Phy 112 Assignment

Name : Farhan Tanjim Tonmoy

Section : 03

Id : 19321009

G-suite email : farhan.tanjim.tonmoy@g.bracu.ac.bd

3.41

(a) Given,

$\sigma_1 = 11 \mu C/m^2$

$= 11 \times 10^{-6} C/m^2$

$R_1 = 0.6 mm = 0.6 \times 10^{-3} m$

$R_2 = 1.7 mm = 1.7 \times 10^{-3} m$

Here,

$Q_1 + Q_2 = 0$

$\Rightarrow \sigma_1 A_1 = -\sigma_2 A_2$

$\Rightarrow \sigma_1 \pi R_1 = -\sigma_2 \pi R_2$

$\Rightarrow \sigma_1 R_1 = -\sigma_2 R_2$

$\Rightarrow \sigma_2 = -\dfrac{\sigma_1 R_1}{R_2}$

$= \dfrac{-11 \times 10^{-6} \times 0.6 \times 10^{-3}}{1.7 \times 10^{-3}} = -3.88 \times 10^{-6} C/m^2$

(Ans)

(b) We know,

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

$$\Rightarrow EA = \frac{q_{enc}}{\epsilon_0}$$

$$\Rightarrow E \cdot 2\pi r l = \frac{\sigma_1 2\pi R_1 l}{\epsilon_0}$$

$$\Rightarrow \vec{E} = \frac{\sigma_1 R_1}{r \epsilon_0}$$

$$= \frac{11 \times 10^{-6} \times 0.6 \times 10^{-3}}{0.9199 \times 10^{-3} \times \epsilon_0}$$

$r = 0.9199 \text{ mm}$
$= 0.9199 \times 10^{-3} \text{ m}$

$$= 810333.5104 \text{ N/C}$$

(Ans)

(c) $$\Delta V = \left| -\int_{R_1}^{R_2} \vec{E} \cdot d\vec{r} \right|$$

$$= \left| -\int_{R_1}^{R_2} \frac{\sigma_1 R_1}{\epsilon_0 r} \cdot \hat{r} \cdot \hat{r}\, dr \right|$$

$$= \left| -\frac{\sigma_1 R_1}{\epsilon_0} \int_{R_1}^{R_2} \frac{1}{r} dr \right|$$

$$= \left| -\frac{\sigma_1 R_1}{\epsilon_0} \left[\ln r \right]_{R_1}^{R_2} \right|$$

$$= \left| -\frac{\sigma_1 R_1}{\epsilon_0} \ln\left(\frac{R_2}{R_1}\right) \right|$$

$$= \left| -\frac{11\times10^{-6} \times 0.6\times10^{-3}}{8.854\times10^{-12}} \cdot \ln\left(\frac{1.7\times10^{-3}}{0.6\times10^{-3}}\right) \right|$$

$$= 776.33 \text{ volts}$$ (Ans)

(d) We know,

$$C = \frac{Q}{\Delta V} = \frac{\sigma_1 . 2\pi R l}{\frac{\sigma_1 R}{\epsilon_0} \cdot \ln\left(\frac{R_2}{R_1}\right)}$$

$$= \frac{2\pi L \epsilon_0}{\ln\left(\frac{R_2}{R_1}\right)}$$

$$= \frac{2\times3.1416\times16\times10^{-2}\times\epsilon_0}{\ln\left(\frac{1.7\times10^{-3}}{0.6\times10^{-3}}\right)}$$

$L = 16$ cm
$= 16\times10^{-2}$ m

$$= 8.56\times10^{-12} \text{ F}$$

(Ans)

3.2||

(a) Given, $q = 14\ \mu C$
$= 14 \times 10^{-6}\ C$

$r_1 = 8m$

$\therefore E = \frac{kq}{r^2} = \frac{8.987 \times 10^9 \times 14 \times 10^{-6}}{(8)^2}$

$= 1965.906\ N/C$ (Ans)

(b) Inside the walls of a hollow conducting sphere
$\vec{E} = 0$
Therefore, $q_{enc} = 0\ C$
(Ans)

(c) Outside the walls of a hollow conducting sphere
$\vec{E} \neq 0$.
So, for $r_2 = 20\ m$,
$q_{enc} = q = 14\mu C = 14 \times 10^{-6}\ C$

$E = \frac{kq_{enc}}{r_2^2} = \frac{8.987 \times 10^9 \times 14 \times 10^{-6}}{(20)^2} = 314.545\ N/C$
(Ans)

(d) $\Phi_{r_2} = \frac{q_{enc}}{\epsilon_0}$

$= \frac{14\times10^{-6}}{8.854\times10^{-12}} = 1581206.234 \ Nm^2/C$ (Ans)

(e) Potential at $r = d = 40m$,

$V_d = \frac{kq}{d} = \frac{8.987\times10^9\times14\times10^{-6}}{40}$

$= 3145.45$ volts.

