BALASORE SCHOOL OF ENGINEERING

DEPARTMENT OF ELECTRICAL ENGINEERING

Sub- Basic Electrical Engineering

Semester – 1st& 2nd

Subject Code- TH-04(A&B)

Submitted by

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CHAPTER - 1

SHORT QUESTIONS

1.What is Electric current?[2017 Q1/a]

Ans: An electric current is a flow of electric charge. In electric circuits this charge is often carried by moving electrons in a wire.

The SI unit for measuring an electric current is the ampere, which is the flow of electric charge across a surface at the rate of one coulomb per second. Electric current is measured using a device called an ammeter.

2**. State Ohms Law.[2015 Q1(a),2016 Q1(a),2018 Q1(a)]**

Ohms Law states that potential difference between two end of conductors is proportional to the current flowing between them provided that temperature remained constant.

Relationship may be expressed as V α I

Or V = IR (where R is the resistance of the material).

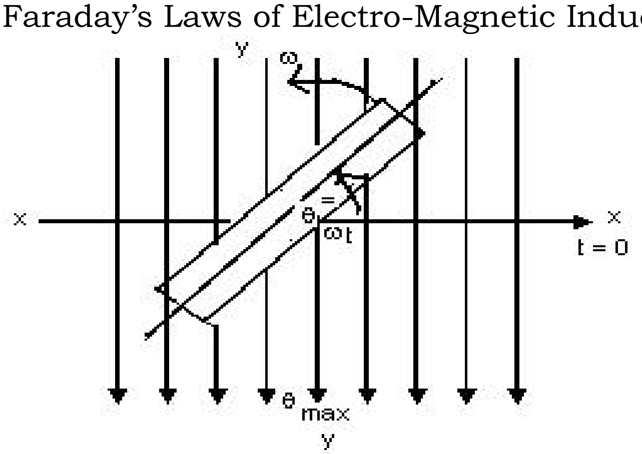
3.Write the relationship between voltage and current.[2019 Q1(a)]

Current is the **flow** of electrons flowing through a circuit. For simplicity, think of it as the number of electrons flowing through the circuit per second. voltage, intuitively, as the **force** driving the electrons through the circuit,

MEDIUM QUESTIONS

1.Explain Faraday's laws of electromagnetic induction.[2017 Q2/b,2016 Q1(c)]

Faraday's Laws of Electro-Magnetic Induction



Generation of Alternating E.M.F.

1. Faraday's first law states that 'when the number of magnetic lines of force(or magnetic flux)passing through a circuit changes, an induced emf is set up in the circuit.
2. Faraday's second law states that the magnitude of emf induced is proportional to the rate of change of magnetic lines of force.
Suppose the flux of a coil having N turns, changes from initial value φ1 weber to the final value of φ2 weber in t seconds. Then , the initial flux linkage = [No. of Turns] x [initial flux linked with coil] =N φ1
Similarly, the final flux linkage = [No. of Turns] x [final flux linked with coil] = N φ2
Hence, the Induced EMF (e) =(Change in flux linkages/Time in seconds)
The corresponding expression in different form is e=d(Nφ/dt)=Ndφ/dt volts
Since the emf set up a current in direction which opposes the very cause producing magnetic field So a minus sign is given to it.
Thus e = -N dφ/dt volt

LENZ's law

Faraday's laws provide no idea regarding the direction of induced EMF. The direction of induced EMF is however, given by Lenz's Law which states that "the direction of the induced current(or EMF) is such that it opposes the very cause producing this current(or EMF)" i.e. it opposes the change in magnetic flux.

LONG QUESTIONS

1. State& explain Kirchhoff's Law.[2015 Q2(a),2017 Q1/b,2019 Q1(c),2018 Q2(a)]

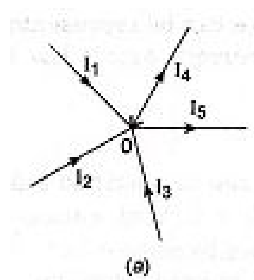
Kirchhoff's current Law

According to Kirchhoff's current Law "In any network of conductors in an electrical circuit, the algebraic sum of the current in all the conductors meeting at any point is zero".

i.e. $\Sigma I = 0$

Let there be a number of conducting elements meeting at a junction 'o' as shown in figure(a).

If the currents I_1,I_2&I_3 are flowing towards 'o'(incoming currents) be taken positive then the currents I4,&I5 flowing away from o(outgoing currents0 be negative then According to KCL, $I_1 + I_2 + I_3 - I_4 - I_5 = 0$



or $I_1 + I_2 + I_3 = I_4 + I_5$

Kirchhoff's voltage Law

According to Kirchhoff's voltage Law 'algebraic sum of the product of current & resistance of each conductor in any closed path(or mesh) in a network plus the algebraic sum of the emf's in that path is zero."

In other words $\Sigma IR + E = 0$

2. State Flemings' Left hand, right hand rule & their uses.[2019 Q1(f)]

Fleming's left hand rule

Fleming's left hand rule states that If we stretch out the thumb, the fore-finger & the middle finger of the left hand so that they are at right angles to each other, than if the fore-finger points in the direction of magnetic field, the middle finger in the direction of current then the thumb points in the direction motion or the mechanical force experienced.

Fleming's left hand rule is used for motor.

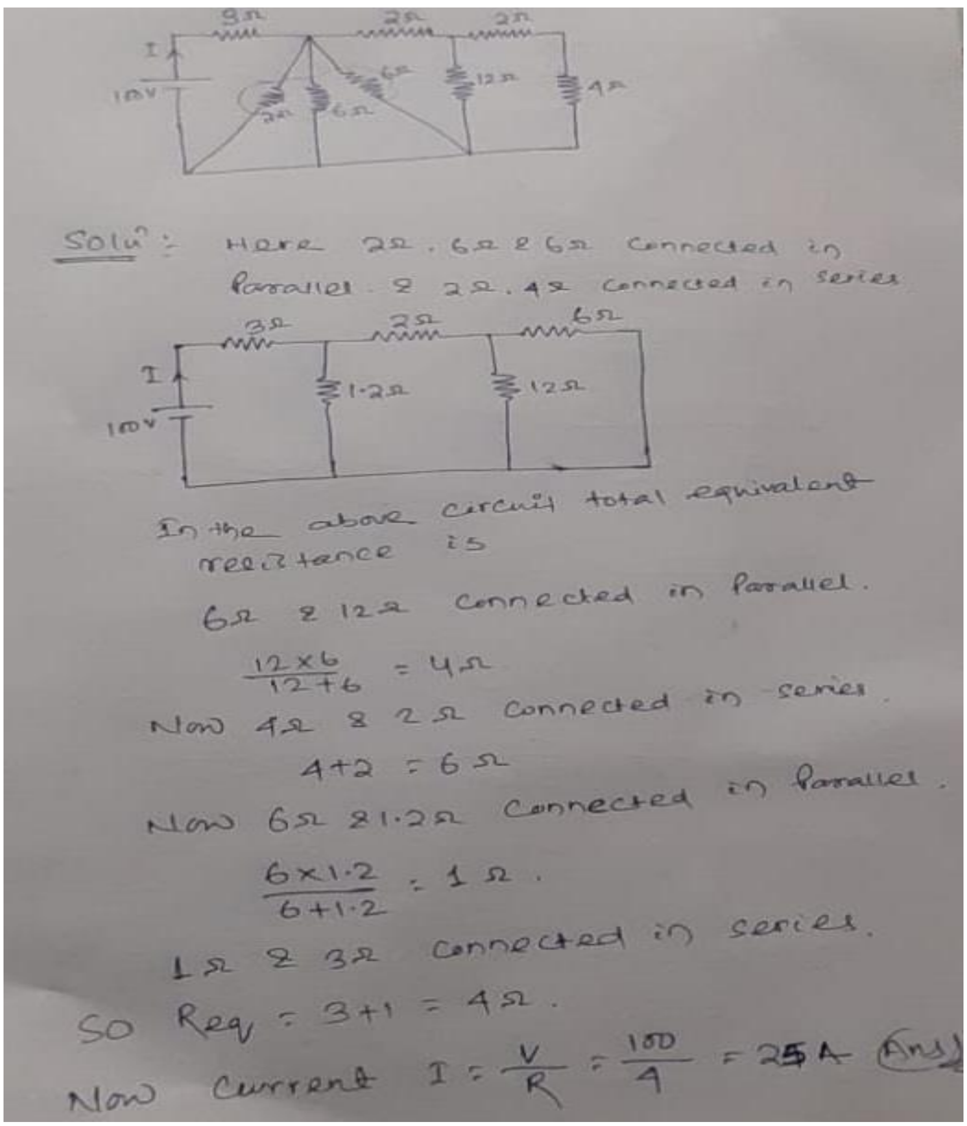
Fleming's right hand rule

Fleming's right hand rule states that If we stretch out the thumb, the fore-finger & the middle finger of the right hand so that they are at right angles to each other and if the fore-finger points in the direction of magnetic field, the thumb points in the direction motion of the conductor then the middle finger points in the direction of current.

Fleming's right hand rule is used in generator.

3. find the current in the circuit given below marked as I.(S-2019)

Solu:-



Solu^n :- Here 2Ω, 6Ω & 6Ω connected in parallel & 2Ω, 4Ω connected in series

In the above circuit total equivalent resistance is

6Ω & 12Ω connected in parallel.

$\frac{12\times6}{12+6} = 4\Omega$

Now 4Ω & 2Ω connected in series.

$4+2 = 6\Omega$

Now 6Ω & 1.2Ω connected in parallel.

$\frac{6\times1.2}{6+1.2} = 1\Omega$.

1Ω & 3Ω connected in series.

So $R_{eq} = 3+1 = 4\Omega$.

Now current $I = \frac{V}{R} = \frac{100}{4} = 25A$ (Ans)

CHAPTER – 2

Short type question & answer.(2 mark each)

1. **What is reluctance?[2016 Q5(a)]**

Reluctance (s) is akin to resistance (which limits the electric Current). Flux in a magnetic circuit is limited by reluctance. Thus reluctance(s) is a measure of the opposition offered by a magnetic circuit to the setting up of the flux.

Reluctance is the ratio of magneto motive force to the flux. Thus

$S = Mmf / \phi$

Its unit is ampere turns per webber (or AT/wb)

2.Define retentivity and coercivity.[2019 Q1(d)]

Retentivity-The ability of a substance to retain or resist magnetization, frequently measured as the strength of the magnetic field that remains in a sample after removal of an inducing field.

Coercivity- The resistance of a magnetic material to changes in magnetization, equivalent to the field intensity necessary to demagnetize the fully magnetized material.

Medium Type Question & answer (5 marks each)

1. Differentiate between Electrical ckt. & magnetic circuit.[]2017 Q6(b)]

Similarities

	Electric Field		Magnetic Field
1)	Flow of Current (I)	1)	Flow of flux (∅)
2)	Emf is the cause of flow of current	2)	MMf is the cause of flow of flux
3)	Resistance offered to the flow of Current, is called resistance (R)	3)	Resistance offered to the flow of flux, is called reluctance (S)
4)	Conductance $(\sigma) = \frac{1}{R}$	4)	Permitivity $(\mu) = 1/S$
5)	Current density is amperes per square meter.	5)	Flux density is number of lines per square meter.
6)	Current (I) - EMF/R	6)	Flux $(\varnothing) = \frac{MMF}{S}$

Dissimilarities

1)	Current actually flows in an electric Circuit.	1)	Flux does not actually flow in a magnetic circuit.
2)	Energy is needed as long as current flows	2)	Energy is initially needed to create the magnetic flux, but not to maintain it.
3)	Conductance is constant and independent of current strength at a particular temperature.	3)	Permeability (or magnetic conductance) depends on the total flux for a particular temperature.

2.Describe BH Curve.[2017 Q7/(iv),2019 Q2(d),2016 Q5(b),2018 Q3(b)]

Ans:The magnetic flux generated by an electromagnetic coil is the amount of magnetic field or lines of force produced within a given area and that it is more commonly called "Flux Density". Given the symbol B with the unit of flux density being the Tesla, T.

