MINISTRY OF HIGH EDUCATION AND SCIENTIFIC RESEARCH
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Medical physics

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THEORETICAL VOCABULARY

Week	Details of the vocabulary
1.	Occupational safety programs and work quality assurance.
2.	The concept of occupational safety and its rules.
3.	The light , nature of the light , light sources , the theories of the light
4.	The electromagnetic spectrum
5.	Velocity of the light , Frequency and energy of the visible light
6.	The reflection , the laws of reflection , reflection at plane and spherical surfaces
7.	Propagation and Reflection of Light
8.	Mirrors , types of mirrors , properties of the image formed by plane mirrors , properties of image formed by plane mirror
9.	Spherical mirrors , center of curvature , axis , vertices , focal length
10.	Concave mirror , properties of image formed by concave mirror
11.	Convex mirror , properties of image formed by convex mirror
12.	Real and virtual images formed by reflected surfaces
13.	Refraction , the laws of refraction , refraction by plane surfaces
14.	The refractive index , relative refractive index
15.	Factors affecting the refractive index

- **THE OBJECTIVES OF SUBJECT**

- 1/ GENERAL OBJECTIVE: THE STUDENTS MUST BE FAMILIAR WITH THE FOUNDATIONS OF THE LIGHT .

- 2/ SPECIAL OBJECTIVE: TO BE ABLE TO KNOW THE PHENOMENA OF REFLECTION AND REFRACTION OF THE LIGHT IN REFLECTED AND REFRACTED MEDIUMS AND APPLICATIONS OF RELATED LAWS .

UNIT ONE /Pre test : Select the correct answer :-

- 1. WHAT IS THE PRIMARY PURPOSE OF OCCUPATIONAL SAFETY PROGRAMS?
- A. INCREASING COMPANY PROFITS ONLY
- B. PROTECTING WORKERS FROM WORKPLACE HAZARDS
- C. REDUCING EMPLOYEE SALARIES
- D. LIMITING EMPLOYEE RESPONSIBILITIES
- 2.WHICH OF THE FOLLOWING IS CONSIDERED A PHYSICAL HAZARD?
- A. BACTERIA
- B. STRESS
- C. NOISE
- D. TOXIC CHEMICALS

UNIT1
OCCUPATIONAL SAFETY PROGRAMS AND WORK ASSURANCE

- SAFETY PROGRAMS ARE SYSTEMATIC PROCEDURES AND POLICIES DESIGNED TO PROTECT WORKERS FROM OCCUPATIONAL HAZARDS, INJURIES, AND DISEASES WITHIN THE WORKPLACE. THESE PROGRAMS ARE ESSENTIAL IN ALL SECTORS, INCLUDING INDUSTRY, HEALTHCARE, ENGINEERING, CONSTRUCTION, AND EDUCATION, BECAUSE THEY HELP CREATE A SAFE AND PRODUCTIVE WORKING ENVIRONMENT. ACCORDING TO THE INTERNATIONAL LABOUR ORGANIZATION, OCCUPATIONAL SAFETY AIMS TO PROMOTE WORKERS' PHYSICAL, MENTAL, AND SOCIAL WELL-BEING WHILE REDUCING WORKPLACE ACCIDENTS AND HEALTH RISKS.OCCUPATIONAL SAFETY PROGRAMS INVOLVE SEVERAL IMPORTANT COMPONENTS. FIRST, HAZARD IDENTIFICATION IS NECESSARY TO RECOGNIZE PHYSICAL, CHEMICAL, BIOLOGICAL, ERGONOMIC, AND PSYCHOLOGICAL RISKS THAT MAY THREATEN EMPLOYEES. SECOND, RISK ASSESSMENT EVALUATES THE PROBABILITY AND SEVERITY OF THESE HAZARDS TO DETERMINE APPROPRIATE PREVENTIVE MEASURES. THIRD, ORGANIZATIONS IMPLEMENT CONTROL METHODS SUCH AS ENGINEERING CONTROLS, ADMINISTRATIVE PROCEDURES, AND PERSONAL PROTECTIVE EQUIPMENT (PPE) INCLUDING HELMETS, GLOVES, SAFETY GLASSES, AND RESPIRATORS.TRAINING AND EDUCATION ARE ALSO FUNDAMENTAL ELEMENTS OF OCCUPATIONAL SAFETY PROGRAMS. WORKERS MUST BE TRAINED IN EMERGENCY PROCEDURES, FIRE PROTECTION, SAFE EQUIPMENT HANDLING, AND FIRST AID PRACTICES. EFFECTIVE SAFETY TRAINING SIGNIFICANTLY REDUCES WORKPLACE ACCIDENTS AND IMPROVES EMPLOYEE AWARENESS. IN ADDITION, ORGANIZATIONS SHOULD ESTABLISH EMERGENCY PREPAREDNESS PLANS TO MANAGE FIRES, CHEMICAL SPILLS, OR OTHER UNEXPECTED INCIDENTS.WORK ASSURANCE REFERS TO THE SYSTEMATIC PROCESS OF ENSURING THAT WORK ACTIVITIES ARE PERFORMED SAFELY, EFFICIENTLY, AND ACCORDING TO ESTABLISHED STANDARDS AND REGULATIONS. IT INCLUDES MONITORING, INSPECTION, AUDITING, INCIDENT REPORTING, AND CONTINUOUS IMPROVEMENT. STANDARD OPERATING PROCEDURES (SOPS) ARE COMMONLY USED TO MAINTAIN CONSISTENCY AND REDUCE OPERATIONAL ERRORS.ONE OF THE MOST RECOGNIZED INTERNATIONAL STANDARDS IN OCCUPATIONAL SAFETY MANAGEMENT IS ISO 45001, WHICH EMPHASIZES LEADERSHIP COMMITMENT, WORKER PARTICIPATION, AND CONTINUOUS IMPROVEMENT OF SAFETY PERFORMANCE.IN CONCLUSION, OCCUPATIONAL SAFETY PROGRAMS AND WORK ASSURANCE ARE ESSENTIAL FOR PROTECTING EMPLOYEES, IMPROVING PRODUCTIVITY, REDUCING ORGANIZATIONAL LOSSES, AND MAINTAINING A SAFE WORKPLACE CULTURE. A SUCCESSFUL ORGANIZATION RECOGNIZES THAT SAFETY IS NOT ONLY A LEGAL OBLIGATION BUT ALSO A

- **SUMMARY**

- OCCUPATIONAL SAFETY PROGRAMS ARE SYSTEMS DESIGNED TO PROTECT WORKERS FROM WORKPLACE HAZARDS AND ACCIDENTS. THESE PROGRAMS INCLUDE HAZARD IDENTIFICATION, RISK ASSESSMENT, SAFETY TRAINING, EMERGENCY PREPAREDNESS, AND THE USE OF PERSONAL PROTECTIVE EQUIPMENT (PPE). WORKPLACE HAZARDS MAY BE PHYSICAL, CHEMICAL, BIOLOGICAL, ERGONOMIC, OR PSYCHOLOGICAL.
- WORK ASSURANCE ENSURES THAT TASKS ARE PERFORMED SAFELY, EFFICIENTLY, AND ACCORDING TO ESTABLISHED STANDARDS THROUGH MONITORING, INSPECTIONS, AND STANDARD OPERATING PROCEDURES (SOPS). INTERNATIONAL STANDARDS SUCH AS ISO 45001 HELP ORGANIZATIONS IMPROVE WORKPLACE SAFETY AND REDUCE RISKS.
- OVERALL, OCCUPATIONAL SAFETY AND WORK ASSURANCE IMPROVE EMPLOYEE PROTECTION, PRODUCTIVITY, AND ORGANIZATIONAL PERFORMANCE

POST TEST

- **1/ WHAT IS A MAJOR BENEFIT OF OCCUPATIONAL SAFETY PROGRAMS FOR ORGANIZATIONS?**
- A. INCREASED ACCIDENTS
- B. REDUCED PRODUCTIVITY
- C. LOWER COMPENSATION AND MEDICAL COSTS
- D. REDUCED EMPLOYEE SATISFACTION
- **2/ WHAT DOES PPE STAND FOR?**
- A. PERSONAL PROTECTION EQUIPMENT
- B. PUBLIC PROTECTION EQUIPMENT
- C. PERSONAL PROTECTIVE EQUIPMENT
- D. PRIVATE PREVENTION EQUIPMENT

UNIT 2/THE LIGHT , NATURE OF THE LIGHT , LIGHT SOURCES , THE THEORIES OF THE LIGHT

PRE TEST

1/WHICH SCIENTIST PROPOSED THE "CORPUSCULAR THEORY," ASSERTING THAT LIGHT CONSISTS OF A STREAM OF TINY PARTICLES EMITTED FROM A LUMINOUS SOURCE?

- A) CHRISTIAN HUYGENS
- B) ISAAC NEWTON
- C) JAMES CLERK MAXWELL
- D) MAX PLANCK

2/ACCORDING TO THE ELECTROMAGNETIC THEORY OF LIGHT, LIGHT WAVES CONSIST OF OSCILLATING ELECTRIC AND MAGNETIC FIELDS THAT ARE:

- A) PARALLEL TO EACH OTHER AND THE DIRECTION OF TRAVEL.
- B) CIRCULARLY POLARIZED ONLY IN A VACUUM.
- C) PERPENDICULAR TO EACH OTHER AND TO THE DIRECTION OF PROPAGATION.
- D) STATIONARY AND DO NOT REQUIRE ENERGY TRANSFER.

UNIT 2:THE LIGHT , NATURE OF THE LIGHT , LIGHT SOURCES , THE THEORIES OF THE LIGHT

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.

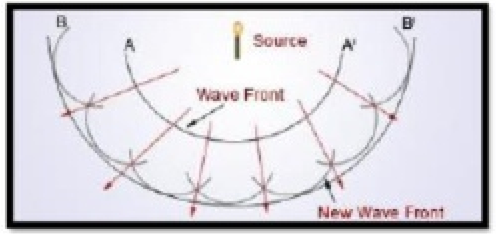
According to this. The disturbance from the source is propagated in the form of waves through space and the energy is distributed equally, in all directions. When these waves carrying energy are incident on the eye, the optic nerves are excited and the sensation of vision is produced. Huygens assumed 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 :

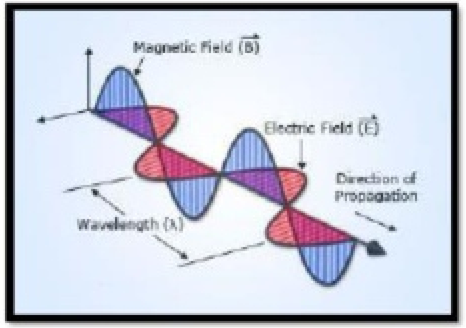
It fails to explain polarization , photoelectric effect and Compton



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.

POST TEST :

Q1 / DEFINE THE LIGHT AND LIST LIGHT SOURSES ?

Q2/LIST THE THEORIES OF LIGHT AND EXPLAIN THE FIRST ONE ?

- **UNIT 3: THE ELECTROMAGNETIC SPECTRUM**
- **PRE TEST:**

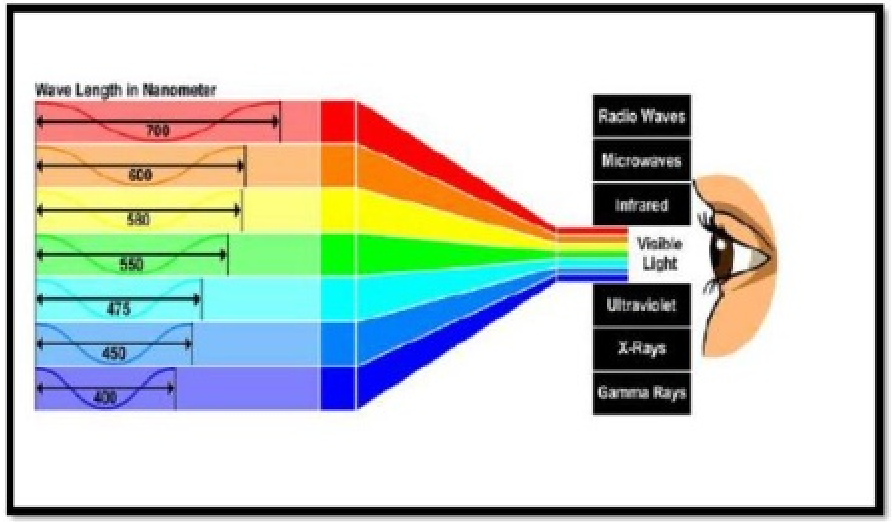
- Q1/ WHAT IS MEAN THE ELECTROMAGNETIC SPECTRUM ?

