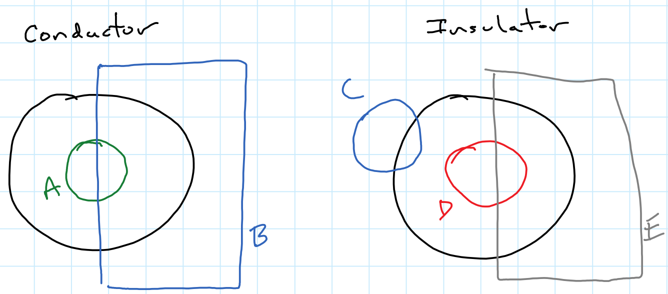
Phy 4B 4/20

Thursday, April 20, 2017 4:38 PM

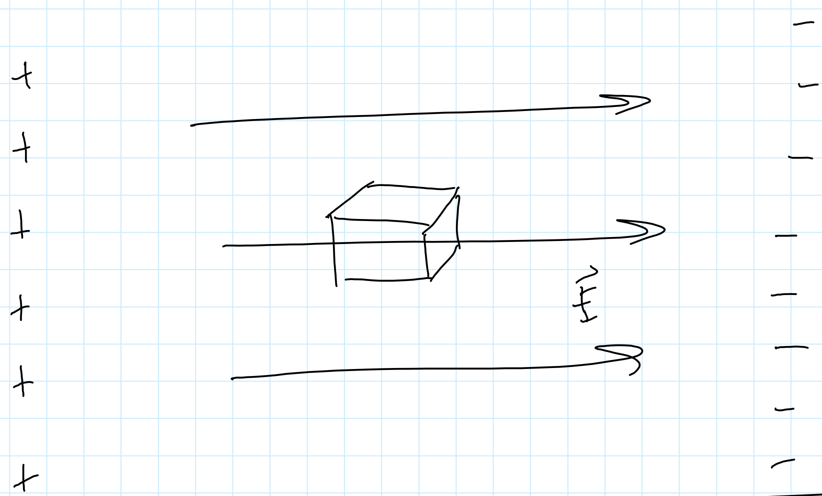
Goals for the Lecture:

1) Understand when Gauss's Law is useful in solving problems and be able to use it to solve problems
2) Understand properties of conductors in electrostatic equilibrium, including shielding of electric fields