The magnetic strength of an electromagnet depends upon the number of turns of the coil, the current flowing through the coil or the type of core material being used, and if we increase either the current or the number of turns we can increase the magnetic field strength, symbol H.

Previously, the relative permeability, symbol μ_r was defined as the ratio of the absolute permeability μ and the permeability of free space μ_o (a vacuum) and this was given as a constant. However, the relationship between the flux density, B and the magnetic field strength, H can be defined by the fact that the relative permeability, μ_r is not a constant but a function of the magnetic field intensity thereby giving magnetic flux density as: $B = \mu H$.

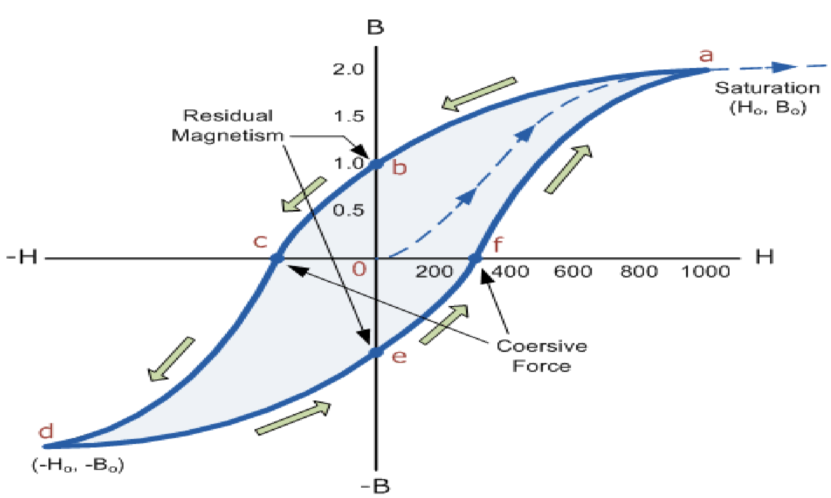
Then the magnetic flux density in the material will be increased by a larger factor as a result of its relative permeability for the material compared to the magnetic flux density in vacuum, $\mu_o H$ and for an air-cored coil this relationship is given as:

$$B = \frac{\Phi}{A} \quad \text{and} \quad \frac{B}{H} = \mu_o$$

So for ferromagnetic materials the ratio of flux density to field strength (B/H) is not constant but varies with flux density. However, for air cored coils or any non-magnetic medium core such as woods or plastics, this ratio can be considered as a constant and this constant is known as μ_o, the permeability of free space, ($\mu_o = 4.\pi.10^{-7}$ H/m).

By plotting values of flux density, (B) against the field strength, (H) we can produce a set of curves called **Magnetisation Curves**, **Magnetic Hysteresis Curves** or more commonly **B-H Curves** for each type of core material used

Magnetic Hysteresis Loop



The **Magnetic Hysteresis** loop above, shows the behaviour of a ferromagnetic core graphically as the relationship between B and H is non-linear. Starting with an unmagnetised core both B and H will be at zero, point 0 on the magnetisation curve.

If the magnetisation current, i is increased in a positive direction to some value the magnetic field strength H increases linearly with i and the flux density B will also increase as shown by the curve from point 0 to point a as it heads towards saturation.

Now if the magnetising current in the coil is reduced to zero, the magnetic field circulating around the core also reduces to zero. However, the coils magnetic flux will not reach zero due to the residual magnetism present within the core and this is shown on the curve from point a to point b.

To reduce the flux density at point b to zero we need to reverse the current flowing through the coil. The magnetising force which must be applied to null the residual flux density is called a “Coercive Force”. This coercive force reverses the magnetic field re-arranging the molecular magnets until the core becomes unmagnetised at point c.

An increase in this reverse current causes the core to be magnetised in the opposite direction and increasing this magnetisation current further will cause the core to reach its saturation point but in the opposite direction, point d on the curve.

This point is symmetrical to point b. If the magnetising current is reduced again to zero the residual magnetism present in the core will be equal to the previous value but in reverse at point e.

Again reversing the magnetising current flowing through the coil this time into a positive direction will cause the magnetic flux to reach zero, point f on the curve and as before increasing the magnetisation current further in a positive direction will cause the core to reach saturation at point a.

Then the B-H curve follows the path of a-b-c-d-e-f-a as the magnetising current flowing through the coil alternates between a positive and negative value such as the cycle of an AC voltage. This path is called a **Magnetic Hysteresis Loop**.

The effect of magnetic hysteresis shows that the magnetisation process of a ferromagnetic core and therefore the flux density depends on which part of the curve the ferromagnetic core is magnetised on as this depends upon the circuits past history giving the core a form of “memory”. Then ferromagnetic materials have memory because they remain magnetised after the external magnetic field has been removed.

However, soft ferromagnetic materials such as iron or silicon steel have very narrow magnetic hysteresis loops resulting in very small amounts of residual magnetism making them ideal for use in relays, solenoids and transformers as they can be easily magnetised and demagnetised.

Since a coercive force must be applied to overcome this residual magnetism, work must be done in closing the hysteresis loop with the energy being used being dissipated as heat in the magnetic material. This heat is known as hysteresis loss, the amount of loss depends on the material’s value of coercive force.

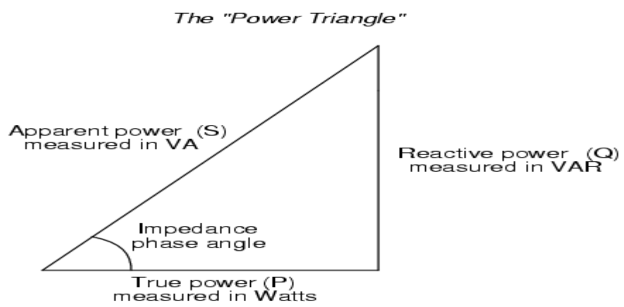
By adding additive’s to the iron metal such as silicon, materials with a very small coercive force can be made that have a very narrow hysteresis loop. Materials with narrow hysteresis loops are easily magnetised and demagnetised and known as soft magnetic materials.

CHAPTER-03

SHORT QUESTIONS

2. Explain power triangle. [2015(S)New]6(a),2017 Q3/b]

Ans :



3. Define time period.[2015(S) Q3(a)]

Ans - The time taken in second to complete one cycle of an alternating quantity is called its time period. It is generally represented by T.

4.Define Frequency. [2017 Q3/a,2015 Q3(a)]

Ans – The number of cycles that occur in one second is called the frequency (f0 of an alternating quantity. It is measured ic cycles/ sec or Hertz. One hertz is equal to one cycle/ sec.

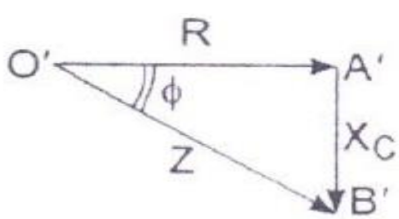
5.Define cycle [2015(S) Q3(a)]

Ans - One complete set of positive and negative values of an alternating quantity is known as cycle.

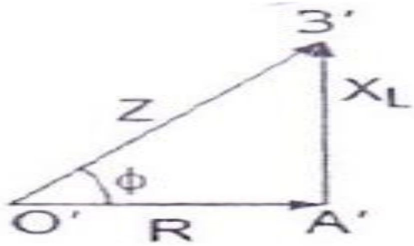
.6. **Define Amplitude.[2015 Q3(a),2016 Q2(a)]**

Ans- The maximum value (negative or positive) attained by an alternating quantity is called is called its amplitude or peak value. The amplitude of an alternating voltage or current is designated by Em(orVm) or Im.

8. Draw the impedance triangle for R-C series circuit.[2016 Q2(b)]



9. Draw the impedance triangle for R-L series circuit.[2016 Q2(b)]



10. What is form factor?[2019 Q1(e),2018 Q4(a)]

Ans -The ratio of R.M.S. value to average value of an a.c. quantity is called form factor.

Form factor = $\frac{\text{R.M.S.value}}{\text{Average value}}$

11.What do you mean by phase angle and power factor.[2017 Q4/a]

Ans: Phase angle: A phase difference expressed as an angle,360 degrees(2π radians)corresponding to one complete cycle.

Power factor: The power factor of an AC electrical power system is defined as the ratio of the real power flowing to the load to the apparent power in the circuit, and is a dimensionless number in the closed interval of −1 to 1

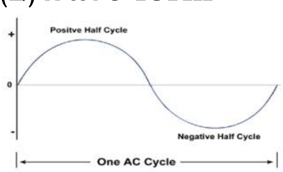
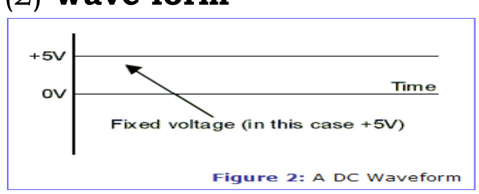
12.What is complex impedance?[2019 Q1(g)]

complex impedance is the ratio of the voltage amplitude to the current amplitude; The phase of the **complex impedance** is the phase shift by which the current lags the voltage.

MEDIUM QUESTIONS

1. State difference between A.C. and D.C.[2015(W)New]2(c)]

Ans : A.C. D.C.

A.C.	D.C.
(1)alternating current	(1) Direct Current
(2)**Wave form** 	(2) **Wave form** 
(3)Sources-Alternators	(3)Sources-DC generators,batteries
(4)Loads can be resistance,inductance and capacitance.	(4)Load can be only resistance.
(5)Ac to dc conversion by rectifiers	(5)Dc to ac conversion by inverters.

2. Explain generation of alternating emf. [2015(W)New]3(b) [2015(S)New]7(iii)]

Ans:-

Consider a conductor of N turns placedperpendicularly in a uniform magnetic field $\Phi_{m.}$

The conductor is rotated anti-clockwise with velocity of ω_m at an anle of $\theta=\omega t$.According to the Faraday's laws of electromagnetic induction emf is induced when a conductor cuts magnetic field.

The component of the magnetic field which is perpendicular to the conductor is given by $\Phi=\Phi_m\cos\omega t$ as explained in the above figure.We know that according to Faraday's laws of electromagnetic induction, $e=N\frac{d\Phi}{dt}$.

Putting the perpendicular component of magnetic field in the above equation-

$e=N\frac{d}{dt}(\Phi_m\cos\omega t)=-N\Phi_m\omega\sin\omega t=E_m\cos(\omega t-\frac{\Pi}{2})$ .In this way an alternating emf is produced.

