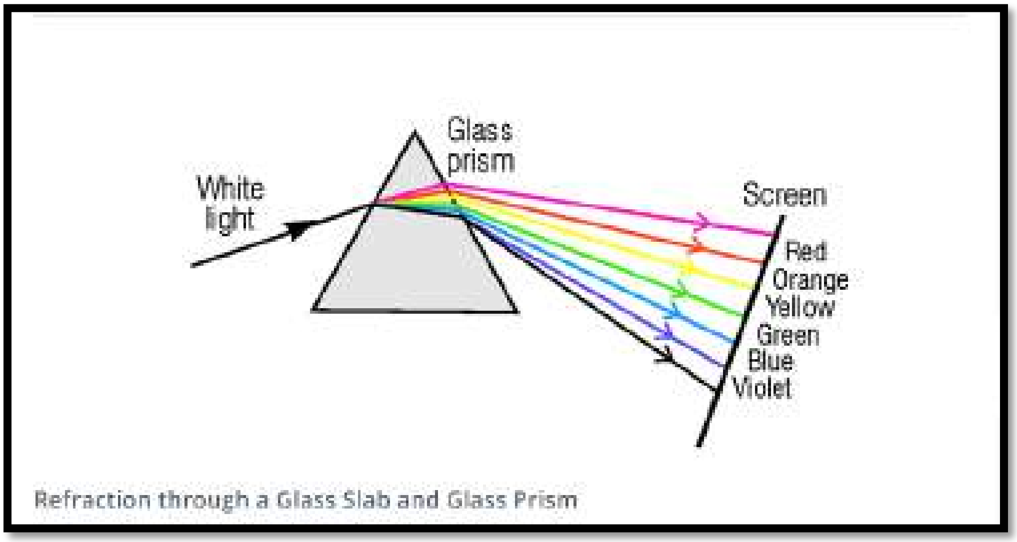
$n_1 \sin\theta_c = n_2 \sin 90^\circ$

$n_1 \sin 37.4° = 1.47 * (1)$

$n_1 = 1.47 / \sin 37.4° = 2.42$

Refraction by prism:

A **prism**, can be used to separate visible light into its different colors. A prism is a pyramid-shaped object made of transparent material, usually clear glass or plastic. The material that is transparent allows light to pass through it. A prism transmits light but slows it down. When light passes from air to the glass of the prism, the change in speed causes the light to change direction and bend. Due to the differences in the refraction index between the air and the glass, light bends once entering the prism. Since the sides are angled, the light bends, even more, when it exits the prism. Longer wavelengths tend to refract less while shorter wavelengths tend to refract more.



Refraction through a Glass Slab and Glass Prism

Prisms in ophthalmology

Prisms are used commonly in ophthalmic practice. In strabismus, they have a diagnostic and therapeutic role.

A prism is a lens which deflects light and can correct ophthalmic misalignment. An ophthalmic prism has an apex and a base. Light rays refracted through a prism always bend toward the base (Snell's law). The power of a prism is designated as "prism diopter" which is a measure of the strabismus deviation.

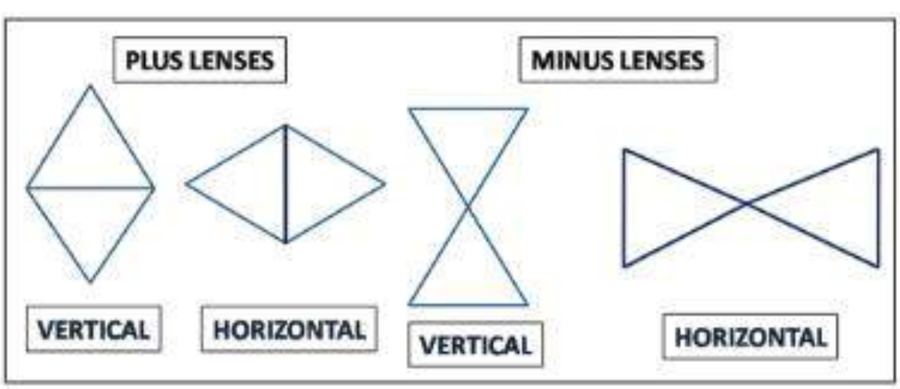
The amount of deflection depends on the refractive index of the material and the position in which the prism is held.

Types of ophthalmic prisms :

Prisms are used for diagnostic and therapeutic purposes. Diagnostic prisms are made of glass or plastic. Glass prisms have a higher refractive index and therefore deflect light more than plastic prisms.
For therapeutic purposes, there are two kinds of prisms: glass and Fresnel. Glass prisms have the disadvantage of being heavy, cosmetically dissatisfying, and giving rise to disturbing reflections and aberrations. Fresnel prisms are based on the principle that the power of the prism will not depend on the thickness of the prism but on the prism angle. These prisms are thinner, cosmetically acceptable, and have less aberrations. However, they reduce visual acuity and contrast sensitivity.

Prismatic Effect of Spherical Lenses:

A plus lens is two prism lenses stacked base to base, while a minus lens is two prisms stacked apex to apex Therefore, spectacles affect the measured strabismus deviations. A plus lens will decrease the measured deviation and a minus lens will increase it.



Prismatic effect of spherical lenses

جامعة الفرات الاوسط التقنية

المعهد التقني النجف

قسم تقنيات فحص البصر

اسم المادة : الفيزياء البصرية

المحاضره الخامسة (الزيغ في العدسات)

(Aberration in lenses)

اعداد

د. رنيم محمد عباس

المرحلة (الأولى)

Aberration In optics is a property of optical system such as lenses that cause light to be spread out over some region of space rather than focused to a point. Aberration cause the image formed by a lens to be blurred or distorted depending on the actual size shape and position. It divided into two categories monochromatic aberration and chromatic aberration.

The aberration of an image is not due to any defect in the construction of the lens, but it is due to the reasons mentioned below: (1) The phenomenon of refraction in the lens and (2) Variation of refractive index of the material of a lens with the wavelength of light.

Monochromatic aberration:

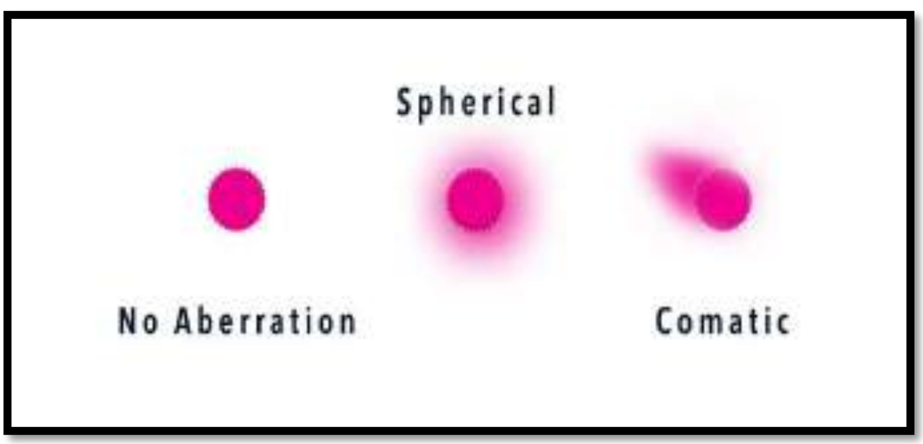
Monochromatic aberrations are optical distortions. These are created by white light passing through the lens at different speeds and angles. There are five different types of monochromatic aberrations. They are, (1) Spherical aberration (2) Coma (3) Astigmatism (4) Curvature of the field and (5) Distortion. These are often referred to by the shape of the distortion created.

1-Spherical Aberration

The inability of lens to bring to a focus a point object to a single point image is called **spherical aberration**. The glass elements of a lens are not flat but curved. The light entering at the edges of a lens refracts more than light entering in the middle. Light entering from the edges hits the optical axis at a different point than light entering in the center. This creates a soft-focus look called a spherical aberration.

2-Coma

The aberration of defect **Coma** occurs when the image of a point object situated just off the axis is comet – like shaped. This type of aberration arises due to the fact that the different zones of a lens produce **unequal lateral magnification** of the image. Coma aberrations are like spherical aberrations. The difference lies in the shape of the distortion. Rather than round, the distortion is elongated, like the shape of a comet. This occurs when light entering at the edge of a lens comes in at an angle. Coma is more obvious at the edges of the frame.



3-Astigmatism

A lens or an optical system corrected for **spherical** aberration and **come** still shows another defect known as **Astigmatism**. A lens suffering from astigmatism will be unable to form a point image of a point object situated far away from the axis. Instead of a point image is a pair of short lines normal to each other and at slightly different distances from the lens.

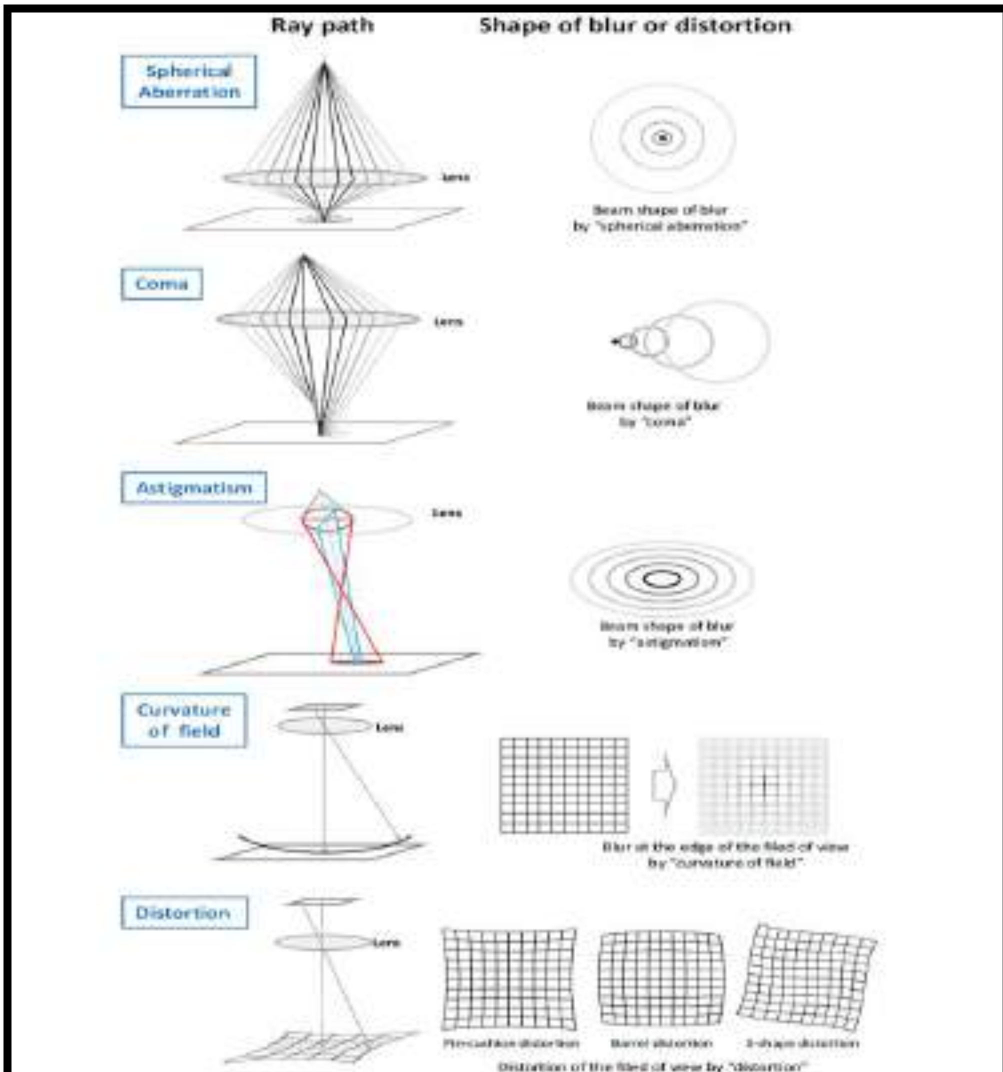
4-Curvature of field

Field curvature concerns the quality of focus across the frame. The image may be sharp in the middle and lose focus towards the edges.

