O P JINDAL SCHOOL, SAVITRINAGAR

CLASS NOTES

CLASS XII PHYSICS | TOPIC : ELCROSTATIC POTENTIAL AND CAPACOTANCE

Date : 04 /04/20 | SUBTOPIC: CAPACITORS AND CAPACITANCE

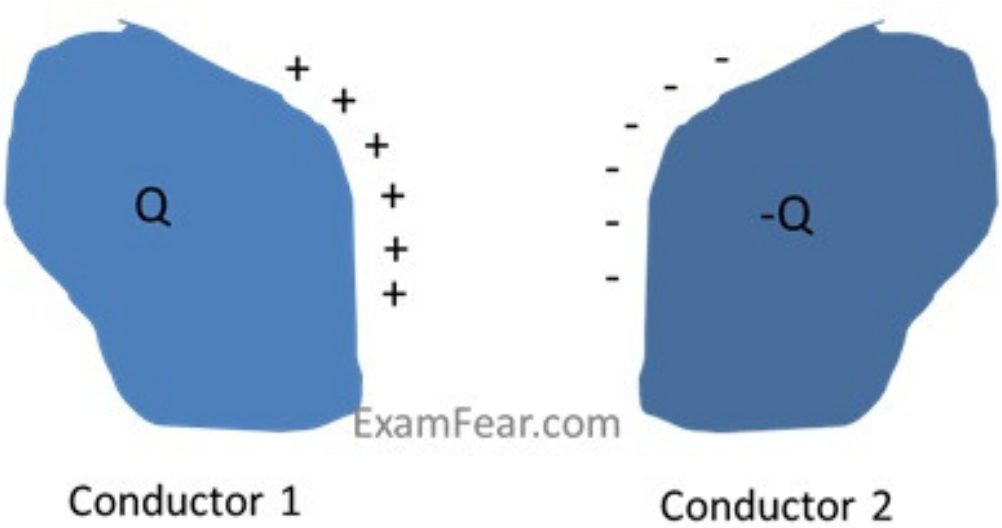
Capacitors and Capacitance

A **capacitor** is a system of two conductors separated by an insulator.

- The total charge of a capacitor is zero while the conductors have charge Q and –Q.
- A single conductor can be considered as capacitor with other conductor at infinity.
- Electric field in the region between the conductors is proportional to the charge Q.

Capacitanceis denoted by, C = Q/V. It depends on:

- Geometrical configuration (shape, size, separation) of the system of two conductors.
- Nature of insulator/dielectric separating.
- Charge on the capacitor leaks away due to reduction in the insulating power of the intervening medium. This happens due to higher potential difference causing strong electric fields.
- Maximum electric field which a dielectric medium can withstand without breakdown and prevent leaking of charge is called **dielectric strength**. Air dielectric strength is $3 \times 10^6\ Vm^{-1}$.
- SI unit of capacitance is **F (Farad).**



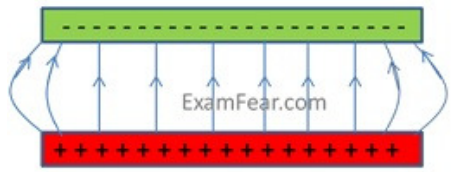
Capacitor - System of 2 conductors separated by an insulator

N.B.-This sheet is prepared from home.

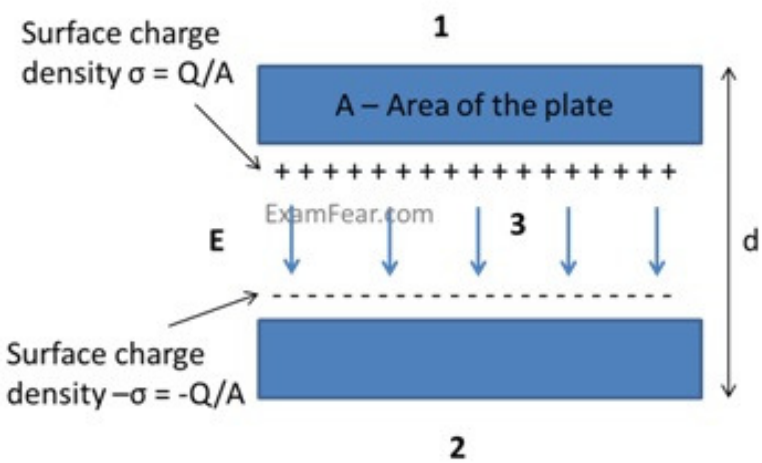
Parallel Plate Capacitor

A parallel plate capacitor is a capacitor with 2 large plane parallel conducting plates separated by a small distance.

