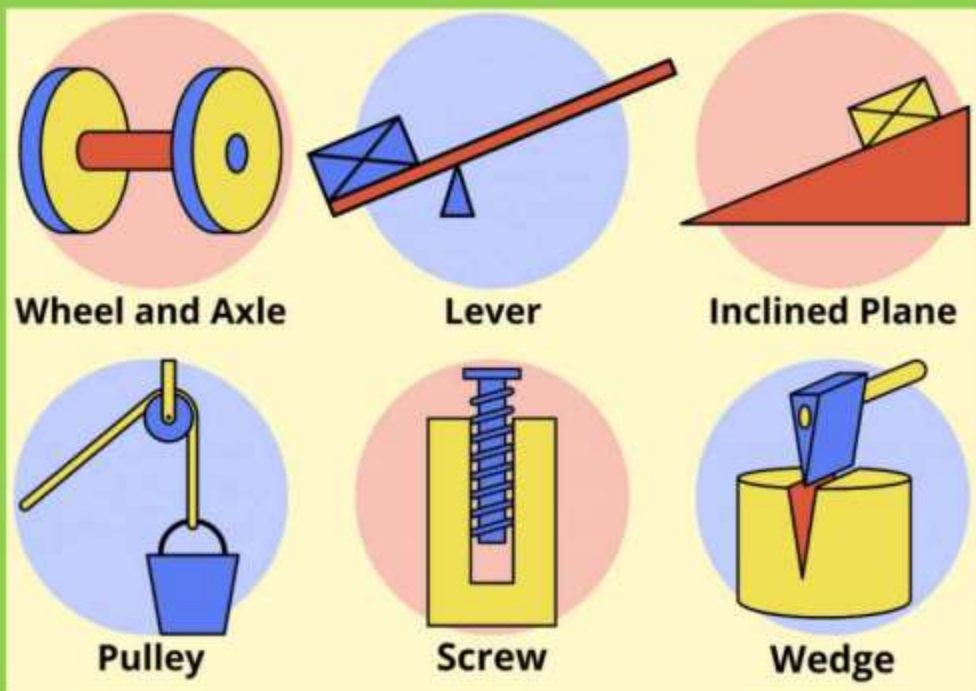
Simple Machine



Physics Short Note

Grade 9

Set by: Girma Hailu (subject teacher)

Unit-5: Simple Machines

A machine is a device that helps make work easier to perform by accomplishing one or more of the following functions:

- transferring a force from one place to another,
- changing the direction of a force,
- increasing the magnitude of a force, or
- increasing the distance or speed of a force.

However, a machine can not multiply both force and speed at the same time.

Important terms

Load (F_L)-is the force applied on the machine

Effort(F_E)- is the force applied to a machine

Work input (W_{in})-is the products of effort and distance moved by effort.

Work output (W_{out})-is the products of load and distance moved by load.

If there were no energy losses inside our machine, then;

Work input (W_{in})= Work output (W_{out})

$$F_e s_e = F_l s_l$$

$$\frac{F_e}{F_l} = \frac{s_l}{s_e}$$

If $s_e < s_l$, then $F_e > F_l$ (machine is speed multiplier)

If $s_e > s_l$, then $F_e < F_l$ (machine is force multiplier)

Actual mechanical advantage (AMA)-is the ratio of load and effort, taking into account energy loss due to friction etc.

$$AMA = \frac{Load}{Effort}$$

Ideal mechanical advantage (IMA)-is the ratio of load and effort, assuming no energy loss due to friction etc.

$IMA = \frac{Load}{Effort}$

Velocity ratio (VR)-is the ratio b/n the distance moved by the effort and distance moved by the load.

$$VR = \frac{s_e}{s_l}$$

Efficiency (γ)- of a machine: Is the ratio between work output and work input

$$\gamma = \frac{W_o}{W_{in}} = \frac{F_l s_l}{F_e s_e} = (\frac{F_l}{F_e})(\frac{s_l}{s_e})$$

$$\gamma = (\frac{F_l}{F_e})\frac{1}{\frac{s_e}{s_l}}) = (MA)(\frac{1}{VR}) = (\frac{MA}{VR})*100\%$$

$$\gamma = \frac{MA}{VR}*100\%$$

Example:

1. If a certain machine lift a 200N load of 8cm when the effort of 40N moves a distance of 102cm.

Find: A) W_{out} B) W_{in} C) AMA d) VR e) γ

Simple Machines

Simple machine, refers to a machine that is, well, simple. This has alot of interpretations includes:

- ✓ A device that only requires a single force to do work.
- ✓ A device for doing work that has only one part
- ✓ A device that uses a single effort to do work against a single load force.

Different types of Simple machine

There are six different types of simple machines:

1. Inclined plane
2. Wedge
3. Screw
4. Lever
5. Wheel and axle
6. Pulley

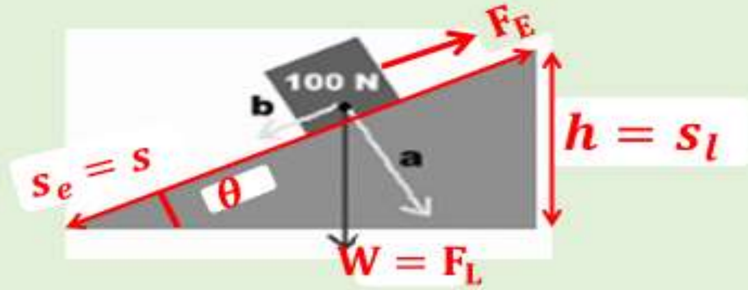
Two groups:
1. Inclined planes:
   - Ramp
   - Wedge
   - Screw
2. Levers:
   - Lever
   - Wheel & Axle
   - Pulley

1. Ramp or Inclined Plane-Both terms are used

- ➢ We can use this machine to move an object to a lower or higher place.
- ➢ It allows us to raise an object with less effort (less energy) than if we lifted it directly upward.

⟹It is a force multiplying machine.

Ramp or Inclined Plane



If the machine is used to raise up on smooth inclined plane with a uniform speed:

$$F_E - mg\sin\theta = 0$$

$$F_E = mg\sin\theta$$

$$F_L = mg$$

$$\Longrightarrow MA = IMA = \frac{F_L}{F_E} = \frac{mg}{(mg\sin\theta)} = \frac{1}{\sin\theta}$$

$$**VR = \frac{s_e}{s_l} = \frac{\frac{h}{\sin\theta}}{h} = \frac{1}{\sin\theta}$$

$$\eta = \frac{MA}{VR} * 100\%$$

$$\eta = \frac{\frac{1}{\sin\theta}}{\frac{1}{\sin\theta}} * 100\% = 100\% = 1$$

When there is friction:

The minimum force required to push the object up on the rough ramp is given by:

$$F_E - (mg\sin\theta \ + f) = 0$$

$$F_E = (mg\sin\theta \ + f)$$

$$F_L = mg \ \text{ and } F_E = \left(mg\sin\theta \ + f\right)$$

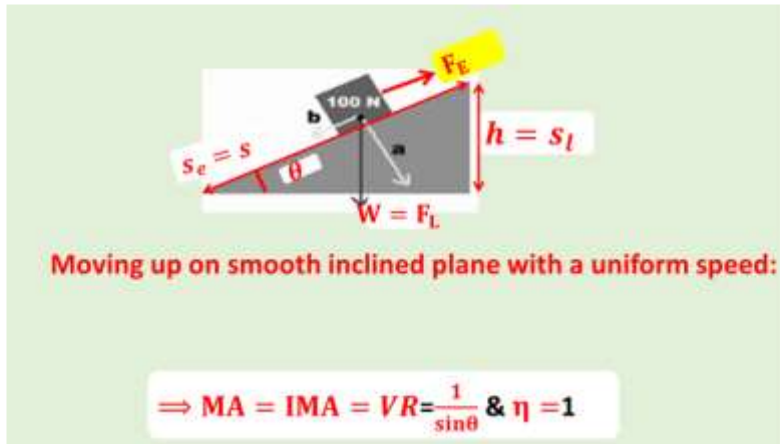
$$s_L = h \text{ and } s_E = \frac{h}{\sin\theta}$$

$$* \, MA = \frac{F_L}{F_E} = \frac{mg}{(mg\sin\theta + f)} = \frac{mg}{(mg\sin\theta + \mu mg\cos\theta)}$$

$$MA = \frac{1}{\left(\sin\theta \ + \mu\cos\theta\right)}$$

$$** VR = \frac{s_e}{s_l} = \frac{\frac{h}{\sin\theta}}{h} = \frac{1}{\sin\theta}$$

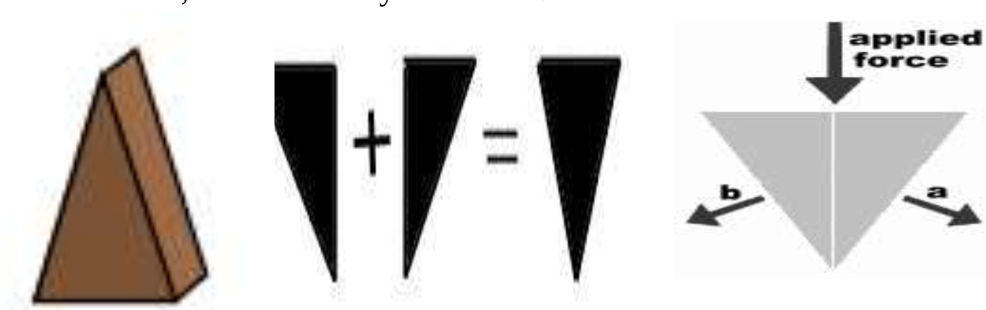
$$VR = \frac{1}{\sin\theta}$$



<u>Examples:</u>

1. A slop of length 50m rises to a height of 10m above the ground. An effort of 100N is needed to push a 250N object up on the ramp. Calculate:
   i. AMA ii. VR iii. efficiency
2. A 200N block is raised to a height of 10m above the ground on a rough inclined plane, which slopes at 53°. If the efficiency of this simple machine is 90%, calculate:
   i. Coefficients of friction
   ii. AMA
   iii. Energy converted to heat, sound or to any other form.

Wedge

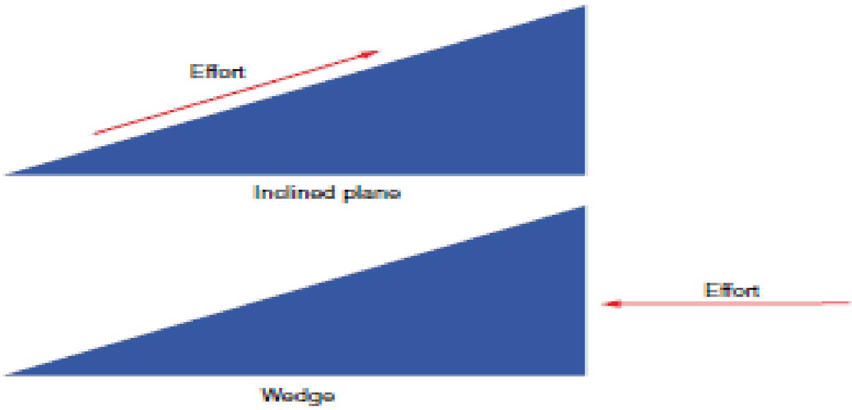


<u>Difference b/n wedge & inclined plane:</u>

**Instead of moving the resistance up an inclined plane, the inclined plane moves the resistance (load)

<u>Example</u>: A wedge consists of a pair of inclined planes set back-to-back make an angle of 15° with each other to separate a 30kg wood. If the efficiency of the wedge is 80%.

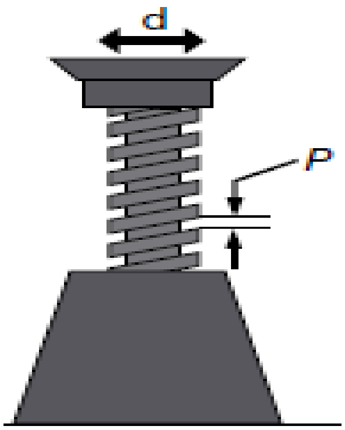
Find its: i. AMA ii. Effort
iii. Work out put iii. Work input



Example: A wedge consists of a pair of inclined planes set back-to-back make an angle of 15° with each other to separate a 30kg wood. If the efficiency of the wedge is 80%.
Find its: i. AMA ii. Effort

3. The Screw

Screw-is an inclined plane wrapped around a cylinder with a helical thread around it. Distance between each thread is known as Pitch (p) which is analogous to the height of the inclined plane.
It is used to hold objects together, to dig in to the ground and to bore through the rock.



Its IMA = VR $\Rightarrow \frac{L}{E} = \frac{\pi d}{p}$

where d-mean diameter of the screw

P-pitch

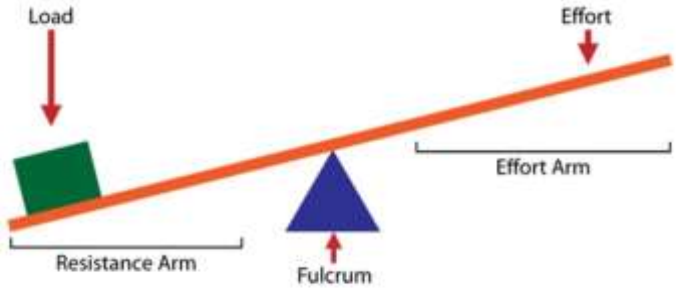
$$W_{in} = Lp \ \& \ W_{in} = Ed$$

Examples of Screws:

- Jar Lids
- Light Bulbs
- Stools
- Clamps
- Jacks
- Wrenches
- Spiral Staircase

Example: An effort of 60N applied on the screw with 1cm pitch. If the head thread of the screw is 4cm find its VR

4. Lever



Lever- A road or rigid bar that rotate about a fixed pivotal point (fulcrum).