Potential at $r = c = 24m$

$V_c = \frac{kq}{d} = 3145.45$ volts.

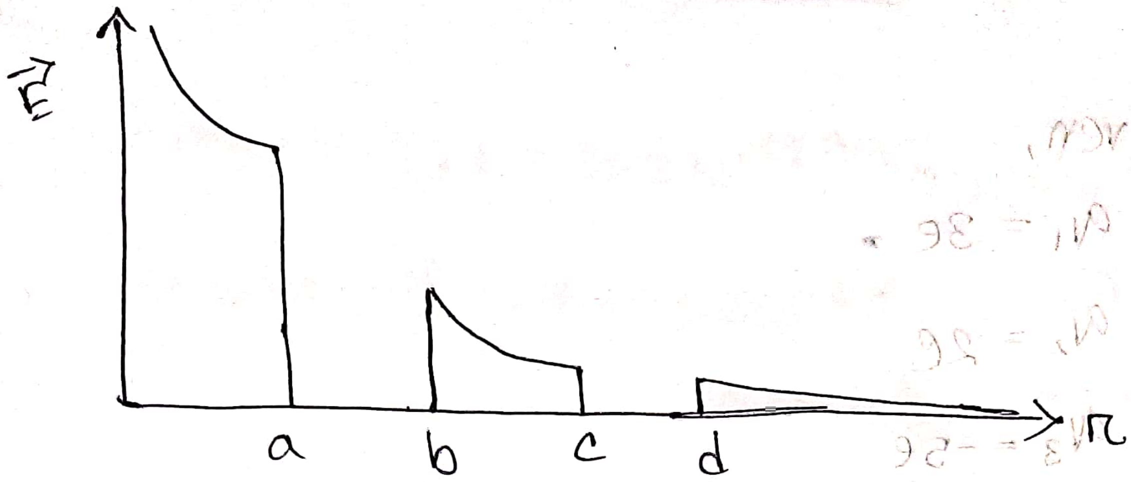
Potential at $r = \frac{c+d}{2} = \frac{40+24}{2} = 32m$,

$V = \frac{kq}{d} = 3145.45$ volts.

(Ans)

Scanned with CamScanner

(f)



(g) At different points,

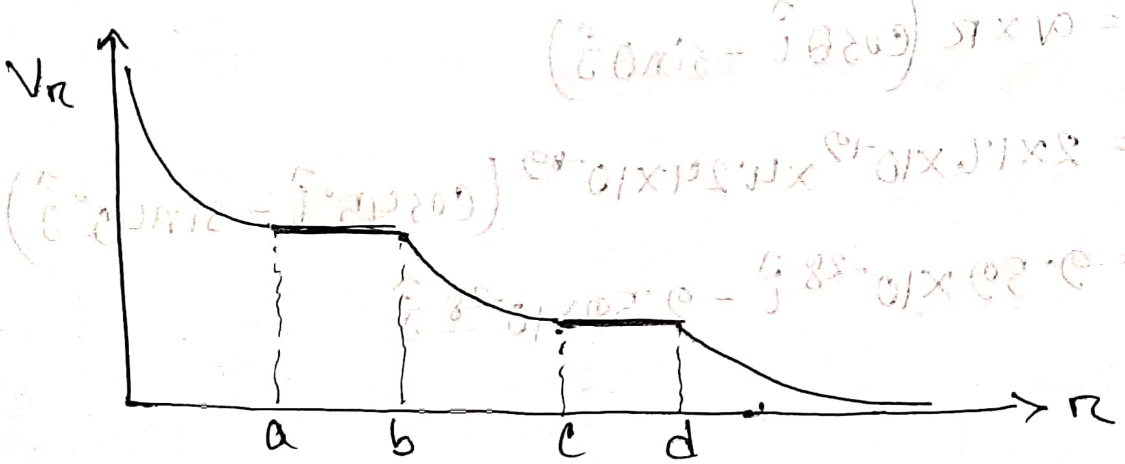
$$V_r = \frac{kq}{r} \quad \text{at } r>d$$