<u>LONG QUESTIONS</u>

1. A coil having resistance of 10Ω and inductance 0.2 H connected to capacitance 20μF in series. Find current, power, apparent power, power factor and reactive power of the circuit. It is connected to 230 V, 50 Hz supply.[2015(w)old]

Ans : Given data: R=10Ω, L=0.2 H, C=20μF

$X_L=2*3.142*50*0.2=62.84\Omega$:$X_c=\frac{1}{2*3.142*50*20*}\ 10^6=159.1\Omega$

$Z=\sqrt{[10^2+(159.1-62.84)^2]}=96.77\Omega$

$I=\frac{230}{96.77}=2.37$ A

$Pf=\cos\Phi=\frac{10}{96.77}=0.103$

Power=230*2.37=545.1 VA

2. A circuit is made up of 10 Ω resistance, 12mH inductance and 281.5μF capacitance in series. The supply voltage is 100 , 50 Hz. Calculate current, power and power factor angle. [2015(W)New]3(c)

Ans : R=10Ω , L=0.012 H, C=281.5μF, V=100V, f=50Hz

$X_L=2*3.142*50*0.012=3.77\Omega$;$X_c=\frac{1000000}{2*3.142*50*281.5}=11.306\Omega$

$Z=\sqrt{[10^2+(11.306-3.77)^2]}=12.52\Omega$

$I=\frac{100}{12.52}=7.987\Omega$

Power(P)=$\frac{100*100}{12.52}$=798.22 watt

Phase angle=$\cos^{-1} 0.7987$=36.99°

3. A circuit consists of resistance R and capacitor having capacitive reactance of 60Ω connected in series across 230 V, A.C. supply,having P.F. 0.8. Determine the value of (i)resistance, (ii)power consumed, (iii) phase angle of the circuit.[2015(s) Q1(c)]

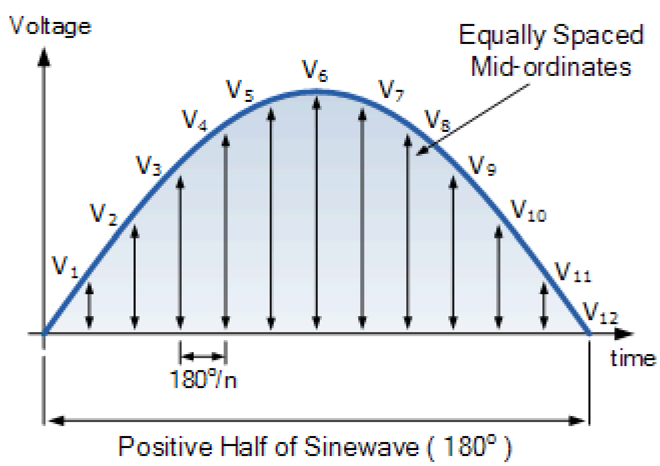
Ans : V=230 V, X_c=60Ω,$\cos\Phi$=0.8

$\sin\Phi=\sqrt{[1-.8)^2]}$=0.6,$\tan\Phi$=0.7,$\frac{Xc}{R}$=.75,R=60/0.75=80Ω

P=$\frac{2302}{80}$=661.25 watt   Power factor angleΦ=$\cos^{-1} 0.8$=36.87°

4.Give a derivation of R.M.S value of A.C electrical quantity.[2017 Q3/c]
The effective or r.m.s. value of an alternating current is that steady current (d.c.) which when flowing through a given resistance for a given time produces the same amount of heat as produced by the alternating current when flowing through the same resistance for the same time

Graphical Method



The graphical method above is a very good way of finding the effective or RMS voltage, (or current) of an alternating waveform that is not symmetrical or sinusoidal in nature. In other words the waveform shape resembles that of a complex waveform. However, when dealing with pure sinusoidal waveforms we can make life a little bit easier for ourselves by using an analytical or mathematical way of finding the RMS value.

A periodic sinusoidal voltage is constant and can be defined as $V_{(t)} = V_{max}*\cos(\omega t)$ with a period of T. Then we can calculate the root-mean-square (rms) value of a sinusoidal voltage ($V_{(t)}$) as:

$$V_{RMS} = \sqrt{\frac{1}{T}\int_0^T V_m^2 \cos^2(\omega t)\, dt}$$

Integrating through with limits taken from 0 to 360° or "T", the period gives:

$$V_{RMS} = \sqrt{\frac{V_m^2}{2T}\left[t + \frac{1}{2\omega}\sin(2\omega t)\right]_0^T}$$

Where: Vm is the peak or maximum value of the waveform. Dividing through further as $\omega = 2\pi/T$, the complex equation above eventually reduces down too:

RMS Voltage Equation

$$V_{RMS} = V_{pk}\frac{1}{\sqrt{2}} = V_{pk} \times 0.7071$$

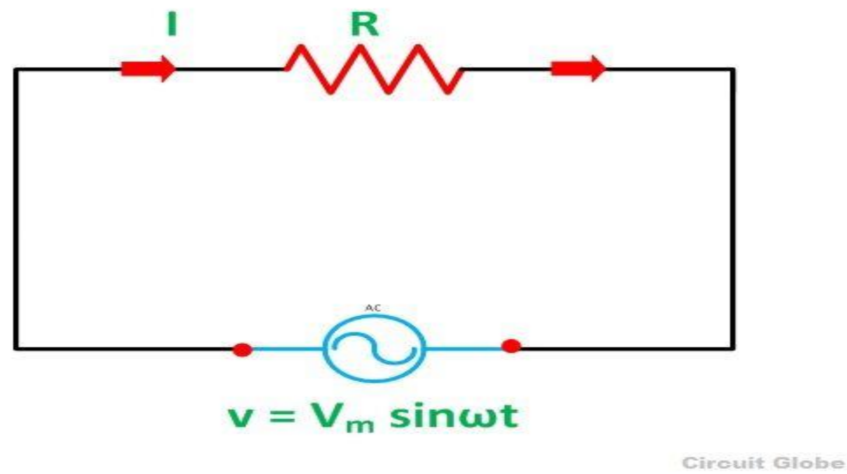
5.Explain and derive AC through pure resistance .[2019 Q2(c)]

In an AC circuit, the ratio of voltage to current depends upon the supply frequency, phase angle, and phase difference. In an AC resistive circuit, the value of resistance of the resistor will be same irrespective of the supply frequency.

Let the alternating voltage applied across the circuit be given by the equation

$$v = V_m \text{Sin}\omega t \,\ldots\ldots\ldots\ldots\ldots(1)$$

Then the instantaneous value of current flowing through the resistor shown in the figure below will be



$$i = \frac{v}{R} = \frac{V_m}{R} \sin\omega t \ldots\ldots\ldots(2)$$

The value of current will be maximum when ωt= 90 degrees or sinωt = 1

Putting the value of sinωt in equation (2) we will getCircuit GlobeCircuit TheoryPure Resistive AC Circuit

Pure Resistive AC Circuit

The circuit containing only a pure resistance of R ohms in the AC circuit is known as **Pure Resistive AC Circuit**. The presence of inductance and capacitance does not exist in a purely resistive circuit. The Alternating current and voltage both move forward as well as backwards in both the direction of the circuit. Hence, the Alternating current and voltage follows a shape of Sine wave or known as the sinusoidal waveform.

In the pure resistive circuit, the power is dissipated by the resistors and the phase of the voltage and current remains same i.e., both the voltage and current reach their maximum value at the same time. The resistor is the passive device which neither produce nor consume electric power. It converts the electrical energy into heat.

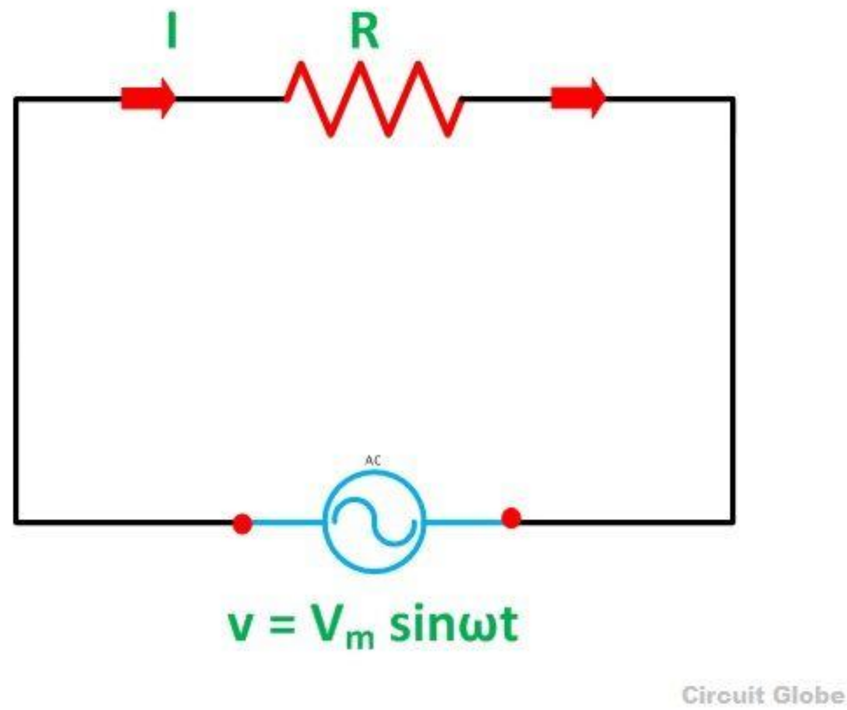
Explanation of Resistive Circuit

In an AC circuit, the ratio of voltage to current depends upon the supply frequency, phase angle, and phase difference. In an AC resistive circuit, the value of resistance of the resistor will be same irrespective of the supply frequency.

Let the alternating voltage applied across the circuit be given by the equation

$$v = V_m \text{Sin}\omega t \ldots\ldots\ldots\ldots\ldots(1)$$

Then the instantaneous value of current flowing through the resistor shown in the figure below will be



$$i = \frac{v}{R} = \frac{V_m}{R} \sin\omega t \dots\dots\dots (2)$$

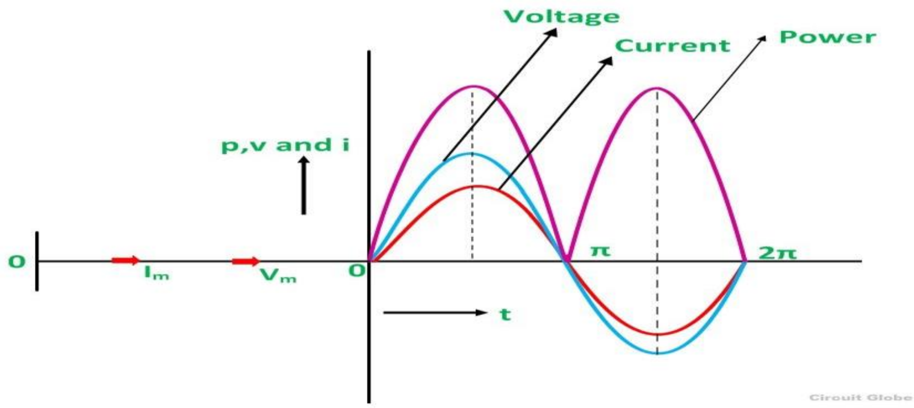
The value of current will be maximum when ωt= 90 degrees or sinωt = 1

Putting the value of sinωt in equation (2) we will get

$$i = I_m \sin\omega t \dots\dots\dots. (3)$$

Phase Angle and Waveform of Resistive Circuit

From equation (1) and (3), it is clear that there is no phase difference between applied voltage and the current flowing through a purely resistive circuit, the i.e. phase angle between voltage and current is zero. Hence, in an AC circuit containing pure resistance, current is in phase with the voltage as shown in the waveform figure below.



Waveform and Phasor Diagram of Pure Resistive Circuit

Power in Pure Resistive Circuit

The three colors red, blue and pink shown in the power curve or the waveform indicate the curve for current, voltage and power respectively. From the phasor diagram, it is clear that the current and voltage are in phase with each other that means the value of current and voltage attains its peak at the same instant of time, and the power curve is always positive for all the values of current and voltage.