- It can help to lift heavy things.
- It has four parts:
  1. Lever stick
  2. Fulcrum
  3. Load (L), and
  4. Effort (E)

- ✓ Position of the fulcrum can make lifting easier or harder.
- ✓ A lever is a board or bar that rests on a turning point
- ✓ fulcrum-turning point
- ✓ The load is a force or object which must be overcome by the lever
- ✓ The applied force or effort or input force is the force you use to move the lever
- ✓ By changing the position of the fulcrum, you can gain extra power with less effort
- ❖ Depending on where the fulcrum is located a lever can multiply either the force applied or the distance over which the force is applied

Three types of levers:

I. 1st class II. 2nd class and III. 3rd class

Common examples of first-class levers include crowbars, scissors, pliers, tin snips and seesaws.

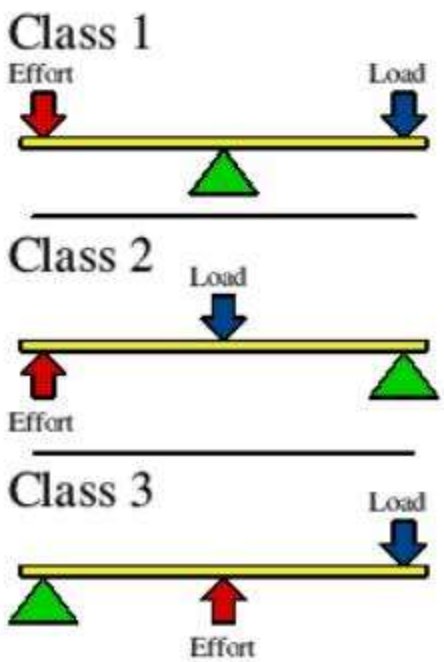
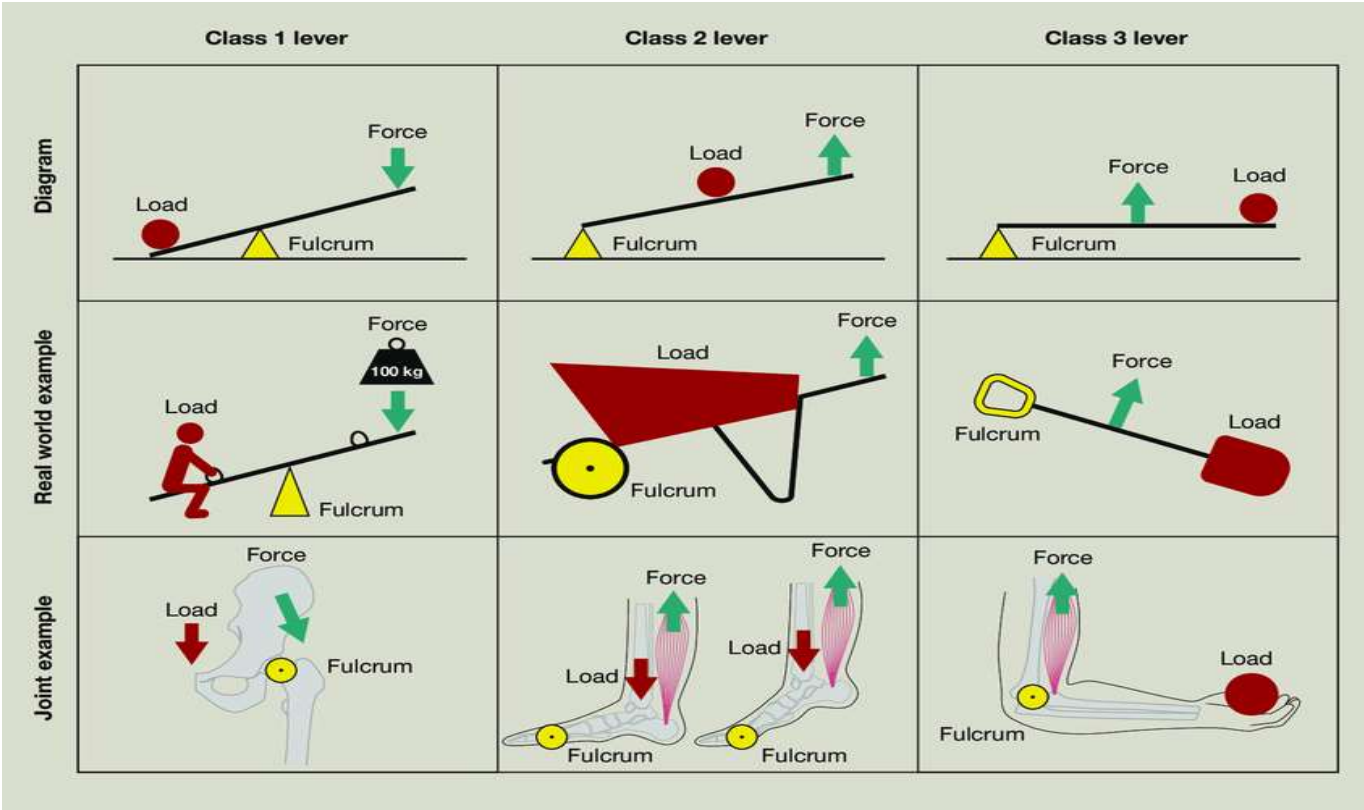
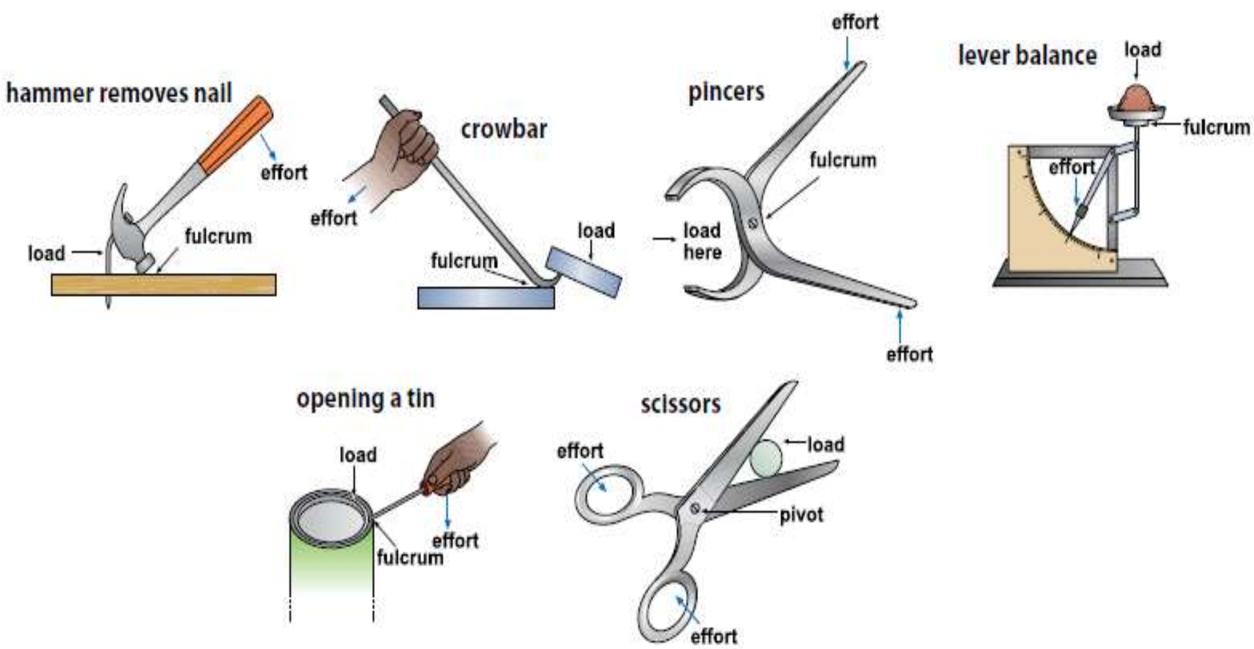


Table 5.1: Three types of levers



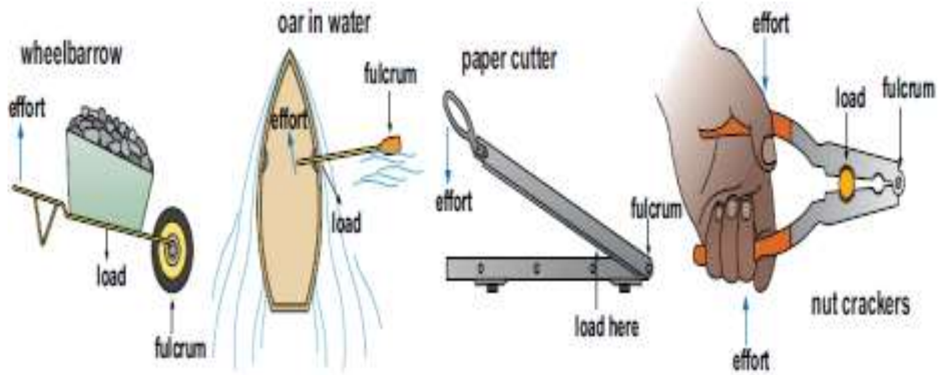


Pincers and scissors are double levers.

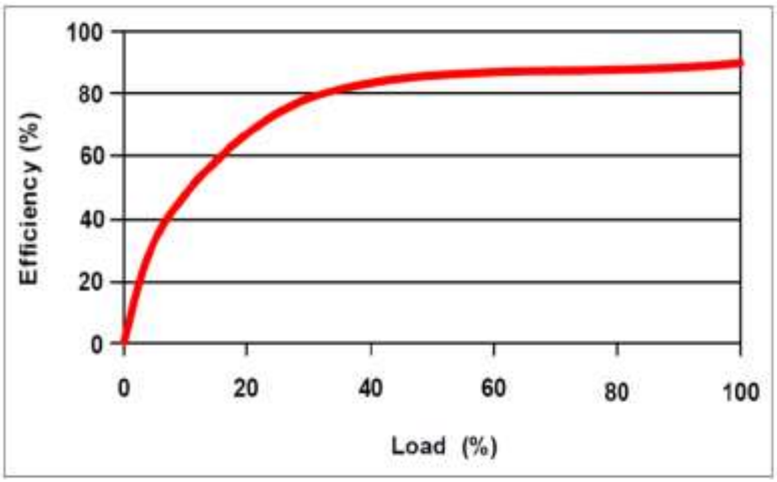
The load is in the center – between the fulcrum and the applied force or effort (E & L are positioned on the same side)

Causes the load to move in the same direction as the force you apply When the load is nearer to the fulcrum, the effort needed to lift the load will be less

If you want to a very large load with a small effort, you must put the load very close to the fulcrum



Note: practically efficiency of a given machine can not be greater than one or **100%** which means energy is created, which is not the case in nature

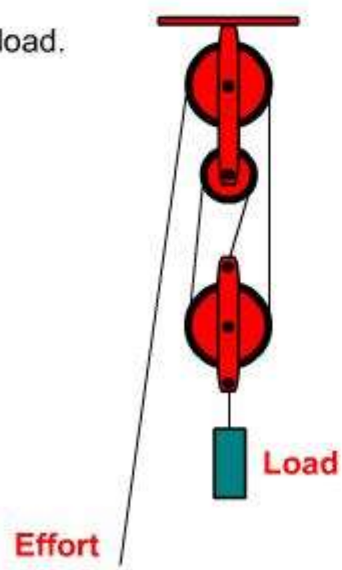


In the third example, three parts of the rope support the load. Each part supports one third of the load, therefore the mechanical advantage is 3.

$$\text{Mechanical advantage} = \frac{\text{Load}}{\text{Effort}}$$

$$\text{Velocity ratio} = \frac{\text{Distance moved by effort}}{\text{Distance moved by load}}$$

The effort force moves three times as far as the load, therefore the velocity ratio is 3.



Physics

Introduction to Basic Electronics

DRIVING THE FUTURE OF

Power Electronics Design

G-10

ODA SBS, Adama

Set by: Girma Hailu (subject teacher)

Unit-6

Introduction to Electronics

Electronics-deals with current conduction through a Vacuum or Gas or Semiconductor or it deals with electrical circuits that involve active electrical components such as vacuum tubes, transistors, diodes and integrated circuits, and associated passive interconnection technologies (resistors, capacitors, inductors)

A plasma is a gaseous collection of ions, electrons, energetically excited molecules, and neutral gas species, normally created by the application of electromagnetic fields.

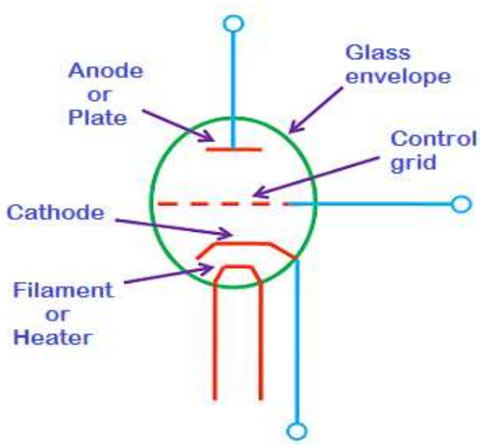
Vacuum tubes- are devices used in machines to a variety of tasks such as:

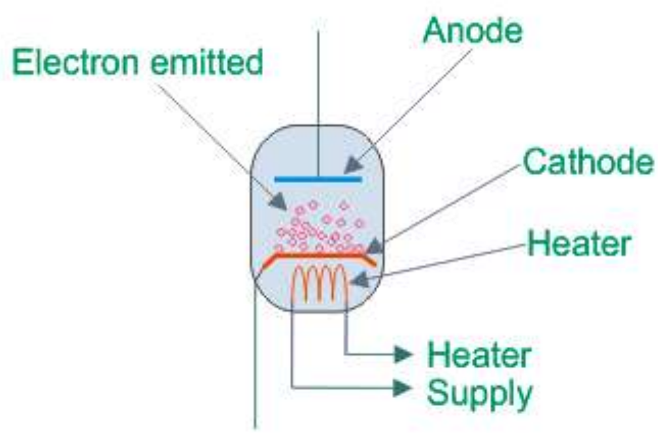
- To amplify current or voltage
- For switching purpose
- To modify or generate electrical signals in lower pressure space.

