HAWASSA CITY ADIMINSTIRATION EDUCATION DEPARITIMENT SECOND SEMESTER COMPESATION LESSON IN 2012E.C

Subject -Physics

Grade 10

Unit -6

Electromagnetic waves and geometrical optics

6.1 Electromagnetic waves

- The vibrations in electromagnetic waves comes from electric and magnetic fields. Electromagnetic waves are produced when a magnetic field and an electric field are at right angles to each others. Charges that are accelerated in an electric and magnetic field produces electromagnetic waves

Representing transverse wave

Electromagnetic waves are transverse wave

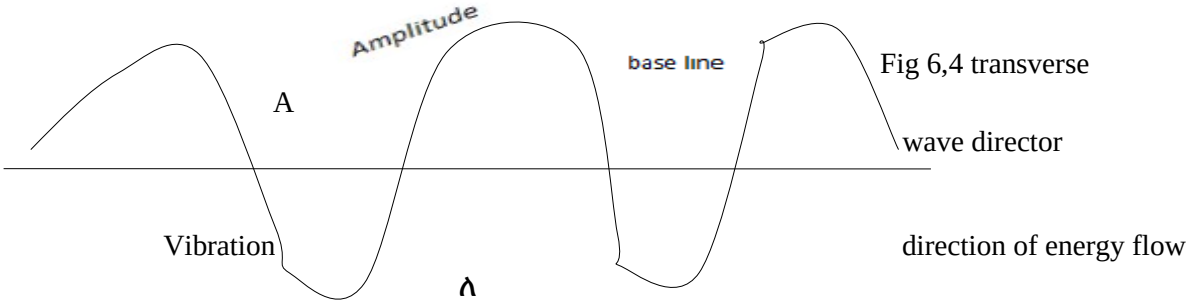


Fig 6,4 transverse

Wave length

- **Amplitude (A)** the distance that the wave moves above or below the base line in meter (m)
- **Frequency of a wave (f)** is the number of complete wave passing a given point in a second in hertz (H7)
- **Wavelength (ʌ)** is the distance between successive equivalent point (usually taken as peaks or troughs) on a wave

Relationship between frequency wavelength and speed

Speed (V) = frequency * wavelength V= f*λ

Where: V- speed in m/s

frequency in Hertz(Hz)

Wave length in meter (m)

Electromagnetic waves emitted by the sun

The sun emits electromagnetic waves with a wide ran ge of frequencies and wavelengths. In vacuum, all electromagnetic waves travel at a speed of $3x10^8$ m/s. they have different wavelengths and frequencies.

Same uses of electromagnetic radiation

Visible light (λ= $6x10^{-7}$m) is the most important part of the electromagnetic spectrum to everyday life

x-ray (λ = 10-10m) are used to take pictures of inside the body to show any bone fractures

Infrared radiation (λ = 10^{-6}m) is used in infrared cameras, width are used in rescue operations to detect the presence of bodies.

Micro waves and radio waves (λ= 1m) are used for communication for example radio and telephone signal

6.2 Reflection of light

Rectilinear propagation of light means that light waves travel in straight line

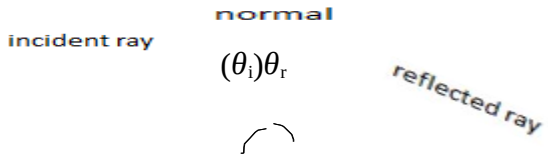


fig 6.8 angles are measured from the normal

The laws of reflection:-

The angle of reflection (θ_r) is equal to the angle of incident (θ_i)

- The beam of light on its way to the mirror is called the incident ray. It hits the mirror at particular angle of incidence After that the reflected ray leaves the mirror at the appropriate angle of reflection.
- The reflected ray lies in the plane which contained the incident ray and the normal

Using the law of reflection to explain how images are formed in a plane mirror and using a ray tracing method to find the position of the image. O