- Q2/WHAT IS THE TYPES OF THE ELECTROMAGNETIC SPECTRUM?

• UNIT 3: THE ELECTROMAGNETIC SPECTRUM

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,

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.

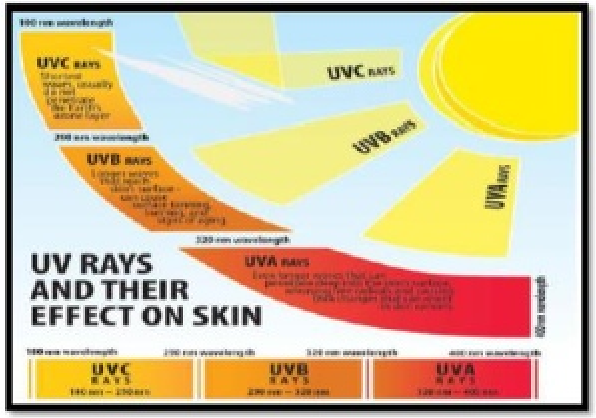
2-Cornea:Because the cornea transmits 96% of incident infrared in the range 700-1400 (nm), the level of damage to occur is quite high, especially in the range of 750-990 (nm). The radiation effects on the cornea from this type of radiation involve protein coagulation of the front and middle layers (the 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

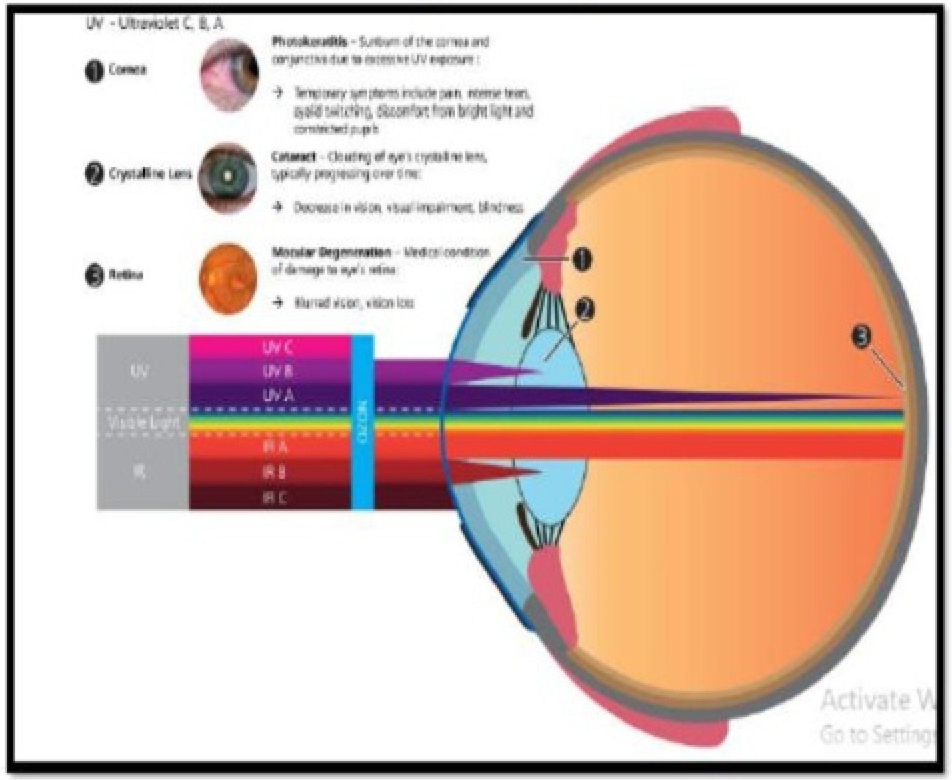


Figure(2): The UV spectrum

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



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).

- **POST TEST :**

- Q1/ COMPARE BETWEEN THE EFFECT OF UV AND IR ?

- Q2/DISCUSE THE EFFECT OF IR RADIATIONS ON CORNEA ?

UNIT 4 /VELOCITY OF THE LIGHT , FREQUENCY AND ENERGY OF THE VISIBLE LIGHT:

PRE TEST :

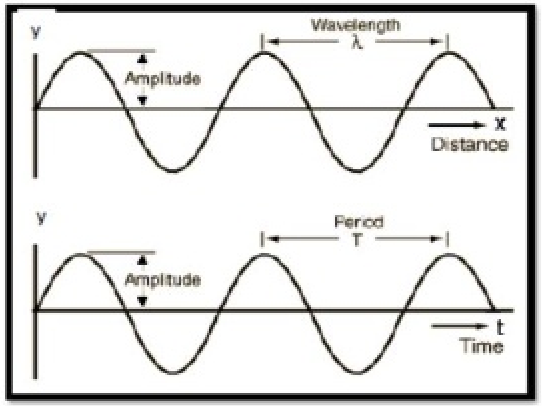
Q1/DEFINE VELOCITY OF LIGHT?

Q2/WRITE RELATIONS OF ENERGY AND FREQUENCY OF LIGHT.

UNIT 4: VELOCITY OF THE LIGHT , FREQUENCY AND ENERGY OF THE VISIBLE LIGHT:

Velocity of the light : The velocity of light in vacuum, commonly denoted (c), is a universal physical constant important in many areas of physics. Its exact value is defined as (3) meters per second (approximately 300000 km/s). In the special and general theories of relativity, c interrelates space and time, and also appears in the famous equation of mass–energy equivalence $E = mc^2$. The speed at which light propagates through transparent materials, such as glass or air, is less than c; similarly, the speed of electromagnetic waves in wire cables is slower than c. The ratio between c and the speed v at which light travels in a material is called the refractive index n of the material ($n = c / v$).

Wavelength of the light : Is the distance from one peak to another, or from one bottom to another, of a wave (which may be an electromagnetic wave, a sound wave, or any other wave). Peak is the highest point of the wave whereas the bottom is the lowest. Since wavelength is distance/length, it is measured in units of lengths such as meters, centimeters, millimeters, nanometers, etc.



The wavelength for various colors of the visible spectrum of light is provided in the table underneath.

Color	Wavelength
Violet	424-400 nm
Indigo	454-425 nm
Blue	489-455 nm
Green	574-490 nm
Yellow	579-575 nm
Orange	649-580 nm
Red	650-750 nm

The famous units used for measuring wavelength { meter(m) , centimeter (cm) , millimeter (mm) , micrometer (μm) , nanometer (nm) , angstrom (A) }.

1 meter = (100 cm) or (10^2cm).

1 meter = (1000 mm) or (10^3mm).

1 meter = (1000000 μm) or (10^6 μm).

1 meter = (1000000000 nm) or (10^9nm).

1 meter = (10000000000 A) or (10^{10} A).

such as optics , acoustics, and radio, frequency is usually denoted by a Latin letter f or v (nu) and measured in hertz .The relation between the frequency and the period, T, of a repeating event or oscillation is given by: f =1/ T and the relationship with wavelength : f = c / wavelength where : (f) is frequency of light , (T) is time period.

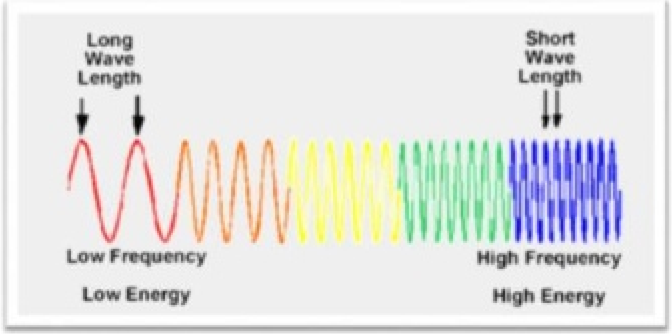


Figure (2): visible light spectrum

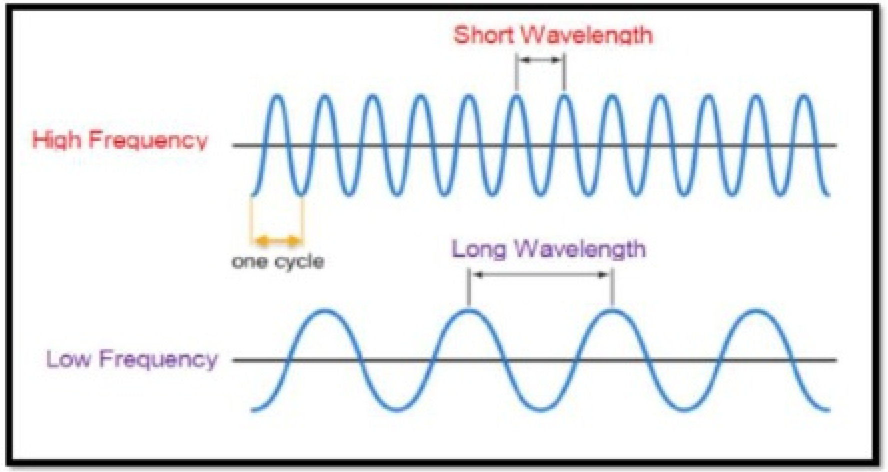


Figure (3): frequency and wavelength of light

Energy of the visible light :

Light energy is a form of electromagnetic radiation. Light consists of photons, which are produced when an object's atoms heat up. Light travels in waves and is the only form of energy visible to the human eye. The amount of energy in those photons is calculated by this equation: E = h f = h c / wavelength Where: (E) is the energy of the photon in Joules, (h) is Planck's constant, which is always ($6.63 * 10^{-34}$) Joule* seconds, and (f)is the frequency of the light in hertz.

Solved problems :

1- A wave has a frequency of 10 Hz and a wavelength of 30m. What's its energy?
   $E= hf = 6.63 * 10^{-34} * 10 = 66 * 10^{-34}$ Joule

2- The speed of sound is 346 m/s. If a sound wave travels at a frequency of 55 Hz, what would its wavelength be? (in cm , nm)

f= c/ wavelength

$= c / f = 346 / 55 = 6.290$ m = 629 cm = $629 * 10^{+7}$ nm

3- A certain red light has a wavelength of 725 nm and another red light has a frequency of 4.28×10^{14} Hz. Which would have the higher energy per photon?

$E_1=hc/\lambda =6.63*10^{-34}*3*10^{8}/725 *10^{-9}m =27.4 *10^{-20}J$

$E_2= hf =6.63*10^{-34} * 4.28 *10^{14}= 28.37 * 10^{-20} J$

The energy of frequncy (4.28×10^{14} Hz) is higher

POST TEST/ CALCULATE THE FOLLOWING QUESTIONS :

- 1- A HELIUM LASER EMITS LIGHT WITH A WAVELENGTH OF 633 NM. WHAT IS THE FREQUENCY OF THE LIGHT? AND WHAT IS THE ENERGY OF IT ?
- 2- CALCULATE THE ENERGY OF A GAMMA RAY PHOTON WHOSE FREQUENCY IS (5.02 X 1020) HZ?
- 3- WHICH WOULD HAVE THE LONGER WAVELENGTH – LIGHT WITH A ENERGY 29.83 * 10-20J OR LIGHT WITH A FREQUENCY OF 5.19 X 1014 HZ?
- 4- CALCULATE THE ENERGY AND FREQUENCY OF RED LIGHT HAVING A WAVELENGTH OF (6.80X10-5) CM?