$$V_r = \frac{kq}{d} \quad \text{at } c<r<d$$

$$V_r = \frac{kq}{r} \quad \text{at } b<r<c$$

$$V_r = \frac{kq}{b} \quad \text{at } a<r<b$$

$$V_r = \frac{kq}{r} \quad \text{at } r<a$$



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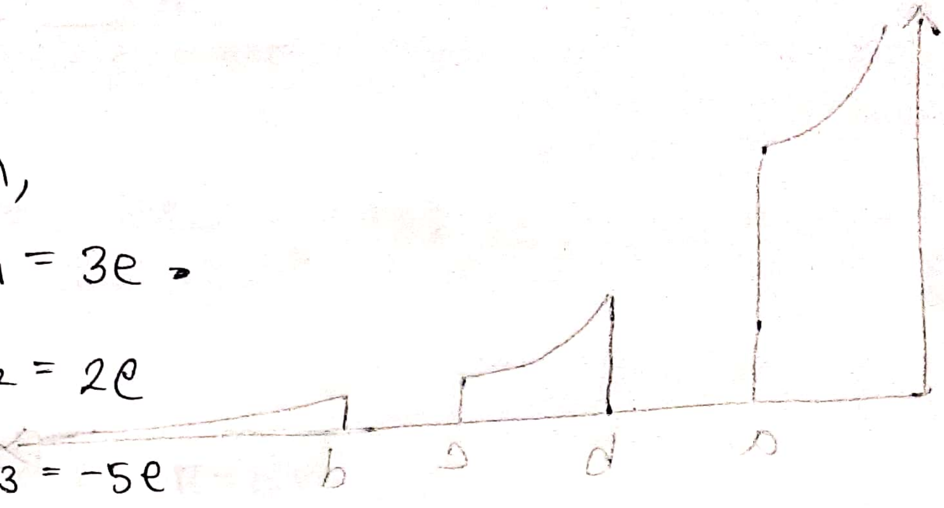


(a) Given,

$q_1 = 3e$

$q_2 = 2e$

$q_3 = -5e$

$r = 3\,nm = 3\times10^{-9}\,m$

for q_3 and q_1

$\vec{P_1} = q\times r\,(-\hat{j})$

$= 3\times1.6\times10^{-19}\times3\times10^{-9}\,(-\hat{j})$

$= -1.44\times10^{-27}\,\hat{j}$

for q_3 and q_2

$r = \sqrt{(3)^2+(3)^2} = 4.24\,nm = 4.24\times10^{-9}\,m$

$\theta = 45°$.

$\therefore \vec{P_2} = q\times r\,(\cos\theta\,\hat{i} - \sin\theta\,\hat{j})$

$= 2\times1.6\times10^{-19}\times4.24\times10^{-9}\,(\cos45°\,\hat{i} - \sin45°\,\hat{j})$

$= 9.59\times10^{-28}\,\hat{i} - 9.59\times10^{-28}\,\hat{j}$

$$\therefore \vec{P}_{net} = \vec{P}_1 + \vec{P}_2$$

$$= -1.44\times10^{-27}\hat{j} + 9.59\times10^{-28}\hat{i} - 9.59\times10^{-28}\hat{j}$$

$$= 9.59\times10^{-28}\hat{i} - 2.399\times10^{-27}$$

(Ans)

~~(b) For q_2 and p~~

(b) $r_{q_2P} = 3\times10^{-9}\,m$

$r_{q_3P} = 3\times10^{-9}\,m$

$r_{q_1P} = \sqrt{(3)^2+(3)^2}\,nm = 4.24\times10^{-9}\,m$

$$\therefore V_P = \frac{kq_1}{r_{q_1P}} + \frac{kq_2}{r_{q_2P}} + \frac{kq_3}{r_{q_3P}}$$

$$= k\left(\frac{(-3\times1.6\times10^{-19})}{4.24\times10^{-9}} + \frac{(-2\times1.6\times10^{-19})}{3\times10^{-9}} + \frac{5\times1.6\times10^{-19}}{3\times10^{-9}}\right)$$

$$= K(-1.13\times10^{-10} - 1.067\times10^{-10} + 2.667\times10^{-10})$$

$= 0.422$ Volts

(Ans)

(c) $P(x,y) \equiv \cancel{(-1,-2)} (-1.5, -3)$

$V(x,y) = 3xy\,(mx+n)$

Here,

~~m = n = 1 N/cm²~~

$m = 1\ N/cm^2$; $n = 1\ N/cm$

$\therefore V_p = 3 \times -1.5 \times 10^{-9} \times -3 \times 10^{-9} \times (1 \times -1.5 \times 10^{-9} + 1)$