5-Distortion

Distortion, is refers to the **deformation** of an image. There are two kinds of deformation, namely **barrel distortion** and **pincushion distortion**.

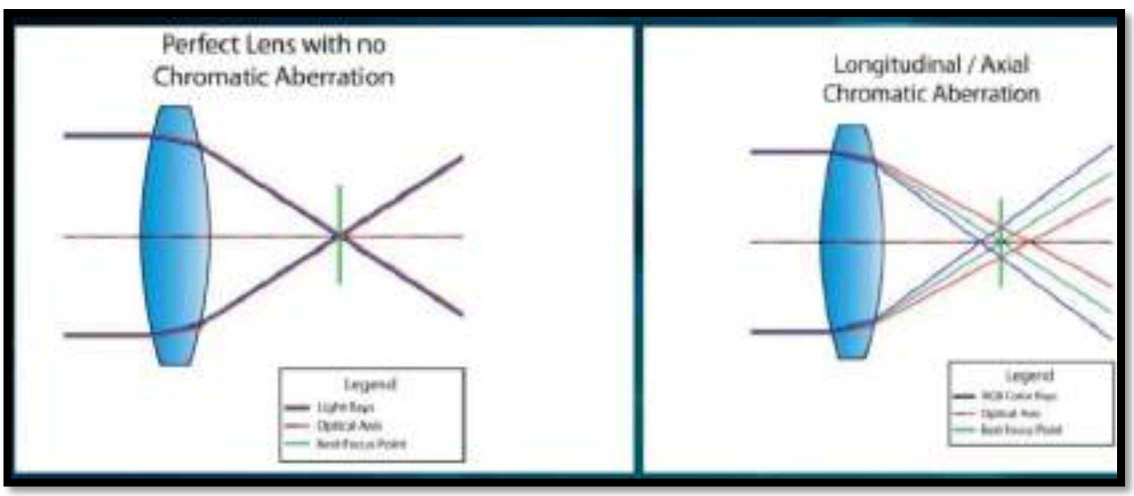
With barrel distortion, the center of the image bulges in the center and looks smaller at the edges.


Ray path
Shape of blur or distortion
Spherical Aberration
Coma
Astigmatism
Curvature of field
Distortion

Chromatic aberration:

Chromatic aberration (present when using more than one wavelength of light) is the variation in the focal length of a lens with respect to the wavelength. The effect is that, for multi wavelength light, the image of an object point will not be focused on a single image point and, therefore, will be blurred .A lens is either unable to bring all wavelengths of color to the same focal plane.

It is due to different colors of light travelling at different speeds while passing through a lens. As a result, the image can look blurred or noticeable colored edges (red, green, blue, yellow, purple, magenta) can appear around objects.



Chromatic aberrations are further classified into two types: transverse and longitudinal.

Transverse chromatic aberration (TCA) occurs when the size of the image changes with wavelength. In other words, when white light is used, red, yellow, and blue wavelengths focus at separate points in a vertical plane

Longitudinal chromatic aberration (LCA) occurs when different wavelengths focus at different points along the horizontal optical axis as a result of dispersion properties of the glass. The refractive index of a glass is wavelength dependent, so it has a slightly different effect on where each wavelength of light focuses, resulting in separate focal points .

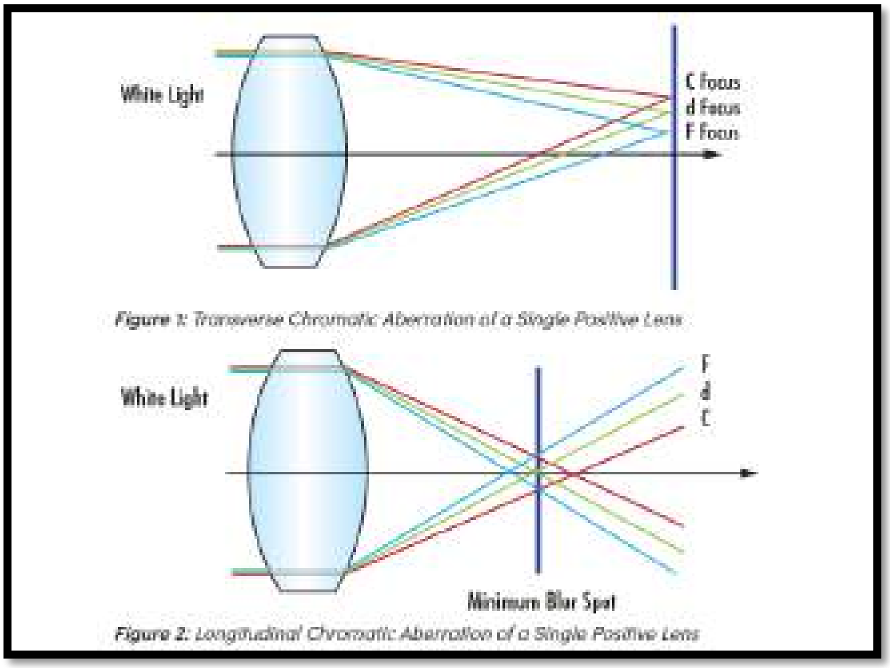


Figure 1: Transverse Chromatic Aberration of a Single Positive Lens

Figure 2: Longitudinal Chromatic Aberration of a Single Positive Lens

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تقنيات فحص البصر

اسم المادة : الفيزياء البصرية

Optical physics

المحاضرة الثالثة : العدسات المركبة

Compound lenses

المرحلة : الاولى

اعداد : د.رنيم محمد عباس

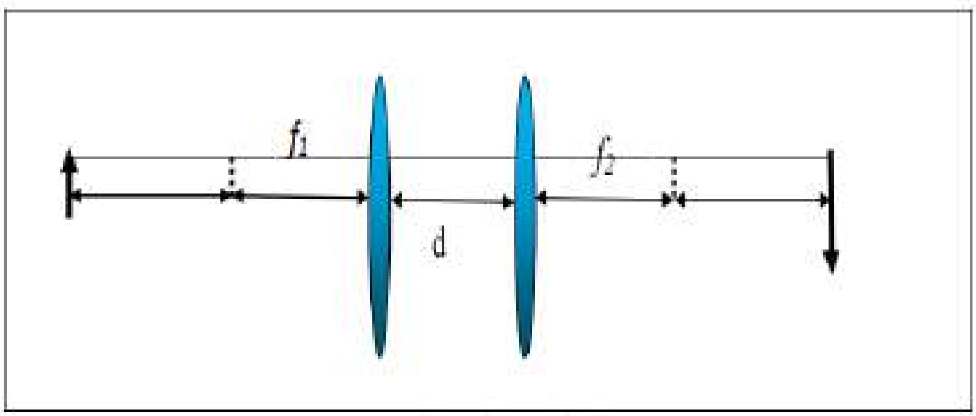
Compound lenses

A **compound lens** uses multiple lenses. The most obvious example of a simple lens is a magnifying glass, which uses a single lens to magnify an object, while an example of a compound lens is a compound microscope, which uses multiple lenses to increase the viewer's capacity to magnify an object.

1-Increase the magnification of the image.

2-Obtain the erect image of an object.

3-Reduce aberrations or defects caused by using a single lens.



$\mathbf{1/f = 1/f_1 + 1/f_2 - (d/f_1 f_2)}$ ……………… (Newton equation for compound lens , if there is a distance between lenses)

f: equivalent focal length

f_1: focal length for first lens

f_2: focal length for second lens

d: distance between lenses

$\mathbf{1/f = 1/f_1 + 1/f_2}$ ………………….(if the lenses contact without distance)

Lens maker's Equation

There is a special formula for lenses that relates the refractive index of a lens with the radii of curvature of its surfaces.

With the focal length known as the lens makers formula, it is a very important formula for the optical design process, because it is related to the type of lens material through its refractive index, and the shape of the lens through its radii of curvature for surfaces, thus identifying the lens by its focal length.

For a thin lens:

$$1/f = (n - 1) [1/R_1 - 1/R_2]$$

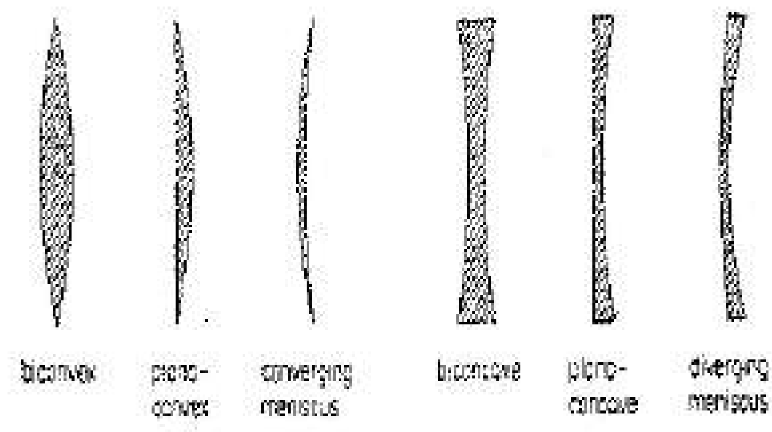
f is the focal length of the lens

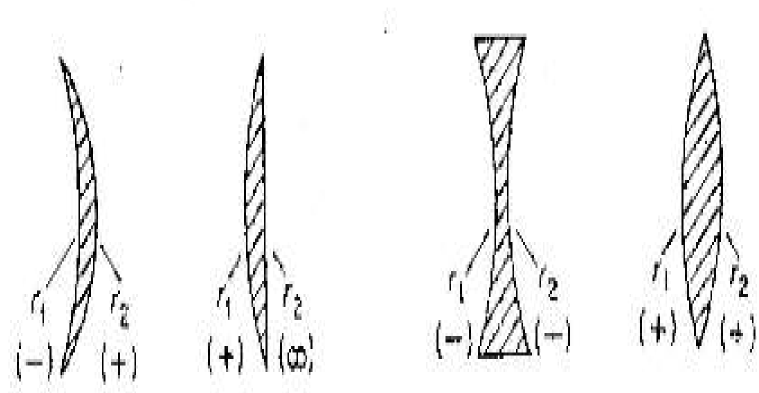
n is the refractive index of the lens material,

R1 is the radius of curvature of the face closest to the object

R2 is the radius of curvature of other face

radius of curvature for plane lens is **infinity**.





NOTE: the sign of the radii is determined accoring to the direction of the incident rays . If the rays fall on a **concave** surface , the sign of (R) is **NEGATIVE** . If the rays fall on **covex** surface , the sign of (R) is **POSITIVE** . Finally , if they fall on a **plane** surface , the sign of (R) is **INFINITY** .

Power of lens

The ability of the lens (P) is represented in the ability of the lens to collect (converging) or disperse(diverging) the light rays falling on it, and the power is calculated through the Caussian formula also with considering the special units called Diopter which equal to (1/m)

P= 1/f

Problems :

1-A plane convex lens made of glass with a refractive index of (1.7) Calculate the radii of curvature of the lens that gives a power to the lens of (5 D) .