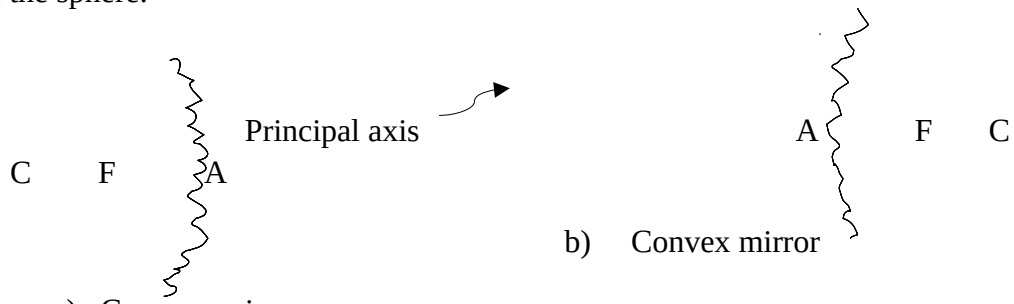
- The first law tells us that the angle of incidence is equal to the angle of reflection i=r Now trace the reflected rays beyond the mirror using dotted lines.

fig 6.4The point where the dotted lines meet is the position of the image, I

Concave mirror I

A mirror with a reflecting surface that bulges inwards, away from the light source.

- Concave mirrors were silvered on the inside of the sphere concaves. A spherical mirror can be thought of as apposition of a sphere which was sliced away and then silvered on outside of the sphere.



a) Concave mirror

b) Convex mirror

- **Center (C)** of the sphere from which the mirror was sliced is known as the center of curvature
- A point at the geometric center of the mirror is called **vertex (A)**
- The line passing through the center of curvature and vertex of the mirror is called the **principal axis**
- The distance from the vertex to the center of curvature is known as **the radius of curvature (R)**
- The point midway between the vertex and the center of curvature of known's **the focal point or principal focus**(F) The focal point of a convex mirror is located behind the mirror and that of the concave mirror is located on the same side as the object.
- The distance from the mirror to the focal point is known as the **focal length (f)** where f=1/2(R)

Distinguish between real and virtual images

When you can focus the light from an image on a screen, the image is called a real image.

Real image:- Is an image that is formed when actual light rays meet, and it can be projected on to a screen

Virtual image:- Is an image that is formed without the meeting of actual rays but from the extension of the reflected ray, and it cannot be projected on to screen.

The mirror equation

Is enables us to find out where and how the image is formed:

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ Where: f- is the focal length

u- is the object distance

v- is tae image distance

Magnification (M) :-is the ratio of image height to object height or image distance to object distance

Magnification (M) = $\frac{image\ height}{object\ height} = \frac{image\ distance}{object\ distance}$

$M = \frac{hi}{ho} = \frac{-v}{u}$

Sign convention: when we use the mirror equation, we need to mate use of the following sign conventions

Focal length (f):- is positive for concave mirror and negative for convex mirror

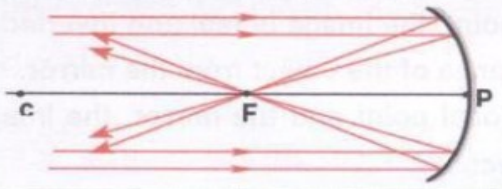
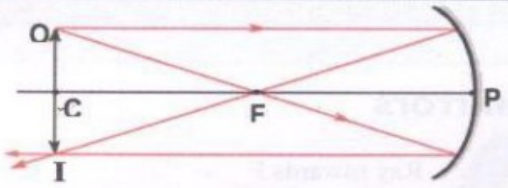
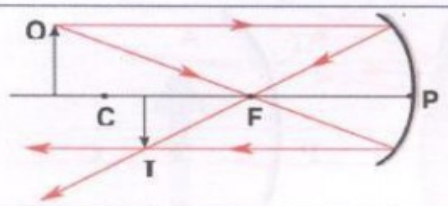
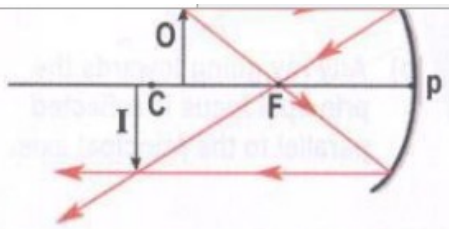
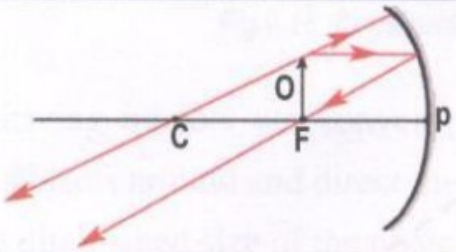
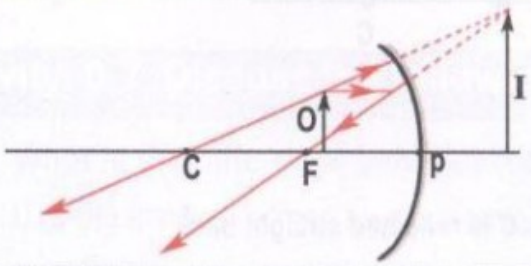
Image distance (v) is positive for real image and negative for virtual image

