PHYSICS

REFLECTION OF LIGHT

REFLECTION

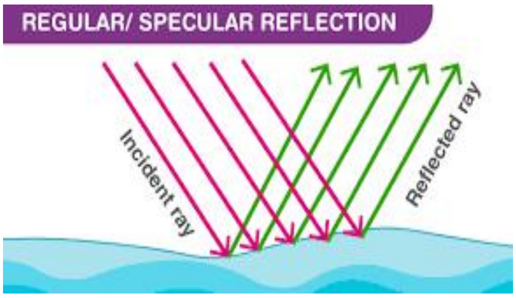
Reflection can simply be defined as the repropagation of light waves when incidented at a particular angle on a plane surface. It is the change in direction of a wavefront at an interface between two different media so that the wavefront returns into the medium from which it originated. Common examples include the reflection of light, sound and water waves.
When light reaches a solid object, one of the things that can happen is that the light can be reflected. The reflected light can be either partially or completely reflected based on the elasticity of the material. For this reason, metals make good reflective surfaces.

TYPES OF REFLECTION

There are two types of reflections.
a. Regular or smooth reflection.
b. Diffused or irregular reflection.

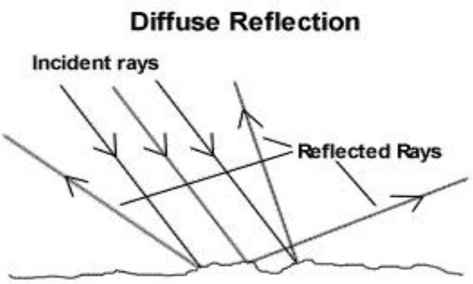
REGULAR OR SMOOTH REFLECTION

Regular reflection describes reflection off of very smooth surfaces. It is the type of reflection that can be seen with a mirror or off of a lake on a day without any wind. This is produced only on smooth surfaces. The rays are reflected and the moment they strike smooth surfaces, rays are produced. Rays formed after reflection are called reflected rays.



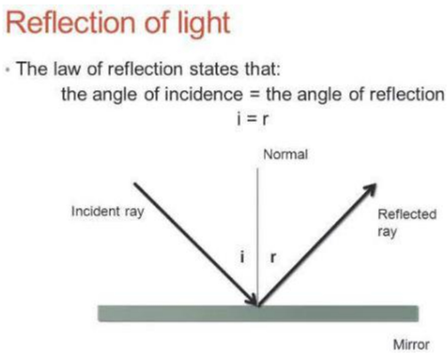
IRREGULAR OR DIFFUSED REFLECTION

When light is incident off of a rough or irregular surface, it can be defined as irregular of diffuse reflection. This occurs when you look at the same lake on a windy day. Diffuse reflection is reflection off of a rough or irregular opaque surface. The rays striking the rough surfaces are scattered or diffusely reflected in different angles. This is because of the lack of arrangement or smoothness on the surface.



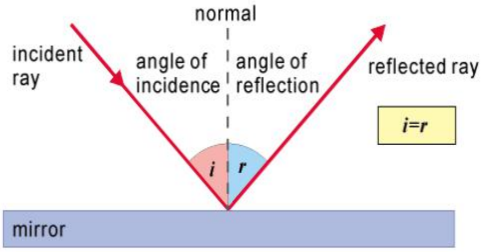
LAWS OF REFLECTION

There are two laws associated with reflection. The first law of reflection states that the incident ray, the reflected ray and the normal ray all lie on the same plane.



The second law of reflection state that, the angle of incidence is equal to the angle of reflection. According to the law incident angle i, is equal to the angle of reflection, r.

i = r



TERMS ASSOCIATED WITH REFLECTION

a. Incident rays, i.

b. Reflected rays, r.

c. Normal, n.

WORKED EXAMPLE

If a ray incidented on a plane mirror, the incident angle is 35° to the normal, the reflected angle is also 35° to the normal. Find the angle of glance.

