Physics

Chapter: - 2nd

Electrostatic Potential and Capacitance

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Electrostatic Potential and Capatitance

CHAPTER :- 2

Q Define Electrostatic potential?

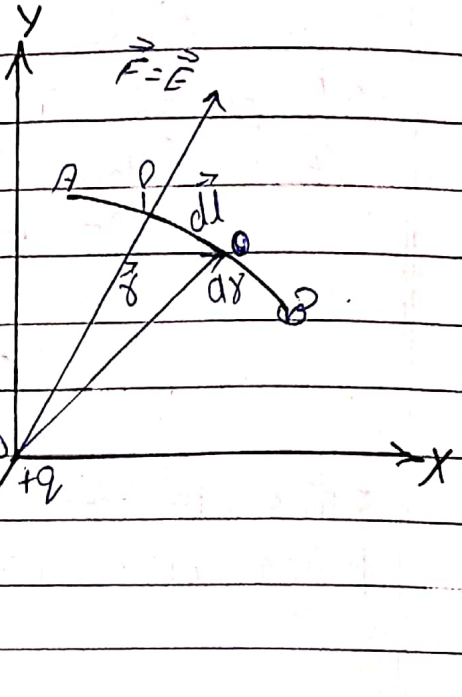
Sol Electric field can be related to a scalar quantity, called electric potential which determines the degree of electrification of a body

(or)

The electric potential at any point in the electric field is the work done per unit charge in bringing a unit(+ve) charge from infinite to that point along any path.

Q:- Show that the electrostatic potential can be represented as the line integral on the electrostatic field

Ans:- Consider a point charge $(+q)$ located at the origin O of Cartesian Coordinate System. Let AB be any path of a unit positive charge in the electric field of point charge $(+q)$



Now force acting on the unit positive charge at a point (P) due to $(+q)$ charge is

$$\vec{F} = \frac{1}{4\pi\epsilon_0}\frac{q\times 1}{r^2}\hat{r}$$

$\therefore$ Electric field due to charge $(+q)$ at point (P) is given by

$$\vec{E} = \frac{\vec{F}}{1} = \vec{F}$$

or $$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\hat{r}$$

If the unit positive charge moves from (P) to another point (Q) in the electric field such that $\vec{PQ} = d\vec{l}$, then work done by the electric field intensity $(\vec{E})$ in moving the unit positive charge from (P) to (Q) is

$$dw = \vec{E}.d\vec{l}$$

Total work done by the electric field ($\vec{E}$) to move the unit positive charge from A to B is given by

$$W_{AB} = \int dw = \int_A^B \vec{E}.d\vec{l}$$

$\int_A^B \vec{E}.d\vec{l}$ is called the line integral of electric field b/w the points A to B.

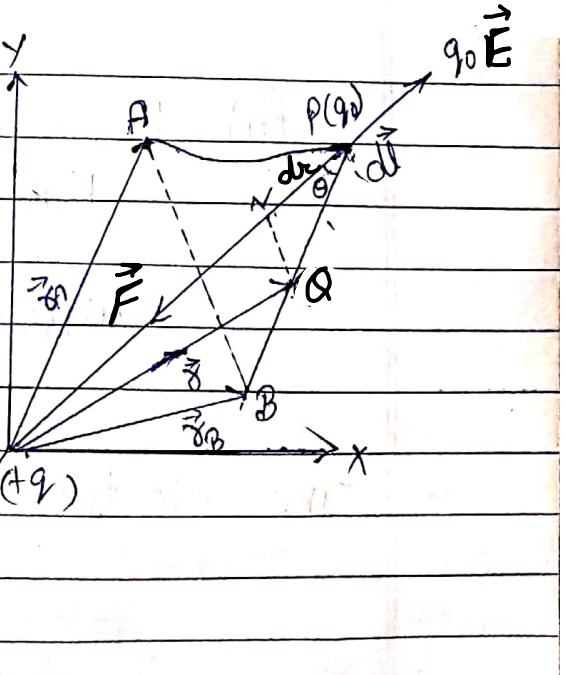
i.e the electrostatic potential can be represented as the line integral on the electrostatic field.

Q:- Show that the work done in moving a point charge in an electric field is independent of the path along which the charge is moved?

(or)

Discuss the conservative nature of electrostatic force.

Ans:- Consider a point charge ($+q$) at origion (O). The force acting on the test charge (q_0) at a point (P) on any path is ($q_0\vec{E}$).



This force acts readily out ward Tendents to accelerate the test Charge (q_0) to prevent this acceleration equal and opposite force $F = -q_0E$ as to be applied on the test charge.

∴ work done to move test charge (P to Q)

$$dw = \vec{F} \cdot d\vec{l} \quad -(i)$$

Total work done

$$\int_A^B dw = \int_A^B \vec{F} \cdot d\vec{l}$$

$$= \int_A^B -q_0 \vec{E} \cdot d\vec{l}$$

$$\int_A^B dw = -q_0 \int_A^B \vec{E} \cdot d\vec{l} \quad -(ii)$$

$$W_{AB} = -q_0 \int_A^B \vec{E}\, d\vec{l} \cos\theta \quad -(ii) \qquad \left[\because E \cdot dl = \cos\theta\right.$$

Draw $ON \perp OP$ so that $PN = dr$

In at ΔPON

$$\cos\theta = \frac{PN}{PQ}$$

$$\cos\theta = \frac{dr}{dl} \Rightarrow dr = \cos\theta\, dl$$

Put this value in equation (i)

$$W_{AB} = -q_0 \int_A^B E \cdot dr$$

$$W_{AB} = -q_0 \int_{r_A}^{r_B} \vec{E} \cdot dr \quad -(iii)$$

The electric field at point (P) due to charge q

$$E = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2}$$

∴ equation (iii) become

$$W_{AB} = -q_0 \int_{r_A}^{r_B} \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2} dr$$

$$W_{AB} = \frac{-q_0 q}{4\pi\varepsilon_0} \int_{r_A}^{r_B} \frac{1}{r^2} dr$$

$$= \frac{-q_0 q}{4\pi\varepsilon_0} \int_{r_A}^{r_B} r^{-2+1} dr$$

$$= \frac{-q_0 q}{4\pi\varepsilon_0} \left[\frac{r^{-1}}{-1} \right]_{r_A}^{r_B}$$

$$= \frac{-q_0 q}{4\pi\varepsilon_0} \left[-\frac{1}{r} \right]_{r_A}^{r_B}$$

$$= \frac{q_0 q}{4\pi\varepsilon_0} \left[\frac{1}{r_B} - \frac{1}{r_A} \right]$$

$$W_{AB} = \frac{q_0 q}{4\pi\varepsilon_0} \left[\frac{1}{r_B} - \frac{1}{r_A} \right]$$

$$W_{AB} = -q_0 \int_A^B \vec{E} \cdot d\vec{l} = \frac{q_0 q_1}{4\pi\varepsilon_0} \left[\frac{1}{r_B} - \frac{1}{r_A} \right]$$

$$\frac{W_{AB}}{q_0} = -\int_A^B \vec{E} \cdot d\vec{l} = \frac{q}{4\pi\varepsilon_0} \left[\frac{1}{r_B} - \frac{1}{r_A} \right]$$

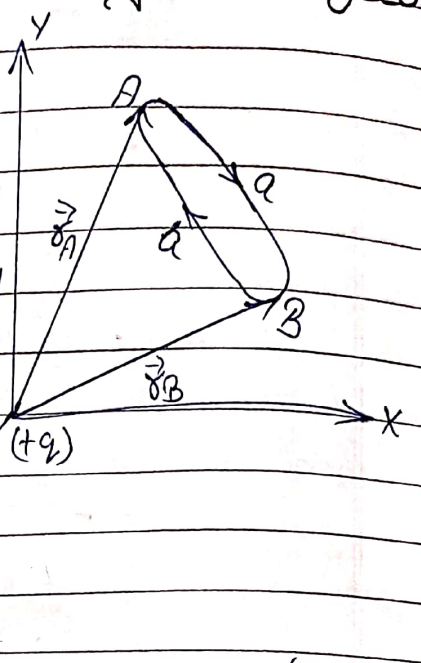
$$\int_A^B \vec{E} \cdot d\vec{l} = \frac{q}{4\pi\varepsilon_0} \left[\frac{1}{r_A} - \frac{1}{r_B} \right]$$

This show that the line intergeral of electric field is indipendent of the actual path flowed by the test charge from one point to another in an electric field so field is called Conservative field. Hence electrostatic field is a Conservative field in Nature.

Q Show that the line intergral of electric field over a

closed path in the electrostatic field is zero?

Ans:- Consider a closed path (AaBbA) in a electric field ($\vec{E}$) due to point charge ($+q$) at origion (O). The intergural of (E) b/w two line points (A and B) along path (a).



$$\int_{Path\,a} \vec{E}\cdot d\vec{l} = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{r_A} - \frac{1}{r_B}\right] \quad (i)$$

The integral of (E) b/w two points (B to A) along path (b)

$$\int_{Path\,b} \vec{E}\cdot d\vec{l} = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{r_B} - \frac{1}{r_A}\right] \quad (ii)$$

Adding (i) and (ii)

$$\int_{Path\,a} \vec{E}\cdot d\vec{l} + \int_{Path\,b} \vec{E}\cdot d\vec{l} = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{r_A} - \frac{1}{r_B}\right] + \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{r_B} - \frac{1}{r_A}\right]$$

$$\int_{Path\,a} \vec{E}\cdot d\vec{l} + \int_{Path\,b} \vec{E}\cdot d\vec{l} = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{r_A} - \frac{1}{r_B}\right] - \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{r_A} - \frac{1}{r_B}\right]$$

$$\int_{Path\,a} \vec{E}\cdot d\vec{l} + \int_{Path\,b} \vec{E}\cdot d\vec{l} = 0 \quad (iii)$$

But $$\int_{Path\,a} \vec{E}\cdot d\vec{l} + \int_{Path\,b} \vec{E}\cdot d\vec{l} = \oint \vec{E}\cdot d\vec{l} \quad (iv)$$

Put eqn (iv) and (iii)

$$\oint \vec{E}\cdot d\vec{l} = 0$$

This show that the line integral of electric field

over a closed path in the electrostatic field is zero.

Q: Define potential diff.?

Ans: The potential diff. b/w any two points in an electric field is defined as the work done per unit charge in moving a unit (+ve) charge from one point to the other against the electrostatic force of the field irrespective of the path followed.

(OR)

The potential diff. b/w any two points in an electric field is the (-ve) linear integral of electric field intensity b/w these points along any path.

We know

$$W_{AB} = -q_0 \int_A^B \vec{E} \cdot d\vec{l}$$

$$\frac{W_{AB}}{q_0} = -\int_A^B \vec{E} \cdot d\vec{l} = \frac{1}{4\pi\varepsilon_0}\left[\frac{1}{r_B} - \frac{1}{r_A}\right]$$

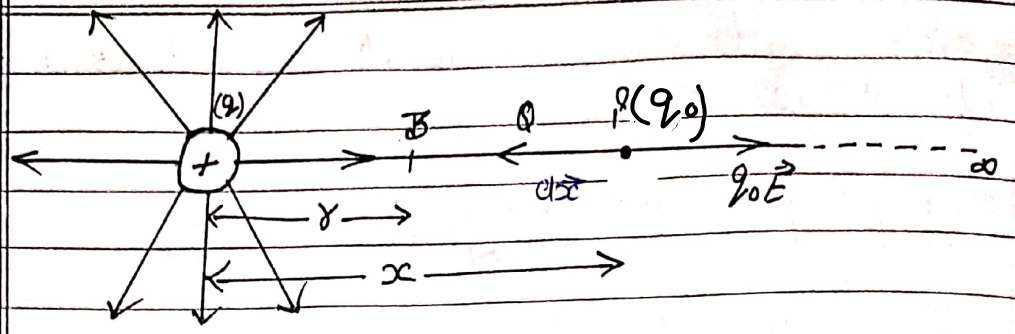
$$\frac{W_{AB}}{q_0} = -q \int_A^B \vec{E} \cdot d\vec{l} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r_B} - \frac{1}{4\pi\varepsilon_0}\frac{q}{r_A}$$

$$W_{AB} = V_B - V_A$$

$$\therefore V_B - V_A = \Delta V = \frac{W_{AB}}{q_0}$$

Q Drive and expration for electric potential due to single point charge?