Thermionic valves (vacuum tubes)

Consist the following main components-

i. Cathode.
ii. Anode also known as the plate.
iii. Control Grid - a regulator for the current flowing Cathode to Anode.
iv. Filament (the heater).





Thermionic emission-the process of electron emission from a metal surface by supplying thermal energy to it or escape of electrons from heated metal surface.

Space charge-negatively charged cloud of electrons emitted form cathode.

Factors affecting Thermionic emissions:

1-Surface area of the metal
2-Temperature of the cathode
3-Types of metals

Thermionic emission - is a process of emission of charge particle (known as thermion) from the surface of a heated metal. The charge particles normally are electrons.

The rate of emission (number of electrons emitted in 1 second) is affected by 4 factors:

1. the temperature of the heated metal, When the temperature of the metal increase, the emission rate of electron will increase.
2. the surface area of the heated metal, When the surface area of the metal increase, the emission rate of electron will increase.

3. the types of metal The rates of thermionic emission are different with regard to different types of metals.
4. the coated material on the surface of the metal. If the surface is coated by a layer of barium oxide or strontium oxide, the rate of emission will become higher.

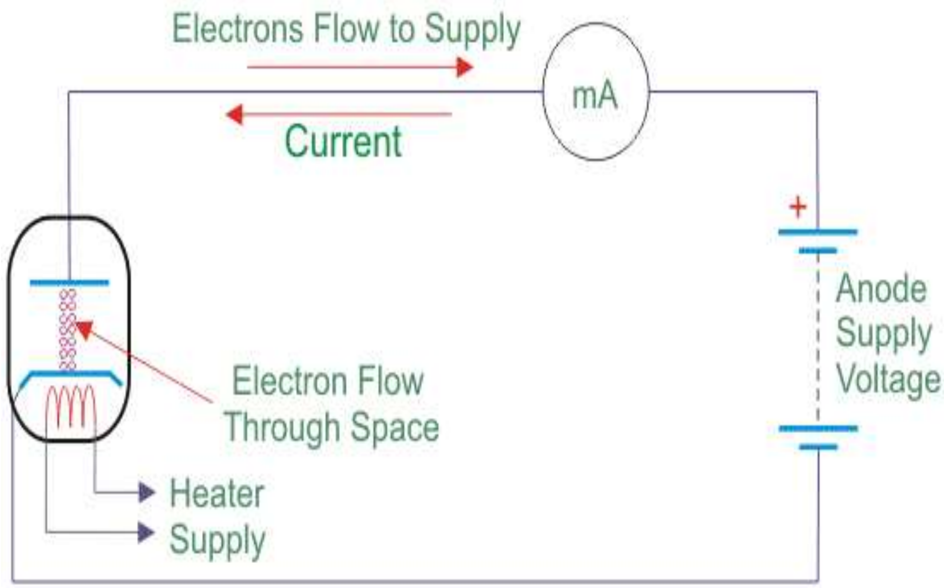
In thermionic emission- the electron emission is achieved by heating the electrode (cathode) to a sufficient temperature.

The higher the temperature, the greater is the emission of electrons.

The commonly used materials for electron emission are tungsten, metallic oxides of barium and strontium.

Work function (W_o): The amount of additional energy required to emit an electron from a metallic surface.

The W_o of pure metals varies (roughly) from 2eV to 6eV. Its value depends upon the nature of the metal, its purity and the conditions of the surface.



Methods of heating diode valves:

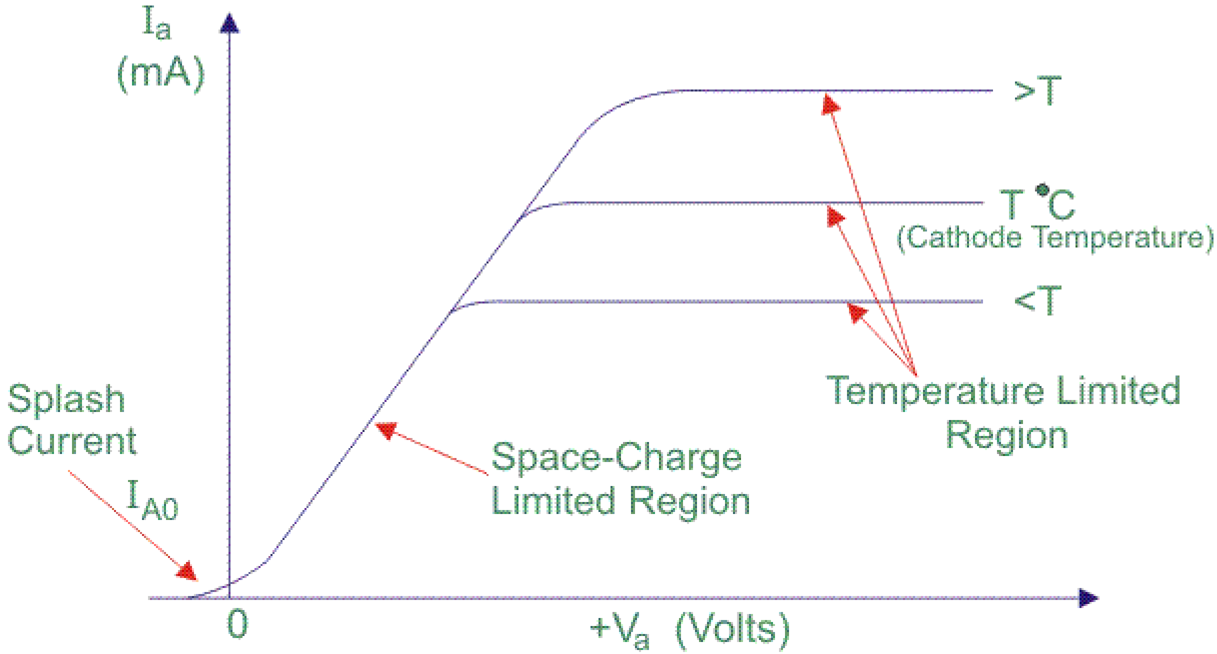
1. **Direct heating-** tungsten wire serves as both the heater and the cathode from which electrons escape.
2. **Indirect heating-**the heater and cathode are separate. In this method we use tungsten wire has heater and coated nickel with oxides, barium or strontium are used as emitter.

Heater voltage – p.d. applied across the heating element.

Anode voltage – p.d. b/n the anode and cathode

Anode current – current which flows through the diode. It depends on the p.d. b/n anode and cathode.

Anode current-anode voltage



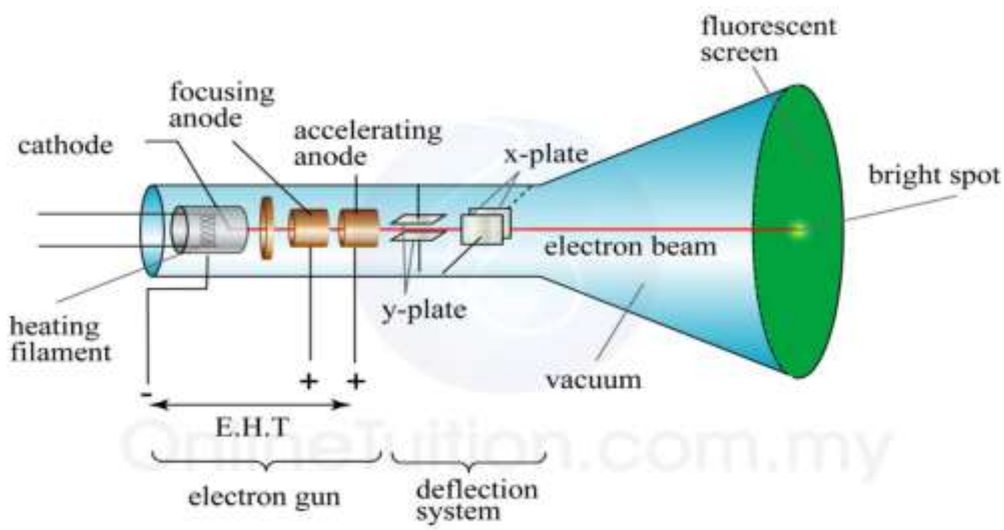
I-V Characteristics of Vacuum Diode under forward bias

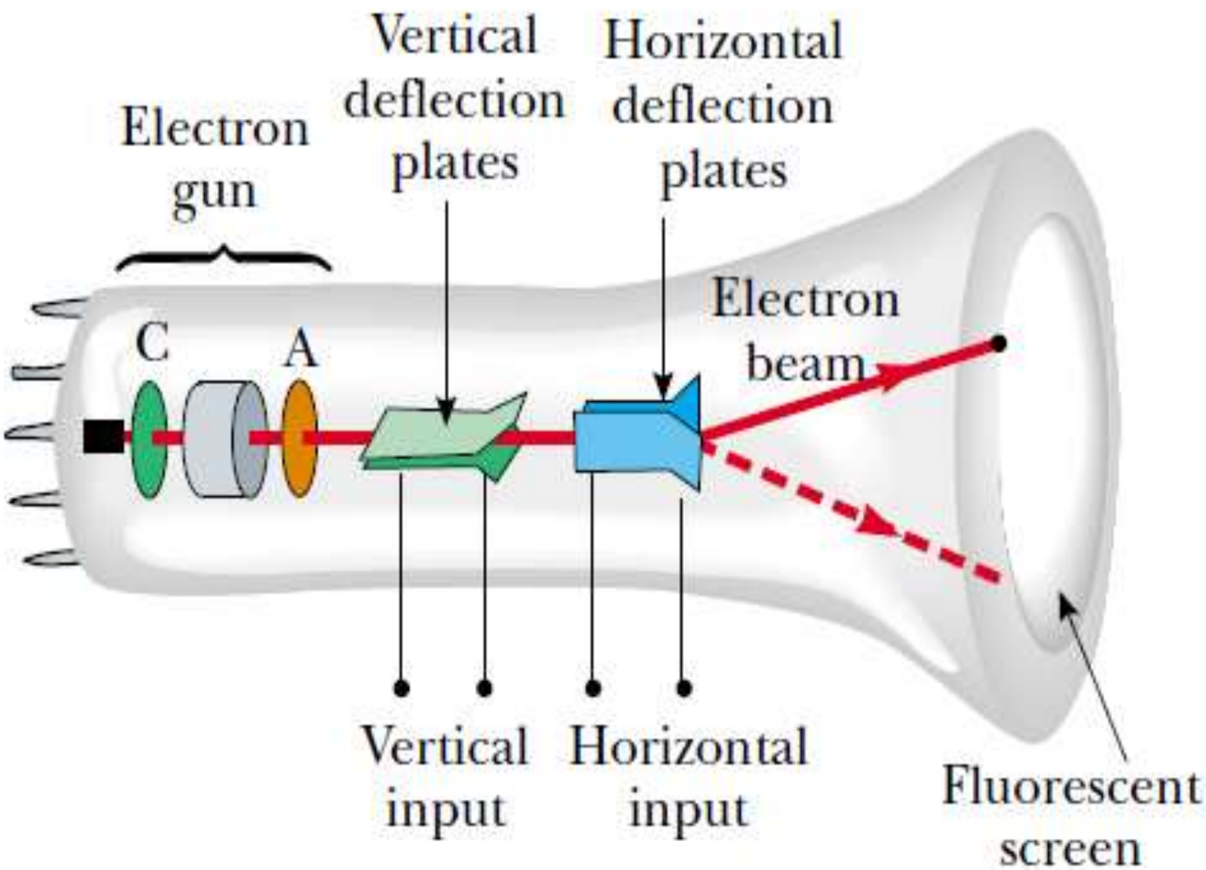
Saturation current – the maximum anode current at temperature limited region

Cathode Ray Oscilloscope (CRO)

CRO- is an instrument which displays electrical signals. CRT is the heart of the CRO. A cathode ray oscilloscope has three main parts:

- Electron gun
- The deflecting system and
- The fluorescent screen





Parts of electron gun: provide a stream of electrons.

- Cathode- sources of electron
- Anode – accelerate electrons along the highly evacuated tube an focus them in to a narrow beam
- Heater – heating up the cathode
- Grid- control space charges

Deflecting part: control the path of the electron beam.

X-Plates - control the left to right motion of the beam (oriented vertically)

y-Plates - control the up-and –down motion of the beam (oriented horizontally)

The fluorescent screen:

1. The screen is coated with a phosphor (fluorescent salt, for example, zinc sulphide).
2. When the electrons hit the screen, it will cause the salt to produce a flash of light and hence a bright spot on the screen.

Some uses of CRO

CRO - convert electrical energy into a graphic image, called the trace. The heart of the device is a vacuum tube with a screen like a TV. When an alternating current (AC) is applied to the CRO inputs, it shows up as a simple wave form on the screen.

1. To measure DC voltage- by connecting the source of unknown DC at the y-plate of the CRO we read the location of the of the spot displaced from the reference point.
2. To measure distance – when a time base potential is applied across the x-plate of CRO the spot on the screen the device change dot in to line and read the distance

3. To measure AC voltage, frequency or period- when any rapidly varying voltage applied across the y-plate of a given CRO and the time is switched, a sinusoidal curve will be observed on the screen and enable us to measure the frequency and period of the signal

Application of Electronic:

i. Communication
ii. Information processing
iii. Medicine and research
iv. Automation

Communication: Electronic communication systems connect people around the world by Using telephones, Internet and computers.

Information processing: Computers solve difficult mathematical problems, maintain vast amounts of data, create complex simulations, and perform a multitude of other tasks that help people in their everyday lives.

Medicine and research: Include product like X-ray machines ECG (Electrocardiogram) use radiation to take images of bones and internal organs. Radiation therapy, or radiotherapy, uses X-rays and other forms of radiation to fight cancer.

