Answer on Question 59739, Physics, Electromagnetism

Question:

A certain capacitor has a capacitance of $50\ pF$ with air between its plates and $370\ pF$ with a plastic between its plates. What is the dielectric constant of the plastic?

Solution:

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 plate overlap, d is the distance between plates. Let's denote the capacitance of the air-filled parallel-plate capacitor as C_1 and the capacitance of the plastic-filled parallel-plate capacitor as C_2, and use our formula:

$$C_1 = \varepsilon_0 \varepsilon_{air} \frac{A}{d}, \qquad (1)$$

$$C_2 = \varepsilon_0 \varepsilon_{plastic} \frac{A}{d}, \quad (2)$$

here, ε_{air}, $\varepsilon_{plastic}$ are the dielectric constants of the air and plastic, respectively.

Also, from the initial condition of the task we know that the area of plate overlap and the distance between plates is constant. So, let's divide the equation (1) by the equation (2):

$$\frac{C_1}{C_2} = \frac{\varepsilon_{air}}{\varepsilon_{plastic}}.$$

From this formula we can find the dielectric constant of the plastic:

$$\varepsilon_{plastic} = \varepsilon_{air} \frac{C_2}{C_1} = 1.00054 \cdot \frac{370 \cdot 10^{-12}\ F}{50 \cdot 10^{-12}\ F} = 7.4$$

Answer: $\varepsilon_{plastic} = 7.4.$