CMR INSTITUTE OF TECHNOLOGY	USN										

Internal Assesment Test III – NOV 2019										
Sub:	UTILIZATION OF ELECTRICAL ENERGY							Code:	15EE742
Date:	16/11/2019	Duration:	90 mins	Max Marks:	50	Sem:	VII	Section :	A & B

Note: Answer any **five FULL** Questions
Sketch neat figures wherever necessary. Answer to the point. **Good luck!**

		Marks	OBE CO	OBE RBT
1.	With a neat sketch explain the working of Indirect Resistance Heating	[10]	CO2	L4
2.	State and explain i). Inverse Square Law ii). Lamberts Cosine rule w. r. t Illumination	[10]	CO2	L4
3.	Discuss briefly about flood lighting	[10]	CO3	L3
4..	Define the following w.r.t Illumination i). Luminous Flus ii). MHCP iii). Coefficient of Utilisation iv). MSCP	[10]	CO3	L2
5.	What is electro deposition ? Discuss the factors that affects the quality of electro deposition	[10]	CO4	L2
6.	Discuss the construction and working principle of LED	[10]	CO2	L2
7.	Discuss the methods of temperature control of resistance ovens	[10]	CO3	L4
8.	Explain Dielectric Heating with neat Diagram.	[10]	CO2	L3

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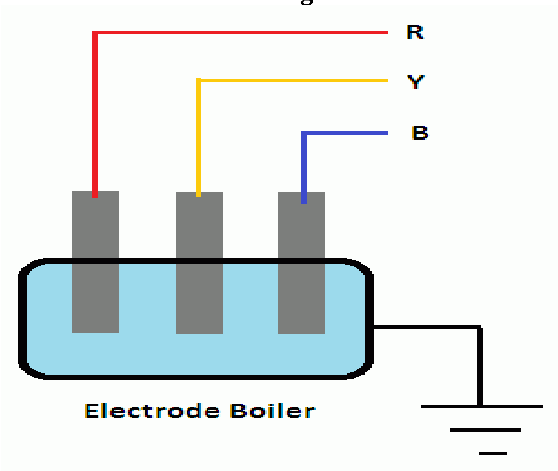
1. **Indirect Resistance Heating:**

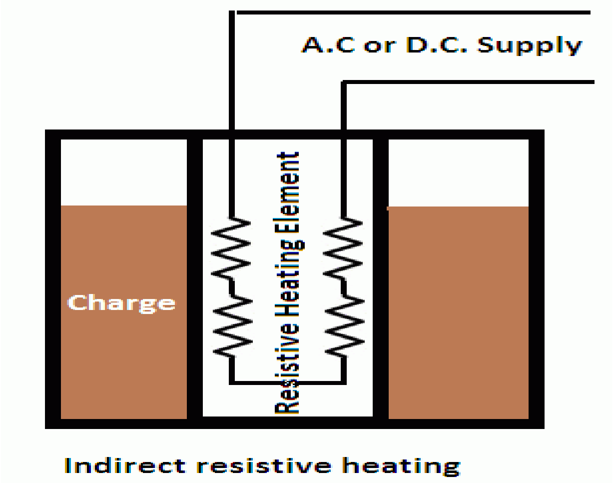


2. In the direct resistance heating, electric current passes through the charge itself. This current produces I^2R losses in the form of heat within the body itself. This principle is made use in heating water by means of electrode boiler.

   In the case of electrode boiler, the electrodes are lowered into the tank filled with water. The current flows through electrodes into the water and water gets heated by I^2R losses. For temperatures up to 100°C, mild steel electrodes are used.

The automatic stirring action is produced in the charge to be heated and no external method of stirring is required to get uniform heating.

Indirect Resistance Heating



In the indirect resistance heating, the current does not flow through the body to be heated but it flows through the resistance elements which get heated up. The heat is then transferred from the heating element to the charge mainly by radiation or convection.

The figure shows a simple sketch of indirect resistance heating oven. In this method heat does not pass through the charge, hence natural stirring action is not there.

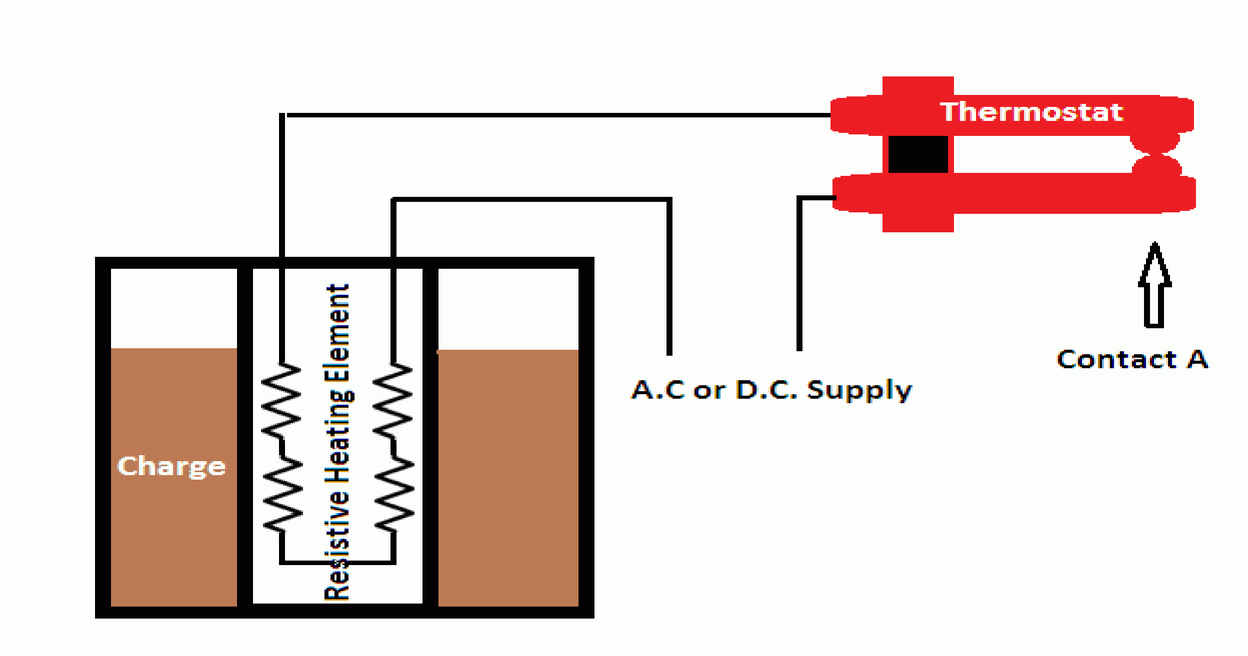
So some external stirring apparatus are employed to get uniform heating in indirect resistance heating method. The appliances that work on this principle include immersion rod, electric kettles, electric iron etc.

