Physics 5B

HW #4

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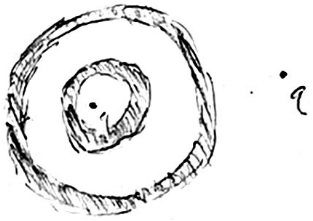
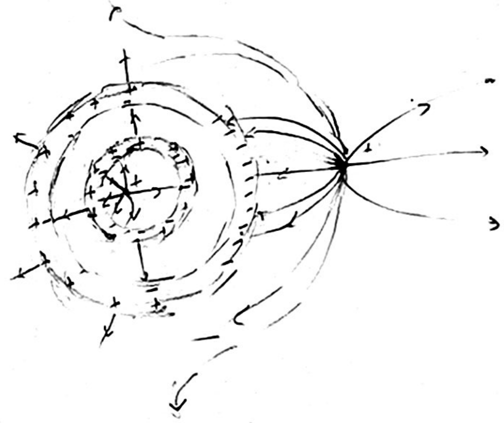
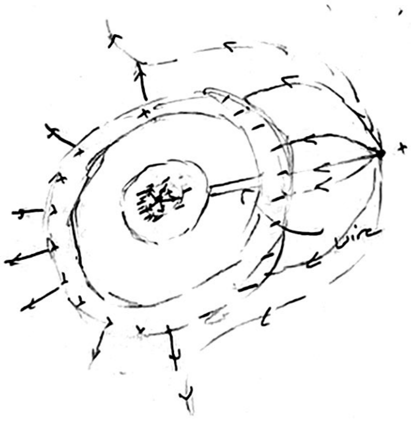
3.33 Two Concentric Shells

Assuming Both q's are positively charged,

(a)



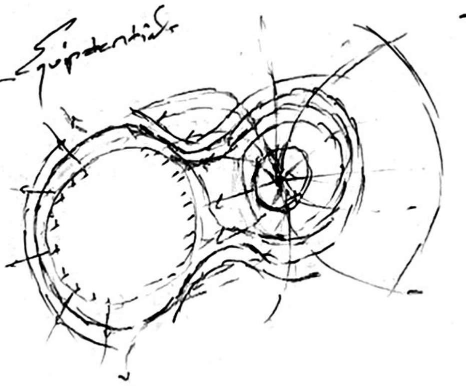




(b)

3.34 Equipotentials

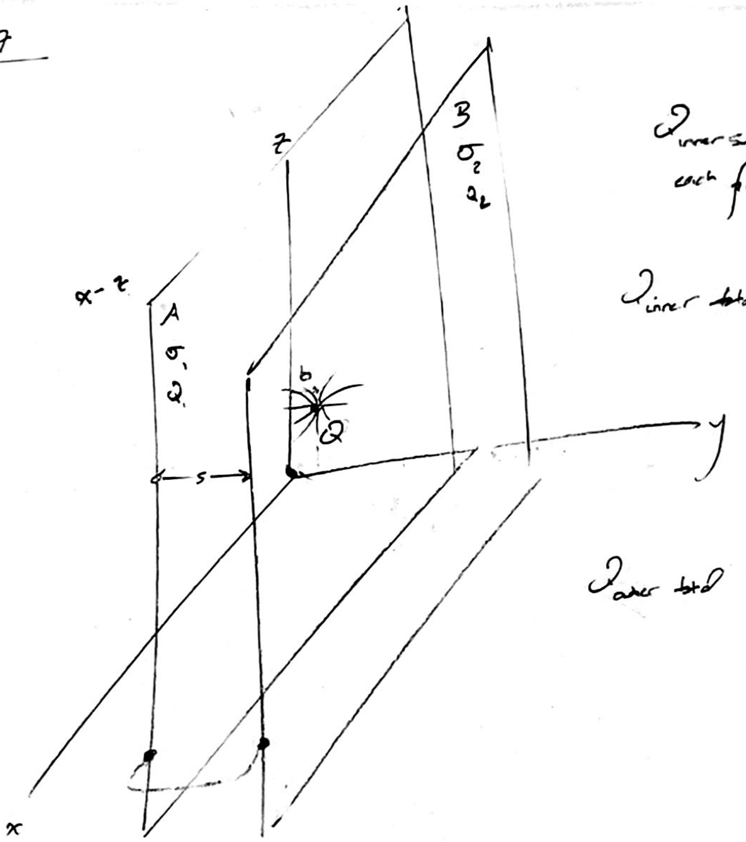
⊥ to field lines



Close to the sphere, Equipotential lines are essentially circles since the neutral conducting sphere is farther away, $\frac{kq}{r}$ is a good approximation

There also must be a point on the sphere where $\vec{E} = \vec{0}$ since the (-) and (+) parts of the sphere separate due to continuity.