Ans:



Consider the electric field due to a point charge (+q) is represented by field line. Let a unit test (q0) is place at point (P) at a distant (x) from (+q).

The electrostatic force acting on the test charge (q0) placed at (P).

$$\vec{F} = q_0\vec{E}$$

Let this force displaces the test charge (q_0) through (dx) from (P) to (Q) against the force (F). Therefore work done to move (q_0) from (P to Q) is

$$dw = \vec{F} \cdot d\vec{x}$$

$$dw = F\,dx\cos\theta$$

$$= q_0 E\,dx\cos 180$$

$$dw = -q_0 E\,dx \quad \text{---(i)}$$

But magnitude of (E) at (P)

$$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{x^2}$$

∴ equation (i) become

$$dw = -q_0\left(\frac{1}{4\pi\varepsilon_0}\frac{q}{x^2}\right)dx$$

$$= \frac{-1}{4\pi\varepsilon_0}\frac{qq_0}{x^2}dx \quad \text{---(ii)}$$

Total work done to move the test charge from (∞ to point B) in the electric field

$$\int_{\infty}^{B} dW = \int_{\infty}^{\gamma} -\frac{1}{4\pi\varepsilon_0}\frac{qq_0}{x^2}\,dx$$

$$W_{\infty B} = -\frac{qq_0}{4\pi\varepsilon_0}\int_{\infty}^{\gamma}\frac{1}{x^2}\,dx$$

$$= \frac{-qq_0}{4\pi\varepsilon_0}\int_{\infty}^{\gamma} x^{-2}\,dx$$

$$= \frac{-qq_0}{4\pi\varepsilon_0}\left[\frac{x^{-1}}{-1}\right]_{\infty}^{\gamma}$$

$$= \frac{-qq_0}{4\pi\varepsilon_0}\left[-\frac{1}{x}\right]_{\infty}^{\gamma}$$

$$W_{\infty B} = \frac{qq_0}{4\pi\varepsilon_0}\left[\frac{1}{\gamma} - \frac{1}{\infty}\right]$$

$$W_{\infty B} = \frac{qq_0}{4\pi\varepsilon_0}\left[\frac{1}{\gamma}\right]$$

$$\frac{W_{\infty B}}{q_0} = \frac{q}{4\pi\varepsilon_0\gamma}$$

But $\frac{W_{\infty B}}{q_0} = V$, Potential at B

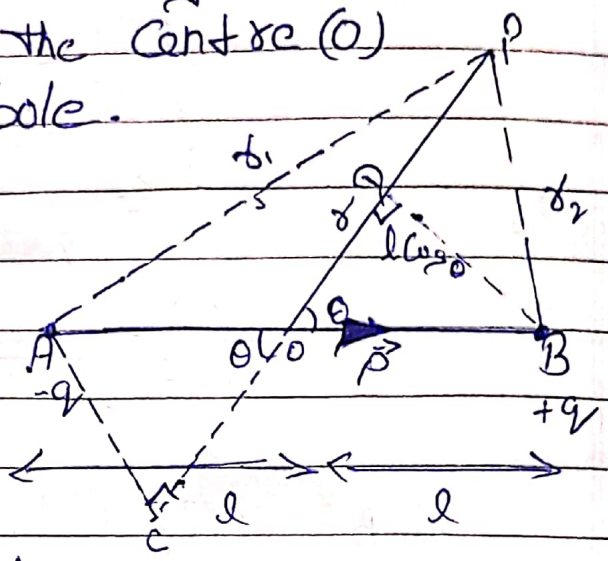
$$V = \frac{q}{4\pi\varepsilon_0\gamma}$$

This is the expression for electric potential due to single point charge.

Note (1) The electric potential due to an isolated (+ve) charge is (+ve) and due to an isolated (-ve) charge is (-ve).

Q. Drive an expression for electric potential at any point due to an electric dipole?

Ans: Consider (P) be a point of observation at a distance (r) from the centre (O) of the electric dipole.



Let (OP) makes an angle (θ) with the dipole moment ($\vec{p}$) and (r_1) and (r_2) be the distance of point (P) from ($-q$) charge and ($+q$) charge respectively.

Potential at point (P) due to ($-q$) charge

$$V_1 = \frac{1}{4\pi\varepsilon_0}\frac{-q}{r_1}$$

$$V_1 = -\frac{1}{4\pi\varepsilon_0}\frac{q}{r_1} \quad \text{---(i)}$$

Potential at point (P) due to ($+q$) charge

$$V_2 = \frac{1}{4\pi\varepsilon_0}\frac{q}{r_2} \quad \text{---(ii)}$$

$\therefore$ Potential at point (P) due to dipole

$$V = V_1 + V_2$$

$$V = -\frac{1}{4\pi\varepsilon_0}\frac{q}{r_1} + \frac{1}{4\pi\varepsilon_0}\frac{q}{r_2}$$

$$= \frac{q}{4\pi\varepsilon_0}\left[-\frac{1}{r_1} + \frac{1}{r_2}\right]$$

$$V = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{r_2} - \frac{1}{r_1}\right] \quad \text{---(iii)}$$

Now Draw a ($\perp$) from (A) which meets the line OP at (C). when produced Back ward also Draw ($BD \perp OP$)

$r_1 = AP \simeq CP = OP + OC = r + l\cos\theta$ (from Δ AOC, $OC = l\cos\theta$)

$r_2 = BP' \simeq DP = OP - OD = r - l\cos\theta$ (from BOD, $OD = l\cos\theta$)

From equation (iii)

$$V = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{r - l\cos\theta} - \frac{1}{r + l\cos\theta}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{r + l\cos\theta - r + l\cos\theta}{(r - l\cos\theta)(r + l\cos\theta)}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{2l\cos\theta}{(r^2 - l^2\cos^2\theta)}\right]$$

$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{q \times 2l\cos\theta}{(r^2 - l^2\cos^2\theta)}\right]$$

$$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{\vec{P}\cos\theta}{r^2 - l^2\cos^2\theta}\right] \quad [\because \vec{P} = q \times 2l]$$

If $r >> l$

$$V = \frac{P\cos\theta}{4\pi\varepsilon_0 r^2}$$

$$V = \frac{\vec{P} \cdot \vec{r}}{4\pi\varepsilon_0 r^2}$$

Special case : If point (P) lies on the axial line of the dipole $\theta = 0$

$$V = \frac{P}{4\pi\varepsilon_0 r^2}$$

$$V \propto \frac{1}{r^2}$$

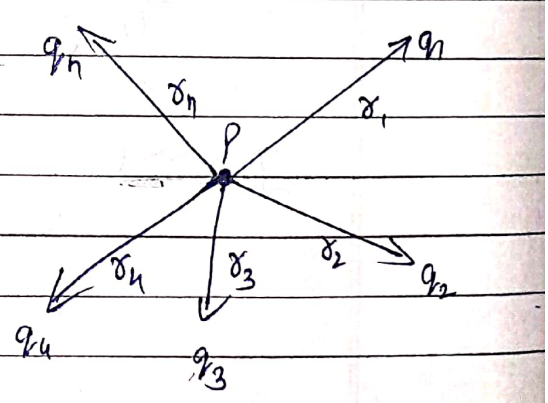
If the point (P) lie on equitorial line of the dipole $\theta = 90$ So $V = 0$

∴ Potential due dipole is zero at all points on the equitorial line of the dipole.

Q:- State and explain principle of superposition of electric potential? or electric Potential due to system of Charges.

Ans:- Principle of Super position: The net potential at any point in the Period of a group of charges is given by the algebraic sum of all the individual potential at that point.

Consider $(q_1, q_2, q_3 \ldots q_n)$ at the charge at distance $(r_1, r_2, r_3 \ldots r_n)$



Potential at (P) due to charge (q_1).

$$V_1 = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{r_1}$$

(due to q_2) $V_2 = \frac{1}{4\pi\varepsilon_0}\frac{q_2}{r_2}$ ----

(due to q_n) ---- $V_n = \frac{1}{4\pi\varepsilon_0}\frac{q_n}{r_n}$

∴ The potential at point (P) due to all charges

$$V = V_1 + V_2 + V_3 + \dots V_n$$

$$V = \frac{q_1}{4\pi\varepsilon_0 r_1} + \frac{q_2}{4\pi\varepsilon_0 r_2} + \dots + \frac{q_n}{4\pi\varepsilon_0 r_n}$$

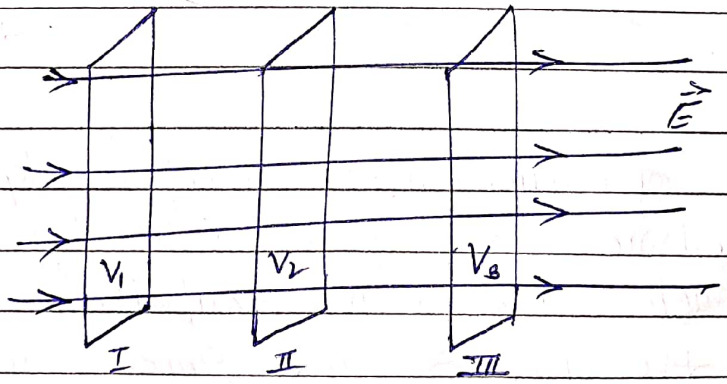
$$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1}{r_1} + \frac{q_2}{r_2} + \dots \frac{q_n}{r_n}\right]$$

$$V = \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{n}\frac{q_i}{r_i}$$

Q:- Define equipotential surface? and what is the value of potential for various cases. what are the properties of equipotential surfaces?

Ans:- Equipotential surface :- A surface at every point of which potential due to charge distribution is the same is called Equipotential surface.

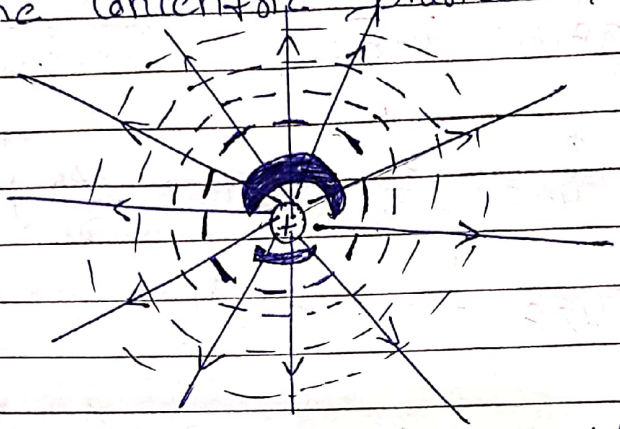
Case I → For a uniform electric field :-



Equipotential for a uniform Electric field $\vec{E}$ are the plane at right angle to the field lines. For a plane equipotential surface the source charged located at infinity.