Object distance (u) is positive for real object and negative for virtual image

Magnification (m) is positive for upright (erect) image and negative for inverted image.

<u>Using ray diagrams for concave mirrors</u>

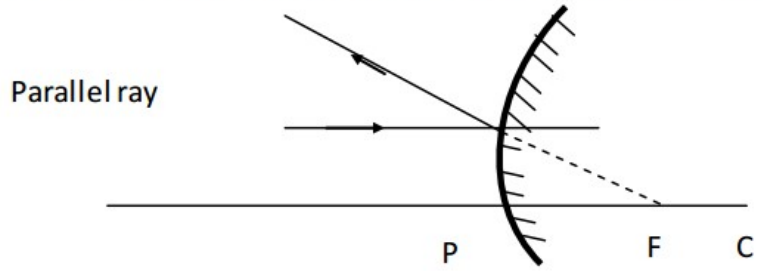
The nature of the image formed by a concave mirror depends on the location of the object

a) 	**Object at infinity (Very far)**	**The image is** 1. At F 2. Real 3. Inverted 4. Smaller than object
b) 	**Object at C (S_0=2F)**	**The image is** 1. Real 2. Inverted 3. Same size 4. At C
c) 	**Object beyond C (s_0 > 2f)**	**The image is** 1. Real 2. Inverted 3. Smaller than object 4. Between C and F
d) 	and C ($2f > s_0 > f$)	1. Real 2. Inverted 3. Large than object 4. Beyond C
e) 	**Object at F (s_0 = f)**	**No image is observed (it is at infinity)**
f) 	**Object between F and P (f> s_0)**	**The image is** (1) Virtual (2) Larger than object (3) Erect (4) Behind the mirror

Using ray diagram for a convex mirror

If an object is placed in front of a convex mirror the location of the image is always between A and F as shown in fig. properties of the image are virtual upright and diminished.

i. Any parallel to the principal axis is reflected so that it appears to come from F.



ii. Any ray going towards the principal focus is reflected parallel to the principal axis.

Fig* convex mirror

Example: you stand 15cm away from a converging mirror of focal length 20cm a/ workout the distance to the image b/ calculate the magnification of the image (for this purpose ignore the minus sign)

Give So= 15cm si=? F=20cm

a) $\frac{1}{50} + \frac{1}{50} = \frac{1}{f} \Rightarrow \frac{1}{51} = ¿\ \frac{1}{f} - \frac{1}{50} = \frac{1}{20} - \frac{1}{15} = \frac{3-4}{60} = \frac{a}{60}$

Si= -60cm

b) M= $\frac{So}{Si} = \frac{60\,cm}{15\,cm} = 4$

Exercise:1- a) what is the focal length of conversing mirror whose radius of curvature is 20cm? **Answer** 40cm b) what is the nature and location of an image if an object is placed 15cm from this mirrors. **Answer** 30cm =Si -real image

6.3 Refraction of light

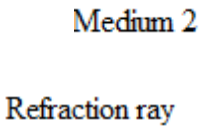
Is the change in the direction of travel of a light beam that occurs the light crosses the boundary between one transparent medium and another

The bending of a wave when its wave front passes obliquely from one medium to another is called refraction. The change in direction of the wave is due to the change in its speed when a wave changes medium its wavelength changes, but the frequency remains constant.