Electron microscopes use electrons rather than visible light to magnify specimens 1 million times or more.

Automation:

Electronic components enable many common home appliances, such as refrigerators, washing machines etc. to function smoothly and efficiently.

Microwave ovens heat food quickly by penetrating it with short radio waves produced by a vacuum tube.

Many automobiles have electronic controls in their engines and fuel systems.

TV picture tube

The older sort of television, with the big heavy tube, is similar to the CRO. The receiver sends currents through coils that are mounted just outside the tube; their magnetic fields deflect the spot of light on the screen so it moves rapidly to trace an ordered path all over the screen.

Insulators, Conductors, and semiconductors

Conduction electrons- free electrons which are responsible for the conduction of current in a conductor

Insulators-materials that block flow of electrons (e.g., rubber, glass, Teflon, mica, etc.). Insulators have empty conduction band.

conductors - materials that permit flow of electrons (e.g., gold, silver, copper, etc.).

***semiconductors**-materials whose conductivity falls between those of conductors and insulators. (e.g., silicon (Si), Germanium (Ge), etc.). They conduct electricity when they are heated or doped. Unlike conductors, increasing temperature in semiconductors increases conductivity.

Semiconductors - form the backbone of electronics. Semiconductors - affect all walks of life, starting from communication, computers, medicine, power, to aviation, defenses and entertainment. The transistors, integrated circuits, lasers, detectors, sensors and other semiconductor devices affect our daily life.

Semiconductor – is a material that has a conductivity level some where between that of conductor and insulators.

Types of semiconductor

i. **Intrinsic (pure) semiconductor**-a semiconductor in an extremely pure form and not containing any dopant

When electric field is applied (p.d.) across an intrinsic semiconductor, the current conduction takes place by two processes, namely; by free electrons and holes.

When semiconductor are heated, free electrons are produced due to the breaking up of some covalent bonds by thermal energy and holes are created in the covalent bonds.

⇒conduction in intrinsic semiconductor is through both free electrons and holes (total current inside the semiconductor is the sum of currents due to free electrons and holes).

ii. Extrinsic (impure) semiconductor: is s.c. doped by addition of small amount impurity (pentavalent & trivalent elements) which is able to change its electrical properties (conduction), making it suitable for electronic applications (diodes, transistors, etc.).

The process of adding impurities to a semiconductor is known as doping. Depending upon the type of impurity added, extrinsic semiconductors are classified into:

i. n-type semiconductor
ii. p-type semiconductor

i. n-type semiconductor

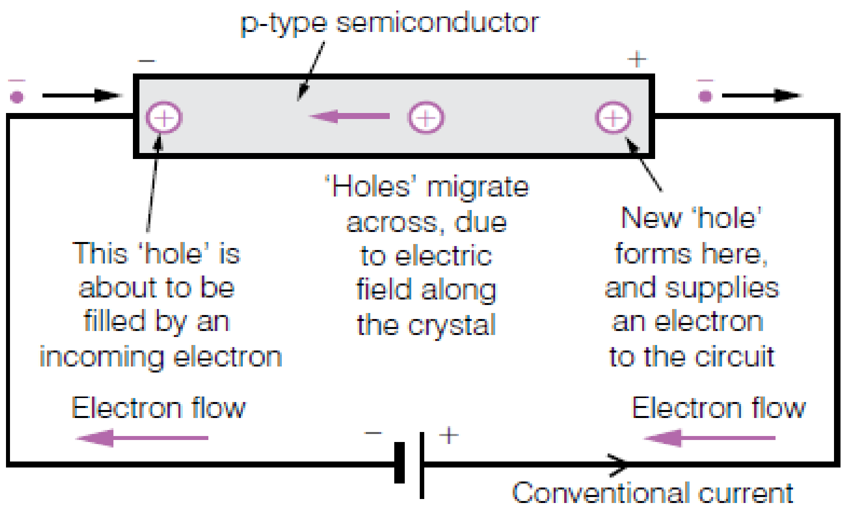
Doping pentavalent impurity provides a large number of free electrons in the semiconductor crystal. Typical examples of pentavalent impurities are arsenic, antimony, Bismuth and Phosphorous etc. Such impurities which produce n-type semiconductor are known as donor impurities because they donate or provide free electrons to the semiconductor crystal.

Electrons are said to be the majority carriers whereas holes are the minority carriers .

ii. p-type Semiconductor:

When a small amount of trivalent impurity is added to a pure semiconductor, it is called p-type Semiconductor.

Doping trivalent impurity provides a large number of holes in p-type. Typical examples of trivalent impurities are gallium , indium, boron etc. They are known as acceptor impurities because the holes created can accept the electrons



Electrons are said to be the minority carriers whereas holes are the majority carriers.

Difference between N-type and P-type extrinsic semiconductors

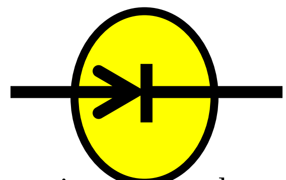
S. No	N-type	P-type
1.	It is donor type	It is acceptor type
2.	Impurity atom is pentavalent	Impurity atom is trivalent
3.	Donor level lies close to the bottom of the conduction band	Acceptor level lies close to the top of the valence band.
4.	Electrons are the majority carriers and holes are the minority carriers	Holes are the majority carriers and electrons are the minority carriers.

<u>Semiconductor Diodes</u>

<u>Diodes</u>: are electronic circuit elements from two or more p-type and n-type and used for rectification.

<u>Rectification</u>: the process of changing Ac to DC in electronic circuit.

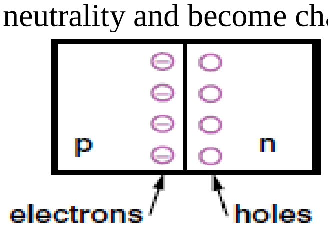
Symbol: **The arrow indicate the direction in which the diode conducts current

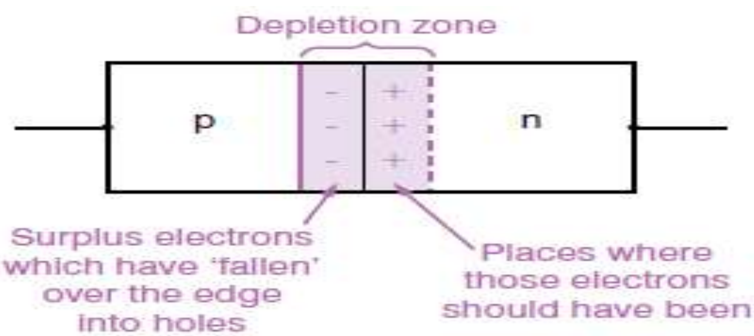


<u>The p-N junction diode</u>

**p–n junctions are elementary "building blocks" of most semiconductor electronic devices such as diodes, transistors, solar cells, LEDs, and integrated circuits formed by joining together n-type and p-type semiconductors.

After joining p-type and n-type semiconductors, electrons from the n region near the p–n interface tend to diffuse into the p region. The regions nearby the p–n interfaces lose their neutrality and become cha





Barrier potential in P-N ju ty
carriers across the junctior

<u>Forward & Reverse bias & V-I characteristics of PN junction Diode</u>

Biasing of Diode: The process of applying an external voltage is called as “biasing”.

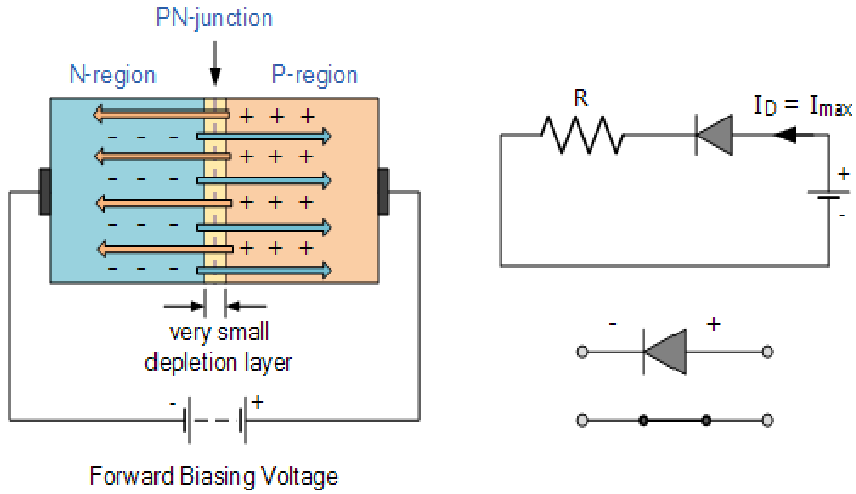
Forward Bias mode is the condition in which negative voltage is applied to the n-type material and a positive voltage is applied to the p-type material.

If this external voltage becomes greater than the value of the potential barrier, approx. 0.7 volts for silicon and 0.3 volts for germanium, the potential barriers opposition will be overcome and current will start to flow.

The application of a forward biasing voltage on the junction diode results:

- the depletion layer becoming very thin, narrow and allowing high currents to flow.

➢ The point at which this sudden increase in current takes place is represented on the static I-V characteristics curve above as the "knee" point.



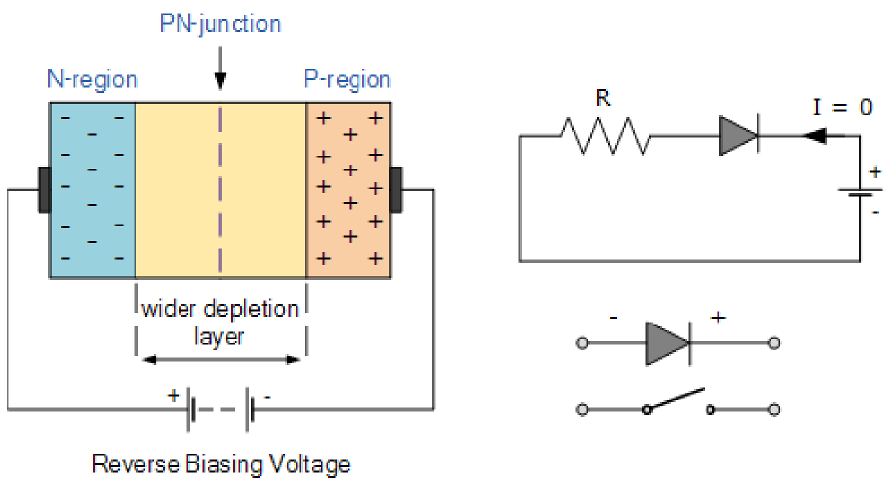
B. **Reverse Biased PN Junction Diode**- a positive voltage is applied to the N-type material and a negative voltage is applied to the P-type material. The positive voltage applied to the N-type material attracts electrons towards the positive electrode and away from the junction, while the holes in the P-type end are also attracted away from the junction towards the negative electrode.

In a Reverse Bias condition:

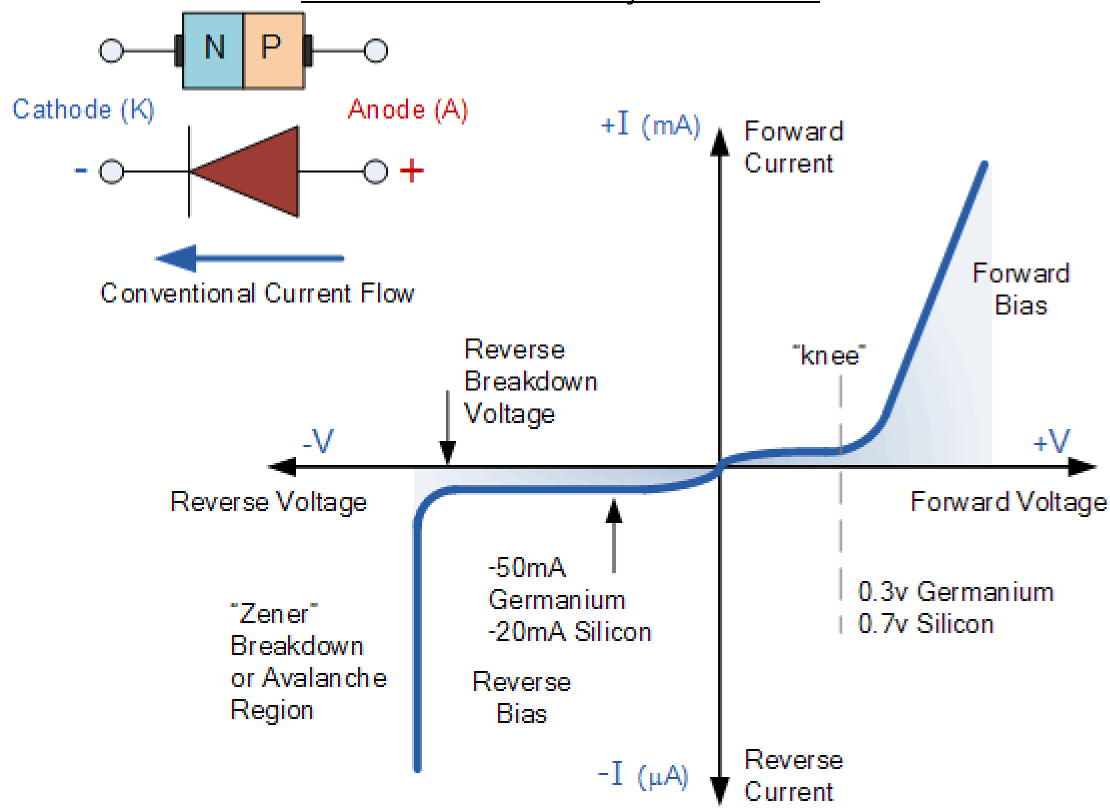
⇒ wider depletion layer

⇒ High potential barrier

⇒ very small leakage current flow through the junction(μA)



<u>V-I characteristics of PN junction Diode</u>

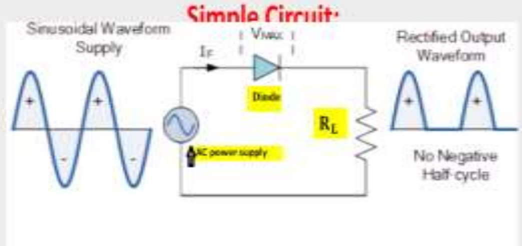


Types of Rectifier :

A. Half Wave Rectifier

In this type the rectifier conducts current only during the +ve half cycles of the A.C. supply.