2-The refractive index of a lens is given as 1.5, two curved surfaces have radius of curvature 10cm and -15cm respectively. Calculate the focal length of the given lens?

3- Find the radius of curvature of the convex lens of index of refractive 1.52 when the radius of one face twice the other and the power of lens 20 D ?

4-The radii of both surfaces of an equiconvex lens of index 1.60 are equal to 8.0 cm. Find its power.

5-A compound lens consisting of a convex lens with a focal length of 20 cm, and a concave lens with a focal length of 20 cm, 10 cm distance between them . Calculate the equivalent focal length.

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تقنيات فحص البصر

اسم المادة : الفيزياء البصرية

Optical physics

المحاضرة الثانية : خواص الصور المتكونة بالعدسات

Properties of images formed by lenses

المرحلة : الاولى

اعداد : د.رنيم محمد عباس

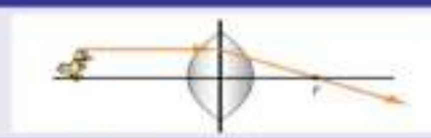
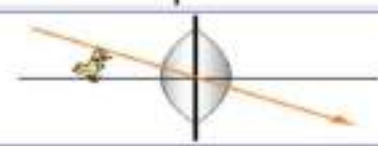
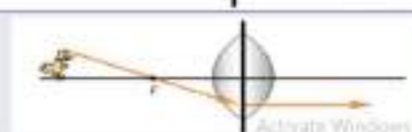
The Lenses

Lens are used to focus light and form an image in cameras, telescopes, microscopes, eyeglasses an even in our eyes. Lenses work very much like mirrors. We will discuss two types of lenses.

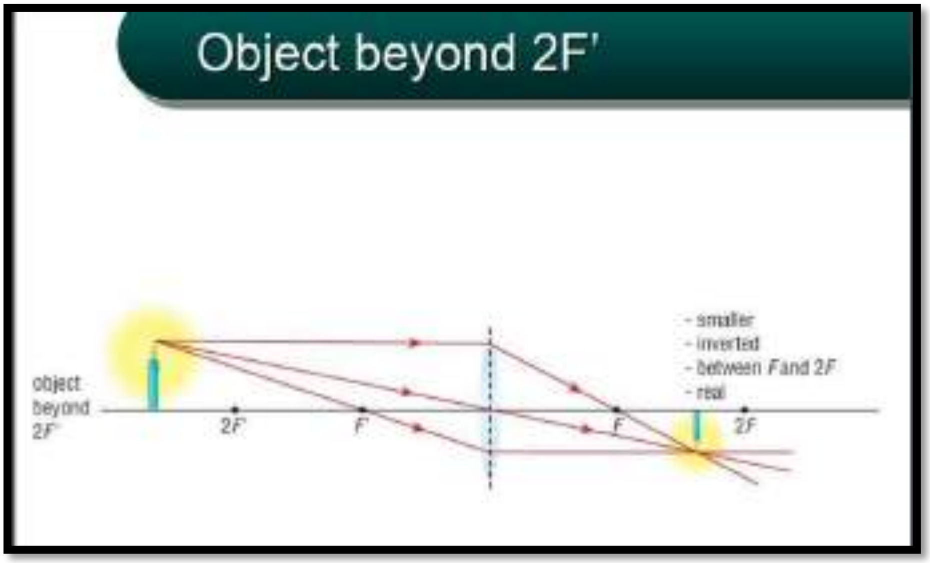
Convex Lenses

The double convex lens is a converging lens. When light waves parallel to the principle axis from an infinitely far object passes through the lens, it will converge at a focal point F on the principle axis. The distance between the focal point and the lens is the focal length, which is always a positive value for converging lenses.

Properties of image formation by convex lens :

Incident Ray	Refracted Ray	Diagram (Thin lens)
Parallel to Principal Axis	Through focus	
Through optic Centre	Ray moves along same path	
Through focus	Parallel to principal axis	

Case 1 :



The position of object :

Beyond 2F’

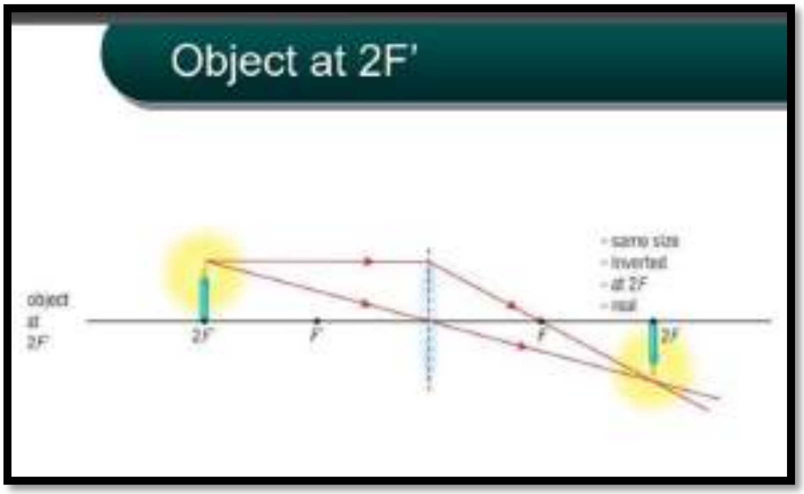
The position of image :

Between F and 2F

Properties of image :

1- Smaller
2- Inverted
3- Real

Case 2 :



The position of object :

At 2F'

The position of image :

At 2F

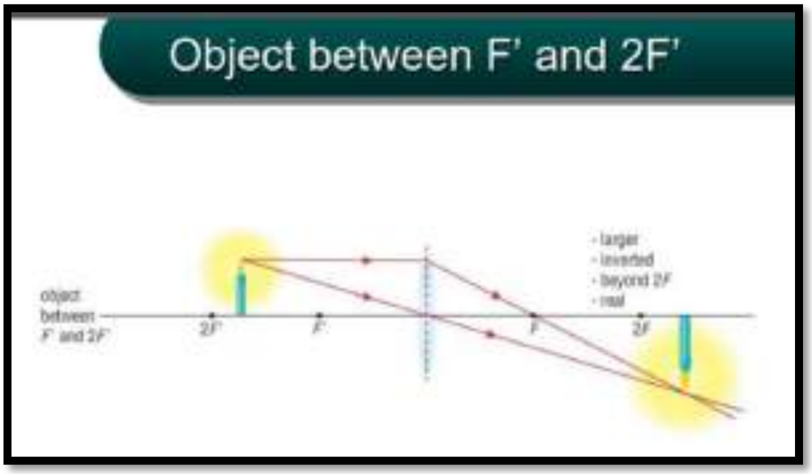
Properties of image :

1-Same size

2-Inverted

3-Real

Case 3 :



The position of object :

between 2F' and F'

The position of image :

beyond 2F

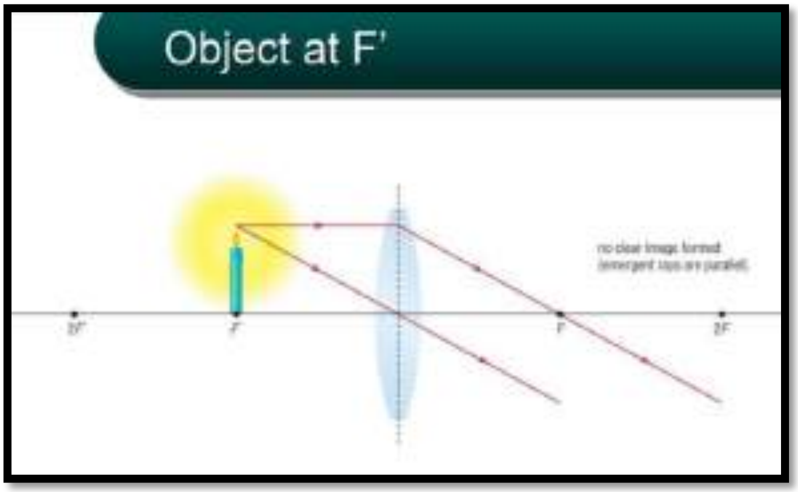
Properties of image :

1- larger

2-Inverted

3-Real

Case 4 :



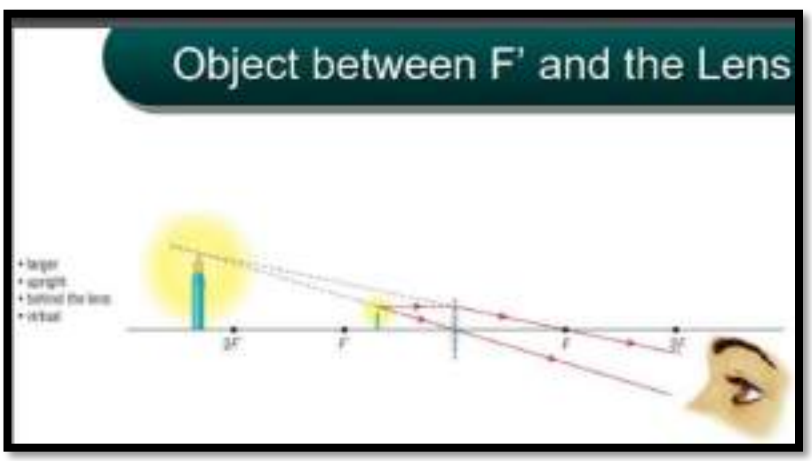
The position of object :

At F'

The position of image :

No clear image formed

Case 5 :



The position of object :

between F' and the lens

The position of image :

Behind the lens

Properties of image :

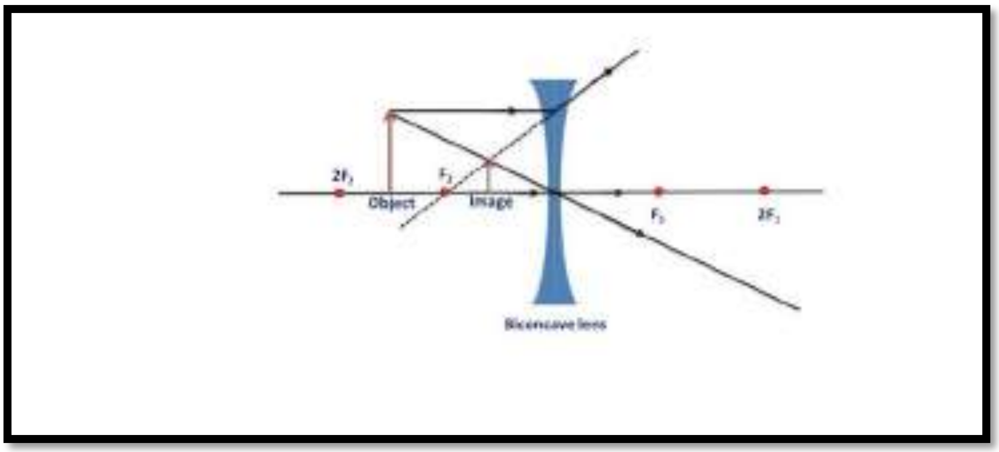
1-larger

2-upright

3-virtual

• Concave Lenses

The double concave lens is a diverging lens. When light waves from an infinitely far object passes through the lens, the light waves will diverge as if it originated from a focal point F on the principle axis. The focal length is always a negative value for diverging lenses.



The position of object :

between 2F'and F'

The position of image :

In front the lens between F' and the lens

Properties of image :

1-smaller

2-upright

3-virtual

Example 1: A magnifying glass has a focal length of (10cm),a person uses it to read at a distance of 8cm,a- find a-the image distance, b-the image properties. f= 10cm, o= 8cm .