- Electric field inside the capacitor has a direction from positive to negative plate.
- For very small'd', the electric field is considered as uniform. For large'd', the electric field is non-uniform and it bends around the corners of the plate which is called **fringing of the field**.



Fringing of the field in a parallel plate capacitor



Parallel Plate Capacitor

Electric field in Region 1 and 2,

$E_1 = \frac{\sigma}{2\varepsilon_0}$, $E_2 = -\frac{\sigma}{2\varepsilon_0}$ where $\sigma = Q/A$

So, $E_{12} = \frac{\sigma}{2\varepsilon_0} - \frac{\sigma}{2\varepsilon_0} = 0$

Electric field in Region 3 will be addition of electric field through the two plates,

$E_3 = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0} = \frac{Q}{\varepsilon_0 A}$

For uniform electric field, potential diff,

$V = Ed = \frac{1}{\varepsilon_0}\frac{Qd}{A}$

Capacitance,

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

Example ExamFear.com

Problem: A parallel plate capacitor with air between the plates has a capacitance of 8pF. What will be the capacitance if the distance between the plates is reduced by half, and the space between them is filled with a dielectric (dielectric constant = 6)?

Solution:

Dielectric constant of air = 1,

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

If distance is halved and dielectric is introduced with k = 6,

$C' = \frac{6\varepsilon_0 A}{d/2}$

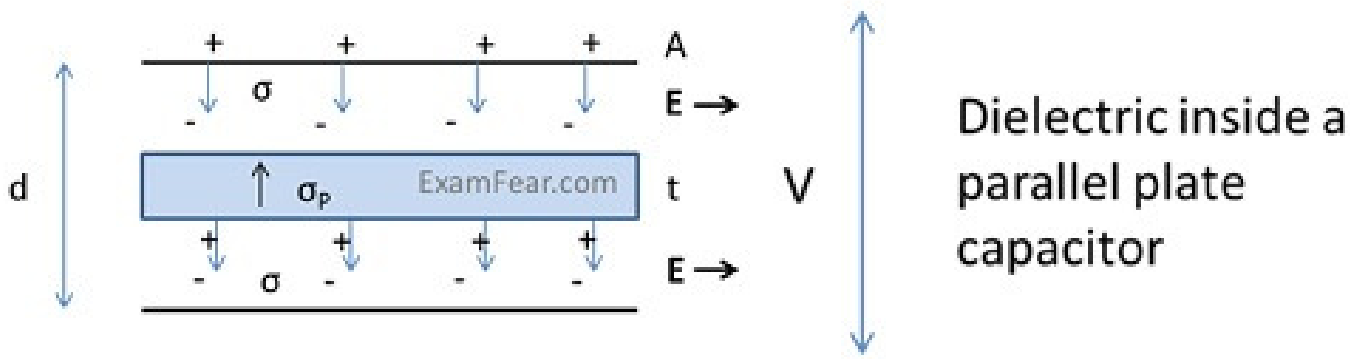
From first equation, C' = 12C

Thus, C' = 12 x 8 = 96 pF

N.B.-This sheet is prepared from home.

Effect of dielectric on Capacitance

When a dielectric is present between the plates of a parallel plate capacitor fully occupying the region, the dielectric is polarized by the electric field. The surface charge densities are considered as σ_p and $-\sigma_p$. Dielectric constant of a substance is the factor by which the capacitance increases from its vacuum value, when the dielectric is fully inserted in between the plates of the capacitor



Electric field inside the capacitor,

$E = \frac{\sigma - \sigma_P}{\varepsilon_0}$

Potential difference across the plates,

$V = Ed = \frac{\sigma - \sigma_P}{\varepsilon_0} d$

For linear dielectrics, σ_p is proportional to E_0

$\sigma - \sigma_P = \frac{\sigma}{K}$

K – dielectric constant of the substance

So, $V = \frac{\sigma d}{\varepsilon_0 K} = \frac{Qd}{A\varepsilon_0 K}$

And $C = \frac{Q}{V} = \frac{A\varepsilon_0 K}{d} = \frac{A\varepsilon}{d}$

ε – permittivity of the medium

For vacuum, K = 1 else $K = \frac{\varepsilon}{\varepsilon_0}$

Also,

$K = \frac{C}{C_0}$ hence K is always > 1.

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