- **UNIT 5/THE REFLECTION , THE LAWS OF REFLECTION , REFLECTION AT PLANE AND SPHERICAL SURFACES**

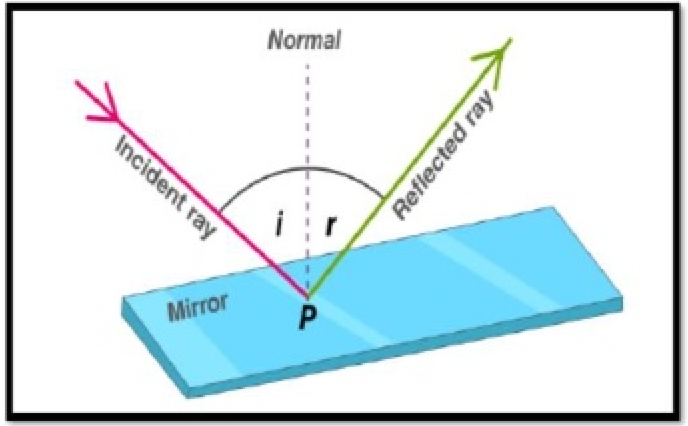
PRE TEST :

Q1 / WHAT IS THE REFLECTION AND WHAT IS THE LAWS ?

Q2 /DESCRIBE THE REFLECTIONS FROM PLANE SURFACES .

• UNIT 5 /THE REFLECTION , THE LAWS OF REFLECTION , REFLECTION AT PLANE AND SPHERICAL SURFACES:

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.

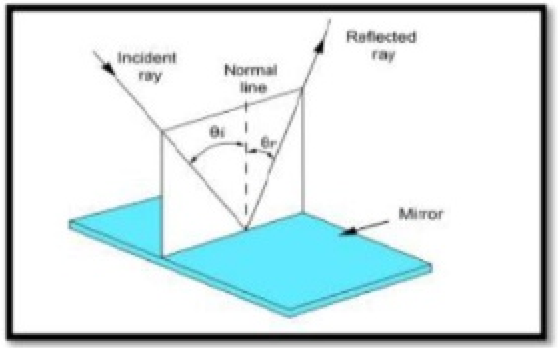
3- **Angle of incidence** : Is the angle between a ray incident on a surface and the line perpendicular to the surface at the point of incidence (called as normal).

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

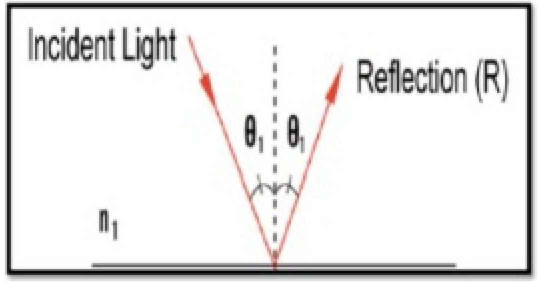
The laws of reflection are as follows:

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.

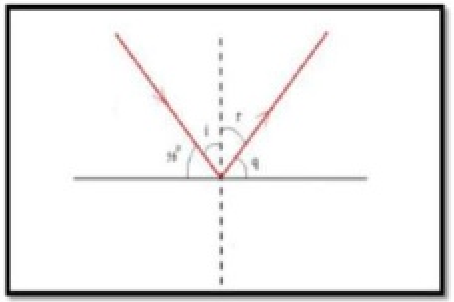


Solved Problem :

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)

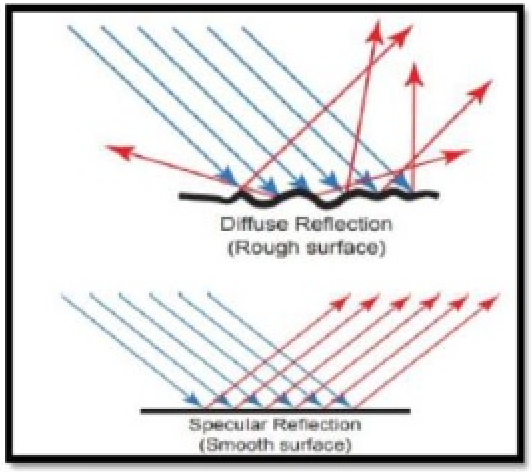
c) i + r = 34 + 34 = 68 °

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

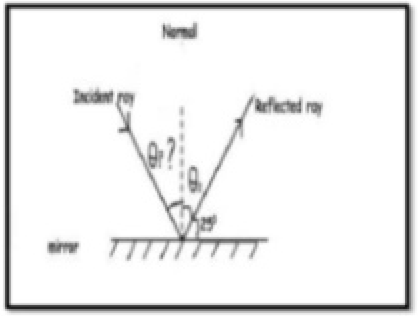
A mirror or surface that resembles the shape of a sphere is termed a spherical mirror or surface. In other words, a spherical mirror looks like it is a part that has been cut from a sphere. Spherical mirrors are of two types – Concave mirrors and Convex mirrors.

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?

Post test :

Q1/ draw the regular reflection and compare with irregular reflection.

Q2/discuss the first and the second laws of light reflection .

- **UNIT 6/ PROPAGATION AND REFLECTION OF LIGHT**
- **PRE TEST :**

- Q1/ DISCUSS THE PROPAGATIONS OF LIGHT.

- Q2/WHAT IS THE LAWS LIGHT PROPAGATIONS ?

UNIT 6/ PROPAGATION AND REFLECTION OF LIGHT

1. INTRODUCTION

LIGHT IS ONE OF THE MOST FUNDAMENTAL PHYSICAL PHENOMENA STUDIED IN PHYSICS. THE WAY LIGHT TRAVELS FROM ONE POINT TO ANOTHER IS KNOWN AS PROPAGATION OF LIGHT. UNDERSTANDING THIS CONCEPT IS ESSENTIAL FOR EXPLAINING VISION, OPTICAL INSTRUMENTS, FIBER OPTICS, AND MANY NATURAL PHENOMENA.

IN CLASSICAL PHYSICS, LIGHT IS TREATED AS AN ELECTROMAGNETIC WAVE THAT CAN ALSO EXHIBIT PARTICLE-LIKE BEHAVIOR (PHOTONS), BUT IN THIS LECTURE WE FOCUS ON ITS WAVE PROPAGATION ASPECTS.

2. NATURE OF LIGHT PROPAGATION

LIGHT PROPAGATES THROUGH SPACE IN A STRAIGHT LINE IN A UNIFORM MEDIUM. THIS BEHAVIOR IS CALLED RECTILINEAR PROPAGATION OF LIGHT.

HOWEVER, WHEN LIGHT ENCOUNTERS DIFFERENT MEDIA OR OBSTACLES, ITS DIRECTION OR SPEED MAY CHANGE DUE TO:

* REFLECTION

* REFRACTION

* DIFFRACTION

* SCATTERING

THESE EFFECTS SHOW THAT LIGHT BEHAVES AS A WAVE UNDER MOST PHYSICAL CONDITIONS.

- **3. SPEED OF LIGHT**
- THE SPEED OF LIGHT IN VACUUM IS A UNIVERSAL CONSTANT:
- C = 3 *10^8 M/S
- WHEN LIGHT TRAVELS THROUGH A MEDIUM (WATER, GLASS, AIR), ITS SPEED DECREASES DEPENDING ON THE OPTICAL DENSITY OF THE MATERIAL.
- THE RELATIONSHIP IS GIVEN BY THE REFRACTIVE INDEX:
- N = C/V
- WHERE:
- * N = REFRACTIVE INDEX
- * C = SPEED OF LIGHT IN VACUUM
- * V = SPEED OF LIGHT IN THE MEDIUM
- A HIGHER REFRACTIVE INDEX MEANS SLOWER PROPAGATION OF LIGHT IN THAT MEDIUM.

- ## 4.WAVE THEORY OF LIGHT PROPAGATION

ACCORDING TO WAVE THEORY, LIGHT SPREADS AS A WAVEFRONT. EACH POINT ON A WAVEFRONT ACTS AS A SOURCE OF SECONDARY WAVELETS.

THIS IS EXPLAINED BY HUYGENS' PRINCIPLE, WHICH STATES:

EVERY POINT ON A WAVEFRONT ACTS AS A SOURCE OF SECONDARY SPHERICAL WAVELETS, AND THE NEW WAVEFRONT IS THE ENVELOPE OF THESE WAVELETS.

THIS PRINCIPLE HELPS EXPLAIN:

* REFLECTION

* REFRACTION

* DIFFRACTION

5. LAWS OF LIGHT PROPAGATION

- **(A) LAW OF RECTILINEAR PROPAGATION**
- LIGHT TRAVELS IN STRAIGHT LINES IN A HOMOGENEOUS MEDIUM.
- **(B) LAW OF REFLECTION**
- WHEN LIGHT HITS A SMOOTH SURFACE:
- * ANGLE OF INCIDENCE = ANGLE OF REFLECTION
- * INCIDENT RAY, REFLECTED RAY, AND NORMAL LIE IN THE SAME PLANE
- **(C) LAW OF REFRACTION (SNELL'S LAW)**
- THIS DESCRIBES HOW LIGHT BENDS WHEN MOVING BETWEEN TWO MEDIA OF DIFFERENT OPTICAL DENSITIES.

6. PHENOMENA AFFECTING PROPAGATION

1. **REFLECTION**

BOUNCING BACK OF LIGHT FROM A SURFACE.

2. REFRACTION

BENDING OF LIGHT DUE TO CHANGE IN SPEED WHEN ENTERING A NEW MEDIUM.

3. DIFFRACTION

SPREADING OF LIGHT WHEN IT PASSES THROUGH A NARROW OPENING OR AROUND OBSTACLES.

4. SCATTERING

REDIRECTION OF LIGHT BY SMALL PARTICLES (E.G., SKY APPEARS BLUE DUE TO RAYLEIGH SCATTERING)

7.APPLICATIONS OF LIGHT PROPAGATION

UNDERSTANDING LIGHT PROPAGATION IS ESSENTIAL IN:

* OPTICAL FIBER COMMUNICATION

* CAMERA AND LENS DESIGN

* TELESCOPES AND MICROSCOPES

* MEDICAL IMAGING (ENDOSCOPY, LASER SURGERY)

* ATMOSPHERIC OPTICS (RAINBOWS, MIRAGES)

SUMMARY :

* LIGHT TRAVELS IN STRAIGHT LINES IN UNIFORM MEDIA

* SPEED OF LIGHT DEPENDS ON THE MEDIUM

* LIGHT BEHAVES AS A WAVE AND FOLLOWS HUYGENS' PRINCIPLE

* REFLECTION, REFRACTION, DIFFRACTION, AND SCATTERING EXPLAIN MOST OPTICAL PHENOMENA

* LIGHT IS AN ELECTROMAGNETIC WAVE THAT CAN TRAVEL THROUGH VACUUM

POST TEST :

Q1/ LIST WITH DETAILS THE PHENOMENA AFFECTING PROPAGATION ?

Q2/WHAT IS THE APPLICATIONS OF LIGHT PROPAGATION?

UNIT 7:MIRRORS , TYPES OF MIRRORS , PROPERTIES OF THE IMAGE FORMED BY PLANE MIRRORS , PROPERTIES OF IMAGE FORMED BY PLANE MIRROR

PRE TEST :

Q1/ DEFINE THE MIRROR ?

Q2/ WHAT IS THE TYPES OF MIRRORS?

