•32 Figure 23-38 shows cross sections through two large, parallel, nonconducting sheets with identical distributions of positive charge with surface charge density $\sigma = 1.77 \times 10^{-22}$ C/m^2. In unit-vector notation, what is $\vec{E}$ at points (a) above the sheets, (b) between them, and (c) below them?

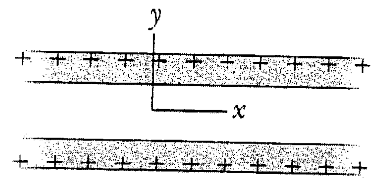
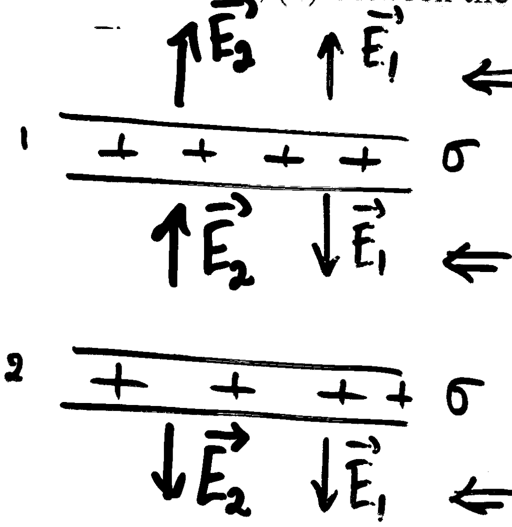


Fig. 23-38 Problem 32.



$\vec{E}_{net,1} = +(E_1 + E_2)\hat{j}$

$\vec{E}_{net,2} = (E_2 - E_1)\hat{j}$

$\vec{E}_{net,3} = -(E_2 + E)\hat{j}$

$E_2 = \frac{\sigma}{2\varepsilon_0} = E_1$

$\Rightarrow \vec{E}_{net,1} = \frac{\sigma}{\varepsilon_0}\hat{j} = 2 \times 10^{-11}$ N/C $\hat{j}$

$\vec{E}_{net,2} = 0$

$\vec{E}_{net,3} = -\frac{\sigma}{\varepsilon_0}\hat{j} = -2 \times 10^{-11}$ N/C $\hat{j}$

•35 In Fig. 23-41, two large, thin metal plates are parallel and close to each other. On their inner faces, the plates have excess surface charge densities of opposite signs and magnitude $7.00 \times 10^{-22}\ C/m^2$. In unit-vector notation, what is the electric field at points (a) to the left of the plates, (b) to the right of them, and (c) between them?

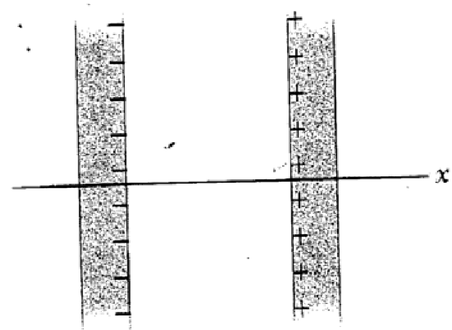
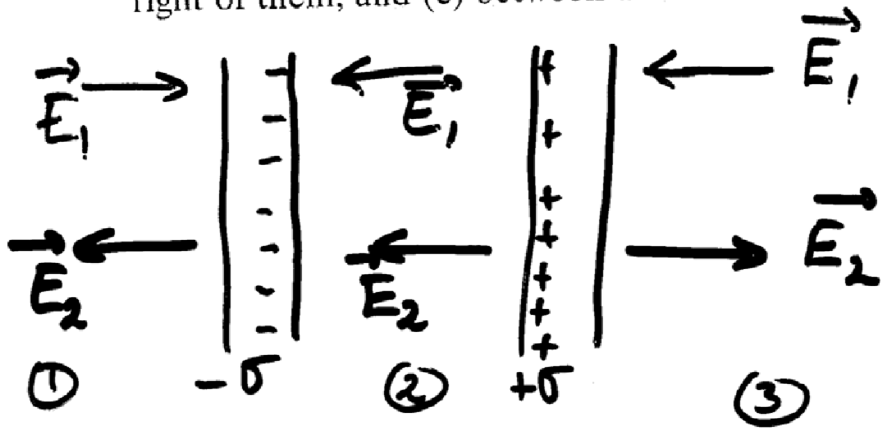


Fig. 23-41 Problem 35.