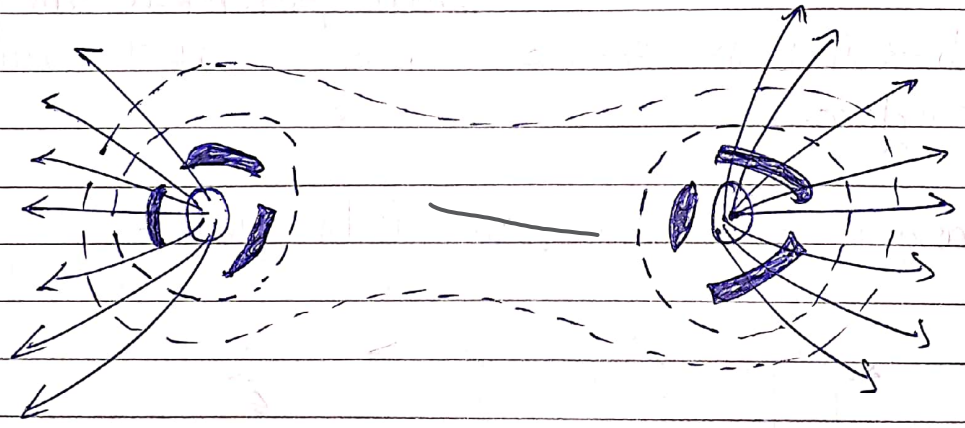
Case II:- For an isolated point charge :-

Equipotential surface for any point for an isolated point charge at the Concentric Spherical surface around the



degree. The potential and the Spherical Surface goes on decreasing as the radius of spherical surface increase.

Case III:- For pair of Similiar point charges :-



The shape of equipotential surface depend upon the algebric sum of potential at different point due to each charge means equipotential surface for two +ve charges at the same value.

Properties of Equipotential Surface:-

(1) No, work is done in moving a test charge from one point to another on an equipotential surface.

Consider two points A and B on the equipotential surface the potential diff. point A and B

$$V_B - V_A = \frac{W_{AB}}{q_0}$$

Since, Every point of equipotential surface has the same value of potential i.e

$$V_A = V_B$$

$$\frac{W_{AB}}{q_0} = 0$$

$$W_{AB} = 0$$

∴ No work is done is moving a test charge to another on the equipotential surface.

(2) Electric fields are ⊥ to the element 'dl' of the equipotential surface. As no work is done in moving a test charge on the equipotential surface $dw = 0$

$dl \rightarrow E$

But $dw = \vec{E} \cdot d\vec{l}$

$\therefore \vec{E} \cdot d\vec{l} = 0$

$E\,dl\cos\theta = 0$

$\cos\theta = 0$ if $\theta = 90°$

$\therefore \vec{E} \perp$ to $d\vec{l}$.

(3) Equipotential surface indicate Regions of strong and weak electro fields.

we know that

$$E = \frac{dv}{dr}$$

$dr = \frac{dv}{E}$ → $dr \propto \frac{1}{E}$

Since dv is constant

$dr \propto \frac{1}{E}$

If $\vec{E}$ is strong dr will be small means equipotential surface are closer in the region of strong electric field on the other hand equipotential surface are farther apart in the region on weak electric field.

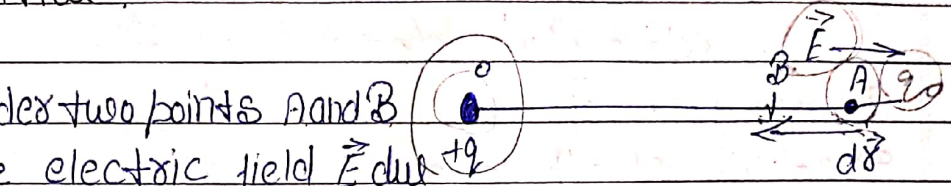
4. Two equipotential surfaces cannot intersect each other. If two equipotential surfaces intersect each other. then at the point of intersection there will be two values of the electric potential. This is not possible. Hence two equipotential surface cannot intersect.

Q. What is the Relation b/w the electric field intensity and potential?

or

Electric field intensity is the gradient of electric potential?

Ans. Consider two points A and B in the electric field $\vec{E}$ due to a point charge (+q) placed at (O). Let us assume that point A and B are so closed to each other that electric field intensity b/w A and B is uniform.



Let (q_0) be the test charge placed at (A) The force acting on (q_0) is $\vec{F} = q_0\vec{E}$

work done to move the test charge from (A to B) is given by

$$dw = \vec{F}\cdot d\vec{r}$$
$$= q_0\vec{E}\cdot d\vec{r}$$
$$dw = q_0 E dr \cos\theta$$
$$dw = q_0 E dr (-1) \quad \because \theta = 180^\circ \text{ b/w } dr \text{ and } \vec{E}$$
$$dw = -q_0 E dr$$
$$\frac{dw}{q_0} = -E dr$$

But $$dV = \frac{dw}{q_0}$$

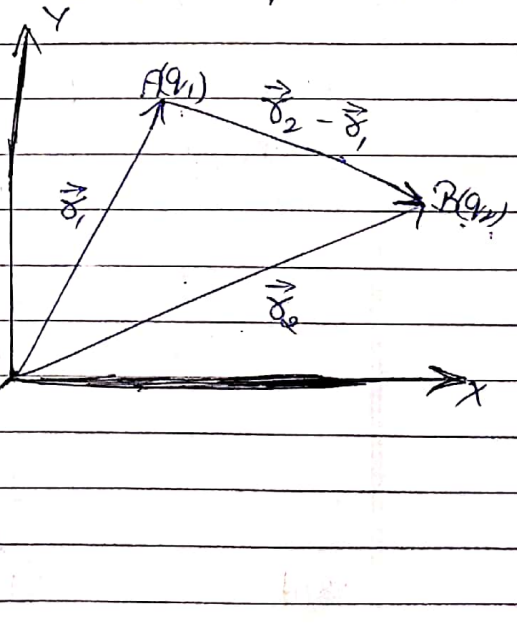
$\therefore$ equ(1) become

$$dV = -E dr$$
$$E = -\frac{dV}{dr}$$

∴ Electric field intensity at a point is equal to the (-ve) gradiant the electric potential. The (-ve) sign show that electric field intensity is the direction of decreasing potential.

Q: Define electric potential energy and Drive an expression of eletric potential energy (i) for a system of two point charges (ii) for a system of three point charges (iii) for a system of (n) point charges?

Sol: Eletric potential Energy:- The work done on a charge (q_2) in bringing it from infinite to a point in the field against the electrical force is called electrical potential energy.



Potential energy of a system for two point charge:→

Consider a system of a two point charge (q_1) and (q_2) such that (q_2) is initially at infinity from charge (q_1) lying in the free space. Now work is done to bring charge (q_2) from infinity to point B near point A because the charge (q_1) at point (A) provide electrostatic field all around it

work done $= V_2 \times q_2$

But $V_2 = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{AB}$

$$W = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{AB} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{|\vec{r}_2 - \vec{r}_1|}$$

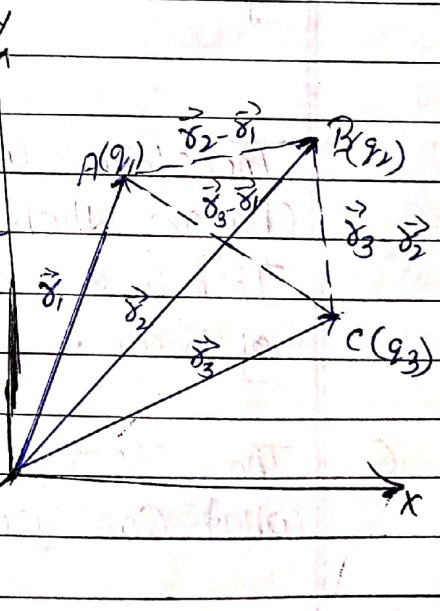
$$W = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}}$$

This work done is stored as P.E of system of two charges

$$U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}}$$

(b) Potential energy of a system of three point charges:-

Consider a system of three point charges (q_1, q_2 and q_3) such that (q_2 and q_3) are initially at infinite distance from charge q_1.



Total work done to bring all the three charges from infinity to their respective position is

$$W = W_1 + W_2 + W_3$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{|\vec{r}_2 - \vec{r}_1|} + \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_3}{|\vec{r}_3 - \vec{r}_1|} + \frac{1}{4\pi\varepsilon_0}\frac{q_2 q_3}{|\vec{r}_3 - \vec{r}_2|}$$

$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1 q_2}{|\vec{r}_2 - \vec{r}_1|} + \frac{q_1 q_3}{|\vec{r}_3 - \vec{r}_1|} + \frac{q_2 q_3}{|\vec{r}_3 - \vec{r}_2|}\right]$$

This work done W = Potential energy (U) of the system of three charges

$$U = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1 q_2}{|\vec{r}_2 - \vec{r}_1|} + \frac{q_1 q_3}{|\vec{r}_3 - \vec{r}_1|} + \frac{q_2 q_3}{|\vec{r}_3 - \vec{r}_2|}\right]$$

$$U = \frac{1}{2}\left[\frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{3}\sum_{\substack{j=1 \\ i\neq j}}^{3}\frac{q_i q_j}{|\vec{r}_j - \vec{r}_i|}\right]$$

Q:- Potential is the degree of electrification of a body? explain?

Sol:- The Potential of a body increase with the increase charge on it

$$V = \frac{q}{4\pi\varepsilon_0 r}$$

Therefore a body higher potential posses more charge then when it is at lower potential. Therefore potential is the degree of electrification of body.

Q In The electric potential is Constant in a region what Can you say about the Electric field?

Ans:- we know that electric field $(E) = -\frac{dV}{dr}$

$\therefore$ electric field, $E = -\frac{d(\text{Constant})}{dr} = 0$

Q No work is done in moving a charge from one point to another on a given surface. what is the nature of the surface?

Ans:- work done in moving a charge from one point to another on an equipotential surface is zero So the given surface is equipotential surface.

Q:- A man standing on the ground touches the power line with bear feet and gets a fatal shock. But a Bird sitting on the power line does not experiance any shock? why?

Ans:- Electric Shock is due to electric current flowing through a living body when the bird sitting on a single high power line. No current pass to its body because its body is equipotential surface that is there is no potential difference. When then touches the same line while standing bear foot on the ground the electric circuit is completed. The hand of the man are at the high potential and his feet are at low potential. hence large amount of current follows through the body of the man and he therefore gets a fatal shock.

Q Can two diff. equipotential surface intersect explain why?

Ans:- No, if they intersect then at the same point of intersection there will be two value of potential this is not possible and hence two equipotential surface cannot intersect.

Q Does the work done in moving a test charge in an electric field depends upon the path follow?

Ans: No.

Q What is shape of the equipotential surface for an isolated point charge?

Ans: Concentric sphere.

Q: Elustrate a Condition in which electric field is zero. But the potential is not zero?

Ans: Electric field inside a Hollow charged sphere is zero. But potential is not zero.

Q: ellustrate a Condition inwhich electric field is not zero But potential is zero?

