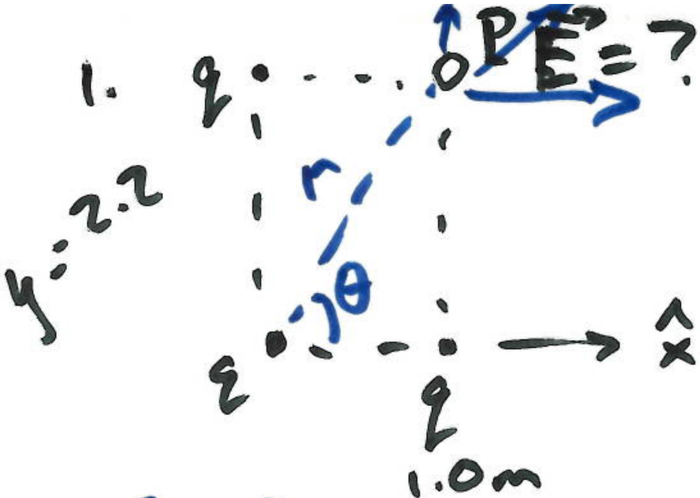
1.



$q = 0.35\,\cancel{m}C$
n for convenience.

$r^2 = x^2 + y^2 = 1m^2 + 2.2m^2 = 5.84m^2$

$r = 2.42m$

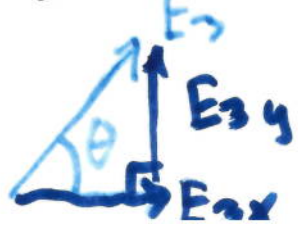
$E_x = \frac{kq}{(1m)^2} = \frac{\cancel{9\times10^9} \cdot 0.35\times\cancel{10^{-9}}}{1^2} = 3.15\frac{N}{C}$

$E_3 = \frac{kq}{r^2} = \frac{9\times10^9 \cdot 0.35\times10^{-9}}{5.84} = 0.54\frac{N}{C}$

$E_y = \frac{kq}{(2.2m)^2} = 0.65\frac{N}{C}$

E_3 needs to be broken into (x, y) components using θ. $\tan\theta = \frac{opp}{adj} = \frac{2.2\cancel{m}}{1.0\cancel{m}}$ $\theta = \tan^{-1}(2.2)$

$\theta = 65.6^\circ$



$E_{3x} = E_3 \cos\theta$ $\quad \cos\theta = \frac{adj}{hyp} = \frac{E_{3x}}{E_3}$

