3.

$$\phi = \oint \vec{E} \circ d\vec{A}$$

Normal to right face is in $\vec{j}$ direction.

a) $\vec{E} = 6\vec{i}$

$$\left(6\vec{i}\right) \circ \vec{j} = 0$$

b) $\vec{E} = -2\vec{j}$

$$\vec{E} \circ d\vec{A} = \left(-2\vec{j}\right) \circ \vec{j} = -2$$

$$\phi = \oint \vec{E} \circ d\vec{A} = -2\int dA = -2(1.4)^2 = -3.92$$

c) $\vec{E} = -3\vec{i} + 4\vec{k}$

$$\vec{E} \circ d\vec{A} = \left(-3\vec{i} + 4\vec{k}\right) \circ \vec{j} = 0$$

d) Total flux must be zero in all cases since equal amounts enter and leave.

5. **Again the integral is hard to evaluate, so this problem is similar to problem #5. A cube has 6 sides.**

$$\phi = \frac{Q}{\varepsilon_0} \text{ for a cube.}$$

$$\phi = \frac{Q}{6\varepsilon_0} \text{ for a side of a cube.}$$

7. **Since the integral would be hard to evaluate, use this trick.**

$$\phi = \oint \vec{E} \circ d\vec{A} = \frac{Q}{\varepsilon_0}$$

$$\phi = \frac{Q}{\varepsilon_0} = \frac{1.8 \times 10^{-6}}{8.85 \times 10^{-12}} = 2.03 \times 10^5$$

17.

$$\sigma = \frac{Q}{A} = 8.1\frac{\mu C}{m^2}$$

$$A = \text{area of sphere} = 4\pi r^2 = 4\pi\left(\frac{1.2}{2}\right)^2 = 4.52\,m^2$$

$$Q = \left(8.1\frac{\mu C}{m^2}\right)\left(4.52\,m^2\right) = 36.6\,\mu C$$

$$\phi = \oint \vec{E} \circ d\vec{A} = \frac{Q}{\varepsilon_0} = \frac{36.6 \times 10^{-6}}{8.85 \times 10^{-12}} = 4.14 \times 10^6\ \frac{n \cdot m^2}{C}$$

21. a) The charge q induces an equal and opposite charge on the cavity wall. So the charge on the cavity wall is -q.

b)The key here is net, i.e. induced charges cancel. A Gaussian surface around the entire object incloses

$$\begin{array}{r} 10\times 10^{-6}\,\text{C} \\ +\ \ 3\times 10^{-6}\,\text{C} \\ \hline 13\times 10^{-6}\,\text{C} \end{array}$$

24.

a) r > R means outside.

$$\varepsilon_0 \oint \vec{E} \circ d\vec{A} = Q$$

$$\lambda = \frac{Q}{L} \Rightarrow Q = \lambda L$$

$$\varepsilon_0 \oint \vec{E} \circ d\vec{A} = Q = \lambda L$$

$$\varepsilon_0 E \oint dA = \lambda L,\ \text{and} \int dA = 2\pi RL$$

$$\varepsilon_0 E(2\pi RL) = \lambda L$$

$$E = \frac{\lambda}{2\pi\varepsilon_0 R}$$

b) r < R means inside.

$$Q = 0 \Rightarrow E = 0$$

29.

a) $\oint \vec{E} \circ d\vec{A} = \frac{Q}{\varepsilon_0} = \frac{q-2q}{\varepsilon_0} = -\frac{q}{\varepsilon_0}$

$E\int dA = E(2\pi rL) = -\frac{q}{\varepsilon_0}$

$E = -\frac{q}{2\pi\varepsilon_0 rL}$

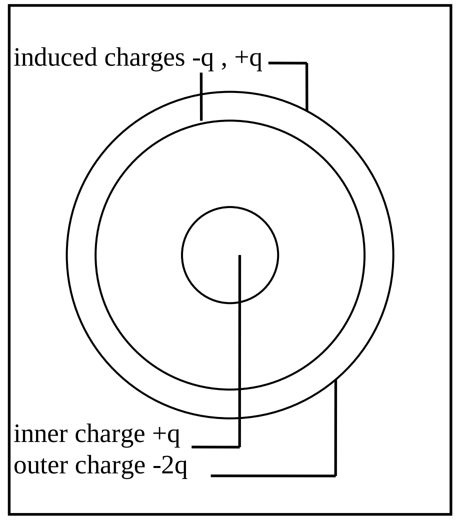
Minus sign means radially inward.

b) $+q$ **inside**

$-2q$ **outer shell**

outside, $+q-2q=-q$

See picture for induced charges.



c) $\oint \vec{E} \circ d\vec{A} = \frac{Q}{\varepsilon_0} = \frac{q}{\varepsilon_0}$

$E\int dA = E(2\pi rL) = \frac{q}{\varepsilon_0}$

$E = \frac{q}{2\pi\varepsilon_0 rL}$

33.