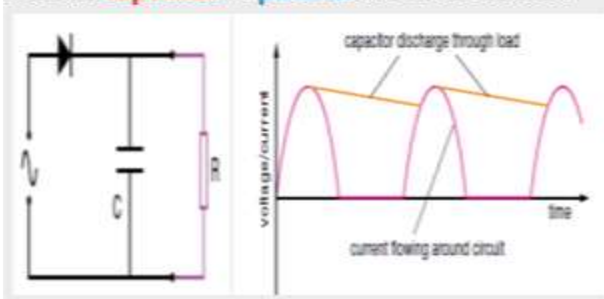
Simple Circuit:



During –ve half cycle no current passes through the diode hence no voltage appears across the load.

Using a diode and a capacitor

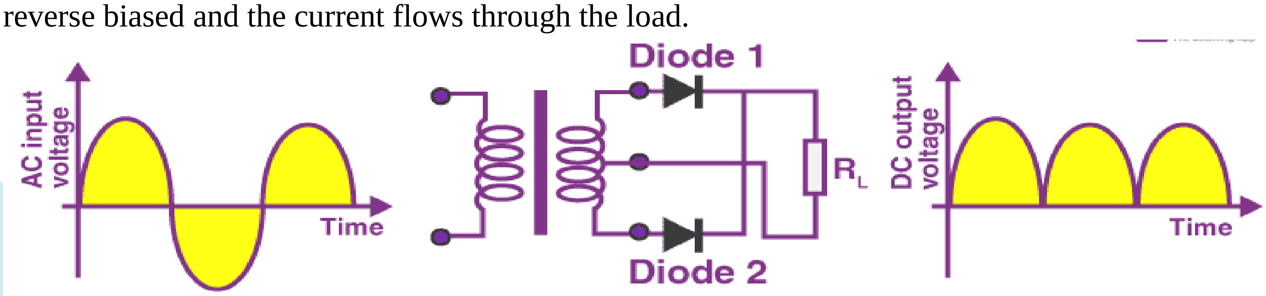
When we use only diodes the out put voltage is not smooth (it varies b/n zero and maximum). To smooth the out put voltage of our rectifiers we use capacitor in parallel with the resistor.



Full Wave Rectifier:

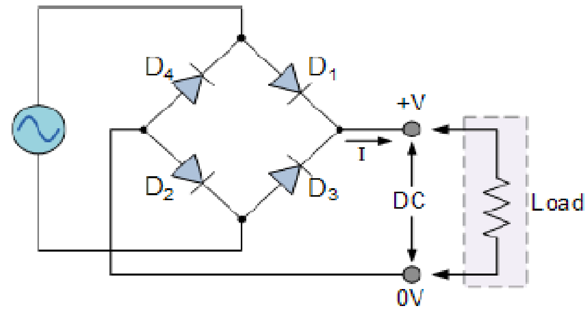
In this type , the rectifier utilizes both half cycles of A.C. input voltage to produce the D.C. output. During the positive half cycle of the supply, diode D_1 conducts , while diode D_2 is reverse biased and the current flows through the load.

Similarly, during the negative half cycle of the supply, diode D_2 conducts , while diode D_1 is reverse biased and the current flows through the load.

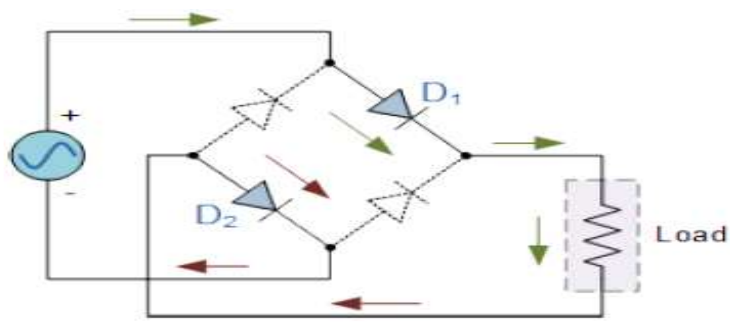


Full Wave Rectification Using 4 Diodes

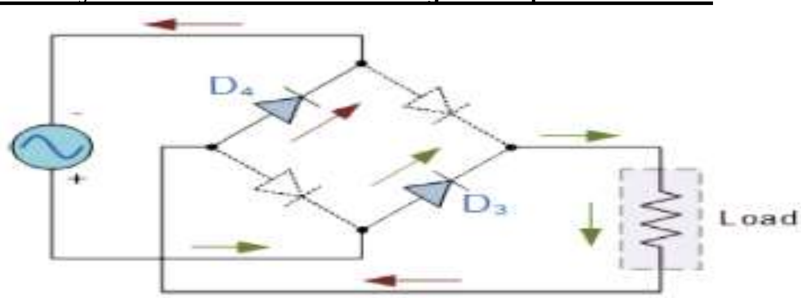
***An arrangement made from four diodes in full wave rectification is known as a bridge rectifier.



The Positive Half-cycle Rectification when D_1 and D_2 are forward



The Positive Half-cycle Rectification when D_3 and D_4 are forward

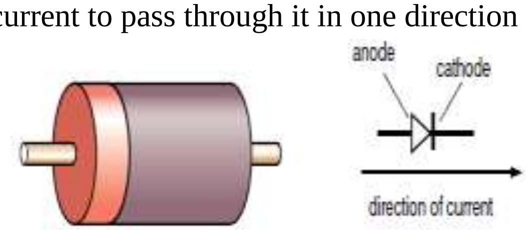


During the negative half cycle of the supply, diodes D3 and D4 conduct in series, but diodes D1 and D2 switch "OFF" as they are now reverse biased. The current flowing through the load is the same direction as before.

Some semiconductor devices

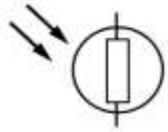
1. **Diode**

A diode is an electronic component with two electrodes – an anode and a cathode – which will only allow electric current to pass through it in one direction

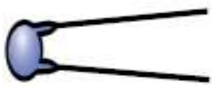


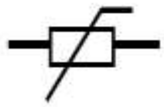
2. LDR

2. **A light-dependent resistor (LDR for short)** conducts electricity, but in the dark it has a very high resistance. The brighter the light, the better it conducts.

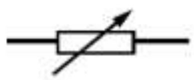


3. **<u>Thermistor</u>**-change heat energy to electrical energy depending on temperature of its surrounding. It has a high resistance in the cold. Its resistance drops as it becomes warmer.



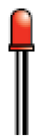


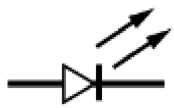
4. **<u>Variable resistor</u>**-it is an electronic semiconductor device whose resistance change with temperature.

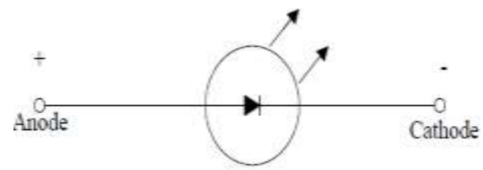


5. **<u>LED</u>**

   Light emitting electronic devices: ones that generate electromagnetic energy under the action of electrical field

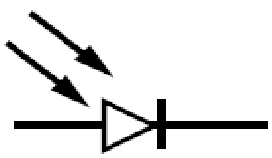






LED symbol

6. **<u>Photodiode</u>**: is a semiconductor device that converts light into current. The current is generated when photons are absorbed in the photodiode.



7. **<u>Photovoltaic cell</u>**- is a form of photodiode.

   The base layer of a photovoltaic solar cell is made of p-type semiconductor material. This is covered with a layer of n-type semiconductor material. When light strikes the junction between n- and p-types of semiconductor, electrons flow through the structure of the cell.

<u>Transistors</u>

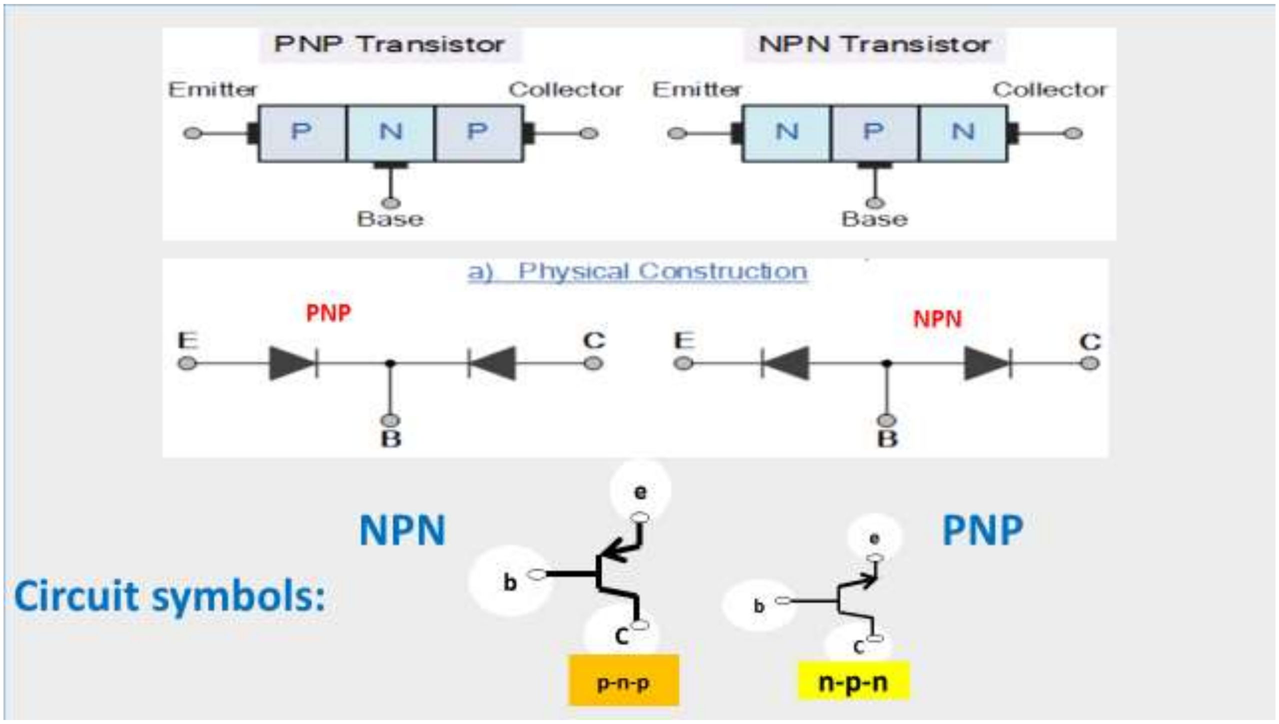
Transistors- are extremely important electronic element formed by sandwiching either p-type or n-type semiconductor between a pair of opposite types.

Transistor- a semiconductor device which transfers a signal from a low resistance to high resistance.

Accordingly there are two types of transistors namely ;

i. p-n-p transistor and ii. n-p-n transistor

Junction transistors has three layers and hence three terminals: Base (b), emitter(e) and collector (c).

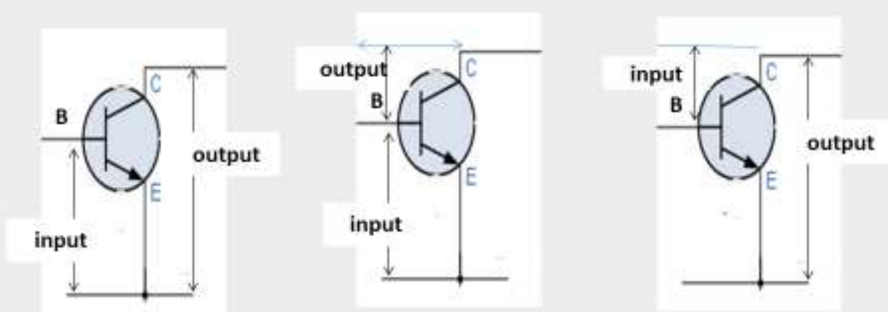


n-p-n transistor

Base - the middle section which forms two pn junctions between emitter & collector
Emitter- the section on one side that supplies carriers (Electrons/Holes)
Collector - section on one side that collects carriers (Electrons/Holes)

Transistor Characteristics:

Depending on the common terminal to the input and the output we can have common emitter, common base or common collector



common emitter common base common collector

Common Emitter (CE) NPN Configuration:

The most commonly used circuit for transistor based amplifiers and represents the "normal" method of bipolar transistor connection.

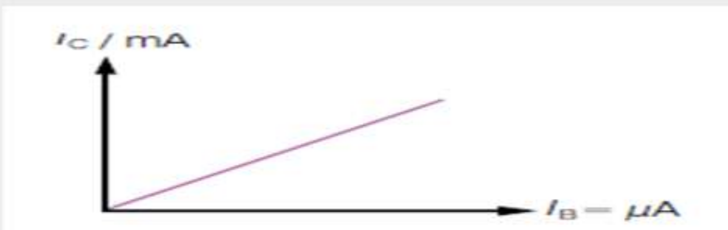
Transistor as switch and as amplifier

- any transistor can perform both as switch and as amplifier
- In simple current amplifier NPN transistor base-emitter junction is forward biased

current amplification factor(current gain) in CE configuration is the ratio of change in collector current to the change in base current.