Incident ray

Medium 1

The refractive index and snell'slaw



Refraction index(n):- a measure of the extent to which a medium refract light.

$$\mathbf{n} = \frac{\sin\theta 1}{sin\theta 1}$$

snell's law:- whenever light crosses a boundary between two media, the sine's of the angle on each side of the boundary bear a constant ratio to each other.

$$\frac{\sin\theta 1}{sin\theta 1} \frac{n_2}{n_1} \frac{v_1}{v_2} \frac{\lambda_1}{\lambda_2}$$

Where: 1 and 2 medium one and medium two

n- refractive index

v- speed of light

λ- wavelength of the light

Example:- If the refractive index of water is a 4/3 and the angle of incidence is 30^0 find

a) The speed of light in water
b) The angle of refraction

Gove:- n_2= n of water 4/3 $V_1=3x10^8$m/s =speed & light in air

$n_1 = 1$ n of air

Solution a) $\frac{n_2}{n_1} = \frac{v_1}{v_2} \Rightarrow$ $V_2 = V_1 (\frac{n_1}{n_2}) =$

$V_2 = 3x10^8 m/s(\frac{1}{\frac{4}{3}}) = ¾ * 3x10^8 m/s = 2.25x10^8 m/s$

B) $\theta i = 30^0$ $\frac{n_2}{n_1} = \frac{\sin\theta 1}{sin\theta 1} = \frac{\frac{4}{3}}{1} = \frac{\sin 30^3}{\sin_r}$

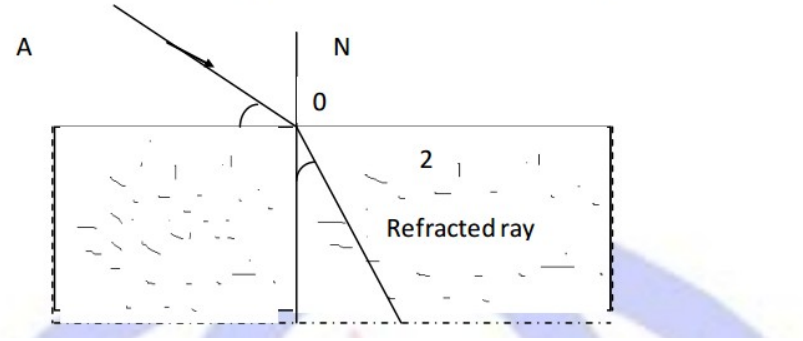
$sin\theta_r = \frac{\sin 30^3}{4/3} = \frac{\frac{1}{2}}{4/3}$ = ½ x ¾ = 3/8 = 0,375

$\theta_r = \sin - (0{,}375) = 22^0$

Lateral displacement: - the per perpendicular distance between the path way of the incident light ray and the one that energies after reflection from two surfaces of a medium

Fig 6:40 **Lateral displacement**

When a ray of light traveling in one transparent medium enters another different transparent medium, its direction is suddenly changed at the surface separating the two medium. The change in the direction of the light is known as refraction of light.



reflected ray

Lateral displacement

Apparent depth

Refraction causes an object submerged in a liquid of light index of retraction to appear closer to the surface than it actually is. We call the depth apparent depth.

n= real depth =D/d n_1

Apparent depth n_2 ***D***

$$\frac{\sin\theta^0}{\sin\theta^r} = \frac{n_1}{n_2} = \frac{d}{D}$$

o

Example: a loin rests on the bottom of a container filled with water of n= 1.33 the apparent depth of the loin is 9cm. How deep is the container?

