Biyani's Think Tank

Concept based notes

Basic Physics

(BCA Part-I)

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Preface

I am glad to present this book, especially designed to serve the needs of the students. The book has been written keeping in mind the general weakness in understanding the fundamental concepts of the topics. The book is self-explanatory and adopts the “Teach Yourself” style. It is based on question-answer pattern. The language of book is quite easy and understandable based on scientific approach.

Any further improvement in the contents of the book by making corrections, omission and inclusion is keen to be achieved based on suggestions from the readers for which the author shall be obliged.

I acknowledge special thanks to Mr. Rajeev Biyani, *Chairman* & Dr. Sanjay Biyani, *Director* (*Acad.*) Biyani Group of Colleges, who are the backbones and main concept provider and also have been constant source of motivation throughout this Endeavour. They played an active role in coordinating the various stages of this Endeavour and spearheaded the publishing work.

I look forward to receiving valuable suggestions from professors of various educational institutions, other faculty members and students for improvement of the quality of the book. The reader may feel free to send in their comments and suggestions to the under mentioned address.

Author

Syllabus

B.C.A. Part-I

Electrical Circuit and Circuit Analysis

[This course is of introductory nature, and therefore, emphasis will be on basic concepts and direct applications of mathematical expressions without rigorous analysis]

Electric Charge, Conductors and Insulators, Coulomb's Law, Quantization and Conservation of Electric Charge, Electric Field, Electric Lines of Force and Gauss's Law of Electrostatics, Electric Potential Energy and Electric Power.

Capacitors, Capacitance, Capacitors in Series and Parallel, Capacitors with Dielectric.

Electric Current, Resistance, Resistivity and Conductivity, Ohm's Law, Electromotive Force, Series and Parallel Combination of Resistance, Current in a Single Loop, Electrical Power Consumption, Multiloop Circuits, Kirchhoff's Current Law, Kirchhoff's Voltage Law, Charging and Discharging of a Capacitor.

Magnetic Field due to a Bar Magnet, Biot-Savat's Law, Magnetic Field due to a Current Carrying Coil, Force between Two Parallel Currents, Magnetic Field inside Solenoid and Toroid, Magnetic Flux, Faraday's Law of Electromagnetic Induction, Magnetic Properties of Material (diamagnetic, paramagnetic and ferromagnetic materials), Induction, Energy Stored in a Inductor, L-R Circuits.

Generation of Alternating EMF, Average and RMS Value of AC, Analysis of AC.

Circuits (Series L-R, Series R-C, Series LCR, Parallel LCR Circuit), Resonance, Three Phase AC Circuits.

DC Generator, DC Motor, Transformer, Single Phase Induction Motor, Three Phase Induction Motor.

Measuring Instruments, Multimeters.

House Wiring Material and Accessories, Types of Wiring, Basic Principle of Earthing, Wiring Layout for a Computer Lab.

Four Terminal Network Analysis, Network Theorems, Superposition, Thevenin, Norton, Reciprocity, Compensation and Maximum Power Transfer Theorems.

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Content

S. No.	Name of Topic
	4.4 Lenz's Law 4.5 Faraday's Laws of EM Induction 4.6 Diamagnetic, paramagnetic and Ferromagnetic Materials 4.7 Self Induction 4.8 Mutual Induction

□ □ □

Chapter-1

Electrostatics

Q.1 Differentiate between conductors and insulators on the basis of flow of charge?

Ans.: **Conductors:** ***Conductors*** are the materials through which electric charge flows easily. In general metals are good conductors. *Examples – Silver, Copper etc.*

Insulators: The poorest of conductors in which the charge does not flow under normal conditions are called ***Insulators***. In general nonmetals are insulators. ***Examples –*** *Glass, Paper etc.*

Q.2 Explain different properties of Charge.

Ans.: **Charges** are of two types:

(a) Positive Charge

(b) Negative Charge

Some **properties** of Charge:

(i) Two charged bodies attract each other or repel one another depending on the nature of charge present on them.

(ii) Charge is a quantized quantity and the quantum of charge is equal to the electronic charge in magnitude.

(iii) In every isolated system the total charge remains constant i.e. the algebraic sum of positive and negative charge does not change in any process taking place in the system.

Q.3 Define Coulomb's Law and explains Absolute Permittivity.

Ans.: **Coulomb's Law:** According to this law ***"stationary charges repel or attract each other and the attractive or repulsive force is directly proportional to the***

magnitude of charges and inversely proportional to the square of the distance between them."

	F	$\propto$	q_1q_2
and	F	$\propto$	$1 / r^2$
i.e.	F	$\propto$	q_1q_2 / r^2
=>	$\mathbf{F}$	**=**	$\mathbf{K\ q_1q_2 / r^2}$
where	K	=	Constant
In M.K.S. System	$\mathbf{K}$	**=**	$\mathbf{9 \times 10^9}$

Absolute Permittivity : Absolute Permittivity of the medium is equal to the multiplication of permittivity of free space (ε_0) and relative permittivity (ε_r) i.e. $\boldsymbol{\varepsilon_0 \varepsilon_r}$ **.**

Permittivity shows the ability of the medium as to many electric lines of force can pass through that medium.

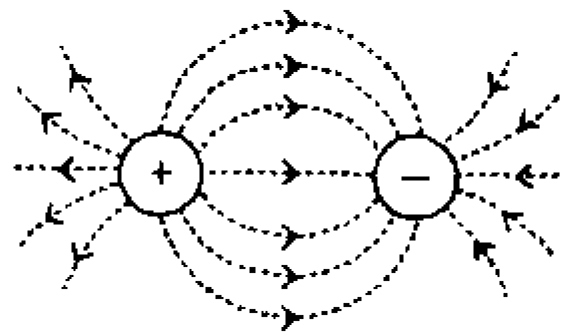
Q.4 Define Electric Field and explain properties of Electric Lines of Forces with the help of diagram.

Ans.: **Electric field:** The region in which a stationary charged particle experiences a force (other than the gravitational force) is called electric field.

An **Electric Line of Force** is that imaginary smooth curve drawn in an electric field along which a free and isolated unit positive charge will move.

Properties of Electric Lines of Force :

(i) Electric lines of force are imaginary and start from a positive charge and end on a negative charge.



(ii) The tangent drawn at any point on the line of force gives the dir^n of resultant electric field at that point.

(iii) No two lines of force intersect each other.

(iv) These lines have a tendency to contract along the length like a stretched elastic string. This explains attraction between opposite charges.

(v) These lines have a tendency to move apart from each other in the dir^n normal to their length. This explains the repulsion between like charges.

Q.5 What do you mean by Electric Flux?

Ans.: **Electric Flux:** The number of electric lines of force passing through an area perpendicularly is called ***Electric Flux***.

Electric flux depends on the angle 'θ' between area vector 'da' and dir^n of electric lines of force and is given by

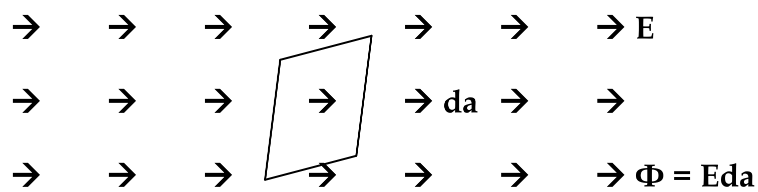
$$\boxed{d\Phi = EdaCos\theta}$$

There may be three **conditions**:

(i) When the frame is perpendicular to dir^n of electric field, In this case angle θ between $\vec{da}$ & $\vec{E}$ is 0°. So electric flux

$$d\Phi = EdaCos0°$$

or **$d\Phi_{Max} = Eda$**



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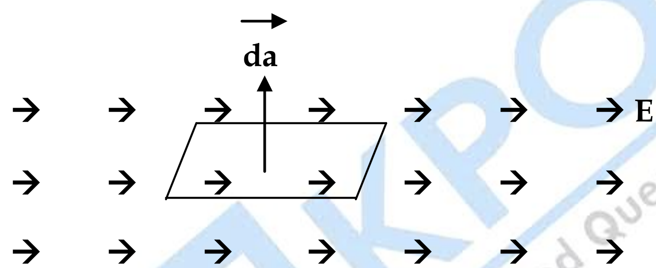


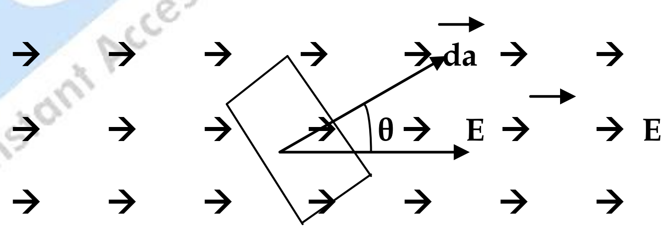
If the frame is parallel to the dir^n of electric lines of force then θ = 90° and flux

$$d\Phi = EdaCos90°$$

$d\Phi = 0$

will be zero i.e. minimum.

(iii)



For any other orientation, the electric flux will be

$d\Phi = EdaCos\theta$

Q.6 State Gauss's Law of Electrostatics. What is its essence?

Ans.: **Gauss's Law of Electrostatics :** According to this law, ***"The total electric flux of an electric field through a closed surface is equal to 4πk or (1 / ε_0) times."*** The net charge enclosed by that surface

i.e. $$\Phi = 4\pi k\sum q = 1/\varepsilon_0\sum q$$

Where $\sum q = q_1 + q_2 + q_3 + \ldots\ldots\ldots$ (total no. of charges inside the surface)

Essence of This Law : This law suggests that the flux through any closed surface is a measure of total charge inside it. For the field lines that originate on a positive charge must either pass out through the surface or else terminate on a negative charge inside. On the other hand, a charge outside the surface will contribute nothing to total flux, since its field lines enter from one side and exit from other. This is the essence of Gauss's Law.

Q.7 What is Electric Potential Energy? What is the significance of Negative Potential Energy of a System?

Ans.: **Electric Potential Energy :** When a charged particle or a charge is placed in an electric field a force acts on it in accordance with Coulomb's Law, if the charge is now displaced from one position to other, work has to be done against the field or by the field. The energy spent in doing this work is stored as potential energy of the system. This is known as ***Electric Potential Energy***.

If an electron is brought near a proton the potential energy will be negative as work will be done by attractive force. ***Negative Potential Energy*** means a bound system as work has to be done by external agency to break the system.

Q.8 Define Electrical Power and the unit Kilowatt–Hour.

Ans.: **Electric Power :** ***Electrical Power*** is defined as the rate at which electrical energy is consumed or developed.

$$\text{Electrical Power } (P) = W / t = VI$$

Its MKS unit is **Joule per Second** or **Watt.**

Kilowatt-Hour (KWH) : Commercially the consumption of electrical energy is expressed in terms of a unit called ***KWH***.