As in DC supply circuit, the product of voltage and current is known as the Power in the circuit similarly the power is same in the AC circuit also, the only difference is that in AC circuit the instantaneous value of voltage and current is taken into consideration. Therefore, the instantaneous power in a purely resistive circuit is given by the equation shown below

Instantaneous power, p= vi

$$p = (V_m \sin\omega t)(I_m \sin\omega t)$$

$$p = \frac{V_m I_m}{2} 2\sin^2\omega t = \frac{V_m}{\sqrt{2}}\frac{I_m}{\sqrt{2}}(1 - \cos 2\omega t)$$

$$p = \frac{V_m}{\sqrt{2}}\frac{I_m}{\sqrt{2}} - \frac{V_m}{\sqrt{2}}\frac{I_m}{\sqrt{2}}\cos 2\omega t$$

The average power consumed in the circuit over a complete cycle is given by

$$P = \text{average of } \frac{V_m}{\sqrt{2}}\frac{I_m}{\sqrt{2}} - \text{ average of } \frac{V_m}{\sqrt{2}}\frac{I_m}{\sqrt{2}} \cos\omega t \ldots\ldots (4)$$

As valve of cosωt is zero

Putting the value of cosωt in equation (4) the value of power will be given by

$$P = V_{r.m.s}I_{r.m.s} - 0$$

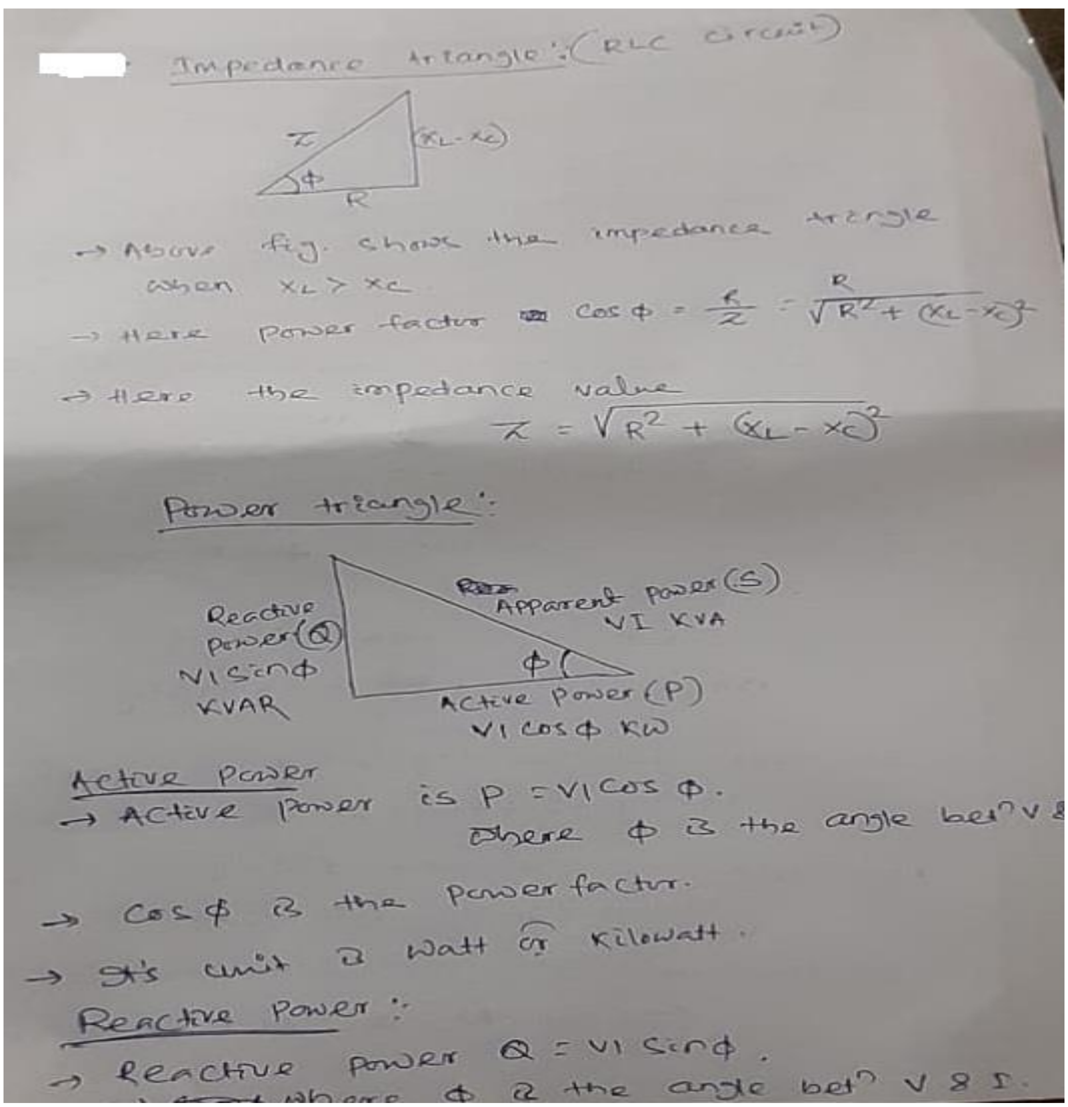
Where,

- P – average power
- $V_{r.m.s}$ – root mean square value of supply voltage
- $I_{r.m.s}$ – root mean square value of the current
- Hence, the power in a pure resistive circuit is given by

$$P = VI$$

The voltage and the current in the pure resistive circuit are in phase with each other having no phase difference with phase angle zero. The alternating quantity reaches their peak value at the interval of the same time period that is the rise and fall of the voltage and current occurs at the same time.

6.Explain Impedance triangle and power triangle with neat diagram.[2019 Q2(e)]



7.A 60w ,220v lamp is connected in series a 100w,220v lamp & the series combination is connected across a 440v supply.which lamp will experience a voltage more than its rated value.(s-2019)

Solu:-

Solⁿ:- Given data:

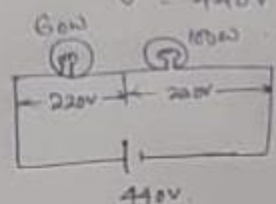
$P_{L_1} = 60$ watt

$P_{L_2} = 100$ watt

$V_{L_1} = 220V$

$V_{L_2} = 220V$

$V = 440V$



for Lamp-01 (60w)

$$P_{L_1} = \frac{V_1^2}{R_1} \Rightarrow R_1 = \frac{V_1^2}{P_{L_1}} = \frac{220^2}{60} = 806.66\ \Omega$$

for Lamp-02 (100w)

$$P_{L_2} = \frac{V_2^2}{R_2} \Rightarrow R_2 = \frac{V_2^2}{P_{L_2}} = \frac{220^2}{100} = 484\ \Omega$$

Now total current drawn from the supply.

$$I = \frac{V}{R} = \frac{440}{(806.66+484)} = \frac{440}{1290.66} = 0.34\ A$$

Now voltage experience by Lamp-1 (60w)

$$V_{L_1} = IR_1 = 0.34 \times 806.66 = 274.26\ V$$

voltage experience by Lamp-2 (100w).

$$V_{L_2} = IR_2 = 0.34 \times 484 = 164.56\ V$$

So 60w Lamp will experience a voltage more than its rated value.

CHAPTER-04

SHORT QUESTIONS

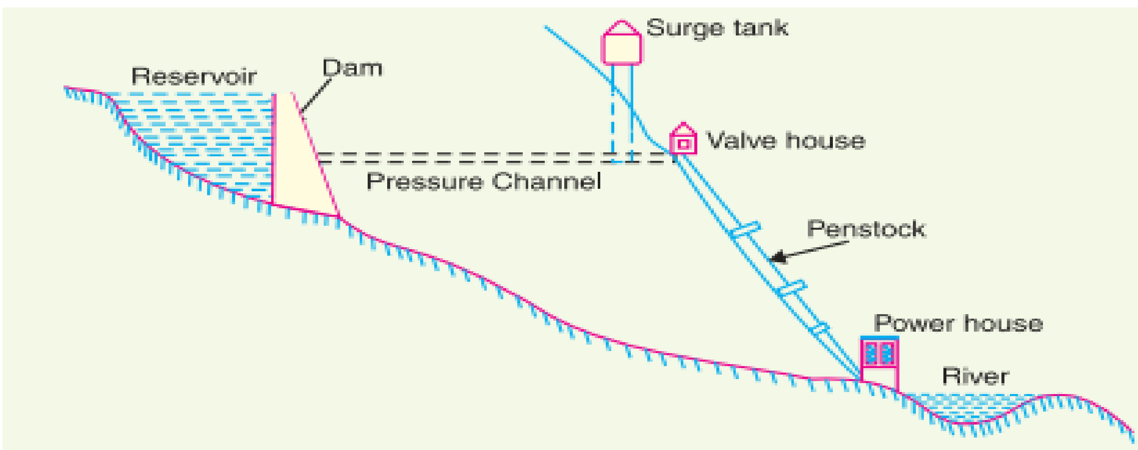
1.What is the function of moderator in Nuclear power plant?[2019 Q1(h)]

A moderator is a material used in a nuclear reactor to slow down the neutrons produced from fission. By slowing the neutrons down the **probability** of a neutron interacting with Uranium-235 nuclei is greatly increased thereby maintaining the chain reaction.

LONG QUESTIONS

1. Write short notes on hydroelectric power plant. [2015(S)New]7(iii),2019 Q4]

Ans-The plant in which potential energy of water at height is used to produce electricity is called hydelpower plant. The block diagram ofhydel power plant is shown below.



Schematic arrangement of a Hydro-electric plant

The components of hydelpower plants are-

- Dam- It is a masonary,earthfill,concrete barrier built on one side of a hill to create water head.
- Reservoir- It is the catchment area on hill in which water from river is stored at ahead.
- Pressure Channel-It is the conduit connecting reservoir to the power house.
- Surge Tank- It is a open tank placed before power house to maintain pressure in the penstock.
- PENSTOCKS:-Penstocks are open or close conduits which carry water to the turbines.They are generally made of reinforced concrete or steel.
- WATER TURBINES: - Water turbines are used to convert the energy of falling water into mechanical energy.
- ALTERNATOR: - The alternator converts the mechanical energy of turbine to electrical energy.

- SPILWAYS: - There are times when the river flow exceeds the storage capacity of thereservoir.In order to discharge the surplus water from the storage reservoir into the riveron the down-stream side of the dam, spill ways are used.
- HEAD WORKS:-The head works consists of the diversion structures at the head of anintake.They generally include booms and racks for diverting floating debris,sluices for by-passing debris,sediments and valves for controlling the flow of water to the turbine.

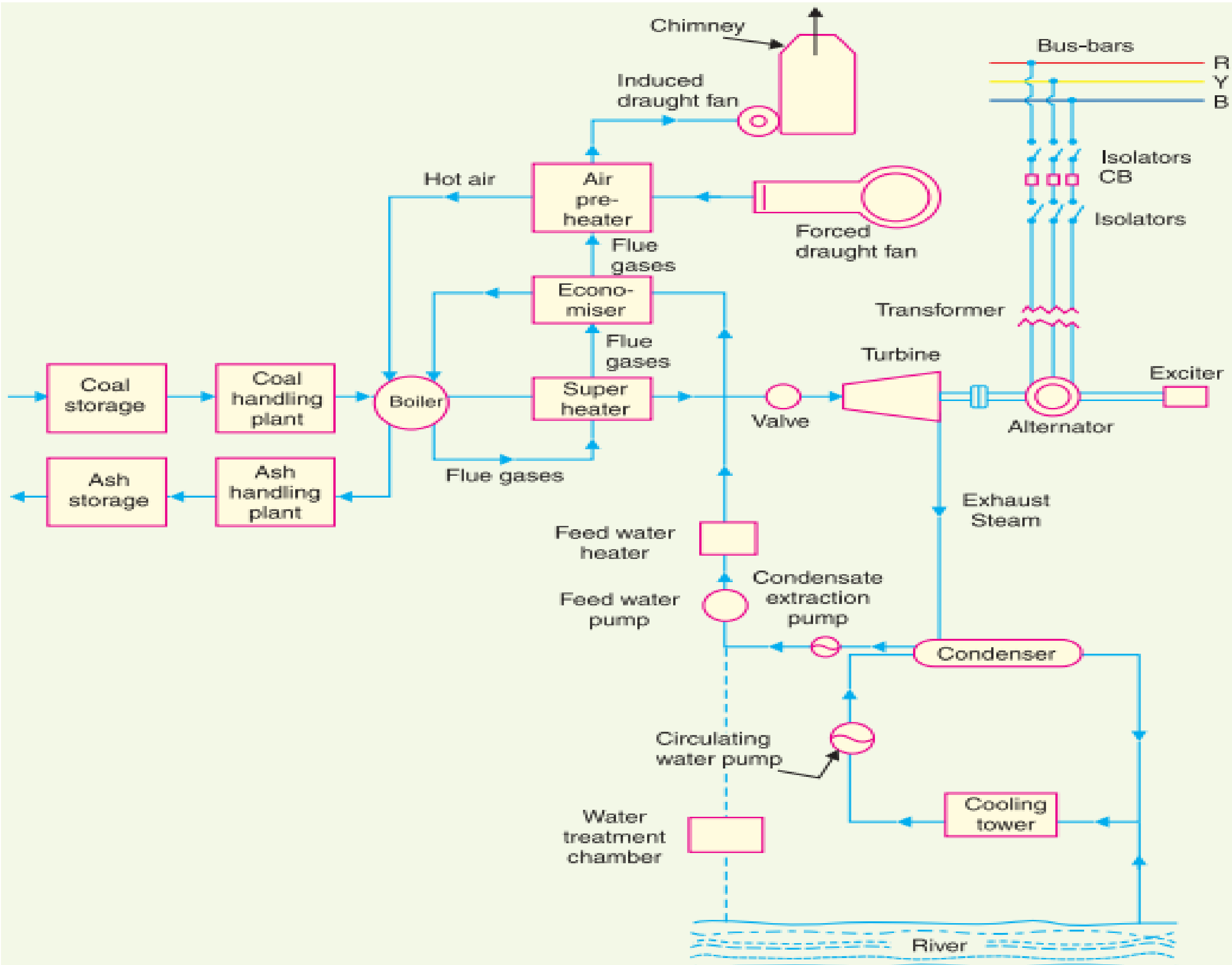
2. Explain how power is generated in a Steam (Thermal) power station with block diagram.[2017 Q5(c),2018 Q5(c)]