SOLUTION

Since incidented and reflected angles are equal, let incident angle be X and reflected angle be Y. Taking the sum of angles on a straight line, that is:

$g + 35° + 35° + 2g = 180°$

$2g + 70° = 180°$

$2g = 180° - 70°$

$2g = 110°$

$g = 110_2$

$g = 55°$

Therefore, angle of glance = 55°.

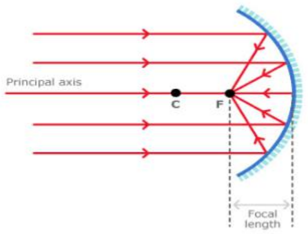
REFLECTION OF LIGHT AT CURVED MIRRORS

There are two types of curved surfaces. These are determined by the size of the curved mirrors while the images produced determine the type of mirrors used.

TYPES OF MIRRORS

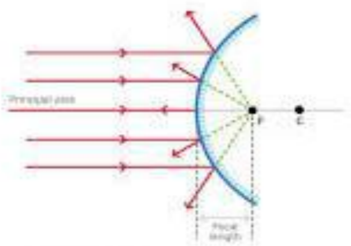
a. Concave mirror:

This is a curved mirror that produces a real image and has the right hand side of its surface coated. The reflecting surface bend inwards causing incident raised to converge after reflection.



b. Convex mirror:

Convex mirror at any point produces virtual images and has its left hand side inwards and coated. it causes incident rays to diverge after reflection. The reflecting surface bend outwards.



TERMS ASSOCIATED WITH CURVED SURFACES

The other terms associated with curved surfaces using a concave mirror as a point of reference. The following terms are associated with curved surfaces.

- Aperture of a mirror.
- Focus.
- Radius of curvature.
- Principal axis.
- Pole.
- Focal length.

APERTURE OF A MIRROR: This is a cut out section from a curved surface where the rays of light propagated can be incidented. It is the distance between the opposite points on the edge of the mirror.

FOCUS: This is the point where the range of light incidented on a curved surface is reflected (to converge at a point). The the point is known as principal focus. It is also the point F1 on the principal axis to which rays parallel and close to the principal axis converg or diverge, depending on the nature of the curved mirror order concave or convex. The principal focus determines whether an image is real or virtual.

RADIUS OF CURVATURE: This is an imaginary centre assumed to be the centre of the curved surface. It is called the centre of the sphere of which the mirror is part of the point C which is known as centre of curvature.

POLE: This is a center point produced on an aperture it is denoted by letter P.

PRINCIPAL AXIS: This is the line joining the pole P to the centre of curvature C. The distance from the centre of curvature to the pole of an aperture is known as principal axis.

FOCAL LENGTH: The distance from the focus point to the pole is known as focal length.

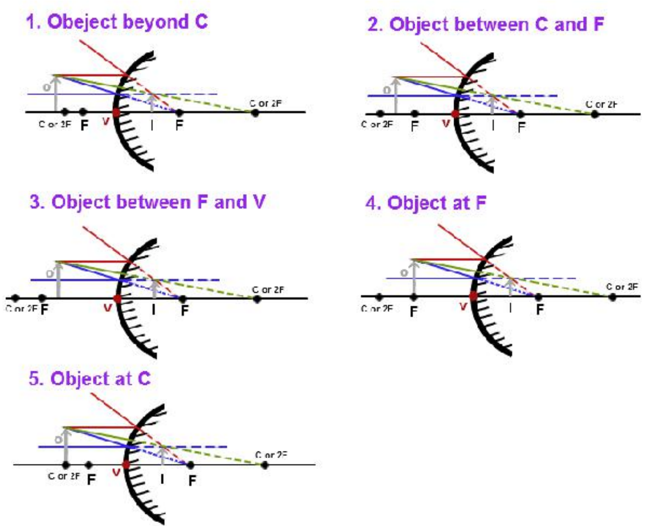
Focal length (f) = Radius of curvature = r

2 2

FORMATION OF IMAGES BY CURVED MIRRORS

Concave mirror: The images formed by a concave mirror are real and inverted unless the object is nearer than its focal point. The image is there for real same size as the object and upright.