UNIT 7:MIRRORS , TYPES OF MIRRORS , PROPERTIES OF THE IMAGE FORMED BY PLANE MIRRORS , PROPERTIES OF IMAGE FORMED BY PLANE MIRROR

OPTICAL MIRRORS: ARE REFLECTIVE SURFACES DESIGNED TO REDIRECT OR MANIPULATE LIGHT IN VARIOUS OPTICAL SYSTEMS. THEY ARE COMMONLY USED IN APPLICATIONS SUCH AS TELESCOPES, LASERS, MICROSCOPES, CAMERAS, AND MANY OTHER DEVICES WHERE LIGHT REFLECTION IS ESSENTIAL. OPTICAL MIRRORS ARE CHARACTERIZED BY THEIR REFLECTIVE COATINGS, SUBSTRATE MATERIALS, SHAPE, AND DESIGN SPECIFICATIONS.

TYPES OF OPTICAL MIRRORS

1. PLANE MIRRORS

- FLAT SURFACES THAT REFLECT LIGHT WITHOUT DISTORTING ITS PATH.
- COMMONLY USED IN PERISCOPES, LASERS, AND ALIGNMENT SYSTEMS.

.2 SPHERICAL MIRRORS

A. CONCAVE MIRRORS

- SPHERICAL MIRRORS WITH A REFLECTIVE SURFACE CURVING INWARD.
- FOCUS PARALLEL LIGHT RAYS TO A SINGLE FOCAL POINT.
- USED IN TELESCOPES, SOLAR CONCENTRATORS, AND HEADLAMPS.

B. CONVEX MIRRORS

- REFLECTIVE SURFACE CURVES OUTWARD.
- DIVERGE LIGHT RAYS, PROVIDING A WIDER FIELD OF VIEW.
- COMMON IN SECURITY AND AUTOMOTIVE APPLICATIONS.

4. DIELECTRIC MIRRORS

- COATED WITH MULTIPLE LAYERS OF DIELECTRIC MATERIALS TO ACHIEVE SPECIFIC REFLECTION PROPERTIES.
- HIGHLY EFFICIENT AND USED IN PRECISION OPTICAL INSTRUMENTS.

5. METALLIC MIRRORS

- COATED WITH METALS LIKE ALUMINUM, SILVER, OR GOLD.
- OFFER HIGH REFLECTIVITY ACROSS A WIDE WAVELENGTH RANGE.
- USED IN BROADBAND AND INFRARED APPLICATIONS.

APPLICATIONS OF OPTICAL MIRRORS

1. LASER SYSTEMS: REFLECT AND DIRECT LASER BEAMS WITH MINIMAL LOSS.
2. ASTRONOMY: REFLECT TELESCOPES UTILIZE MIRRORS TO GATHER AND FOCUS LIGHT FROM DISTANT STARS.
3. MEDICAL DEVICES: ENDOSCOPES AND OTHER DIAGNOSTIC TOOLS EMPLOY MIRRORS TO GUIDE LIGHT.
4. IMAGING SYSTEMS: CAMERAS AND PROJECTORS USE MIRRORS FOR BEAM CONTROL AND

- THE IMAGE FORMED BY A PLANE MIRROR HAS THE FOLLOWING PROPERTIES:

1. NATURE OF THE IMAGE

- VIRTUAL: THE IMAGE CANNOT BE PROJECTED ONTO A SCREEN BECAUSE IT IS FORMED BY THE APPARENT DIVERGENCE OF LIGHT RAYS (NOT ACTUAL INTERSECTION).
- ERECT: THE IMAGE APPEARS UPRIGHT AND MAINTAINS THE SAME ORIENTATION AS THE OBJECT.

2. SIZE OF THE IMAGE

- EQUAL SIZE: THE IMAGE IS OF THE SAME SIZE AS THE OBJECT (MAGNIFICATION = 1).

3. LATERAL INVERSION

- THE IMAGE UNDERGOES LATERAL INVERSION, MEANING THE LEFT SIDE OF THE OBJECT APPEARS AS THE RIGHT SIDE IN THE IMAGE, AND VICE VERSA.
- THIS IS WHY TEXT APPEARS REVERSED WHEN VIEWED IN A MIRROR.

4.DISTANCE OF THE IMAGE

- THE IMAGE IS FORMED

AS FAR BEHIND THE MIRROR AS THE OBJECT IS IN FRONT OF IT.

- IF THE OBJECT IS PLACED AT A DISTANCE OF FROM THE MIRROR, THE IMAGE WILL APPEAR AT BEHIND THE MIRROR.

5.POSITION OF THE IMAGE

- OPPOSITE THE OBJECT: THE IMAGE APPEARS DIRECTLY OPPOSITE THE OBJECT IN THE MIRROR

APPLICATIONS OF PLANE MIRROR IMAGES

1. DAILY USE: DRESSING MIRRORS, BATHROOM MIRRORS.

2. OPTICAL SYSTEMS: PERISCOPES, KALEIDOSCOPES.

3. SCIENTIFIC DEVICES: REFLECTING LIGHT FOR EXPERIMENTS.

4. DECORATIVE PURPOSES: ILLUSIONS IN ARCHITECTURE AND DESIGN.

- **POST TEST:**

Q1/WHAT IS THE APPLICATIONS OF PLANE MIRROR?

Q2/DESCRIBE THE PROPERTIES OF IMAGES FORMED BY PLANE MIRROR?

UNIT 8/PLANE MIRRORS ARE WIDELY USED IN OPTOMETRY FOR VARIOUS DIAGNOSTIC, THERAPEUTIC, AND EDUCATIONAL PURPOSES. THEIR ABILITY TO REFLECT LIGHT WITHOUT DISTORTING IMAGES MAKES THEM IDEAL FOR OPTICAL ASSESSMENTS AND VISUAL DEMONSTRATIONS. BELOW ARE THE KEY USES OF PLANE MIRRORS IN OPTOMETRY:

1. INDIRECT OPHTHALMOSCOPY

- PLANE MIRRORS ARE USED IN INDIRECT OPHTHALMOSCOPES TO REFLECT LIGHT INTO THE EYE.
- PURPOSE:
- TO ILLUMINATE AND EXAMINE THE RETINA, OPTIC NERVE, AND OTHER INTERNAL STRUCTURES OF THE EYE.
- BENEFIT:
- ALLOWS A WIDER FIELD OF VIEW AND BETTER FOCUS ON THE FUNDUS.

2. RETINOSCOPY

- PLANE MIRRORS ARE INCORPORATED IN RETINOSCOPES, WHICH ARE USED TO DETERMINE REFRACTIVE ERRORS OF THE EYE.
- PURPOSE:
- REFLECT LIGHT INTO THE EYE TO OBSERVE THE MOVEMENT OF THE LIGHT REFLEX ON THE RETINA.
- HELPS ASSESS MYOPIA, HYPEROPIA, AND ASTIGMATISM.
- MECHANISM:

3. OPTICAL TRAINING AND VISION THERAPY

- PLANE MIRRORS ARE USED IN VISION THERAPY EXERCISES TO IMPROVE BINOCULAR VISION, EYE COORDINATION, AND TRACKING SKILLS.
- EXAMPLES:
- PATIENTS PRACTICE FOCUSING ON OBJECTS AND ADJUSTING EYE MOVEMENTS USING MIRROR REFLECTIONS.
- HELPS IN TREATING CONVERGENCE INSUFFICIENCY AND STRABISMUS.

4. PERIMETRY TESTING

- PLANE MIRRORS ARE SOMETIMES USED IN OLDER OR MANUAL PERIMETRY SYSTEMS TO REFLECT LIGHT STIMULI INTO DIFFERENT PARTS OF THE PATIENT'S VISUAL FIELD.
- PURPOSE:

ASSESS PERIPHERAL VISION AND DIAGNOSE CONDITIONS LIKE GLAUCOMA.

5. DIAGNOSTIC DEVICES

- IN DEVICES LIKE PHOROPTERS AND SLIT LAMPS, PLANE MIRRORS HELP DIRECT LIGHT OR IMAGES TOWARD THE PATIENT OR PRACTITIONER FOR BETTER VISUALIZATION OF THE EYE.

6. BINOCULAR VISION ASSESSMENT

- PLANE MIRRORS ASSIST IN TESTING OCULAR ALIGNMENT AND FUSION BY REFLECTING IMAGES FOR THE PATIENT TO VIEW SIMULTANEOUSLY WITH BOTH EYES.

- **MIRROR EQUATION** :IS A FUNDAMENTAL FORMULA IN OPTICS THAT RELATES THE OBJECT DISTANCE (DO), IMAGE DISTANCE (DI), AND FOCAL LENGTH (F) OF A SPHERICAL MIRROR. IT IS EXPRESSED AS:
- 1/F = 1/D0+ 1/DI

WHERE:

F:FOCAL LENGTH OF THE MIRROR (MEASURED IN METERS OR CENTIMETERS).

DI: IMAGE DISTANCE (DISTANCE FROM THE MIRROR TO THE IMAGE, POSITIVE FOR REAL IMAGES AND NEGATIVE FOR VIRTUAL IMAGES).

DO: OBJECT DISTANCE (DISTANCE FROM THE MIRROR TO THE OBJECT, ALWAYS NEGATIVE FOR SPHERICAL MIRRORS).

SIGN CONVENTIONS FOR THE MIRROR EQUATION

TO USE THE MIRROR EQUATION CORRECTLY, YOU MUST FOLLOW THE NEW CARTESIAN SIGN CONVENTION:

1. POSITIVE VALUES:

- OBJECT DISTANCE IS ALWAYS POSITIVE (OBJECT IS ON THE LEFT OF THE MIRROR).
- FOCAL LENGTH IS POSITIVE FOR A CONCAVE MIRROR.
- IMAGE DISTANCE IS POSITIVE FOR REAL IMAGES (FORMED ON THE SAME SIDE AS THE OBJECT FOR CONCAVE MIRRORS).

2. NEGATIVE VALUES:

- FOCAL LENGTH IS NEGATIVE FOR A CONVEX MIRROR.

- **MAGNIFICATION FORMULA**

THE MAGNIFICATION OF AN IMAGE FORMED BY A MIRROR IS GIVEN BY:

M= HI / HO   OR   M= – (DI/DO)

WHERE:

M LAGER THAN (1) : MAGNIFIED IMAGE.

M SMALLER THAN (1) :DIMINISHED IMAGE.

M=1 :IMAGE IS THE SAME SIZE AS THE OBJECT.

M= (–)(INVERTED IMAGES HAVE NEGATIVE MAGNIFICATIONS).

M= (+) (UPRIGHT IMAGE)

UNIT 9/ SPHERICAL MIRRORS , CENTER OF CURVATURE , AXIS , VERTICES , FOCAL LENGTH

PRE TEST :

Q1 / WHAT IS THE SPHERICAL MIRROR?

Q2 /WHAT IS THE PARAMETER OF SPHERICAL MIRROR ?

UNIT 9 /SPHERICAL MIRRORS , CENTER OF CURVATURE , AXIS , VERTICES , FOCAL LENGTH

A SPHERICAL MIRROR :IS A TYPE OF MIRROR WITH A SURFACE THAT IS A SEGMENT OF A SPHERE. THE CURVED SURFACE DETERMINES THE BEHAVIOR OF LIGHT RAYS WHEN THEY ARE REFLECTED, LEADING TO VARIOUS APPLICATIONS AND CHARACTERISTICS.

STRUCTURE AND GEOMETRY OF SPHERICAL MIRRORS

SPHERICAL MIRRORS ARE DERIVED FROM A HYPOTHETICAL SPHERE AND HAVE SEVERAL KEY GEOMETRIC FEATURES:

1.VERTEX (V): THE GEOMETRIC CENTER OF THE MIRROR'S REFLECTIVE SURFACE.

