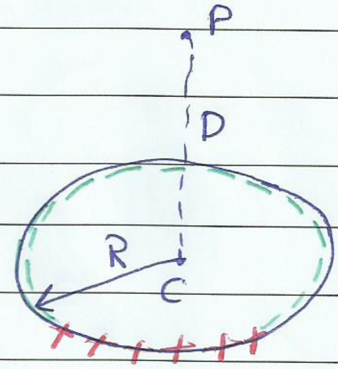
(24–9)

$R = 8.20\,cm$

$Q_1 = +7.07\,pC$

$Q_2 = -6Q_1 = -42.42\,pC$



a) $dV = k\dfrac{dq}{r}$

$dV_c = \dfrac{1}{4\pi\epsilon_0}\dfrac{dq}{R}$

$V_c = \dfrac{1}{4\pi\epsilon_0 R}\int dq = \dfrac{Q}{4\pi\epsilon_0 R} = \dfrac{+Q_1 + {}^-6Q_1}{4\pi\epsilon_0 R} = \dfrac{-5Q_1}{4\pi\epsilon_0 R}$

$= \dfrac{9\times10^{9} \times -5\times 7.07\times10^{-12}}{8.2\times10^{-2}} =$

$V_c = (-)\ 3.88V$

b) Find V_p? at $D = 2.05\,cm$

$V_p = \dfrac{k\,Q}{\sqrt{R^2+D^2}} = \dfrac{k(\overset{+}{Q_1} + {}^-6Q)}{(D^2+R^2)^{1/2}} = \dfrac{-5Q_1}{4\pi\epsilon_0(D^2+R^2)^{1/2}}$

$= \dfrac{-5\times9\times10^{9}\times 7.07\times10^{-12}}{\left[(2.05\times10^{-2})^2 + (8.20\times10^{-2})^2\right]^{1/2}}$

$= \dfrac{-5\times7.07\times10^{-12}\times9\times10^{9}}{8.45\times10^{-2}}$

$V_p = (-)3.77V$

D1

(24-11) $E_x = -\frac{\partial V}{\partial x} = (-)\left[\frac{-2V_s - 0}{0.4-0}\right] = (-)\left[\frac{(-2)\times 1000}{0.4}\right]$

slope of V vs. x

$E_x = 5000 V/m$

$E_y = -\frac{\partial V}{\partial y} = -\left[\frac{0.8V_s - 0}{0.4-0}\right] = -\left[\frac{0.8\times 1000}{0.4}\right]$

slope V vs. y

$E_y = (-)2000 V/m$

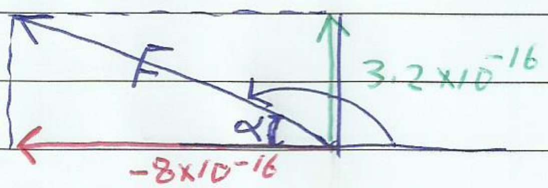
$\vec{E} = 5.0\times 10^3\hat{i} - 2.0\times 10^3\hat{j}$ V/m

$\vec{F} = q\vec{E} = -1.6\times 10^{-19}\left[5.0\times 10^3\hat{i} - 2.0\times 10^3\hat{j}\right]$

$\vec{F} = -8\times 10^{-16}\hat{i} + 3.2\times 10^{-16}\hat{j}$ N

$= (-8\hat{i} + 3.2\hat{j})\times 10^{-16}$ N Force on the election

$F = \sqrt{F_x^2 + F_y^2}$



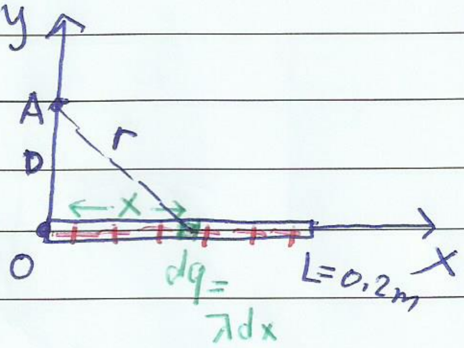
$= \sqrt{(-8)^2 + (3.2)^2}\times 10^{-16}$