2. **Convex mirror**: A convex mirror always forms a virtual, diminished and erect image, irrespective of the position of the object from the mirror.



LINEAR MAGNIFICATION AND MIRROR FORMULAE

Linear magnification is defined as the ratio of the image height to the object height or the ratio of the image distance to the object distance. It has no unit. It can be mathematically expressed as:

M = height of images → distance of images

height of object → distance of object

M= 1=

Magnification can be found by drawing to scale.

MIRROR FORMULAE

When object at a distance U from a curved mirror, either concave or convex of focal length F1, radius of curvature r, and an image distance V are formed from the mirror, the general formula for mirror is represented by:

$\frac{1}{\ } + \frac{1}{\ } = \frac{1}{\ }$ (1)

Where:

V = image distance

U = object distance

f = focal length.

f = _

r = 2f..................... (2)

Multiplying through by V;

1 (v) + 1 (v) = 1 (v)

1 + _= _

But m = –

–

m = – -1 .... (3)

f = _

m = V - 1 ÷ – = (4)

SOLVED EXAMPLES

A concave mirror of radius of curvature 20cm produces an inverted image 3 times the size of an object placed on and perpendicular to the axis. Calculate the position of the object and the image.

Solution:

r = 20cm

f = r/2

20/2 = 10cm

m = v/u = 3

v = 3u

Using 1/f = 1/u + 1/v

1/10 = 1/u + 1/3u since v = 3u

1/10 = 1/4u

3 + 1/ 3u

4/3u

1/10 = 4/3u

Cross multiply

10 × 4 = 1 × 3u

40 = 3u

u = 40/3

u = 13.3cm

V = 3u

V=3×13.3

V = 40cm.

An object, 40cm long is placed in front of a concave mirror of focal length, 15cm so that it is perpendicular to and has one end resting on the axis mirror. Calculate the linear position of the image and its linear magnification.

Solution:

f = 15cm

u = 40cm

v = unknown

Using 1/v + 1/u = 1/f

1/v = 1/f - 1/u

1/v = 1/15 - 1/40

(40 – 15) / 600

1/v = 25/600

v = 600/25

v = 24cm

m = v/u

24/60

m = 3/5

= 0.6ans.

PRACTICAL APPLICATION OF CONCAVE AND CONVEX MIRROR

Concave mirror

The concave mirror is a converging mirror, so that it is used for many purposes, It is used as a torch to reflect the light, It is used in the aircraft landing at the airports to guide the aeroplanes, It is used in shaving to get an enlarged and erect image of the face. The concave mirror is used in front lights of cars to reflect the light, it is used in marine lighthouses that are found at the marine ports and at the airports to guide the ships and it is used in the solar ovens. The concave mirror is used in the solar ovens and the solar furnaces to collect a large amount of solar energy in the focus of the mirror for cooking food, heating water, recharging power backups or melting metals respectively. Concave mirrors are used in satellite dishes, they are used in telescopes, Dentist and ENT doctors use them to obtain a larger image than the original of the teeth, ear or skin etc. Concave mirrors are used in the electron microscopes and magnifying glasses, they are used in the visual bomb detectors and they are used in the flash light mirror of camera.

Convex mirror

One of the most common uses for the convex mirror is the passenger-side mirror on your car. These convex mirrors are used for cars because they give an upright image and provide a wider field of view as they are curved outwards. Convex mirrors are also often found in the hallway of various buildings including hospitals, hotels, schools, stores and apartment building. Usually, these mirrors are mounted to a wall or ceiling at points where hallways cross each other or make a sharp turn. This eliminates blind spots and provides people with a good overview of their surroundings. The convex mirror is also used to provide safety for motorists on roads, driveways and in alleys where there is a lack of visibility. A convex mirror is also a simple way of improving the safety in your warehouse or production environment. In a work environment or warehouse convex mirrors can be placed at crossings or blind spots to enable workers to see approaching forklifts, other vehicles or approaching colleagues. This provides your employees with the necessary overview of their work environment and therefore increases the safety in your workplace. Another use of the convex mirror in this work environment is during the production process, such as on the conveyor belt to view your product from different angles. This can increase the quality of your products by becoming aware of any faults in the production and increase the efficiency of the production process by eliminating the necessity to check your products by picking them up from the conveyor belt.