3.37

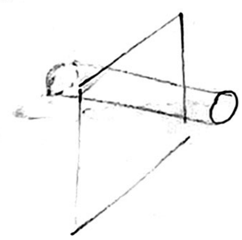


$Q_{\text{inner surface each face}}$?

$Q_{\text{inner total}} = -Q \Longrightarrow$ if Q is stationary, a total $(-Q)$ will be able to move to interior

$Q_{\text{outer total}} = +Q$

Let there be a plane of charge (Q), uniformly distributed on the plane of $y = s$

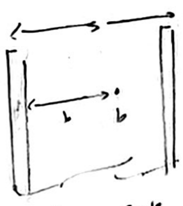


$$\oint \vec{E} \cdot d\vec{a} = \frac{Q_{enc}}{\epsilon_0}$$

$$2EA = \frac{\sigma A}{\epsilon_0} \Longrightarrow |\vec{E}| = \frac{\sigma}{2\epsilon_0}, \quad \sigma A = Q, \quad \sigma = \frac{Q}{A}$$

with only one side, $|\vec{E}| = \dfrac{\sigma}{\epsilon_0}$

① $E_1 = \dfrac{\sigma_1}{\epsilon_0}, \quad E_2 = \dfrac{\sigma_2}{\epsilon_0}$



② $\dfrac{\cancel{k}(\sigma_1 \cancel{A})}{b} = \dfrac{\cancel{k}(\sigma_2 \cancel{A})}{s-b}$

Same potential

① & ②

$$\frac{E_1}{E_2} = \frac{\sigma_1}{\sigma_2}, \quad \frac{\sigma_1}{b} = \frac{\sigma_2}{s-b}$$

$$\sigma_1 = \frac{b}{s-b}\sigma_2 \Longrightarrow \frac{E_1}{E_2} = \frac{b}{s-b} \Longrightarrow \frac{Q_1}{Q_2} = \frac{b}{s-b}, \quad Q_1 + Q_2 = -Q$$

Given That

$$\frac{Q_1}{Q_2} = \frac{b}{s-b} \quad \& \quad Q_1 + Q_2 = -Q$$

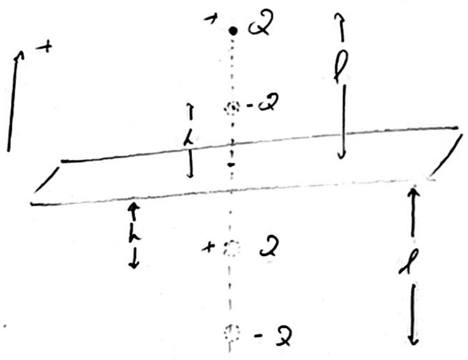
$$Q_1 = Q_2 \frac{b}{s-b} \Longrightarrow Q_2 + \frac{b}{s-b} Q_2 = -Q$$

$$\frac{s}{s-b} Q_2 = -Q \Longrightarrow \underline{Q_2 = -Q \frac{s-b}{s}}$$

$$Q_1 = -Q\left(\frac{\cancel{s-b}}{s}\right)\left(\frac{b}{\cancel{s-b}}\right) = \underline{-Q \frac{b}{s}}$$

$$Q_1 = -\frac{b}{s} Q \quad / \quad Q_2 = -Q \frac{s-b}{s}$$

3.38 Two Charges & a plane



$+Q_{\text{plane}}$

$$\sum F = \frac{Q^2}{4\pi\varepsilon_0}\left(\frac{1}{(l-h)^2} - \frac{1}{(2h)^2} + \frac{1}{(l+h)^2}\right) = 0$$

$$= \cancel{\frac{Q^2}{4\pi\varepsilon_0}}\left(\frac{1}{l^2 - 2lh + h^2} - \frac{1}{4h^2} + \frac{1}{l^2 + 2lh + h^2}\right) = 0$$