Temperature Control of Resistance Furnaces

Temperature control is necessary for resistance furnace or oven. The temperature may be kept constant or varied according to requirements. Control may be manual or automatic. Temperature can be controlled in oven or furnace by the following ways:

- **Use of variable Number of Elements**. In this method, the number of heating elements in working is changed, so total power input is changed.
- **Change of Connections**: In this method, the elements are arranged to be connected either in series or in parallel or combination of both in star or in the delta by means of switches at different instants according to the requirements.
- **Transformer Tappings**. The voltage across the oven can be controlled by changing the transformer tappings. This can be done by stepping down the supply voltage to the ovens. This is the economical method for voltage control. Moreover, in this method, automatic temperature control is done by thermostatic control.
- Very accurate heat control can be obtained by SCRs.
- **Thermostat control circuit**: This is used in the automatic heating appliances to control the temperature. It is connected in series with the resistance element. It is made of a bimetallic strip.

Thermostat control circuit



A bimetallic strip consists of two strips of different metals having the different coefficient of expansions, securely fastened together. When the thermostat is connected in series with the resistance element current starts flowing through the thermostat, bimetallic strip starts bending.

After some time contact point, A shown in figure opens and the current flowing through the resistance element stops. Now no current is flowing through the circuit, bi-metallic strip starts cooling, bi-metallic strip regains its original shape and hence contact point A closes. Thus, thermostat controls heating of element by making and breaking the circuit again and again.

A screw is provided in thermostat, which varies the tension between the two strips and hence varies the making and breaking time of the contact point A.

Properties of Electrical Resistance Heating Elements

- **High resistivity**: It should have high specific resistance so that small quantity of wire is required to produce a certain amount of heat.
- **The low-temperature coefficient of resistance**: The resistance heating element material should possess the low-temperature coefficient of resistance, so that resistance may not vary with the change in temperature.
- **High melting point**: The melting point of the material used should be very high so that high temperature can be obtained.
- **Free from oxidation**: It should be free from oxidation to ensure a long life of the heating element.

Most commonly material used for the heating element is either alloy of nickel and chromium or the alloy of nickel, chromium and iron. These are used for temperatures up to 1100°C. The composition of the alloy for resistance heating elements depends upon the working temperature. For higher temperatures silicon carbide, tungsten and graphite are used.

Eureka is a copper-nickel alloy approximately 56% copper and 44% nickel. It is used where the low-temperature coefficient is required, such as in instrument coils, shunts, etc.

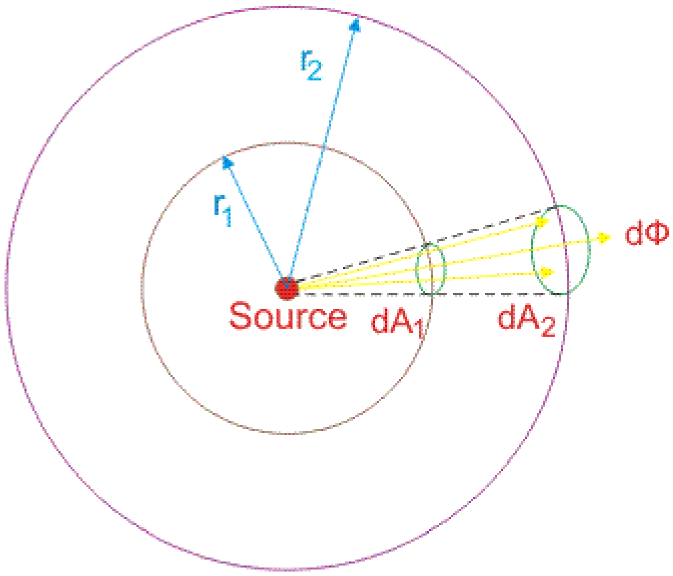
2.a). Inverse Square Law of Illumination.

The Inverse Square Law of Illuminance

This law states that the Illuminance (E) at any point on a plane perpendicular to the line joining the point and source is inversely proportional to the square of the distance between the source and plane.

$$E = \frac{I}{d^2}$$

Where, I is the luminous intensity in a given direction.



Suppose a source is present with luminous intensity I in any direction. From this source two distances are taken as the radius making this source as centre.

As per the above figure, the two radiuses are r_1 and r_2. At distance r_1 dA_1 is the elementary surface area taken. In this direction of dA_1, dA_2 is considered at r_2 distance. dA_1 and dA_2 are within same solid angle Ω with same distributed luminous flux Φ. Area dA_1 at r_1 receives the same amount of luminous flux as area dA_2 at r_2 as the solid are the same.

$$Intensity\ I = \frac{d\phi}{d\Omega}\ is\ for\ dA_1\ and\ Intensity\ I = \frac{d\phi}{d\Omega}\ is\ for\ dA_2$$

Again solid angle for both elementary surfaces

$$d\Omega = \frac{dA_1}{r_1^2} = \frac{dA_2}{r_2^2}\ldots\ldots\ldots\ldots equation(i)$$

The Illuminance at distance

$$r_1 = E_1 = d\phi/dA_1 = Id\Omega/dA_1\ldots\ldots\ldots\ldots equation(ii)$$

The Illuminance at distance

$$r_2 = E_2 = d\phi/dA_2 = Id\Omega/dA_2\ldots\ldots\ldots\ldots equation(iii)$$

Now, from equation (i) we get,

$$dA_2 = \frac{r_2^2}{r_1^2}dA_1\ldots\ldots\left[As\ d\Omega = \frac{dA_1}{r_1^2}\frac{dA_2}{r_2^2}\right]$$