$$|\vec{E}_1| = |\vec{E}_2| = \frac{\sigma}{2\varepsilon_0}$$

region ①: $\vec{E}_{net} = (E_1 - E_2)\hat{i} = 0$

region ②: $\vec{E}_{net} = -(E_1 + E_2)\hat{i} = \frac{\sigma}{\varepsilon_0}\hat{i} = -8\times10^{-11}\hat{i}$

region ③: $\vec{E}_{net} = (E_2 - E_1)\hat{i} = 0$

••38 Two large metal plates of area 1.0 m^2 face each other. They are 5.0 cm apart and have equal but opposite charges on their inner surfaces. If the magnitude E of the electric field between the plates is 55 N/C, what is the magnitude of the charge on each plate? Neglect edge effects.

$$E = \frac{\sigma}{\varepsilon_0} \Rightarrow \sigma = \varepsilon_0 E$$

$$= 55 \times 8.85 \times 10^{-12}$$

$$= 4.9 \times 10^{-10} \frac{C}{m^2}.$$

••39 In Fig. 23-43, a small, nonconducting ball of mass $m = 1.0$ mg and charge $q = 2.0 \times 10^{-8}$ C (distributed uniformly through its volume) hangs from an insulating thread that makes an angle $\theta = 30°$ with a vertical, uniformly charged nonconducting sheet (shown in cross section). Considering the gravitational force on the ball and assuming the sheet extends far vertically and into and out of the page, calculate the surface charge density σ of the sheet. SSM

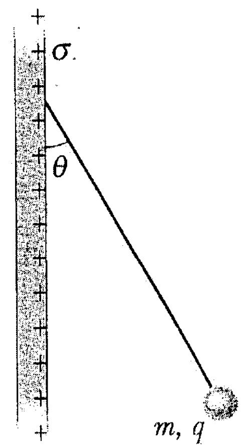
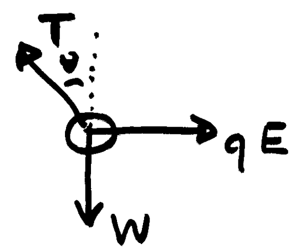


Fig. 23-43 Problem 39.

$$E = \frac{\sigma}{2\varepsilon_0}$$



$$T \sin\theta - \frac{\sigma}{2\varepsilon_0} q = 0 \quad \text{—} (1)$$

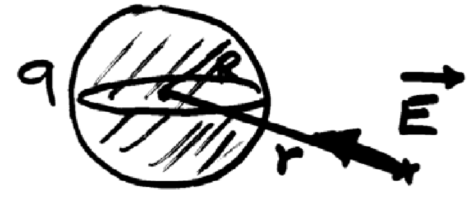
$$T \cos\theta - mg = 0 \quad (2)$$

$$\tan\theta = \frac{q\sigma}{2\varepsilon_0 mg} \Rightarrow \sigma = \frac{2\varepsilon_0 mg}{q}$$

$$\sigma = 5 \times 10^{-9}\ \text{C/m}^2.$$

•43 An unknown charge sits on a conducting solid sphere of radius 10 cm. If the electric field 15 cm from the center of the sphere has the magnitude 3.0×10^3 N/C and is directed radially inward, what is the net charge on the sphere? SSM

Since the $\vec{E}$ is radially inward $\Rightarrow$ the charge q is negative. The charge is distributed on the surface of the sphere (conductor).



$$|\vec{E}| = \frac{k|q|}{r^2} \Rightarrow |q| = \frac{|\vec{E}| r^2}{k}$$

$$|q| = \frac{3 \times 10^3 \times (0.15)^2}{9 \times 10^9} = 7.5 \times 10^{-9} \text{ C}$$

$$= 7.5 \text{ nC}$$

The charge is negative!

---

extra:

$\vec{E}$ inside $= 0$. This is a conductor.

find $\vec{E}$ at $r = 5$ cm! $E = 0$

" " $r = 7$ cm! $E = 0$

••49 In Fig. 23-50, a **solid** sphere of radius $a = 2.00$ cm is concentric with a spherical conducting shell of inner radius $b = 2.00a$ and outer radius $c = 2.40a$. The sphere has a net uniform charge $q_1 = +5.00$ fC; the shell has a net charge $q_2 = -q_1$. What is the magnitude of the electric field at radial distances (a) $r = 0$, (b) $r = a/2.00$, (c) $r = a$, (d) $r = 1.50a$, (e) $r = 2.30a$, and (f) $r = 3.50a$? What is the net charge on the (g) inner and (h) outer surface of the shell?