One Kilowatt–Hour (1 unit of electrical energy) is the energy consumed in one hour i.e. 3600 Sec. by a device whose power is one Kilowatt i.e. 1000 Watts.

$$1 \text{ KWH} = 3.6 \times 10^6 \text{ Joules}$$

Q.9 What is the Physical Significance Potential?

Ans.: Definition of Potential : Total work done in moving a unit positive charge from infinity to any point in the electric field is known as the ***Potential*** at that point.

$$V_{p} - V_{\infty} = W / q_0$$

Physical Significance : The level of electric charge in any object is the potential of that object or the level of electric charge at any point is the potential at that particular point.

<u>Multiple Choice Questions</u>

1. The force of attraction or repulsion between charges follows:
   (a) Square law of distance (b) Inverse square law of distance
   (c) Both (a) and (b) (d) None of (a) and (b) ( )

2. When the distance between two equal charges is decreased to half and their magnitude of charges also decreased to half, the force between them:
   (a) Remains unchanged (b) Reduces to half
   (c) Becomes half (d) None of the above ( )

3. Electric field intensity due to a point charge follows:
   (a) Falls inversely proportional to the distance
   (b) Falls inversely proportional to the square root of the distance
   (c) It does not change with distance
   (d) Falls inversely proportional to the square of the distance ( )

4. One volt potential difference is equivalent to:
   (a) 1 Newton/coulomb (b) 1 erg/Coulomb
   (c) 1 Joule/coulomb (d) 1 Coulomb/Joule ( )

5. The Unit of electric field intensity is:
   (a) Newton/meter (b) Coulomb/Newton
   (c) Newton/Coulomb (d) Joule/Newton ( )

6. The value of 1 electron volt is:
   (a) 1.6×10^{-19}J (b) 1.6×10^{19}J
   (c) 3.2×10^{-19}J (d) 1.6×10^{-20} J ( )

7. The energy stored in an capacitor is in the form of:
   (a) Kinetic energy (b) Potential energy
   (c) Magnetic energy (d) Elastic energy ( )

8. Which of the following is not conserved:
   (a) Mass (b) Charge
   (c) Total energy (d) Momentum ( )

9. One volt potential difference is equivalent to:
   (a) Newton/Coulomb (b) Erg/Coulomb
   (c) Joule/Coulomb (d) Coulomb/Joule ( )

10 What will be the potential energy of the proton-electron system in a hydrogen atom? r is the radius of the orbit of the electron:
   (a) – Ke/r (b) $-Ke^2/r$
   (c) +Ke/r (d) $+Ke^2/r$ ( )

11 The distance between two charges q_1 and q_2 is r, and then the electric potential energy of this system will be:
   (a) $\frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^3}$ (b) $\frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$
   (c) $\frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r}$ (d) $\frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^{3/2}}$ ( )

12 A charge q is placed at a distance of 10 cm from a charge of 8×10^{-8} C. If the force between the two charges is 0.072 N, the value of q is:
   (a) 10^{-3} C (b) 10^{-5} C
   (c) 10^{-6} C (d) 10^{-8} C ( )

13 If the distance and value of the charges located at different points are doubled, then the force acting between them will be:

(a) Double (b) Half
(c) Unchanged (d) Four time ( )

14. The unit for electric field intensity is:
(a) Newton/Coulomb (b) Joule/Coulomb
(c) Volt-meter (d) Newton/meter ( )

15. A charge q is placed on the corner of a cube. The flux emerging out of the cube will be:
(a) q/ϵ_0 (b) $q/2\epsilon_0$
(c) $q/8\epsilon_0$ (d) $q/6\epsilon_0$ ( )

16 The intensity of an electric field at some point distance r from the axis of infinite long pipe having charges per unit length as q will be:
(a) Proportional to r^2
(b) Proportional to r^3
(c) Inversely proportional to r
(d) Inversely proportional to r^2 ( )

17 The dielectric constant of aluminum is:
(a) 1 (b) Zero
(c) 10 (d) Infinity ( )

18. The charge of same magnitude q are placed at four corners of a square of side a. The value of potential at the centre of square will be:
(a) 4kz/a (b) $4\sqrt{2kq}\ /a$
(c) $4kq\sqrt{2a}$ (d) $kq/a\sqrt{2a}$ ( )

19 If a soap bubble is positively charged, then its radius:
(a) Increases`
(b) Decreases
(c) Remain unchanged
(d) First increases and then decreases ( )

20. If a charge Q is brought near another charge Q, then total energy of the system:
(a) Remains same (b) Increases
(c) Decreases (d) None ( )

21 If a positive charge is established in an electric field against the Coulomb force then:
(a) Work is done by electric field
(b) Energy is utilized from some external sources
(c) Intensity of electric field decreases
(d) Intensity of electric field increase ( )

22. A point has 10 volt potential, if a charge of + 10coulomb is brought from infinity to that point, then the work done will be:
(a) 10 J (b) 100 J
(c) 1 J (d) 2 J ( )

23 Which of the following experiment verifies quantization of charge?
(a) Rutherford (b) Millikan's oil drop
(c) Discharge of gases (d) Faraday's electrolysis ( )

24. Which is not a property of conductors?
(a) Have free electrons
(b) Resistance increases with temperature
(c) Negligible bank gap
(d) Contains electron - hole pairs ( )

25. Which is wrong about coulomb's force?
(a) It is a long range force
(b) it follows inverse square law
(c) It does not depend on medium
(d) It may be attractive as well as repulsive ( )

26 Which relation violates the law of conservation of electric charge?
(a) $n \rightarrow p + e^- + \bar{v}$ (b) $P \rightarrow n + e^+ + v$
(c) $\gamma \rightarrow e^+ e^-$ (d) $\gamma \rightarrow e^+ e^+$ ( )

27. A charge + Q is placed at the centre of a cube, the amount of electric flux through its entire surface is:
(a) $\frac{Q}{\epsilon_0}$ (b) $\frac{Q}{2\epsilon_0}$
(c) $\frac{Q}{6\epsilon_0}$ (d) Zero ( )

28. The electrostatic potential energy of a system of two stationary point charges + q_1 and - q_2 are separated by a distance r is given by:
(a) $\frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$ (b) $(-)\frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$

(b) $+\frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r}$ (d) $(-)\frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r}$ ( )

S.NO.	Q:1	2	3	4	5	6	7	8	9
Ans	A	B	C	C	C	A	B	B	A
S.NO.	10	11	12	13	14	15	16	17	18
Ans	A	C	C	B	D	D	C	B	D
S.NO.	19	20	21	22	23	24	25	26	27/28
Ans	C	A	C	A	B	A	C	A	C/B

Chapter-2

Capacitors

Q.1 Relate Capacity with Voltage and Charge. How it is said that Potential of Earth is zero?

Ans.: When a conductor is charged, its electric level i.e. electric potential rises. The increase in potential is proportional to the charge given to it.

If increase in potential is V when charge Q is given to the conductors, then

$$Q \propto V$$

$$\text{OR} \quad Q = CV \quad \text{- - - (1)}$$

C is constant and is called capacity of the conductor. It depends on the geometry of the conductors, medium around it and nearness of other conductors.

From eq." (1) $\boxed{C = Q/V}$

Unit of capacity in M.K.S. System is Farad (F)

$$\boxed{1 \text{ Farad} = \frac{1 \text{ Coulomb}}{1 \text{ Volt}}}$$

As we know that electric potential belongs to electrical level of charge at particular point or in any object. Since the size of earth is very – very large, therefore, the level of charge is also very small thus potential of earth is said to be zero.

Q.2 Describe the factors on which Capacitance of Parallel Plate Capacitor depends.

Ans.: Capacity of a Parallel Plate Capacitor is given by

$$\boxed{C = \varepsilon_0 A / d \quad \text{Farad}}$$

Where ε_0	->	Permittivity of air or vacuum
A	->	Area of the plates
D	->	distance between them

From this formula, we see that

$$C \propto A$$

And $$C \propto 1/d$$

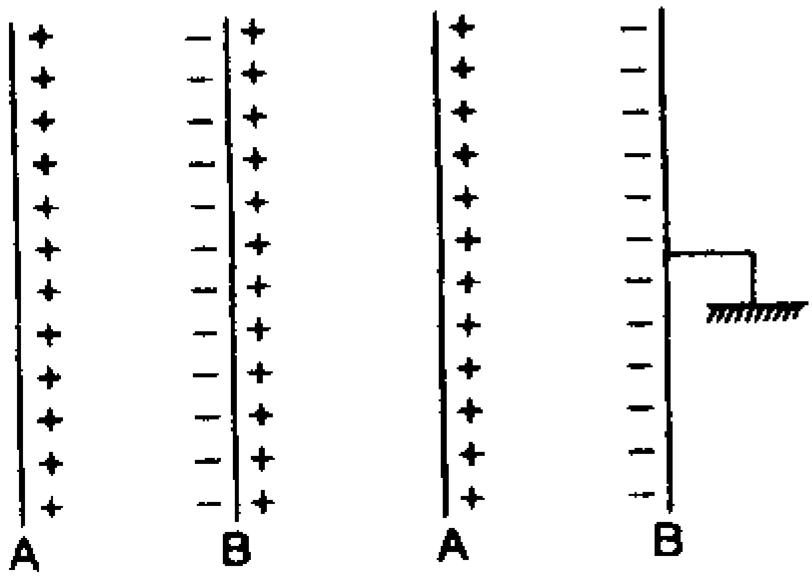
Therefore, for increasing the capacity, the area of plates must be increased and distance between them be decreased. It means capacity depends on the area of the plates and distance between the plates.

Capacity also depends on the dielectric constant of the medium between the plates.

Q.3 What is a Capacitor? Explain its principle.

Ans.: **Condenser or Capacitor :** The ***Condenser*** is an arrangement in which the capacity of a conductor is increased by placing another earthed conductor close to it.

A condenser works on the principle that by placing a earthed conductor near a given charge conductor, the potential can be reduced substantially and capacity can be increased.