Ans – <u>Thermal power station</u>

<u>MAIN UNITS OF PLANT</u>

- COAL STORAGE PLANT: - Coal is transported to the power station by road or rail and is stored in coal storage plant.
- COAL HANDLING PLANT: - : From the coal storage plant coal is delivered to the coal handling plant where it is pulverized for rapid combustion without using excess amount ofair.
- ASH STORAGE PLANT: - The coal is burnt in the boiler & the ash produced after the complete combustion of coal is removed to the ash handling plant.
- ASH HANDLING PLANT: - the ash from ash handling plant is then delivered to the ash storage plant for subsequent use as fertilizer etc.
- BOILER:- The heat of combustion of coal in the boiler is utilized to convert water into steam at very high temperature and pressure. The flue gases from the boiler makes their journey through super heater, economizer, air pre-heater & are finally exhausted to the atmosphere through the chimney.
- SUPERHEATER:- The steam produced in the boiler is wet and is passed through super heater where it is dried and super heated.
- ECONOMISER:- An economizer is essentially a feed water heater & derives heat from the flue gases for the purpose.
- AIR PREHEATER:- Air pre-heater increases the temperature of the air supplied for coal burning by deriving heat from flue gases.
- FORCED DRAUGHT FAN :-It draws air from atmosphere which is supplied to the boiler for effective combustion.
- INDUCED DRAUGHT FAN : it draws the flue gas and sends to chimney.
- CHIMNEY:- The hot flue gases go to the atmosphere though chimney.
- STEAM TURBINE:- The dry and super heated steam from the super heater is fed to the steam turbine which converts the heat energy of steam to mechanical energy.
- ALTERNATOR:- The alternator converts the mechanical energy of steam turbine to electrical energy.
- CONDENSER: - In order to improve the efficiency of the plant the steam exhausted from the turbine is condensed by means of a condenser. The condensate from the condenser is used as feed water to the boiler.

➢ COOLING TOWER: The cooling tower provides a cooling arrangement for the feed water to be reused in boiler.



Working of Thermal power Plant : When the water from condenser is fed to the boiler through Economiser it remains a little hot .The Boiler is a extremely heated chamber because of a continuous burning of Coal in presence of air injected by F.D fan through pre-heater. So,the water gets converted to steam with very high temperature and pressure and reaches the Steam Turbine through Super-Heater. The Internal Energy of Steam gets converted to Mechanical Energy by Turbine and the Alternator converts the mechanical Energy of Turbine output to Electrical Energy .The Electrical Energy thus produced is supplied to the Bus-Bar for Power use.

Q-3.Explain how power is generated in nuclear power station with block diagram.

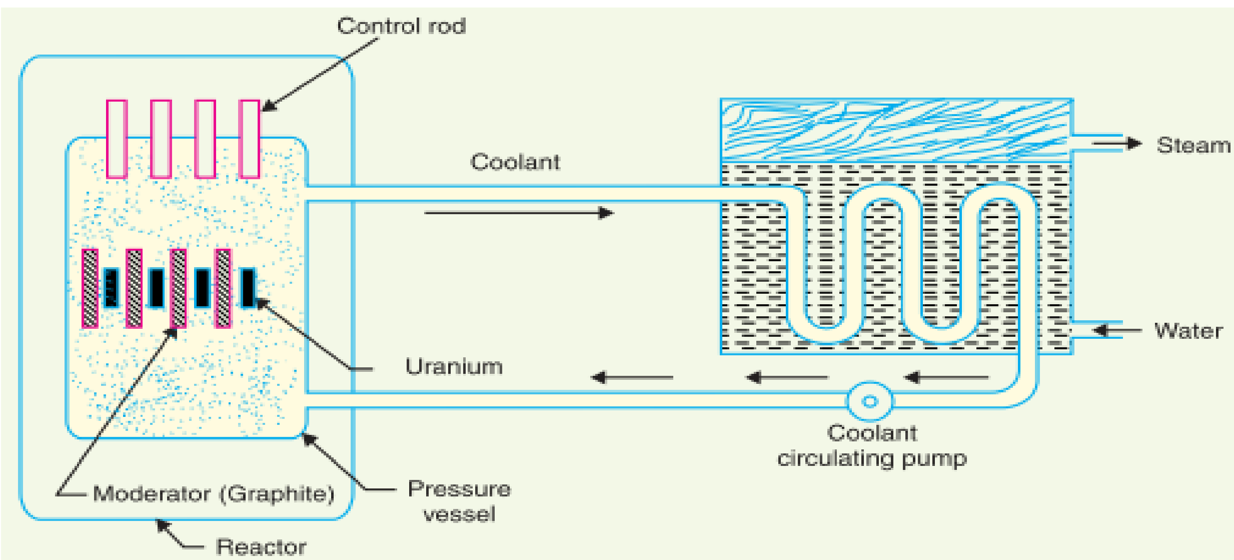
Ans - NUCLEAR POWER STATION**[2015(S)2(b),2017 Q5/c]**

When a U-235 atom is struck by a slow neutron ,it will split into two or more fragments. This is called a nuclear fission .This splitting (fission) is accompanied by release

of thermal energy in large quantity and two or three fast neutrons. These fast moving neutrons are slowed down by moderators so that they have high probability to hit other u- 235 atoms which in turn get fissioned and release heat and neutrons. This continuous self sustaining sequence of nuclear fissions is called CHAIN REACTION.

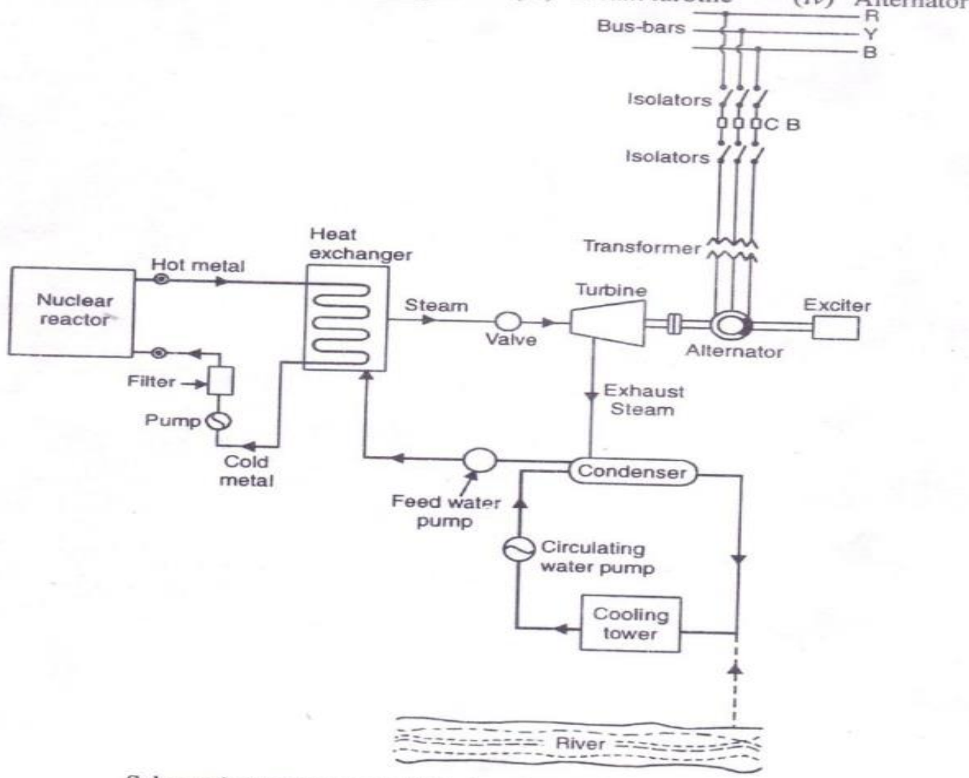
MAIN UNITS OF PLANT

- NUCLEAR REACTOR: - It is an apparatus in which the nuclear fuel(U235) is subjected to nuclear fission.
- HEAT EXCHANGER:-The coolant gives up heat to the heat exchanger which is utilized in raising the steam & after giving up heat the coolant is again fed to the reactor.
- STEAM TURBINE:- The dry and super heated steam from the super heater is fed to the steam turbine which converts the heat energy of steam to mechanical energy.
- ALTERNATOR:- The alternator converts the mechanical energy of turbine to Electrical Energy.



Nuclear Reactor

(i) Nuclear reactor (ii) Heat exchanger (iii) Steam turbine (iv) Alternator.



Schematic arrangement of Nuclear Power Station

Working of Nuclear Power Plant : As discussed earlier, the chain reaction produces a huge amount of heat inside the Nuclear Reactor and requires a lot of care to control this reaction. The heat of the Reactor is carried to Heat-Exchanger by molten sodium which also heats the water injected into this Heat Exchanger chamber. After the water gets converted to steam with very high temperature and high pressure ,the Turbine converts the internal Energy of steam to Mechanical Energy and this is converted to Electrical Energy by Alternator as before.

CHAPTER-05

SHORT QUESTIONS

1. **State relation between line voltage and phase voltage, line current and phase current in star and delta connected system. [2015 Q7(a),2019 Q1(j)]**

   Ans: In star connection

   - Line voltage = $\sqrt{3}$ X Phase voltage
   - Line current = Phase current

   In Delta connection

   - Line voltage = phase voltage
   - Line current = $\sqrt{3}$ X phase current

2. **What is back emf? [2015(W)New]4(a)]**

Ans:Backemf-It is the emf induced in the armature conductor of dc motor when the conductor rotates in the magnetic field.

$$E=\frac{ZNp\Phi}{60*A}$$.

3.What is commutator ?[2017 Q5/a]

Ans: The function of a commutator, in a dc generator, is to collect the current generated in armature conductors. Whereas, in case of a dc motor, commutator helps in providing current to the armature conductors. A commutator consists of a set of copper segments which are insulated from each other.

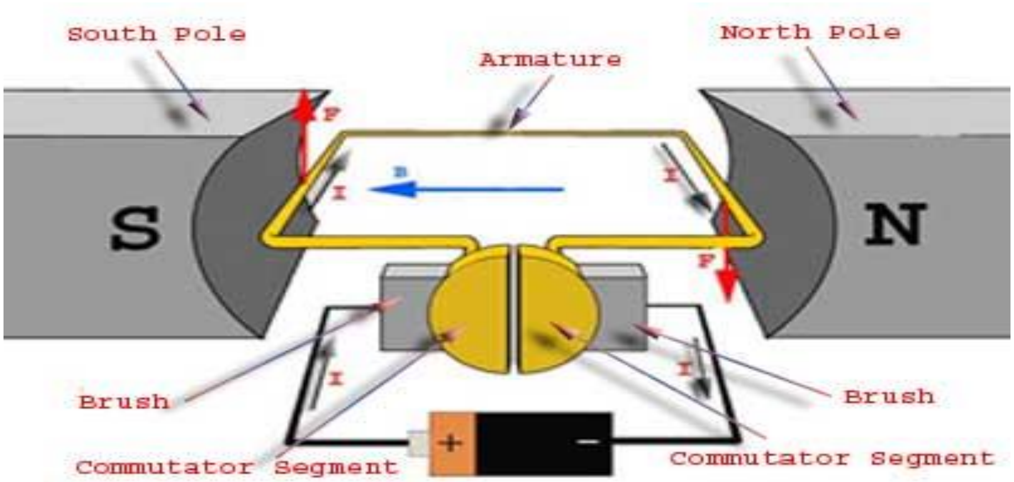
4.what is the necessity of starter in dc motor?[2019 Q1(i)]

Starters are used to protect **DC motors** from damage that can be caused by very high current and torque during startup. They do this by providing external resistance to the **motor**, which is connected in series to the **motor's** armature winding and restricts the current to an acceptable level.

