Answer on Question 60287, Physics – Electromagnetism

Question:

A parallel plate capacitor is to be designed with a voltage rating of 1 kV using material of dielectric constant 3 and electric field strength $10^6\ V/m$. What minimum area of plates is required to have a capacitance 50 pF?

Solution:

First of all, let's find the distance between the plates. We can find it from the definition of the electric field strength: $E = \frac{V}{d}$, here, V is the potential difference between the plates of a parallel plate capacitor (or voltage), d is the distance between the plates.

Then, we get:

$$d = \frac{V}{E} = \frac{1.0 \cdot 10^3\ V}{10^6\ V/m} = 0.001\ m.$$

Let's recall the formula for the capacitance of the parallel-plate capacitor:

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

here, C is the capacitance of the parallel-plate capacitor, ε_0 is the permittivity of free space, ε is permittivity of the dielectric material (or dielectric constant), A is the area of the plates, d is the distance between the plates.

Then, from this formula we can find the minimum area of the plates that required to have a capacitance 50 pF:

$$A_{min} = \frac{Cd}{\varepsilon_0 \varepsilon} = \frac{50 \cdot 10^{-12}\ F \cdot 0.001\ m}{8.854 \cdot 10^{-12}\ \frac{F}{m} \cdot 3} = 19.0 \cdot 10^{-4}\ m^2 = 19\ cm^2.$$

Answer:

$A_{min} = 19.0 \cdot 10^{-4}\ m^2 = 19\ cm^2.$