12th - PHYSICS - 2024

English Medium

Unit Test - 2

Model exam - 2

Total Mark : 15m

Date : 16/04/2024 (3 × 5 = 15m)

1) Obtain the expression for capacitance for a parallel plate capacitor

2) Obtain the expression for energy stored in the parallel plate capacitor

3) A parallel plate capacitor has square plate of side 5cm and separated by a distance of 1mm a) calculate the capacitance of this capacitor b) If a 10V battery is connected to the capacitor what is the charge stored in any of the plates ? (The value of $\varepsilon_0 = 8.85 \times 10^{-12} N^{-1} m^{-2} C^2$)

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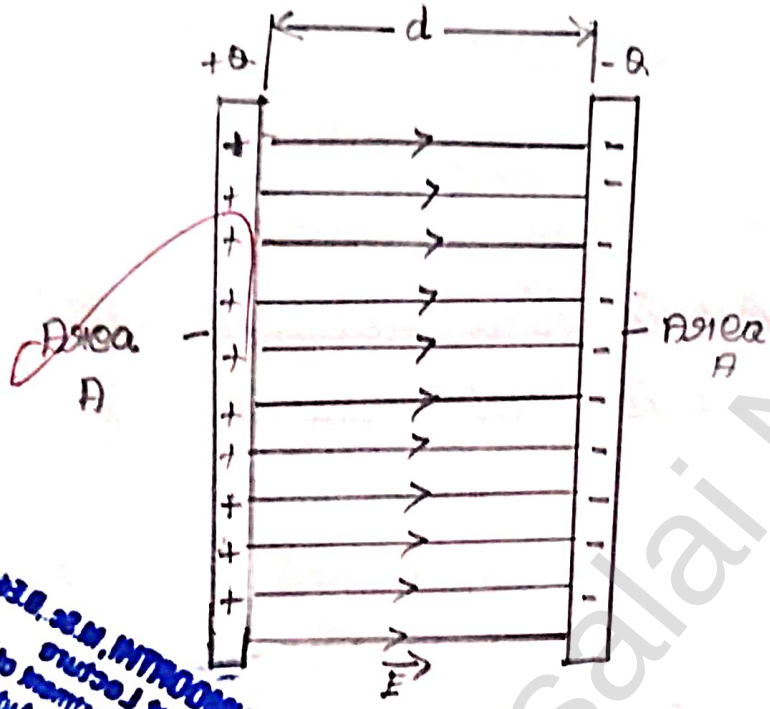
17) Obtain the expression for capacitance for a parallel plate capacitor

15/04/24
Monday

(X)
3 mark



Two parallel plate capacitor

d → distance

E → Electric field

A → cross sectional area

capacitor

$$C = \frac{Q}{V} \rightarrow (1)$$

C → capacitance of conductor

Q → charge

V → potential difference

$V = Ed \rightarrow (2)$

$E \rightarrow$ Electric field

$d \rightarrow$ distance

Electric field

$$E = \frac{Q}{A\varepsilon_0} \rightarrow (3)$$

$Q \rightarrow$ charge

$A \rightarrow$ cross sectional area

$\varepsilon_0 \rightarrow$ permittivity of free space

From equation (2)

$$V = Ed$$

$$V = \left(\frac{Q}{A\varepsilon_0}\right) d$$

$$V = \frac{Qd}{A\varepsilon_0} \rightarrow (4)$$

i) $A \uparrow$ $C \uparrow$

ii) $d \uparrow$ $V \uparrow$

From equation (1)

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

$$C = \frac{Q}{\frac{Qd}{A\varepsilon_0}}$$

$$C = \frac{Q A \varepsilon_0}{Qd}$$

$$C = \frac{\varepsilon_0 A}{d} \rightarrow (5)$$

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LA

18) Obtain the expression for energy stored in the parallel plate capacitor

Capacitor not only stores the charge but also it stores energy.

capacitor energy stored

workdone

$$dW = V\,dQ$$

capacitor

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

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

$$dW = \frac{Q}{C}\,dQ$$

Total workdone

$$W = \int_0^Q dW$$

$$W = \int_0^Q \frac{Q}{C}\,dQ$$

$$W = \int_0^Q \left(\frac{1}{C}\right) Q\, dQ$$

$$W = \frac{1}{C} \int_0^Q Q\, dQ$$

$$\int x\, dx = \frac{x^{n+1}}{n+1} + C$$

$$W = \frac{1}{C}\left[\frac{Q^{1+1}}{1+1}\right]_0^Q$$

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

$$W = \frac{1}{C}\left[\frac{Q_2}{2} - (0)^2/_2\right]$$

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

$$W = \frac{1}{C}\left[\frac{Q^2}{2}\right]$$

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

Capacitor

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

$$Q = CV$$

$$W = \frac{1}{2C}(Q^2)$$

$$W = \frac{1}{2C}(CV)^2$$

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

$$W = 1/2\, CV^2$$

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

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

$$V = Ed$$

$$W = \frac{1}{2} \frac{\varepsilon_0 A}{d} (Ed)^2$$

$$W = \frac{1}{2} \frac{\varepsilon_0 A}{d} E^2 d^2$$

$$W = \frac{1}{2} \varepsilon_0 A (E^2 d)$$

$$W = U_E$$

workdone Electrostatic potential energy

~~K.E~~

$$U_E = \frac{1}{2} \varepsilon_0 (Ad) E^2$$

$$U_E = u_E$$

$$u_E = \frac{1}{2} \varepsilon_0 E^2$$

Ad = volume of the space between the Capacitor Plates.

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5 mark

Example Sum 1.20

A parallel plate capacitor has square Plate of side 5 cm and separated by a distance of 1mm a) calculate the capacitance of this capacitor b) If a 10 V battery is connected to the capacitor what is the charge stored in any one of the Plates ? (The value of $\varepsilon_0 = 8.85 \times 10^{-12} N^{-1} m^{-2}$ (2)

Parallel Plate capacitor

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

$$A = (5cm)^2$$

$$A = (5 \times 10^{-2})^2$$

$$A = (5)^2 \times (10^{-2})^2$$

$$A = 25 \times 10^{-4} m^2$$

$$d = 1mm$$

$$d = 1 \times 10^{-3} m$$

a)

$$\varepsilon_0 = 8.854 \times 10^{-12} \qquad C = \frac{\varepsilon_0 A}{d}$$

$$C = \frac{8.854 \times 10^{-12} \times 25 \times 10^{-4}}{1 \times 10^{-3}}$$

$$C = \frac{8.854 \times 25 \times 10^{-12} \times 10^{-4} \times 10^{+3}}{(1)}$$

$$C = 8.854 \times 25 \times 10^{-16} \times 10^{3}$$

$$C = 221.350 \times 10^{-13}$$

$$C = 22.1350 \times 10^{-12}$$

$$C = 22.1350 \text{ Pf}$$

b) Charge stored

$V = 10V$

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

$Q = CV$

$Q = 22.1350 \times 10^{-12} \times 10$

$Q = 221.350\ pC$

Pf -> Pico farad

PC -> Pico Coulomb