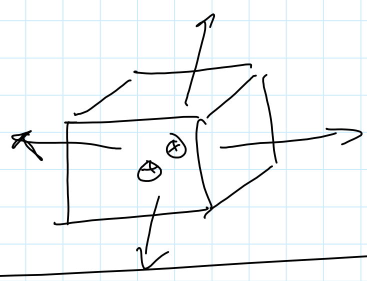
worksheet p.37



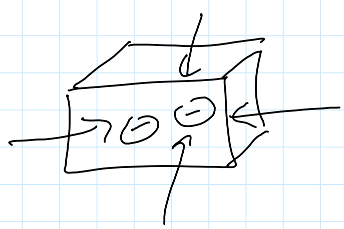
B = E > D > C > A = 0



$\Phi = 0$

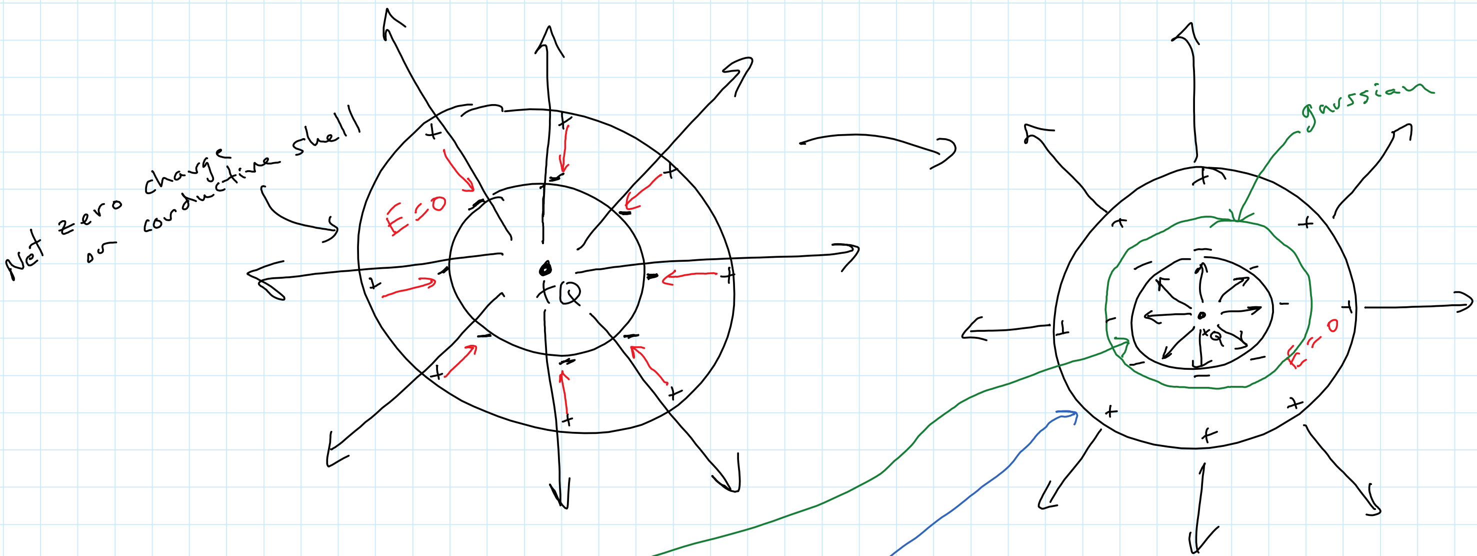


Φ is positive



Φ is Negative

Conductive shell (Find charge on inner and outer surfaces)



find q_{inner} and q_{outer} :

on inner surface of conductor

inside gaussian surface

$$\oint \cancel{\vec{E}}^{\,0} \cdot d\vec{A} = \frac{q_{enclosed}}{\epsilon_0}$$ for the gaussian surface

$$0 = \frac{q_{enclosed}}{\epsilon_0}$$

$$q_{enclosed} = 0$$

So, $q_{inner} = -Q$

then : $q_{inner} + q_{outer} = q_{\text{Net charge on conductive shell}}$

$$q_{inner} + q_{outer} = 0$$

$$q_{outer} = +Q$$

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worksheet 2.40

a) $\Phi_A = \Phi_C$ so, both enclose the same amount of charge

Worksheet P.40

a) $\Phi_A = \Phi_C$ so, both enclose the same amount of charge

so, the conductive shell has no net charge

$$\left.\begin{aligned} q_{inner} &= -Q_0 \\ q_{outer} &= +Q_0 \end{aligned}\right\} \quad q_{inner} + q_{outer} = 0$$

b) $\Phi_C = 3\,\Phi_A$ so, charge on conductive shell must be $+2Q_0$

$q_{inner} = -Q_0$ must cancel $+Q_0$ inside cavity

$$q_{inner} + q_{outer} = +2Q_0$$

$$q_{outer} = +3Q_0$$

c) $\Phi_A = \dfrac{q_{in}}{\epsilon_0} = \dfrac{+Q_0}{\epsilon_0}$

d) $\Phi_C = 0$ so, Net charge on conductive shell must be $-Q_0$

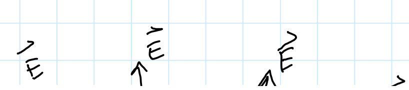
$$q_{inner} = -Q_0$$

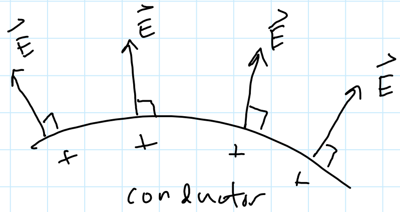
$$q_{inner} + q_{outer} = -Q_0$$

$$q_{outer} = 0$$

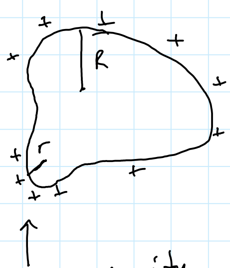
Conductors in electrostatic equilibrium:

1) excess charge goes to outer most surface
2) $E = 0$ inside conductor
3) $E \perp$ to surface (just outside of conductor)