MEDIUM QUESTIONS

1. Explain principle of operation of dc motor.(2015)(W)Old;2(b) [2015(W)New]4(c),2018 Q6(a)]

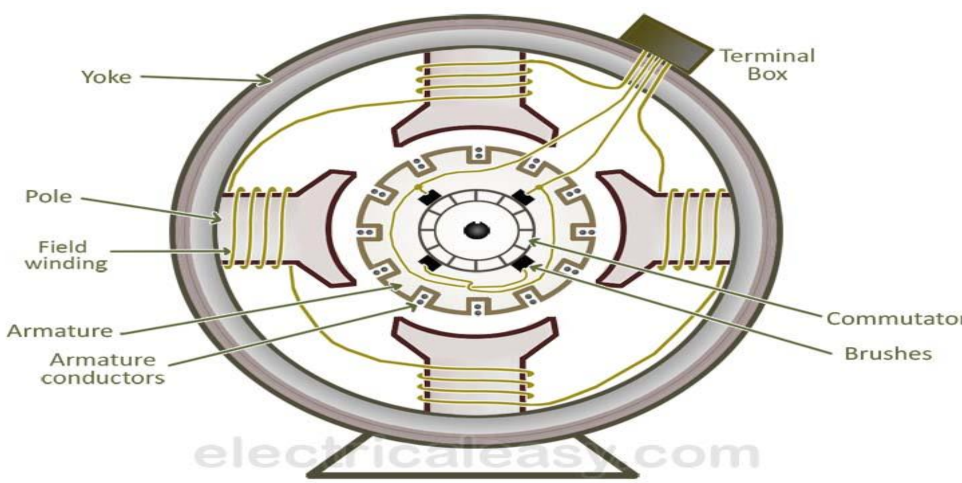
Ans : A DC motor in simple words is a device that converts direct current(electrical energy) into mechanical energy. It’s of vital importance for the industry today, and is equally important for engineers to look into the working principle of DC motor in details that has been discussed in this article. In order to understand the operating principle of DC motorwe need to first look into its constructional feature.



Now to go into the details of the operating principle of DC motorit's important that we have a clear understanding of Fleming's left hand rule to determine the direction of force acting on the armature conductors of DC motor.

Fleming's left hand rule says that if we extend the index finger, middle finger and thumb of our left hand in such a way that the current carrying conductor is placed in a magnetic field (represented by the index finger) is perpendicular to the direction of current (represented by the middle finger), then the conductor experiences a force in the direction (represented by the thumb) mutually perpendicular to both the direction of field and the current in the conductor.

2. Explain main parts of dc machines.[2015(W)4(b),2016 Q3(a)]



The above figure shows the constructional details of a simple **4-pole DC machine**. A DC machine consists two basic parts; stator and rotor. Basic constructional parts of a DC machine are described below.

1. **Yoke:** The outer frame of a dc machine is called as yoke. It is made up of cast iron or steel. It n provides mechanical strength to the whole assembly and the magnetic flux produced by the field winding.
2. **Poles and pole shoes:** Poles are joined to the yoke with the help of bolts or welding. They carry field winding and pole shoes are fastened to them. Pole shoes serve two purposes; (i) they support field coils and (ii) spread out the flux in air gap uniformly.
3. **Field winding:** They are usually made of copper. Field coils are wound and placed on each pole and are connected in series. They are wound in such a way that, when energized, they form alternate North and South poles.
4. **Armature core:** Armature core is the rotor of the machine. It is cylindrical in shape with slots to carry armature winding. The armature is built up of thin laminated circular steel disks for reducing eddy current losses. It may be provided with air ducts for the axial air flow for cooling purposes. Armature is keyed to the shaft.
5. **Armature winding:** It is usually a former wound copper coil which rests in armature slots. The armature conductors are insulated from each other and also from the armature core.
6. **Commutator and brushes:** The function of a commutator, in a dc generator, is to collect the current generated in armature conductors. Whereas, in case of a dc motor, commutator helps in providing current to the armature conductors. A commutator consists of a set of copper segments which are insulated from each other. Brushes are usually made from carbon or graphite. They rest on commutator segments and slide on the segments when the commutator rotates keeping the physical contact to collect or supply the current.

4 . What is the necessity of starter?[2015(W)7(b),2018 Q7(a)]

Ans.As current drawn by a d.c. motor armature is given by the relation.

$I_a = V - E_b / R_a$

when the motor is at rest, i.e. N=0, no back emf developed in the armature. If now full supply voltage is applied across the stationary armature, then it will draw a very large current as armature resistance is very small. This excessive current will blow out the fuses and may damage the commutator and brushes etc.

To avoid this happening, a resistance is introduced in series with the armature (for the duration of starting period only i.e. 5 to 10 seconds) which limits the starting current to a safe value. The starting resistance is gradually cut out as the motor gains speed and develops the back emf. This starting resistance with some protective devices is known as starter.

5.What are the types of D.C generators. Explain with circuit diagram[2017 Q4/b,2018 Q6(b)]

Ans: *Energy can be converted from one form to other form"* – A generator does the same – it converts mechanical energy to electrical energy. Mechanical energy can be created by using water turbines, steam turbines, internal combustion engines etc. And a generator converts this mechanical energy to electrical energy. Generators can be broadly classified as AC generators and DC generators. Here lets take a look the the types of DC generators.

DC generators are classified based on their method of excitation. So on this basis there are two types of DC generators:-

1. Separately excited DC generator

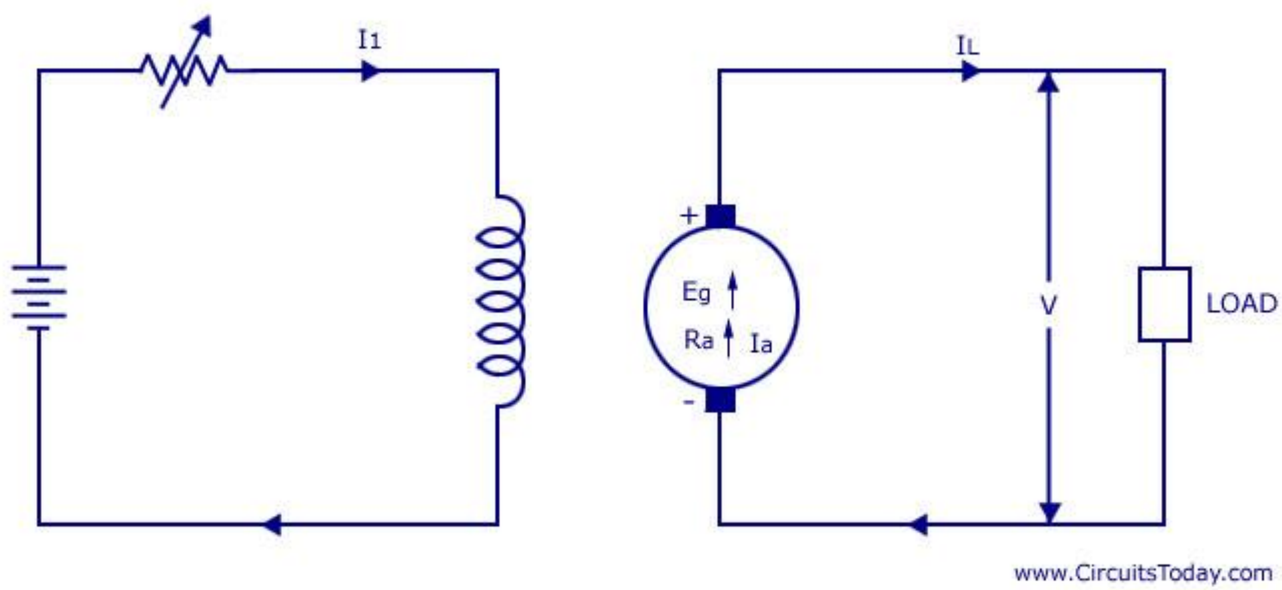
2. Self excited DC generator

Self excited DC generator can again be classified as **1) DC Series generator 2) DC Shunt generator and 3) DC Compound generator.**

Let's take a brief look at how all these differ.

1. Separately excited DC generator

As you can guess from the name itself , this dc generator has a field magnet winding which is excited using a separate voltage source (like battery). You can see the representation in the below image. The output voltage depends on the speed of rotation of armature and field current. The higher the speed of rotation and current – the higher the output e.m.f



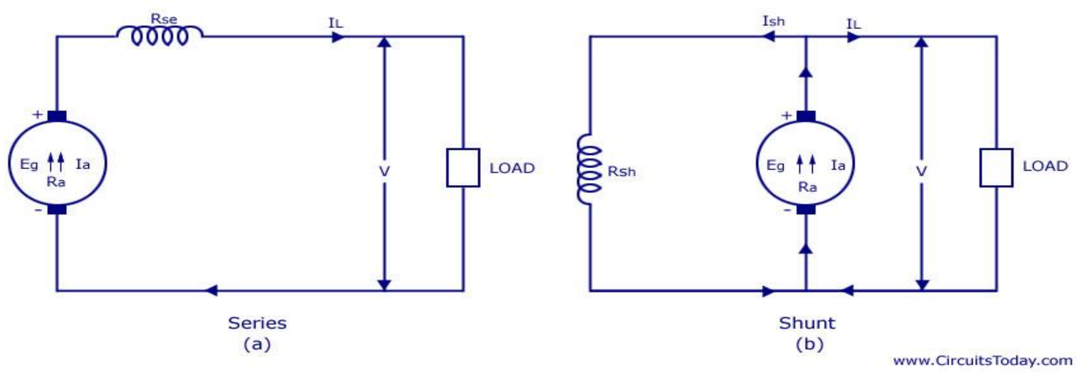
Note: Separately excited DC generators are rarely used in practice.

2. Self Excited DC Generator

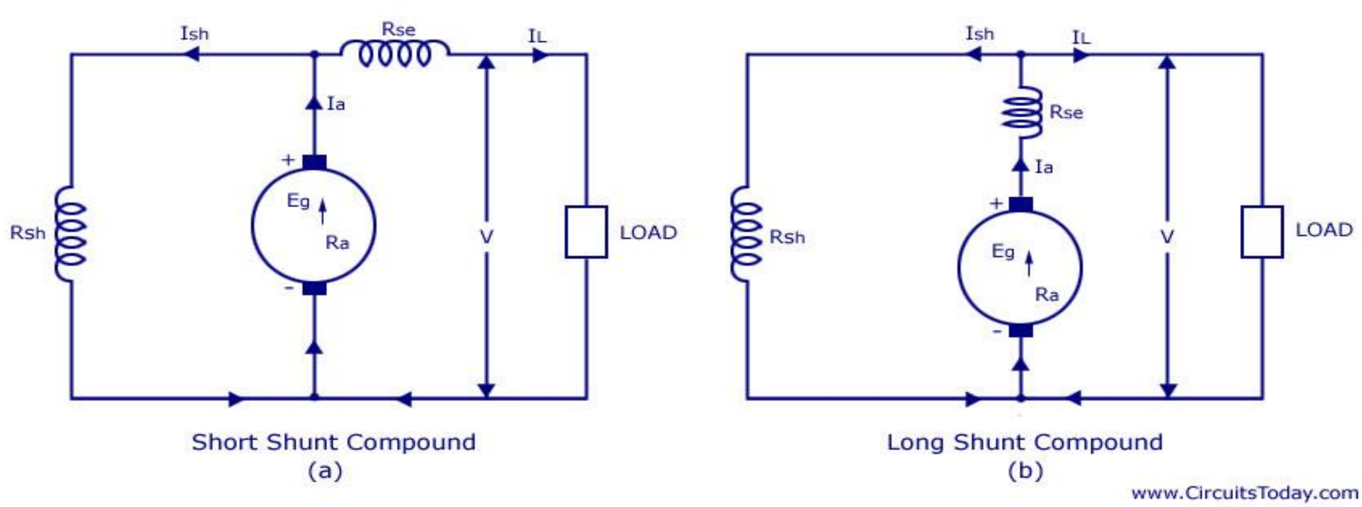
These are generators in which the field winding is excited by the output of the generator itself. As described before – there are three types of self excited dc generators – they are **1) Series 2) Shunt and 3) Compound.**

A series DC generator is shown below in fig (a) – in which the armature winding is connected in series with the field winding so that the field current flows through the load as well as the field winding.Field winding is a low resistance,thick wire of few turns. Series generators are also rarely used!