Current Amplification Factor in common Emitter(A_I):

$$A_I = \frac{\Delta I_C}{\Delta I_B}$$



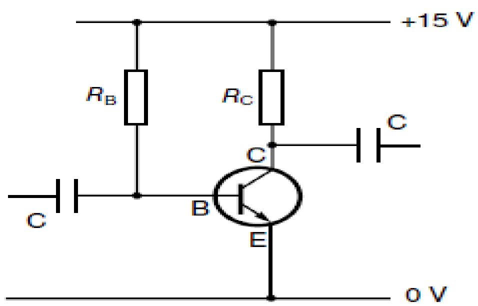
Signal- any particular current, voltage, or power in a circuit.

Quiescent-DC base current or voltage (that is, a steady DC before any input signal is applied)

<u>A simple amplifier with negative feedback</u>

Feedback means taking some of the output signal and feeding it back to the input. Negative feedback means that as the output signal rises, a portion is fed back in such a way as to make the input go down a bit and therefore cause the output to drop.

Voltage amplification factor:

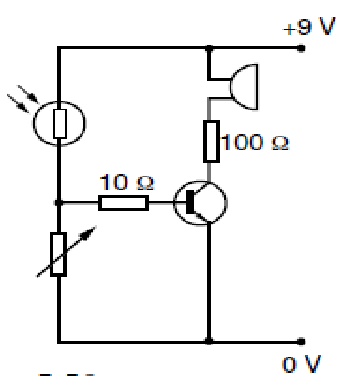


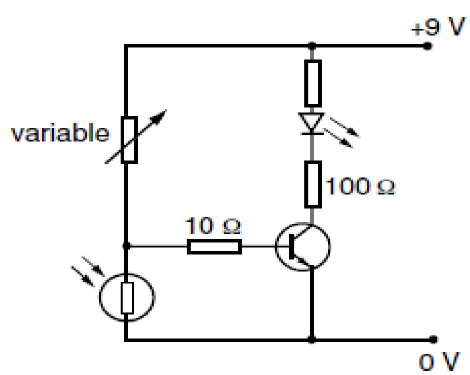
$A_V = \frac{\Delta V_{output}}{\Delta V_{input}}$ (voltage gain)

<u>Using LDR, LED, thermistor, photovoltaic cell and Transistor</u>

LDR, LED and transistor

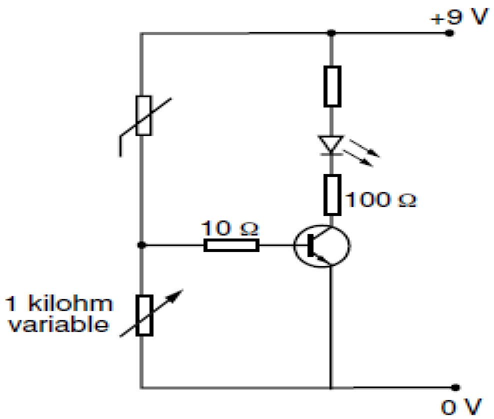
The LDR has a very high resistance when light levels are low, preventing current flowing in the circuit in which it is connected. This circuit could be the basis for a burglar alarm





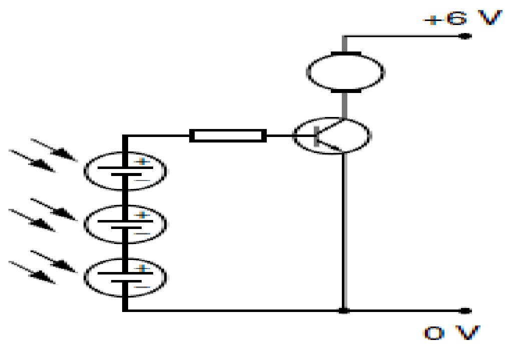
Thermistor, LED and transistor

The thermistor has a very high resistance at low temperatures, no current flows to the base of the transistor at low temperatures, and no current is able to flow in the circuit containing the LED. This circuit could give a visual (or audible if a buzzer were used in place of the LED) warning of overheating.



Photovoltaic cells and transistor

If no light falls on the photovoltaic cells, no current is generated in that circuit.



Example:

A diode is electronic component that (ESSLCE in 2014/2015EC)

A. allow current to pass through it either from cathode to anode or from anode to cathode
B. allow the flow of current when its p-type region is connected to the negative terminal of a cell.
C. allow electric current to pass through it in one direction.
D. is useful to convert a DC voltage to AC voltage

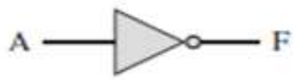
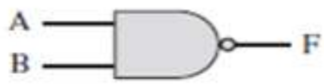
Logic gates

Logic gates-are combination of switches in logic circuits of digital systems. (circuit with several inputs but only one output)

Logic gates use the binary digits 0 and 1 for their operation. Where 0 represents ‘low’, ‘off’, ‘false’ or ‘no’ and 1 represents ‘high’ , ‘on’, ‘true’ or ‘yes’ signals.

There are five types of basic logic gates from which all the more complicated logic gates are constructed. Those are: NOT, OR, NOR, AND and NAND gates

Types of basic logic circuits

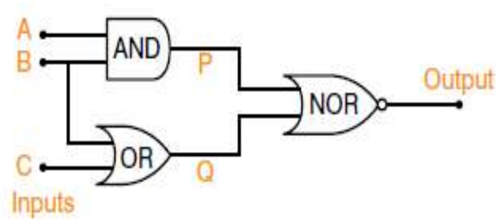
Name	Graphical Symbol	Algebraic Function	Truth Table
AND		$F = A \bullet B$ or $F = AB$	A B F 0 0 0 0 1 0 1 0 0 1 1 1
OR		$F = A + B$	A B F 0 0 0 0 1 1 1 0 1 1 1 1
NOT		$F = \overline{A}$ or $F = A'$	A F 0 1 1 0
NAND		$F = \overline{AB}$	A B F 0 0 1 0 1 1 1 0 1 1 1 0
NOR		$F = \overline{A + B}$	A B F 0 0 1 0 1 0 1 0 0 1 1 0

Combination of Logic Gates

More than one logic gate may be combined to increase the range of control tasks that can be performed.

Logic circuit of n inputs have 2^n different combinations of 0s and 1s.

Example: Determine the possible outputs of this logic circuit.



Physics G- 10

Unit-6

Electro Magnetic Waves and Geometric Optics

Optics

Optics

"Geometrical optics"
ex: applications of
Lenses and Mirrors

"Wave optics"
ex: Interference
Diffraction
Polarization

"Quantum optics"
ex: Photoelectric
effect

Reflection

Reflection-is the bouncing off a wave from a reflecting surface.

Laws of reflection:

i. The angle of incidence is equal to the angle of reflection. (for both smooth and rough surfaces)(case a below).

****Remember that angles are always measured from the normal.

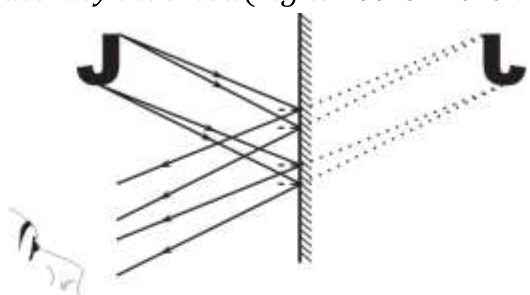
i. For smooth surfaces, parallel rays all reflect at the same angle. The surface then looks shiny and can form images. This is called specular reflection.
ii. Reflection from rough surface is in random directions. This is called diffuse reflection (case c below).

Image formed by plane mirror:

Plane mirror- is a flat and smooth reflecting surface.

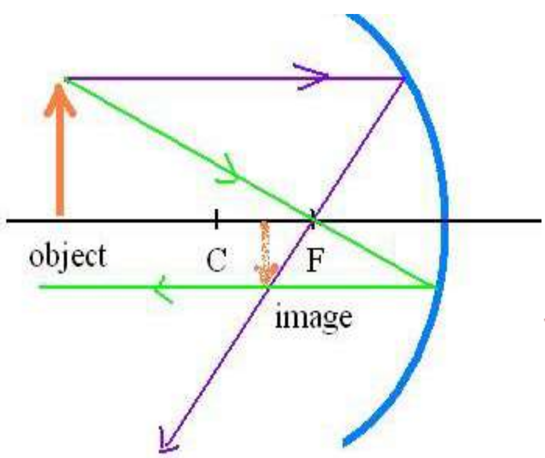
Image formed by plane mirror:

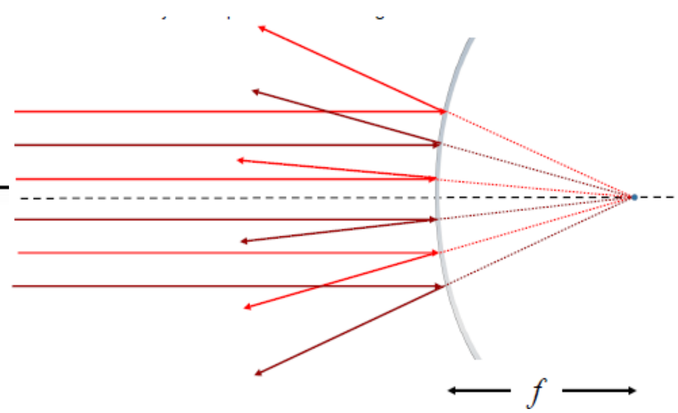
- ✓ Image distance is equal to that of the object ($s_o = s_i$).
- ✓ The size of the object is equal to that of the object ($h_o = h_i$).
- Nature of the image : $virtual,\ erect\ and\ lateraly\ inverted(right$ looks like left in the image.)



Types of spherical mirrors: concave and convex mirror

- concave mirror-silvered on the inside
- convex mirror-silvered on the out side





Principal axis- is the line passing through the center of the curvature of a curved mirror

Radius of a curvature-is the radius of the sphere from which the curved mirror is formed.

Principal focus (F)-is the point to which reflected rays converge.

Focal length (f)- is the distance from the vertex of the mirror to the principal focus. (half of the radius of curvature)

magnificationthe ratio between the height of an image and the height of the object

$M = \frac{h_i}{h_o} = \frac{s_i}{s_o}$

Real image –is an image that is formed when actual light rays meet, and can be projected on to a screen.

Virtual image –is an image that is formed without the meeting of actual light rays but from the extension of the reflected rays, and it cannot be projected onto the screen.

Finding position and nature of the image formed by a concave mirror using a ray tracing method

In a 3-step process, use three principal rays to draw a ray diagram.

Step One: Draw a ray, starting from the top of the object, parallel to the principal axis and then through "f" after reflection.

Step Two: Draw a ray, starting from the top of the object, through the focal point, then parallel to the principal axis after reflection.

Step Three: Draw a ray, starting from the top of the object, through C, then back upon itself.

The intersection of these 3 lines is the location of the image.

After getting the intersection, draw an arrow down from the principal axis to the point of intersection. (image)

FOR CONCAVE MIRRORS:

The best means of summarizing this relationship is to divide the possible object locations into five general areas or points:

Case 1: the object is located *beyond* the center of curvature (C)

Case 2: the object is located at the center of curvature (C)

Case 3: the object is located between the center of curvature (C) and the focal point (F)

Case 4: the object is located at the focal point (F)

Case 5: the object is located *in front of* the focal point (F)

Case 1: Object beyond C

Location: image will always be located somewhere in between the center of curvature and the focal point.

Orientation: image will be an inverted image.

Size: reduced in size (M is less than 1).

Type: image is a real image.

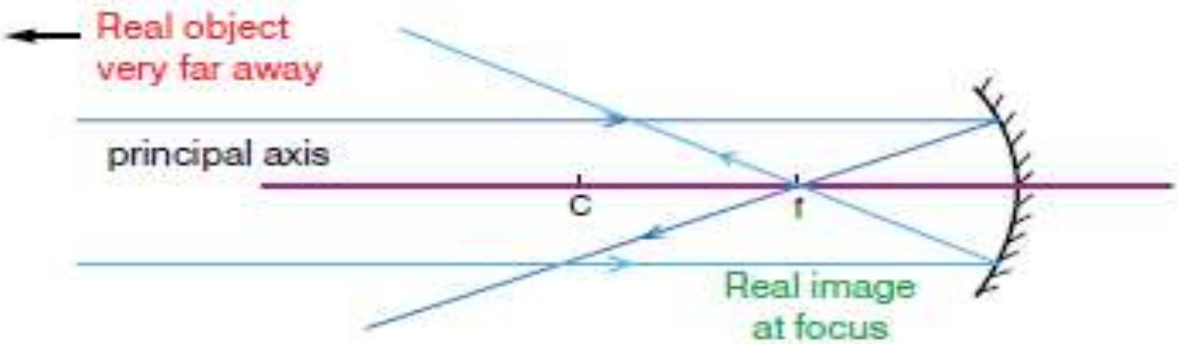
Case 2: Object located at C

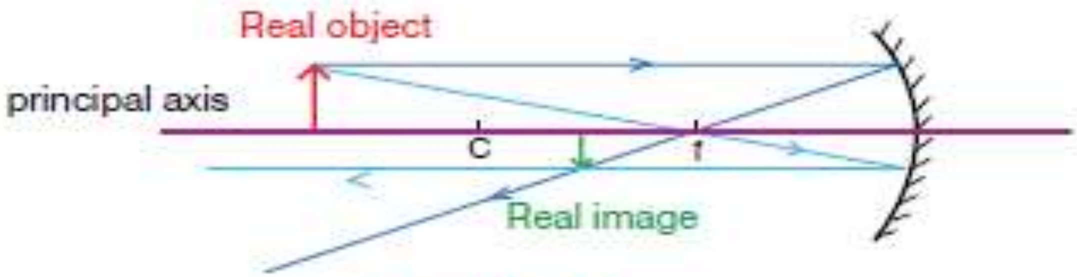
Location: image will also be located at the center of curvature.