2. CENTER OF CURVATURE (C): THE CENTER OF THE SPHERE FROM WHICH THE MIRROR'S SURFACE IS TAKEN.

3. RADIUS OF CURVATURE (R): THE RADIUS OF THE SPHERE; IT IS THE DISTANCE BETWEEN THE POLE AND THE CENTER OF CURVATURE.

4. PRINCIPAL AXIS: AN IMAGINARY LINE PASSING THROUGH THE POLE AND THE CENTER OF CURVATURE.

5. FOCUS (F): THE POINT WHERE PARALLEL LIGHT RAYS CONVERGE (CONCAVE MIRROR) OR APPEAR TO DIVERGE (CONVEX MIRROR) AFTER REFLECTION.

FOR CONCAVE MIRROR – IS DEFINED AS A POINT WHERE THE INCIDENT PARALLEL RAYS CONVERGE AFTER REFLECTION ON THE MIRROR.

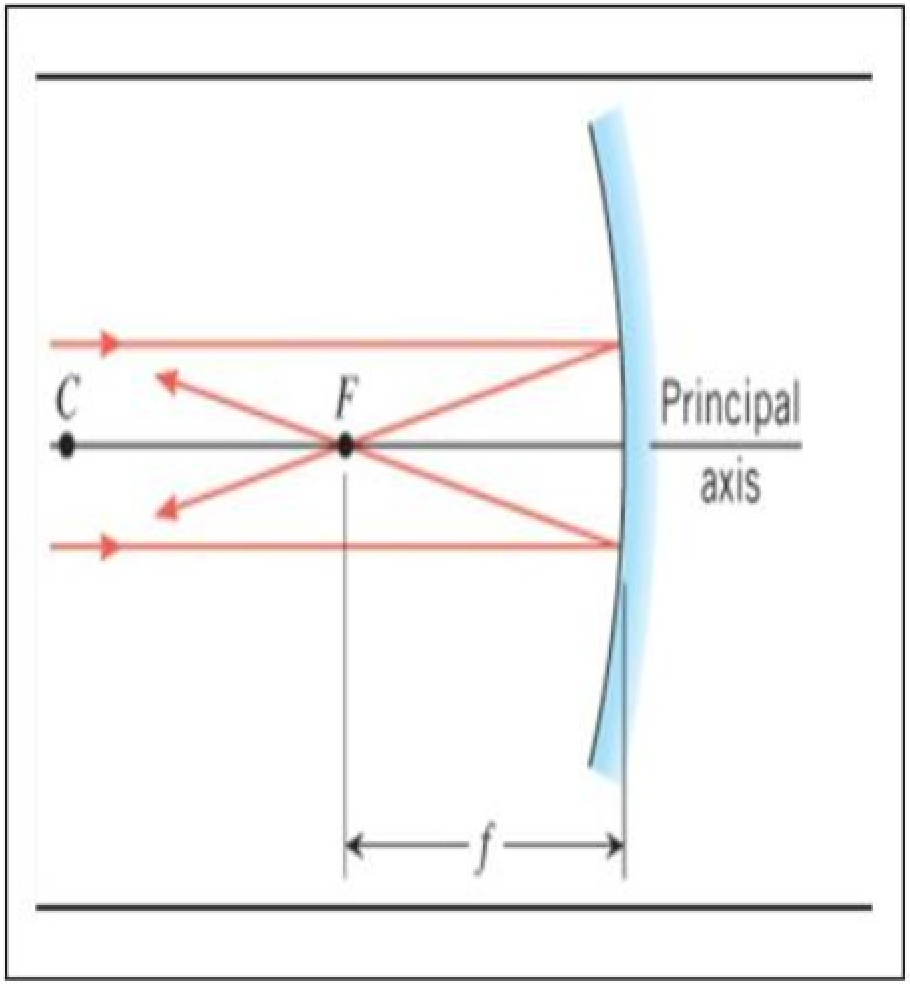
* ITS FOCAL POINT IS REAL (PRINCIPLE).

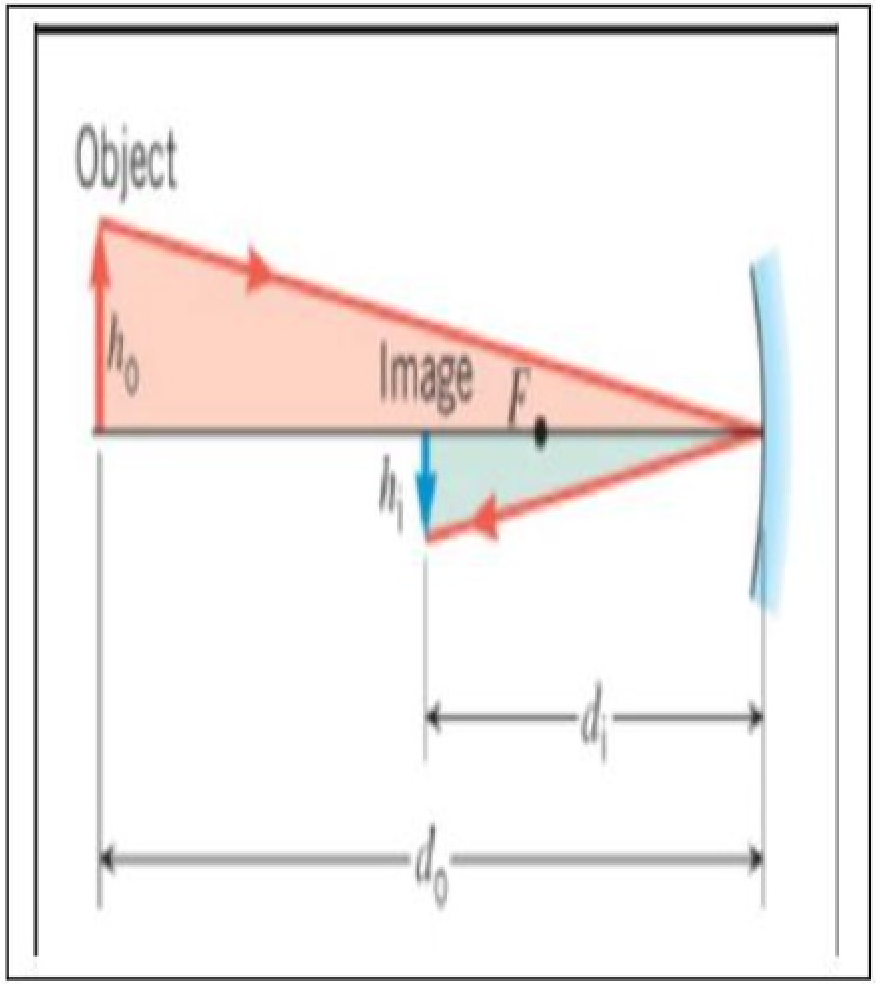
FOR CONVEX MIRROR – IS DEFINED AS A POINT WHERE THE INCIDENT PARALLEL RAYS SEEM TO DIVERGE FROM A POINT BEHIND THE MIRROR AFTER REFLECTION.

*ITS FOCAL POINT IS VIRTUAL.

6. FOCAL LENGTH (F): THE DISTANCE BETWEEN THE POLE AND THE FOCUS.

RELATIONSHIP BETWEEN FOCAL LENGTH (F) AND RADIUS OF CURVATURE (R)


C
F
Principal
axis
f


Object
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TYPES OF SPHERICAL MIRRORS

A. CONCAVE MIRROR (CONVERGING MIRROR)

- DEFINITION: A SPHERICAL MIRROR WITH THE REFLECTIVE SURFACE ON THE INNER SIDE OF THE SPHERE.
- BEHAVIOR: PARALLEL RAYS OF LIGHT CONVERGE AFTER REFLECTION AND MEET AT A POINT (THE FOCUS).
- REFLECTION RULES FOR CONCAVE MIRRORS:

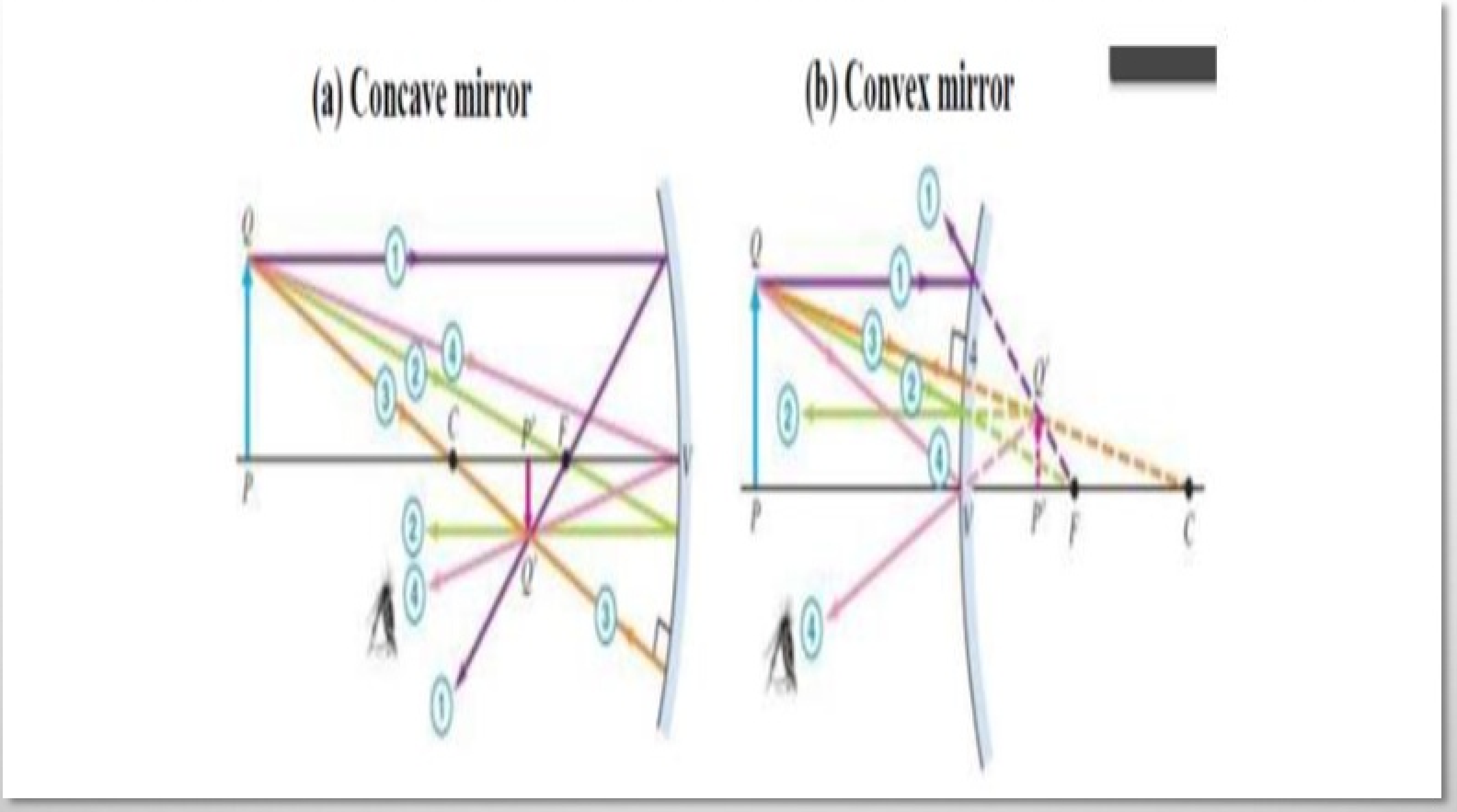
1. RAYS PARALLEL TO THE PRINCIPAL AXIS REFLECT THROUGH THE FOCUS.
2. RAYS PASSING THROUGH THE FOCUS REFLECT PARALLEL TO THE PRINCIPAL AXIS.
3. RAYS PASSING THROUGH THE CENTER OF CURVATURE REFLECT BACK ALONG THEIR ORIGINAL PATH.
4. OBLIQUE RAYS FOLLOW THE LAW OF REFLECTION, WHERE THE ANGLE OF INCIDENCE EQUALS THE ANGLE OF REFLECTION

B. CONVEX MIRROR (DIVERGING MIRROR)

- DEFINITION: A SPHERICAL MIRROR WITH THE REFLECTIVE SURFACE ON THE OUTER SIDE OF THE SPHERE.
- BEHAVIOR: PARALLEL RAYS OF LIGHT DIVERGE AFTER REFLECTION, APPEARING TO ORIGINATE FROM A POINT BEHIND THE MIRROR (VIRTUAL FOCUS).

