DPP – 05
CLASS – 12th
TOPIC – Parralel plate Capacitor

Q.1 At what distance should the two plates each of surface area 0.2 m × 0.1 m of an air capacitor be placed in order to have the same capacitance as a spherical conductor of radius 0.5 m?

Q.2 An air capacitor has plates of 6 cm diameter. At what distance should the plates be placed so as to have the same capacitance as a sphere of diameter of 90 cm?

Q.3 A parallel plate capacitor has each plate of 0.06 m diameter separated by 0.05 cm of air. What is the capacitance of the capacitor? What would be the radius of a sphere having the same capacitance?

Q.4 A parallel plate capacitor has two plates of sides 0.055 m and 0.04 m of air. Their distance apart is 0.7mm. The dielectric constant of the medium in between is 4. Find the capacitance of the capacitor.

Q.5 A parallel plate capacitor has plates of area 0.02 m^2 and separation between the plates 1 mm. What potential difference will be developed, if a charge of 1 nC is given to the capacitor? If the plate separation is now increased to 2 mm, what will be the new potential difference?

Q.6 When a slab of insulating material 4 mm thick is introduced between the plates of a parallel plate capacitor, it is found that the distance between the plates has to be increased by 3.2mm to restore the capacitance to its original Value. Calculate dielectric constant of the material.

Q.7 A slab of dielectric constant K has the same area as the plates of a parallel plate capacitor but has a thickness $3d/4$, where d is the separation between the plates. How is the capacitance changed, when the slab is inserted between the plates.

Q.8 What happens to the capacitance of a capacitor, when a dielectric is introduced between its plates? Explain qualitatively.

Q.9 Derive an expression for the capacitance of a parallel plate capacitor. How the capacitance is affected, if a dielectric slab of thickness equal to the separation between the plates in introduced between the plates.

Q.10 Explain why the capacitance of a parallel plate capacitor increase, when a dielectric slab is introduced between the plates. Define relative permittivity of a dielectric.

Q.11 Three capacitors of capacitances 2 μF, 3μF and 4μF are connected (i) in series; (ii) in parallel. Compare the effective capacitances in the two cases.

Q.12 The capacitances of three capacitors are in the ratio 1 : 2 : 3. Their equivalent capacitance in parallel is gerater than their equivalent capacitance in series by 60/11 μF. Calculate their individual capacitances.

SOLUTION

(PHYSICS) Electric Potential & Capacitance

DPP – 05

CLASS – 12th

TOPIC – Parralel plate Capacitor

Sol.1 Capacitance of the spherical conductor,

$$C = 4\pi\ \varepsilon_0 R$$

Or $$C = 4\pi\ \varepsilon_0 \times 0.5 \quad \text{............ (i)}$$

Let d be the distance between the two plates of air capacitor.

Area of each plate, A = 0.2 × 0.1 = 0.02 m^2

$\therefore$ $$C = \frac{\varepsilon_0 A}{d} = \frac{\varepsilon_0 \times 0.02}{d} \quad \text{................. (ii)}$$

From the equations (i) and (ii), we have

$$\frac{\varepsilon_0 \times 0.02}{d} = 4\pi\ \varepsilon_0 \times 0.5$$

Or $$d = \frac{0.02}{4\pi \times 0.5} = 3.183 \times 10^{-3}\,m$$

Sol.2 Proceed as in problem no. 8.

Sol.3 Proceed as in problem no. 8.

Sol.4 Here K = 4, A = 0.055 × 0.04 m^2

d = 0.7 mm = 0.7 × 10^{-3} m

$\therefore$ $$C = \frac{8.854 \times 10^{-12} \times 4 \times 0.055 \times 0.04}{0.7 \times 10^{-3}}$$

= 1.1 × 10^{-10} F

Sol.5 $$C = \frac{\varepsilon_0 A}{d} = \frac{8.854 \times 10^{-12} \times 0.02}{1 \times 10^{-3}} d$$

= 1.77 × 10^{-10} F

Now, $$V = \frac{q}{C} = \frac{10^{-9}}{1.77 \times 10^{-10}} = 5.65\,V$$

On increasing the separation :

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

$= \frac{8.854 \times 10^{-12} \times 0.02}{2 \times 10^{-3}}$

$= 8.854 \times 10^{-11}F$

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

$= \frac{10^{-9}}{8.854 \times 10^{-11}} = 11.3V$

Sol.6 Let A be the area of each plate and *d*, the distance between them. Then,

$$C = \frac{\varepsilon_0 A}{d} \qquad \text{................ (i)}$$

On introducing dielectric slab:

Let K be the dielectric constant of the slab and d' the distance between the plates. Then,

$$C = \frac{\varepsilon_0 A}{d' - t(1 - 1/K)} \qquad \text{.................(ii)}$$

From the equations (i) and (ii), we have

$$d' - t\left(1 - \frac{1}{K}\right) = d$$

Here, $d' = d + 3.2 \times 10^{-3}$ m and t = 4 mmm = 4×10^{-3} m

$\therefore \quad d + 3.2 \times 10^{-3} - 4 \times 10^{-3}\left(1 - \frac{1}{K}\right) = d$

Or $\quad 1 - \frac{1}{K} = \frac{3.2 \times 10^{-3}}{4 \times 10^{-3}} = 0.8$

Or $\quad K = 5$

Sol.7 Let A be the area of each plate and d, the distance between them. Then,

$$C = \frac{\varepsilon_0 A}{d} \qquad \text{.............. (i)}$$

On introducing dielectric slab:

When a slab of dielectric constant K and thickness t is introduced between the plates of the capacitor, its capacitance is given by

$$C' = \frac{\varepsilon_0 A}{d - t(1 - 1/K)}$$

Here, $t = 3\,d/4]$

Therefore, the equation (ii) becomes

$$C' = \frac{\varepsilon_0 A}{d - \frac{3d}{4} \times (1 - \frac{1}{K})}$$

$$= \frac{\varepsilon_0 A}{d\left\{1 - \frac{3}{4} \times \left(1 - \frac{1}{K}\right)\right\}}$$

Using the the equation (i), we have

$$C' = \frac{C}{\left(\frac{1}{4} + \frac{3}{4K}\right)} = \frac{4\,K}{K+3} C$$

Sol.8 The introduction in a capacitor will reduce the effective charge on plate and therefore will increase the capacitance.

Sol.9 *

Sol.10 *

Sol.11 4 : 39

Sol.12 Let the capacitances of the three capacitors be C, 2 C and 3 C.

When connected in parallel:

$$C' = C + 2\,C + 3\,C = 6C$$

When connected in series:

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

Or $$C'' = \frac{6\,C}{11}$$

According to the statement of the problem,

$$6\ C = \frac{6C}{11} + \frac{60}{11}$$

Or $C = 1\ \mu F$

Therefore, capacitances of the three capacitors are $1\ \mu F$, $2\ \mu F$, and $3\ \mu F$.