REFRACTION OF LIGHT

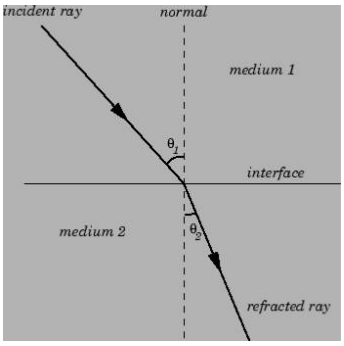
Refraction is defined as the property of a change in the direction of light, when it passes from one medium to another. In the process of refraction, the direction to which the ray of light follows changes as well as velocity, but the frequency remains the same along the line of propagation. The wavelength of transmission also changes.

LAWS OF REFRACTION

Two laws are associated with refraction. The first law of refraction states that the incident ray, refracted ray and the normal at the point of incidence all lie in the same plane.

The second law states that the ratio of sine of the angle of incidence to the sine of the angle of refraction is constant for all rays passing from one medium to another. The two laws of refraction were postulated by a physicist called Snell.

Snell's first law of refraction is given as; ___= a constant **n**.



TERMS ASSOCIATED WITH REFRACTION

i. The incident ray: This is the direction of rays of the light from the source to the first medium.

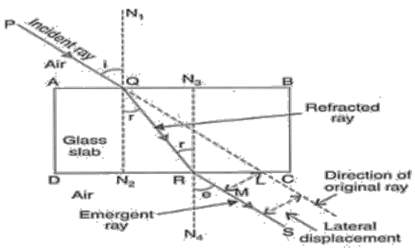
The refracted ray: This is a direction to which the light travels from the point of incidence to the second medium which is always denser than the first medium.

The angle of incidence: This is the angle at which the incident ray’s mixes with the normal in the first medium.

The angle of refraction: This is the angle at which the refracted ray mixes with the normal in the second medium.

REFRACTION THROUGH RECTANGULAR GLASS PRISM

We can seriously study and understand these using a rectangular glass block. A thick rectangular glass block ABCD, is placed horizontally on a plain sheet of paper and outline of the glass block is drawn with a pencil. A light is passed into the glass surface AB along a line PQ inclined at an acute angle to the normal QN. The ray is reflected in the glass slab and emerges from the side CD, along a line RS. The glass block is then removed and the line QR representing the path of the light ray in the glass is drawn. The line RS is found to be parallel to the line PQ.

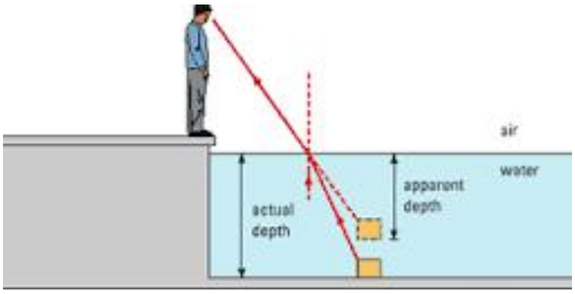


If the incident ray is along the normal NQ, that is, at an angle of 90° to the side AB, (i = 0) it passes straight through the glass emerging on the face CD without a change in direction.

REFRACTIVE INDEX

Refractive index is a constant used to express the nature of medium through which light ray is propagated. The refractive index determines the extent of permeability at which ray travels through a medium. The ratio of sine i to sine rl which is equal to a constant is known as the refractive index. This can also be defined as the nature of the material which a medium is made of. Sometimesit is defined in relation to the extent to which a medium allows light rays to pass through it.

REAL AND APPARENT DEPTH



The depth of a swimming pool or river always appears shallower than it actually is. When a glass block is placed on top of an object example a pin, the object when viewed from directly above appears nearer the top. This apparent depth is caused by refraction. Real depth, apparent depth and refractive index and related by the formula;

n = real depth / apparent depth

n = D/d

WORKED EXAMPLE

What is the real depth of a swimming pool which appears to be 10m deep when viewed directly from above its surface? (Refractive index of water 4/3).