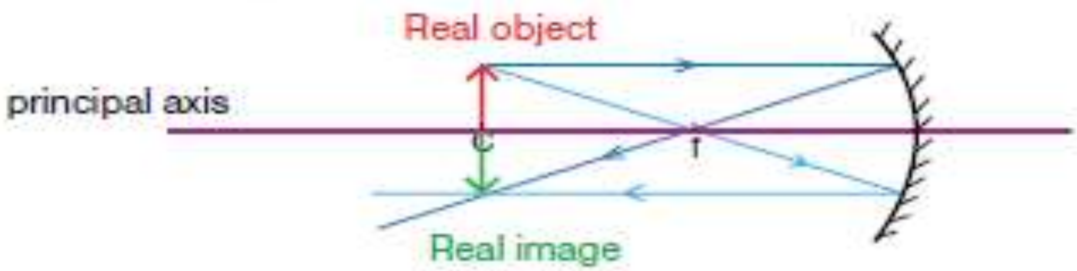
Orientation: image will be an inverted image.

Size: same size (M = 1).

Type: image is a real image.







Case 3: Object between C &f

Location: object is located in front of the center of curvature, the image will be located beyond the center of curvature.

Orientation: image will be an inverted image.

Size: image is enlarged (M is greater than 1).

Type: image is a real image.

Case 4: The object is located at f

No image is formed. Light rays from the same point on the object will reflect off the mirror and neither converge nor diverge. After reflecting, the light rays are traveling parallel to each other and do not result in the formation of an image. ($s_i = \infty$)

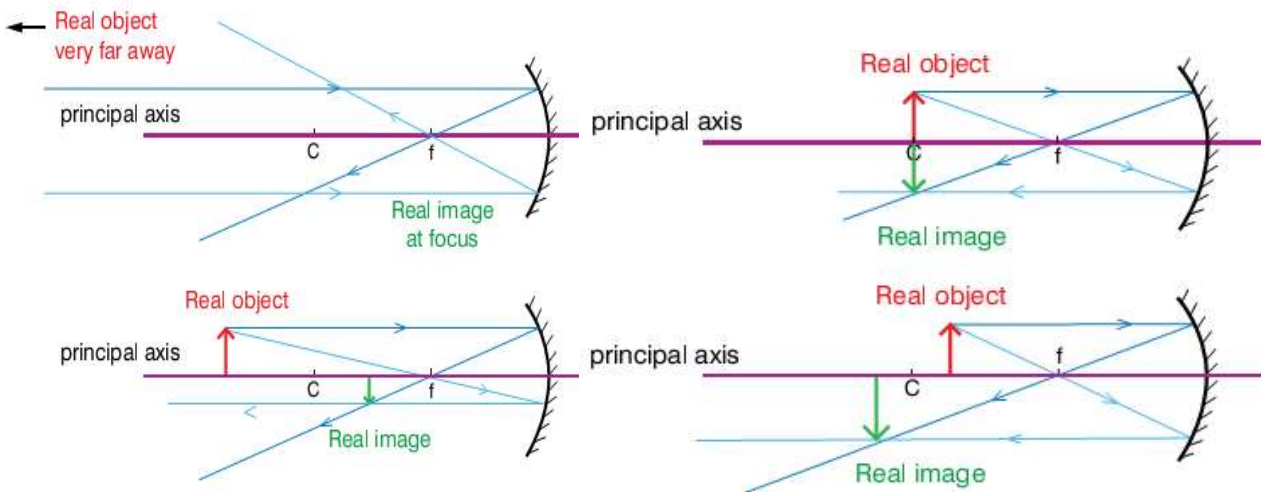
Case 5: Object located in front of f

Location: at the opposite side of the mirror (behind mirror).

Orientation: image will be an upright (erect) image.

Size: image is enlarged (M is greater than 1).

Type: virtual image. (by extending the reflected rays backwards beyond the mirror. The point of their intersection is the virtual image location.



(4) Position, size and nature of image formed by the spherical mirror

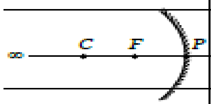
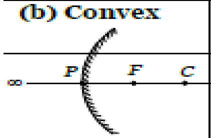
Mirror	Location of the object	Location of the image	Magnification, Size of the image	Nature	
				Real virtual	Erect inverted
(a) Concave	At infinity *i.e.* $u = \infty$	At focus *i.e.* $v = f$	$m << 1$, diminished	Real	inverted
	Away from centre of curvature ($u > 2f$)	Between f and $2f$ *i.e.* $f < v < 2f$	$m < 1$, diminished	Real	inverted
	At centre of curvature $u = 2f$	At centre of curvature *i.e.* $v = 2f$	$m = 1$, same size as that of the object	Real	inverted
	Between centre of curvature and focus : $F < u < 2f$	Away from the centre of curvature $v > 2f$	$m > 1$, magnified	Real	inverted
	At focus *i.e.* $u = f$	At infinity *i.e.* $v = \infty$	$m = \infty$, magnified	Real	inverted
	Between pole and focus $u < f$	$v > u$	$m > 1$ magnified	Virtual	erect
(b) Convex	At infinity *i.e.* $u = \infty$	At focus *i.e.*, $v = f$	$m < 1$, diminished	Virtual	erect
	Anywhere between infinity and pole	Between pole and focus	$m < 1$, diminished	Virtual	erect

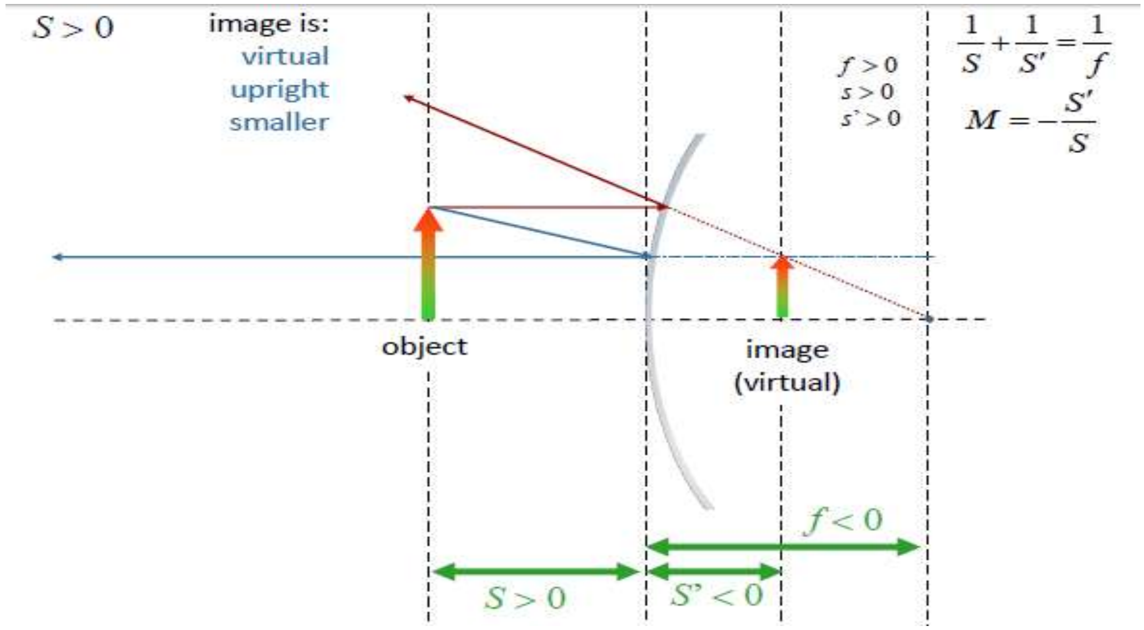
Image formed by a Convex mirror

Location: at the opposite side of the mirror (behind mirror).

Orientation: image will be an upright (erect) image.

Size: image is reduced(M <1).

Type: virtual image. (by extending the reflected rays backwards beyond the mirror. The point of their intersection is the virtual image location.



Nature, position and relative size of the image formed by a convex mirror

Position of the object	Position of the image	Size of the image	Nature of the image
At Infinity	At the focus F, behind the mirror	Highly diminished, point sized	Virtual and erect
Between infinity and the pole P of the mirror	Between P and F behind the mirror	Diminished	Virtual and erect

<u>Finding position and nature of the image formed by a mirror using the mirror equation</u>

The mirror equation enable us to find out where and how the image if formed. It is given by:

$$\frac{1}{f} = \frac{1}{s_o} + \frac{1}{s_i}$$

Where, f -focal length

s_o −distance of the object *and*

s_i − *distance of the image*

The sign conventions for the given quantities in the mirror equation and magnification equations are as follows:

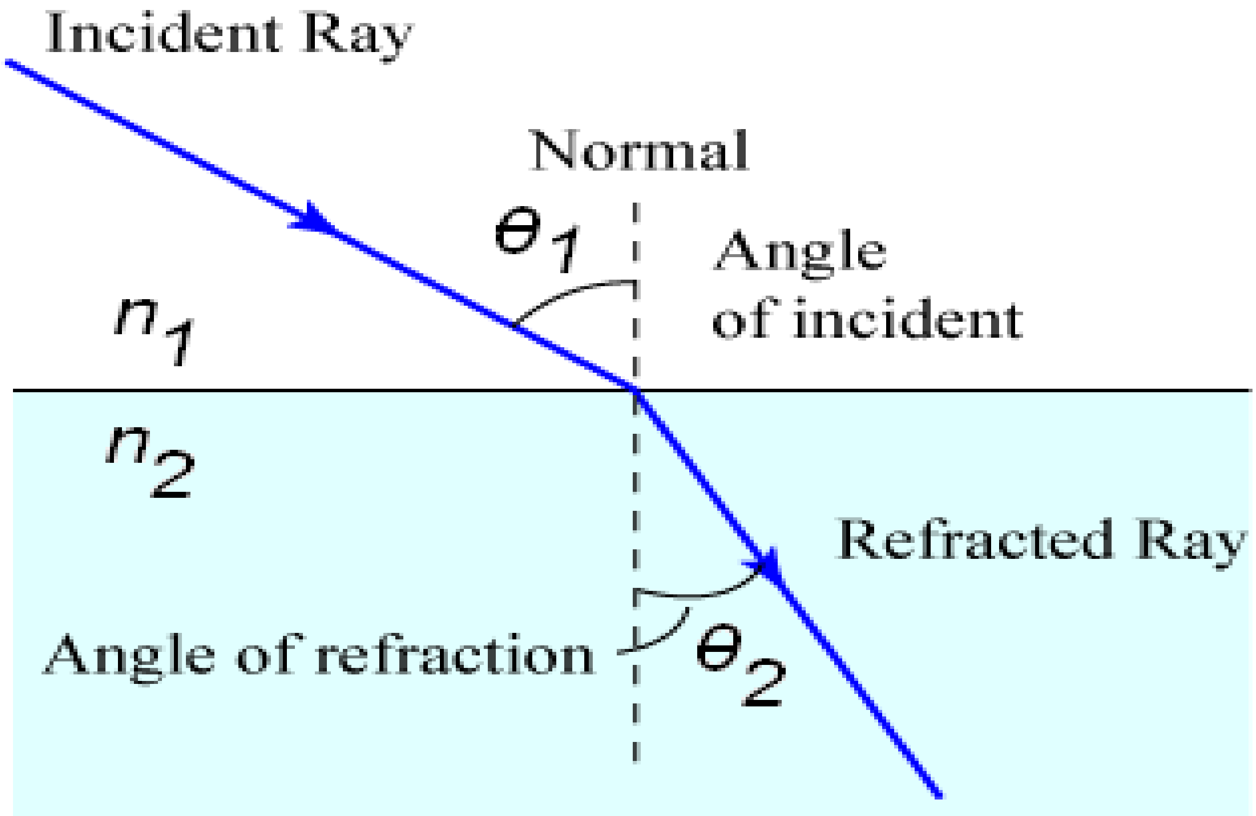
- ❖ f is +veif the mirror is a concave mirror
- ❖ f is -veif the mirror is a convex mirror
- ❖ s_i is +veif the image is a real image and located on the objects side of the mirror.
- ❖ s_i is -veif the image is a virtual image and located behind the mirror.
- ❖ h_i is -veif the image is an upright image (and therefore, also virtual)
- ❖ $h_i$is +veif the image an inverted image (and therefore, also real)

Refraction

Refraction is the bending of light as it crosses the interface between two different transparent media.

Refraction occurs because the wave speed differs in different media.

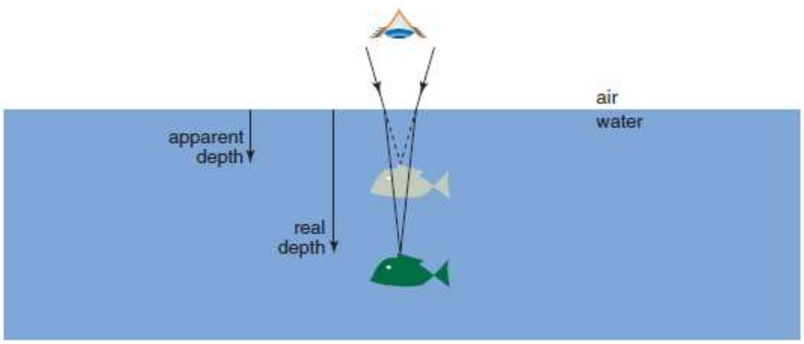
For light, the index of refraction n describes the speed change.



- A ray of light from a rarer medium to a denser medium slows down and bends towards the normal.
- On the other hand the ray of light going from a denser medium to a rarer medium is speeded up and bends away from the normal. This bending ability of a medium is known as the index of refraction or refractive index (ratio of the speed of light in vacuum to that in the material medium).

