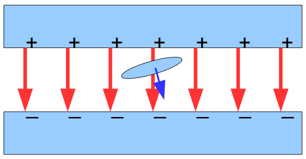
Chapter 6 Problem 24 †



Given

$\epsilon_0 = 8.85 \times 10^{-12}\ C^2/Nm^2$
$Q = 20\ \mu C = 20.0 \times 10^{-6}\ C$
$A_{plate} = 150\ cm^2$
$r = 3.0\ cm = 3.0 \times 10^{-2}\ m$
$\theta = 5.0°$

Solution

Find the flux through a circle located between the two plates.

Since the two plates have equal and opposite charge on them, the electric field outside the two plates cancel and all the electric field is concentrated between the plates. The charge is located on the inside surfaces of the plates as illustrated above. The surface charge density on the inner surface of the plate is

$$\sigma = \frac{Q}{A_{plate}}$$

First we need to convert the area into square meters

$$A_{plate} = 150\ cm^2 \left(\frac{1.00\ m}{100\ cm}\right)^2 = 0.015\ m^2$$

Now

$$\sigma = \frac{20.0 \times 10^{-6}\ C}{0.015\ m^2} = 1.33 \times 10^{-3}\ C/m^2$$

Since the field is concentrated between the plates, the electric field is equal to

$$E = \frac{\sigma}{\epsilon_0}$$

$$E = \frac{1.33 \times 10^{-3}\ C/m^2}{8.85 \times 10^{-12}\ C^2/Nm^2} = 1.50 \times 10^8\ N/C$$

Now the flux through the circle is

$$\Phi = \vec{E} \cdot \vec{A} = EA\cos\theta$$

The area of the circle is

$$A = \pi r^2 = \pi(3.0 \times 10^{-2}\ m)^2 = 2.83 \times 10^{-3}\ m^2$$

The flux is then

$$\Phi = (1.50 \times 10^8\ N/C)(2.83 \times 10^{-3}\ m^2)\cos 5.0° = 4.23 \times 10^5\ Nm^2/C$$

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†Problem from Univesity Physics by Ling, Sanny and Moebs (OpenStax)