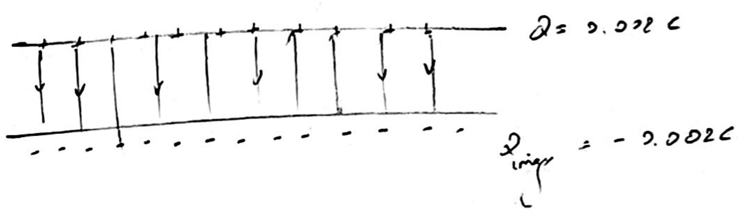
$$\frac{1}{4h^2} = \frac{2(l^2 + h^2)}{(l^2 - h^2)^2}$$

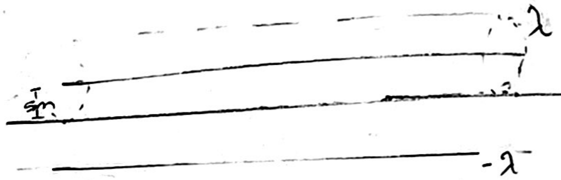
$$h^4 + 10l^2h^2 - l^4 = 0$$

let $y = h^2 \Longrightarrow y^2 + 10l^2 y - l^4 \Longrightarrow$ $\boxed{y = \sqrt{\frac{-5 + 4\sqrt{2}}{7}}\, l}$

33a A wire above Earth

$Q_{total} = 200\lambda = 200(10^{-5}) = 0.002\ C$





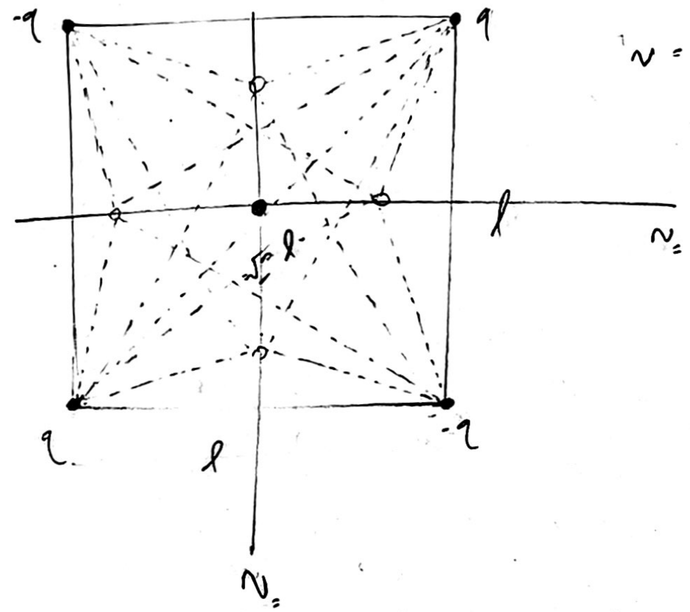
$\oint \vec{E}_{tot} \cdot d\vec{a} = \frac{\lambda \ell}{\epsilon_0}$

$E(\cancel{2}\pi 5 \cancel{\ell}) = \frac{\cancel{2}\lambda \cancel{\ell}}{\epsilon_0}, \quad \frac{\lambda}{\pi(5)\epsilon_0} = 7.2 \cdot 10^4 \ \frac{\text{Volt}}{\text{meter}}$

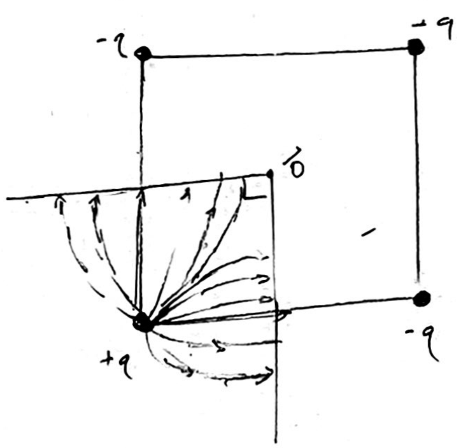
$\vec{E}_{image\ line} = \frac{\lambda}{20\pi\epsilon_0} = \frac{10^{-5}}{20\pi\epsilon_0} = 1.8\times 10^4\ V/m$

$\vec{F}_{line} = q\vec{E} = 0.002\ C\,(1.8\times 10^4\ N/m) = \underline{\underline{36N\,(-\hat{j})}}$

Point Charge near a Corner



$$V = \frac{1}{4\pi\epsilon_0} \sum_i^n \frac{q_i}{r_i}$$



This method only works where the sheet is divided in an angle at the bend where $\theta = 2\pi/N$ where $N \in \mathbb{Z}$, $\theta = 120^\circ$, $2\pi/3$ won't work.