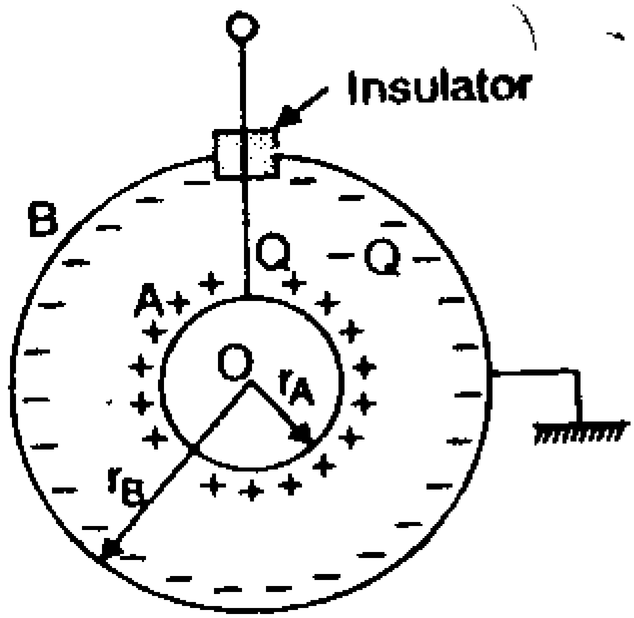
(i) (ii)

As shown in fig.(i) when we place another conductor (B) near a charged conductor (A), then by induction an opposite charge is induced on the inner surface of B and an equal similar charge is induced on the outer surface.

The opposite negative charge on B decreases the potential of A but the similar positive charge on outer surface of B increases the potential of A. This similar charge on B can be removed by connecting outer surface of B to ground. Then potential will decrease more and capacity will increase.

Q.4 Explain Spherical Capacitor.

Ans.: Spherical Capacitor : It consists of two concentric hollow metal spheres, which do not touch each other at any point.



Let radius of spheres A and B are r_A and r_B respectively, where $r_A < r_B$. If the inner sphere is given a charge +Q, a charge –Q is developed on inner surface of B and a charge +Q on the outer surface of B, by induction.

If air is the medium between spheres, the potential on the surface of A due to charge +Q on it is

$$V_A = \frac{1}{4\pi\varepsilon_0} \frac{Q}{r_A}$$

Similarly, the potential on the surface of A due to charge -Q on B is

$$V_B = \frac{1}{4\pi\varepsilon_0} \frac{-Q}{r_B}$$

So, resultant potential of A is

$$V = V_A - V_B = \frac{1}{4\pi\varepsilon_0} \frac{Q}{r_A} - \frac{1}{4\pi\varepsilon_0} \frac{-Q}{r_A}$$

$$= \frac{Q}{4\pi\varepsilon_0} \frac{(r_B - r_A)}{r_A\, r_B}$$

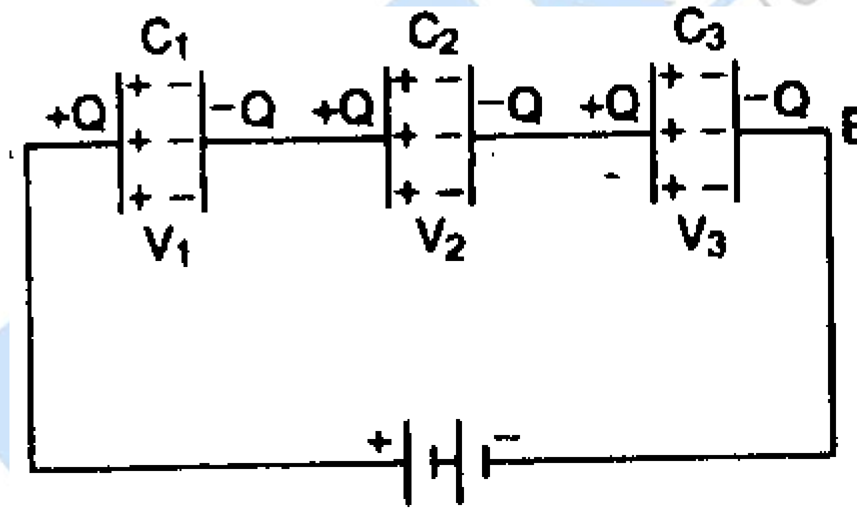
Therefore capacity of Spherical Capacitor

$$C = \frac{Q}{V} = \frac{Q \times 4\pi\varepsilon_0 r_A r_B}{Q (r_B - r_A)}$$

$$\boxed{C = 4\pi\varepsilon_0 \frac{r_A r_B}{(r_B - r_A)}}$$

Q.5 Describe Series Combination of Capacitors. Explain relation between Equivalent Capacitance and Smallest Capacitance in the combination.

Ans.: Series Combination of Capacitors :



V

In Series Combination, the first plate of the first condenser is connected to the source of charge and second plate of the last condenser is connected to second terminal of source or is earthed. The second plate of first condenser is connected to first plate of second condenser; the second plate of second condenser is connected to first plate of third condenser and so on as shown in figure.

The potential difference across these condensers depends on the capacities of these condensers. Suppose the values of potential difference across C_1, C_2 and are C_3 are V_1, V_2 and are V_3 respectively.

So $V_1 = \frac{Q}{C_1}$, $V_2 = \frac{Q}{C_2}$ & $V_3 = \frac{Q}{C_3}$

If total potential difference is V then

$$V = V_1 + V_2 + V_3$$

$$\Rightarrow = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$$

$$\Rightarrow \frac{V}{Q} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

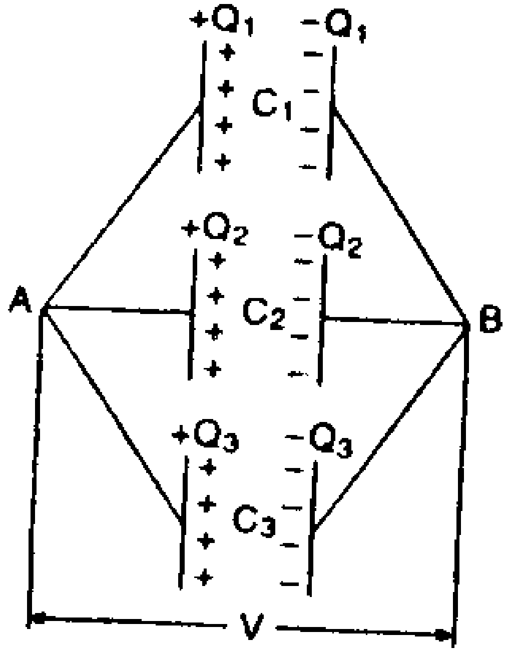
$$\Rightarrow \boxed{\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$$

Where C is resultant capacity.

The resultant Series Capacitance is always less than the Smallest Capacitance in the combination.

Q.6 Describe Parallel Combination of Capacitors.

Ans.: Capacitors in Parallel :



In this combination first plate of all capacitors are joined at one point which is connected to one terminal of the source, the second plate of all capacitors are joined at another point which is earthed or connected to the second terminal of the source.

If the charge given by the source is +Q, this charge is distributed on the condensers in parallel according to their capacities as potential difference V is same for all.

If the amount of charge received by the condensers are Q_1 , Q_2 and Q_3 then

$$Q = Q_1 + Q_2 + Q_3$$

$$\Rightarrow Q = C_1V + C_2V + C_3V$$

$$\Rightarrow Q = V(C_1 + C_2 + C_3)$$

$$\Rightarrow Q/V = C_1 + C_2 + C_3$$

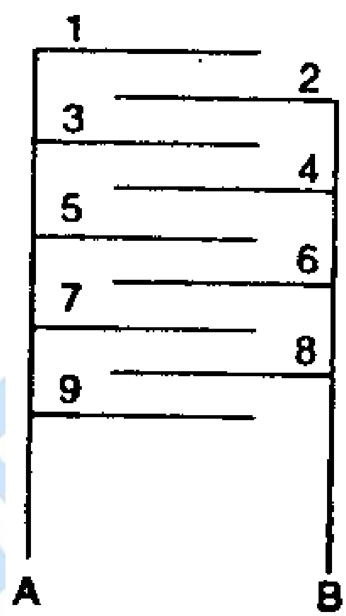
$$\Rightarrow \boxed{\mathbf{C = C_1 + C_2 + C_3}}$$

Where C is equivalent capacity.

In Parallel Combination, the Resultant Capacitance is more than the capacitances of Individual Capacitors.

Q.7 What is a Gang Condenser? Explain its construction and working.

Ans.: **Gang Condenser :** It is a **special type of Plate Condenser.** It consists of two groups of semicircular parallel plates.



The alternative plates are connected to one rod A and the other plates to another rod B. One group of plates remains stationary but the other can be rotated with the help of knob. By rotation of one set of plates the overlapping area of the plates can be varied. The two groups of plates form a combination of condensers in parallel. By changing their effective area, the resultant capacitance can be varied. It the effective area of each plate is A and n plates have been used then the resultant capacity.

$$C = \frac{(n-1)\varepsilon_0 A}{D}$$

Where d is the distance between successive plates.

Q.8 What is the effect of placing a Dielectric Medium between the Plates of a Capacitor?

Ans.: When dielectric material placed between the charged plates of a capacitor, the centres of negative and positive charge distributions in the atoms or molecules no longer remain coincident but get separated. The centre of negative charge distribution gets displaced towards the positive plate and centre of positive charge distribution towards the negative plates. This phenomenon is called ***Polarization***.

Due to this polarization, negative charge gets accumulated on the surface of dielectric near the positive plate and an equal positive charge appears on the surface of dielectric near the negative plates. This accumulation of charge on the two surfaces of dielectric reduces the applied electric field. If the dielectric constant of the medium is K then the electric field intensity between the charged plates of a parallel plate condenser becomes.

$$E_K = \frac{\sigma}{\varepsilon} = \frac{\sigma}{\varepsilon_0 K}$$

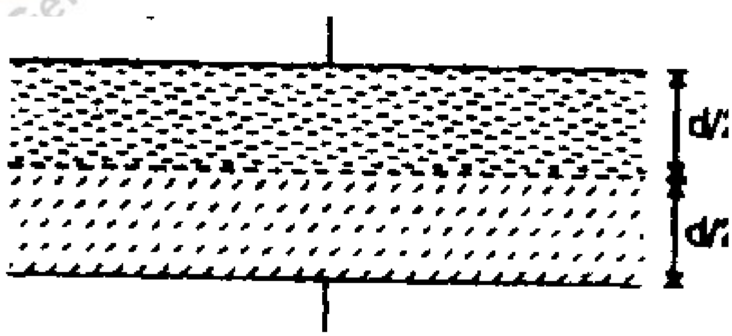
And due to this capacity of dielectric filled capacitor is K times, the capacity in air or vacuum.

$$\boxed{C_m = KC}$$

Where $C = \frac{\varepsilon_0 A}{d}$ Farad

Q.9 A Parallel Plate Capacitor of plate area A and separation of is filled with two materials each of thickness d/2 and dielectric constants ε_1 and ε_2 respectively. What is its equivalent capacitance?

