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CAPACITANCE OF A PARALLEL PLATE CAPACITOR WITH AND WITHOUT DIELECTRIC MEDIUM BETWEEN THE PLATES,

CLASS-XII

SUBJECT : PHYSICS
CHAPTER NUMBER: 02
CHAPTER NAME : ELECTROSTATIC POTENTIAL AND CAPACITANCE

LEARNING OUTCOME

After this lesson, students will be able:

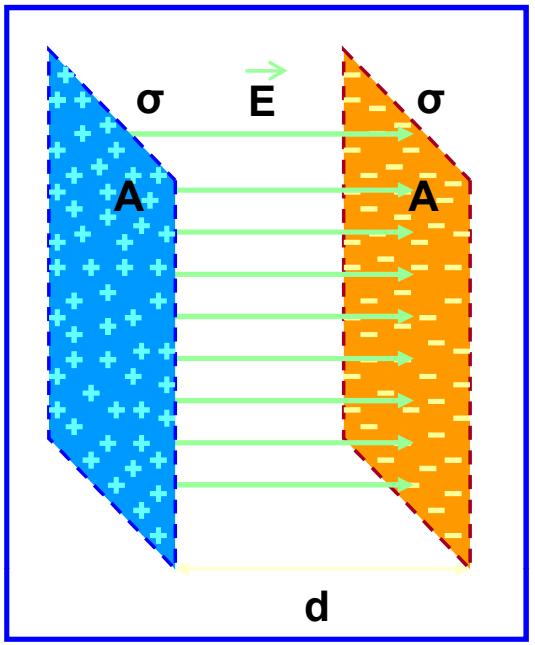
- To derive expressions for capacitance of parallel plate capacitor.
- To derive expressions for capacitance of parallel plate capacitor with and without dielectric.
- To find out capacitance of a parallel plate capacitor with compound dielectric.
- To list three factors that determine the capacitance of a capacitor..

Slide 2

1	@Format for content and slide heading is missing? Just like you have mentioned in DOC., We need to specify, for each slide's heading and text content, what will be the font style +amanrouniyar@odmegroup.org _Assigned to you_ -Swoyan Satyendu , 6/17/2020

CAPACITANCE OF PARALLEL PLATE CAPACITOR:

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



If the space between the plates is filled with dielectric medium of relative permittivity ε_r, then

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

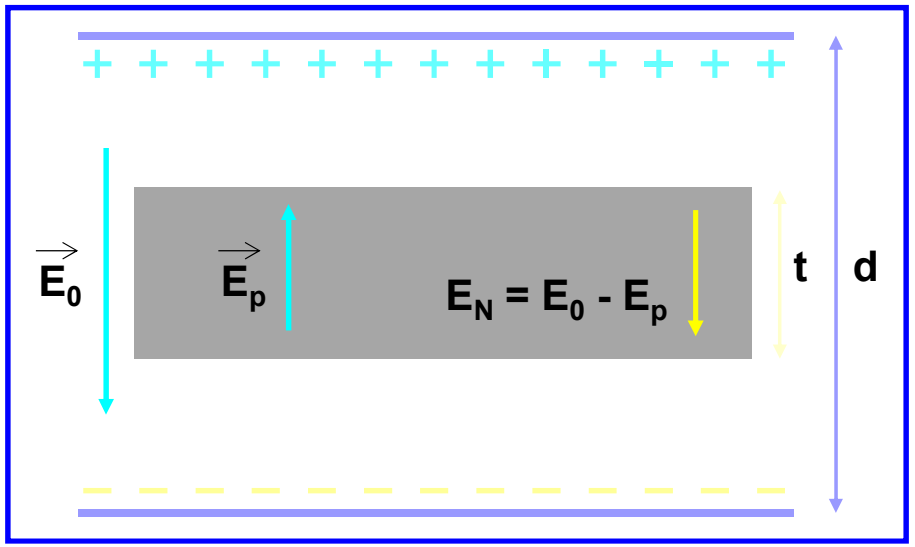
Capacitance of a parallel plate capacitor is

(i) directly proportional to the area of the plates and

(ii) inversely proportional to the distance of separation between them.

CAPACITANCE OF PARALLEL PLATE CAPACITOR WITH DIELECTRIC SLAB:

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



$C > C_0$. i.e. Capacitance increases with introduction of dielectric slab.