A shunt DC generator is shown in figure (b), in which the field winding is wired parallel to armature winding so that the voltage across both are same. The field winding has high resistance and more number of turns so that only a part of armature current passes through field winding and the rest passes through load.



A compound generator is shown in figure below. It has two field findings namely Rsh and Rse. They are basically shunt winding (Rsh) and series winding (Rse). Compound generator is of two types – 1) Short shunt and 2) Long shunt



Short shunt:- Here the shunt field winding is wired parallel to armature and series field winding is connected in series to the load. It is shown in fig (1)

Long shunt:- Here the shunt field winding is parallel to both armature and series field winding (Rse is wired in series to the armature). It is shown in figure (2)

LONG QUESTIONS

1. Explain working principle of 3-Φ induction motor. [2015(W)New]5(c) [2015(S)New]7(a)

Ans : Basic working principle of an Induction Motor

In a DC motor, supply is needed to be given for the stator winding as well as the rotor winding. But in an induction motoronly the stator winding is fed with an AC supply.

- Alternating flux is produced around the stator winding due to AC supply. This alternating flux revolves with synchronous speed. The revolving flux is called as "Rotating Magnetic Field" (RMF).
- The relative speed between stator RMF and rotor conductors causes an induced emf in the rotor conductors, according to the Faraday's law of electromagnetic induction. The rotor conductors are short circuited, and hence rotor current is produced due to induced emf. That is why such motors are called as induction motors.

  (This action is same as that occurs in transformers, hence induction motors can be called as rotating transformers.)

- Now, induced current in rotor will also produce alternating flux around it. This rotor flux lags behind the stator flux. The direction of induced rotor current, according to Lenz's law, is such that it will tend to oppose the cause of its production.
- As the cause of production of rotor current is the relative velocity between rotating stator flux and the rotor, the rotor will try to catch up with the stator RMF. Thus the rotor rotates in the same direction as that of stator flux to minimize the relative velocity. However, the rotor never succeeds in catching up the synchronous speed. This is the basic working principle of induction motor of either type, single phase of 3 phases.

3. Derive the emf equation of DC generator.[2015(S)4(b),2017 Q7/(iii),2019 Q5]

Ans.Let ϕ= flux / pole in webber.

Z = Total Number of armature conductors.

P = No of generator poles

A = No of Parallel paths in armature

N = Armature rotation in revolutions per minute (RPM)

Generated EMF (Eg) = emf induced in any one Parallel path in armature.

Average emf. Generated / Conductor $=\frac{d\phi}{dt}$

Now flux cut/ conductor in one revolution dϕ= ϕPwb

Therefore time for one revolution dt = $\frac{60}{N}$

Hence $\frac{d\phi}{dt} = \frac{\phi P}{\frac{60}{N}} = \frac{\phi PN}{60}$

No of conductor in one parallel path = $\frac{Z}{P}$

Emf generated per parallel path = $\frac{\phi PN}{60}$ X $\frac{Z}{P}$ = $\frac{\phi PNZ}{60A}$

Where A = 2 for wave – winding.

A = P for lap – winding

CHAPTER-06

SHORT QUESTIONS

1.Why earthing is used?[2015(W)5(a)]

Ans :Earthing**-** The process of connecting metallic bodies of all the electrical apparatus and equipment to the huge mass of earth by a wire having negligible resistance is called earthing.

2.State different types of electrical wiring. [2015(W)New]4(a),2016 Q6(a)]

Ans :Types of wiring are used :-

(i) Cleat wiring
(ii) Wooden casing and capping wiring
(iii) CTS or TRS wiring
(iv) Lead sheathed wiring
(v) Conduit Pipe Wiring

3. What is Electrical energy?[2017 Q6/a]

Ans: Electrical power is the rate of consumption of electrical energy. This means Energy=Power×Time

In Symbol, E=P×t

The Unit of energy will depend upon the unit of power and unit of time. Thus Watt.Second is the unit of energy.

1 watt.second=1 joule

Medium type question

1. What is the protective device used in household wiring, write short notes on it.[2016 Q7(a)]

Ans- Protective device are as follow,

Fuse – It is a wire made up of its alloy connected in series with the phase. If there is excessive current flows through the circuit the the fuse wire burns to protect the circuit.

Miniature circuit breaker (MCB) – It has same function as fuse but when heavy current pass through it, it will trip automatically to protect the circuit.

Circuit breaker – These devices are used for high voltage operation. They break the circuit automatically under fault condition. After the fault is rectified the connection is restored manually.

Lighting arrestor – it is a protective device which used to protect device from high current caused by lighting. This high current caused by lighting is passed to ground without affecting the other electrical devices connected in the circuit

LONG QUESTIONS

1. A house is connected with following electrical loads 3 bulbs 100 Watt each, 4 tube light 40 Watt each, one heater 1500 W, 5 fans 60 W each, one motor 250 V, 2 Amp, p f 0.6. All are running for 6 hours daily. Calculate the monthly electrical bills for December if the unit cost is Rs. 4.[2015(W)7(c)]

Ans :

ITEMS	RATINGS	NOS.	WORKING HOURS	ENERGY IN KWh
Bulb	100W	03	06	(100*03*6)/1000=1.8
Tube	40W	04	06	(40*4*6)/1000=0.96
Heater	1500W	01	06	(1500*01*6)/1000=09
Fan	60W	05	06	(60*05*6)/1000=1.8
Motor	250*2*0.6=300W	01	06	(300*01*6)/1000=1.8
Total energy consumed per day				15.36KWh

Energy consumed in the month of December=15.36*31=476.16KWh

Total cost=476.16*4=Rs. 1904.64/-

2. Following arethe details of load on a domestic house connected through a supplymeter.

8 lamps 60W each working 6 hours per day

6 tubes 40W each working 8 hours per day

1 refrigerator 80W each working 24 hours per day

1 pump0.5 H.P.working 2 hours per day

If the cost of each unit of energy is Rs. 2.40 for first 50 units and rest of the amount is Rs. 4.00, what will be the electricity bill for the month of January? [2015(S)New]5(c)

Ans :

Items	Rating	Nos.	Working hours	Energy in KWh
Lamps	60W	08	06	(60*8*6)/1000=2.88
Tubes	40W	06	08	(40*6*8)/1000=1.92
Fridge	80W	01	24	(80*24*01)/1000=1.92
Pump	0.5*746=373W	01	02	(373*01*02)/1000=0.746
Total energy consumed per day				7.466KWh

Energy consumed in the month of January=31*7.466=231.466KWh

Total cost=(50*2.40)+(181.466*4)=120+725.864=Rs. 845.864/-

3.Short notes on "Types of wiring".[2017 Q7/(ii),2019 Q6]

Types of Wiring

Different methods of wiring are used under different conditions. The selection of an individual system of wiring depends upon on the following factors.

(i) Initial cost
(ii) Durability
(iii) Mechanical Protection
(iv) Fire safety
(v) Appearance
(vi) Accessibility

Taking the above factors into account, any of the following types of wining are used :-

(i) Cleat wiring
(ii) Wooden casing and capping wiring
(iii) CTS or TRS wiring
(iv) Lead sheathed wiring
(v) Conduit Pipe Wiring

(1) **Cleat Wiring**

Single core VIR (Vulcanized India Rubber) or PVC (Poly Vinyl Chloride) cables are used in this wiring. The cables are run in grooves of glazed porcelain cleats which are fastened in wooden plugs (gutties) mounted on walls.

Merits

(i) It is cheapest system of wiring.
(ii) A little skill is required to lay the wining.
(iii) The wiring can be dismantled easily and used again with very little waste of material.

Demerits

(i) There is no protection from mechanical injury, fire, gas or water.
(ii) It is rarely employed for permanent jobs.
(iii) It is not good looking.

2. **Wooden casing and capping wiring**

The casing is base which consists of wooden block of seasoned teak wood and has usually tow grooves to accommodate wires. The casing is fixed on the wall with the help of screws and gutties. After placing the wires in the grooves casing at the top is covered by means of rectangular strips of seasoned wood of same width known as capping with the help of screws.

Merits :

(i) It gives better appearance then cleat wiring.

(ii) There is sufficient mechanical and environmental protection to the wires/ cables used.

(iii) Easy to inspect only by opening the capping.

(iv) Easy to install and rewire.

Demerits

(i) Costlier in compare to cleat wiring.

(ii) There is risk of fire.

(iii) It is not suitable for damp situation.

3. **C.T.S. or T.R.S. wiring**

In this system of wiring generally C.T.S. (cable Tyre Sheath) or T.R.S. (Tough Rubber Sheathed) conductors are employed. The conductors are run on well seasoned perfectly straight and well varnished teak wood batten of different width. The width of the batten is
chosen depending upon the number of wires to be run on it.

Merits

(i) It is easy to install and repair.

(ii) It gives nice appearance.

(iii) This type of wiring gives sufficient mechanical protection to the cable.

Demerits

(i) The conductors are upon and liable to mechanical injury, can not be used in workshop.

(ii) It takes more time for installation.

(iii) The fire risk is high.

(iv) Its performance is affected under damp condition.

4. **Lead Sheathed Wiring**

This system of wiring is similar to CTS or TRS wiring. Only difference is that in this case VIR conductors covered with lead alloy sheath (metal sheathed cable) are used. The lead sheathed cables are run on the Wooden battens.

Merits

(i) The conductors are protected against mechanical injury.

(ii) It is free from fire hazards.

(iii) It can be installed in open space.

(iv) It has longer life.

Demerits

(i) It is relatively expensive due to the cost of lead sheath.

(ii) In case of leakage, there is every risk of shock.

(iii) Skilled labour and proper supervision is required. Other wise, the durability of insulation may be affected.

5. **Conduit wiring**

There are two types of conduit wiring

(i) Surface conduit wiring

(ii) Concealed conduit wiring

In surface conduit wiring the conduit run over the wall supported by means of saddles where as in concealed conduit wiring the conduit is embedded in the walls and ceilings by placing in the premade cavity in them.

Merits

i. The wiring presents a neat and attractive appearance.

ii. It gives good protection against fire, mechanical damage & moisture.
iii. Its durability is very high.

Demerits

i. It is costly system of wiring.
ii. Highly skilled technician is necessary.
iii. It requires more time for erection.