Son $\frac{n_1}{n_2} = \frac{d}{D} \Rightarrow$ D= $(\frac{n_2}{n_1})$d = 9cm x $(\frac{1.33}{1}$¿ = 12cm

- Total internal refraction to occur, two conditions must be full filled.
  1. Light must travel from denser medium such as water or glass in to less dense medium such as air
  2. The angle of incidence must be greater than the critical angle (θc) is the angle of incidence for which the angle of refraction is 90^0

$$\frac{\sin_1}{\sin_r} = \frac{n_2}{n_1} \Rightarrow \frac{\sin\theta^0}{\sin 90^0} = \frac{n_2}{n_1} \quad \sin 90^0 = 1$$

Convex and concave lenses

Convex (converging) lensi is thicker at its centre than at its edges and converges parallel light rays and hence it is called converging lens.

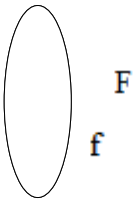
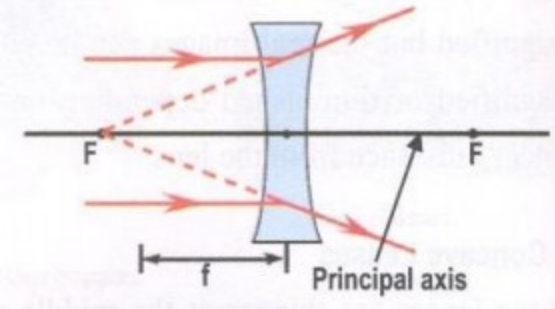


Fig* concave lens

Concave (diverging) lens is thicker

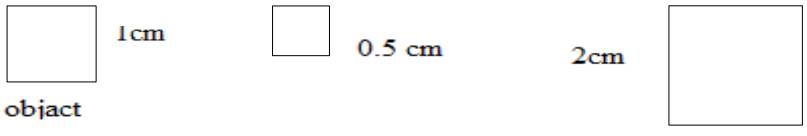
At its edges than at its center and diverges parallel light rays and hence it is called **diverging lens**.



The power of a lens is the measure of the strength of the lens to converge or diverge light

$$\text{Power of lens} = \frac{1}{focal\,length} = 1/f$$

Magnification this is just a number the number of times the image is larger than the object a magnification of less than 1 means that the image is smaller.



Magnification =0.5 magnification =2

The thin lens formula ⇒

Where $\boxed{\frac{1}{so} + \frac{1}{si} =}$

f- focal length of the lens

S_o- the object from the object to the centre of the lens

S_i – the distance from the centre of the lens to where the image is formed

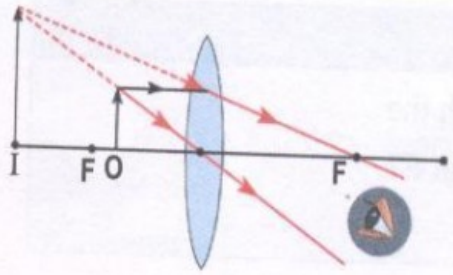
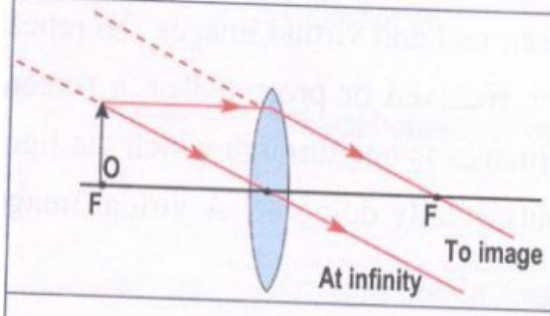
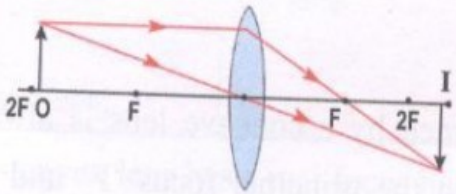
Magnification = $\frac{Si}{So}$