Sol.:

$1/f = 1/i + 1/O =$

$1/10 = 1/i + 1/8 = -40cm$

$m = -(i/o) = -(-40/8) = 5.56$

the image is :virtual, upright, magnified

Ex.2: find the image position of a 7.6cm high flower placed at 25cm to the left of the converging lens (f= 5cm),b-find the value of magnification of the lens, c- the image properties.

Sol.:

a- $1/f = 1/i + 1/o$ ……….. $1/5 = 1/i + 1/25 = 6.25$ cm

b- $m = -(i / o) = -6.25/25 = -0.25$

c-the image is : real ,inverted, smaller in size

Ex.3: a concave lens with a focal length of 60cm, forms a virtual image at 20cm to the left of lens for the object. Find:1-the object distance,2-the magnification.

sol.:

1/o+1/i = **1**/ **f**

1/o+1/-20 = 1/-60 ………. O=30 cm

m= **-** (i / o) = **-** (-20 /30) = 0.66

the image is virtual, upright, smaller in size

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تقنيات فحص البصر

اسم المادة : الفيزياء البصرية

Optical physics

المحاضرة الاولى : كيف ينتقل الضوء في العين

How dose light travel in the eye

المرحلة : الاولى

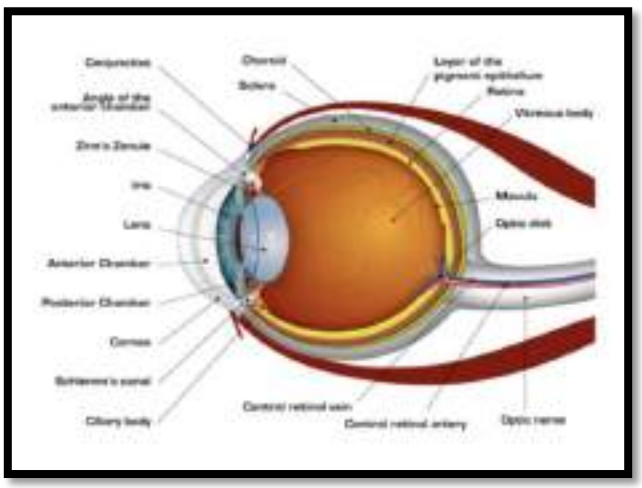
اعداد : د. رنيم محمد عباس

The Eye & Vision

The human eye achieves vision by forming an image that stimulates nerve endings, creating the sensation of sight. Like a camera, the eye consists of an aperture and lens system at the front, and a light-sensitive surface at the back. Light enters the eye through the aperture- lens system, and is focused on the back wall. The lens system consists of two lenses: the corneal lens on the front surface of the eye, and the crystalline lens inside the eye. The space between the lenses is filled with a transparent fluid called the aqueous humor. Also between the lenses is the iris, an opaque, colored membrane. At the center of the iris is the pupil, a muscle-controlled, variable- diameter hole, or aperture, which controls the amount of light that enters the eye. The interior of the eye behind the crystalline lens is filled with a colorless, transparent material called the vitreous humor. On the back wall of the eye is the retina, a membrane containing light-sensitive nerve cells known as rods and cones. Rods are very sensitive to low light levels, but provide us only with low-resolution, black-and-white vision. Cones allow us to see in color at higher resolution, but they require higher light levels. The fovea, a small area near the center of the retina, contains only cones and is responsible for the most acute vision. Signals from the rods and cones are carried by nerve fibers to the optic nerve, which leads to the brain. The optic nerve connects to the back of the eye; there are no light-sensitive cells at the point where it attaches, resulting in a blind spot.

The Refraction of Light by the Eye

Light entering the eye is first bent, or refracted, by the cornea -- the clear window on the outer front surface of the eyeball. The cornea provides most of the eye's optical power or light bending ability. After the light passes through the cornea, it is bent again -- to a more finely adjusted focus -- by the crystalline lens inside the eye. The lens focuses the light on the retina. This is achieved by the ciliary muscles in the eye. They change the shape of the lens, bending or flattening it to focus the light rays on the retina. This adjustment in the lens is necessary for bringing near and far objects into focus. The process of bending light to produce a focused image on the retina is called "refraction". Ideally, the light is "refracted" in such a manner that the rays are focused into a precise image on the retina. Many vision problems occur because of an error in how the eyes refract light. In nearsightedness (myopia), the light rays form an image in front of the retina. In farsightedness (hyperopia), the rays focus behind the retina. In astigmatism, the cornea is shaped like a football instead of a baseball. This causes light rays to focus on more than one plane, so that a single clear image cannot be formed on the retina. As we age, we find reading or performing close-up activities more difficult. This condition is called presbyopia,



and it results from the crystalline lens loosing flexibility, and therefore the ability to bend light.

Spherical Refracting Surfaces:

A simple lens consists of a single piece of transparent material, while a compound lens consists of several simple lenses (*elements*), usually arranged along a common axis. Lenses are made from materials such as glass or plastic. A lens can focus light to form an image, unlike a prism, which refracts light without focusing. Devices that similarly focus or disperse waves and radiation other than visible light are also called lenses.

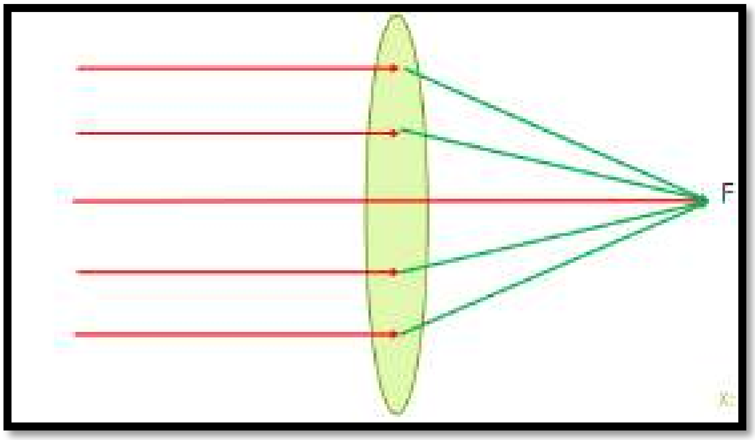
Lenses are used in various imaging devices like telescopes and cameras. They are also used as visual aids in glasses to correct defects of vision such as myopia and hyperopia.

Types Of Thin Lenses

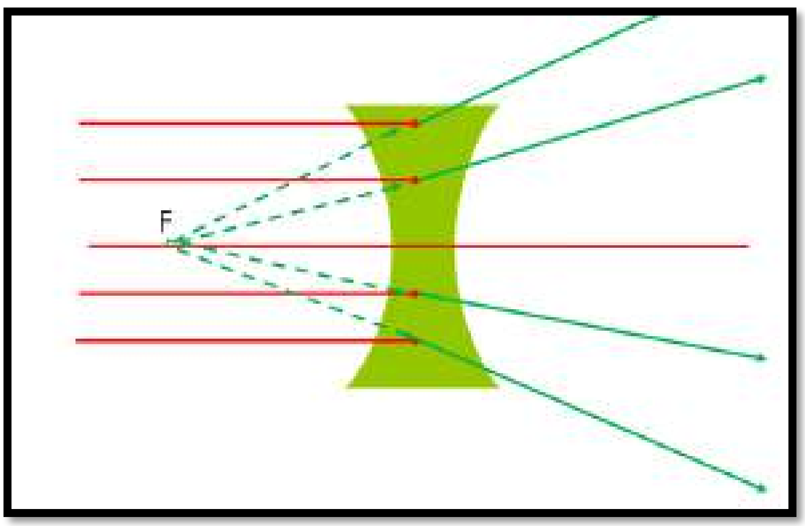
The classification of a lens depends on how the light rays bend when they pass through the lens. The two main types of lenses are:

- **Convex Lens (Converging)**
- **Concave Lens (Diverging)**

A transparent material bound by two surfaces, of which one or both surfaces are spherical, forms a lens. This means that a lens is bound by at least one spherical surface. In such lenses, the other surface would be plane. A lens may have two spherical surfaces, bulging outwards. Such a lens is called a double convex lens. It is simply called a convex lens. It is thicker at the middle as compared to the edges. Convex lens converges light rays as shown in Fig



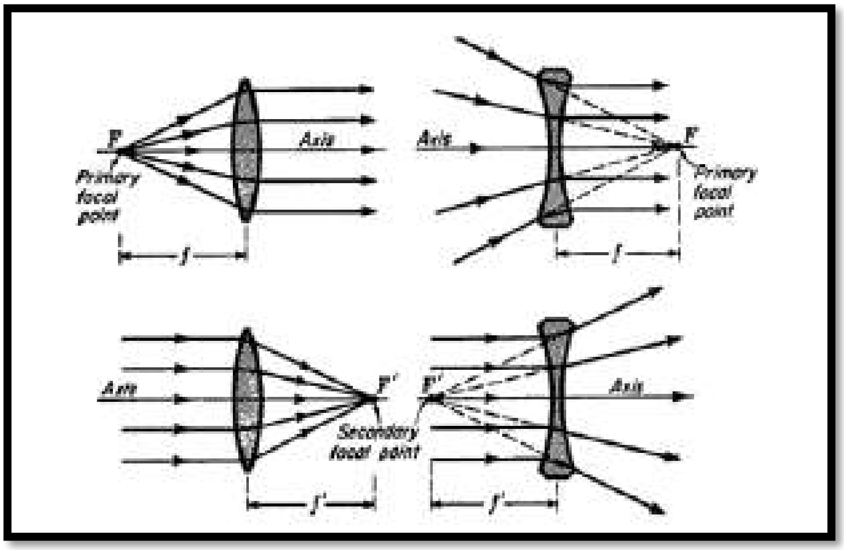
Double concave lens is bounded by two spherical surfaces, curved inwards. It is thicker at the edges than at the middle. Such lenses diverge light rays as shown in Fig. Such lenses are also called diverging lenses. A double concave lens is simply called a concave lens.



FOCAL POINTS AND FOCAL LENGTHS

Diagrams showing the refraction of light by convex lens and by concave lens are given in figure. The axis in each case is a straight line through the geometrical center of the lens and perpendicular to the two faces at the points of intersection. For spherical lenses this line which joins the centers of curvature of the two surfaces.

Ray diagrams shown in the figure illustrates the primary and secondary focal points F and F' and the corresponding focal lengths f and f' of thin lenses.



The primary focal point (F) of convex lens: an axial point having the property that any ray coming from it , travels parallel to the axis after refraction.

The secondary focal point (F') of convex lens: an axial point having the property that any incident ray traveling parallel to the axis will, after refraction, proceed toward.

The primary focal point (F) of concave lens: an axial point having the property that any ray proceeding toward it travels parallel to the axis after refraction.

The secondary focal point (F') of concave lens: an axial point having the property that any incident ray traveling parallel to the axis will, after refraction, appear to come from, F'.

Focal length: The distance between the center of a lens and either of its focal points, these distances denoted by f and f ' in the below figure.

lens equations :

1) $1/f = 1/O + 1/i$, (Gaussian law for thin lens)

(f is always negative for concave lens , and always positive for convex lens

2) Magnification , m = - i/ o = hi/ ho, (m, hi : negative for inverted image and positive for upright image) , (m >1 / the image larger than object)

(m<1/ the image smaller than object , m =1/ the image in the same size with object)

3)O is always positive if the object in front of lens , i positive for real image and negative for virtual image

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(Medical physics)
المحاضرة الخامسة / الانكسار
(Refraction)
المرحلة / الاولى

اعداد / د. رنيم محمد عباس

Refraction

In physics, refraction is the change in the path of a wave passing from one medium to another or from a gradual change in the medium. The electromagnetic waves constituting light are refracted when crossing the boundary from one transparent medium to another because of their change in speed. A ray of light of one wavelength, or color (different wavelengths appear as different colors to the human eye), that passing from air to glass is refracted, or bent, by an amount that depends on its speed in air and glass, the two speeds depending on the wavelength. A ray of sunlight is composed of many wavelengths that in combination appear to be colorless. Upon entering a glass prism, the different refractions of the various wavelengths spread them apart as in a rainbow.