$= 0.54\frac{N}{C}\cos 65.6°$

$= 0.22\frac{N}{C}$

$E_{3y} = E_3 \sin\theta$

$= 0.54\frac{N}{C}\sin 65.6°$

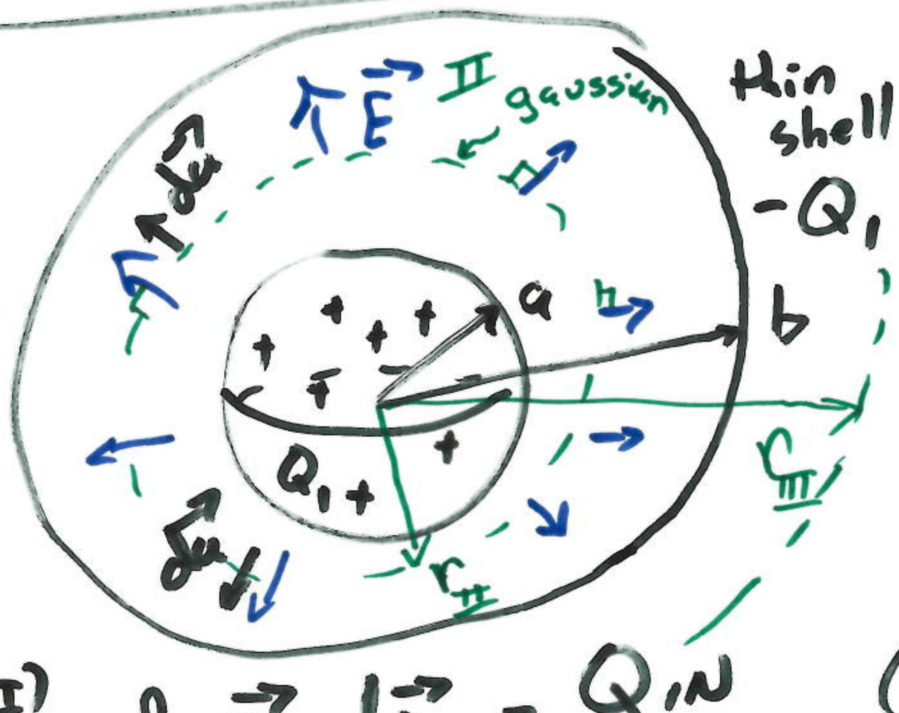
$= 0.49\frac{N}{C}$

$\vec{E} = (E_x + E_{3x}, E_y + E_{3y})$

$= (3.15 + 0.22, 0.65 + 0.49)\frac{N}{C}$

$$\boxed{\vec{E} = (3.37, 1.14)\frac{N}{C}}$$

2.



I $r < a$

II $a < r < b$

III $b < r$

Find $\vec{E}(r)$.

(II)

$\vec{E} \parallel d\vec{a}$

$$\oint \vec{E}\cdot d\vec{a} = \frac{Q_{IN}}{\epsilon_0} = \frac{Q_1}{\epsilon_0}$$

$\oint E\,da =$

E const.

$$E \underbrace{\oint da}= $$

$$E\, 4\pi r^2 = \frac{Q_1}{\epsilon_0}$$

$$E = \frac{Q_1}{4\pi\epsilon_0 r^2} = \frac{k Q_1}{r^2}$$

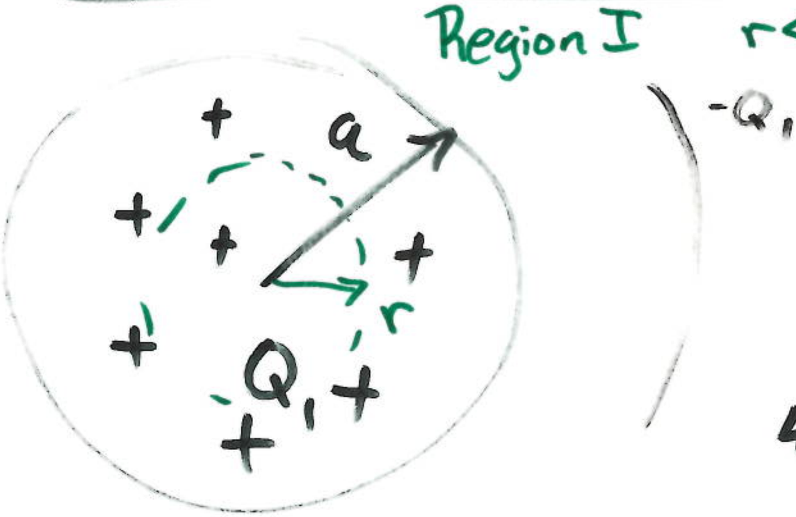
III) $\oint \vec{E}\cdot d\vec{a} = \frac{Q_{IN}}{\epsilon_0}$ $Q_{IN} = 0.$

thus $E_{III} = 0.$

$$4\pi r^2 E = 0$$

$$E = 0$$

Region I $r<a$ "inside inner sphere"



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

$$4\pi r^2 E = \frac{\rho V_{IN}}{\epsilon_0}$$

constant

$$\rho = \frac{\text{charge}}{\text{volume}} = \frac{Q_1}{\frac{4}{3}\pi a^3} = \frac{\text{total } Q}{\text{total } V}$$

$$Q_{IN} = \rho V_{IN} = \rho \frac{4}{3}\pi r^3$$

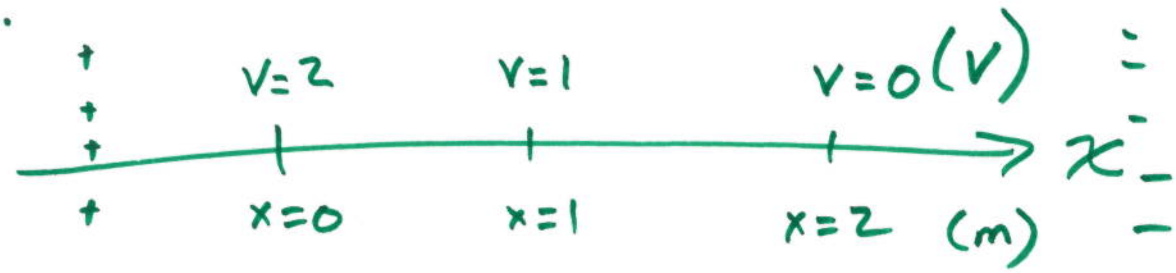
$$= \frac{Q_1}{\frac{4}{3}\pi a^3} \cdot \frac{4}{3}\pi r^3 = Q_1 \frac{r^3}{a^3}$$

$$4\pi r^2 E = \frac{Q_1}{\epsilon_0} \frac{r^3}{a^3}$$

$$\boxed{E_I = \frac{Q_1 r}{4\pi \epsilon_0 a^3}}$$

$r<a$
inside
the inner
sphere.