Ans.: Formula :



$$C = \frac{Q}{V} = \frac{\varepsilon_0 A}{\left(\frac{t_1}{k_1} + \frac{t_2}{k_2}\right)}$$

Here t_1 & t_2 are thickness and k_1 & k_2 are dielectric constants.

In this question

$$t_1 = t_2 = d/2$$

$$\text{and } k_1 = \varepsilon_1 \ \& \ k_2 = \varepsilon_2$$

So,

$$C = \frac{\varepsilon_0 A}{\left(\frac{d/2}{\varepsilon_1} + \frac{d/2}{\varepsilon_2}\right)}$$

$$= \frac{\varepsilon_0 A}{\frac{d}{2}\left(\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2}\right)}$$

$$= \frac{2\varepsilon_0 A}{d\left(\frac{\varepsilon_2 + \varepsilon_1}{\varepsilon_1 \varepsilon_2}\right)}$$

=> $$\boxed{C = \frac{2\varepsilon_0 A}{d} \frac{\varepsilon_1 \varepsilon_2}{(\varepsilon_1 + \varepsilon_2)}}$$

Multiple Choice Questions

Q:01 A parallel plate capacitor is given a charge Q. If the separation between the plates is doubled, its capacity will be:

(a) unchanged (b) Zero

(c) doubled (d) half ( )

Q:02 In a charged capacitor the energy resides:

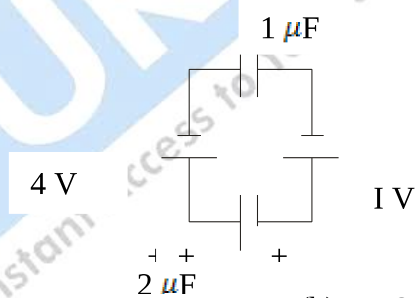
(a) on the positive plate
(b) on both the positive and negative plates
(c) in the field between the plates
(d) around the edge of the capacitor plates ( )

Q:03 In a charged capacitor the energy appears as:
(a) magnetic energy
(b) electromagnetic energy
(c) electrostatic energy
(d) neither electric nor magnetic ( )

Q:04 Two condensers of capacitor C_1 and C_2 charged to potential V_1 and V_2 are joined by a wire. The loss of energy E is:
(a) $E = (C_1 + C_2)(V_1 - V_2)^2$ (b) $E = \frac{C_1 + C_2}{C_1 C_2}(V_1 - V_2)^2$
(c) $E = \frac{C_1 C_2}{C_1 + C_2}(V_1 - V_2)^2$ (d) $E = \frac{C_1 C_2}{2(C_1 + C_2)}(V_1 - V_2)^2$

Q:05 On heating the dielectric constant of an insulator:
(a) remains constant (b) increase
(c) decreases (d) nothing can be predicted ( )

Q:06 A charge on each capacitor in the circuit is :



(a) $1\,\mu C$ (b) $2\,\mu C$
(c) $3\,\mu C$ (d) $4\,\mu C$ ( )

Q:07 If dielectric medium of constant K is filled between the plates of a capacitor, then its capacity increases:
(a) $\frac{1}{K}$ times (b) k times
(b) K^2 times (d) $\frac{1}{k^2}$ times ( )

Q:08 The energy stored in an capacitor is in the form of:
(a) Kinetic energy (b) Potential energy

(c) Magnetic energy (d) Elastic energy ( )

Q:09 The capacitance of a capacitor does not depend upon:
(a) Shape of plates (b) Size of Plates
(c) Charge on plates (d) Separation between plates ( )

Q:10 A 4 μ F capacitor is charged to 400 V. The energy stored in it will be:
(a) 0.16 J (b) 0.32 J
(c) 0.64 J (d) 1.28 J ( )

Q:11 Four capacitor each of capacity 3 Farad are connected in series. The resultant capacity will be:
(a) $\frac{3}{4}\ Farad$ (b) $\frac{4}{3}\ Farad$
(c) $12\ Farad$ (d) $\frac{1}{12}\ Farad$ ( )

Q:12 A parallel plate capacitor is given a charge Q. If the area of plates is doubled, its capacity will be:
(a) Halved (b) Doubled
(c) Zero (d) Unchanged ( )

Q:13 A capacitor stores energy in the form of :
(a) Electromagnetic field (b) Magnetic field
(c) Electric Field (d) None of the above ( )

Q:14 The capacitances of two capacitors are C_1 and C_2 It ehy charged to the same potential, then the ratio of their charges will be:
(a) $\frac{\sqrt{C_2}}{\sqrt{C_1}}$ (b) $\frac{\sqrt{C_1}}{\sqrt{C_2}}$
(c) $\frac{C_2}{C_1}$ (d) $\frac{C_1}{C_2}$ ( )

Q:15 Unit of capacitance is:
(a) Coulomb (b) Volt
(c) Henry (d) Farad ( )

Q:16 Two capacitors of capacitances 2 μF and 4 μF are connected in series. Their equivalent capacitance will be:
(a) 6 μ F (b) 2 μ F
(c) $\frac{4}{3}\mu$ F (d) 8 μ F ( )

Q:17 On heating the dielectric constant of an insulator:

(b) remains constant (b) increase

(c) decreases (d) nothing can be predicted

( )

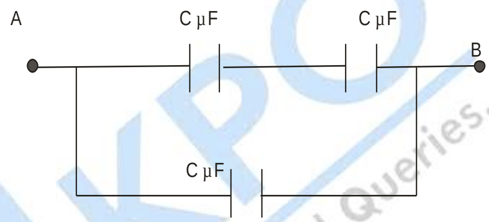
Q:18The equivalent capacitance of the circuit between A and B is:

(a) 3 C μ F

(b) $\frac{C}{3}\ \mu F$

(c) $\frac{3}{2}\ C\ \mu F$

(d) $\frac{2C}{3}\ C\ \mu F$



( )

. Q:19 When dielectric material is inserted between the plates of a capacitor its capacitance

(a) decreases (b) increase

(c) ions constant (d) reduces to zero

S.NO.	Q:1	2	3	4	5	6	7	8	9
Ans	D	B	C	D	A	A	B	B	A
S.NO.	10	11	12	13	14	15	16	17	18
Ans	A	A	B	C	D	D	C	B	D

Chapter-3

Electric Current

Q.1 State Ohm's Law.

Ans.: **Ohm's Law :** This law states that ***if the physical conditions of a conductor (such as temperature, pressure etc. remain same, then the current flow through it is directly proportional to the potential difference applied across it.***

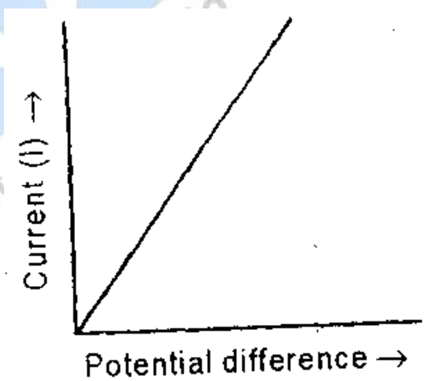
Therefore, if V is the potential difference across the ends of a conductor and I is the current flowing through it, then

i.e. $V \propto I$

=> $\boxed{V = RI}$

=> $\frac{V}{I} = R$ (Constant)

This constant is known as resistance of the conductor.



(Graph between applied Potential Difference V and Current I)

Q.2 Define Resistance of a Conductor. On what factors and how does the Resistance of a Conductor depend?

Ans.: The obstruction produced in the motion of free electrons is called ***Electrical Resistance of Conductor.***

$$\boxed{R = V/I}$$

Practical unit of resistance is ***Ohm***. If the potential difference across the ends of a conductor is one volt and the current flowing through it is one ampere, then the resistance of the conductor is one Ohm.

Resistance of a Conductor depends on the following factors :

(i) **Length of the Wire :** The resistance of a conducting wire is directly proportional to its length i.e.

$$R \quad \propto \quad l$$

(ii) **Cross Sectional Area or Thickness of the Wire :** The resistance of the wire is inversely proportional to cross sectional area of the wire i.e.

$$R \quad \propto \alpha \quad 1/A$$

(iii) **Material of the Wire :** If wires of same length and same thickness are made from different materials, then their resistance will be different.

Thus if the length and cross-sectional area of the wire are l and A respectively, then the resistance

$$R \quad \alpha \quad l/A$$

$$=> \quad \boxed{R \quad = \quad \rho\, l/A}$$

Where ρ is a constant, called the ***Specific Resistance or Resistivity*** of the material of the wires.

Q.3 Define Specific Resistance. Why alloys as manganin and constantan are used to make resistance wires of resistance?

Ans.: We know that

$$R \quad = \quad \rho\, l/A$$

Where ρ is called the ***Specific Resistance or Resistivity*** of the material of the wire. From the above relation

$$\text{if} \quad l \quad = \quad 1 \text{ metre}$$

$$\text{and} \quad A \quad = \quad 1 \text{ m}^2$$

Then $\boxed{R = \rho}$

Thus the resistivity or specific resistance of the material of a wire is equal to the resistance of a wire of that material having a length of 1 metre and cross sectional area of 1 m^2. Unit of specific resistance is Ohm – m.

The resistivity of alloys also increases with the rise of temperature. There are certain alloys such as manganin and constantan for which effect of temperature is very small because of their negligible temperature coefficient of resistance. On account of their high resistivity and negligible temperature coefficient of resistance these alloys are used to make resistance wires for resistance boxes, potentiometers, meter bridges etc.

Q.4 Difference between EMF and Terminal Voltage.

Ans.: Electromotive Force (E) : The EMF of a cell in a closed circuit is equivalent to the work done for the flow of unit positive charge through the external and internal resistance.

Terminal Voltage (V) : Terminal voltage is equivalent to the work done for the flow of unit positive charge through the external resistance only.