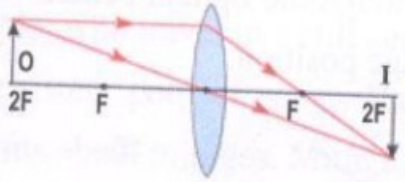
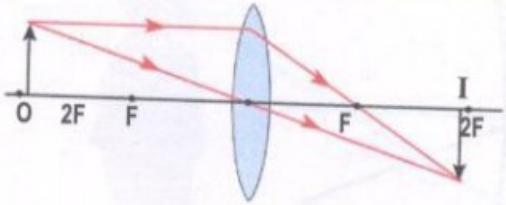
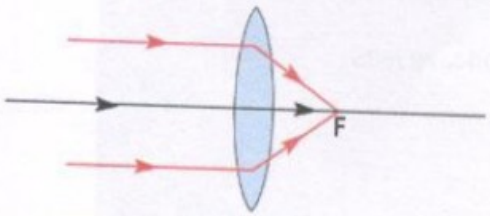
Example An object is placed 40cm from a converging lens of focal length 20cm where will the image be formed and what is its magnification?

Son. So= 40cm = 0.4m f=20m=0.2m

$\frac{1}{so} + \frac{1}{f} \Rightarrow \frac{1}{0.2} = \frac{1}{0.2} = \frac{1}{0.4} + \frac{1}{si} \Rightarrow \frac{1}{si} = -\frac{1}{0.4} + \frac{1}{0.4} \frac{1}{0.2} = 5\text{-}2.5$

So $\frac{1}{si}$ = 2.5cm ⇒ Si = $\frac{1}{2.5}$ = 0.4m

	Object Between Lens and F	The image is 1. Behind the object 2. Virtual 3. Erect 4. Larger than the object
	Object at F	No image is formed the image is at infinity
	Object Between F and 2 F	The image is 1. Behind 2F 2. Real 3. Inverted 4. Larger than the object

	Object at 2F	The image is 1. At 2 F 2. Real 3. Inverted 4. Same size as object
	Object beyond 2F	The image is 1. Between F and 2F 2. Real 3. Inverted 4. Smaller than the object
	Object at infinity (Very Far)	The image is 1. At F 2. It is a point image.

Finding the position and nature of an image formed by a convex and concave lens

Example:- An object 4cm high is located 10cm from a converging iens of focal length 20cm what is the nature, size and location of the image?

Given Lo=4cm So=10cm f=20cm Si =? Hi=?

Sol n $\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \Rightarrow \frac{1}{v} = \frac{1}{f} - \frac{1}{si} \Rightarrow \frac{1}{u} = \frac{1}{20} - \frac{1}{10}$ ¿ $\frac{1-2}{20}$ = - 1/20

V=-20cm, virtual

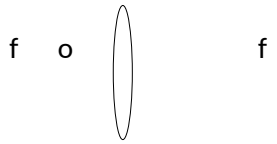
$\frac{hi}{ho} = \frac{-v}{u} \Rightarrow$ hi =ho ($\frac{-v}{u}$)= - 4cm ($\frac{-20\,cm}{10\,cm}$ + $8\,cm$, evect

The simple microscope:- is a magnifying glass. If the object lies between the focus of the lens and the lens itself, the light comes out diverging see fig 6.65, No real image will be formed. If you place your eyes as shown, however, you should see something a virtual image, the image you see is the right way up and enlarged.

I o

Fig 6.65 you will see a virtual image at

fig 6.67 the image you see is upright enlarged and further back than the object



The telescope

A telescope is designed for seeing more detail in an object that is a long distance a way.

The Human eye:- The eye is basically a converging lens made of living tissue, and forms an inverted image on the retina the normal human eye can focus objects comfortable form about 25ccm to infinity and it may be defected for many reasons

Defects of vision and their corrections

Common defects of the eye are the following

A) **Short sight (myopia**): A short sighted person can only see nearby objects clearly

- This defect is corrected bn placing a diverging lens inform of the eye.