Solution:

n = real depth / apparent depth

n = 4/3

Apparent depth = 10m

Cross multiply

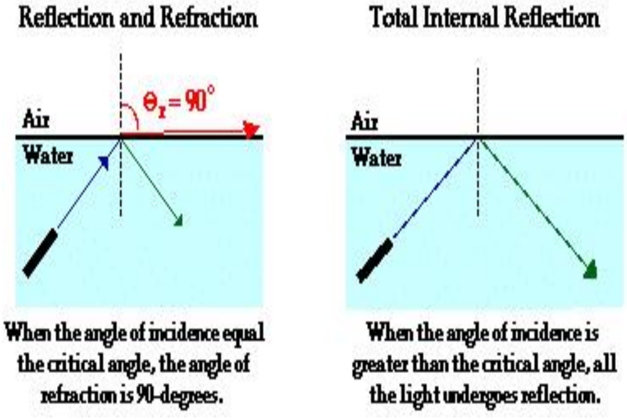
4 × 10 = 3 × real depth

Real depth = $\frac{40}{3}$

13.13m.

TOTAL INTERNAL REFLECTION

When a ray of light passes from optically denser medium to optically less dense medium, there exists a weak internal reflection and a strong refraction. But as the angle of incidence increases, the angle of refraction also increases and at the same time, the intensity of the reflected ray gets stronger and that of the refracted ray becomes weaker. When the angle of incidence exceeds the critical angle, there is no refraction and a total reflection occurs. This phenomenon is called total internal reflection.



CONDITIONS FOR TOTAL INTERNAL REFLECTION

The conditions under which total internal reflection occurs are:

- Light rays must travel through a denser medium to a less dense medium.
- The angle of incidence must exceed critical angle.

APPLICATION OF TOTAL INTERNAL REFLECTION

The principle of total internal reflection is adopted in the invention and operation of the following:

- Binoculars
- Mirage
- Refractometer
- Optical fibres
- Total reflecting prisms are employed in periscopes, prism binoculars, projection lanterns and cameras.
- Total internal reflection of radio waves is employed.

CRITICAL ANGLE

This is the angle of incidence in the denser medium when the angle of refraction in the less dense medium is 90°.

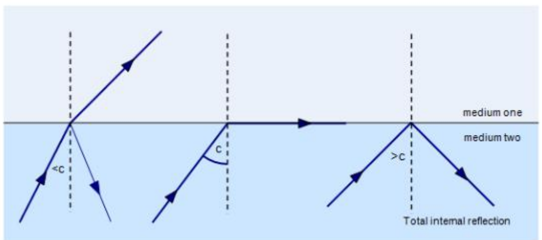


Figure 1

REFRACTION OF LIGHT THROUGH TRIANGULAR GLASS PRISM

let us consider the passage of light rays through a triangular glass prism drawn above. The ray of light AB passes through the prism side PQ. The incident, the refracted and the emergent rays are as shown above. We observe that the emergent ray is not parallel to the incident ray but is at an angle to it. The prism deviates theincident ray through an angle known as angle of deviation. This is the angle between the incident ray and emergent ray of light passing through a prism. The amount of deviation is determined by:

a. The angle of incidence.

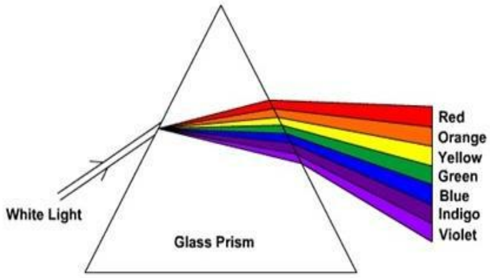
b. The refracting angle (A) of the prism and

c. The refractive index of the material of the prism.