4) surface charge density is greatest where radius of curvature is smallest



$r < R$

charge density highest here

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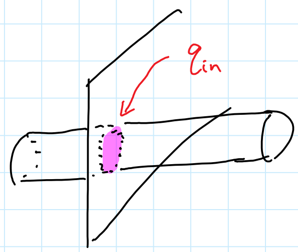
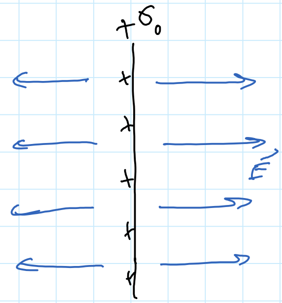
worksheet p. 35

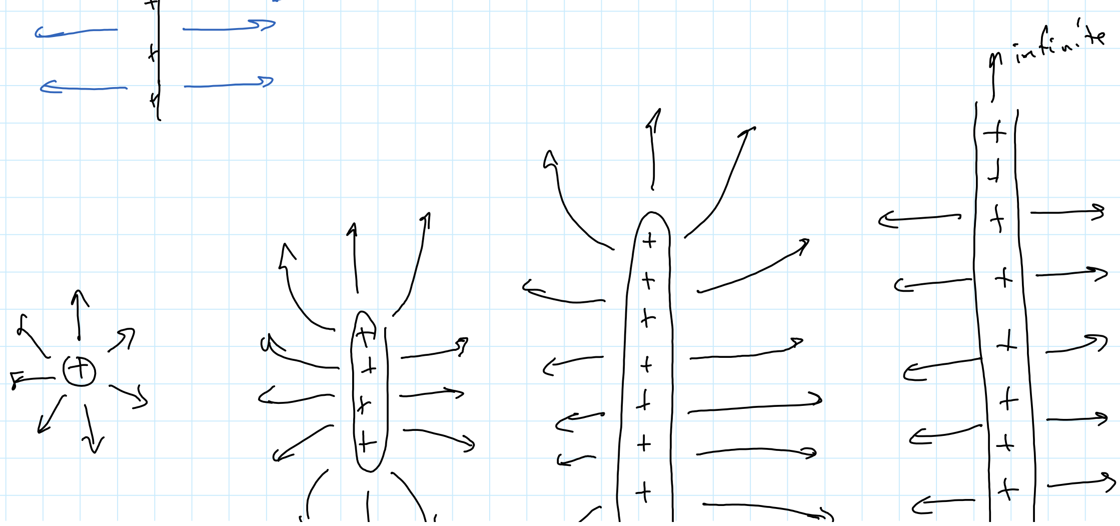
1)

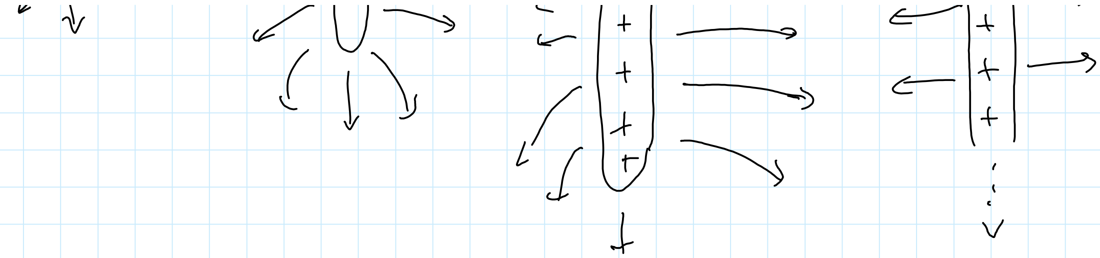


$q_{in} = A_1 \sigma_0$ or $A_2 \sigma_0$ since $A_1 = A_2$

2)







NO

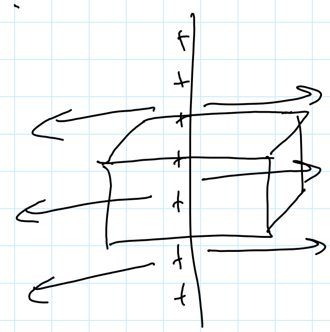
3) $E_L = E_R$

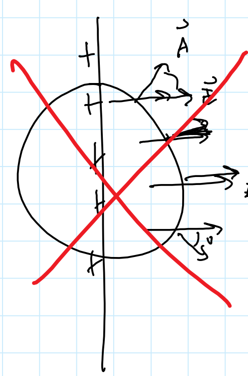
$A_1 = A_2$

4) Φ_1 and Φ_2 are Non-zero

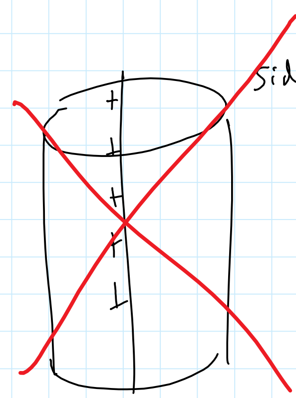
$\Phi_3 = 0$

what other gaussian surface would be a good choice for an infinite sheet of charge?