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{n_2}{n_1}$$

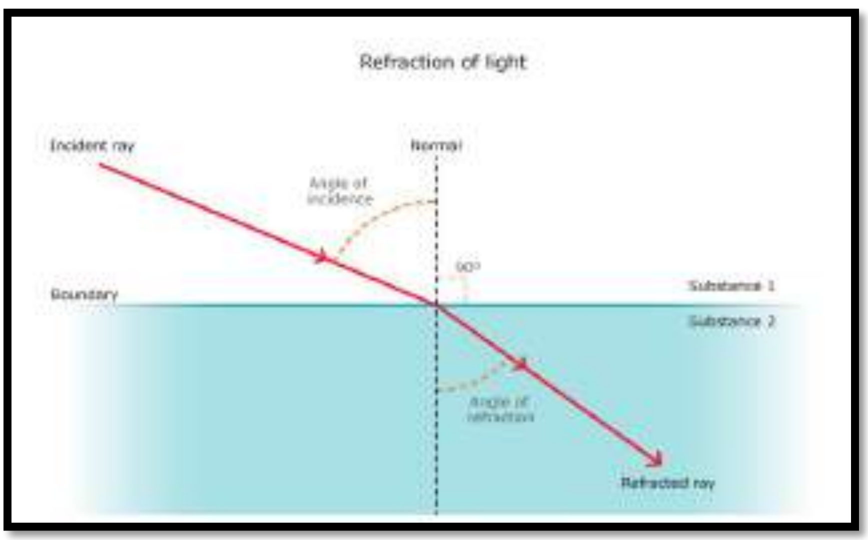


Figure (1) : Refraction of light

Refraction of light is shown in the figure above. When light travels from air into glass, the light slows down and changes direction slightly. When light travels from a less dense substance to a denser substance, the refracted light bends more towards the normal line. If the light wave approaches the boundary in a direction that is perpendicular to it, the light ray doesn't refract in spite of the change in speed.

Laws of Refraction of Light

Laws of refraction state that:

- The incident ray refracted ray, and the normal to the interface of two media at the point of incidence all lie on the same plane.
- The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant. This is also known as Snell's law of refraction.

  sin_i/sin_r=constant=μ

Snell's Law

Snell's law gives the degree of refraction and relation between the angle of incidence, the angle of refraction and refractive indices of a given pair of media. We know that light experiences the refraction or bending when it travels from one medium to another medium, hence called Snell's law.

Snell's law is defined as "*The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant, for the light of a given color and for the given pair of media".* Snell's law formula is expressed as:

sin_i/sin_r=constant=μ

$n_1 sin_1 = n_2 sin_2$

Where *i* is the angle of incidence and *r* is the angle of refraction. This constant value is called the refractive index of the second medium with respect to the first.

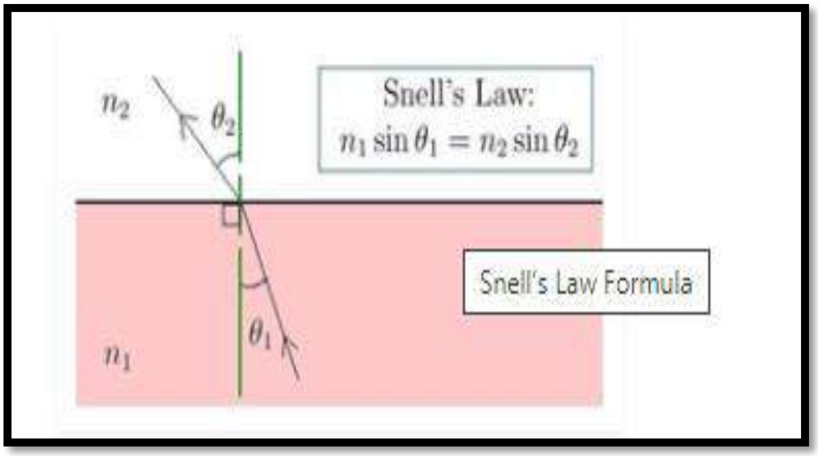


Figure (2) : Snell's law

Solved problem :

Light travels from air into an optical fiber with an index of refraction of 1.44. (a) If the angle of incidence on the end of the fiber is 22°, what is the angle of refraction inside the fiber? (b) Sketch the path of light as it changes media.

(a)

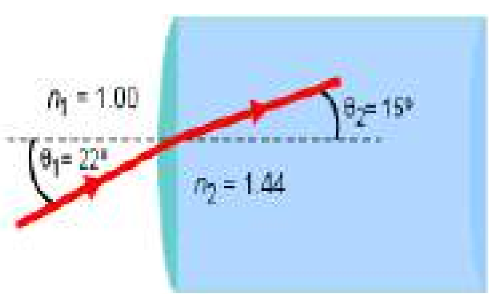
$$n_1 sin_1 = n_2 sin_2$$

(1.00) sin 22° = 1.44 sin θ_2.

sin θ_2 = (1.00/1.44) sin 22° = 0.260

$\theta_2 = \sin^{-1}$ (0.260) = 15°.

(b)



Relative refractive index :

Is the ratio of the speed of light in the medium 1 to the speed of light in medium 2.

$$n_r = \frac{\text{speed of light in medium 1}}{\text{speed of light in medium 2}}$$

Absolute Refractive Index :

Is the ratio of the speed of light in vacuum (c) to the speed of light in the medium (v) . The value of absolute refractive index is greater than unity.

n = c / v

Note:(n=1 for air , 1.33 for water , 1.520 for glass , and 2.419 for diamond)

Wavelength and the Index of Refraction:

As light moves from air into water, it not only slows, but the wavelength changes , the wavelength becomes shorter in the denser medium of water.

n= wavelength in vacuum / wavelength in medium

Solved Problem :

1-The speed of light in an unknown medium is measured to be (**2.76×10^8 m/s**) , What is the index of refraction of the medium?

n = c/v = 3*10^8 / 2.76 * 10^8 = 1.08

Home Work :

1- Optical fibers are generally composed of silica (which represent a medium), with an index of refraction around (1.44). Find the velocity of light that traveled in a silica (or in medium)?

2- Light with speed (2* 10^8 m/s) traveled in unknown medium and then passed in glass with speed (1.5 *10^8 m/s) . Find relative refractive index ? and absolute refractive index for glass ?

3-The wavelength of red light from (He-Ne laser) is 633 nm in air but 474nm inside the eye ball. Calculate a-the index of refraction inside the eye ball. b-the speed of light inside the eye ball.

4- Light traveling through an optical fiber (n=1.44) reaches the end of the fiber and exits into air. If the angle of incidence on the end of the fiber is 30^o, what is the angle of refraction outside the fiber?

5- A ray of light is incident through glass, on an interface separating glass and water, What is the angle of refraction if the angle of incidence of the ray in glass is 25 °?

6-What should be the angle of incidence of a light ray incident through air on the boundary separating air from water so that the angle of refraction is 30 °?

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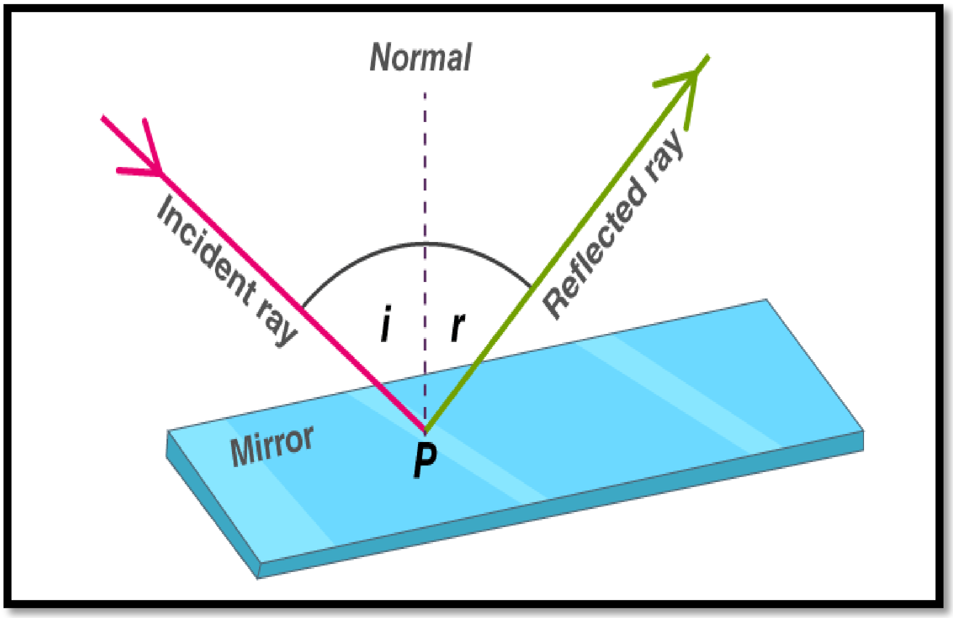
Reflection: The change in direction of a ray at an interface between two different media so that the ray returns into the medium from which it originated. Common examples include the reflection of light, sound and water waves. In acoustics, reflection causes echoes and is used in sonar.



Figure(1) : Reflection of light

Now we define some terms of reflection :

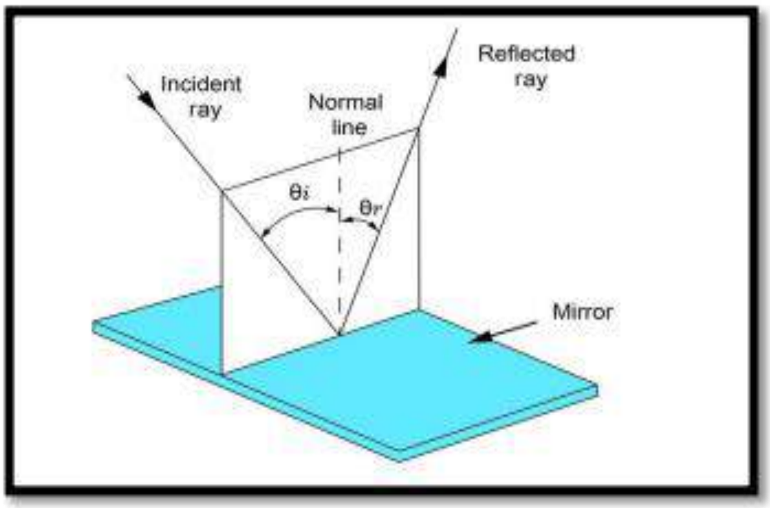
1- **Incident ray** : in physics, a ray of light that hits a surface.
2- **Reflected ray** : A ray of light or another form of radiant energy that is thrown back from a non absorbing surface is called reflected ray.
3- **Angle of incidence** : Is the angle between a ray incident on a surface and the line perpendicular to the surface at the point of incidence (called as normal).