Apparent Depth

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



Total internal reflection

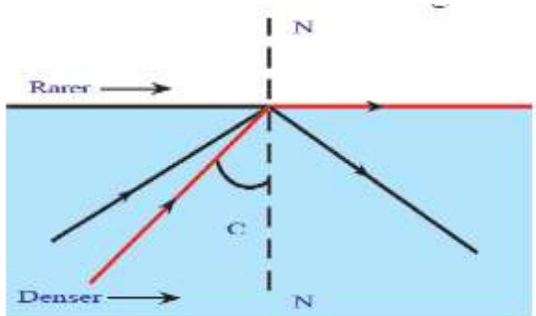
Critical angle – is the angle of incidence for which the angle of refraction is 90°

- Total internal reflection to occur, two conditions must be full filled:

i. Light travelling in a medium such as water or glass comes to a surface with a medium in which it travels faster (usually air).

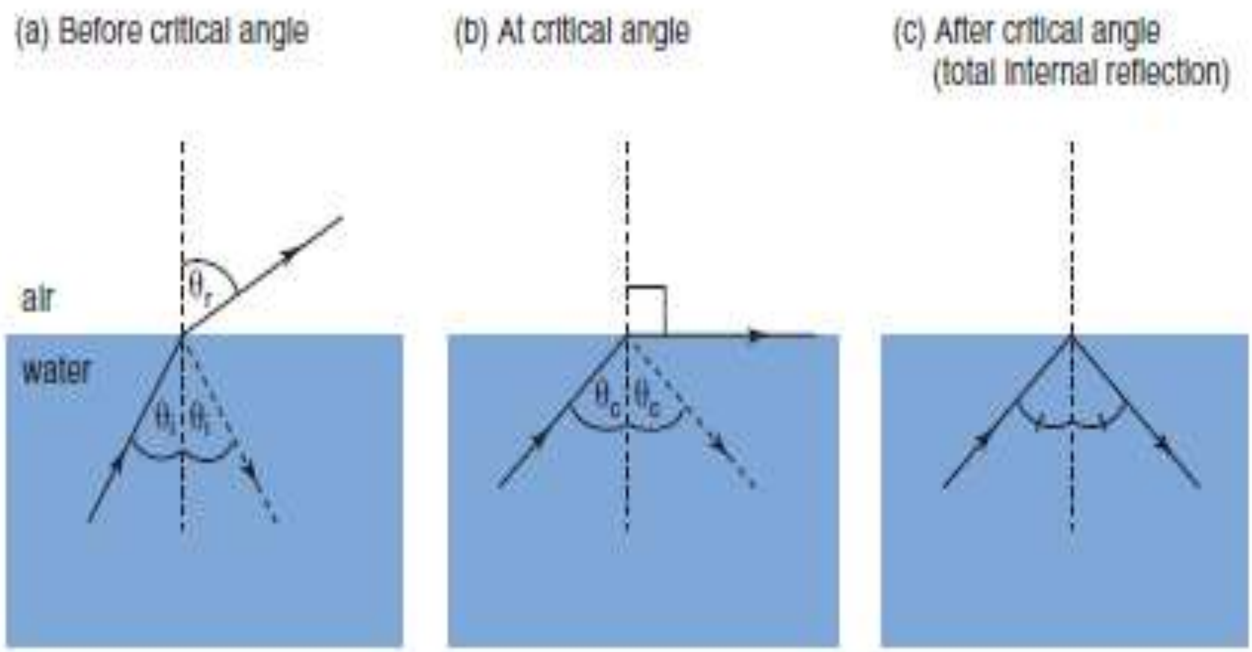
ii. It hits the inside of this surface at an angle of incidence greater than the critical angle.

$\sin\theta c = n2/n1$



Total internal reflection

- The angle of incidence for when the angle of refraction is 90° is called the critical angle.



<u>Applications of total internal reflection:</u>

- Total internal reflection is the basic principle for working of optical fibre.
- An optical fibre is a thin tube of transparent material that allows light to pass through without being refracted into the air or another external medium.
- A thin, flexible cable containing an optical fibre can be placed inside a person's body to transmit pictures of the condition of organs and arteries, without the need for invasive surgery. The same can be done in industry when there is a problem with complex machinery.

Lenses

Convex (converging) (positive) lens: Convex lens has its two surfaces bulging outward. It makes the parallel rays of light to converge to a point(focus).

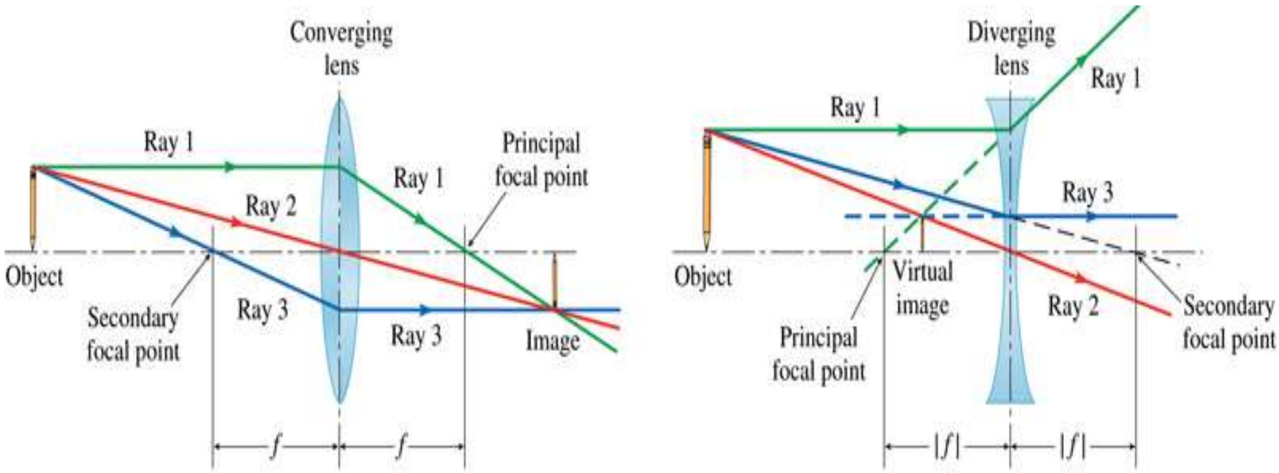
Concave (diverging) (negative) lens: A concave lens has its two surfaces caving inward. It makes parallel rays of light to spread from a point (focus)

IMAGE FORMATION IN LENSES

In order to draw the image formed by any lens, only two rays are required. These two rays are:

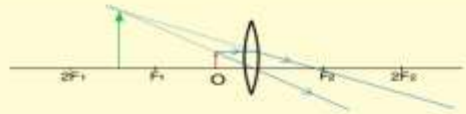
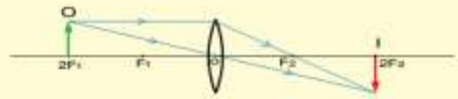
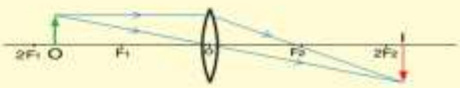
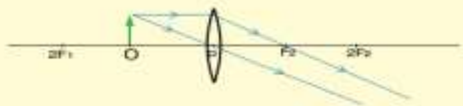
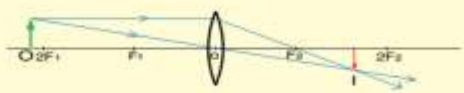
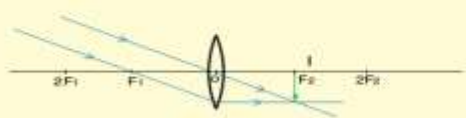
i. A ray parallel to the principal axis of the lens converges after refraction at the principal focus of convex lens. It appears to diverge off in the case of concave lens.

ii. A ray towards the optical centre falls on the lens symmetrically and after refraction passes through it undeviated.



Nature, position and relative size of the image formed by a convex lens for various positions of the object.

Position of the object	Position of image formed	Nature of image	Size of image
(A) For convex lens			
(i) between *F* and pole	infront of lens	virtual and erect	enlarge
(ii) at *F*	at infinitely	real and inverted	highly enlarged
(iii) between *F* and 2*F*	beyond 2*F*	real and inverted	enlarge
(iv) at 2*F*	at 2*F*	real and inverted	same size
(v) beyond 2*F*	between *F* and 2*F*	real and inverted	smaller in size
(vi) at infinity	at *F*	real and inverted	highly diminished
(B) For concave lens			
anywhere infront of lens	on the same side between *F* and pole	virtual and erect	always smaller

Position of object	Key diagram	Image is
Between F_1 and lens		virtual erect magnified
At $2F_1$		real inverted same size as object
Between F_1 and $2F_1$		real inverted magnified
At F_1		formed at infinity real inverted magnified
Beyond $2F_1$		formed between F_1 and $2F_1$ real inverted diminished
At infinity		formed at F_1 inverted real highly diminished

Nature, position and relative size of the image formed by a concave lens for various positions of the object.

Position of the object	Position of the image	Relative size of the image	Nature of the image
At infinity	At focus F_1	Highly diminished point sized	Virtual and erect
Between infinity & optical centre O of the lens	Between focus F_1 and optical centre O	Diminished	Virtual and erect

<u>Power of a lens</u>

<u>Power of a lens</u> – is a measure of its ability to converge parallel beam of rays incident on it. It is measured in a unit known as diopter.

$$P = \frac{1}{f} \text{ (in diopter)}$$

$$1D = 1m^{-1}$$

<u>Angular magnification</u>

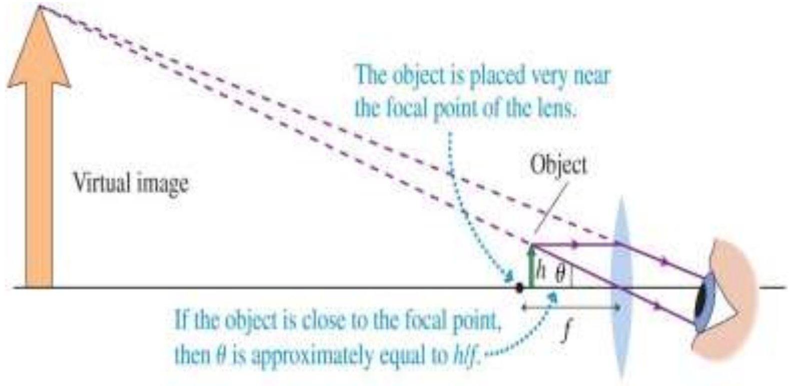
Size of the image formed at the retina depends on the angle θ subtended by the object at the eye. Norma eye can not focus on an object closer than 25cm (near point). If $s_o < 25$cm, perceived retinal image becomes fuzzy. Near point normally varies with age.

Simple Magnifying lens consist a single converging lens.

$m_\theta = \frac{25cm}{f}$ ($m_\theta - angular\ magnification$)

A Simple Magnifying lens

Increases the apparent size of an object.



Compound microscope

A Compound microscope– consists of one lens, of focal length $f_{ob} < 1cm$ and an eye piece (the lens near the eye), that has a very short length f_e of a few centimeters.

The two lenses are separated by a distance l that is much greater than either f_{ob} or f_e. The object which is placed just out side the focal point of the objective, forms a real, inverted image closer to the focal; point of the eye piece. The eyepiece (serve as simple magnifier) produce a virtual, enlarged image.

Lateral magnification magnification of the objective :

$m_o = \frac{L}{f_{ob}}$ (L-distance b/n F_{ob} and F_{ey})

Angular magnification magnification of by the eyepiece is given by:

$$m_e = \frac{25cm}{f_{ey}}$$

Overall magnification:

$$M = m_o m_e = (\frac{L}{f_{ob}})(\frac{25cm}{f_{ey}})$$

Refractive Telescope

Telescope-designed to view large objects, such as galaxies, stars and planets, at large distance, where as microscope are designed for just the opposite purpose.

The objective lens forms a real, inverted image on (very near to the focal point of the eye piece. The eyepiece produce a virtual, enlarged image at infinite distance.

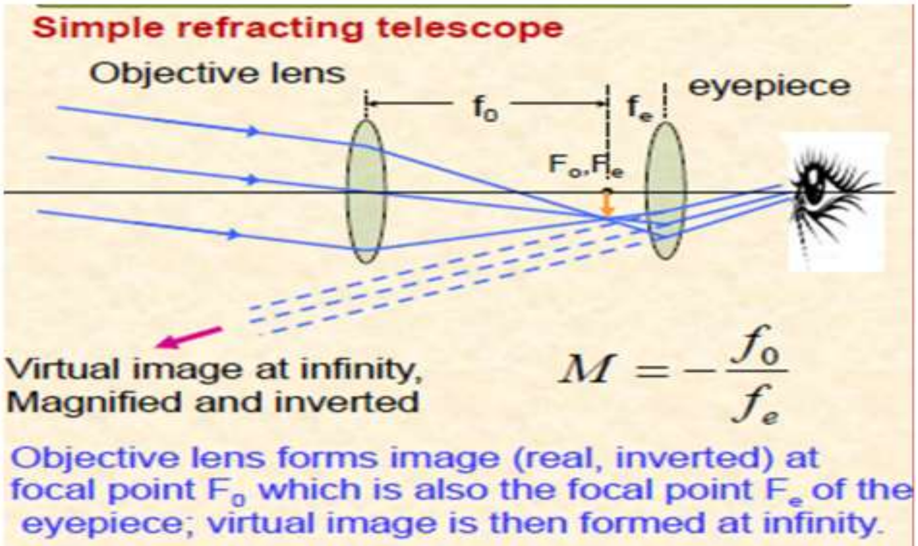
Refractive Telescope

Angular magnification magnification of by the eyepiece is given by:

$$m_e = -\frac{f_{ob}}{f_{ey}} = \frac{\theta}{\theta_o}$$

$\theta\ angle subtended\ by\ the\ final\ image$

$\theta_o - angle subtended\ by\ the$ objective



- When white light or sun light passes through a prism it splits up into constituent colors. This phenomenon is called dispersion and arises due to the fact that refractive index of prism is different for different colors of light. So, different colors in passing through a prism are deviated through different angles. Rainbow, the most colorful phenomenon in nature, is primarily due to the dispersion of sunlight by rain drops suspended in air.