B, long sight (Hyper metropia)

- A long sighted person can only see distant objects clearly the defect is corrected by spectacles of covering lens

C, Old sight (presbyopia) :- is the inability of the eye to focus as people get a get. It can b corrected by two pair spectacles, diverging and covering.

D, Astigmatism:- it is caused when the eye has two different focal lengths, the remedy is a pair of spectacles fitted with cylindrical lenses.

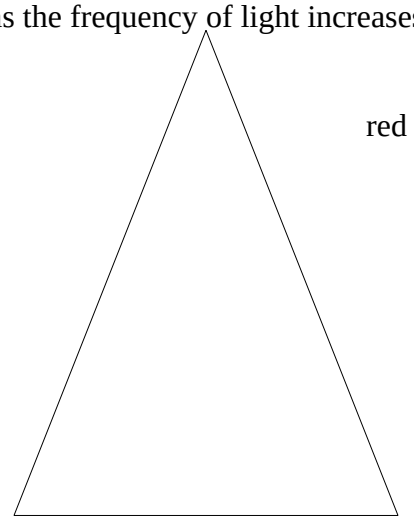
Diffraction of light

Diffraction of light (or any type of wave) is a change in direction that happens as the waves move through or round obstacle

Dispersion of light

Dispersion:- is the process of splitting white into components by refracting it through prism.

As white light pass through a prism, seven colures are seen on a screen. The frequency increases from red to violet, and at the same time the wavelength decreases the refractive index of the prism increases as the frequency of light increases.



red

orange

yellow

green

blue

indigo

Dispersion **violet**

Summery

- Electromagnetic waves are produced when electric fields and magnetic fields are at right angles to each other
- Electromagnetic waves emitted by the sun have a wide continuous range of frequencies(and wavelengths) this is called the electromagnetic spectrum.
- X- rays are used to take pictures of inside the body to show any bone fractures, they are absorbed more by bone (which is denser than the surrounding muscles)
- Micro-waves are radio waves are used for communications for example, radio and telephone signals
- Rectilinear propagation of light simply means that light travels in straight lines
- The law of reflection are
    - The angle of reflection is equal to the angle of incidence
    - The reflected ray lies in the plane which contains the incident ray and the normal
- Real images can be focused on a screen: virtual images cannot be focused on a screen.
- When using the mirror equation, virtual images have a negative sign
- Refraction is the change in the direction of travel of a light beam that occurs as the light crosses the boundary between one transparent medium and another.
- The refractive index of a material is n= $\frac{sin\theta i}{\sin \theta i} = \frac{real\, dept\, h}{apparant\, dept\, h}$
- The critical angle θc is the angle of incidence in a dense medium when the angle of refraction in a less dense medium is 90^0
- Total internal reflection occurs when the angle of incidence is more than the critical angle
- Total internal reflection is used in optical fibers because the light is trapped within the cable as shown in

fig 6.83 l

Work sheet

1. A water wave gas wavelength of 2cm and a frequency of 15Hz find its speed
2. A radar wave is transmitted and latter reflected off an aircraft, and received $1.2x10^{3}$see after being sent out how far is the air craft?
3. A candle 6cm high is located 60cm from a concave mirror whose focal length is 20cm. find the position, nature and size of the image.
4. What is the frequency of an x-ray with a wavelength of $1x10^{-10}$m?
5. A light bulb is placed in front of a concave mirror of focal length 3.6cm. If the image is formed at the same location as the object with respect to the mirror, find the object distance.
6. Determine the focal length of a convexes mirror which produces an image that is 10cm behind the mirror when the object is located at a distance of 35 cm from the mirror
7. A ray of light in air is approaching the boundary with a layer of crown glass at an angle of 42^{0} Determine the angle of refraction of the light ray upon entering and leaving the crown glass (n=1.52) the two faces are parallel as shown in Fig 6.40 above.

42^{0} Boundary -1

Boundary -2

θ_r

8. The speed of light in a certain substance is $1.5x10^{8}$m/s. determine the index of refraction of the material
9. A light of wavelength 640nm passes from air into glass of index of refraction 1.5.what is the wavelength of the light.