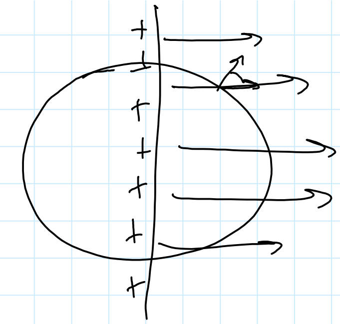




side view



top view



5) use Gauss's Law to find E:

$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$$

$$\int_{Lf} \vec{E} \cdot d\vec{A} + \underbrace{\int_{side} \vec{E} \cdot d\vec{A}}_{0} + \int_{Rt} \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$$

$$E A_2 + 0 + E A_1 = \frac{\sigma A_1}{\epsilon_0}$$

$A_1 = A_2 = A$

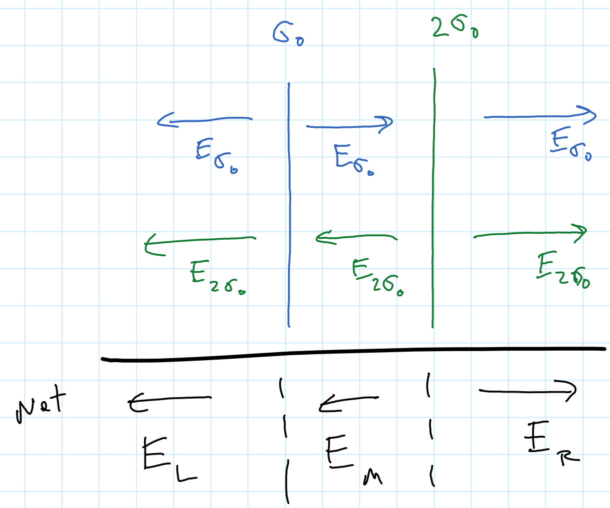
$$2EA = \frac{\sigma A}{\epsilon_0}$$

$$E = \frac{\sigma}{2\epsilon_0}$$ insulating sheet of charge

p. 36 B) 1) $q_{in} = \sigma_0 A + 2\sigma_0 A$

$= 3\sigma_0 A$

2)



$$E_L = E_R = E_{\sigma_0} + E_{2\sigma_0}$$

$$(\vec{E}_L = -\vec{E}_R)$$

$$E = \frac{\sigma}{2\epsilon_0}$$ in general for an infinite sheet of charge

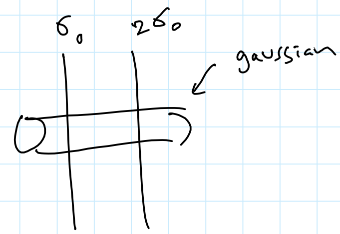
$$E_{\sigma_0} = \frac{\sigma_0}{2\epsilon_0}$$

$$E_{2\sigma_0} = \frac{2\sigma_0}{2\epsilon_0} = \frac{\sigma_0}{\epsilon_0}$$

$$E_L = E_R = \frac{3}{2}\frac{\sigma_0}{\epsilon_0}$$

Now, use Gauss's Law: (see if you get the same result)

$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$$

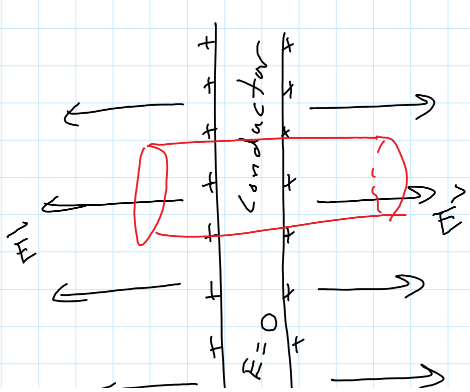


$$\int_L \vec{E} \cdot d\vec{A} + \underbrace{\int_{side} \vec{E} \cdot d\vec{A}}_{0} + \int_{Rt} \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$$