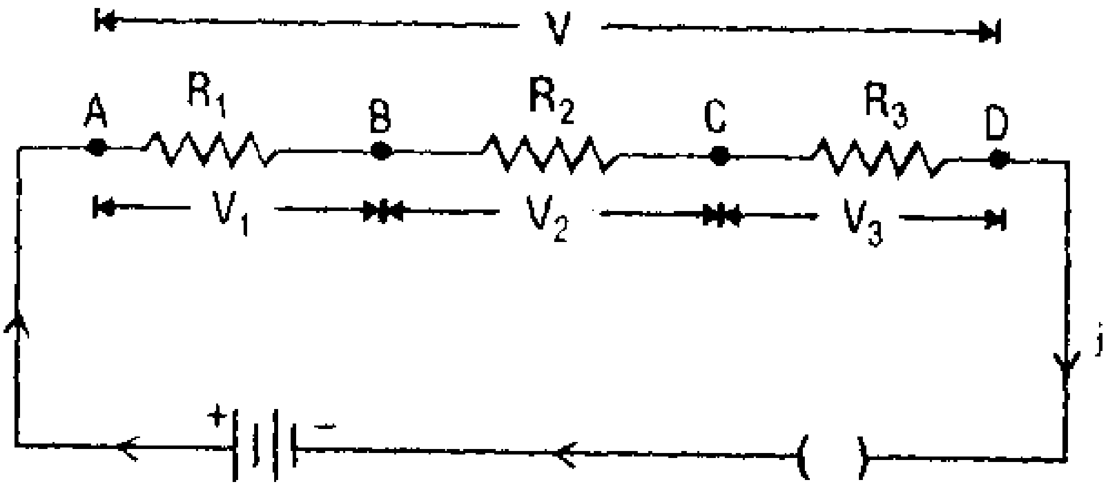
E is always greater than V and their difference is equal to the potential drop across the interval resistance of the cell.

$$E - Ir = V$$

Or we can say that the EMF (E) is the amount of work done in driving a unit positive charge around the whole circuit (external and internal) while the potential difference (V) in the closed circuit is the amount of work done in driving a unit positive charge through the external resistance only.

Q.5 Explain the Series and Parallel Combination of Resistance.

Ans.: Series Combination of Resistances : In this combination, the second end of the first resistance is connected to first end of the second resistance and so on. In such a combination, same amount of current flows in all resistance but the potential difference across the resistance changes according to their resistance.



Let i is the current flowing through R_1, R_2 & R_3, then by Ohm's law

$$V_1 = i R_1, \quad V_2 = i R_2 \quad \text{and} \quad V_3 = i R_3$$

If total potential difference applied by the battery is V, then

$$V = V_1 + V_2 + V_3$$

$$= i R_1 + i R_2 + i R_3$$

$$= i (R_1 + R_2 + i R_3) \quad \text{———— (1)}$$

If the equivalent resistance of the combination is R, then by Ohm's law

$$V = iR \quad \text{———— (2)}$$

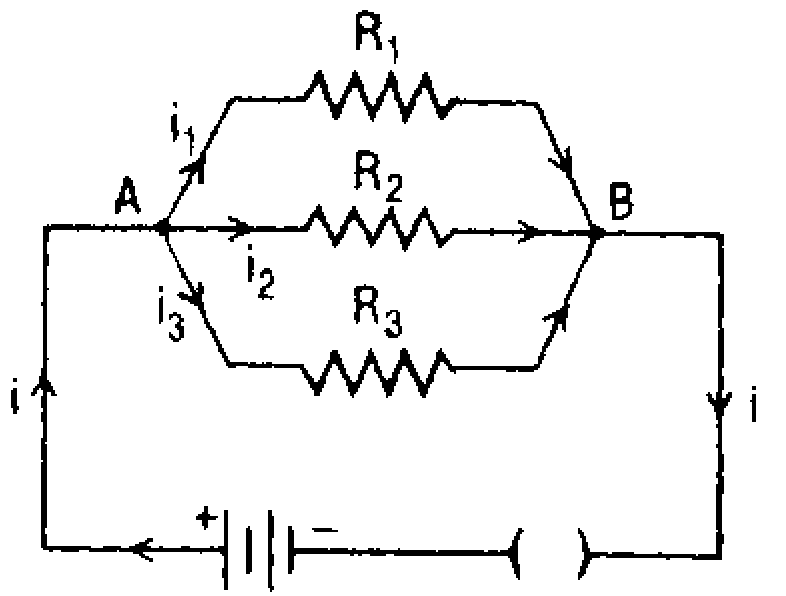
Comparing equations (1) and (2)

$$iR = i(R_1 + R_2 + R_3)$$

$$\boxed{R = R_1 + R_2 + R_3}$$

Thus the equivalent resistance of resistances connected in series is equal to sum of individual resistance.

Parallel Combination of Resistances : In this combination one end of all resistances are connected together at one point and other end of all resistances are connected together at another point.



Suppose the current supplied by the battery is i, this current is divided into three parts, i_1 flowing through R_1, i_2 flowing through R_2 and i_3 flowing through R_3.

$$i = i_1 + i_2 + i_3$$

If the potential difference between A and B is V, then

$$i_1 = \frac{V}{R_1}, \quad i_2 = \frac{V}{R_2} \quad \& \quad i_2 = \frac{V}{R_3}$$

Using these values

$$i = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\Rightarrow i = V\left(\frac{1}{R_1} \quad \frac{1}{R_2} + \frac{1}{R_3}\right)$$

$$\Rightarrow \frac{i}{V} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\Rightarrow \mathbf{1 = 1 + 1 + 1}$$

$$\overline{R} \qquad \overline{R_1} \qquad \overline{R_2} \qquad \overline{R_3}$$

Thus the reciprocal of the equivalent resistance of the resistances connected in parallel is equal to the sum of the reciprocals of individual resistances.

Q.6 What is the need of Kirchhoff's Laws? Explain Kirchhoff's Current Law with the help of examples.

Ans.: Need of Kirchhoff's Law : Ohm's Law gives the relation between the potential differences across a conductor and the current flowing through it. In complex circuits i.e. electrical networks direct use of Ohm's Law is not possible. Therefore to determine the current flowing through any branch of network and the voltage at the node, Kirchhoff's Laws are used.

Kirchhoff's Current Law : According to this law the algebraic sum of the currents meeting at any junction or node is zero i.e.

$$\sum i = 0$$

The current towards the junction are taken as positive and going away from the junction are taken as negative.

So applying Kirchhoff's Law in this figure

$$i_1 - i_2 - i_3 - i_4 + i_5 = 0$$

OR $$i_1 + i_5 = i_2 + i_3 + i_4$$

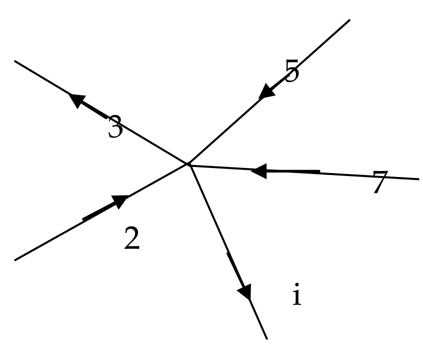
Example :

In this figure to find out the value of i, we apply Kirchhoff's Current Law

$$5 + 7 + 2 - 3 - i = 0$$

$$\Rightarrow 11 - i = 0$$

$$\Rightarrow i = 11 \text{ Amp.}$$



Q.7 Explain Kirchhoff's Voltage Law with help of examples.

Ans.: Kirchhoff's Voltage Law : According to this law, the algebraic sum of the voltages in a specified direction along a closed loop of an electrical circuit is zero.

$$\sum \Delta v = 0$$

We adopt the following sign conventions :

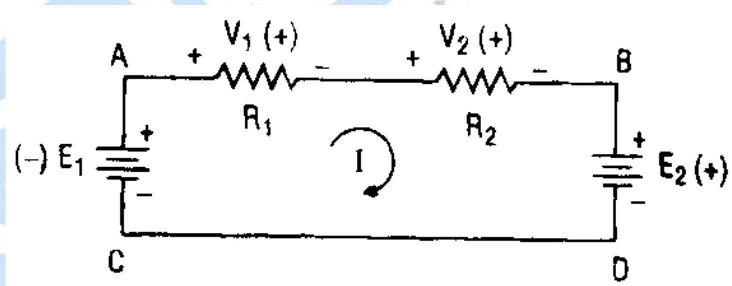
(i) The EMF of a cell is taken negative if we move in the direction of increasing potential (i.e. from –ve pole to +ve pole) through the cell and is taken +ve if we move in the direction of decreasing potential (i.e. from +ve pole to –ve pole) through the cell.

(ii) The voltage drop across any resistance will be +ve if these are in the direction of current flow.

Using these two conditions and starting from point A

$$V_1 + V_2 + E_2 - E_1 = 0$$

OR $$V_1 + V_2 = E_1 - E_2$$



Thus the algebraic sum of all the voltage drops in a closed loop is equal to the sum of EMFs in the loop.

Q.8 Explain Charging of Capacitor.

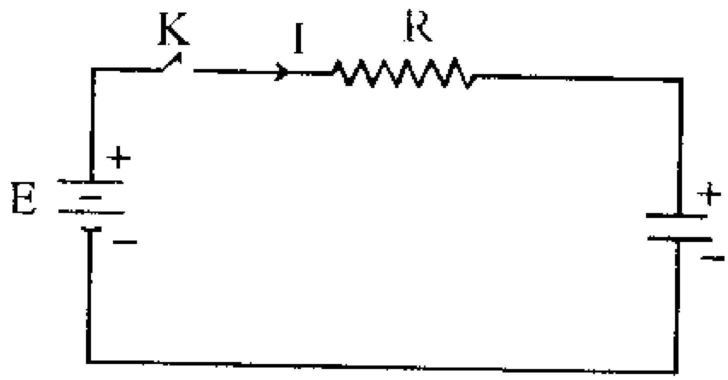
Ans.: Charging of Capacitor :

In this circuit when we close the key k, let q be the charge on capacitor at time t and I be the current in the circuit.

The potential difference across capacitor will be q/c.