Ans Electric field on equitorial line of a dipole is not zero But potential is zero

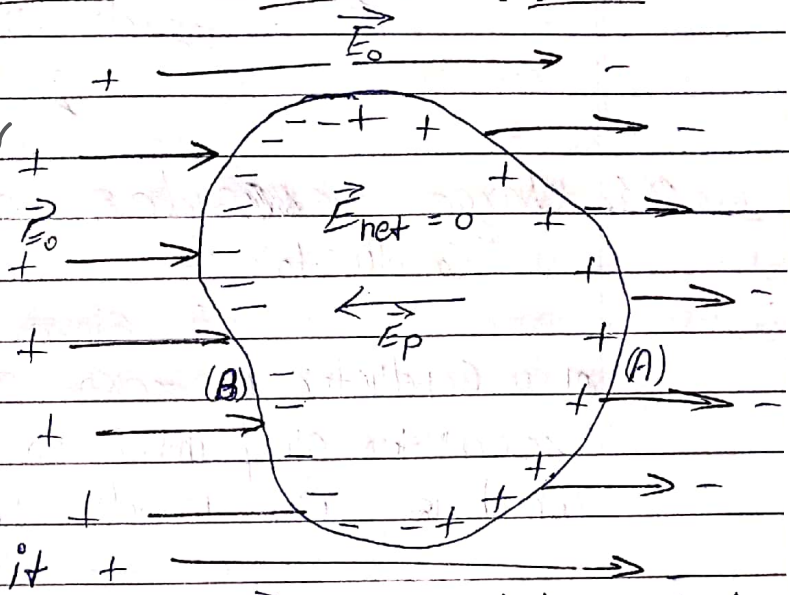
Q: A man inside an insulated metalic cage does not receive a shock, when the is highly charged why?

Ans: Since circuit blw the man and the cage is not Complete So no Current will pass through the body of the man hence man will not Received any Shock

Electrostatic potential and Capacitance

Q1: Behavior of the Conductor in electric field :-

(i) The Net electric field intensity in the Interior of a Conductor is zero.



Explanation:-

A Conductor contain large No. of free electron when it is place in the electric field $\vec{E}_0$ each electron experiance a force ($F = -e\vec{E}_0$) in a direction opposite to the direction of applied electric field E_0. So free electrons will move and collect towards positive of the applied field on the surface of conductor such that the side (A) of the Conductor become (+ve)ly charge due to the transfer of free electron the side (B) and therefore side (B) of conductor become (-ve)ly charged. This redistribution of charge will create its on field called induced electric field, which will Cancel the applied electric field (E_0) inside the Conductor hence net electric field Inside of the Conductor placed in the electric field is zero.

(ii) Net charge in the Interior of a Conductor is zero.

According to Gausses theorm

$$\oint_S \vec{E} \cdot d\vec{S} = \frac{q}{\varepsilon_0}$$

$\because \vec{E}$ is inside the Conductor is zero. ie $\vec{E}=0$

$q=0$

(3) Charge resides on the surface of a Conductor :-

Since the electric field in the Interior of a Conductor is zero so it must also the zero for all points on the gaussian surface. which is also inside the surface.

Acc. to Gausses law The Net charge inside the gaussian surface must be zero if access (q) is not inside the gaussin surface then it must lei on the surface of Conductor. So charge cannot reside in the interior of the Conductor it can only resides on the surface of the Conductor.

(4) Electric potential for interior Conductor :-

$$dV = -E\,dr$$

But $E = 0$

$$dV = 0$$

V = Constant.

Q Define electro static shielding ?

Ans:- The method of protecting a certain region from the effect of electric field is called electrostatic shielding.

Q:- It is advised to be inside a car or a bus than to stand under a tree during thunder storm. Explain why?

Sol:- During thunderstorm, a strong electric field exists in the atmosphere, A car or a bus can be compared to a conductor with cavity. The electric field inside the cavity of the conductor is zero, hence inside the car we are electrostatically shielded. This is not true under a tree.

Q:- A sensitive device misbehaves due to a nearby strong electrostatic field. Suggest a possible way to correct it?

Ans:- The instrument may be placed in the cavity of a conductor because electric field inside the conductor is zero. The instrument is to be kept insulated from the conductor

Q:- Define polarizability and its unit?

Sol:- For a single molecule, induced electric dipole moment ($\vec{P}$) is proportional to the applied electric field ($\vec{E}$) ie $\vec{P} \propto \varepsilon_0 \vec{E}$.

$$\vec{P} = \varepsilon_0 \alpha \vec{E}$$

where α is a constant and is called atomic or molecule polarizability

$$\alpha = \frac{P}{\varepsilon_0 E}$$

SI Unit = m^3

Q Define Dielectrics and purpose?

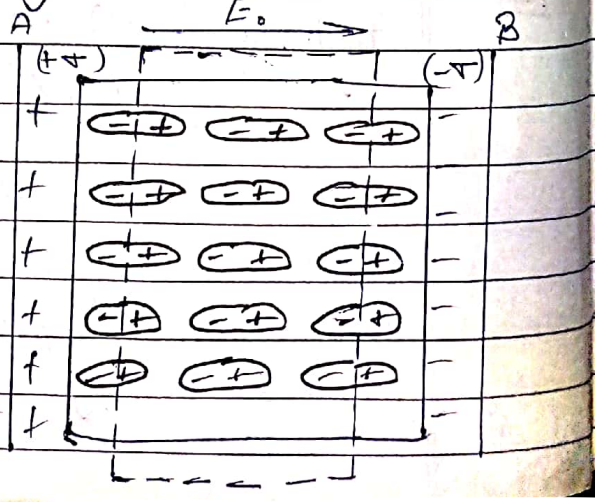
Ans:- The non-conducting materials in which induced charges are produced on their faces on the application of electric fields are called dielectrics.

eg:- Air, H_2 gas, glass, mica, paraffin wax, transformer oil etc.

~~Ans~~ purpose :- A dielectric increases the capacitance of a capacitor while keeping the two conducting plates insulated from each other.

Q Define Polarization of a Dielectric slab and give its expression?

Ans: Polarization of a dielectric is the process of inducting equal and opposite charges on the two opposite faces of the dielectric on the application of electric field.



Consider parallel Conducting plates having vacuum b/w the plates. Let $\vec{E_0}$ be the intensity of electric field b/w the plates. If (±σ) be the surface charge

density of positive plate and $(-\sigma)$ be the surface charge density of negative plate then magnitude of applied electric field is given by

$$E_0 = \frac{\sigma}{\varepsilon_0}$$

Let us introduce a non-polar dielectric slab b/w the plates. Each atom will be 'elongated' due the displacement of its charges under the effect of applied electric field ie polarized.

Now, each atom/molecule of the dielectric having dipole moment experiences a torque in the direction of the field ($\vec{E_0}$) and all the dipoles get aligned in the direction of the applied electric field. The interior charges shown in the dotted rectangle cancel the effect of one another. Therefore, the net effect is zero.

Q Define capacitance of a capacitor?

Ans:- The capacity of electrical capacitance of a Conductor is defined as the charge required to raise its potential through one unit.

(or)

Capacitance is the Ratio of the electric charge to the electric potential.

Let (q) is the charge on a Conductor and (V) its potential then

$$q \propto V$$

$$q = CV$$

where (C) is Constant of proposstionalty and is called electric capacitance

If $V = 1$

$$(\text{So } C = q)$$

Unit of Capacitance:- Farad (F)

The capacitance of a Conductor is said to be one (farad) if one Coulomb of charge is required to raise its potential through one volt.

Dimention of Capacitance:- $C = \frac{q}{V}$

$C = \frac{q}{w/q}$ $(\because V = w/q)$

$C = \frac{q^2}{w} = \frac{(It)^2}{w}$ $[\because q^2 = (It)^2$

$C = \frac{[A^2][T^2]}{[ML^2T^{-2}]} = [M^{-1}L^{-2}T^4A^2]$

Q Define Capacitor How it is represented? What is the purpose and uses of Capacitor?

ns:- A Capacitor Consist of two Conducting bodies separated by Non-Conducting medium. It can store large amount of Electric charge in small space.

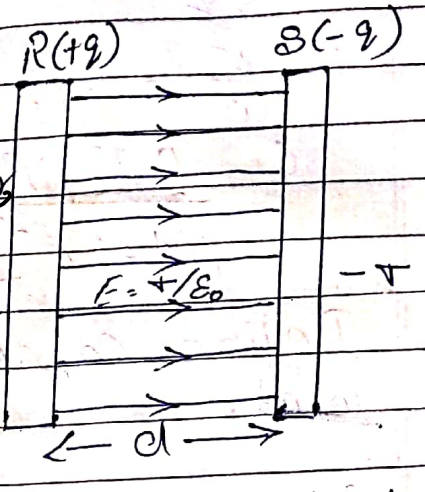
It is Represented by —||— , —/||—

fixed Variable Capacitor

Types of Capacitor:- They are named after the shape of the Conductor that Conductor used that is like plate, Spherical, cy lindrical etc or after the name of the dielectric medium. Eletrolytic paper, mica, Ceramic.

purpose:- It is used to Store the electric charge. By storing charge it also store electric charge so it is used in electric amplifiers, Radio sets, T.V., all the electric instruments.

2. Q:- Desrive and exproation for capacitance of a ||el plate Capacitor?



Ans:- Let (d) is the distance blw two plates of Capacitor plate(R) is given (+q) and plate(S) is given (-q). Let (+σ) be the surface charge density of plate (R) and (-σ) be the surface charge density of plate (S).

$$E = \frac{\sigma}{\varepsilon_0} \quad \text{— (1)}$$

But $E = \frac{dV}{dr} = \frac{V}{d}$ [dV and dr for small area]

$$V = Ed$$

$$V = \frac{\sigma d}{\varepsilon_0}$$

Since $\sigma = \frac{q}{A}$

$$\boxed{V = \frac{qd}{\varepsilon_0 A}}$$

But $C = \frac{q}{V}$

$$C = \frac{q \varepsilon_0 A}{qd}$$

$$\boxed{C = \frac{\varepsilon_0 A}{d}}$$

Capacitance of a parallel plate capacitor is directly

proportional to the area of plate and inversely proportional to the distance of separation.

Q:- Define dielectric Constant of dielectric material and explain by the Capacitance of a ||el plate Capacitor increases when dielectric slab is introduced b/w the plates?

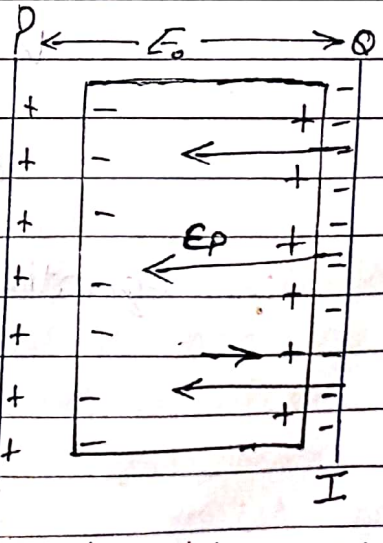
Dielectric Constant:- The Ratio applied electric field intensity (E_0) to the reduced value of electric field intensity (E) on placing a dielectric b/w the plates of the Capacitor is called dielectric Constant.

ie $$K = \frac{E_0}{E}$$

since $E_0 > E$ $\therefore$ K is always more then one It is also known as Specific Conductive

Capacitance of a ||el plate Capacitor having vacuum b/w the plates of the capacitor is given by

$$C_0 = \frac{\varepsilon_0 A}{d} \quad -(1)$$



Now, let us introduce a dielectric slab of thickness 't' b/w the plates of the capacitor.