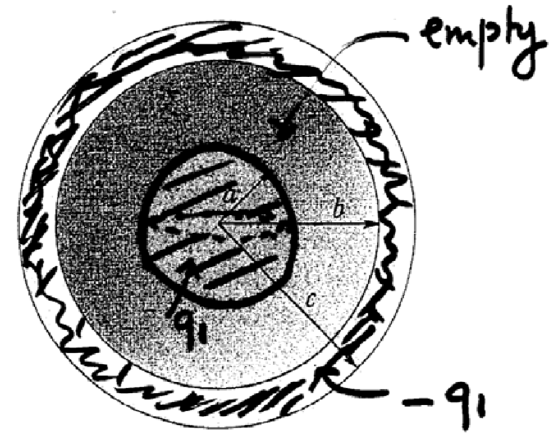


Fig. 23-50 Problem 49.

a) $E_1 = \frac{k q_1}{a^3} r = \frac{k q_1}{a^3}(0) = 0$

b) $E_2 = \frac{k q_1}{a^3} r = \frac{k q_1}{a^3}\frac{a}{2} = \frac{k q_1}{2a^2} = 0.056 \frac{N}{C}$

c) $E_3 = \frac{k q_1}{a^3} r = \frac{k q_1}{a^3} a = \frac{k q_1}{a^2} = 0.112 \frac{N}{C}$

d) $E_4 = \frac{k q_1}{r^2} = \frac{k q_1}{(1.5a)^2} = 0.05 \, N/C$

e) $E_5 = 0$ (inside the conductor)

f) $E_6 = \frac{k(q_1 + q_2)}{r^2} = \frac{k(q_1 - q_1)}{r^2} = 0$

g) $Q_{int} = -q_1$

h) $Q_{out} = 0$

(70) Figure 23-55 shows, in cross section, three infinitely large nonconducting sheets on which charge is uniformly spread. The surface charge densities are $\sigma_1 = +2.00\ \mu C/m^2$, $\sigma_2 = +4.00\ \mu C/m^2$, and $\sigma_3 = -5.00\ \mu C/m^2$, and distance $L = 1.50$ cm. In unit-vector notation, what is the net electric field at point P?

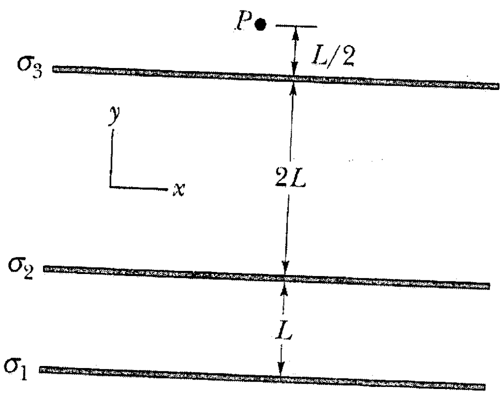
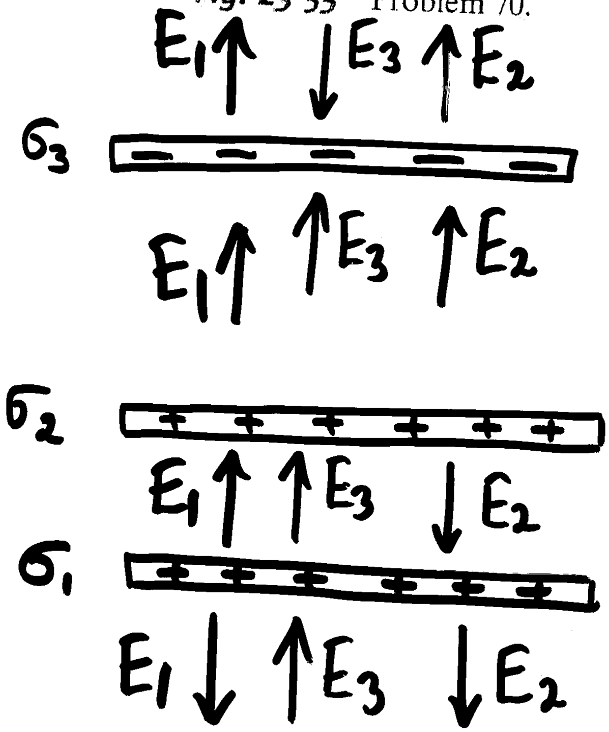


Fig. 23-55 Problem 70.



$$\vec{E}_{net} = (E_1 + E_2 - E_3)\hat{j} = \left(\frac{|\sigma_1|}{2\varepsilon_0} + \frac{|\sigma_2|}{2\varepsilon_0} - \frac{|\sigma_3|}{2\varepsilon_0}\right)\hat{j}$$

$$= \frac{2\mu C + 4\mu C - 5\mu C}{2\times 8.85\times 10^{-12}} = 5.7\times 10^{4}\ N/C.$$