$\vec{F} = 8.62\times 10^{-16}$ N; at $\alpha = \tan^{-1}\left(\frac{3.2}{-8}\right) = -21.8°$

at 158.2° with +x counter clockwise

D2

(24-14) $\lambda = bx$, $b = 15nC/m^2$, $L = 0.2m$



a) Find V at $x=0$,

$$dV_0 = \frac{k\,dq}{x} , \quad r = x$$

$$dV_0 = \frac{k\lambda dx}{x} = \frac{kbx\,dx}{x}$$

$$V_0 = kb\int_0^L dx = kbL = (9\times10^9)(15\times10^{-9})(0.2)$$
$$= 27\,\text{Volt}$$

b) Find V at point A on y-axis at $D = 0.15m$

$$dV_A = \frac{k\,dq}{r} = \frac{k\lambda dx}{\sqrt{x^2+D^2}} = \frac{kbx\,dx}{\sqrt{x^2+D^2}}$$

$$V_A = kb\int_0^L \frac{x\,dx}{\sqrt{x^2+D^2}} , \quad \text{let } u = x^2+D^2$$
$$du = 2x\,dx$$

$$= kb\int\frac{(du/2)}{\sqrt{u}} = \frac{kb}{2}\int u^{-1/2}du = \frac{kb}{2}\left[\frac{u^{1/2}}{1/2}\right]$$

$$= kb\left[\sqrt{x^2+D^2}\right]_0^L = kb\left[\sqrt{L^2+D^2} - D\right]$$

$$V_A = \frac{b}{4\pi\epsilon_0}\left[\sqrt{L^2+D^2} - D\right]$$

$$= (9\times10^9)(15\times10^{-9})\left[\sqrt{(0.2)^2+(0.15)^2} - 0.15\right]$$
$$= 135\,[0.25 - 0.15]$$

$$V_A = 13.5V$$

(24-17) $V = 2xyz^2$, Find E at the point $(-1\hat{i} - 2\hat{j} + 4\hat{k})m$

$$E_x = -\frac{\partial V}{\partial x} = (-)2yz^2$$

$$E_y = -\frac{\partial V}{\partial y} = (-)2xz^2$$

$$E_z = -\frac{\partial V}{\partial y} = -(4xyz)$$

$$E_x = (-)[2(-2)(4)^2] = +16\,V/m$$

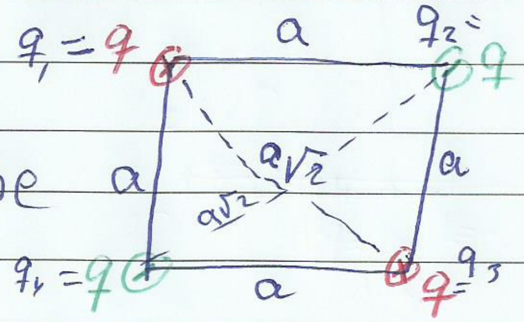
$$E_y = -[(2)(-1)(4)^2] = +32\,V/m$$

$$E_z = -[(4)(-1)(-2)(4)] = -32\,V/m$$

$$\vec{E} = 16\hat{i} + 32\hat{j} - 32\hat{k}\ \ V/m$$

$$E = \sqrt{(16)^2+(32)^2+(32)^2} = \sqrt{2304}$$
$$= 48\,V/m$$

(24-33) $q = 5\,pC$, $a = 64\,cm$



a) How much Work must be done by an external agent to build the System?

$$W_{\substack{\text{done}\\ \text{by } F_{ext}}} = W_{q_1} + W_{q_2} + W_{q_3} + W_{q_4}$$

$$\infty \rightarrow \square \quad \infty \rightarrow \square \quad \infty \rightarrow \square \quad \infty \rightarrow \square$$

$$= 0 + q_2\left(\frac{q_1}{4\pi\epsilon_0 a}\right) + q_3\left(\frac{q_1}{4\pi\epsilon_0 a\sqrt{2}} + \frac{q_2}{4\pi\epsilon_0 a}\right) + q_4\left(\frac{kq_1}{a} + \frac{kq_2}{a\sqrt{2}} + \frac{kq_3}{a}\right)$$

$$= \frac{1}{4\pi\epsilon_0 a}\left[q_2 q_1 + \frac{q_3 q_1}{\sqrt{2}} + q_3 q_2 + q_4 q_1 + \frac{q_4 q_2}{\sqrt{2}} + q_4 q_3\right]$$

$$= \frac{1}{4\pi\epsilon_0 a}\left[-q(+q) + \frac{(+q)(+q)}{\sqrt{2}} + (+q)(-q) + (-q)(+q) + \frac{(-q)(-q)}{\sqrt{2}} + (-q)(+q)\right]$$

$$= \frac{q^2}{4\pi\epsilon_0 a}\left[-1 + \frac{1}{\sqrt{2}} - 1 - 1 + \frac{1}{\sqrt{2}} - 1\right]$$

$$= \frac{q^2}{4\pi\epsilon_0 a}\left[-4 + \frac{2}{\sqrt{2}}\right] = \frac{(9\times10^{9})(5\times10^{-12})^2}{0.64}\left[-2.585786\right]$$