Due to polarization, equal and opposite induced charges appear on the two faces of the dielectric slab. These induced charges given rise to induced electric field ($\vec{E_p}$) which is in a dielectric slab opposite to the applied field ($\vec{E_0}$). The reduced value of the electric field in the dielectric

$$E = (E_0 - E_p)$$

Now $E = (E_0 - E_p)$ exist in a region of thickness 't' and E_0 field exist in a region of thickness $(d-t)$

Potential diff. b/w the two plates of the capacitor is given by

$$V = E_0(d-t) + Et$$

Since $\frac{E_0}{E} = K \quad E = \frac{E_0}{K}$

$$V = E_0(d-t) + \frac{E_0}{K}t = E_0\left[(d-t) + \frac{t}{K}\right] \rightarrow (ii)$$

$$E_0 = \frac{\sigma}{\epsilon_0} = \frac{q}{A\epsilon_0} \Rightarrow V = \frac{q}{A\epsilon_0}\left[(d-t) + \frac{t}{K}\right] \rightarrow (iii)$$

$\therefore$ equation (ii) become

$$C = \frac{q}{V} = \frac{qA\epsilon_0}{q\left[(d-t) + \frac{t}{K}\right]}$$

$$C = \frac{\epsilon_0 A}{\left[(d-t) + \frac{t}{K}\right]}$$

$$C = \frac{A\epsilon_0}{d\left[\left(1 - \frac{t}{d}\right) + \frac{t}{dK}\right]} \quad \text{---(iv)}$$

Dividing equation (iv) by (i)

$$\frac{C}{C_0} = \frac{1}{\left[\left(1-\frac{t}{d}\right)+\frac{t}{dk}\right]} = \frac{1}{1-\frac{t}{d}\left(1-\frac{1}{k}\right)}$$

$$\boxed{C = \frac{C_0}{1-\frac{t}{d}\left(1-\frac{1}{k}\right)}}$$

$\therefore (C > C_0)$

$\therefore$ Since Capacitance of ||el plate capacitor increase on the introduction of a dielectric slab b/w the plates of the capacitor.

Special Case :- If $t=d$ ie The dielectric Slab completly fid in the plate of the capacitor

$$\therefore C = \frac{C_0}{1/k}$$

$$\boxed{C = kC_0}$$

$\therefore$ Capacity of ||el plate Capacitor increases by a factor (k).

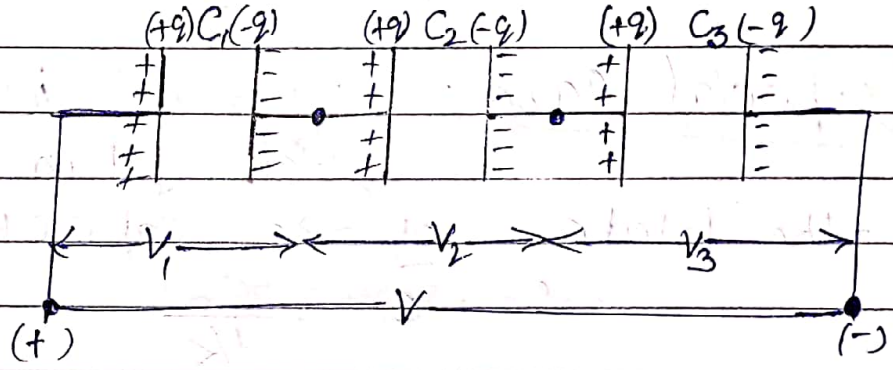
we know $k = \frac{C}{C_0}$

$\therefore$ dielectric Constant Can also be defined as the Ratio of the capacitance of a ||el plate Capacitor with dielectric Slab b/w the plates to the capacitance the ||el plate Capacitor with vaccum b/w the plates.

Q The atmosphere is not electrical neutral explain why?

1:- The atmosphere of the earth is been continuously charged by lightning and thunderstorm all over the glob and maintain an equilibrium with the discharge during normal weather condition hence atmosphere cannot become electrically neutral.

2:- Three capacitor C_1, C_2, C_3 are connected in series drive and expression for the equivalent capacitor?



Let C_1, C_2, C_3 are the capacitor connected in series Let (V) be the applied potential diff. accross the two terminal of the combination each capacitor has same charge (q) when connected in series then the total potential diff (V) accross the arrangement will be divided as (V_1, V_2, V_3) accross the capacitor (C_1, C_2, C_3)

$$V = V_1 + V_2 + V_3 \quad \text{---(1)}$$

But $V_1 = \frac{q}{C_1}, V_2 = \frac{q}{C_2}, V_3 = \frac{q}{C_3}$

$\therefore$ equation (1) become

$$\frac{q}{C} = \frac{q}{C_1} + \frac{q}{C_2} + \frac{q}{C_3}$$

$$\frac{q}{C} = q\left[\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right]$$

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

were (C) is the capacitance of the serice combination called equivalent capacitance

If n capacitance are connected in serices

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots + \frac{1}{C_n}$$

$$\frac{1}{C} = \sum_{i=1}^{n} \frac{1}{C_i}$$

Note:- (i) In case two capacitor C_1 and C_2 are connected in serice then effective capicitance is given by

$$\frac{1}{C_2} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$= \frac{C_2 + C_1}{C_1 C_2}$$

$$\frac{1}{C} = \frac{C_1 + C_2}{C_1 C_2}$$

$$C = \frac{C_1 C_2}{C_1 + C_2}$$

(ii) The effective capactance of two capacitor in serices is less then that of either of the two individual capacitance

Q Two capacitor each of capacity 2 μF are connected in serice calculate the equalant capacitance of the combination.

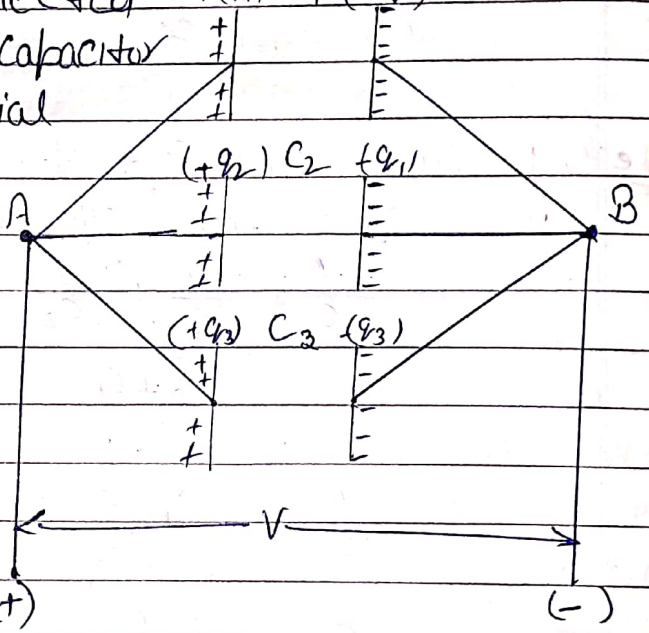
Sol: Here given that the $C_1 = 2\mu F$ and $C_2 = 2\mu F$

$$C = \frac{2 \times 2}{2+2}$$

$$C = \frac{4}{4} = 1$$

Q If three capacitor are connected in ||el.

Ans: Let C_1, C_2, C_3 are the three capacitor of diff. capacitancies connected in ||el. Here all capacitor have equal potential diff. (V) across them in ||el Combination each capacitor have diff. amount of charges ie (q_1, q_2, q_3) passed by capacitor (C_1, C_2, C_3) respectable



$$\therefore q = q_1 + q_2 + q_3$$

But $q = CV$, $q_1 = C_1V_1$, $q_2 = C_2V_1$, $q_3 = C_3V$

$$CV = C_1V_1 + C_2V_1 + C_3V_1$$

$$CV = (C_1 + C_2 + C_3)V$$

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

where (C) is called equivalent capacitance If (n) capacitor are connected in ||el

$$C = C_1 + C_2 + C_3 + \dots + C_n$$

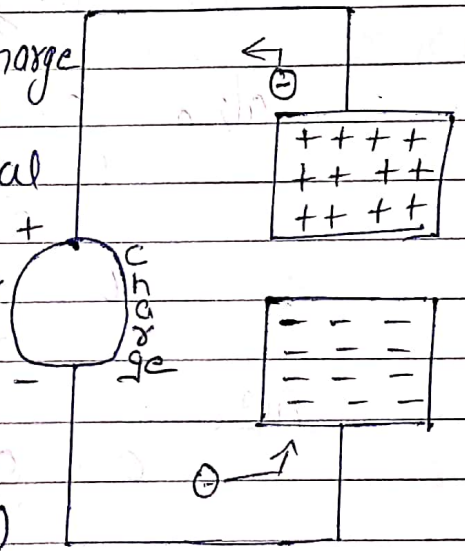
$$C = \sum_{i=1}^{n} C_i$$

e:- The equivalent capacitance of 11x1 plate capacitance is greater then any of the capacitances in the combination.

Q:- Prove that energy stored in a 11x1 plate capacitor can be expressed by the Relation $(1/2)(Q^2/C)$?(or) Drive and expression for energy stored when capacitor are combine in serice and parallel?

s:- Let at any instant a charge (q) be on the plate of a capacitor then potential difference b/w the plates of the capacitor is given by.

$$\left(V = \frac{q}{C}\right)$$



If extra charge (dq) is trancefer to capacitor then work done to do so is stored as electric potential energy in the capacitor

$$dU = dw = V dq$$

$$\therefore dw = \frac{q}{C} dq$$

$$\int dU = \int_0^Q \frac{q}{C} dq$$

$$U = \frac{1}{C} \int_0^Q q\, dq$$

$$U = \frac{1}{C}\left[\frac{q^2}{2}\right]_0^Q$$

$$U = \frac{1}{C}\left[\frac{Q^2}{2} - 0\right]$$

$$U = \frac{1}{C}\frac{Q^2}{2}$$

$$U = \frac{Q^2}{2C}$$

Other Relation for ... potential energy of the capacitor.

We know that

$$U = \frac{1}{2}\frac{Q^2}{C}$$

also $Q = CV$

$$U = \frac{1}{2}\frac{C^2V^2}{C}$$

$$U = \frac{CV^2}{2}$$

Also

$$C = \frac{Q}{V}$$

$$\therefore U = \frac{1}{2}\frac{Q^2}{QV}$$

$$U = \frac{1}{2}QV$$

V/Q

A 10 pF capacitor is connected to a 100 V battery. How much electrostatic energy is stored in the capacitor?

Ans

we know that

$$U = \frac{1}{2}CV^2$$

$C = 10\,pF = 10 \times 10^{-12}\,F$

$V = 100\,V$

$$U = \frac{1}{2} \times 10^{5} \times 10^{-12} \times 100 \times 100$$

$$U = 5 \times 10^{-8}$$

Energy Stored in Series Combination of Capacitor

Consider (n) capacitor each of capacitance ($C_1, C_2, C_3 \ldots C_n$) connected in Series.

$$\left(\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots + \frac{1}{C_n}\right)$$

We know that

$$U = \frac{1}{2} \cdot \frac{Q^2}{C} = \frac{Q^2}{2} \cdot \frac{1}{C}$$

Energy Stored in Series Combination

$$U = \frac{Q^2}{2} \cdot \frac{1}{C}$$

$$U = \frac{Q^2}{2}\left[\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots + \frac{1}{C_n}\right]$$

$$U = \frac{Q^2}{2C_1} + \frac{Q^2}{2C_2} + \frac{Q^2}{2C_3} + \cdots + \frac{Q^2}{2C_n}$$

$$(U = U_1 + U_2 + U_3 + \ldots U_n)$$

where ($U_1, U_2, U_3 \ldots U_n$) are the energy stored in the individual capacitor resp.