Using Kirchhoff's Voltage Law

$$E = \frac{q}{C} + RI \qquad \text{\_\_\_\_\_\_\_\_\_\_\_\_ (1)}$$



As time increases the charge on the capacitor increases and finally acquires the maximum value q_0. At this state, potential difference across capacitor becomes equal to EMF (E), thus

$$E = \frac{q_0}{C} \qquad \text{\_\_\_\_\_\_\_\_\_\_\_\_ (2)}$$

Putting this in equation (1)

$$\frac{q_0}{C} = \frac{q}{C} + RI$$

Or $$q = q_0 - RCI$$

Or $$I = \frac{1}{RC}(q_0 - q) \qquad \text{\_\_\_\_\_\_\_\_\_\_\_\_ (3)}$$

Or $$\frac{dq}{dt} = \frac{1}{RC}(q_0 - q)$$

Or $$dq = -1 \; (q - q_0)$$

dt RC

$$\Rightarrow \frac{dq}{(q - q_0)} = \frac{-1}{RC}\, dt$$

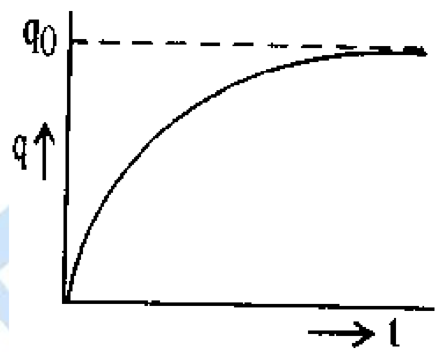
Integrating eq^n (3)

$$\log_e(q - q_0) = \left(\frac{-1}{RC}\right) t + C_1$$

Now at t = 0, q = 0

$$\text{So,} \quad \log_e(-q_0) = C_1$$

By putting this value of C_1



$$\log_e(q - q_0) - \log_e(-q_0) = \frac{-1}{RC}\, t$$

$$\log_e \left\{\frac{q - q_0}{-q_0}\right\} = -1 \frac{t}{RC}$$

$$\frac{q - q_0}{-q_0} = \frac{-1}{RC}\, t$$

$$q - q_0 = -q_0\, e^{-t/RC}$$

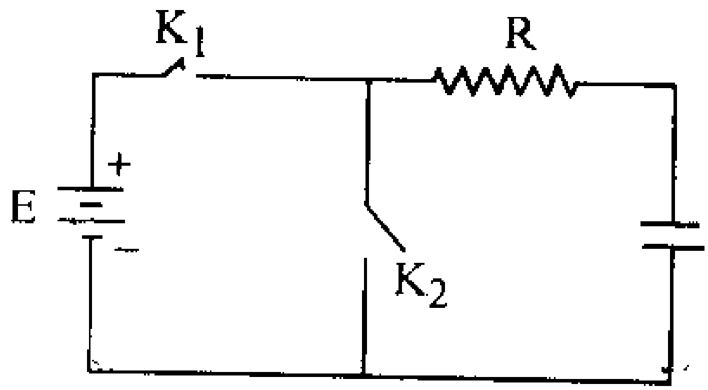
$$\boxed{\mathbf{q = q_0(1 - e^{-t/RC})}}$$

Q.9 Explain Discharging of a Capacitor.

Ans.: Discharging of a Capacitor :

Capacitor is discharged through a resistance R by closing key k_2 (keeping k_1 open.

Let q be the charge on the capacitor at time t and I be the current flowing through R at this moment. The initial charge on capacitor is $q_0 = EC$. During discharging process as E=0, so by Kirchhoff's Law



$$\frac{q}{C} + RI = 0 \qquad \text{——— (1)}$$

OR $$R\frac{dq}{dt} + \frac{q}{C} = 0$$

OR $$\frac{dq}{dt} = \frac{-1}{RC} q$$

OR $$\frac{dq}{q} = \frac{-1}{RC} dt \qquad \text{——— (2)}$$

Integrating eq^n (2)

$$\text{Log}_e\, q = \frac{-1}{RC} dt + B$$

At $t = 0, q = q_0 = EC$

So, $$B = \text{Log}_e (q_0)$$

Substituting the value of B

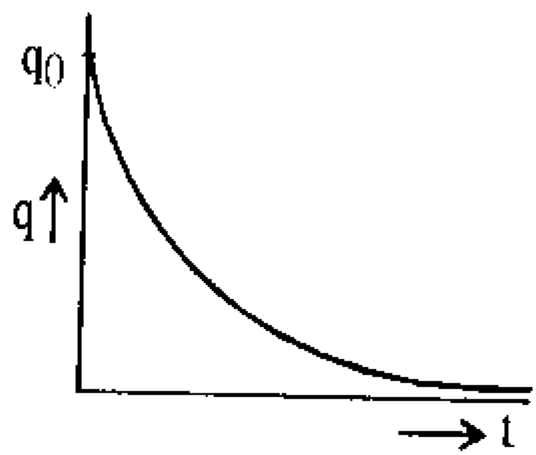
$$\log_e q = \frac{-1}{RC} dt + \log_e q_0$$

$$\log_e q - \log_e q_0 = \frac{-1}{RC} t$$

$$\log_e \left(\frac{q}{q_0}\right) = \left(\frac{-1}{RC}\right) t$$

$$\boxed{q = q_0 e^{-t/RC}}$$

Thus the charge on capacitor decreases exponentially with time t as shown below.



Q.10 What is Time Constant of an RC Circuit.

Ans.: Time Constant of an R-C Circuit : In an R-C circuit, the growth of charge and potential difference across the capacitor during charging or discharging are dependent on time. During both these processes maximum current flows at the start and then the current decays exponentially with time. The rate of variation of all these quantities (charge, potential and current) infact depends on the value of time t relative to the product RC. The product RC has the dimensions of time and is called ***Time Constant*** of the circuit and is represented by τ.

During charging

$$q = q_0(1 - e^{-t/\tau})$$

and $$I = I_0 e^{-t/\tau}$$

During discharging

$$q = q_0 e^{-t/\tau}$$

and $$I = -I_0 e^{-t/\tau}$$

At t = τ during charging

$$q = q_0(1 - e^{-1})$$

$$q = q_0(1 - 0.37)$$

$$\boxed{q = 0.63\, q_0}$$

and $$\boxed{I = 0.37\, I_0}$$

i.e. time constant is the time at which during charging the charge on capacitor increase about 63% of the maximum value while current decreases to 37% of the maximum value.

Multiple Choice Questions

Q:01 The energy stores in an inductance coil is given by:

(a) $\frac{q^2}{2C}$ (b) $\frac{LI^2}{2}$

(c) $\frac{L^2 I}{2}$ (d) LI^2 ( )

Q:02 Two resistances of 0.275 ohm and 0.778 ohm are connected in parallel. The total resistance shall be:

(a) More than 0.275 ohm (b) Less than 0.275 ohm

(c) Equal to 1.053 ohm (d) More than 0.778 ohm ( )

Q:03 The specific resistance of a wire depends upon:

(a) Its length (b) Its cross-section area

(c) Its dimensions (d) Its material ( )

Q:03 When two resistances are connected in series, they have:

(a) Same voltage (b) Same resistance
(c) Same current (d) Different current ( )

Q:04 Unit of resistivity is:

(a) ohm/meter (b) ohm/meter^2
(c) ohm-meter (d) ohm-meter^2 ( )

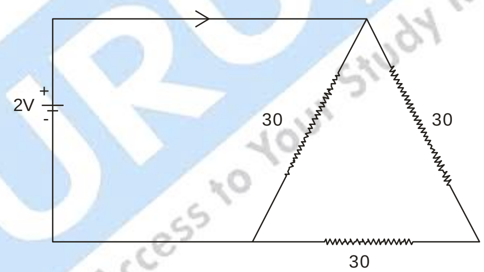
Q:05 Kirchhoff's first low is related to the law of:

(a) Conservation of energy
(b) Conservation of charge
(c) Conservation of mass
(d) Conservation of angular momentum ( )

Q:06 The conductivity of superconductor is :

(a) Infinite (b) Very large
(c) Very small (d) Zero ( )

Q:07 The current i in the given circuit is:



(a) $\frac{1}{45}$ Amp. (b) $\frac{1}{15}$ Amp.
(c) $\frac{1}{10}$ Amp. (d) $\frac{1}{5}$ Amp. ( )

Q:08 The example of non-ohmic resistance is:

(a) Copper wire (b) Carbon wire
(c) Diode (d) Tungsten wire ( )

Q:09 The resistance of a conductor depends on:

(a) Its length only (b) Its cross - sectional area
(c) Its temperature (d) All of the above ( )

Q:10 Unit of potential difference is:

(a) Volt (b) Ampere
(c) Joule (d) Coulomb ( )

11 The diameters of two resistance wires of equal length and of the same material are in the ratio of 1 : 2 the ratio of their resistances will be:
(a) 1 : 2 (b) 1 : 4
(c) 4 : 1 (d) 2 : 1 ( )

12. The conductivity of a superconductor is:
(a) Zero (b) Small
(c) Large (d) Infinite ( )

13 Unit of resistivity is :
(a) ohm/m (b) ohm/m^2
(c) ohm-m (d) $ohm\text{-}m^2$ ( )

14. In a closed circuit, kirchhoff's second law represents:
(a) ohm's law
(b) Charge - conservation law
(c) Current-conservation low
(d) None of the above ( )

15. The charging current in R-C circuit varies with time I as:

(a) $I = I_o e^{\frac{t}{RC}}$ (b) $I = I_o e^{\frac{t}{RC}}$

(c) $I = I_o\left\{1 - e^{-\frac{t}{RC}}\right\}$ (d) $I = I_o\left\{1 + e^{\frac{t}{RC}}\right\}$ ( )

16 The resistance of straight conductor does not depend on its:
(a) Temperature (b) Length
(c) Material (d) Shape of cross-section ( )

17. The unit of specific conductance is:
(a) Ohm (b) Ohm-M
(c) Siemen (d) mho-m ( )

18. The example of non-ohmic resistance is:
(a) Copper wire (b) Carbon wire
(c) Diode (d) Tungsten wire ( )

Q:19 A flow of 10^7 electrons per second in a conducting wire constitutes a current of:

(a) 1.6×10^{-26} A (b) 1.6×10^{12} A
(c) 1.6×10^{-12} A (d) 1.6×10^{26} A ( )

Q:20 Indentify the set in which all the materials are good conductors of electricity.
(a) Cu, Ag and Au (b) Cu, Si and diamond
(c) Cu, Hg and NaCL (d) Cu, Fe and Hg ( )

Q:21 When a current flows in a conductor, the order of magnitude of drift velocity of electrons through it is:
(a) 10^{10} m/s (b) 10^{-2} m/s
(c) 10^{10} cm/s (d) 10^{-7} cm/s ( )

Q:22. The temperature co-efficient of resistance is positive for:
(a) Carbon (b) Copper
(c) Si (d) Ge ( )

Q:23 The temperature co-efficient of resistance is negative for:
(a) Ge (b) Copper
(c) Aluminum (d) Nickel ( )

Q:24. The example of non-ohmic resistance is:
(a) Copper wire (b) Carbon resistance
(c) Diode (d) Tungsten wire ( )

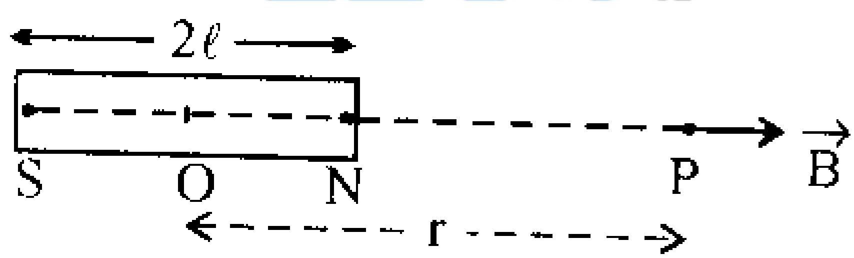
S.No	Q:1	2	3	4	5	6	7	8	9
Ans	B	C	C	C	B	B	C	B	D
S.NO.	10	11	12	13	14	15	16	17	28
Ans	A	C	C	C	C	C	D	A	B
S.NO.	19	20	21	22	23	24			
Ans	C	A		B	A	C			

Chapter-4

Magnetism

Q.1 Obtain an expression for the Magnetic Induction due to a Bar Magnet at a point on its axis.