CAPACITANCE OF PARALLEL PLATE CAPACITOR WITH DIELECTRIC SLAB:

If the dielectric slab occupies the whole space between the plates, i.e. t = d, then

$$C = K C_0$$

Dielectric Constant

$$K = \frac{C}{C_0}$$

POINTS TO REMEMBER

- Here electric field hence P.D decreases by a factor k (dielectric constant)

  $\therefore E = \frac{E_0}{K}$ and $V = \frac{V_0}{K}$ [Here E = Reduced Field = E_0 - E_P]

- Induced charge in the dielectric is given by

  $q_i = q[1 - \frac{1}{K}]$ [for metallic K = infinity, $q_i = q$]

- If a conducting slab ($K = \infty$) partially fills between plates, then

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

- If the metal slab fills the space between the plates i.e. t = d then

  $$C = \frac{A\varepsilon_0}{0} = \infty$$

CAPACITANCE OF PARALLEL PLATE CAPACITOR WITH DIELECTRIC SLAB:

Effect of DIELECTRIC on various parameters when a slab of di electric 'K' fills the entire space between the plates

Physical Quantity	**With Battery disconnected**	**With Battery connected**
Charge	Remains the same	Increases ($K C_0 V_0$)
Capacitance	Increases ($K C_0$)	Increases ($K C_0$)
Electric Field	Decreases $E_N = E_0 - E_p$	Remains the same
Potential Difference	Decreases	Remains the same
Energy stored	Remains the same	Increases ($K U_0$)

NUMERICAL

Question: A slab of material of dielectric constant ‘K’ has the same area as the plates of parallel plate capacitor, but has thickness 3d/4, where d is the separation of the plates. How is the capacitance changed when the slab is inserted between the plates.

Numerical

Question: A dielectric slab (dielectric constant =k) is introduced between the plates of a charged air capacitor when the battery remains connected what happens to

i. **P.D between plates**
ii. **Electric field**
iii. **Capacitance**
iv. **Charge**
v. **Electrostatic potential energy**

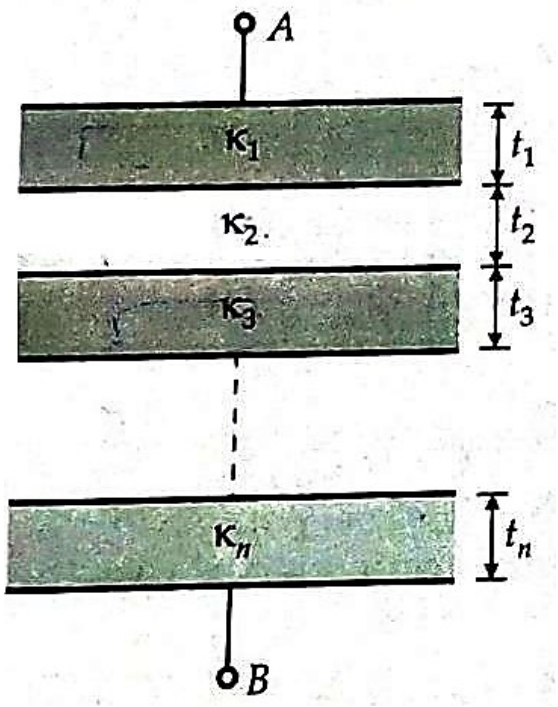
NUMERICAL

Question: A dielectric slab of dielectric constant k is introduced between the plates of a charged air capacitor when the battery is disconnected, what happens to its

i. **Electric charge**
ii. **P.D**
iii. **Capacitance**
iv. **Field**
v. **Electrostatic potential energy**

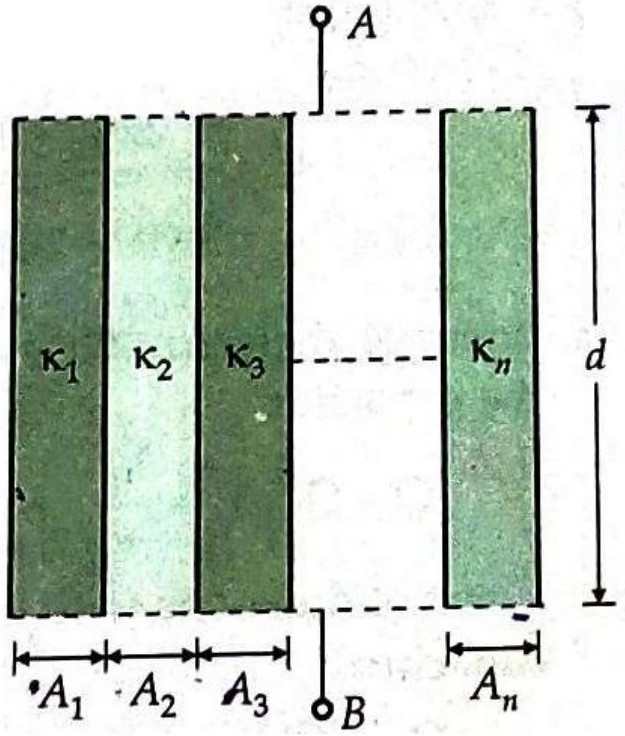
CAPACITANCE OF A PARALLEL PLATE CAPACITOR WITH COMPOUND DIELECTRIC

Series Type Arrangement



$$C = \frac{\epsilon_0 A}{\frac{t_1}{k_1} + \frac{t_2}{k_2} + .. + \frac{t_n}{k_n}}$$