3.

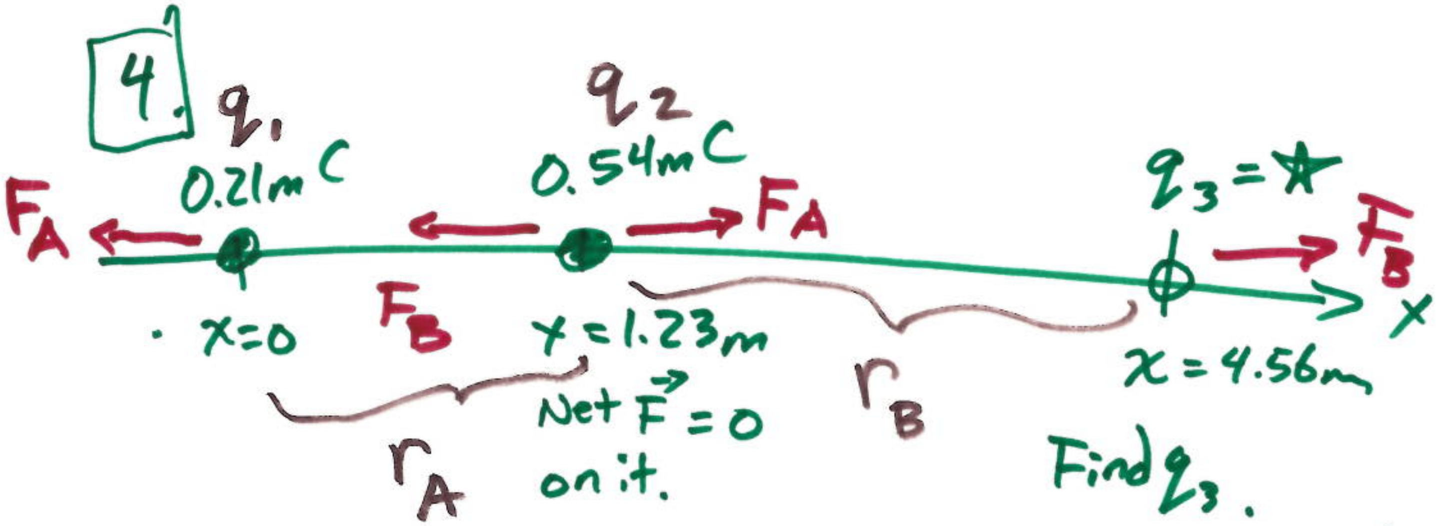


Find E_x in this region.

$$E_x = -\frac{dV}{dx} = -\frac{\Delta V}{\Delta x} = \frac{-(1-2)V}{(1-0)m} = \frac{1V}{m}$$

$\vec{E}_x > 0$ points $\longrightarrow$

4.



Find q_3.

$q_3 > 0$ to also repel the 0.54mC charge.

$F_A = F_B$ (magnitude)

$$\frac{\cancel{k}\,|q_1 \cancel{q_2}|}{r_A^2} = \frac{\cancel{k}\,|\cancel{q_2}\, q_3|}{r_B^2}$$

$$\frac{r_B^2}{r_A^2}\, q_1 = q_3$$

$$\frac{(4.56-1.23)^2\, m^2}{(1.23m)^2} \times 0.21mC = q_3 = \left(\frac{3.33m}{1.23m}\right)^2 \cdot 0.21mC$$

$$\boxed{q_3 = 1.54\ mC}$$

5. $V(x) = 1.0\,\text{V} + 0.12\,\frac{\text{V}}{\text{m}} \cdot x$

find $E_x(x)$

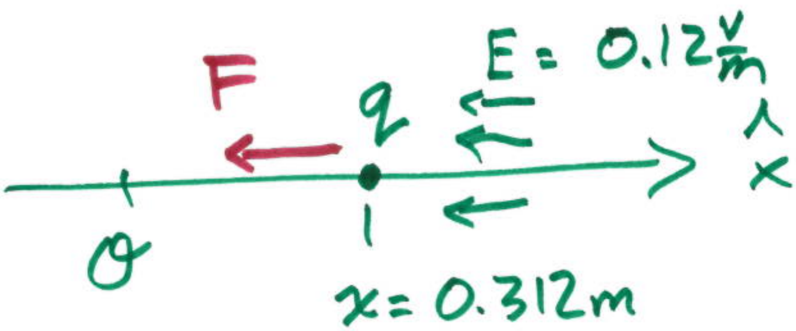
↑

x-component.