Ans.: Magnetic Induction due a Bar Magnet at a point on its axis :



Let a point P on its axis at a distance r from its centre. The distance of point P from the N – Pole will be (r – l) while from S – Pole it will be (r + l). The magnetic field intensity at P due to N – Pole will be

$$\frac{\mu_0}{4\Pi} \quad \frac{m}{(r - l)^2}$$

and due to S-Pole it will be

$$\frac{\mu_0}{4\Pi} \quad \frac{m}{(r + l)^2}$$

So, resultant magnetic field intensity at P is

$$B = \frac{\mu_0}{4\Pi}\left\{\frac{m}{(r-l)^2} - \frac{m}{(r+l)^2}\right\} \quad \text{along the axis}$$

$$= \frac{\mu_0}{4\Pi}\,\frac{m(r+l)^2 - m(r-l)^2}{(r^2-l^2)^2}$$

$$B = \frac{\mu_0}{4\Pi}\,\frac{4mlr}{(r^2-l^2)^2}$$

$$= \frac{\mu_0}{4\Pi}\,\frac{2Mr}{(r^2-l^2)^2} \quad \text{(where } M = 2ml\text{)}$$

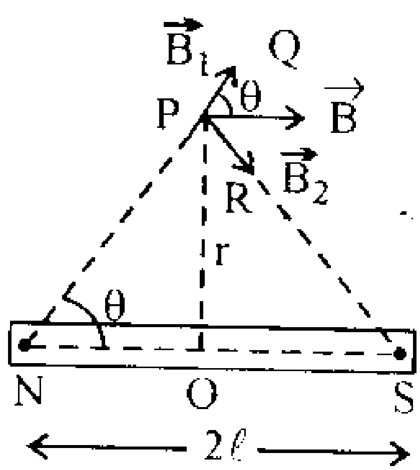
For a short magnet r > > l, so l^2 will be negligible compared to r^2.

$$= \frac{\mu_0}{4\Pi}\,\frac{2Mr}{r^4}$$

$$\boxed{\mathbf{B = \frac{\mu_0}{4\Pi}\,\frac{2M}{r^3}}}$$

Q.2 Obtain an expression for the Magnetic Induction due to a Bar Magnet at a point on its equatorial line.

Ans.: Magnetic Induction due to a Bar Magnet at a point on its equatorial line:



Consider point P on equatorial line of magnet at distance r from its centre. The distance of P from both the poles will be the same, equal to $(r^2 + l^2)^{1/2}$

The intensity of magnetic field due to N – Pole will be

$$B_1 = \frac{\mu_0}{4\Pi} \frac{m}{(r^2 + l^2)} \quad \text{along PQ}$$

The intensity of magnetic field due to S – Pole will be

$$B_2 = \frac{\mu_0}{4\Pi} \frac{m}{(r^2 + l^2)} \quad \text{along PR}$$

The components of $\vec{B_1}$ & $\vec{B_2}$, which are perpendicular to the axis being equal and opposite, will cancel each other while the components parallel to the axis being in the same direction will get added.

So, resultant magnetic field at P will be in a direction parallel to the axis and will be given as

$$B = B_1 \cos\theta + B_2 \cos\theta$$

$$B = \frac{\mu_0}{4\Pi} \frac{2m}{(r^2 + l^2)} \cos\theta$$

$$= \frac{\mu_0}{4\Pi} \frac{2m}{(r^2 + l^2)} \frac{l}{(r^2 + l^2)^{1/2}}$$

$$= \frac{\mu_0}{4\Pi} \frac{M}{(r^2 + l^2)^{3/2}} \quad \text{(where } M = 2ml\text{)}$$

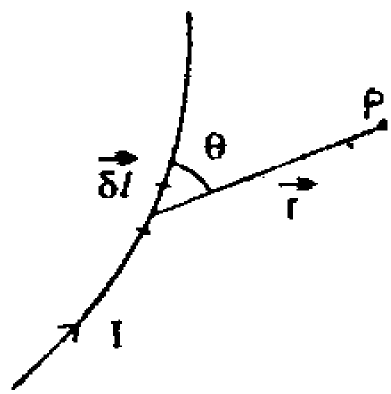
For a small magnet $l << r$, so that

$$\mathbf{B = \frac{\mu_0}{4\Pi} \frac{M}{r^3}}$$

Q.3 State Biot-Savart's Law.

Ans.: Biot – Savart's Law : This law is used to determine the magnetic field intensity at a certain point.

This law states that magnetic field intensity δB at a certain point due to a current carrying element



δl of the conductor is

(i) directly proportional to current I.

(ii) directly proportional to length δl of the current element.

(iii) directly proportional to $\sin\theta$, where θ is angle between the position vector $\vec{r}$ of the point of observation with respect to the element and the element $\vec{\delta l}$

(iv) inversely proportional to the square of the distance r of the observation point from the element, i.e.

$$\delta B \;\alpha\; \frac{I\,\delta l \sin\theta}{r^2}$$

In free space or non magnetic medium

$$\boxed{\delta B = \frac{\mu_0}{4\Pi}\frac{I\,\delta l \sin\theta}{r^2}} \quad \textbf{Tesla}$$

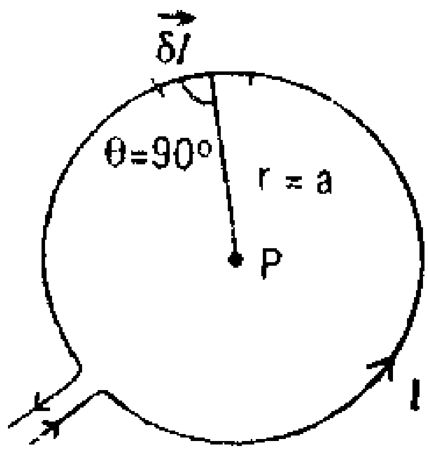
Where μ_0 = Permeability of free space = $4\Pi \times 10^{-7}$ Weber/A-m

For other media μ is used in place of μ_0 for the permeability of that medium.

Q.4 Obtain an expression for the Magnetic Induction at the Centre of a Current Carrying Coil.

Ans.: Magnetic Induction at the Centre of Coil due to Circular Current Carrying Coil :

As shown in figure, the distance of observation point (centre) from each element of the coil is equal to the radius 'a'. In addition the position vector r makes an angle of 90˚ with each element. Hence Sinθ = Sin90˚ = 1. Thus from Biot-Savart's Law. The magnetic induction due to a current carrying element δl at the point P



$$\delta B = \frac{\mu_0}{4\Pi} \frac{I\delta l}{a^2}$$

The direction of magnetic field due to all the elements is same. Therefore total magnetic induction at the centre of the coil is

$$B = \Sigma \delta B$$

$$= \frac{\mu_0}{4\Pi} \frac{I}{a^2} \Sigma \delta l$$

$$= \frac{\mu_0}{4\Pi} \frac{I}{a^2} (2\Pi a)$$

$$\boxed{\mathbf{B = \frac{\mu_0 I}{2a}}}$$

If the coil has n turns, then

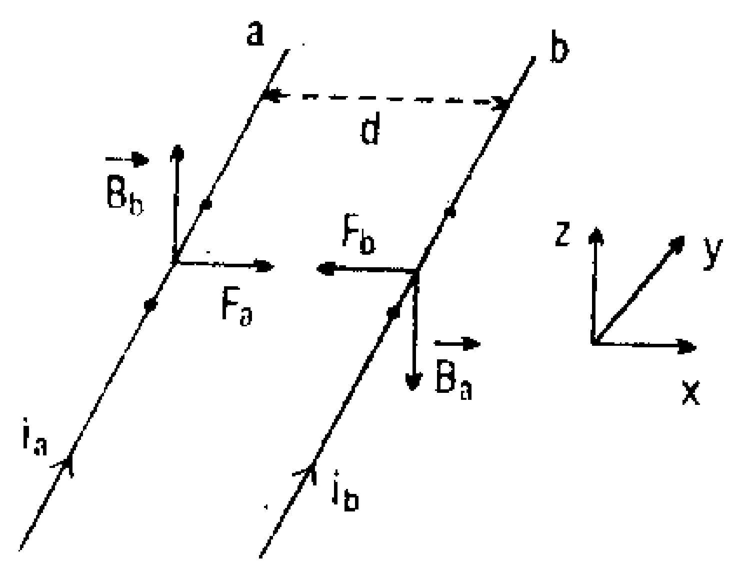
$$\Sigma \delta l = 2\Pi an$$

$$\boxed{B = \frac{\mu_0 nI}{2a}} \quad \textbf{Tesla}$$

Q.5 Determine the Force per unit length between Two Current Carrying Parallel Conductors.

Ans.: Force between Two Current Carrying Parallel Conductor :

Let two infinately long parralel conductors separated by distance 'd'. Let i_a & i_b are the currents in these conductors. These conductors are formed to exert force on each other. It is confirmed experimentally that mutual force is attractive when current in those conductors flow in the same direction but repulsive when current in the conductors are in opposite direction.



The magnetic field produced by current 'i_a' flowing in the wire 'a' at a distance 'd' is

$$B_a = \frac{\mu_0 ia}{2\Pi d}$$

According to Right Hand Palm rule, field B_a is perpendicular to the plane of paper and directed downwards.

This means that second current carrying conductor is now placed in field B_a hence it will experience a force due to $\vec{B}_a$. The magnitude of this force F_b on the element δl of wire will be

$$F_b = i_b \, \delta l \, B_a$$

$$F_b = \frac{\mu_0}{2\Pi} \frac{i_a i_b \delta l}{d}$$

This direction of F_b will be towards conductor a. Thus the force per unit length of wire 'b'

$$\frac{F_b}{\delta l} = \frac{\mu_0}{2\Pi} \frac{i_a i_b}{d}$$

Similarly force per unit length of wire 'a' due to the magnetic field produced by wire b will be

$$\boxed{\frac{F_a}{\delta l} = \frac{\mu_0}{2\Pi} \frac{i_a i_b}{d}}$$

Q.6 Define Magnetic Flux. State Faradey's Laws of Electromagnetic Induction.