REFLECTION RULES FOR CONVEX MIRRORS:

1. RAYS PARALLEL TO THE PRINCIPAL AXIS APPEAR TO DIVERGE FROM THE FOCUS BEHIND THE MIRROR.
2. RAYS DIRECTED TOWARD THE FOCUS REFLECT PARALLEL TO THE PRINCIPAL AXIS.
3. RAYS DIRECTED TOWARD THE CENTER OF CURVATURE REFLECT BACK ALONG THEIR ORIGINAL PATH


(a) Concave mirror
(b) Convex mirror
Q
P
C
P'
F
V
Q'
1
2
3
4

POST TEST :

Q1 /DEFINE SPHERICAL MIRROR PARAMETER ?

Q2/ FOCAL LENGTH OF THE CONCAVE MIRROR HAVE ………..SIGHN

A-POSITIVE

B-NEGATIVE

C-NEUTRAL

UNIT 10 / CONCAVE MIRROR , PROPERTIES OF IMAGE FORMED BY CONCAVE MIRROR

PRE TEST :

Q1 / LIST THE PROPERTIES OF IMAGES FORMED BY CONCAVE MIRRORS ?

Q2/ AN OBJECT ITS HEIGHT (4 CM) WAS PLACED AT DISTANCE (20 CM) FROM CONVEX MIRROR HAS FOCAL LENGTH (12 CM). FIND POSITION OF THE IMAGE

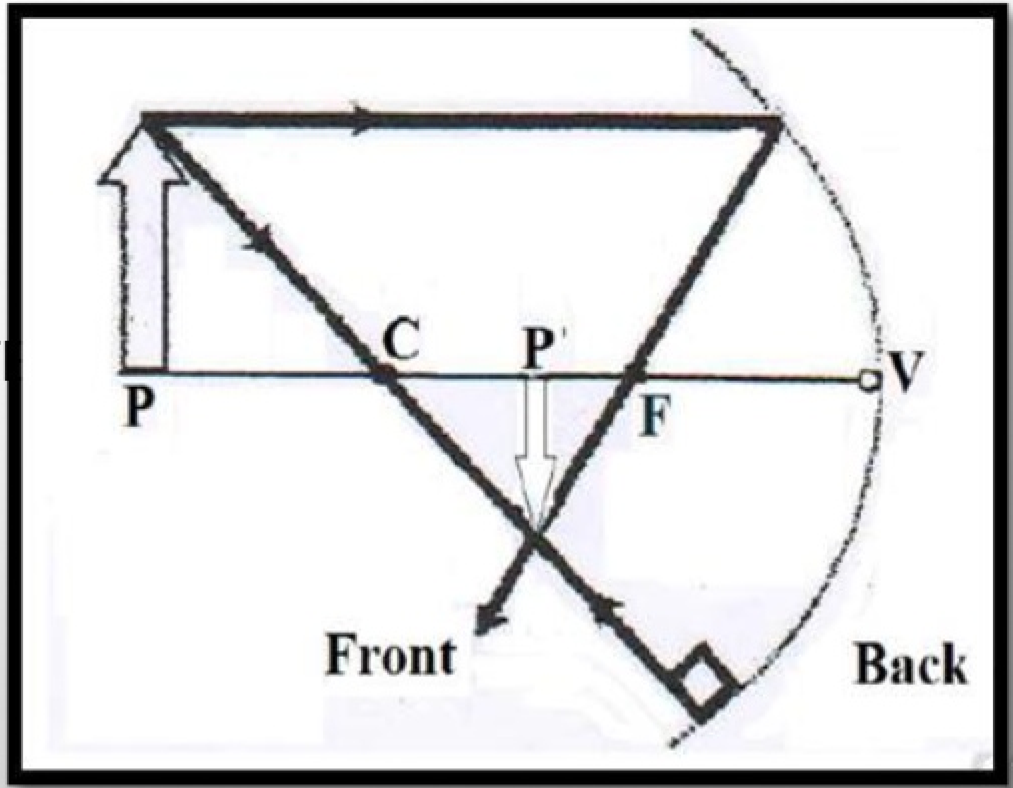
A- (7.5 CM) B- (- 5.5 CM) C- (- 7.5 CM) D- (5.5 CM)

IMAGES FORMED BY A CONCAVE MIRROR:

DEPEND ON THE POSITION OF THE OBJECT RELATIVE TO THE MIRROR'S FOCUS (F), CENTER OF CURVATURE (C), AND PRINCIPAL AXIS. THE PROPERTIES OF THE IMAGE VARY BASED ON THESE POSITIONS AS FOLLOWS:

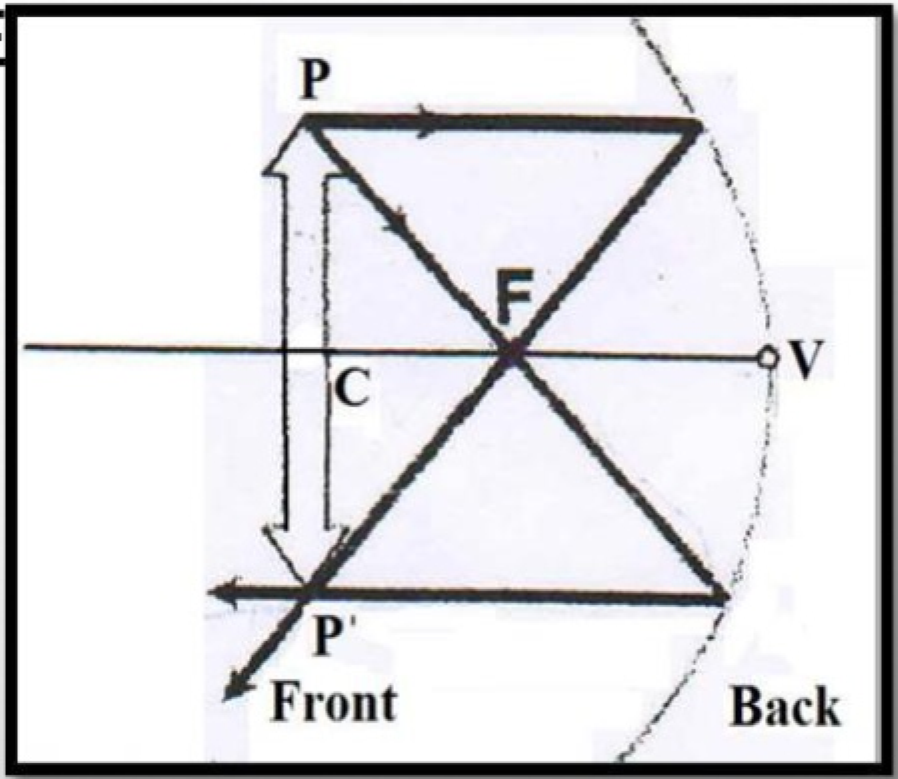
1.OBJECT BEYOND CENTER OF CURVATURE (C):

- POSITION OF IMAGE: BETWEEN C AND F (INVERTE
- SIZE OF IMAGE: SMALLER THAN THE OBJECT.
- NATURE OF IMAGE: REAL AND INVERTED.



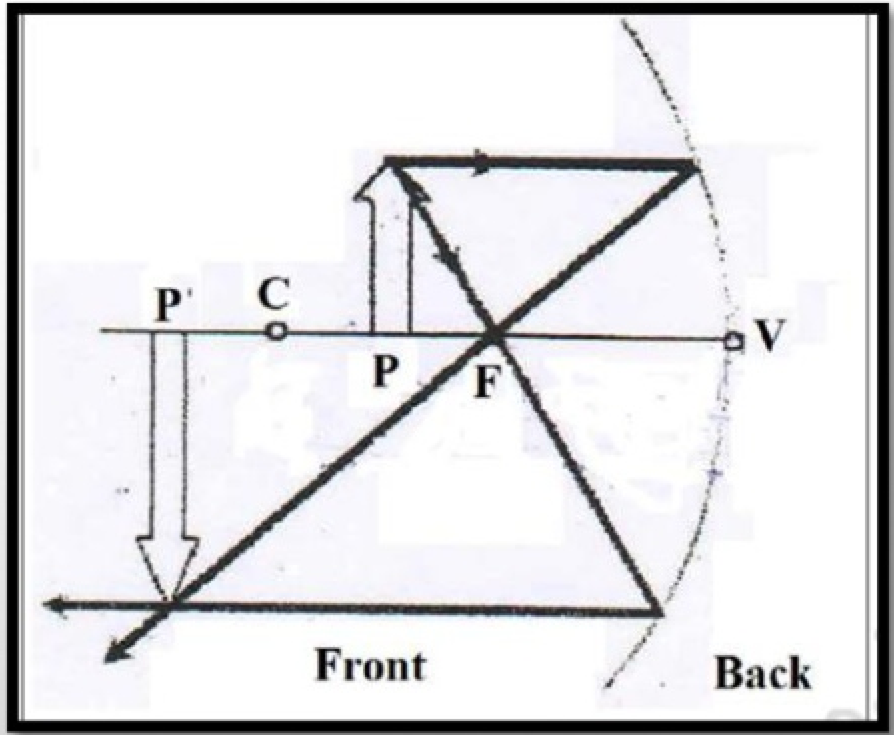
2.OBJECT AT CENTER OF CURVATURE

- POSITION OF IMAGE: AT C (INVERTED).
- SIZE OF IMAGE: SAME SIZE AS THE OBJECT.
- NATURE OF IMAGE: REAL AND INVERTED.



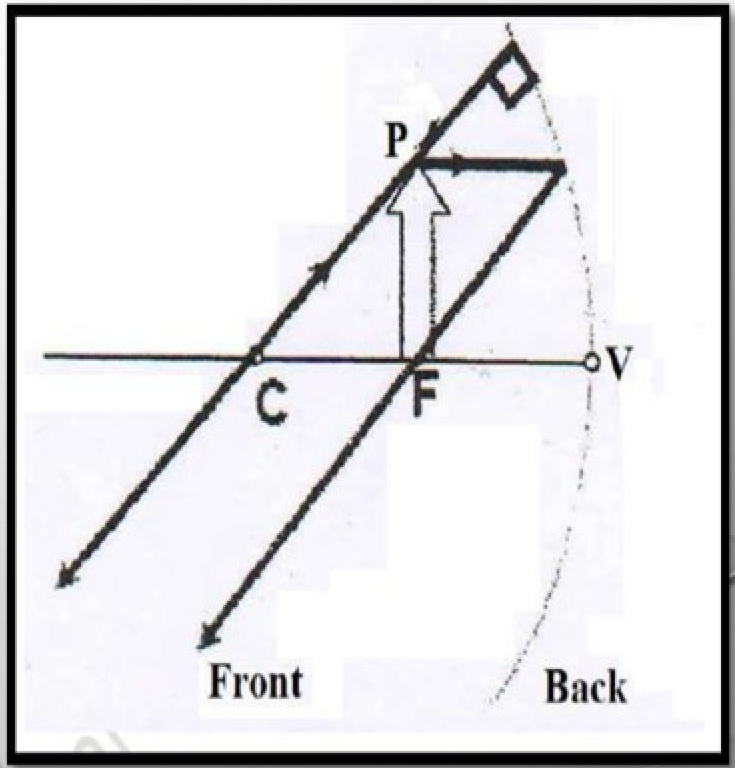
3.OBJECT BETWEEN C AND F (CLOSER TO THE MIRROR):

- POSITION OF IMAGE: BEYOND C.
- SIZE OF IMAGE: LARGER THAN THE OBJECT.
- NATURE OF IMAGE: REAL AND INVERTED.