Now in the equation (iii),

$$E_2 = Id\Omega/dA_2$$

$$Putting\ dA_2 = \frac{r_2^2}{r_1^2}dA_1\ we\ get$$

$$E_2 = \frac{Id\Omega}{\frac{r_2^2}{r_1^2}dA_1} = \frac{r_1^2}{r_2^2} \cdot \frac{Id\Omega}{dA_1} = \frac{r_1^2}{r_2^2}E_1$$

$$Or, \ \frac{E_1}{E_2} = \frac{r_1^2}{r_2^2}$$

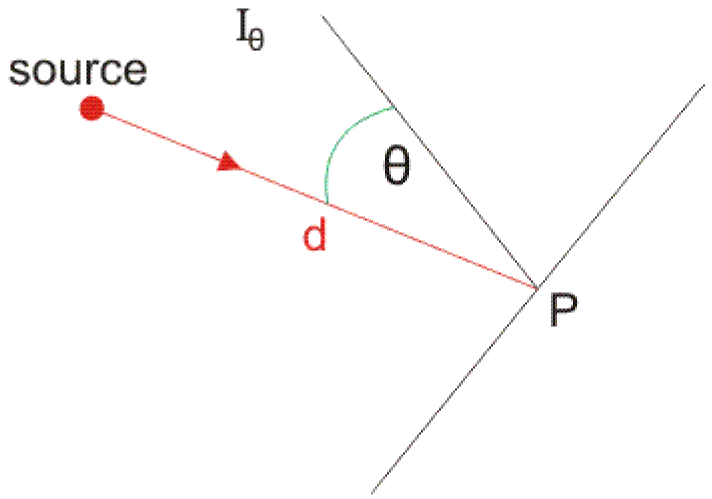
This indicates the well known inverse square law relationship for point source.
It is seen that Illuminance varies inversely as the square of the illuminated point from the source.
If the light source is not a point source, then we can assume this large source as the summation of many point sources.
This relationship can be applied to all light sources.

b). Lamberts Cosine law:

The law states that Illuminance at a point on a plane is proportional to the cosine of the angle of light incident (the angle between the direction of the incident light and the normal to the plane).

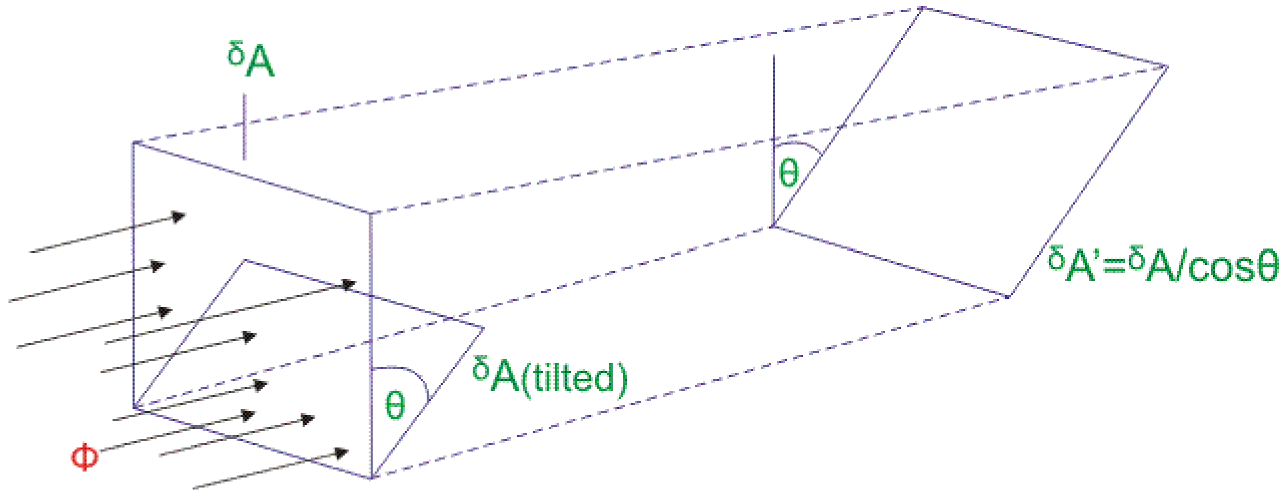
$$E = \frac{I_\theta}{d^2}\cos\theta$$

It is the point source Illuminance equation.
Where, I_θ is the luminous intensity of the source in the direction of the illuminated point, Θ is the angle between the normal to the plane containing the illuminated point and the line joining the source to the illuminated point, and d is the distance to the illuminated point.



But for non point source, the cosine law of Illuminance can be analyzed in term of luminous flux instead of luminous intensity.
The Illuminance or the surface density of the light flux received by an elementary area varies with the distance from the light source and the angle of the elementary area with respect to the direction of the light flux.
The maximum Illuminance occurs when the element of area receives the light flux normal to its surface.
When the element of area is tilted with respect to the direction of the light flux, the Illuminance or flux density on the elementary surface is reduced. This can be thought of in two ways.

1. The tilted elementary area (δA) cannot intercept all the light flux it previously received and so the Illuminance falls.
2. If the elementary area (δA) increases, the Illuminance $\frac{\delta\Phi}{\delta A}$ falls.



For case (1) when the element δA is tilted by an angle Ө the amount of flux intercepted δA is given by

$$\phi' = \frac{\phi}{\delta A} \times \delta A \cos\theta = \phi \cos\theta$$

So the flux received by δA is reduced by a factor cosӨ. Now the Illuminance at δA is

$$E' = \frac{\phi'}{\delta A} = \frac{\phi}{\delta A}\cos\theta = E_{max}\cos\theta$$

For case (2) if all the flux intercepted by larger element δA' :

$$\delta A' = \frac{\delta A}{\cos\theta}$$

So Illuminance becomes

$$E' = \frac{\phi}{\delta A'} = \frac{\phi}{\delta A/\cos\theta} = \frac{\phi}{\delta A}\cos\theta = E_{max}\cos\theta$$

Both cases of these approach result in

$$E = E_{max}\cos\theta$$

3). Flood Lighting

A **floodlight** is a broad-beamed, high-intensity artificial light. They are often used to illuminate outdoor playing fields while an outdoor sports event is being held during low-light conditions. More focused kinds are often used as a stage lighting instrument in live performances such as concerts and plays.