$$= (3.5156\times10^{-13})(-2.585786)$$

$$= -9.1\,J\times10^{-13}\,J = -0.91\,pJ$$

b) $W_E = -W_{\text{done by } F_{ext}}$

$$= +9.1\times10^{-13}\,J = 0.91\,pJ$$

c) $U_{\text{stored in the system}} = -W_E = -9.1\times10^{-13}\,J = -0.91\,pJ$

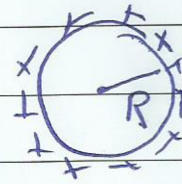
$$= W_{\text{done } F_{external}}$$

$$= -9.1\times10^{-13}\,J = -0.91\,pJ$$

D4

(24-39)

a) Find V_{escape} of the electron from the surface of a sphere

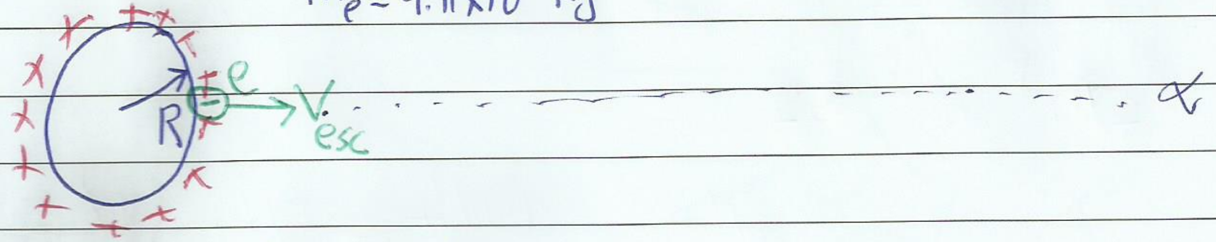


$R = 20\,cm$

$q = +1.6\times10^{-15}\,C$

$q_e = -e$

$m_e = 9.11\times10^{-31}\,kg$



$$(K+U)_i = (K+U)_f$$

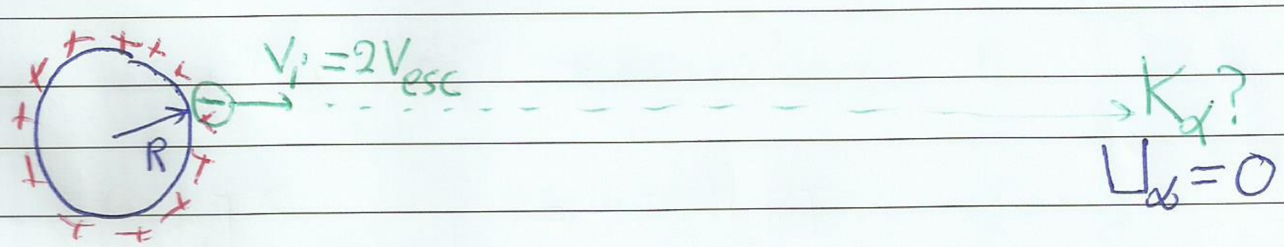
$$(K+U)_i = (K+U)_\infty \quad , \quad K_\infty = 0, \ U_\infty = 0$$

$$\frac{1}{2}mv_{esc}^2 + {}^{-}e\left(\frac{+q}{4\pi\epsilon_0 R}\right) = 0+0$$

$$\frac{1}{2}mv_{esc}^2 = \frac{qe}{4\pi\epsilon_0 R} \Rightarrow V_{escape} = \sqrt{\frac{2qe}{m(4\pi\epsilon_0 R)}}$$

$$V_{escape} = \sqrt{\frac{(2)(1.6\times10^{-15})(1.6\times10^{-19})\,9\times10^{9}}{(9.11\times10^{-31})(0.2)}} = 5\times10^{3}\,m/s$$

b)



$$K_i + U_i = K_\infty + U_\infty \quad , \quad U_\infty = 0 \text{ (always)}$$

$$\frac{1}{2}m_e v_i^2 + -e\left(\frac{+q}{4\pi\epsilon_0 R}\right) = K_\infty$$

$$\frac{1}{2}m_e(10\times10^{3})^2 - \frac{eq}{4\pi\epsilon_0 R} = K_\infty$$

$$\left(\frac{1}{2}\right)(9.11\times10^{-31})(10^{8}) - \frac{9\times10^{9}\times1.6\times10^{-19}\times1.6\times10^{-15}}{0.2} = K_\infty$$

