(1)

11-05-86

A thin conducting square with $A = LL$ $\quad Q_T = -10.0\,\mu C$, $\quad L = 2{,}0\,m$

we have to find E above the square at distance $z = 1$ or 2 cm $<< L$, thus we use Ex. 5.8 in the book, ignore edges and realize the field is perpendicular to the square (away from the edges). For the disk in Ex. 5.8

$$\bar{E}(z) = \frac{2\pi\sigma}{4\pi\epsilon_0}\left\{1 - \frac{z}{\sqrt{R^2+z^2}}\right\}\hat{k}$$

above the center of the disk in the xy-plane

we look at

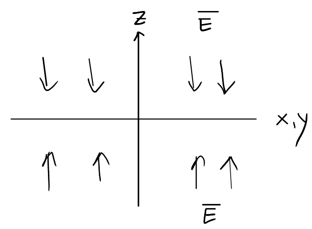
$$1 - \frac{z}{R\sqrt{1+\left(\frac{z}{R}\right)^2}} = 1 - \left(\frac{z}{R}\right)\frac{1}{\sqrt{1+\left(\frac{z}{R}\right)^2}} = f\left(\frac{z}{R}\right)$$

$$\lim_{x\to 0} f(x) = 1 \quad \to \quad \bar{E}(z) \simeq \frac{\sigma}{2\epsilon_0}\hat{k} \quad \text{if } z << L$$

for the square in the xy-plane. It is a conductor, the charge is distributed on both sides

$$\to \quad \sigma = \frac{Q_T}{2L^2}$$

(2)



as $\sigma < 0$

In next chapter we see this for an infinite conducting plate with surface charge

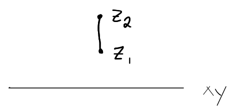
For $z > 0$: $\quad \bar{E} = -\frac{|\sigma|}{2\epsilon_0}\hat{k} = -\frac{|Q_T|}{2\epsilon_0 L^2}\hat{k}$

b) $\quad \bar{F} = -e\frac{\sigma}{2\epsilon_0}\hat{k} = |eQ_T|\frac{\hat{k}}{2\epsilon_0 L^2}$ $\quad$ repulsive for on the electron $z > 0$

c) Same answers as before as the electric field does not change with distance

d) The work by the force, when $-e$ is moved from $z_1 \to z_2$

it is positive due to the repulsive force



$$\Delta W = \int_{z_1}^{z_2}\bar{F}\cdot d\bar{r} = \int_{z_1}^{z_2} dz\ \bar{F}\cdot\hat{k} = \bar{F}\cdot\hat{k}\,(z_2 - z_1)$$

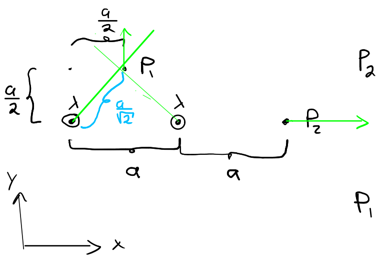
$$= -e\frac{\sigma}{2\epsilon_0}(z_2 - z_1)$$

$$= |eQ_T|\frac{1}{2\epsilon_0 L^2}(z_2 - z_1) > 0$$

(3)

11-05-96

Infinite line charges, find the field at P_1 and P_2

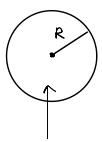


$$P_2: \quad \bar{E} = \frac{\lambda}{2\pi\epsilon_0}\left\{\frac{1}{2a} + \frac{1}{a}\right\}\hat{i} = \frac{\lambda\hat{i}}{2\pi\epsilon_0}\frac{3}{2a}$$

$$P_1: \quad \bar{E} = \frac{\lambda}{2\pi\epsilon_0}\left\{\frac{\sqrt{2}}{a}\cdot 2\right\}\cdot\underbrace{\cos\left(\frac{\pi}{4}\right)}_{1/\sqrt{2}}\hat{j}$$

$$= \frac{\lambda}{2\pi\epsilon_0}\frac{2}{a}\hat{j} = \frac{\lambda}{\pi\epsilon_0 a}\hat{j}$$

11-06-54 $\quad$ Infinite cylinder with space charge density ρ



we use Gauß to find E inside and outside the cylinder (it can not be conducting if it has a charge distribution of this kind)

$$Q_T = 2\pi L\int_0^R r\,dr\cdot\alpha r = 2\pi L\alpha\frac{R^3}{3}$$

$\rho = \alpha r$, $\quad \alpha = $ Const. $\qquad = 2\pi L\,\alpha R^2/3$

(4)

$$\oint \bar{E}\cdot d\bar{A} = \frac{Q_{enc}}{\epsilon_0}$$

surface integral, we select a concentric cylinder surface at which E must be constant due to the cylindrical symmetry

$r > R$: all the charge is within the Gauß surface

$$L\cdot 2\pi r E_r = \frac{2\pi L\alpha R^3}{3\epsilon_0} \to E_r = \frac{\alpha R^3}{3\epsilon_0 r} \to \bar{E} = \frac{\alpha R^3}{3\epsilon_0 r}\hat{r}$$

$r < R$: $\quad Q_{enc} = \frac{2\pi}{3}L\alpha r^2$

$$E_r = \frac{\alpha r^2}{3\epsilon_0} \quad \to \quad \bar{E} = \frac{\alpha r^2}{3\epsilon_0}\hat{r}$$

In $r = R$ $E(r)$ is continuous, but the derivative is not due to the step in the distribution at the surface

11-06-66

At the surface of a spherical conductor the field is $\overline{E} = \frac{kq}{r^2}\,\hat{r}$

In equilibrium the field close to a surface of a conductor is perpendicular to it and $E = \frac{\sigma}{\epsilon_0}$

Can we get these facts to be in agreement?

$$q = 4\pi r^2 \sigma$$

$$\hookrightarrow E = \frac{kq}{r^2} = \underbrace{\left(\frac{1}{4\pi\epsilon_0}\right)}_{k} \frac{(4\pi r^2 \sigma)}{r^2} = \frac{\sigma}{\epsilon_0}$$