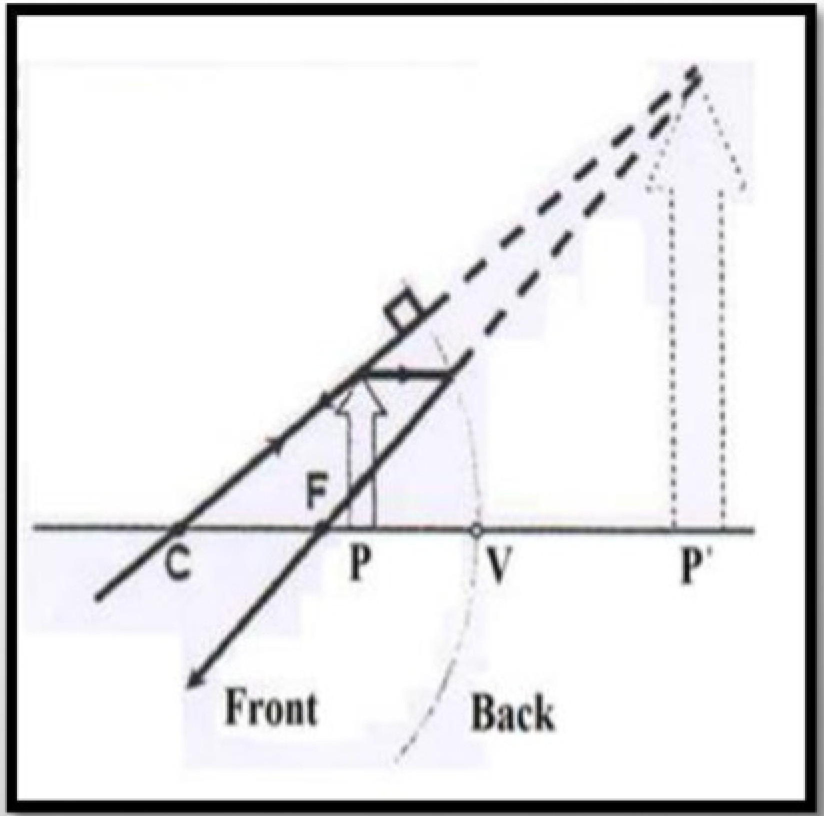
4.OBJECT AT FOCUS (F):

- POSITION OF IMAGE: AT INFINITY.
- SIZE OF IMAGE: HIGHLY MAGNIFIED (THEORETICALLY INFINITE).
- NATURE OF IMAGE: REAL AND INVERTED.



5.OBJECT BETWEEN F AND THE MIRROR (INSIDE THE FOCUS):

- POSITION OF IMAGE: BEHIND THE MIRROR.
- SIZE OF IMAGE: LARGER THAN THE OBJECT.
- NATURE OF IMAGE: VIRTUAL AND UPRIGHT.



POST TEST

Q1/ FIND THE PROPERTIES OF IMAGE FORMED BY CONCAVE MIRROR IF OBJECT LOCATED AT FOCUS (F)?

Q2/ OBJECT AT CENTER OF CURVATURE (C), PROPERTIES OF IMAGE IS………

A-REAL AND INVERTED

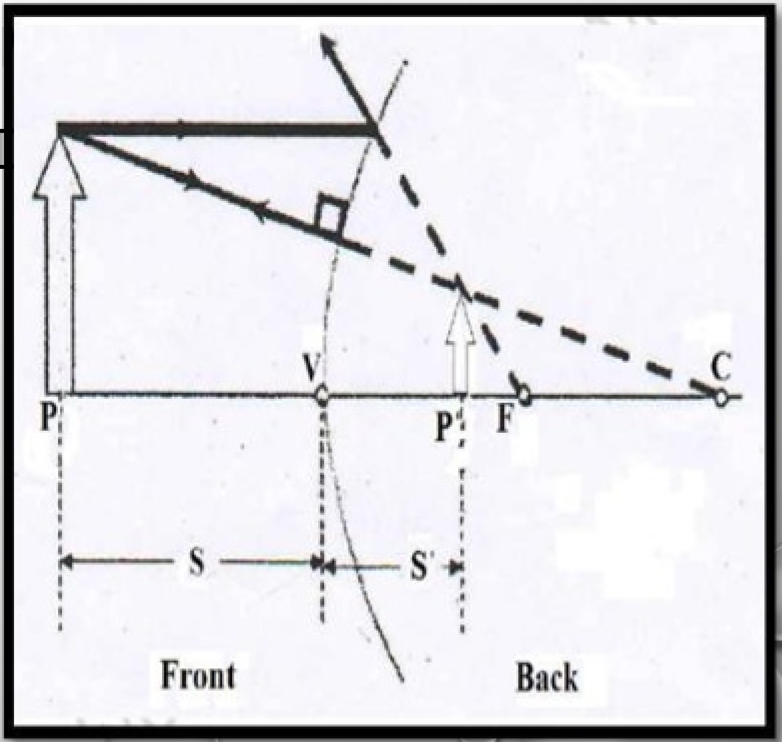
B-REAL AND UPRIGHT

UNIT 11: CONVEX MIRROR , PROPERTIES OF IMAGE FORMED BY CONVEX MIRROR

PROPERTIES OF IMAGES FORMED BY CONVEX MIRROR :

IMAGES FORMED BY A CONVEX MIRROR EXHIBIT CONSISTENT CHARACTERISTICS, REGARDLESS OF THE OBJECT'S POSITION. A CONVEX MIRROR ALWAYS PRODUCES:

- POSITION OF IMAGE: BETWEEN THE FOCUS (F) AND THE
- SIZE OF IMAGE: SMALLER THAN THE OBJECT (DIMINISHED
- NATURE OF IMAGE: VIRTUAL AND UPRIGHT.



THESE PROPERTIES ARE GOVERNED BY THE SPHERICAL MIRROR EQUATION:

$1/F = 1/DO + 1/DI$

WHERE:

F:FOCAL LENGTH OF THE MIRROR.

DO:DISTANCE OF THE OBJECT FROM THE MIRROR.

DI:DISTANCE OF THE IMAGE FROM THE MIRROR.

(LATERAL) MAGNIFICATION OF THE SPHERICAL MIRROR, M IS DEFINED AS THE RATIO BETWEEN IMAGE HEIGHT, HI AND OBJECT HEIGHT, HO

$M = HI/HO = -(DI/DO)$

TABLE BELOW SHOWS THE SIGN CONVENTION FOR EQUATION OF SPHERICAL MIRROR

Physical quaintly	Positive sign (+)	Negative sign (-)
Object distance, d_o	Real object (in front of the mirror)	Virtual object (at the back of mirror)
Image distance, d_i	Real image (same side of the object)	Virtual image (opposite side of the object)
Focal length, f	Concave mirror	Convex mirror
magnification, M	Upright image	Inverted image

EXAMPLES

1-AN OBJECT IS PLACED 10 CM IN FRONT OF A CONCAVE MIRROR WHOSE FOCAL LENGTH IS 15 CM. DETERMINE: A- POSITION OF IMAGE, B. LINEAR MAGNIFICATION AND STATE THE PROPERTIES OF IMAGE.

SOLUTION

DO = + 10 CM, F = + 15 CM

A.BY APPLYING THE EQUATION OF SPHERICAL MIRROR, THUS

1/F = 1/DO + 1/DI

1 / 15 = 1/ 10 + 1/DI

DI=-30 CM

THE IMAGE IS 30 CM FROM THE MIRROR ON THE OPPOSITE SIDE OF THE OBJECT (OR 30 CM AT THE BACK OF THE CONCAVE MIRROR).

B.THE LINEAR MAGNIFICATION IS GIVEN BY:

M= -(D I/ DO) = -(-30/10) = 3

THE PROPERTIES OF IMAGE ARE:

VIRTUAL

UPRIGHT

MAGNIFIED

POST TEST :

A 1.5 CM HIGH DIAMOND RING IS PLACED 20 CM IN FRONT OF A CONCAVE MIRROR WHOSE RADIUS OF CURVATURE IS 30 CM. DETERMINE: A- THE POSITION OF THE IMAGE, B- ITS SIZE.

UNIT 12/ REAL AND VIRTUAL IMAGES FORMED BY REFLECTED SURFACES

PRE TEST :

Q/WHAT IS THE REAL AND THE VIRTUAL IMAGES ?

UNIT 12/ REAL AND VIRTUAL IMAGES FORMED BY REFLECTED SURFACES

SPHERICAL MIRRORS HAVE MULTIPLE APPLICATIONS IN OPTOMETRY DUE TO THEIR ABILITY TO MANIPULATE LIGHT ACCURATELY AND EFFECTIVELY. THEIR CURVED SURFACES MAKE THEM ESSENTIAL IN VARIOUS DIAGNOSTIC AND THERAPEUTIC INSTRUMENTS. HERE ARE SOME KEY USES:

1. OPHTHALMOSCOPY

- SPHERICAL MIRRORS ARE A CORE COMPONENT OF OPHTHALMOSCOPES. THEY FOCUS LIGHT INTO THE EYE, ALLOWING OPTOMETRISTS TO EXAMINE THE RETINA, OPTIC NERVE, AND BLOOD VESSELS CLEARLY.

2. RETINOSCOPY

- IN RETINOSCOPES, SPHERICAL MIRRORS PROJECT LIGHT INTO THE EYE AND REFLECT THE RETINAL IMAGE. THIS PROCESS HELPS IN DETERMINING REFRACTIVE ERRORS LIKE MYOPIA, HYPEROPIA, AND ASTIGMATISM.

3. CORNEAL MEASUREMENTS

- INSTRUMENTS LIKE KERATOMETERS AND CORNEAL TOPOGRAPHERS USE SPHERICAL MIRRORS TO MEASURE THE CURVATURE OF THE CORNEA. THESE MEASUREMENTS ARE

4. BINOCULAR INDIRECT OPHTHALMOSCOPY (BIO)

- BIO DEVICES UTILIZE SPHERICAL MIRRORS TO DIRECT LIGHT INTO THE EYE WHILE PROVIDING A WIDE-ANGLE VIEW OF THE RETINA. THIS IS ESSENTIAL FOR DETECTING PERIPHERAL RETINAL DISORDERS, SUCH AS RETINAL TEARS OR DETACHMENT.

5. VISUAL FIELD ANALYSIS

- SPHERICAL MIRRORS ARE INCORPORATED IN VISUAL FIELD TESTING DEVICES TO DIRECT VISUAL STIMULI TO SPECIFIC AREAS, AIDING IN THE DIAGNOSIS OF CONDITIONS LIKE GLAUCOMA OR OPTIC NERVE DAMAGE.

6. ABERRATION MEASUREMENT

- IN WAVEFRONT ABERROMETRY, SPHERICAL MIRRORS ARE USED TO ANALYZE HIGHER-ORDER ABERRATIONS IN THE EYE, CONTRIBUTING TO PRECISE VISION CORRECTION THROUGH CUSTOM LENSES OR REFRACTIVE SURGERY.

7. PHOROPTERS

- SPHERICAL MIRRORS IN PHOROPTERS HELP DIRECT AND ALIGN LIGHT DURING REFRACTION TESTS, ENSURING ACCURATE MEASUREMENTS FOR CORRECTIVE PRESCRIPTIONS.

ADVANTAGES OF SPHERICAL MIRRORS IN OPTOMETRY:

- VERSATILITY: BOTH CONCAVE AND CONVEX MIRRORS CAN BE USED DEPENDING ON THE APPLICATION.
- ACCURACY: THEIR PREDICTABLE GEOMETRY ALLOWS FOR PRECISE LIGHT FOCUSING OR DIVERGENCE.
- COST EFFICIENCY: THEY ARE SIMPLER AND MORE AFFORDABLE TO PRODUCE COMPARED TO SPECIALIZED OPTICAL SURFACES LIKE ASPHERIC MIRRORS.