Energy Stored In Parell Combination Of Capacitor

Consider (n) capacitor of capacitances ($C_1, C_2, C_3 \ldots C_n$) connected in ||el. The equivalent combination

$$(C = C_1 + C_2 + C_3 + \ldots + C_n)$$

we also know that the energy stored in the capacitor

$$U = \frac{1}{2} CV^2$$

$$U = \frac{1}{2} V^2 (C_1 + C_2 + C_3 + \ldots + C_n)$$

$$U = \frac{1}{2} C_1 V^2 + \frac{1}{2} C_2 V^2 + \frac{1}{2} C_3 V^2 + \frac{1}{2} \ldots \frac{1}{2} C_n V^2$$

$$(U = U_1 + U_2 + U_3 + \ldots + U_n)$$

∴ It is concluded that the total energy stored in series or ||el combination is the sum of the energies stored in the invidual combination

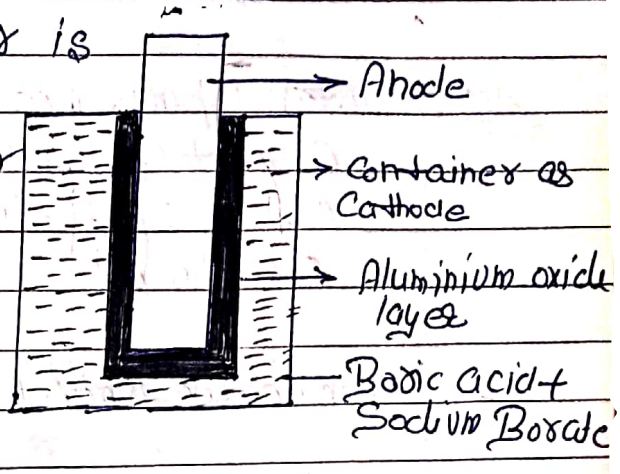
Q Why should be capacitor circuit we carfully handed when the circuit is just switch off?

Ans:- A capacitor when charge it discharges slowly on the disconnection from the circuit that is removal of external potential diff. across it. if this capacitor is touched by some one he may feel shock due to large charge still present on the capacitor.

Q What type of capacitor used in an electric

fan. Discribe its Construction and working?

Sol: An electrolytic capacitor is used in the fan.
The capacitor is using motor of an electric fan.
Construction of a simple electrolytic capacitor is shown in the figure.



The metallic anode (generally aluminium) gets a thin deposite of aluminium oxide due to electrolytes. This layer acts as a dielectric. The metallic container and the solution act and cathode. Since the layer of dielectric is very thin so it has large storage capacity.

Q:- Find the potential of a sphere having charge of 5 μc and capacitance of 1nF?

Ans: we know that

$$V = \frac{q}{C}$$

Here $q = 5\mu C = 5\times10^{-6} C$

$C = 1nF = 1\times10^{-9} F$

$$\therefore V = \frac{5\times10^{-6}}{1\times10^{-9}}$$

$$V = 5\times10^{3} V$$ Ans:

Q:- The four capacitor of capacitances 1pF, 2pF, 3pF, 4pF are connected in H.T. Find the capacitance of the combination of capacitor also find

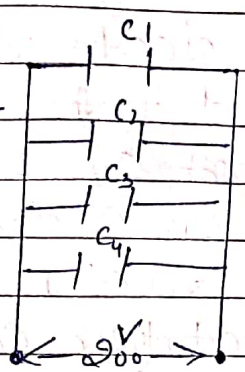
The charge on each capacitor if the combination is connected to 200V.

Ans: Total capacitance of the curcit

$C = C_1 + C_2 + C_3 + C_4$

$C = 1 + 2 + 3 + 4$ μF

$C = 10$ μF



Since we know that

The potential is same in (1) Combination and diff. Capacitor have diff. charges

$\therefore q_1 = C_1 V = 1 \times 200 = 200$ μC

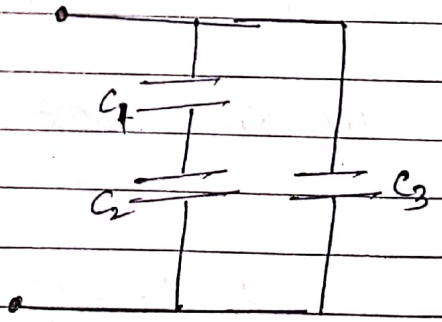
$q_2 = C_2 V = 2 \times 200 = 400$ μC

$q_3 = C_3 V = 3 \times 200 = 600$ μC

$q_4 = C_4 V = 4 \times 200 = 800$ μC

V.V

Q Calculate the equilant capacitance of the combination given in the fig:- $C_1 = 5$ MF, $C_2 = 10$ MF, $C_3 = 8$ MF



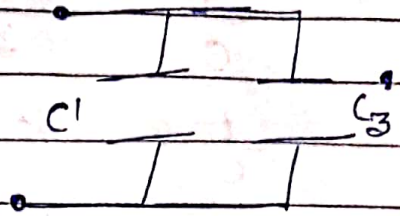
Sol: Since C_1 and C_2 are in serice therefore there equilant capacitance.

$$\frac{1}{C'} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$= \frac{1}{5} + \frac{1}{10}$$

$$\frac{1}{C'} = \frac{8+1}{10} = \frac{9}{10}$$

$$C' = 10/3$$



Now C' and C_3 are in ||el

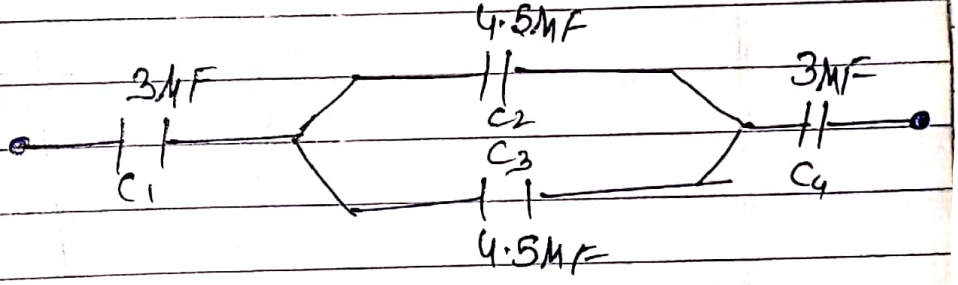
$$C_4 = C' + C_3$$

$$= \frac{10}{3} + 3$$

$$= \frac{10+9}{3}$$

$$C = \frac{19}{3}\,\mu F = 6.33\,\mu F$$

Q:- Calculate the equilant capacitance of the following combination



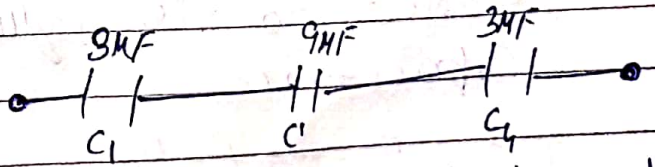
Ans:- Let $C_1 = 3\mu F$, $C_2 = 4.5\,MF$, $C_3 = 4.5\,MF$, $C_4 = 3\mu F$

Since C_2 and C_3 are in ||el therefore there equitant capacitance

$$C' = C_2 + C_3$$

$$C' = 4.5 + 4.5$$

$$C' = 9\,MF$$



Since C_1, C' and C_4 are in Serice ~~therefore~~ there equilant capacitance

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C'} + \frac{1}{C_4}$$

$$\frac{1}{C} = \frac{1}{3} + \frac{1}{9} + \frac{1}{3}$$

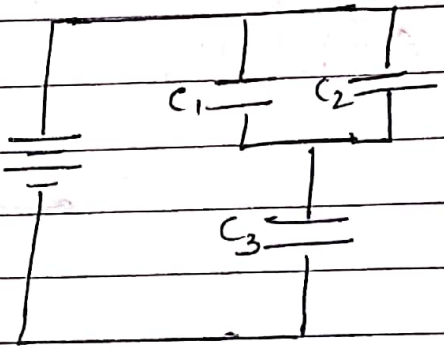
$$\frac{1}{C} = \frac{3 + 1 + 3}{9}$$

$$\frac{1}{C} = \frac{7}{9}$$

$$C = \frac{9}{7} = 1.29\ MF$$

Q (a) Find the equivalent capacitance of combination shown in the fig. assume that $C_1 = 10MF$, $C_2 = 5MF$, $C_3 = 4MF$

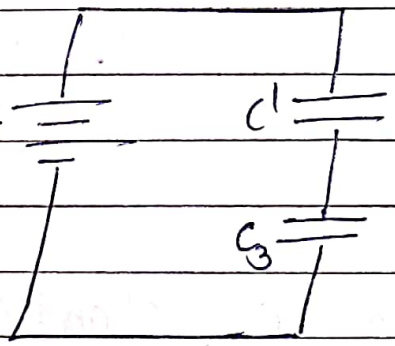
(b) if $V = 12.5$ then calculate charge on C_1



Sol (a) Since C_1 and C_2 are in 11x1 therefore the equivalent capacitance

$$C' = C_1 + C_2$$
$$C' = 10 + 5$$
$$C' = 15\ MF$$

Now C' and C_3 are in serice So there equilant Capacitance



$$\frac{1}{C} = \frac{1}{C'} + \frac{1}{C_3}$$

$$\frac{1}{C} = \frac{1}{15} + \frac{1}{4}$$

$$\frac{1}{C} = \frac{4+15}{60} = \frac{19}{60}$$

$$C = \frac{60}{19} = 3.16\,pF$$

(b) we Know that

$$q = CV$$

$$q = 3.16 \times 12.6$$

$$q = 39.5\,PF$$

$$V' = 2.63\,V$$

Since C_1 and C_2 are in 11&l so same potential diff. (V') across C_1 and C_2

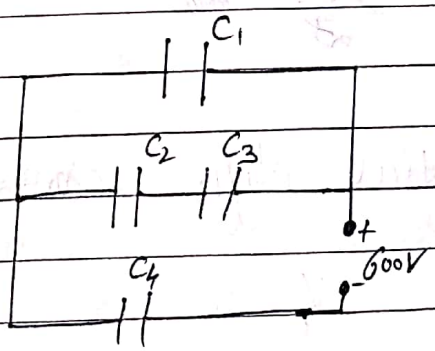
Charge on C_1

$$q_1 = C_1 V'$$

$$= 10 \times 2.63$$

$$q_1 = 26.3\,PF$$

Q obtained the equivlant capacitance of the following Networrk for a 600V Supply determine the charge and Voltage across $C_1 = C_4 = 100\,PF$, $C_2 = C_3 = 200\,PF$



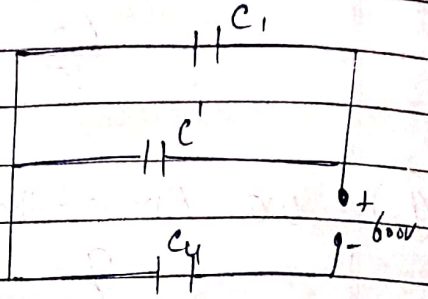
Sol: (a) Since C_2 and C_3 are in Series

∴ equivalant capacitance

$$\frac{1}{C'} = \frac{1}{C_2} + \frac{1}{C_3}$$

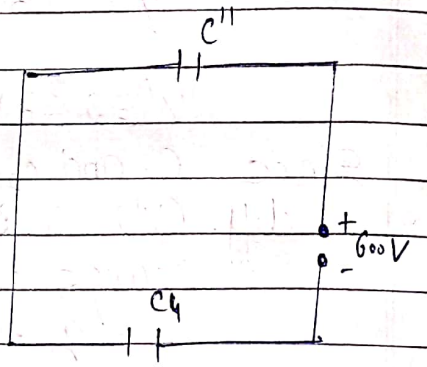
$$\frac{1}{C'} = \frac{1}{200} + \frac{1}{200} = \frac{1+1}{200} = \frac{2}{200} = \frac{1}{100}$$

$$C' = 100\,pF$$



Now C_1 and C' are in ||xl so equivalent capacitance

$$C'' = C_1 + C_2'$$
$$C'' = 100 + 100$$
$$C'' = 200$$



Now C_4 and C'' are in series so equivalent capacitance

$$\frac{1}{C} = \frac{1}{C''} + \frac{1}{C_4}$$

$$= \frac{1}{200} + \frac{1}{100}$$

$$\frac{1}{C} = \frac{1+2}{200} = \frac{3}{200}$$

$$C = \frac{200}{3} = 66.7\,pF.$$

(b) potential diff. across C_4

$$V_4 = \frac{q_4}{C_4}$$

$$V = \frac{q_4}{100 \times 10^{-12}\,V} \quad \text{---(i)}$$

∴ V across C'

$$V = \frac{q_4}{C'} = \frac{q_4}{200 \times 10^{-12}\,V} \quad \text{---(ii)}$$

Adding equ. (i) and (ii)

$$\frac{q_4}{100\times10^{-12}} + \frac{q_4}{200\times10^{-12}} = 600$$

$$q_4\left[\frac{1}{100\times10^{-12}} + \frac{1}{200\times10^{-12}}\right] = 600$$

$$q_4 = \frac{600\times 200\times10^{-12}}{3}$$

$$q_4 = 4\times10^{-8}\,C$$

Since P.D across C_4

$$V = \frac{q_4}{C_4}$$

$$V = \frac{4\times10^{-8}}{100\times10^{-12}}$$

$$V = 400$$

C_1 and C' are in ||el so Voltage across them is same.

