1. Question

(a)

(1) $d = V_0 \cdot \cos 45^\circ \cdot t$

$t = \frac{d}{V_0 \cdot \cos 45^\circ}$

$= \frac{4 \cdot 10^{-2} m \cdot \sqrt{2}}{5 \cdot 10^{6} m/s}$

$\simeq 1.13 \times 10^{-8} s$

$V_f = 0 \qquad t' = \frac{t}{2} = 0,56 \cdot 10^{-8} s$

$V = V - at'$

$a = \frac{V}{a'} = \frac{V_0 \cdot \sin\theta}{t'} = \frac{5 \cdot 10^6 m/s}{\sqrt{2} \cdot 0.56 \cdot 10^{-8} s}$

$a = 6.3 \times 10^{14} m/s^2$

+y direction

$6.3 \times 10^{14} m/s^2$

(II)

$eE = m \cdot a$

$ma = eE - E$

$= \frac{mu}{e}$

$= \frac{9.11 \times 10^{-31} kg \cdot 6.3 \times 10^{14} m/s^2}{1.6 \times 10^{-19} C}$

$E = 3,6 \times 10^{3} N/C$

$V^2 = V_v^2 - 2ah$

$h = \frac{V_v^2}{2a}$

$= \frac{\left(\frac{5}{\sqrt{2}} \times 10^6\right)^2}{2 \cdot 6.3 \times 10^{14} m/s^2}$

$= 1 \times 10^{-2} m$

$h = 1 cm$

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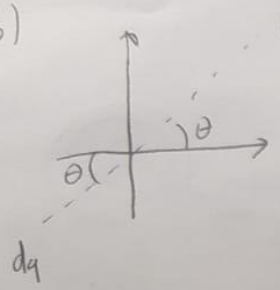
1. Question

b)



$dq = \lambda R\, dQ$

$dE_x = \frac{k_e \lambda R}{R^2} \cos Q\, dQ$

$= \frac{k_e \lambda}{R} \cos Q\, dQ \Rightarrow \Delta E_x = R\left(\frac{\lambda}{R}\right)\cos Q\, \Delta Q$

$E_x = \frac{1}{4\pi\varepsilon_0}\left(\frac{\lambda}{R}\right)\int_0^{\frac{\pi}{2}} \cos Q\, dQ = k\frac{\lambda}{R}\cdot\vec{x}$

$E_y = E \sin Q$

$dE_y = \frac{k_e \lambda R}{R^2} \sin Q \cdot dQ$

$E_y = \frac{1}{4\pi\cdot\varepsilon_0}\left(\frac{\lambda}{R}\right)\int_0^{\frac{\pi}{2}} \sin Q\, dQ = k\frac{\lambda}{R}\vec{y}$

$\Delta E_y = k\left(\frac{\lambda}{R}\right)\sin Q\, \Delta Q$

$E_{net} = k\left(\frac{\lambda}{R}\right)\vec{x} + k\left(\frac{\lambda}{R}\right)\vec{y}$

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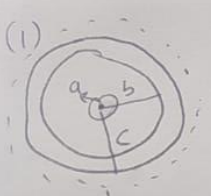
2. Question

Gauss Law

$\oint E \cdot A = \frac{q_{in}}{\varepsilon_0}$

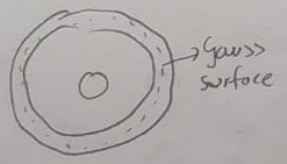
(I)



Gauss surface

$E = \frac{+2Q - Q}{\varepsilon_0 \cdot 4\pi r^2}$ $\quad E = \frac{Q}{2\pi \cdot \varepsilon_0 \cdot r^2}$

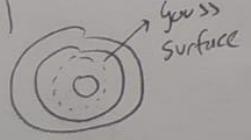
(II)



Gauss surface

$\oint E \cdot A = \frac{q_{in}}{\varepsilon_0}$ $\quad E = \frac{Q}{\varepsilon_0 \cdot A} = 0$ (inside the conducting shell) therefore 0

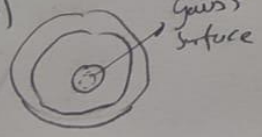
(III)



Gauss surface

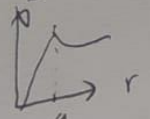
$\oint E \cdot A = \frac{q_{in}}{\varepsilon_0}$ $\quad E = \frac{+3Q}{\varepsilon_0 \cdot 4\pi r^2} = \frac{3Q}{4\pi \cdot \varepsilon_0 \cdot r^2} = k \cdot \frac{3Q}{r^2}$

(IV)