In the top tiers of many professional sports, it is a requirement for stadiums to have floodlights to allow games to be scheduled outside daylight hours. Evening or night matches may suit spectators who have work or other commitments earlier in the day, and enable television broadcasts during lucrative primetime hours. Some sports grounds which do not have permanent floodlights installed may make use of portable temporary ones instead. Many larger floodlights (see bottom picture) will have gantries for bulb changing and maintenance. These will usually be able to accommodate one or two maintenance workers. The most common type of floodlight is the metal-halide lamp, which emits a bright white light (typically 75–100 lumens/Watt). Sodium-vapor lamps are also commonly used for sporting events, as they have a very high lumen to watt ratio (typically 80–140 lumens/Watt), making them a cost-effective choice when certain lux levels must be provided.[1]

LED floodlights are bright enough to be used for illumination purposes on large sport fields. The main advantages of LEDs in this application are their lower power consumption, longer life, and instant start-up (the lack of a "warm-up" period reduces game delays after power outages).

4). A . Luminous Flux

Radiant flux (radiant power). The time rate of flow of radiant energy, evaluated in terms of a standardized visual response.

\Phi _{v}=K_{m}\int \Phi _{e,\lambda } V\left (\lambda \right)d\lambda$\Phi v = Km \int \Phi e,\lambda V(\lambda) d\lambda$, where:

Φ_v = luminous flux, (lumens, lm)
$\Phi_{e,\lambda}$ = watts per nanometer
λ = wavelength (nanometers, nm)
V(&lamda;) = the spectral luminous efficiency function
K_m = the maximum spectral luminous efficacy, (lumens per watt, lm/W)

b). **MHCP:** It is known as the **mean** of candle power in all directions in the horizontal plane containing the source of light.

c). **Coefficient of Illumination**: A **coefficient** of utilization (CU) is a measure of the efficiency of a luminaire in transferring luminous energy to the working plane in a particular area. The CU is the ratio of luminous flux from a luminaire incident upon a work plane to that emitted by the lamps within the luminaire.

d). **MSCP:** The average candle power of a source is the average value of its candle power in all the directions. • It is obtained by flux (in lumen) emitted in all the directions in all planes divided by $4*\pi$ • This average candle power is known **MSCP** or Mean Spherical Candle Power.

5). Electrodeposition: Electrodeposition, also known as electroplating, is the process of depositing material onto a conducting surface from a solution containing ionic species (salts). This fabrication technique is commonly used to apply thin films of material to the surface of an object to change its external properties such as to increase corrosion protection, increase abrasion resistance, improve decorative quality, or simply to deposit a layer which is part of a more complicated device. For example nickel metal is electroplated on automotive products so as to inhibit against corrosion, and copper metal is electrodeposited on to circuit boards to provide low resistance pathways between electronic components. Electrodeposition can not only be used for plating simple metals but also alloys (mixtures of metals) and semiconductors.

- **Factors affecting electrodeposition: Nature of Electrolyte**: The formation of a smooth deposit largely depends upon the nature of electrolyte employed. The electrolytes from which complex ions can be obtained, such as cyanides, provides a smooth deposit.
- **Current Density**: The appropriate current densities for different electroplating processes are shown in the table. At these current densities, the deposit of metal will be uniform and fine-grained. At the other current densities, the deposits will be coarse and crystalline in nature.
- **Temperature**: A low temperature of the solution favors formation of small crystals of metals and a high temperature, large crystals. In some cases, this is very marked a difference of only 15 degree Celsius resulting in a 50% decrease in strength of metal deposited. On the other hand, a high temperature may give beneficial results due to increased solubility of salts and increased conductivity.
- **Conductivity**: The use of a solution of good conductivity is important from standpoint of view of the economy in power consumption and also because it reduces the tendency to form trees and rough deposits.
- **Addition Agents**: These are the substances which take little or no direct part in chemical reactions but influence the nature of deposits. When these are added to electrolytes promote the formation of small crystals and smooth deposits and at the same time permit the use of higher current densities. They also assist in producing a bright finish. The substances in use are glue, gelatin, albumin, glucose, dextral, phenol, glycerin, gum and many others.

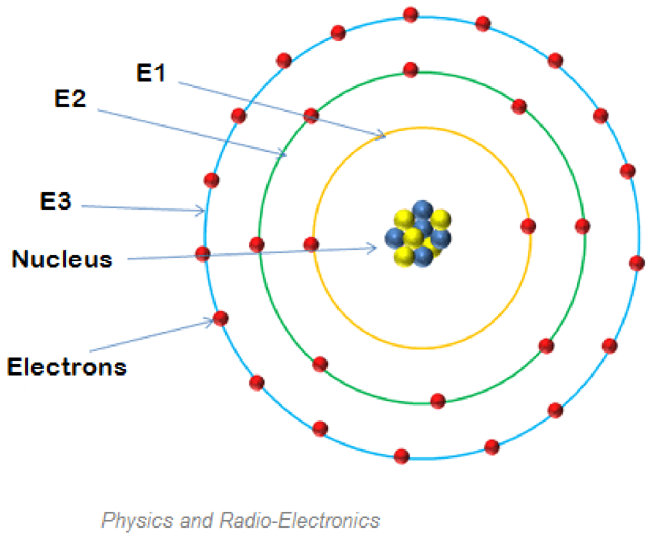
6). Construction and Working of LED

Light is a type of energy that can be released by an atom. Light is made up of many small particles called photons. Photons have energy and momentum but no mass.

Atoms are the basic building blocks of matter. Every object in the universe is made up of atoms. Atoms are made up of small particles such as electrons, protons and neutrons.

Electrons are negatively charged, protons are positively charged, and neutrons have no charge.

The attractive force between the protons and neutrons makes them stick together to form nucleus. Neutrons have no charge. Hence, the overall charge of the nucleus is positive.



The negatively charged electrons always revolve around the positively charged nucleus because of the electrostatic force of attraction between them. Electrons revolve around the nucleus in different orbits or shells. Each orbit has different energy level.

For example, the electrons orbiting very close to the nucleus have low energy whereas the electrons orbiting farther away from the nucleus have high energy.