$$V_1 = 600 - 400$$

$$V_1 = 200\,V$$

$$q_1 = C_1V_1$$

$$q_1 = 100\times10^{-12}\times200$$

$$= 2\times10^{-8}\,C$$

As C_2 and C_3 are in Series so the charge equal Capacitance

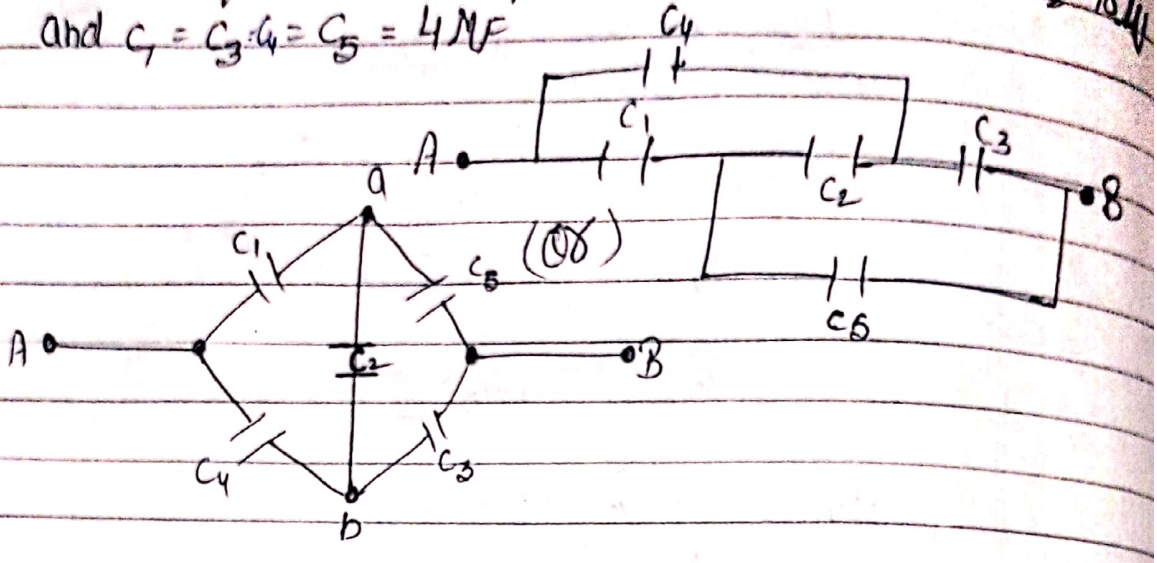
$$V_2 = V_3 = \frac{200}{2} = 100V$$

$$q_2 = C_2V_2$$

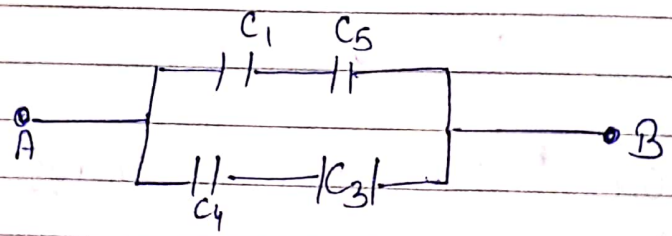
$$= 100\times200\times10^{-2}$$

$$= 2\times10^{-8}\,C$$

Q Find the equivalent capacitance A and B take $C_2 = 10\mu F$ and $C_1 = C_3 = C_4 = C_5 = 4\mu F$



Sol:- Since $C_1 = C_4 = C_3 = C_5 = 4\mu F$ since point A and B are at the same potential it means no charge flow through C_2 and hence it has no role in the circuit



Since C_1 and C_5 are in series so equivalent capacitance

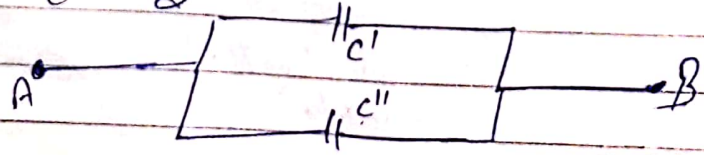
$$\frac{1}{C'} = \frac{1}{4} + \frac{1}{4} = \frac{1+1}{4} = \frac{2}{4} = \frac{1}{2}$$

$$C' = 2$$

also C_4 and C_3 are in series so equivalent capacitance

$$\frac{1}{C''} = \frac{1}{C_4} + \frac{1}{C_3} = \frac{1}{4} + \frac{1}{4} = \frac{1}{2}$$

$$C'' = 2$$



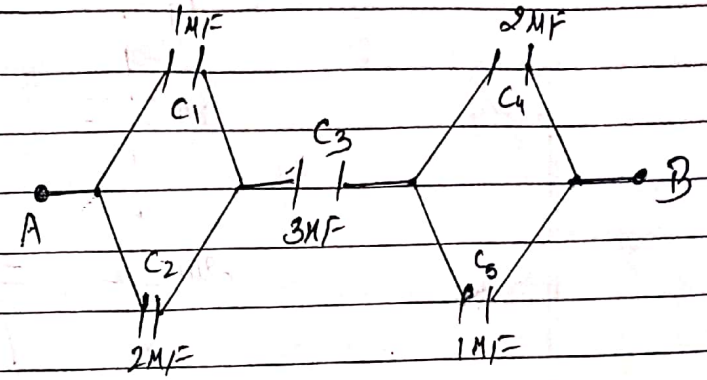
Now C' and C'' are in ||el So equivalant capacitance

$C = C' + C''$

$C = 2 + 2$

$C = 4\ \mu F$

Q

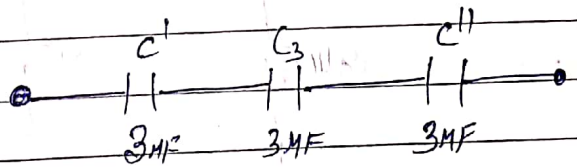


Since C_1 and C_2 are in ||el So equivalant Capcitance

$C' = C_1 + C_2 = 1 + 2 = 3\ MF$

also C_4 and C_5 are in ||el So equivalant capacitance

$C'' = C_4 + C_5 = 2 + 1 = 3MF$



Since C', C_3 and C'' are in series So equivalant Capacitance

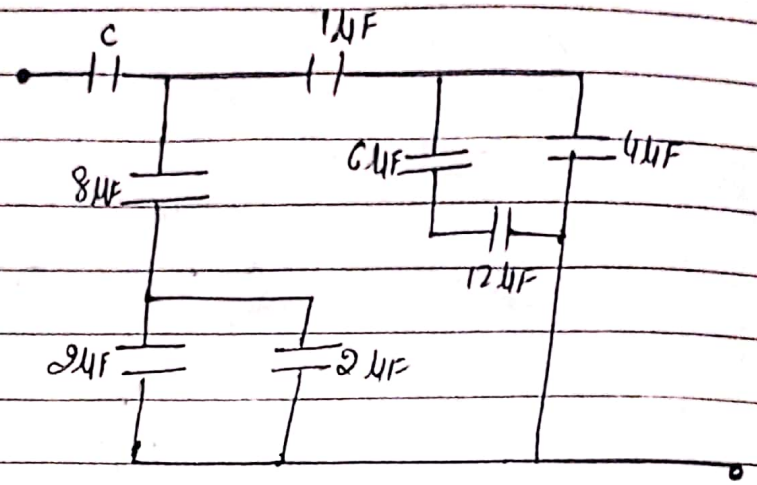
$$\frac{1}{C} = \frac{1}{C'} + \frac{1}{C_3} + \frac{1}{C''}$$

$$\frac{1}{C} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3}$$

$$\frac{1+1+1}{3}$$

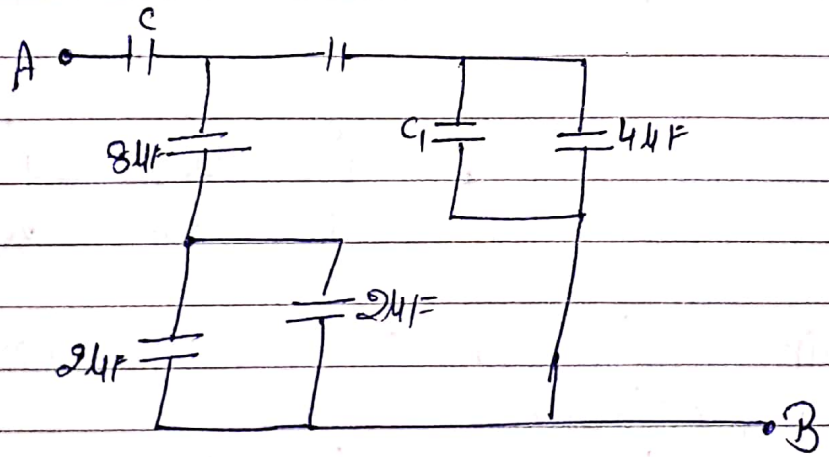
$$\frac{1}{C} = \frac{3}{3} \Rightarrow C = 1\ MF$$

Q:- Find the value of C if the equivalent capacitance between the points A and B in the given figure is 1 μF



Sol Capacitors of capacitances of 6 μF and 12 μF are in series, So their effective capacitance C_1 is given by

$$\frac{1}{C_1} = \frac{1}{6} + \frac{1}{12} = \frac{2+1}{12} = \frac{3}{12} = \frac{1}{4} \Rightarrow C_1 = 4\,\mu F$$



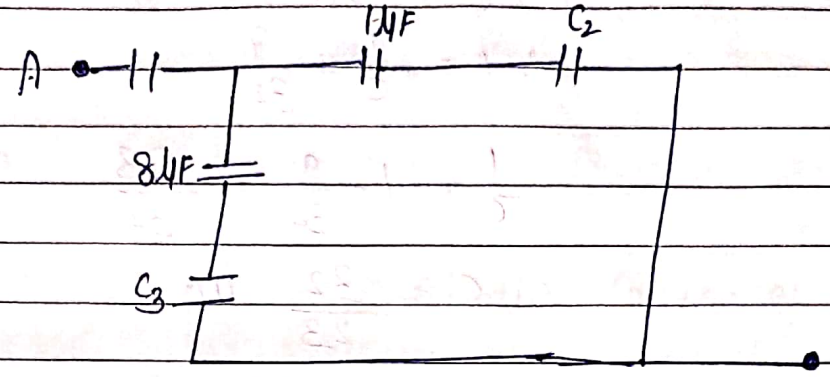
Now C_1 and 4 μF are in parallel so there effective capacitance C_2 is given by

$$C_2 = C_1 + 4\,\mu F$$
$$C_2 = 4 + 4$$
$$C_2 = 8\,\mu F$$

Also 2μF and 2μF are in ||el So C_3

$C_3 = 2+2\ \mu F$

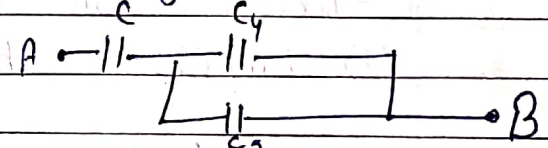
$C_3 = 4\mu F$



C_2 and 1 μF are in series, so their effective Capacitance.