Gauss surface

$\oint E \cdot A = \frac{q_{in}}{\varepsilon_0}$



$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{+3Q}{r^3} \cdot r$

$\oint E \cdot dA = 4\pi r^2 \cdot \varepsilon = \frac{3Q}{\varepsilon_0}$

$\rho \cdot V = q_{in}$

(V)

inner surface (+) → because the
outer surface (-) → inside sphere

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3. Question

a) $\lambda = \frac{Q}{L} = 40 \times 10^{-6}\ C/m$

$\lambda = 4 \times 10^{-5}\ C/m$

$F = q \cdot E \qquad F = \lambda \cdot L \cdot E$

$m = N \cdot L \qquad \lambda \cdot L \cdot E = N \cdot L \cdot a \rightarrow F_n = ma$

$a = \frac{\lambda \cdot E}{\mu} \qquad a = \frac{4 \times 10^{-5} \cdot 100}{0,1} \qquad a = 4 \times 10^{-2}$

$V_f^2 - V_i^2 = 2 \cdot 4 \times 10^{-2} \cdot 2$

$V_f^2 = 16 \times 10^{-2}$

$V_f = 4 \times 10^{-1}\ m/s$

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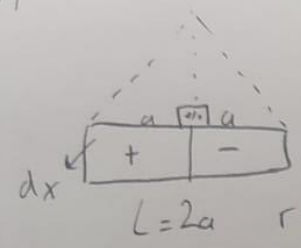
3. Question

b)



$$V_2 = K \cdot \frac{-Q}{L} \cdot \ln\left(a + \sqrt{a^2+d^2}\right)$$

↓ according to positive part

$$V_1 + V_2 = 0$$

for the part of (+)

$$dV = K \cdot \frac{dq}{r} = \frac{K \cdot \lambda\, dx}{\sqrt{d^2+x^2}} = K\lambda \int \frac{dx}{\sqrt{d^2+x^2}}$$

$$V_1 = K \cdot \frac{Q}{L} \cdot \ln\left(x + \sqrt{d^2+x^2}\right)\Big|_0^a$$

$$V_1 = k \cdot \frac{Q}{L} \cdot \ln\left(a + \sqrt{a^2+d^2}\right)$$

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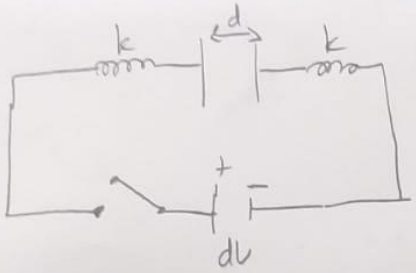
4. Question



a) $dV = 100V$

$d = 8.00\,mm$

$C = 2.00\,MF$

$C = \frac{\varepsilon_0 . A}{d}$

$C_{new} = \frac{\varepsilon_0 . A}{d'}$ $\quad d' = \frac{d}{2}$

$C_{new} = \frac{\varepsilon_0 . A}{d/2} = \frac{2 . \varepsilon_0 . A}{d} \rightarrow C_{new} = 2C$

(I) Charge collects on each plate

$Q = C . \Delta V$

$= C' . \Delta V = (2.2 \times 10^{-6}) . 100 = 400 \times 10^{-6} C$

$Q = 400\,mC$

(II) What is the spring constants

$F = \frac{Q^2}{2\varepsilon_0 A} = \frac{4C^2 (\Delta V)^2}{2\varepsilon_0 A} = \frac{2C(\Delta V)^2}{d}$

one string stretches $\frac{d}{4}$ when d change $\frac{d}{2}$

$k = \frac{F}{x} = \frac{2C(\Delta V)^2/d}{d/4} = \frac{2 . 2 \times 10^{-6} . 100^2}{\frac{(8 \times 10^{-3})^2}{4}}$

$k = 2500\,N/m$

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4. Question

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b) dia = 0.40m I = 50 μA

(I) $I = N.e$ $N = \frac{I}{e} = \frac{50 \times 10^{-6} A}{1.6 \times 10^{-19}}$ $N = 3.1 \times 10^{14}$

(II) $J = \frac{I}{A} = \frac{50 \times 10^{-6} A}{\frac{\pi D^2}{4}} = \frac{50 \times 10^{-6} A}{\frac{\pi (0.4 \times 10^{-3})^2}{4}}$

$J = 398\ A/m^2$

(III)

$V = 3.4 \times 10^7\ m/s$

$V_f^2 = V_i^2 + 2ad$

$(3.4 \times 10^7) = 0^2 + 2.a.5 \times 10^{-3}$

$F = m.a = E.q$ $E = \frac{m.a}{q}$ $E = \frac{9.11 \times 10^{-31} . 1.15 \times 10^{17}}{1.6 \times 10^{-19}}$ $E = 6.57 \times 10^5 \frac{N}{C}$