4- **Angle of reflection** : The angle between a reflected ray and the normal drawn at the point of incidence to a reflecting surface

Laws of reflection

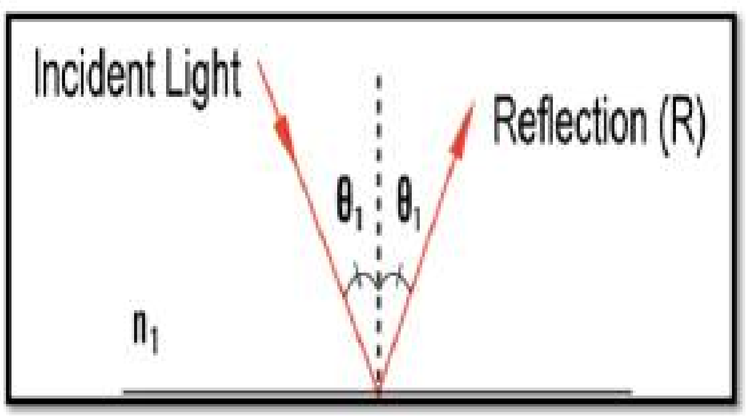
The laws of reflection are as follows:

1. **First law** : The incident ray, the reflected ray and the normal to the reflection surface at the point of the incidence lie in the same plane.



Figure(2) : First law

2. **Second law** :The angle which the incident ray makes with the normal is equal to the angle which the reflected ray makes to the same normal.



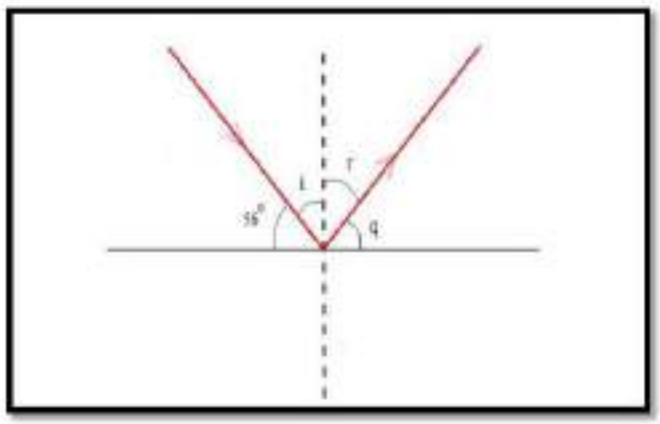
Figure(3) : second law

Solved Problem :

A light ray strikes a reflective plane surface at an angle of 56° with the surface.

a) Find the angle of incidence. b) Find the angle of reflection. c) Find the angle made by the incident and reflected rays.

Solution :



a) angle of incidence: i = 90 - 56 = 34 °

b) angle of reflection r = i = 34 ° (by the law of reflection)

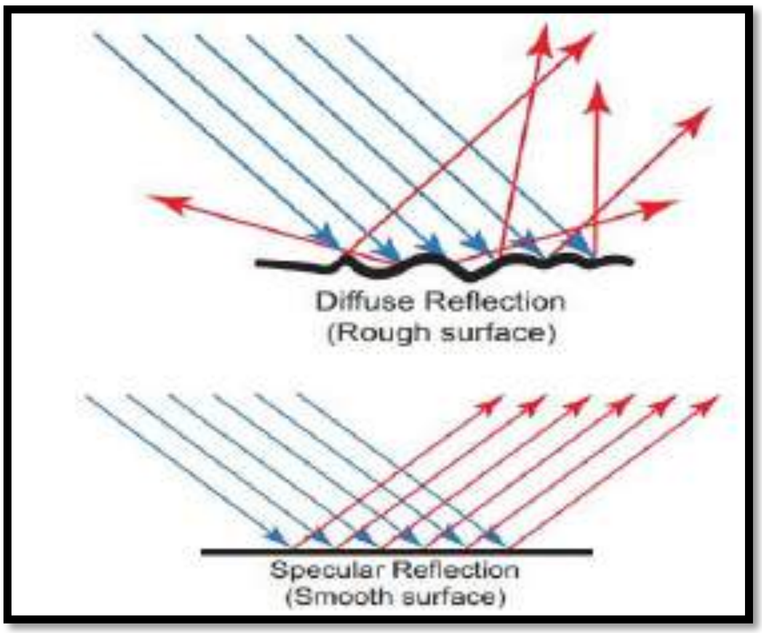
c) i + r = 34 + 34 = 68 °

Reflection of light at plane surfaces:

When the light strikes the plane surface and comes back in the same medium, the occurring phenomenon is the reflection of light. And the surface from which the light gets reflected is known as the reflecting surface. When such a phenomenon occurs, the light obeys the two laws of reflection .

When a beam of light strikes the smooth surface and gets reflected at the same angle, the surface is known as a regular or smooth surface. In this phenomenon of light, the angle of incidence is equal to the angle of reflection, and the three lines lie in the same plane . The images in the regular reflection are clear, and the images are produced through shiny and polished surfaces.

On the other hand, when a beam of light strikes an irregular or rough surface, the beam light gets reflected with different angles of reflection. This process or phenomenon is known as irregular reflection, and such a surface is known as an irregular reflecting surface. The images in irregular reflection are not clear and the images are produced through hard surfaces like wood, paper, cardboard



Figure(4) : types of reflection

Reflection of light at spherical surfaces

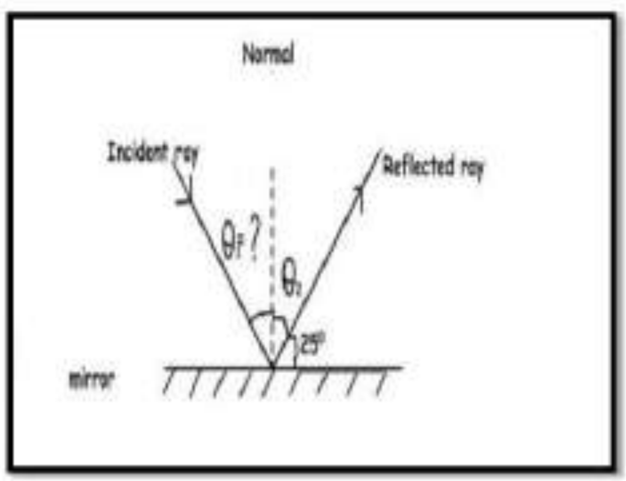
A mirror or surface that resembles the shape of a sphere is termed a spherical mirror or surface. In other words, a spherical mirror looks like it is a part that has been cut from a sphere. Spherical mirrors are of two types – Concave mirrors and Convex mirrors.

Concave mirror – Also referred to as converging mirrors, this type of mirror is known to converge the rays that fall on it. When a light beam strikes at the concave mirror, the light rays converge at a single point. And this type of mirror curves inward. Such mirrors are used as vehicle mirrors as well as in street lights.

Convex mirror – Unlike Convex mirror, this type of mirror has an outward curve. The images formed by the Convex mirror are erect, virtual and diminished. When the beam of light strikes the surface, the lines get reflected by either diverging or spreading out. For this reason, these mirrors are known as diverging mirrors.

H.W :

1- According to figure , find : a- angle of reflection, b- angle of incident .



2- A ray of light strikes a plane mirror at an angle of 40° to the mirror surface , what will be the angle of reflection ?

3- A ray of light strikes a plane mirror such that its angle of incidence is 30° , what angle dose the reflected ray make with mirror surface?

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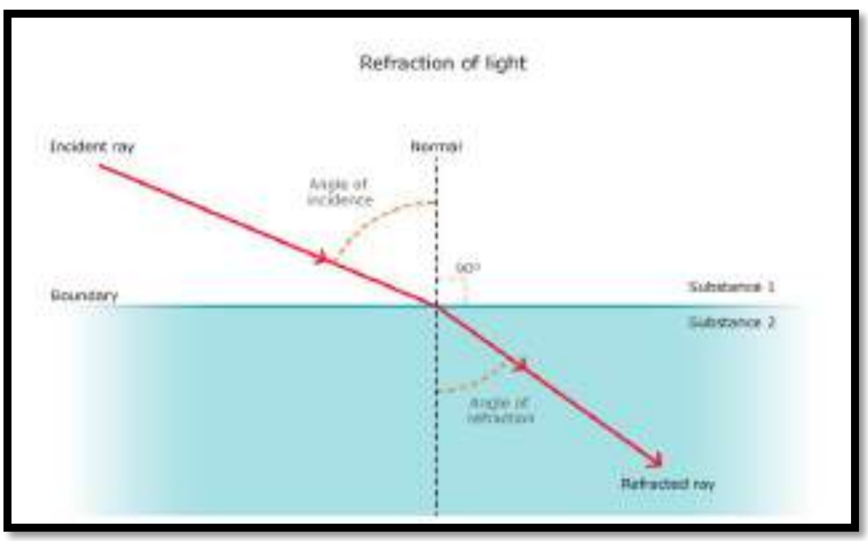

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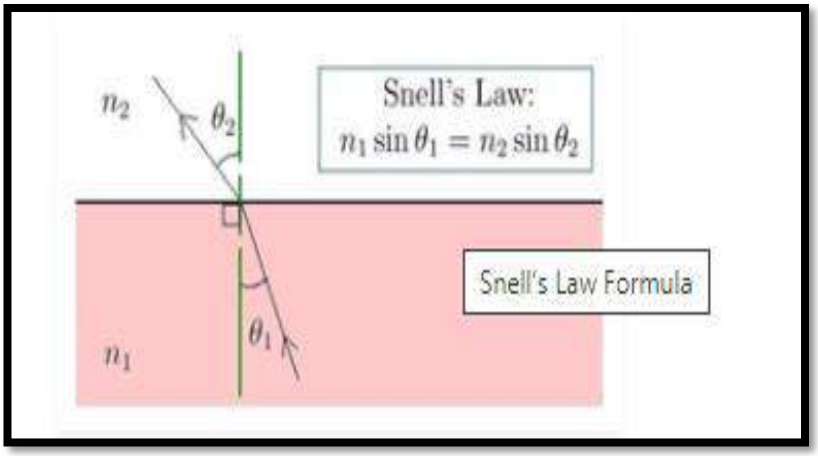

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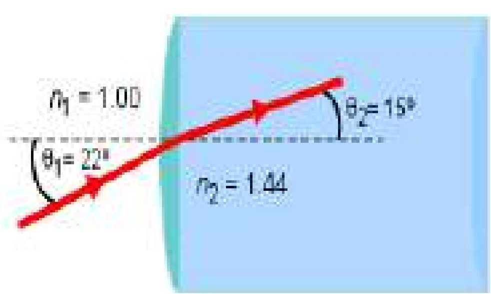

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(*Medical physics*)