Experiment shows that the angle of deviation (d) varies with the angle of incidence (i). At minimum deviation, i = e. Hence, at minimum deviation, the refractive index (n) of the glass, the refracting angle of the prism and the angle of minimum deviation (D) are related by the equation: $n = \sin \frac{1}{2}(A + D) \div \sin \frac{1}{2} A$

DISPERSION OF WHITE LIGHT

Sir Isaac Newton observed that when white light is passed through a prism, an elongated coloured patch of light is obtained on a screen placed behind the prism.

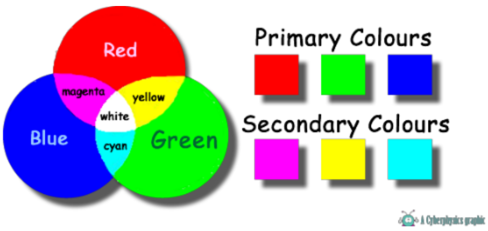


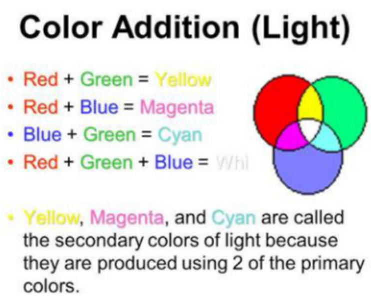
The coloured pattern is known as the spectrum of white light. The spectrum consists of Red, Orange, Yellow, Green, Blue, Indigo and Violet (ROYGBIV) in that order from the apex side A of the prism. discussion is there for The separation of white light into its component colours of ROYGBIV. Dispersion is due to the fact that different colours of white light travel at different speeds through the glass. Monochromatic light is the light of one wavelength.

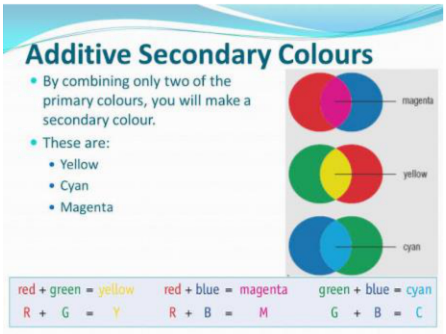
ADDITION AND SUBTRACTION OF COLOURS

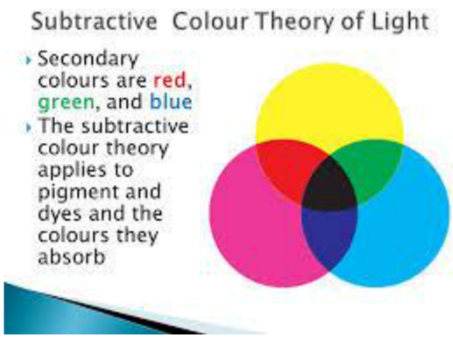
We can obtain a variety of colours by mixing the different colours of the spectrum. We cannot however, obtain Red, Green and Blue colours by mixing other colours. These three colours are there for call the primary colours. The adding of the primary colours to produce other colours is known as the additive colour mixing or additive combination of colours. The colours we get by mixing any two of the primary colours is called the secondary colours. Example of such mixing are:

Red + Green = Yellow
Blue + Green = Cyan (turquoise or blue-green colour)
Red + Blue = Magenta (a purple colour)
Red + Green + Blue = White
Green + Magenta = White
Blue + Yellow = White
Red + Cyan = White


Red
magenta
yellow
white
Blue
cyan
Green
Primary Colours
Secondary Colours
A Cyberphysics graphic


Color Addition (Light)
Red + Green = Yellow
Red + Blue = Magenta
Blue + Green = Cyan
Red + Green + Blue =
Yellow, Magenta, and Cyan are called the secondary colors of light because they are produced using 2 of the primary colors.


Additive Secondary Colours
By combining only two of the primary colours, you will make a secondary colour.
These are:
Yellow
Cyan
Magenta
magenta
yellow
cyan
red + green = yellow
R + G = Y
red + blue = magenta
R + B = M
green + blue = cyan
G + B = C


Subtractive Colour Theory of Light
Secondary colours are red, green, and blue
The subtractive colour theory applies to pigment and dyes and the colours they absorb