- **APPLICATION OF SPHERICAL MIRRORS :**

CONCAVE MIRRORS:

- TELESCOPES: USED IN REFLECTING TELESCOPES TO FOCUS LIGHT FROM DISTANT STARS.
- MEDICAL INSTRUMENTS: DENTAL MIRRORS AND INSTRUMENTS FOR CLOSE EXAMINATION.
- LIGHTING DEVICES: USED IN FLASHLIGHTS, CAR HEADLIGHTS, AND SEARCHLIGHTS TO FOCUS LIGHT BEAMS.
- SOLAR COLLECTORS: FOCUS SUNLIGHT ONTO A SMALL AREA TO GENERATE HEAT OR

- **CONVEX MIRRORS:**
  - REARVIEW MIRRORS: PROVIDES A WIDER FIELD OF VIEW FOR VEHICLES.
  - SAFETY MIRRORS: INSTALLED IN STORES, PARKING LOTS, AND AT INTERSECTIONS FOR SURVEILLANCE AND VISIBILITY.
  - OPTICAL DEVICES: USED IN IMAGING SYSTEMS TO EXPAND THE FIELD OF VIEW.

POST TEST

Q/COMPARE BETWEEN IMAGES FORMED BY CONCAVE AND CONVEX MIRRORS

UNIT 13 / REFRACTION , THE LAWS OF REFRACTION , REFRACTION BY PLANE SURFACES

- PRE TEST :

Q/ WHAT DOES THE CONCEPT OF REFRACTION PHENOMENON MEAN ?

Q/ WHAT IS THE LAWS OF REFRACTION ?

- **UNIT 13 / REFRACTION , THE LAWS OF REFRACTION , REFRACTION BY PLANE SURFACES**

- 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.

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

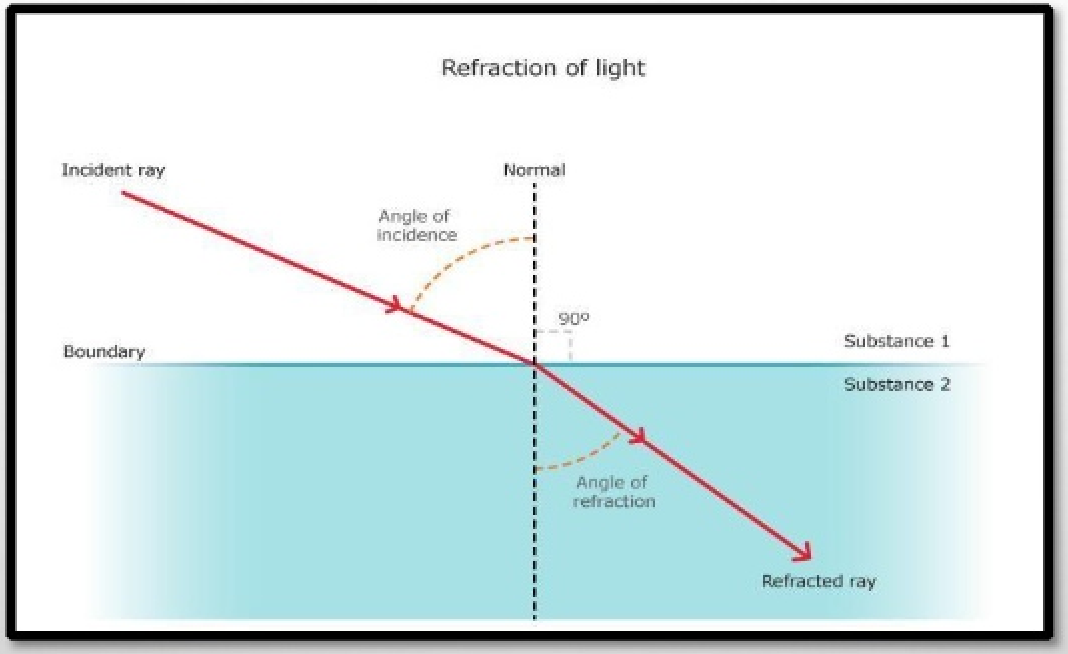


Figure (1) : Refraction of light

- **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.

$sin\ \Theta i/sin\Theta r$=CONSTANT=N

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:

$sin\Theta i / sin\Theta r$=CONSTANT=N

$n1 sin\Theta 1 = n2 sin\Theta 2$

WHERE Θ1 IS THE ANGLE OF INCIDENCE AND Θ2 IS THE ANGLE OF REFRACTION

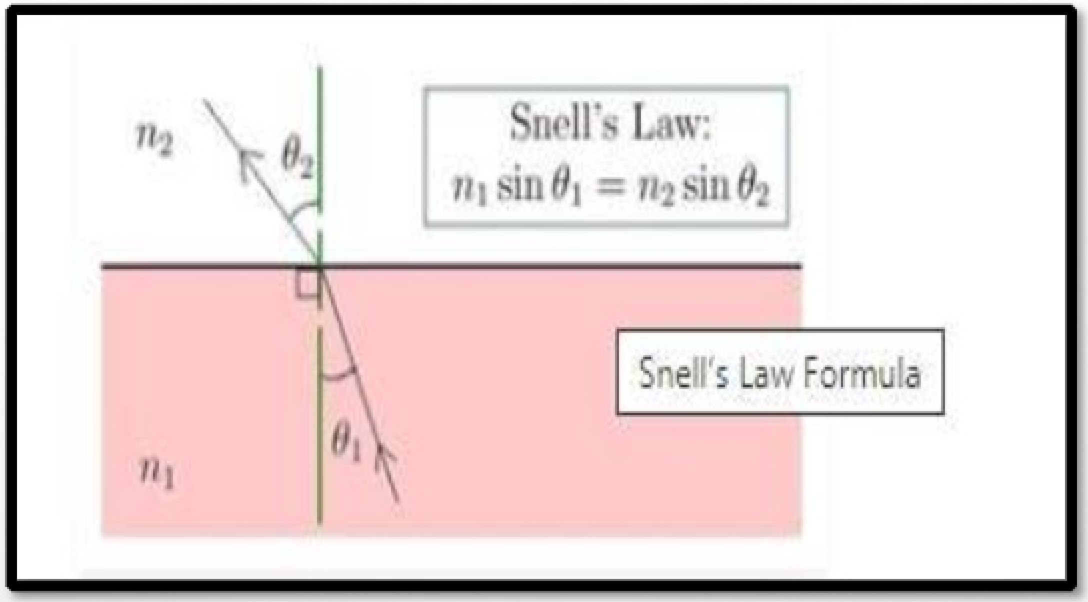


Figure (2) : Snell's law

Refraction by a Plane Surface :

When light passes obliquely from one medium to another (e.g., air to glass), the plane surface at the interface causes the light to change direction due to the difference in the optical densities of the two media. This bending of light follows Snell's Law and leads to various optical phenomena.

POST TEST

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 22O, WHAT IS THE ANGLE OF REFRACTION INSIDE THE FIBER? (B) SKETCH THE PATH OF LIGHT AS IT CHANGES MEDIA.

UNIT 14 /THE REFRACTIVE INDEX , RELATIVE REFRACTIVE INDEX

RELATIVE REFRACTIVE INDEX :

IS THE RATIO OF THE SPEED OF LIGHT IN THE MEDIUM 1 TO THE SPEED OF LIGHT IN MEDIUM 2.

$$nr = \frac{\textbf{speed of light in medium 1}}{\textbf{speed of light in medium 2}}$$

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.

$N = C / V$

POST TEST:

Q/ LIGHT TRAVELS FROM A VACUUM INTO GLASS WITH SPEED $2*10^8$ M/S , CALCULATE THE REFRACTIVE INDEX OF THE GLASS ?

UNIT 15 / FACTORS AFFECTING THE REFRACTIVE INDEX

PRE TEST :

Q/ ENUMERATE THE FACTORS AFFECTING THE REFRACTIVE INDEX?

UNIT 15 / FACTORS AFFECTING THE REFRACTIVE INDEX

THE REFRACTIVE INDEX OF A MATERIAL MEASURES HOW MUCH LIGHT SLOWS DOWN AS IT PASSES THROUGH THAT MATERIAL, COMPARED TO ITS SPEED IN A VACUUM. SEVERAL FACTORS CAN INFLUENCE THE REFRACTIVE INDEX OF A SUBSTANCE:

1. **WAVELENGTH OF LIGHT**: THE REFRACTIVE INDEX IS WAVELENGTH-DEPENDENT. GENERALLY, MATERIALS HAVE A LOWER REFRACTIVE INDEX FOR LONGER WAVELENGTHS (RED LIGHT) AND A HIGHER REFRACTIVE INDEX FOR SHORTER WAVELENGTHS (BLUE OR VIOLET LIGHT). THIS IS KNOWN AS DISPERSION.

2. **TEMPERATURE**: AS TEMPERATURE INCREASES, THE REFRACTIVE INDEX OF MOST MATERIALS DECREASES. THIS OCCURS BECAUSE THE INCREASED THERMAL ENERGY CAUSES MOLECULES TO VIBRATE MORE, REDUCING THE MATERIAL’S OPTICAL DENSITY AND, CONSEQUENTLY, ITS REFRACTIVE INDEX.

3. **PRESSURE:** THE REFRACTIVE INDEX CAN ALSO BE AFFECTED BY PRESSURE, ESPECIALLY IN GASES. FOR MOST MATERIALS, INCREASING THE PRESSURE TYPICALLY INCREASES THE REFRACTIVE INDEX, AS THE MATERIAL BECOMES DENSER.

4. **COMPOSITION AND DENSITY**: THE REFRACTIVE INDEX IS INFLUENCED BY THE DENSITY OF THE MATERIAL. MATERIALS WITH HIGHER ATOMIC OR MOLECULAR DENSITY GENERALLY HAVE A HIGHER REFRACTIVE INDEX BECAUSE LIGHT INTERACTS MORE WITH THE ATOMS OR MOLECULES IN DENSER SUBSTANCES. DIFFERENT SUBSTANCES, LIKE GLASS, WATER, OR AIR, HAVE DIFFERENT REFRACTIVE INDICES DUE TO THEIR MOLECULAR STRUCTURE.

5. **IMPURITIES**: THE PRESENCE OF IMPURITIES OR DIFFERENT PHASES IN A MATERIAL CAN ALTER ITS REFRACTIVE INDEX. IMPURITIES MAY CHANGE THE DENSITY OR THE POLARIZABILITY OF THE MATERIAL, WHICH IN TURN CHANGES HOW LIGHT INTERACTS WITH IT.

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

LATERAL DISPLACEMENT:

IN A GLASS SLAB WITH PARALLEL SURFACES:

THE INCIDENT RAY IS DISPLACED LATERALLY BUT EMERGES PARALLEL TO ITS ORIGINAL DIRECTION.

MATHEMATICAL REPRESENTATION :

LATERAL DISPLACEMENT IN A GLASS SLAB:

$D=T\ [\ \sin(\Theta 1-\Theta 2)\ /\ \cos\ \Theta 2]$

WHERE:

T: THICKNESS OF THE SLAB.

D : LATERAL SHIFT OF THE EMERGENT RAY.

POST TEST

Q/ A LIGHT RAY PASSES THROUGH A GLASS SLAB OF THICKNESS T=5CM . THE ANGLE OF INCIDENCE IS 45. CALCULATE THE LATERAL DISPLACEMENT OF THE LIGHT RAY.

GIVEN DATA

- THICKNESS OF THE SLAB: 5 CM
- ANGLE OF INCIDENCE: 45

Q/ THE SPEED OF LIGHT IN AN UNKNOWN MEDIUM IS MEASURED TO BE (2.76 X 108 M/S) , WHAT IS THE INDEX OF REFRACTION OF THE MEDIUM?