Problem 1A

A certain material has a dielectric constant of 3.2 and a dielectric strength of $16 \times 10^6$ volts/meter. If it is used as the dielectric material in a parallel-plate capacitor, what minimum area may the plates of the capacitor have in order that the capacitance be $7.0 \times 10^{-2}$ µF and that the capacitor be able to withstand a potential difference of 4000 volts?

\[ C = \frac{k \varepsilon_0 A}{d} \quad \text{(parallel-plate capacitor)} \]

For \( A \) to be a minimum, we must pick \( d \) to be a minimum. The minimum \( d \), \( d_{\text{min}} \), is determined by:

\[ V_{\text{max}} = E_{\text{max}} d_{\text{min}} \]

or

\[ d_{\text{min}} = \frac{V_{\text{max}}}{E_{\text{max}}} = \frac{4000 \text{ Volts}}{16 \times 10^6 \text{ Volts/meter}} = 2.5 \times 10^{-1} \text{ m} \]

\[ \varepsilon_0 \]

\[ A_{\text{min}} = \frac{C d_{\text{min}}}{k \varepsilon_0} = \frac{(70 \times 10^{-2} \text{ F})(25 \times 10^{-4} \text{ m})}{(3.2)(8.85 \times 10^{-12} \text{ F/m})} = 6.18 \times 10^{-4} \text{ m}^2 \]

\[ \approx 0.061 \text{ m}^2 \]