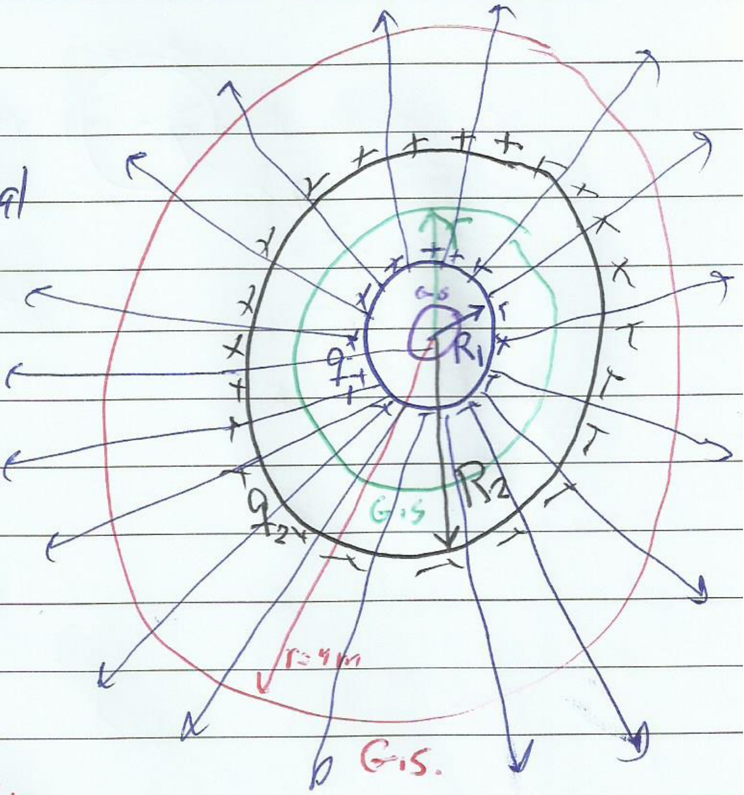
$$K_\infty = 4.56\times10^{-23} - 1.15\times10^{-23} = 3.41\times10^{-23}\,J$$

DS

(24-48) $(R_1 = 0.5m, R_2 = 1m)$
2 Conducting spherical shell.

$q_1 = +3\mu C$

$q_2 = +1\mu C$



Find the Electric Field at a) $r = 4m$ b) $0.7m$ c) $r = 0.2m$

a) $\vec{E}$ at $r = 4m$

Draw a G.S. to be a sphere of radius $= r = 4m$

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

$$E 4\pi r^2 \cos 0 = \frac{q_1 + q_2}{\epsilon_0}$$

$$E = \frac{q_1 + q_2}{4\pi\epsilon_0 r^2}, \quad r \geq R_2$$

$$= \frac{9\times10^9 \times (4\times10^{-6})}{(4)^2} = 2.25\times10^3 \ N/C$$

b) Draw a G.S to be a sphere of radius, $r = 0.7m$

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

$$E 4\pi r^2 \cos 0 = \frac{q_1}{\epsilon_0}$$

$$E = \frac{q_1}{4\pi\epsilon_0 r^2}, \quad R_1 \leq r \leq R_2$$

$$= \frac{9\times10^9 \times 3\times10^{-6}}{(0.7)^2} = 5.5\times10^4 \ N/C$$

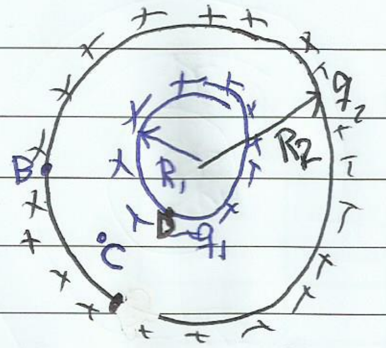
c) Draw a G.S. to be a sphere of radius $= 0.2$

$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{enc}}{\epsilon_0}, \quad E = 0, \quad q_1 = 0$$

D6

Find V at d) r = 4m e) r = 1m f) r = 0.7m

g) r = 0.5m h) r = 0.2m i) r = 0



$q_1 = +3\mu C$, $R_1 = 0.5m$

$q_2 = +1\mu C$, $R_2 = 1m$

d) $V(r) = V_1 + V_2$

$= \frac{kq_1}{r} + \frac{kq_2}{r}$, $r \geq R_2$

$= \frac{k(q_1+q_2)}{r}$, $r \geq R_2$

$V(4) = \frac{9\times10^9 \times +4\times10^{-6}}{4}$

$= 9\times10^3 V$

e) $V_B = V_1 + V_2$

$= \frac{kq_1}{R_2} + \frac{kq_2}{R_2}$

$V_B(1) = \frac{k(q_1+q_2)}{R_2} = \frac{9\times10^9 \times (+4\times10^{-6})}{1} = 36\times10^3 V$

f) $V_C(r)$? $r = 0.7m$

$V_C(r) = \frac{kq_1}{r} + \frac{kq_2}{R_2}$, $R_1 \leq r \leq R_2$

$V_C(0.7) = \frac{9\times10^9 \times +3\times10^{-6}}{0.7} + \frac{9\times10^9 \times +1\times10^{-6}}{1}$