Parallel Type Arrangement

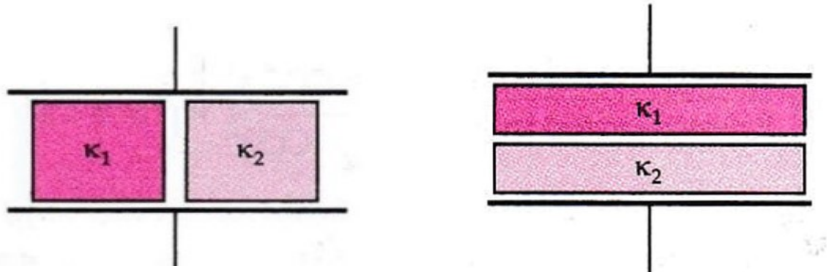


$$C = \frac{\epsilon_0 A}{dn}(k_1 + k_2 + .. + k_n)$$

NUMERICAL

a) Find the ratio of the capacitances of a capacitor filled with two dielectrics of same dimensions but of dielectric constants K_1 and K_2, respectively.

b) A capacitor is filled with two dielectrics of the same dimensions but of dielectric constants K_1 =2 and K_2 =3. Find the ratio of capacities in two possible arrangements.



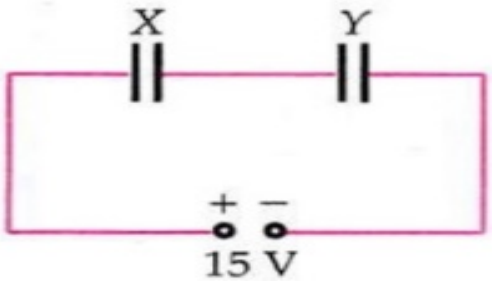
HOME ASSIGNMENT

1. Two parallel plate capacitors, X and Y, have the same area of plates and same separation between them. X has air between the plates while Y contains a dielectric medium of $\varepsilon_r = 4$.

   a) Calculate capacitance of each capacitor if equivalent capacitance of the combination is 4 **μf.**

   b) Calculate the potential difference between the plates of X and Y.

   c) What is the ratio of electrostatic energy stored in X and Y?



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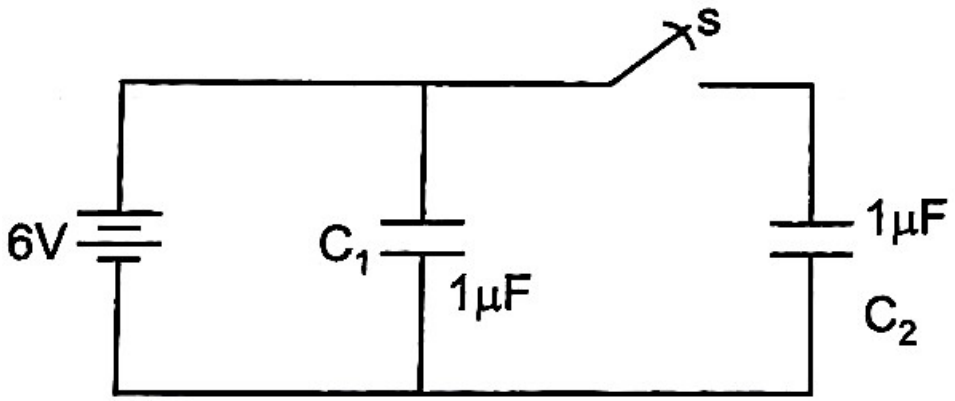
HOME ASSIGNMENT

Question: The figure below shows two identical capacitors C_1 and C_2, each of $1\mu F$ capacitance, connected to a battery of $6V$. Initially, switch S is closed. After some time, S is left open and a di-electric slab of dielectric constant $K = 3$ is inserted to fill completely the space between the plates of two capacitors. How will the

a) charge

b) potential difference between the plates of the capacitors be affected after the slabs are inserted?



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