4.A residential building has following loads

(i) 3 lamps of 60w each working 5hrs per daily

(ii) 5 fluroscent lamps of 40w each working 6hrs per day

(iii)4 fans of 80w each working 10hrs per day

(iv)1kw heater working 4hrs per day

(v)A 2H.P motor working 2hrs per day

Determine the energy consumption and cost of energy consume for the month of January if the rate of energy consumption is 1.40/-.[2017 Q6/c]

Ans:

ITEMS	RATINGS	NOS.	WORKING HOURS	ENERGY IN KWh
Lamp	60W	03	05	(60*03*5)/1000=0.9
Fluroscent lamp	40W	05	06	(40*5*6)/1000=1.2
Heater	1000W	01	04	(1000*01*4)/1000=4
Fan	80W	04	10	(80*04*10)/1000=3.2
Motor	2×746=1492W	01	02	(1492*01*2)/1000=2.984
Total energy consumed per day				12.284KWh

Energy consumed in the month of January=12.284*31=380.804KWh

Total cost=380.804*1.40=Rs. 533.12/-

<u>CHAPTER-07</u>

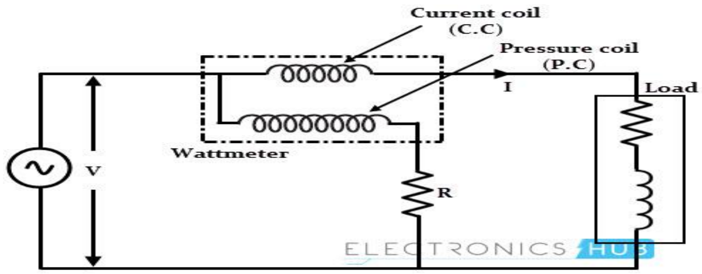
<u>SHORT QUESTIONS</u>

1. What are the torques in measuring instruments?[2015(w)(Old)1(ii)]

Ans : The torques are deflecting torque,controlling torque,damping torque.

2.Draw the connection diagram of 1-Φ wattmeter. [2015(W)New]6(a)

Ans :



3. What is the function of controlling torque in indicating instruments?[2015(S)5(a)]

Ans :Controlling torques are used to keep the pointer in the desired position of dial in the measuring instrument.

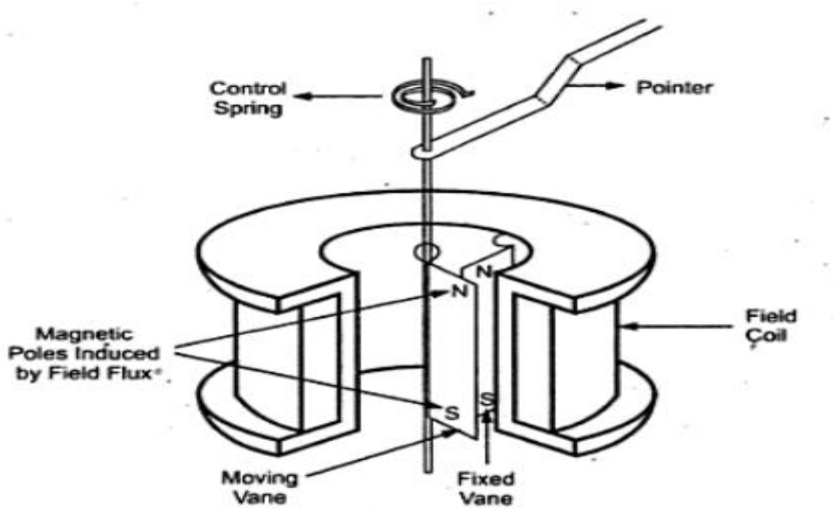
MEDIUM QUESTIONS

1. Explain M.I. (repulsion) type instrument and its use. [2015(w)(Old)1(ii)5(b)]

Ans :Moving Iron Repulsion Type Instrument

These instruments have two vanes inside the coil, the one is fixed and other is movable. When the current flows in the coil, both the vanes are magnetised with like polarities induced on the same side. Hence due to repulsion of like polarities, there is a force of repulsion between the two vanes causing the movement of the moving van. The repulsion type instruments are the most commonly used instruments.

The Fig. 2 shows the radial vane repulsion type instrument. Out of the other moving iron mechanism, this is the most sensitive and has most linear scale.



The two vanes are radial strips of iron. The fixed vane is attached to the coil. The movable vane is attached to the spindle and suspended in the induction field of the coil. The needle of the instrument is attached to this vane.

Even though the current through the coil is alternating, there is always repulsion between the like poles of the fixed and the movable vane. Hence the deflection of the pointer is always in the same direction. The deflection is effectively proportional to the actual current and hence the scale is calibrated directly to read amperes or volts. The calibration is accurate only for the frequency for which it is designed because the impedance is different for different frequencies.

2. State different uses of M.I. type instruments. [2015(W)New]6(b)

Ans :Moving-ironammetersandvoltmetersaremanufactured,mainlyformeasurements in 50-hertz AC circuits. In a moving-ironammeter,thefieldcoil is connected in series to thecircuitcontainingthecurrent to be measured; in a moving-ironvoltmeter, it isconnected in parallel.Moving-ironmeasuringmechanismsarealsoused inratiometers.Themostwidelyusedmoving-ironinstrumentsareswitchboardinstruments ofclasses1.5and2.5,althoughinstruments of class0.5andeven ofclass0.1aremanufactured.Thelatterinstrumentsmay be usedforfrequencies of up to 800hertz.

<u>LONG QUESTIONS</u>

1. Explain different types of torques used in measuring instruments. [2015(W)New]6(c),2017 Q6/b]

Ans :All analogue electrical indicating instruments require three devices:

(a) A deflecting or operating torque

A mechanical force is produced by current or voltage which causes the pointer to deflect from its zero position.

(b) **A controlling torque**

The controlling force acts in opposition to the deflecting force and ensures that the deflection shown on the meter is always the same for a given measured quantity .it also prevents the pointer always going to the maximum deflection. There are two main types of
spring control and gravity control.

(c)**Damping torque**-The damping force ensures that the pointer comes to rest in its final position quickly andwithout undue oscillation.Example-eddy current damping,air-friction damping,fluid friction damping.

2.Short notes on "PMMC type instruments".[2017 Q7/(i),2019 Q2(f)]

Ans:PERMANENT MAGNET MOVING COIL (PMMC) TYPE INSTRUMENT:
CONSTRUCTION:

The moving-coil instruments may be dealt with considering a rectangular coil of N turns, free to rotate about a vertical axis.

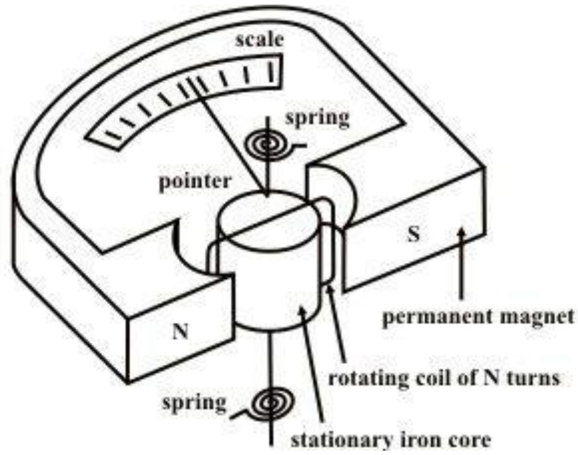


Figure 7.3(a) PermanentMagnet Magnet Moving Coil Instrument .

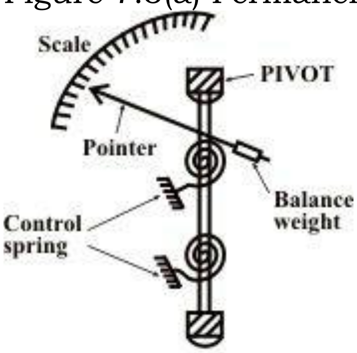


Figure 7.3(b) Spring control ,balance weight arrangement of PMMC instrument.

Figure 7.3(a) shows the construction of a PMMC instrument. A moving coil instrument consists of a permanent magnet to provide a magnetic field and a small light weight coil is wound on arectangular soft iron core that is free to rotate around its vertical axis. When a current is passedthrough the coil windings, a torque is developed on the coil by the interaction of the magnetic field and the field set up by the current in the coil. The aluminium pointer attached to rotating coil and the pointer moves around the calibrated scale indicates the deflection of the coil. To reduce parallax error a mirror is usually placed along with the scale . A balance weight is also attached to the pointer to counteract its weight shown in figure 7.3(b). The use of hairsprings attached to each end of the coil as shown in Fig.7.3(a) to return the coil to its original position when there is no current through the coil . These hairsprings are not onlysupplying a restoring torque but also provide an electric connection to the rotating coil. With the use of hairsprings , the coil will return to its initial position when no current is flowing through the coil. When the developing force between the magnetic fields (from permanent magnet andelectromagnet) is exactly equal to the force of the springs, the coil rotation will stop. The cioil set up is supported on the jeweled bearings in order to achieve free movement. An ironcore is placed inside the coil to concentrate the magnetic fields. The curved pole faces ensure the turning force on the coil increases as the current increases. It is assumed that the coil sides are situated in a uniform radial magnetic field of flux density B wb/m^2 , let the length of a coil side (within the magnetic field) be L (meter), the distance from each coil to the axis be r (meter) and the distance between the two coil sides is b(meter), b=2r(meter).

WORKING PRINICIPLE:

The interaction between the induced field and the field produced by the permanentmagnet causes a deflecting torque, which results in rotation of the coil. The spiralspring produces a control torque. The induced currents in a metal former or core on which the coil is wound or in the circuit of the coil itself. As the coil moves in the field of the permanent magnet , eddy currents aresetup in the metal former or core. The magnetic field produced by the eddy current opposes the motion of the coil . The pointer will therefore swing move slowly to its proper position and come to rest quickly with very little oscillation. Electromagnetic damping is caused by the induced effects in the moving coil as it rotates in magnetic field, provided the coil forms part of closed electric circuit.

DEFLECTING TORQUE:

Let B=Flux density in the air gap (wb/m^2)
I=Current flowing through the coil (Amp)
N=No of turns in the coil depends upon the design.
L=Length of the coil or height of the coil in the magnetic field(m)
b=(2r) breadth of the coil or width of the coil in 'meter'
=Angle between the plane of magnetic field & current carrying conductor.

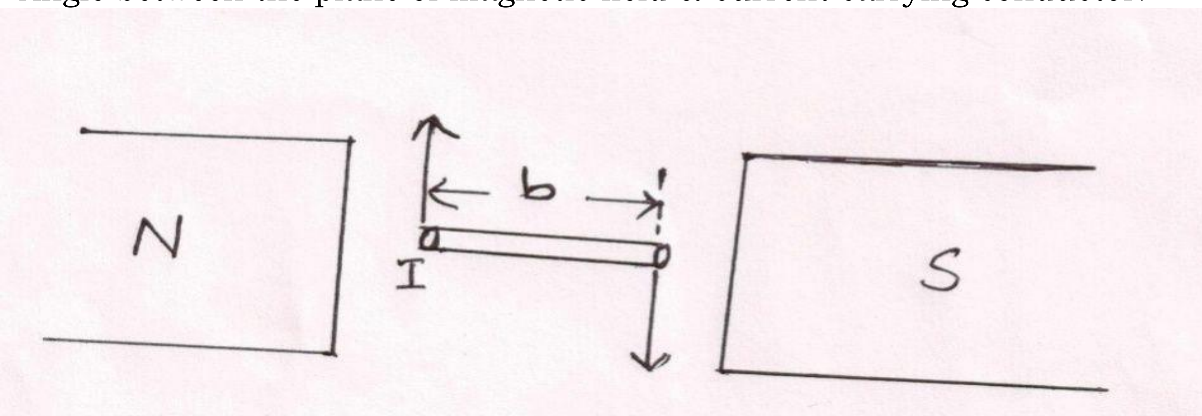


Fig. 7.3(c) Arrangement of conductor inside magnetic field
We know that when current carrying conductor placed in a magnetic field a force is experienced in it.
Force on each conductor is equal to BIL.
Force on each side of the coil =BILxN
=BILN (Newton, N) (7.31)
Torque due to both coil sides=bxF
=(2r)(BILN)
=BILNxb
=BI(Lb)N
=BINA (Newton Meter) (N-M)
Where A=2rL=bL=Area,
Now deflecting torque, T_d =BINA (7.32)
The above equation (7.32) is valid while the iron core is cylindrical and the air gap between the coil and pole faces of the permanent magnet is uniform. This result flux density B is constant and the torque is propertional to the coil current and instrument scale is linear.
Now control torque $T_c = K\theta$, for spring control
Where K=spring constant.
On steady state,
Controlling Torque =Deflecting Torque
i.e., $K\Theta = BINA$
$\theta = (BAN/K)I$
$\Theta \alpha I$(7.33)