Ans.: Magnetic flux : The magnetic flux Φ linked with any surface placed in magnetic field $\vec{B}$ is measured by total number of magnetic lines of force passing through it. If we imagine that a plane surface of area A is placed in uniform magnetic field (In which lines of force are parallel and equidistant) then magnetic flux Φ is given as

$$\Phi = \vec{B} \, . \, \vec{A} = BA\text{Cos}\theta$$

Where θ is the angle between area vector & magnetic field.

Faraday's Laws of Electromagnetic Induction :

(i) Faraday's First Law : Whenever the magnet flux linked with a circuit changes with time an induced EMF is developed in the circuit. The induced EMF in the circuit exists so long as the change in magnetic flux continues. This law gives the cause of generation of induced EMF.

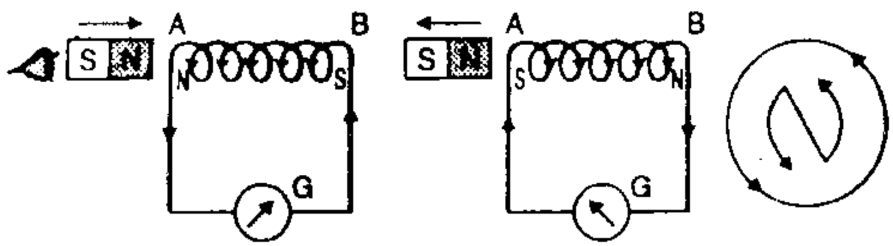
(ii) Faraday's Second Law : The magnitude of induced EMF in a circuit is equal to the rate at which the magnetic flux linked with the circuit changes.

Q.7 State Lenz's Law with suitable example.

Ans.: **Lenz's Law :** The direction of induced EMF and induced current is obtained with the help of this law. According to this law the direction of induced current in the circuit is always such that it opposes the very cause which has produced it.

This law is applicable to closed circuits only.

Suppose a bar magnet SN is pushed towards the coil then induced EMF must oppose the motion of magnet towards the coil. A north pole is formed at the face of the coil opposite to magnet and magnet is repelled. And when viewed from the side of magnet, the current in coil is anticlockwise.



(a) (b)

Similarly when the magnet is moved away from the coil, a south pole is formed at the opposite face and the attractive force between south and north poles opposes the motion, therefore, the current in the coil will be clockwise.

Q.8 Explain Phenomena of Dia, Para and Ferromagnetic Materials.

Ans.: **Diamagnetic Substances :** Those materials which are repelled by magnetic field i.e. a force acts on them from higher magnetic field region (in opposite direction) such as water, sodium chloride etc. are called ***Diamagnetic Substances***.

Paramagnetic Substances : Those materials which experience a magnetic field i.e. the force acts from weaker magnetic field region are called ***Paramagnetic Substances***. The force acting on the substances is very small in comparison to the force on the substances as iron, nickel etc.

Ferromagnetic Substances : The substances such as iron, nickel and cobalt experience a strong force of attraction by magnetic field and are called ***Ferromagnetic Substances***.

If a small bar of a substance is suspended between the poles of a magnet, then diamagnetic substance tends to align perpendicular to the magnetic field, paramagnetic substance tends to align parallel to the magnetic field and ferromagnetic substance tends to align to the magnetic field even by weak field.

Q.9 Show the dependence of Magnetic Susceptibilities of Dia, Para and Ferromagnetic Materials on Temperature.

Ans.: **Magnetic Susceptibility (X)** is a property which determines how easily a magnetic material can be magnetized.

Magnetic susceptibility of diamagnetic substances does not depend on the temperature since motion of electrons does not depend upon the temperature.

Magnetic Susceptibilities of Paramagnetic Substances depend upon the temperature and according to Curies' law the magnetic susceptibility X of Paramagnetic Substance is given as

$$X \propto 1 / T$$

$$\Rightarrow \boxed{X = C / T}$$

C is called ***Curie's Constant***

Magnetic Susceptibility of Ferromagnetic materials depends upon temperature. Its dependence on temperature is according to ***Curie – Weiss Law*** and given as

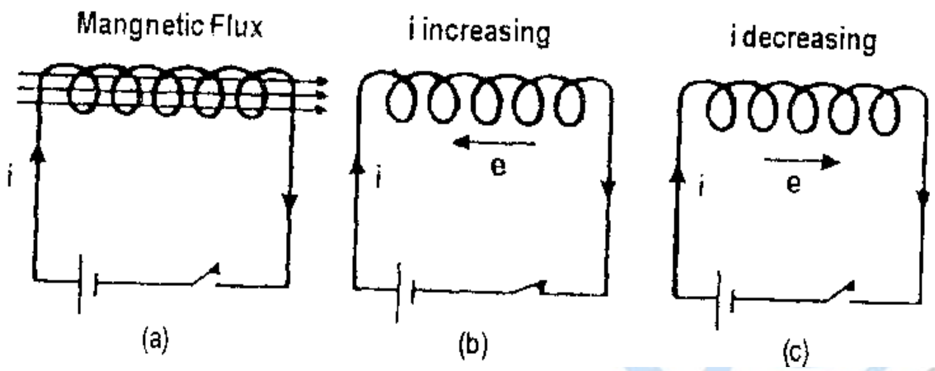
$$\boxed{X = \frac{C}{T - T_c}}$$

Where T_c is called ***Curie Temperature***

Curie Temperature is that temperature at or below which a material behaves like a ferromagnetic material and above which it behaves like a paramagnetic material.

Q.10 Define Self Induction and Mutual Induction.

Ans.: Self Induction :



Due to change in current passing through a coil, the magnetic field produced by it and the magnetic flux linked with it changes with time, producing an induced EMF in the coil. This phenomena is called ***Self Induction***. The phenomena of self induction occurs in every current carrying circuit or element.

Mutual Induction :

The phenomena of electromagnetic induction in which, on changing the current in one coil an opposing induced EMF is produced in a neighboring coil, is known as ***Mutual Induction***.

Multiple Choice Questions

1 Magnetic induction due to a solenoid of length 'L' radius R, no. of turns N and current I is:

(a) $\mu_0 NI$ (b) $\mu_0 NIL$

(c) $\frac{\mu_0 NI}{2\pi R}$ (d) $\frac{\mu_0 NI}{L}$ ( )

2 The unit of magnetic flux density is:

(a) Weber/m (b) Weber

(c) Weber/m^2 (d) amp/m ( )

3. The commercial unit of electrical energy is:
   (a) Joules (b) Watt
   (c) Kilowatt (d) Kilowatt hour ( )

4 The magnetic induction at the centre of a circular current carrying coil of redius 'r" is:
   (a) $\frac{\mu_O n_i}{2a}$ (b) $\frac{2\mu_O n_i}{a}$
   (c) $\frac{\mu_O n_i}{a}$ (d) Zero ( )

5 The rays which remain unperfected in a magnetic field are:
   (a) $\beta - rays$ (b) $\alpha - rays$
   (c) $\gamma - rays$ (d) Positive rays ( )

6 The cause of diamagnetism is:
   (a) Orbital motion of electrons (b) Spin motion of electrons
   (c) Paired electrons (d) None of the above ( )

7 A bar magnet of magnetic moment 'M' is cut into two equal parts. The magnetic moment of either of part will be:
   (a) 2 M (b) $\frac{M}{2}$
   (c) $\frac{M}{4}$ (d) Zero ( )

8 The coefficient of self induction of a coil is given by:
   (a) L = $\left\{\frac{e}{-\frac{di}{dt}}\right\}$ (b) L = $-e\frac{di}{dt}$
   (c) L = $\frac{di}{edt}$ (d) L = $-\frac{di}{edt}e^2$ ( )

9 The peak value of a.c. is 4 Ampere the root mean square value of current in the circuit is:
   (a) 4 Ampere (b) $4\sqrt{2}$ Ampere
   (c) $x = \frac{4}{\sqrt{2}}$ Ampere (d) 8 Ampere ( )

10 Magnetic field is produced by the flow the current in a straight wire. This phenomenon is based on:
   (a) Faraday's (b) Maxwell's law

(c) Coulomb's law (d) Biot-Sawart law
( )

11 Unit of magneto motive force is:
(a) Ampere/meter (b) Ampere-meter
(c) Ampere (d) Weber-meter ( )

12. The direction of lines of force of magnetic field produced due to flow of direct current in a conductor is formed by:
(a) Lenz/s law (b) Right hand rule
(c) Faraday's law (d) Biot-svart's law ( )

13 Who discovered magnetic effect of current?
(a) Faraday (b) Oersted
(c) Ampere (d) Bohr ( )

14 The value of magnetic induction B at different points situated on the axis of current carrying wire will be:
(a) Zero (b) Maximum
(c) Proportional to current (d) None of above ( )

15 The field intensity due to current I flowing through a straight long wire is proportional to:
(a) I (b) I^2
(c) $\sqrt{I}$ (d) I/I ( )

16 When current is passed, through two long straight wires in same direction then there will.
(a) be force of repulsion between the wires
(b) be force of attraction between the wires
(c) Not be any force of attraction between the wires
(d) Not be any force in opposite direction mutually ( )

17. The current flowing in opposite direction mutually.
(a) Attract each other
(b) Repel each other
(c) do not affect each other
(d) Attract sometimes and repel sometimes ( )

18 The value of magnetic induction inside a solenoid along the radius:

(a) Is zero
(b) decreases with distance from the axis
(c) is uniform
(d) increases with distance from the axis ( )

19 The formula for magnetic induction at the centre of current carrying circular coil of radius r is:

(a) $\frac{\mu_0 I}{2\pi r}$ (b) $\frac{\mu_0 I}{\pi}$

(c) $\frac{\mu_0 I}{2r}$ (c) $2\mu I r$ ( )

20 A circular coil A and radius r carries a current I. Another circular coil B of radius 2r carries a current 2I. The magnetic fields at the centers of the circular coils are in the ratio of:
(a) 4 :1 (b) 3 : 1
(c) 2 :1 (c) 1 : 1 ( )

21 Magnetic field do not interact with:
(a) Stationary electric charges
(b) Moving electric charges
(c) Stationary permanent magnets
(d) Moving permanent magnets ` ( )

22. Diamagnetism is:
(a) Distortion effect
(b) Orientation effect
(c) Both distortion and orientation
(d) Cooperative phenomena ( )

23 The permeability of a substance is zero. Then it is:
(a) Diamagnetic (b) Paramagnetic
(c) ferromagnetic (d) anti ferromagnetic ( )

S.NO.	**Q:1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Ans	**D**	**B**	**D**	**A**	**C**	**A**	**B**	**A**	**C**

S.NO	10	11	12	13	14	15	16	17	18
Ans	D	D	B	A	C	A	A	A	C
S.NO	19	20	21	22	23				
Ans	C	A	A	C	C				