Answer on Question #45157-Physics-Electromagnetism

Suppose you have to design a parallel plate capacitor having capacitance $C = 4.2\ nF$ and the value of maximum operating potential for the capacitor is to be $U = 4 \cdot 10^4\ V$. Further, the dielectric material to be filled between the plates must be nylon whose dielectric strength is $E = 25 \cdot 10^6 \frac{V}{m}$ and its dielectric constant is $k = 2.6$. Calculate the minimum plate area you can use for such a capacitor.

Solution

A parallel plate capacitor with a dielectric between its plates has a capacitance given by

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

where k is dielectric constant, $\varepsilon_0 = 8.85 \cdot 10^{-12} \frac{F}{m}$ is the permittivity of free space, A is plate area, d is the distance between the plates.

The minimum plate area is

$$A = \frac{Cd}{k\varepsilon_0}.$$

For a parallel plate capacitor

$$E = \frac{U}{d} \to d = \frac{U}{E}.$$

Therefore

$$A = \frac{CU}{k\varepsilon_0 E} = \frac{4.2 \cdot 10^{-9} \cdot 4 \cdot 10^4}{2.6 \cdot 8.85 \cdot 10^{-12} \cdot 25 \cdot 10^6} = 0.292\ m^2.$$

Answer: $\mathbf{0.292\ m^2}$.