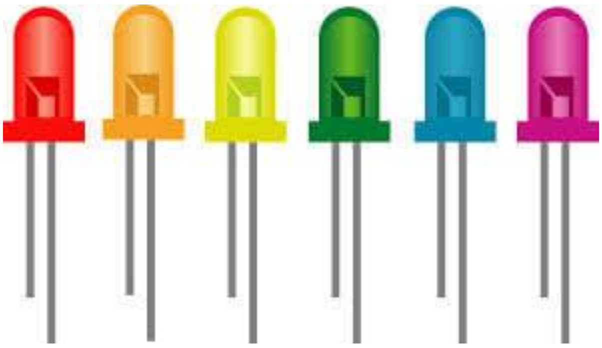
The electrons in the lower energy level need some additional energy to jump into the higher energy level. This additional energy can be supplied by the outside source. When electrons orbiting the nucleus gains energy from outside source they jump into higher orbit or higher energy level.

The electrons in the higher energy level will not stay for long period. After a short period, the electrons fall back to lower energy level. The electrons which jump from higher energy level to lower energy level will releases energy in the form of a photon or light. In some materials, this energy lose is released mostly in the form of heat. The electron which loses greater energy will releases a greater energy photon.

What is Light Emitting Diode (LED)?

Light Emitting Diodes (LEDs) are the most widely used semiconductor diodes among all the different types of semiconductor diodes available today. Light emitting diodes emit either visible light or invisible infrared light when forward biased. The LEDs which emit invisible infrared light are used for remote controls.

A light Emitting Diode (LED) is an optical semiconductor device that emits light when voltage is applied. In other words, LED is an optical semiconductor device that converts electrical energy into light energy.



When Light Emitting Diode (LED) is forward biased, free electrons in the conduction band recombines with the holes in the valence band and releases energy in the form of light.

The process of emitting light in response to the strong electric field or flow of electric current is called electroluminescence.

A normal p-n junction diode allows electric current only in one direction. It allows electric current when forward biased and does not allow electric current when reverse biased. Thus, normal p-n junction diode operates only in forward bias condition.

Like the normal p-n junction diodes, LEDs also operates only in forward bias condition. To create an LED, the n-type material should be connected to the negative terminal of the battery and p-type material should be connected to the positive terminal of the battery. In other words, the n-type material should be negatively charged and the p-type material should be positively charged.

The construction of LED is similar to the normal p-n junction diode except that gallium, phosphorus and arsenic materials are used for construction instead of silicon or germanium materials.

In normal p-n junction diodes, silicon is most widely used because it is less sensitive to the temperature. Also, it allows electric current efficiently without any damage. In some cases, germanium is used for constructing diodes.

However, silicon or germanium diodes do not emit energy in the form of light. Instead, they emit energy in the form of heat. Thus, silicon or germanium is not used for constructing LEDs.

Layers of LED

A Light Emitting Diode (LED) consists of three layers: p-type semiconductor, n-type semiconductor and depletion layer. The p-type semiconductor and the n-type semiconductor are separated by a depletion region or depletion layer.

P-type semiconductor

When trivalent impurities are added to the intrinsic or pure semiconductor, a p-type semiconductor is formed.

In p-type semiconductor, holes are the majority charge carriers and free electrons are the minority charge carriers. Thus, holes carry most of the electric current in p-type semiconductor.

N-type semiconductor

When pentavalent impurities are added to the intrinsic semiconductor, an n-type semiconductor is formed.

In n-type semiconductor, free electrons are the majority charge carriers and holes are the minority charge carriers. Thus, free electrons carry most of the electric current in n-type semiconductor.

Depletion layer or region

Depletion region is a region present between the p-type and n-type semiconductor where no mobile charge carriers (free electrons and holes) are present. This region acts as barrier to the electric current. It opposes flow of electrons from n-type semiconductor and flow of holes from p-type semiconductor.

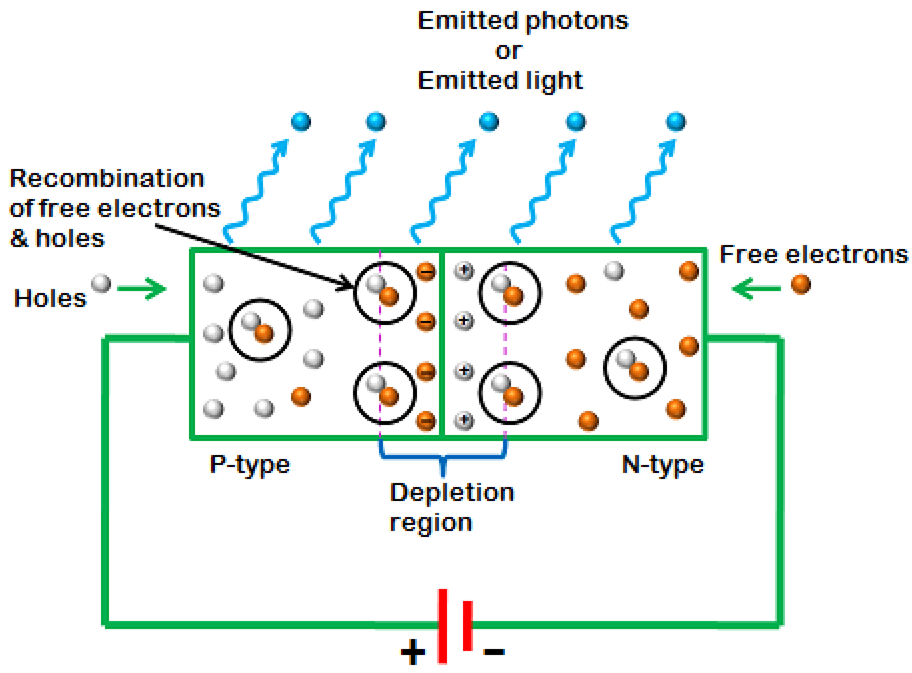
To overcome the barrier of depletion layer, we need to apply voltage which is greater than the barrier potential of depletion layer.

If the applied voltage is greater than the barrier potential of the depletion layer, the electric current starts flowing.

How Light Emitting Diode (LED) works?

Light Emitting Diode (LED) works only in forward bias condition. When Light Emitting Diode (LED) is forward biased, the free electrons from n-side and the holes from p-side are pushed towards the junction.