$$E_x = -\frac{\partial V}{\partial x} = \boxed{-0.12\,\frac{\text{V}}{\text{m}}}$$

↑ in $-\hat{x}$ direction.

find $\vec{F}$ on $q = 0.019\,\text{mC}$
at $x = 0.312\,\text{m}$.
Include directions.



$$\vec{F} = q\,\vec{E}$$

$$\boxed{F = 0.019\,\text{mC} \times 0.12\,\frac{\text{V}}{\text{m}} \text{ in } -\hat{x} \text{ dir.}}$$

$$F = 2.28 \times 10^{-6}\,\underbrace{\text{N}}_{}^{\text{C}\frac{\text{V}}{\text{m}}} \text{ in } \underline{-\hat{x} \text{ direction}}$$

$1\,\text{mC} = 10^{-3}\,\text{C}$ and $\frac{1\,\text{V}}{\text{m}} = \frac{1\,\text{N}}{\text{C}}$

q_1 q_2 $U<0$

$U = \frac{k q_1 q_2}{r^2}$

other nearby charges. Which of the following statements (if any) are true (any number could be true):

(a) they have opposite charges True

(b) they are attracted toward one another True

(c) work is required to move the charges further away from one another True

(d) the magnitude of the force on one charge equals the magnitude of the force on the other charge $F = K q_1 q_2 / r^2$ True

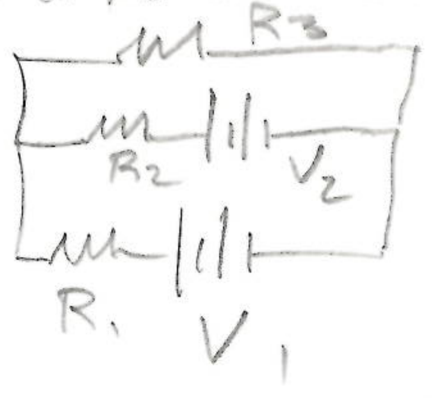
(e) the direction of the force on one charge is opposite to the direction of the force on the other charge True

(f) the force vector on one charge points toward the other charge True

(g) the acceleration of one charge only equals the acceleration of the other charge if the masses of each charge are equal. False the $\vec{a}$ point opp. directions.

7. (Figure given) Set up the integral to find the voltage at a point P located on the x-axis at position x due to a uniformly charged finite rod, length L, total charge Q, which is oriented along the y-axis from y=0 to y=L.

8. Simple DC Circuit



Given V_1 V_2
R_1 R_2 R_3
find I through each R.

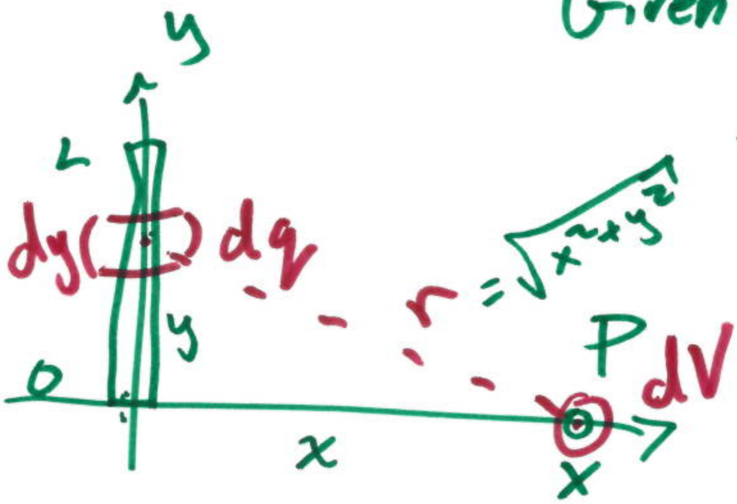
$V_1 = 1.1V$
$V_2 = 2.2V$

$R_1 = 123\Omega$
$R_2 = 231\Omega$
$R_3 = 321\Omega$

7. Set up integral to find V at P due to rod (y-axis) as pictured.

Given: L, x, λ picture.

$\lambda = \dfrac{Q}{L} =$ charge per unit length.