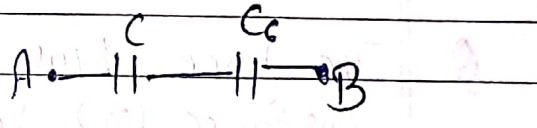
$$\frac{1}{C_4} = \frac{1}{8} + \frac{1}{1} = \frac{8+1}{8} = \frac{9}{8}\ \mu F$$

$$C_4 = \frac{8}{9}\ \mu F$$



Similarly 8μF and C_3 are in series, so their effective Capacitance

$$\frac{1}{C_5} = \frac{1}{8} + \frac{1}{C_3}$$



$$= \frac{1}{8} + \frac{1}{4}$$

$$= \frac{1+2}{8} = \frac{3}{8}$$

$$C_5 = \frac{8}{3}\ \mu F.$$

C_4 and C_5 are parallel, so their effective Capacitance

$$C_6 = C_4 + C_5 = \frac{8}{9} + \frac{8}{3} = \frac{8+24}{9} = \frac{32}{9}\ \mu F$$

Now C and C_6 are in series

∴ Equivalent capacitance C' is given by

$$\frac{1}{C'} = \frac{1}{C} + \frac{1}{C_c}$$

But $C' = 1\,\mu F$

$$\therefore 1 = \frac{1}{C} + \frac{9}{32}$$

$$\frac{1}{C} = 1 - \frac{9}{32} = \frac{23}{32}$$

$$\therefore C = \frac{32}{23}\,\mu F$$

$$= 1.39\,\mu F$$

Q:- The Law of force that governs the force b/w two electric charge was discovered by
(a) Amperes (b) faraday (c) Coulomb (d) OHM.

Sol:- (c) Coulomb

Q The force b/w the electron saprated by a distance (γ) varies as
(a) γ^2 (b) γ^{-2} (c) γ (d) γ^{-1}

Sol:- (a) γ^{-2}

Q:- The existance of a (-ve) charge on a body emplise that it has

(a) Lost some of its electron (b) lost some its proton
(c) accuride some electron from out side
(d) accuride some proton from out side.

Sol:- (a) accuride some electron from out side

Q Holospherical Conductor of Radius (R) is given a charge (Q) work done in moving charge (q) from its centre to the surface is

(a) $\frac{Qq}{4\pi\varepsilon_0 R}$ (b) $\frac{Qq}{2\pi\varepsilon_0 R}$ (c) $\frac{Qq}{\pi\varepsilon_0 R}$ (d) 0

Sol (d) 0

Q If (Q) is situated at the centre of the cube the electric flux through one of faces of the cube is.

(a) $\frac{q}{\varepsilon_0}$, (b) $\frac{q}{2\varepsilon_0}$ (c) $\frac{q}{4\varepsilon_0}$ (d) $\frac{q}{6\varepsilon_0}$

Sol (d) $\frac{q}{6\varepsilon_0}$

Q:- The dielectric constant of metal is

(a) one (b) greater then one

(c) zero (d) infinite

Sol (d) infinite.

Q:- Equal charges given to two sphere of different radii the potential will

(a) is more on smaller sphere

(b) is more on bigger sphere

(c) is equal to both Sphere

(d) Depends on the Nature of material of the Sphere.

Ans (a) is more on Smaller Sphere.

Q A ||el plate capacitor is first charge charged and the dielectric Slab is introduce b/w the plate The quantity that remain unchanged is:-

(a) Charge (b) potential (c) Capacity (d) Energy

Sol (a) Charge.

Q The capacity of an isolated Conducting Sphere of radius (R) is proportional to
(a) R^2 (b) $\frac{1}{R^2}$ (c) $\frac{1}{R}$ (d) R

Sol:- (d) R

Q:- Three diff. Capacitor are Connected in Series
(a) They will have equal Charges
(b) They will have same potential
(c) both one and two
(d) None of these

Sol:- (a) They will have equal charges.

Q:- The Net charge on a current Carring Conductor is
(a) (+ve) (b) (-ve) (c) Constant (d) Zero.

Sol- (d) Zero.

Q Putting dielectric substance b/w two plate Cap of Condenser The Capacity, potential, and potential energy resp.
(a) increase, decreases, decreases
(b) D , $\frac{I}{4}$, $\frac{I}{4}$
(c) 1 , $\frac{1}{4}$, $\frac{1}{4}$
(d) D , D , D

Sol:- (a) I, D, D

Q:- what are the unit of $(K) = \frac{1}{4\pi\varepsilon_0}$

(a) $C^2N^{-1}m^{-2}$ (b) Nm^2C^{-2} (c) Nm^2C^2 (d) Unitless

Sol:- (b) Nm^2C^{-2}

Q:- What is the angle b/w electric dipole movement and the electric field strength due to (1st) on the the equitorial line.

(a) zero (b) 90° (c) 180° (d) None of these

Ans (c) 180°

Q electric field due to uniformly charged sphere is maximum as

(a) Centre of the sphere (b) inside the surface (c) at the surface (d) At infine from Centre

Sol:- (c) at the surface

Q:- If a glass Rod is rubbed with a silk it accures a (+ve) charge because

(a) Proton are added to it.

(b) Proton removed from it.

(c) electrons are added to it

(d) electrons are removed to it

Sol:- (d) electrons are removed to it.

Q when a soap bubble is charged

(a) it Contracts (b) it expand (c) it burst (d) it neither Contracts and nor expand.

Sol:- (b) it expand.

Q Unit of permittivity of free space is

(a) $CN^{-2}m^{-1}$ (b) Nm^2C^{-1} (c) $C^2N^{-2}m^{-2}$ (d) $C^2N^{-1}m^{-2}$

Sol:- (d) $C^2N^{-1}m^{-2}$

Q Which of the following is not the property of equipotential surface is
(a) The donot cross each other.
(b) They are concentric suphere for uniform electric field
(c) The Rate of change potential wr with distance on them is zero.
(d) They can be imaginary sphere.

Sol (c) The Rate of change of potential with distance on them is zero.

Q A electrical dipole of movement (p) is lying along a uniform electric field (E) The work done in rotating the dipole by 90° is
(a) (pE) (b) $\sqrt{2}pE$ (c) $\frac{pE}{2}$ (d) $2pE$

Sol (a) pE.

Q: The unit of intensity of electric field is
(a) NC^{-1} (b) JC^{-1} (c) Vm (d) Nm^{-1}

Sol (a) NC^{-1}

Q The electric field inside a thin spherical shell of uniform surface charge density is
(a) zero (b) constant (c) proportional to the distance from the centre. (d) None of these.

Sol: zero.

Q: In a charge conductor The charge resides in the
(a) inner surface (b) center (c) outer surface

(d) None of these

Sol (c) outer surface

Q A unit charge is moved along an equipotential surface having potential of four Volt. The work done is
(a) 4J (b) zero (c) -2J (d) (+ve) infinite

Sol:- zero

Q work done in moving a positive charge on an equipotential surface is

(a) positive (b) negative (c) zero (d) None of the

Sol (c) zero.

Q Earth surface is considered to be as
(a) zero potential (b) negative potential
(c) positive potential (d) infinite potential

Sol (c) zero potential.

Q Inbringing an electron electron toward another electron, electrostatic potential energy of the system
(a) decrease (b) increases
(c) become zero (c) remain same

Sol (b) increases.

Q Increasing the charge on the plates of a capacitor means:-
(a) increasing the capacitance (b) increasing the potential diff b/w the plate (c) both (a and b)
(d) None of these

Sol (b) Increasing the potential diff b/w the plate.

Q Dielectric slab is introduced b/w the plates of a charge capacitor what hepped
(a) Its charge increases (b) its charge remain same
(c) Its capacitance increase (d) b and c

Sol (d) b and c

Q:- while a capacitor remain connected to a battery a dielectric slab is sliped b/w the plate of the capacitor.
(a) The energy stored in the capacitor decreases
(b) electric filed b/w the plate increases
(c) potential diff b/w the plates is changed
(d) battery charges flow to the battery to the the capacitor

Ans (a) The energy stored in the capacitor decreases.

Q A sheet of aluminium foil of negligible thickness is introduced b/w the plates of a capacitor the capacitance of the capacitor
(a) increases (b) decreases (c) remain same
(d) infinite

Sol (a) increases

Q A Comb run through dry hair attracts small bites of paper this is due to
(a) Comb with good Conductor (b) paper is good Conductor
(c) The atom in the paper get polarised by the charge Comb (d) The Comb possess megnatic property.

Sol (c) The atom in the paper get polarised by the charge comb.

Formula :-

(1) Electrostatic potential :-

$$V = \frac{\text{work}}{\text{charge}} \quad \left(V = \frac{W}{q}\right)$$

$[ML^2T^{-3}A^{-1}]$

Unit (Volts)

(2) Electrostatic potential Due to point charge

$$V = \frac{q}{4\pi\varepsilon_0 r}$$

Due to system of charges :-

$$V = \frac{1}{4\pi\varepsilon_0} \sum_{i=1}^{n} \frac{q_i}{r_i}$$

(3) Electric potential due to Electric dipole :-

$$V = \frac{1}{4\pi\varepsilon_0} \frac{p\cos\theta}{r^2}$$

(1) On the axis :- $(\theta = 0)$

$$\therefore \quad V = \pm \frac{p}{4\pi\varepsilon_0 r^2}$$

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(11) In the equatorial plane, $\theta = \frac{\pi}{2}$

$$\left[\cos\frac{\pi}{2} = 0\right]$$

$$V = \frac{1}{4\pi\varepsilon_0}(0)$$

$$\boxed{V = 0}$$

(4) Electrostatic Potential Energy of a System of two Point charges :-

$$U = W = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1 q_2}{r_{AB}}\right)$$

(5) Potential Energy of a dipole in an External field :-

$$U = W = -\vec{p}\cdot\vec{E} = -pE\cos\theta.$$

(6) Dielectric Constant (K)

$$K = \frac{E_0}{E}$$

(7) Polarisation (P)

$$\boxed{P = \chi\varepsilon_0 E_0}$$

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(8) Electric Susceptibility :

$$P = \chi \varepsilon_0 E$$

(9) Capacitor and Capacitance

$$C = \frac{Q}{V}$$

$[M^{-1} L^{-2} T^{4} A^{2}]$

$$C = 4\pi\varepsilon_0 r$$

Unit :- Farad

(10) Parallel plate Capacitor :-

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

Effect of dielectric in it :-

$$C' = \frac{K \varepsilon_0 A}{d} \Rightarrow C' = Ke$$

Capacitance, $C = \dfrac{\varepsilon_0 A}{d - t + \frac{t}{K}}$

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(11) Capacitors in series :-

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n}$$

(12) Capacitors in parallel :-

$$C = C_1 + C_2 + \cdots + C_n$$

(13) Energy stored in a capacitor :-

$$\left[U = \frac{1}{2} \varepsilon_0 E^2\right] \text{ or } \left[U = \frac{1}{2} C V^2\right]$$

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