When free electrons reach the junction or depletion region, some of the free electrons recombine with the holes in the positive ions. We know that positive ions have less number of electrons than protons. Therefore, they are ready to accept electrons. Thus, free electrons recombine with holes in the depletion region. In the similar way, holes from p-side recombine with electrons in the depletion region.



Light Emitting Diode (LED)

Physics and Radio-Electronics

Because of the recombination of free electrons and holes in the depletion region, the width of depletion region decreases. As a result, more charge carriers will cross the p-n junction.

Some of the charge carriers from p-side and n-side will cross the p-n junction before they recombine in the depletion region. For example, some free electrons from n-type semiconductor cross the p-n junction and recombines with holes in p-type semiconductor. In the similar way, holes from p-type semiconductor cross the p-n junction and recombines with free electrons in the n-type semiconductor.

Thus, recombination takes place in depletion region as well as in p-type and n-type semiconductor.

The free electrons in the conduction band releases energy in the form of light before they recombine with holes in the valence band.

In silicon and germanium diodes, most of the energy is released in the form of heat and emitted light is too small.

However, in materials like gallium arsenide and gallium phosphide the emitted photons have sufficient energy to produce intense visible light.

How LED emits light?

When external voltage is applied to the valence electrons, they gain sufficient energy and breaks the bonding with the parent atom. The valence electrons which breaks bonding with the parent atom are called free electrons.

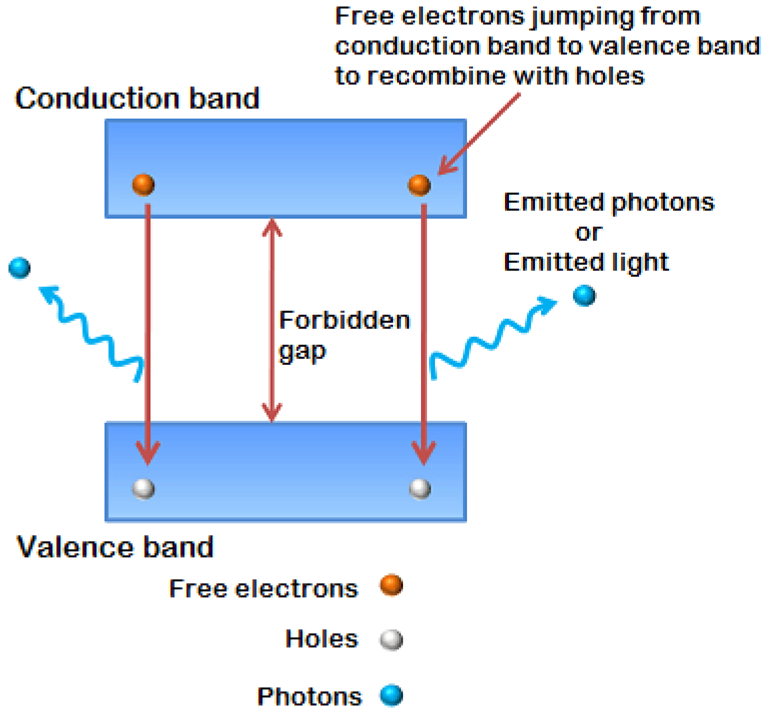
When the valence electron left the parent atom, they leave an empty space in the valence shell at which valence electron left. This empty space in the valence shell is called a hole.

The energy level of all the valence electrons is almost same. Grouping the range of energy levels of all the valence electrons is called valence band.

In the similar way, energy level of all the free electrons is almost same. Grouping the range of energy levels of all the free electrons is called conduction band.

The energy level of free electrons in the conduction band is high compared to the energy level of valence electrons or holes in the valence band. Therefore, free electrons in the conduction band need to lose energy in order to recombine with the holes in the valence band.

The free electrons in the conduction band do not stay for long period. After a short period, the free electrons lose energy in the form of light and recombine with the holes in the valence band. Each recombination of charge carrier will emit some light energy.



Process of light emission in LED

Physics and Radio-Electronics

The energy lose of free electrons or the intensity of emitted light is depends on the forbidden gap or energy gap between conduction band and valence band.

The semiconductor device with large forbidden gap emits high intensity light whereas the semiconductor device with small forbidden gap emits low intensity light.

In other words, the brightness of the emitted light is depends on the material used for constructing LED and forward current flow through the LED.

In normal silicon diodes, the energy gap between conduction band and valence band is less. Hence, the electrons fall only a short distance. As a result, low energy photons are released. These low energy photons have low frequency which is invisible to human eye.

In LEDs, the energy gap between conduction band and valence band is very large so the free electrons in LEDs have greater energy than the free electrons in silicon diodes. Hence, the free electrons fall to a large distance. As a result, high energy photons are released. These high energy photons have high frequency which is visible to human eye.

The efficiency of generation of light in LED increases with increase in injected current and with a decrease in temperature.

In light emitting diodes, light is produced due to recombination process. Recombination of charge carriers takes place only under forward bias condition. Hence, LEDs operate only in forward bias condition.

When light emitting diode is reverse biased, the free electrons (majority carriers) from n-side and holes (majority carriers) from p-side moves away from the junction. As a result, the width of depletion region increases and no recombination of charge carriers occur. Thus, no light is produced.

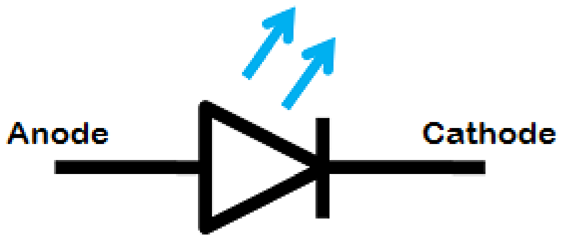
If the reverse bias voltage applied to the LED is highly increased, the device may also be damaged.

All diodes emit photons or light but not all diodes emit visible light. The material in an LED is selected in such a way that the wavelength of the released photons falls within the visible portion of the light spectrum.

Light emitting diodes can be switched ON and OFF at a very fast speed of 1 ns.

Light emitting diode (LED) symbol

The symbol of LED is similar to the normal p-n junction diode except that it contains arrows pointing away from the diode indicating that light is being emitted by the diode.