Need To Do:

r in terms of ...

dq ...

set up limits

$$\int dV = \int \frac{k\,dq}{r}$$

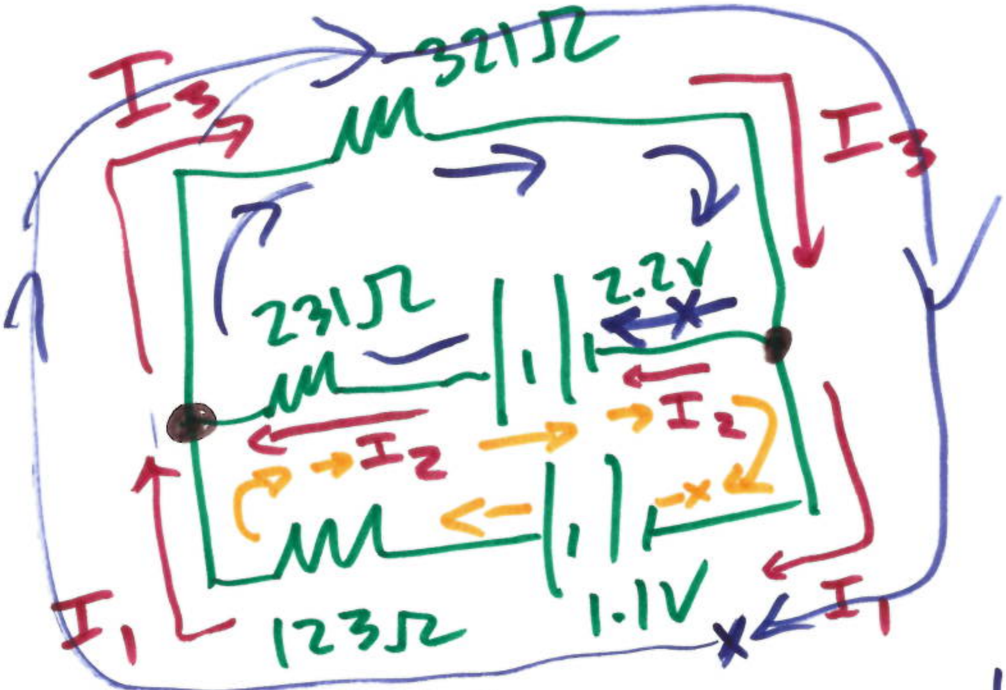
$$V = k \int \frac{dq}{r}$$

$$\lambda = \frac{Q}{L} = \frac{dq}{dy} \rightarrow dq = \lambda dy$$

$$V = k \int_{y=0}^{y=L} \frac{\lambda dy}{\sqrt{x^2+y^2}}$$

$$V = \lambda k \int_{0}^{L} \frac{dy}{\sqrt{x^2+y^2}}$$

8. Find I through each branch



3 currents exist.

Loop Rules (2)

$\sum V_{loop} = 0$

Junction Rule:

$\sum I_{IN} = \sum I_{out}$

$I_1 + I_2 = I_3$

outer loop:

$+1.1V - I_1 (123\Omega) - I_3\, 321\Omega = 0$

upper loop

$+2.2V - I_2 (231\Omega) - I_3\, 321\Omega = 0$

lower loop:

$+1.1V - I_1 (123\Omega) + I_2\, 231\Omega - 2.2V = 0$

Junc.

outer solve I_1

$\frac{1.1}{123} - I_3 \frac{321}{123} = \frac{123}{123} I_1$

$0.0089 - 2.6 I_3 = I_1$

upper: solve I_2

$$2.2 - 321 I_3 = 231 I_2$$

$$\frac{2.2}{231} - \frac{321}{231} I_3 = I_2$$

$$0.0095 - 1.4 I_3 = I_2$$

Junc.

$$I_1 + I_2 = I_3$$

$$\underbrace{0.0089 - 2.6 I_3}_{} + \underbrace{0.0095 - 1.4 I_3}_{} = I_3$$

$$0.018 = (1 + 1.4 + 2.6) I_3 = 5 I_3$$

$$3.68 \times 10^{-3} A = I_3$$

$$\boxed{3.68 mA = I_3}$$

$$0.0095 - 1.4 (3.68 \times 10^{-3}) = I_2$$

$$4.35 \times 10^{-3} A = I_2$$

$$I_1 + I_2 = I_3$$

$$I_1 = I_3 - I_2 = 3.68 mA - 4.35 mA$$

$$\boxed{I_1 = -0.67 mA}$$