Let $\overleftarrow{i}$ **be a unit vector to the left.**

a) **to the left:** $\vec{E} = \left(\frac{\sigma}{2\varepsilon_0}\right)\overleftarrow{i} + \left(\frac{-\sigma}{2\varepsilon_0}\right)\overleftarrow{i} = 0$

b) **to the right:**

$\vec{E} = \left(\frac{\sigma}{2\varepsilon_0}\right)(-\overleftarrow{i}) + \left(\frac{-\sigma}{2\varepsilon_0}\right)(-\overleftarrow{i}) = 0$

c) **between the plates:**

$\vec{E} = \left(\frac{\sigma}{2\varepsilon_0}\right)\overleftarrow{i} + \left(\frac{-\sigma}{2\varepsilon_0}\right)(-\overleftarrow{i}) = \left(\frac{\sigma}{\varepsilon_0}\right)\overleftarrow{i}$

$= \left(\frac{7\times 10^{22}\,C/m^2}{8.85\times 10^{-12}\,n\cdot m^2/C^2}\right)\overleftarrow{i} = (7.9\times 10^{11}\,n/C)\overleftarrow{i}$

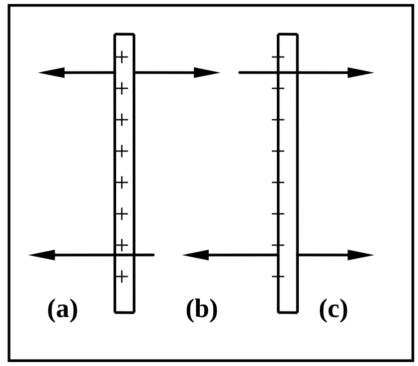
36.

E for a single sheet is $\dfrac{\sigma}{2\varepsilon_0}$

in (a), 2 E fields add; $E = 2\left(\dfrac{\sigma}{2\varepsilon_0}\right) = \dfrac{\sigma}{\varepsilon_0}$

in (b), 2 E fields cancel; $E = 0$

in (c), 2 E fields add; $E = 2\left(\dfrac{\sigma}{2\varepsilon_0}\right) = \dfrac{\sigma}{\varepsilon_0}$



46.

a) Double the radius but the flux remains the same.

$$\phi = -750\,\frac{n \cdot m^2}{C}$$

b) $\phi = \oint E \circ dS = \dfrac{q}{\varepsilon_0}$

$$-750 = \frac{q}{8.85 \times 10^{-12}}$$

$$q = -6.6 \times 10^{-9}\,C$$

57.

a) Inside sphere: $Q = 0,\ \therefore E = 0$

b) $\oint E \circ dA = 4\pi kQ$

$$E\int dA = E\left(4\pi r^2\right) = 4\pi kQ$$

$$E = \frac{kQ}{r^2}$$

$$E = \frac{\left(9 \times 10^9\right)\left(2 \times 10^{-7}\right)}{(.25)^2} = 2.88 \times 10^4\,\frac{n}{C}$$

c) $E = \dfrac{\left(9 \times 10^9\right)\left(2 \times 10^{-7}\right)}{(3)^2} = 200\,\dfrac{n}{C}$

62.

a) $@P_1 \quad r = .015\,m$

$$\oint E \circ dA = 4\pi kQ$$

$$E\int dA = E\left(4\pi r^2\right) = 4\pi kQ$$

$$E = \frac{kQ}{r^2} = \frac{\left(9\times 10^9\right)\left(1\times 10^{-7}\right)}{\left(.015\right)^2} = 4\times 10^6\ \frac{n}{C}$$

b) E inside a conductor is zero.

The induced charge on the inner wall is $-q$.

So $Q = +q - q = 0$ within the metal wall.

Additional Problem

(40.)

a) – q (induced charge)

b) + q (induced charge)

c) For r < a, $\varepsilon_0 \oint E \circ dA = q$

$$\varepsilon_0 E(4\pi r^2) = q$$

$$E = \frac{q}{4\pi\varepsilon_0 r^2}$$

d) $E = \dfrac{q - q}{4\pi\varepsilon_0 r^2} = 0$ for a < r < b

e) $E = \dfrac{q - q + q}{4\pi\varepsilon_0 r^2} = \dfrac{q}{4\pi\varepsilon_0 r^2}$ for r > b

f) $E = \dfrac{q - q}{4\pi\varepsilon_0 r^2} = 0$

g) $E = \dfrac{q}{4\pi\varepsilon_0 r^2}$

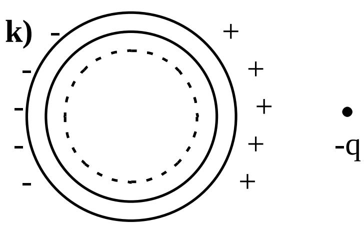
h) Point charge - q outside changes the charge distribution on the shell by induction.

i) This has no effect on any charges on the inner surface

j) There is a force on the second charge

k) There is no force on the first charge. There is no E - Field in the gaussian surface due to - q.
- q rearrranges the surface charge, but has no effect on conductor

k)



l) no