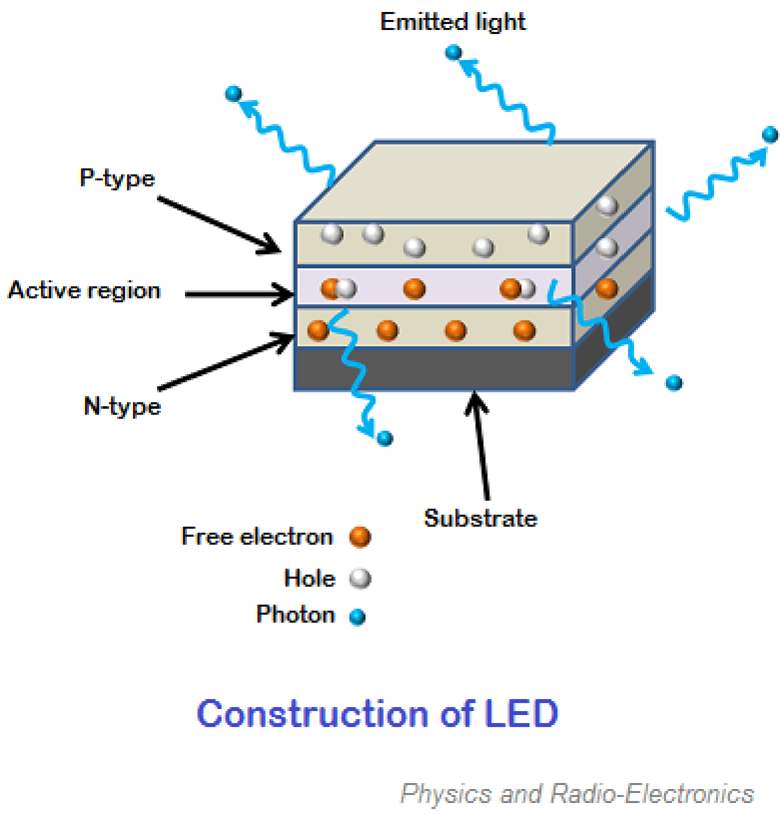
LED symbol

LEDs are available in different colors. The most common colors of LEDs are orange, yellow, green and red.

The schematic symbol of LED does not represent the color of light. The schematic symbol is same for all colors of LEDs. Hence, it is not possible to identify the color of LED by seeing its symbol.

LED construction

One of the methods used to construct LED is to deposit three semiconductor layers on the substrate. The three semiconductor layers deposited on the substrate are n-type semiconductor, p-type semiconductor and active region. Active region is present in between the n-type and p-type semiconductor layers.



When LED is forward biased, free electrons from n-type semiconductor and holes from p-type semiconductor are pushed towards the active region.

When free electrons from n-side and holes from p-side recombine with the opposite charge carriers (free electrons with holes or holes with free electrons) in active region, an invisible or visible light is emitted.

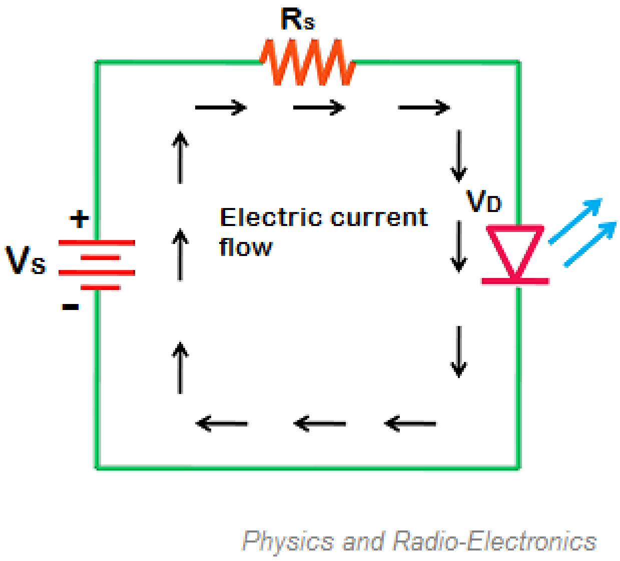
In LED, most of the charge carriers recombine at active region. Therefore, most of the light is emitted by the active region. The active region is also called as depletion region.

Biasing of LED

The safe forward voltage ratings of most LEDs is from 1V to 3 V and forward current ratings is from 200 mA to 100 mA.

If the voltage applied to LED is in between 1V to 3V, LED works perfectly because the current flow for the applied voltage is in the operating range. However, if the voltage applied to LED is increased to a value greater than 3 volts. The depletion region in the LED breaks down and the electric current suddenly rises. This sudden rise in current may destroy the device.

To avoid this we need to place a resistor (R_s) in series with the LED. The resistor (R_s) must be placed in between voltage source (Vs) and LED.



The resistor placed between LED and voltage source is called current limiting resistor. This resistor restricts extra current which may destroy the LED. Thus, current limiting resistor protects LED from damage.

The current flowing through the LED is mathematically written as

$$I_F = \frac{V_S - V_D}{R_S}$$

Where,

I_F = Forward current

V_S = Source voltage or supply voltage

V_D = Voltage drop across LED

R_S = Resistor or current limiting resistor

Voltage drop is the amount of voltage wasted to overcome the depletion region barrier (which leads to electric current flow).

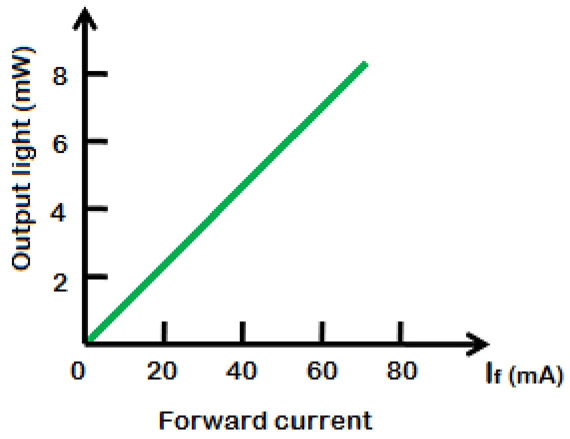
The voltage drop of LED is 2 to 3V whereas silicon or germanium diode is 0.3 or 0.7 V.

Therefore, to operate LED we need to apply greater voltage than silicon or germanium diodes.