$= 38.57\times10^3 + 9\times10^3$

$= 47.57\times10^3 V$

g) V_D at $r = 0.5m$?

$V_D(0.5) = \frac{kq_1}{R_1} + \frac{kq_2}{R_2} = \frac{9\times10^9 \times +3\times10^{-6}}{0.5} + \frac{9\times10^9 \times +1\times10^{-6}}{1}$

$V_D(0.5) = \quad = 54\times10^3 + 9\times10^3 = 63\times10^3 V$

h) V at 0.2m? i) V at r = 0 these 2 points have the V they are inside R_1

$V = \frac{kq_1}{R_1} + \frac{kq_2}{R_2} = 63\times10^3 V$ for all $r \leq R_1$

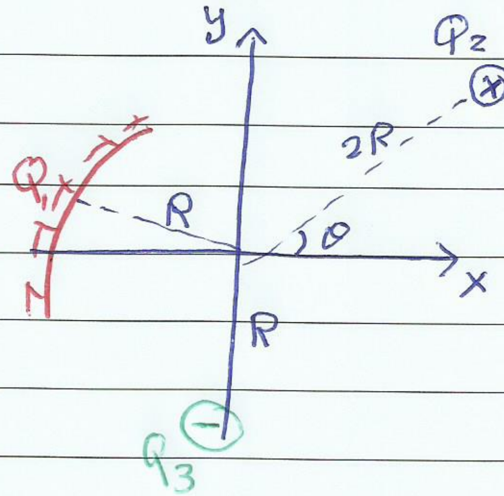
(24-61)

$Q_1 = +7.21\,pC$

$Q_2 = 4Q_1 = 28.84\,pC$

$Q_3 = -2Q_1$
$= -14.42\,pC$

$R = 2\,m$



a) $V_{center} = V_1 + V_2 + V_3$

$V_1 = \dfrac{kq}{R}$ from the arc

$= \dfrac{9\times10^{9} \times {}^{+}7.21\times10^{-12}}{2} = \overset{+}{0}.032\,V = +32\,mV$

$V_2 = \dfrac{9\times10^{9} Q_2}{2R} = \dfrac{9\times10^{9}\times {}^{+}28.84\times10^{-12}}{4} = \overset{+}{0}.065\,V = {}^{+}65\,mV$

$V_3 = \dfrac{9\times10^{9} Q_3}{R} = \dfrac{9\times10^{9}\times {}^{-}14.42\times10^{-12}}{2} = \overset{-}{0}.065\,V = -65\,mV$

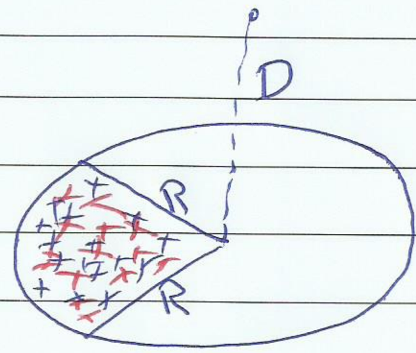
$V_{center} = V_1 + V_2 + V_3 = {}^{+}32 + {}^{+}65 + {}^{-}65$
$= +32\,mV$

b) Do this part.

(24-67) $R = 64\,cm$

$\sigma = 7.73\,fC/m^2$

$D = 45\,cm$



$V_{disk} = \dfrac{\sigma}{2\epsilon_0}\left[\sqrt{R^2+D^2} - D\right]$

We did this in a lecture

$V_{\frac{1}{4}Disk} = \dfrac{1}{4} V_{disk} = \dfrac{1}{4}\left[\dfrac{\sigma}{2\epsilon_0}\right]\left[\sqrt{R^2+D^2} - D\right]$

$= \dfrac{1}{4}\left[\dfrac{7.73\times10^{-15}}{2(8.85\times10^{-12})}\right]\left[\sqrt{0.64^2+0.45^2} - 0.45\right]$

$= \dfrac{1}{4}\left[1.45\times10^{-4}\right] = 3.63\times10^{-5}\,V$