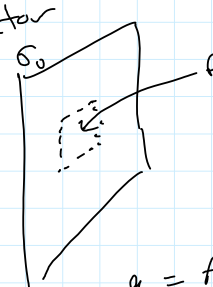
$$EA + 0 + EA = \frac{3\sigma_0 A}{\epsilon_0}$$

$$E = \frac{3}{2}\frac{\sigma_0}{\epsilon_0}$$

Conductive Sheet



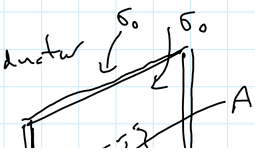
insulator



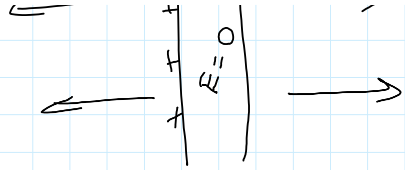
insulator can have only one side

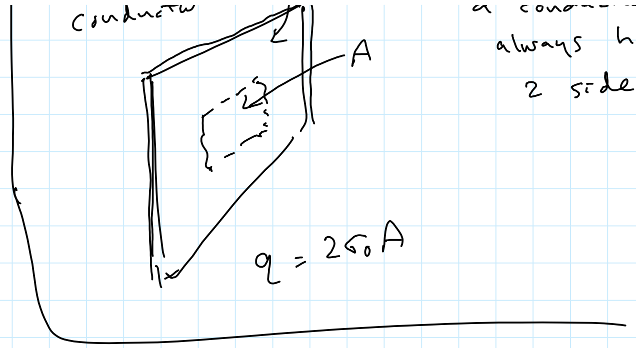
$q = A\sigma_0$

conductor



a conductor always has 2 sides





a conductor always has 2 sides

$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$$

$$\int_{Lf} \vec{E} \cdot d\vec{A} + \underbrace{\int_{side} \vec{E} \cdot d\vec{A}}_{0} + \int_{Rt} \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$$

$$EA + 0 + EA = \frac{q_{in}}{\epsilon_0}$$

$$2EA = \frac{q_{in}}{\epsilon_0} \qquad q_{in} = 2\sigma_0$$

$$2EA = \frac{2\sigma A}{\epsilon_0}$$

$$E = \frac{\sigma}{\epsilon_0}$$ for a conductive sheet of charge

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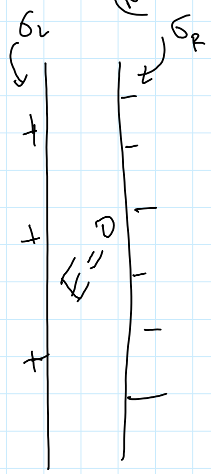
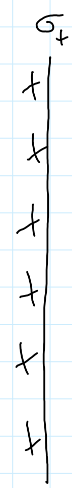
Conductive sheet of charge (Net Negative)



insulating sheet of charge (Net positive)



Let $\sigma_+ = +10\ \frac{\mu C}{m^2}$

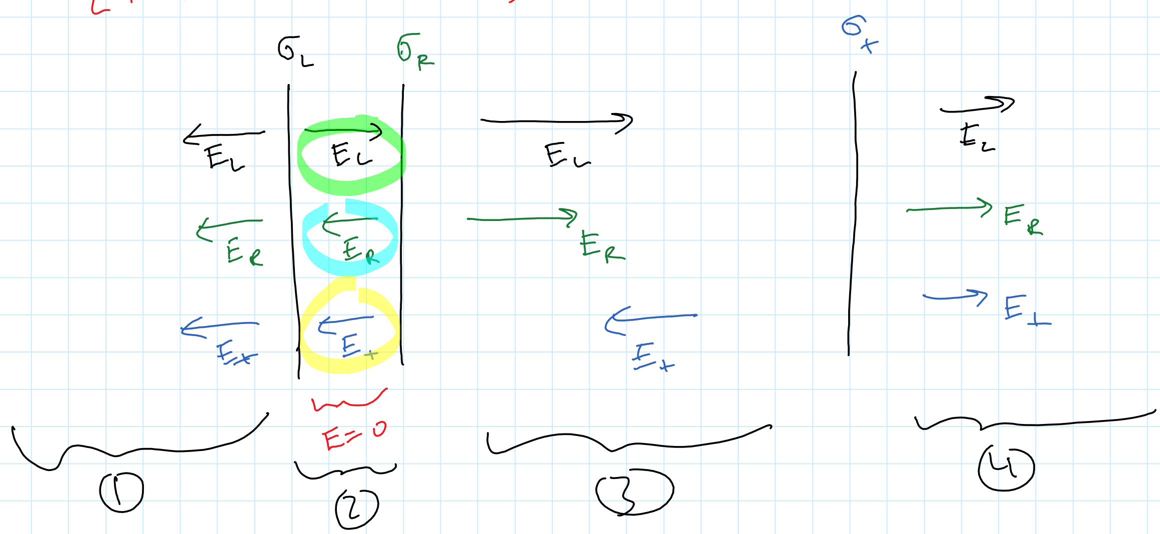
when all alone in space:

$$\sigma_{conductor} = -6 \ \frac{\mu C}{m^2}$$

Find 1) σ_L and σ_R on conductor after insulator is brough near

2) E everywhere

[Treat them as 3 insulating sheets of charge]



we know: $\sigma_L + \sigma_R = 2\,\sigma_{conductor}$

$$\vec{E}_L + \vec{E}_R + \vec{E}_+ = 0 \quad \text{inside conductor}$$

$$+\frac{\sigma_L}{2\epsilon_0} - \frac{\sigma_R}{2\epsilon_0} - \frac{\sigma_+}{2\epsilon_0} = 0 \qquad \rightarrow +$$

$$\sigma_L - \sigma_R - \sigma_+ = 0$$

$$\sigma_L - \sigma_R - 10 = 0 \qquad (1)$$

$$\sigma_L + \sigma_R = 2(-6) \qquad (2)$$

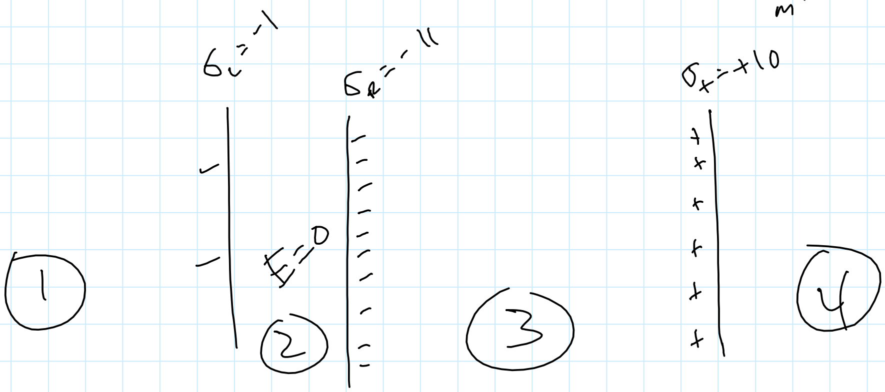
$$10 + \sigma_R + \sigma_R = -12$$

$$2\sigma_R = -22$$

$$\sigma_R = -11 \ \frac{\mu C}{m^2}$$

$\sigma_R \qquad \frac{}{m^2}$

$$\sigma_L = -1 \quad \frac{\mu C}{m^2}$$



$$E_1 = -\frac{\sigma_L}{2\epsilon_0} - \frac{\sigma_R}{2\epsilon_0} - \frac{\sigma_+}{2\epsilon_0} = -\frac{(-1)}{2\epsilon_0} - \frac{(-11)}{2\epsilon_0} - \frac{(+10)}{2\epsilon_0} = \frac{2}{2\epsilon_0} = \frac{1}{\epsilon_0}$$

$$= +\frac{1}{\epsilon_0} \longrightarrow$$ [Positive is to the right]

$$E_2 = 0$$

$$E_3 = E_L + E_R - E_+ = \frac{\sigma_L}{2\epsilon_0} + \frac{\sigma_R}{2\epsilon_0} - \frac{\sigma_+}{2\epsilon_0} = \frac{(-1)}{2\epsilon_0} + \frac{(-11)}{2\epsilon_0} - \frac{(+10)}{2\epsilon_0}$$

$$= -\frac{22}{2}\frac{1}{\epsilon_0} = -\frac{11}{\epsilon_0}$$ (Negative is to the left)

$$E_4 = -\frac{1}{\epsilon_0}$$ (Negative is to the left)