المحاضرة الثانية / الطيف الكهرومغناطيسي

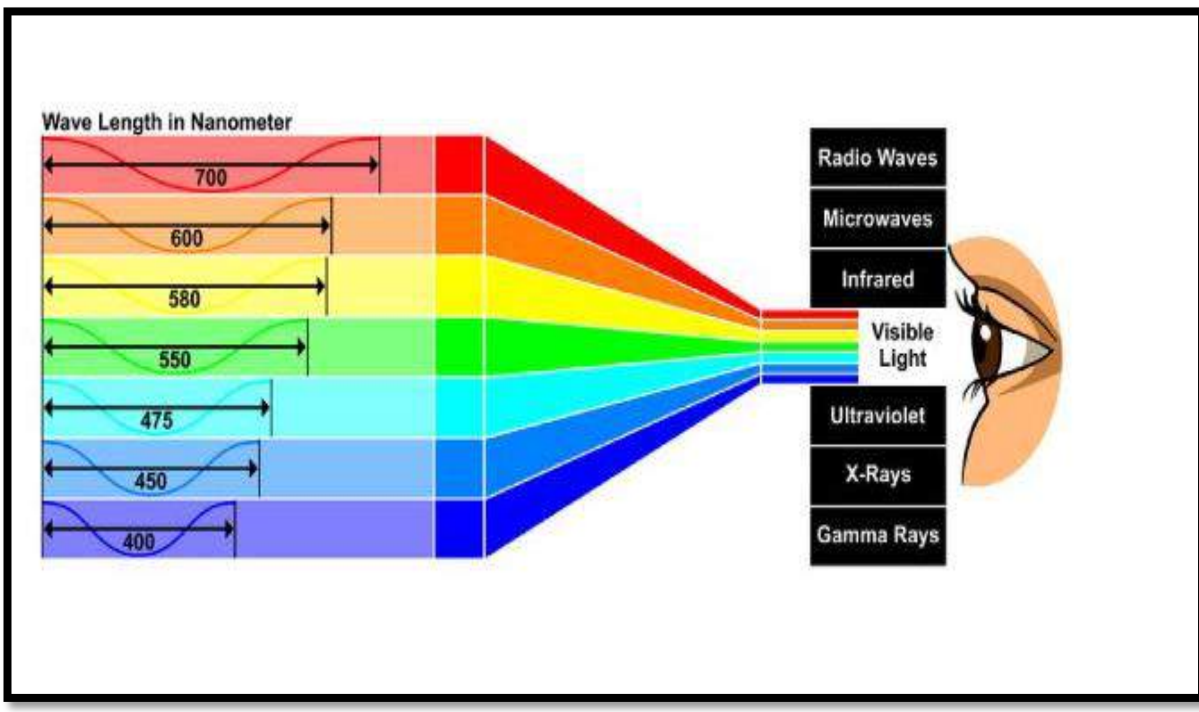
(*The electromagnetic spectrum*)

المرحلة / الاولى

اعداد / د. رنيم محمد عباس

The electromagnetic spectrum :

Is the range of frequencies (the spectrum) of electromagnetic radiation and their respective wavelengths and photon energies. The electromagnetic spectrum covers electromagnetic waves with frequencies ranging from below one hertz to above 1025 hertz .This frequency range is divided into separate bands, and the electromagnetic waves within each frequency band are called by different names; beginning at the low frequency (long wavelength) these are : radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays at the high-frequency (short wavelength) (which represent end of spectrum).



Figure(1): The electromagnetic spectrum

Types of radiation :

1-Radio waves: Radio waves are have the longest wavelengths of all the electromagnetic waves. Radio waves are often used to transmit data and have been used for all sorts of applications including radio, satellites, radar, and computer networks.

2- Microwaves: Are waves with short wavelength, from about 10 centimeters to one millimeter. This waves is used to heat food in microwave ovens, and for industrial heating and medical diathermy. Microwaves are the main wavelengths used in radar, and are used for satellite communication, and wireless networking technologies such as Wi-Fi, although this is at intensity levels unable to cause thermal heating.

3- Infrared radiation: is invisible radiant energy, electromagnetic radiation with longer wavelengths than those of visible light, extending from the nominal red edge of the visible spectrum at 700 (nm) to 1 (mm). Human eye can see IR up to at least 1050 (nm) only in some experiments . It is divided into three sub-ranges: IR-A, or near infrared (from 780 to 1400 (nm)); IR-B or far infrared (1400 to 3000 (nm)); IR-C (3000 to 10000 (nm)) .Evidently, IR-C is the most dangerous for the human eye, because of the higher wavelength, farthest from the visible spectrum. Most of the thermal radiation emitted by objects near room temperature is infrared. This type radiation is used in industrial, scientific and medical applications: night vision devices using active near-infrared illumination allow people or animals to be observed without the observer being detected in darkness, infrared astronomy uses sensor-equipped telescopes to detect objects such as planets, and infrared thermal-imaging cameras are used to detect heat loss in insulated systems, to observe changing blood flow in the skin, and to detect overheating of electrical apparatus . Other application include: short-ranged wireless communication, spectroscopy, environmental monitoring, industrial facility inspections, and remote temperature sensing thermal efficiency analysis

the most important harmful effects on eye are: 1- **Eyelids:** The most common affections on the eyelid range from mild reddening to third degree burns and, in extreme cases, death of the skin, when are exposed to very high levels of infrared delivered over a short period of time or to low levels of infrared over a long period. Infrared eyelid affections are hardly ever found in the industrial applications.

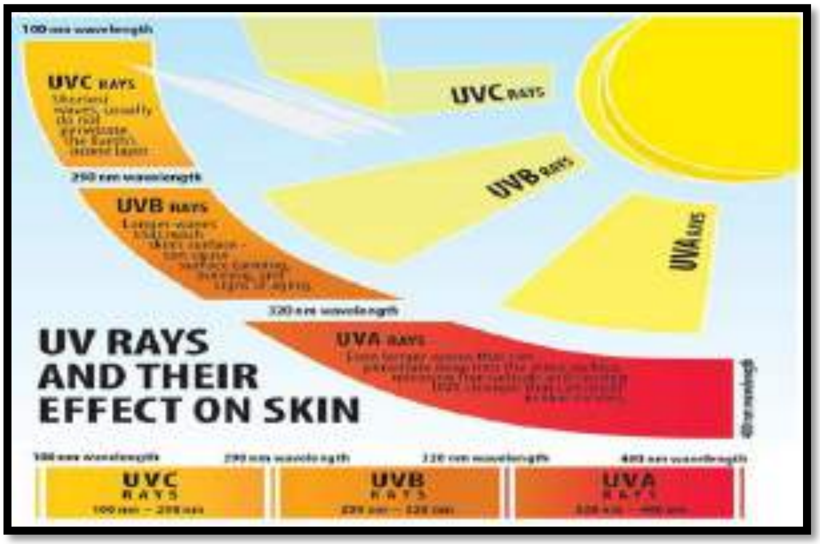
2-Cornea:Because the cornea transmits 96% of incident infrared in the range 700-1400 (nm), the level of damage to occur is quite high, especially in the range of 750-990 (nm). The radiation effects on the cornea from this type of radiation involve protein coagulation of the front and middle layers (the epithelium and stroma). At higher dose of IR, damage to the cornea produces immediate pain and vascularization. Eventually, the burn can causes ulcers, which leads to loss of transparency and opacification.

3-Iris: Depending on the degrees of pigmentation, the iris can absorbs between 53% and 98% of incident infrared in the 750-900 (nm) range. In long exposure, the most common medical affections are swelling, cell death. The higher wavelengths can cause inflammations and burns. **4-Lens:** The crystalline transmits wavelengths higher than (1400 nm) selected by the cornea and aqueous humor. The most common affection is cataract, which is associated with certain types of occupations involving prolonged exposure to IR. **5-Retina**: The energy radiation that is reaching the retina is absorbed by the epithelium. Depending on some factors (pupil size, the optical quality of the retinal image, exposure duration, size of the retinal image, quality of the retina), high infrared energy causes a rise in temperature and some kind of damage. Also, the retinal pigmentation is very important, that is the cause that the most common damages are burns and depigmentation.

4- Visible light: is the part of the electromagnetic spectrum that is visible to the human eye. Radiation from this range of wavelengths is called visible light or simply light. A normal human eye responds to wavelengths from about 390 (nm) to 700 (nm) with frequency approximately to a band of 430–790 (THz). Specific wavelengths within the spectrum correspond to a specific color based upon how humans typically perceive light of that wavelength. The long wavelength end of the spectrum corresponds to light that is perceived by humans to be red and the short wavelength end of the spectrum corresponds to light that is perceived to be violet. Other colors within the spectrum include orange, yellow, green and blue. There are only three primary colors (red, green, blue). The remaining colors are actually combinations of these. Depending on the health of the eye and brain, as well as artistic sense, the human eye can see different colors and shades thereof

White light is a combination of lights of different wavelengths in the visible spectrum. Passing white light through a prism splits it up into the several colors of light observed in the visible spectrum between 750 nm and 400 nm.

5- Ultraviolet radiation: UV or Ultraviolet Rays are a type of ray that appear on the electromagnetic spectrum . UV rays are emitted from the sun, and reach the Earth after a long journey through space. They can travel very fast; have a short wavelength, and a high yet decreasing frequency. There are three types of known Ultraviolet ray, named after the letters A, B and C, none of which (humans) can visibly see. UVA and UVB , are the two types of Ultraviolet ray that people on Earth are exposed too. They both have their benefits and dangers, UVA rays(400nm-320nm) can penetrate into a person's skin (can penetrate the middle layer of the skin (dermis)) further than that of a UVB rays, although they can cause cell damage deep into the skin as well as DNA changes. Unlike UVA rays, Ultraviolet B rays(320nm-290nm)do not penetrate as far into the skin (can penetrate the outer layer of the skin (epidermis)), instead affecting the surface and causing burning that can be seen. UVC (290nm-100nm), cannot penetrate the Earth's ozone layer which means blocked by the stratospheric ozone layer.

