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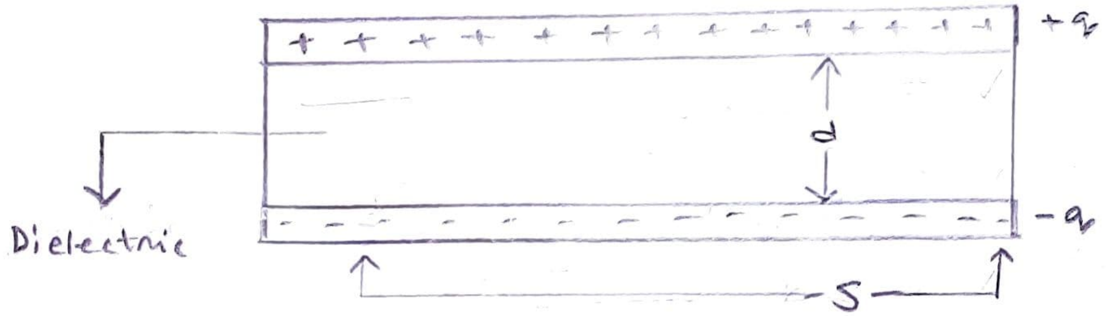
Section: DA

Answer of the Question NO-1



Given that,

Area of the plate of the parallel-plat capacitor

$= S$

Uniform distance between two plates $= d$

Constant permittivity of filled dielectric $= \epsilon$

The electric field intensity between the plates will be uniform.

Let consider, a gausian surface enclosed the charge q on the positive plate.

According to Gauss's Law,

$$\epsilon_0 \oint \vec{E} \cdot \vec{dS} = q$$

$$\Rightarrow \epsilon_0 \int E \cdot dS = q \quad \text{[Since, E and ds are parallel]}$$

$$\Rightarrow \epsilon_0 ES = q \text{ ——— (1)}$$

The potential difference between the plates is given by,

$$V = \int \vec{E} \cdot \vec{dl}$$

$$\Rightarrow V = \vec{E} \int dl \quad \text{[Since, E and dl are parallel]}$$

$$\Rightarrow V = Ed \quad \text{—— (2)}$$

We know that,
the capacitance of parallel plate capacitor is

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

$$\Rightarrow C = \frac{\epsilon_0 \cancel{E} S}{\cancel{E} d} = \frac{\epsilon_0 S}{d}$$

But, we know that. $\epsilon = \epsilon_0 k$

$$\therefore \epsilon_0 = \frac{\epsilon}{k} \quad \text{[Where, } k = \text{Relative permeability]}$$

$$\therefore C = \frac{\frac{\epsilon}{k} S}{d} = \frac{\frac{\epsilon S}{k}}{d}$$

$$\therefore C = \frac{\epsilon S}{kd}$$

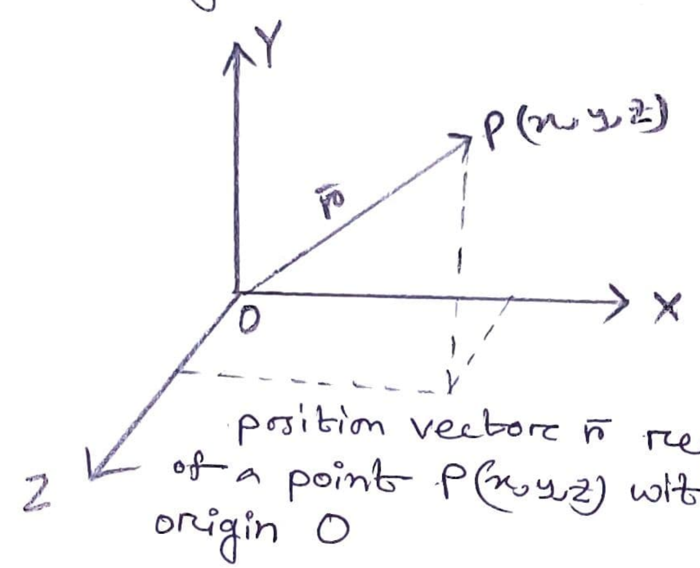
Answer: Capacitance,

$$C = \frac{\epsilon S}{kd}$$ where, k = relative permeability

Answer of the Question NO-2

* Position vector:

A position vector represents the position of a point in space in relation to an arbitrary reference origin.



position vector $\vec{r}$ represents the position of a point $P(x,y,z)$ with respect to the origin O

* Electric displacement vector:

In a dielectric material, the presence of an Electric field E ~~cauge~~ causes the bound charges in the material to slightly separate, including a local electric dipole moment. The effect of free and bound charge within materials accounts for Electric displacement field or vector field.

Answer of the Question NO-3

* Poisson's equation :

Poisson's equation is easily derived from Gauss's law for a linear, isotropic medium,

$$\nabla \cdot D = \rho_v \quad — (1)$$

Here,
∇ = Divergence operator
D = Electric displacement field
ρ_v = free charge volume density

Again,

$$D = \epsilon E \quad — (2)$$

And the gradiand relationship,

$$E = -\nabla V \quad — (3)$$

By substituion we have,

$$\nabla \cdot (-\epsilon \nabla V) = \rho_v$$

$$\Rightarrow \nabla \cdot \nabla V = -\frac{\rho_v}{\epsilon}$$

$$\therefore \nabla^2 V = -\frac{\rho_v}{\epsilon}$$

This is poisson's equation

* Laplace's Equation:

From the poisson's equation we know,

$$\nabla^2 V = -\frac{\rho_v}{\varepsilon}$$

A special case of this equation occurs when $\rho_v = 0$.

$\therefore \nabla^2 V = 0$ This is known as Laplace's equation.