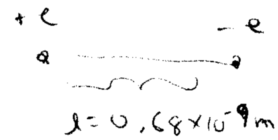
Workshop 2

P 21-62



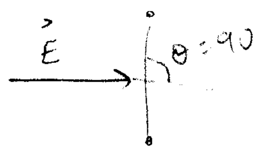
$E = 2.2 \times 10^{4}$ N/C

a)

$$\vec{p} = Q\vec{l}$$

$$p = el = (1.6 \times 10^{-19}\,C)(0.68 \times 10^{-9}\,m) = \boxed{1.088 \times 10^{-28}\,C\cdot m}$$

b)



$$\vec{\tau} = \vec{p} \times \vec{E}$$

$$= |\vec{p}||\vec{E}|\sin\theta \qquad \sin 90 = 1$$

$$= elE\,(1)$$

$$\boxed{\tau = 2.4 \times 10^{-24}\,N\,m}$$

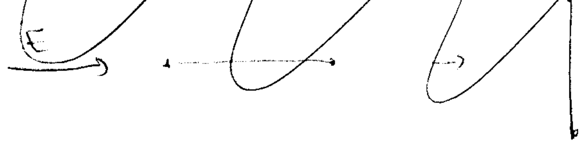
direction into or out of plane of drawing, depending on direction of $\vec{E}$

c) this time, $\theta = 45°$

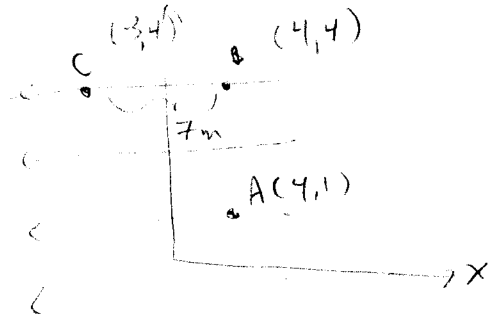
$\sin 45 = \frac{1}{\sqrt{2}}$

$$\tau' = \frac{\tau}{\sqrt{2}} = 1.7 \times 10^{-24}\,N\cdot m$$

~~d)~~ $\cancel{W = \Delta U = (-pE\cos\theta_f) - (-pE\cos\theta_i)}$



P 23-11 $\qquad \vec{E} = -4.2\ N/C\ \hat{i}$



a) $V_{BA} = V_B - V_A = -\int_a^b \vec{E} \cdot d\vec{l} = 0$

since $d\vec{l} \perp \vec{E}$

The points A and B are at the same potential.

b) $V_{CB} = V_C - V_B = -\int_B^C \vec{E} \cdot d\vec{l}$

$= -\int_B^C E\, dl \sin 90^\circ$

$= -E(1)\int_B^C dl$

$= E(-7m)$

$= -(-4.2\ N/C)(-7m)$

$\boxed{V_{CB} = -29.4\ V}$

c) $V_{CA} = V_C - V_A = -29.4V$

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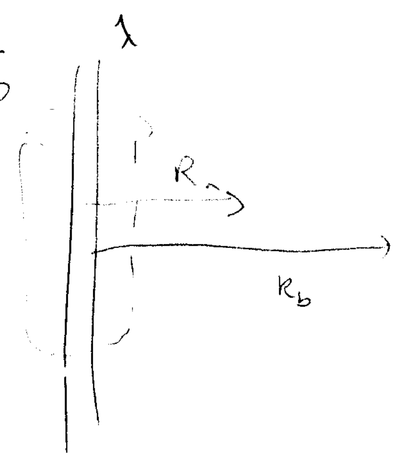


$V_{ba} = V_b - V_a = -\int_a^b \vec{E} \cdot d\vec{l}$

$\vec{E} = ?$

draw gaussin surface

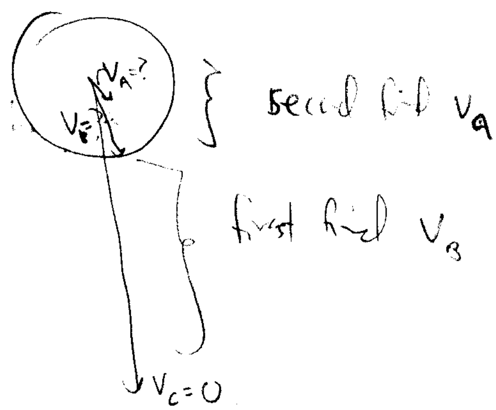
$\int \vec{E} \cdot d\vec{A} = Q_{enc}/\epsilon_0$