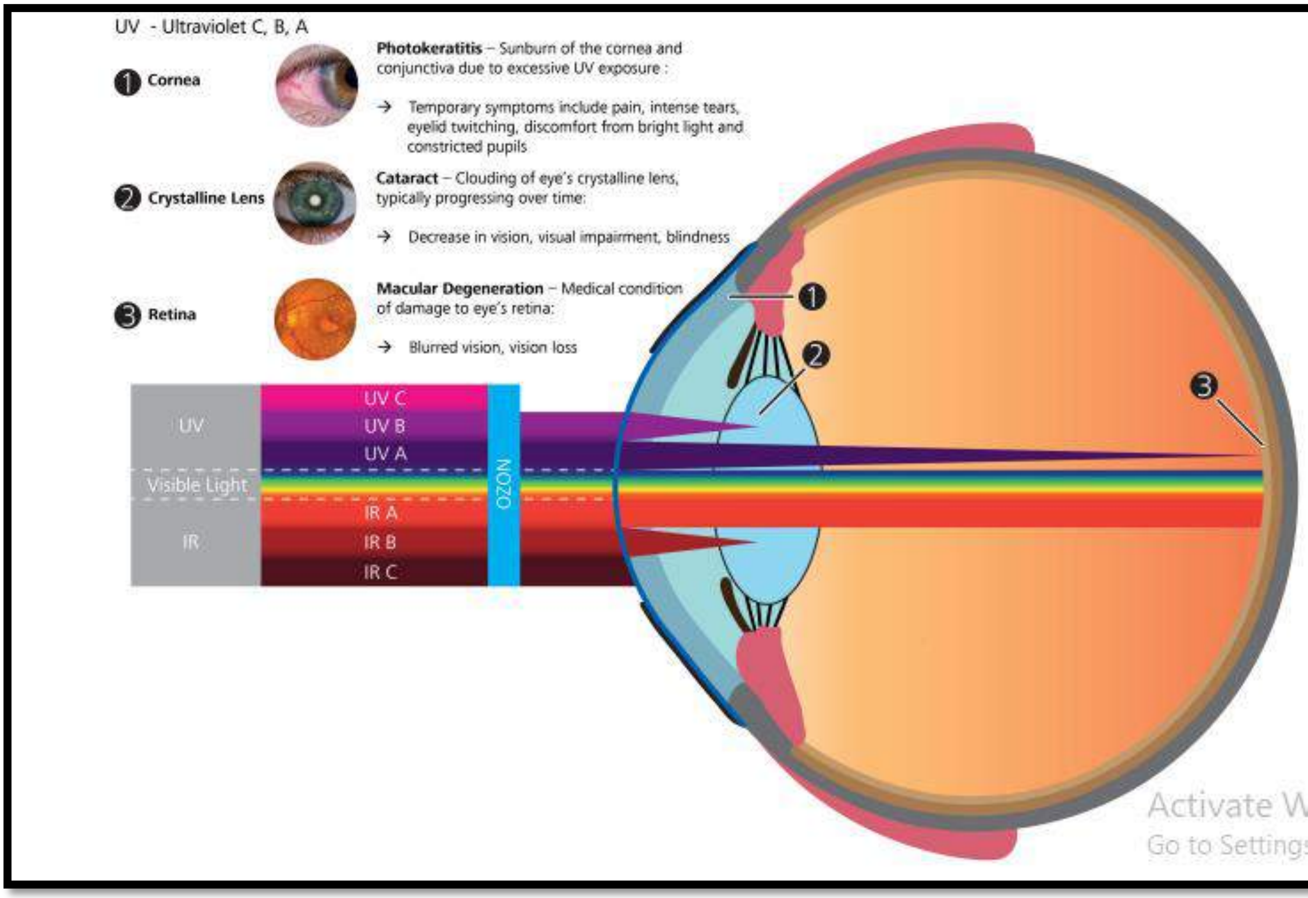


Figure(2): The UV spectrum

6-X-rays: X-rays with photon energies above 5–10 (keV) are called hard X-rays, while those with lower energy are called soft X-rays . Due to their penetrating ability, hard X-rays are widely used to image the inside of objects, as in medical radiography and airport security. Other applications of X-rays include: crystallography (including the study of the DNA), astronomy (study of X-ray emission from celestial objects), microscopic analysis (to produce images of very small objects), airport security (luggage scanners), border control truck scanners use X-rays for inspecting the interior of trucks, X-rays can produce burning in the human body tissues, including eye. Hard X-rays have shorter wavelengths than soft X-rays and as they can pass through many substances with little absorption, they can be used to 'see through' objects with 'thicknesses' less than that equivalent to a few meters of water.

7-Gamma rays: As the wavelengths of electromagnetic waves get shorter, their energy increases. Gamma rays are the shortest waves in the spectrum and, as a result, have the most energy. Gamma rays are sometimes used in treating cancer for their penetrating ability and in taking detailed images for diagnostic medicine.

Harmful rays and the eye



A schematic diagram of the eye showing the relative propagation of the different optical radiation bands through the ocular tissue. The optical media (cornea lens, aqueous humor and vitreous humor) are generally transparent only to wavelengths in the visible and IRA bands. UVC and UVB are mostly absorbed by the nucleotide bases and aromatic amino acids and therefore do not propagate past the cornea and the lens, respectively. The IR bands beyond 1400 nm (IRB and IRC) are increasingly absorbed by water molecules and do not penetrate past the superficial cornea. UVA and UVB radiation reaching the retina varies with age . Under certain circumstances the different structures of the human eye and the retina may be damaged by solar or coherent laser radiation.

The visible and invisible rays have chemical and thermal effects, such as what occurs from burning the center of vision of the retina (Macula) at looking directly at the sun during the eclipse, and the harmful effects are divided into:

Effect of UV :

Ultraviolet rays, if the rate of exposure to them increases, have a bad effect on the eye, which varies if the exposure is sudden or permanent, as follows :

1-Sudden exposure (high intensity of radiation): Such as exposure to intense light during welding.

Damages:

acute keratitis with redness, Severe pain in the eyes, tearing and inability to see.

2-Continuous exposure (low intensity of radiation): such as noon, desert and tropical areas.

Damages :

1-Its effect on the dyed material in the skin, causing increased color, redness, or peeling of the skin, if the exposure period is prolonged.

2- Some types of keratitis.

3- One of the reasons for the occurrence of (cataract).

Effect of IR :

Infrared rays carry the thermal effect of the sun's rays, and it is known what happens in terms of burning the paper when the sun's rays are focused on it by means of a positive (collecting) lens.

Damages :

Cataract and burning of the retina .

The protective lenses :

The use of sunglasses, especially in the afternoon when the amount of ultraviolet radiation increases, prevents the arrival of a high percentage from these rays to the eye. Sunglasses completely prevent ultraviolet radiation by adding special materials that absorb these rays called Chromospheres (inside the lens material).

جامعة الفرات الاوسط
المعهد التقني / النجف
قسم تقنيات فحص البصر

اسم المادة / الفيزياء الطبية

(Medical physics)

المحاضرة الاولى / الضوء (Light)

المرحلة / الاولى

اعداد / د. رنيم محمد عباس

Light : is an electromagnetic radiation visible to the human eye , responsible for the visual perception . Ranges from the wavelength of light between (400 nm to 700 nm) . The main characteristics of visible light are intensity , direction of propagation , frequency or wavelength , spectrum , and polarization , while its velocity in a vacuum is estimated at ($3*10^8$ m / s) and is one of the fundamental constants in nature. It is common to all types of electromagnetic radiation (EMR), that visible light is emitted and absorbed in the form of small "beams" called photons that can be studied as particles or waves . This characteristic is called the duality of a particle wave . The study of light is known as optics , and it is an important research field in modern physics .

The nature of light : light is a kind of energy that travels in waves . Light travels very fast and in straight lines . It can travel through a vacuum and many other media .

Light sources:

There are two general sources of light:

1-Natural light sources : that are all the time or occasionally present in nature without human intervention, like (the sun is the main primary and natural source of light, the moon is also natural light source. However, the moon is secondary light source, because it only reflects light of the sun.)

2-Artificial light sources : that were introduced by humans because of certain advantages , like (Fire, Oil lamps ,Candles, Gas lamps, Electric arc lamps ,Incandescent lamps ,Gas discharge lamps , fluorescent lamps, etc.)

Theories of light

1-Newton's theory (or particles theory): Around 1700 the great Newton, supposed that light was made up of small particles . The particles theory was postulated by ancient Greeks and was favored by Sir Isaac Newton. According to this theory, a luminous body continuously emits tiny, light and elastic particles called particles in all directions. These particles are so small that they can readily travel through the interstices of the particles of matter with the velocity of light and they possess the property of reflection from a polished surface or transmission through a transparent medium. When these particles fall on the retina of the eye, they produce the sensation of vision. On the basis of this theory, phenomena like rectilinear propagation, reflection and refraction could be accounted for, satisfactorily.

Main drawback of this theory :

1- This theory couldn't explain the phenomena of (interference , diffraction , and polarization) of light .
2- The velocity of light in denser medium is grater than its velocity in low dense medium .
3- This theory assumes that the source of light loses the mass at it emits corpuscles.

2- Huygens' principle (or wave theory) : The first person to explain how wave theory can also account for the laws of geometric optics was Christiaan Huygens in 1670. The main feature or characteristics of Huygens wave theory are

(1) Light travels from one place to another in vacuum or transparent medium in the form of waves.

(2) These waves are emitted by the source of light & travel with uniform velocity in the homogeneous medium. (3) To explain propagation of light waves through vacuum he suggested the existence of hypothetical medium called (ether)present everywhere , and this medium is necessary for the propagation of waves & the whole space is filled with an imaginary medium called Ether. (4) Experimentally he proved that velocity of light in rarer medium is greater than in denser medium.

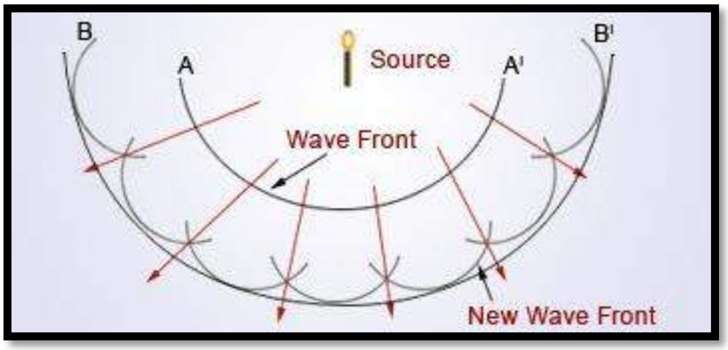
According to this. The disturbance from the source is propagated in the form of waves through space and the energy is distributed equally, in all directions. When these waves carrying energy are incident on the eye, the optic nerves are excited and the sensation of vision is produced. Huygens assumed these waves to be longitudinal, in which the vibration of the particles is parallel to the direction of propagation of the wave. Assuming that energy is transmitted in the form of waves, Huygens could satisfactorily explain reflection, refraction .

Huygens had a very important in sight into the nature of wave propagation which is nowadays called *Huygens' principle*, this principle states that:

Every point on a wave-front may be considered a source of secondary spherical wavelets which spread out in the forward direction at the speed of light. The new wave-front is the tangential surface to all of these secondary wavelets. According to Huygens' principle, a plane light wave propagates though free space at the speed of light. This theory explain the phenomena (reflection , refraction , interference and diffraction) .

Main drawback of this theory :

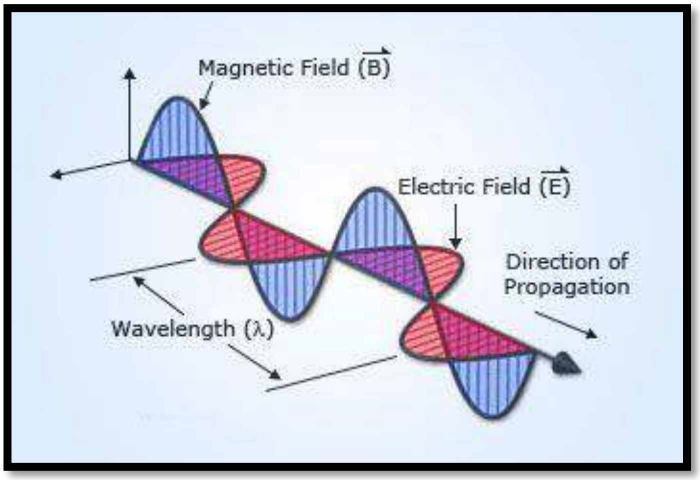
It fails to explain polarization , photoelectric effect and Compton



Figure(1): Huygens' principle

3-Electromagnetic Theory : Electromagnetic theory of light was put forward by James Clerk Maxwell in 1873. According to this theory, light consist of fluctuating electric and magnetic fields propagating in the form of electromagnetic waves. But this theory failed to explain the photoelectric effect. Maxwell found that light is an electromagnetic wave at a speed equal to the speed of light. Maxwell, in his equations, proved that electromagnetic is a wave with frequency and velocity. He was able to calculate the speed of light mathematically approximated, and was able to prove that all electromagnetic waves are moving in the vacuum at the speed of light

In a vacuum, this value was calculated to be 3×10^8 m/s. This is exactly the speed of light observed from the experiment. Maxwell suggested that this isn't coincidence rather light is an electromagnetic wave. An electromagnetic wave consists of changing electric and magnetic fields which are perpendicular to each other. So, the light wave is transverse in nature.



Figure(2):electromagnetic wave

4-Quantum Theory of Radiation: Wave theory of light couldn't explain certain phenomena such as photoelectric effect, atomic excitation, Compton Effect etc. In 1905 AD, Albert Einstein proposed a new theory of light called quantum theory based on the assumptions of Max Planck. According to this theory, light consists of a tiny packet of energy called quanta or photons. The energy of each 'Quanta' given by;

$E = h f$

E =Energy of each quanta
h = Planck's Constant
f = frequency of radiation

The absorption and the release of energy is always in the integral multiple of this energy.

5-Dual Nature of Light: Some experiments show wave nature of light whereas the some show particle nature of light. Instead of considering light as wave or particle we must treat light as having both particle and wave nature. This is called Dual nature of light.