Light emitting diodes consume more energy than silicon or germanium diodes to operate.

Output characteristics of LED

The amount of output light emitted by the LED is directly proportional to the amount of forward current flowing through the LED. More the forward current, the greater is the emitted output light. The graph of forward current vs output light is shown in the figure.



Visible LEDs and invisible LEDs

LEDs are mainly classified into two types: visible LEDs and invisible LEDs.

Visible LED is a type of LED that emits visible light. These LEDs are mainly used for display or illumination where LEDs are used individually without photosensors.

Invisible LED is a type of LED that emits invisible light (infrared light). These LEDs are mainly used with photosensors such as photodiodes.

What determines the color of an LED?

The material used for constructing LED determines its color. In other words, the wavelength or color of the emitted light depends on the forbidden gap or energy gap of the material.

Different materials emit different colors of light.

Gallium arsenide LEDs emit red and infrared light.

Gallium nitride LEDs emit bright blue light.

Yttrium aluminium garnet LEDs emit white light.

Gallium phosphide LEDs emit red, yellow and green light.

Aluminium gallium nitride LEDs emit ultraviolet light.

Aluminum gallium phosphide LEDs emit green light.

7). Temperature control of Resistance Ovens

Temperature control is necessary in resistance ovens or furnaces. Temperature may be kept constant or varied according to requirements. Control may be manual or automatic.

Temperature can also be controlled by various combinations of groups of resistances used in oven or furnace in the following ways:

1. Use of Variable Number of Elements:

In this method, the number of heating element in working are changed, so total power input is changed.

2. Change of Connections:

In this method the elements are arranged to be connected either in series or in parallel or combination of both in star or in delta by means of switches at different instants according to the requirements.

3. Transformer Tappings:

The voltage across the oven can be controlled by changing the transformer tappings. This can be done by stepping down the supply voltage to the ovens. This is the economical method for voltage control. Moreover in this method automatic temperature control is done by thermostatic control.

4. External Series Resistance:

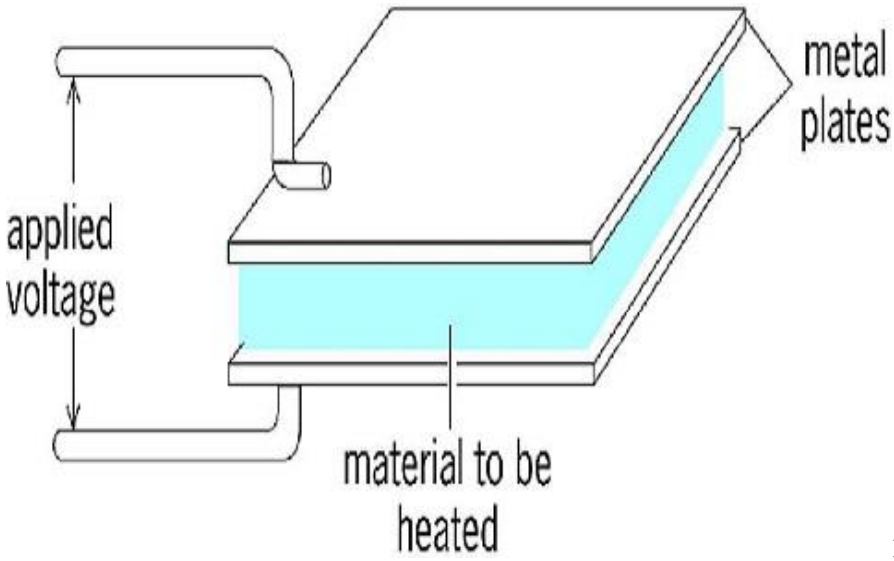
The voltage across the oven can be controlled by varying external resistance connected in series with the circuit. Its use is limited to small furnaces due continuously wastage of power in the controlling resistance.

Protective device such as overload relay is provided and set to trip the circuit at 10 or 15% above normal current against damage. In addition to above, fuses are also provided either in the main circuit of oven or in the hold on coil of the energizing contactor to provide necessary protection due to failure of automatic control system.

8). Dielectric Heating

The definition of dielectric heating can be stated as – 'the process of heating up material by causing dielectric motion in its molecules using alternating electric fields". All materials are made up of molecules that are composed of atoms. The Dielectric Heating circuit diagram is shown below.

Polar molecules contain electric dipole moments. When such molecules are exposed to the electric field, they try to align themselves in the direction of the field. When the applied field oscillates, these molecules of the material undergo rotations in order to keep themselves aligned with the field. When the field changes direction, these molecules also reverse their direction. This process is called "Dielectric Rotation".



Dielectric Heating

The temperature of the molecules is related to the kinetic energy of the molecules. In the dielectric rotation of the molecules, as the kinetic energy of the molecules increases, the temperature of the molecules increases. When the molecules collide or come in contact with other molecules, this energy gets transferred to all parts of the material thus heating up the material.

Thus dielectric rotation in the material is often referred to as Dielectric heating of the material. This heating is done using either electric fields of RF frequencies or electromagnetic fields. The applied field should be oscillating for dielectric rotation to take place. The frequency and wavelength of the applied field also affect the functioning of the system.

Dielectric Heating Working

As described below, the circuit diagram of the dielectric heating system consists of two metals plates to which the electric field is applied. The material to be heated is placed in between these two metals. There are two types of ways in which material are heating using the heating process.

Heating using low-frequency waves, as a near – field effect and heating with high-frequency waves using electromagnetic waves. The type of materials heated using these different types of waves is also different.

Low-frequency waves have higher wavelengths. Thus they can penetrate through non-conductive materials more deeply than electromagnetic waves. The systems using low-frequency fields should have the distance between the radiator and absorber to be less than $1/2\pi$ of the wavelength. So, the process of heating using a low-frequency electric field is near – contact process.

Higher frequency systems have lower wavelengths. Electromagnetic waves and microwaves are used for these systems. In these systems, the distance between metal plates is larger than the wavelength of the applied field. In these systems, conventional far-field electromagnetic waves are formed between the metal plates.

Applications of Dielectric Heating

Dielectric heating principle using high-frequency electric fields was proposed in the 1930s at Bell Telephone Laboratories. By varying the frequency of electric fields the Dielectric systems are designed for many types of applications.