$2\pi r \cancel{l} E = \frac{\lambda \cancel{l}}{\epsilon_0}$

$E = \frac{\lambda}{2\pi\epsilon_0} \frac{1}{r}$

The field is not constant with r. Outside, the field is that of a point charge with $Q = \frac{\rho_0}{\epsilon_0}\left[\frac{r_0^3}{3} - \frac{r_0^5}{5r_0^2}\right]4\pi$

$$Q = \frac{\rho_0 4\pi}{\epsilon_0}\left(\frac{2}{15}\right) r_0^3$$



$$V_B = \overset{0}{V_c} - V_B = -\int E \cdot dl = \frac{1}{4\pi\epsilon_0}\,\frac{\frac{8\pi\rho_0 r_0^3}{15}}{r_0} = \frac{2\rho_0 r_0^2}{15\epsilon_0}$$ (see class notes)

so $V_B = \frac{2\rho_0 r_0^2}{15\epsilon_0}$

now $V_r - V_{r_0} = -\int_{r_0}^{r}\left(\frac{\rho_0}{\epsilon_0}\left[\frac{r}{3} - \frac{r^3}{5r_0^2}\right]\right)dr$

$$V_r - \frac{2\rho_0 r_0^2}{15\epsilon_0} = -\frac{\rho_0}{\epsilon_0}\left[\frac{r^2}{6} - \frac{r^4}{20r_0^2}\right]_{r_0}^{r}$$

$$= -\frac{\rho_0}{\epsilon_0}\left[\frac{r^2}{6} - \frac{r^4}{20r_0^2} - \frac{r_0^2}{6} + \frac{r_0^4}{20r_0^2}\right]$$

$$V_c = \frac{\rho_0}{\epsilon_0}\left[-\frac{r^2}{6} + \frac{r^4}{20r_0^2} + \frac{r_0^2}{6} - \frac{r_0^2}{20}\right] + \frac{2\rho_0}{\epsilon_0}\frac{r_0^2}{15}$$

algebra

$$= \frac{\rho_0}{\epsilon_0}\left(\frac{r_0^2}{4} - \frac{r^2}{6} + \frac{r^4}{20r_0^2}\right)$$

so $V_{ba} = -\int_a^b \frac{\lambda}{2\pi\epsilon_0}\frac{1}{r}\,dr$

$= -\frac{\lambda}{2\pi\epsilon_0}\int_{R_a}^{R_b}\frac{1}{r}\,dr$

$= -\frac{\lambda}{2\pi\epsilon_0}\left[\ln R_B - \ln R_A\right]$

$V_{ba} = \frac{\lambda}{2\pi\epsilon_0}\ln\frac{R_A}{R_b}$

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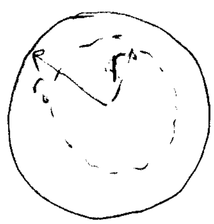
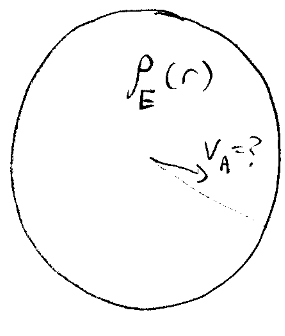
$V_b - V_a = -\int_a^b \vec{E}\cdot d\vec{l}$

$\vec{E} = ?$





$V_B = 0$
$r \to \infty$

$\int \vec{E}\cdot d\vec{A} = E\, 4\pi r^2$

$Q_{encl} = \int dq$

$= \int \rho\, dV$

$= \int_0^r \rho_0\left[1 - \frac{r'^2}{r_0^2}\right] 4\pi r'^2\, dr'$

$= \rho_0 4\pi \int_0^r \left(r'^2 - \frac{r'^4}{r_0^2}\right) dr'$

$Q_{enc} = \rho_0 4\pi\left[\frac{r^3}{3} - \frac{r^5}{5r_0^2}\right]$

$E\, 4\pi r^2 = \frac{\rho_0 4\pi\left(\frac{r^3}{3} - \frac{r^5}{5r_0^2}\right)}{\epsilon_0}$

$\vec{E} = \frac{\rho_0}{\epsilon_0}\left[\frac{r}{3} - \frac{r^3}{5r_0^2}\right]\hat{r}$