321.

Problem 29.19 (RHK)

A metal plate 8.0 cm *on a side carries a total charge of* 6.0 μC. *We will calculate in the infinite plate approximation* (a) *the electric field* 0.50 mm *above the surface of the plate near the plate's centre;* (b) *the field at a distance of* 30 m.

Solution:

(a)

The area of the metal plate which is 8.0 cm on a side is $A = \left(8.0 \times 10^{-2}\right)$ m^2.

Total charge on the plate is $Q = 6.0 \times 10^{-6}$ C.

On a metallic plate charge will be equally divided on its two sides, front and back. Therefore, the surface charge density on each side of the plate will be

$$\sigma = \frac{Q}{2A} = \frac{6.0 \times 10^{-6}}{2 \times 64 \times 10^{-4}} \text{ C m}^{-2} = 4.69 \times 10^{-4} \text{ C m}^{-2}.$$

In the infinite plate approximation the electric field at a distance of 0.50 mm above the surface and for that

matter at any other distance from the plate will be given by

$$E = \frac{\sigma}{\varepsilon_0} = \frac{4.69\times10^{-4}}{8.85\times10^{-12}}\ \text{N C}^{-1} = 5.3\times10^{7}\ \text{N C}^{-1} = 53\ \text{MN C}^{-1}.$$

(b)

If we want to estimate the field at a distance of 30 m from the plate, we can assume that the total charge of $6.0\ \mu\text{C}$ is concentrated at a point and in this approximation the electric field will be

$$E(30\ \text{m}) = \frac{6.0\times10^{-6}}{4\pi\varepsilon_0\times30^2}\ \text{N C}^{-1} = \frac{8.99\times10^{9}\times6.0\times10^{-6}}{9\times10^{2}}\ \text{N C}^{-1}$$

$$= 60\ \text{N C}^{-1}.$$