$\cancel{= 5.99 \times 10^{-18}}\ V$

$= 1.34 \times 10^{-17}$

(Ans)

(d) $V_{p,net} = \cancel{5.99 \times 10^{-18}} + 0.422\ V + 1.34 \times 10^{-17}\ V$

$= 0.422\ V$

~~Potet~~

at point P,

Potential energy of a proton,

$U = Vq$ | $q = 1.6 \times 10^{-19}\ C$

$= 0.422 \times 1.6 \times 10^{-19}\ J$

$= 6.7 \times 10^{-20}\ J$

(Ans)

(e) $\vec{E}_{q_2P} = \dfrac{K\, q_2}{(r_{q_2P})^2}(\hat{j})$

$= \dfrac{8.987\times10^9 \times 2\times1.6\times10^{-19}}{(3\times10^{-9})^2}\hat{j}$

$= 319537777.8\,\hat{j}$ N/C

$\vec{E}_{q_3P} = \dfrac{K\, q_3}{(r_{q_3P})^2}(-\hat{i})$

$= \dfrac{8.987\times10^9 \times (-5)\times1.6\times10^{-19}}{(3\times10^{-9})^2}(-\hat{i})$

$= -798844444.4\,\hat{i}$

$\vec{E}_{q_1P} = \dfrac{K\, q_1}{(r_{q_1P})^2}(\sin45^\circ\hat{j} + \cos45^\circ\hat{i})$

$= \dfrac{8.98\times10^9\times3\times1.6\times10^{-9}}{(4.24\times10^{-9})^2}\times(0.707\hat{i} + 0.707\hat{j})$

$= 169646021.7\,\hat{i} + 169646021.7\,\hat{j}$

$\therefore \vec{E}_{net} = \cancel{3195}\ \vec{E}_{q_1P} + \vec{E}_{q_2P} + \vec{E}_{q_3P}$

$= 319537777.8\,\hat{j} - 798844444.4\,\hat{i} + 169646021.7\,\hat{i}$
$+ 169646021.7\,\hat{j}$

$$= -629198422.7\hat{i} + 489183799.5\hat{j}$$

(Ans)

(f) (i) $\vec{F} = \vec{E}q$

$$= (-629198422.7\hat{i} + 489183799.5) \times 1.6 \times 10^{-19}$$

$$= -1 \times 10^{-10}\hat{i} + 7.827 \times 10^{-11}\hat{j}$$

(Ans)

(ii) $$|\vec{F}| = \sqrt{(-1\times10^{-10})^2 + (7.827\times10^{-11})^2}$$

$$= 1.27 \times 10^{-10} \text{ N}$$

$$\therefore a = \frac{|F|}{m_p} = \frac{1.27\times10^{-10}}{1.67\times10^{-27}}$$

$$= 7.6 \times 10^{16} \text{ ms}^{-2}$$

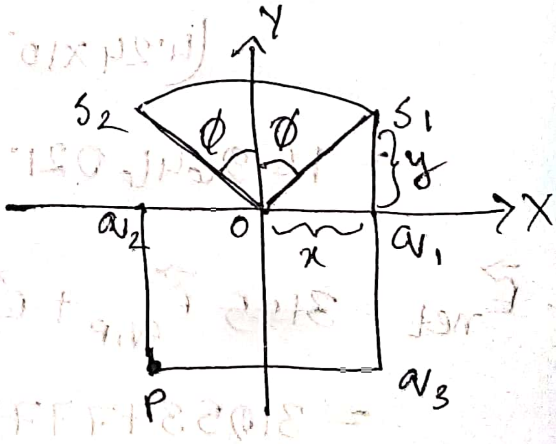
(Ans)

(g) $\tan(90^\circ - \phi) = \tan\frac{\pi}{4} = 1$

$$\therefore \frac{y}{x} = 1$$

$$\therefore y = x$$

$$\therefore y = x = 1.5 \text{ nm}$$



$\therefore S_1 \equiv (1.5, 1.5)$; $S_2 = (-1.5, 1.5)$

$\therefore V_{S1} = 3 \times 1.5 \times 10^{-9} \times 1.5 \times 10^{-9} (1 \times 1.5 \times 10^{-9} + 1)$

$= 6.75 \times 10^{-18}$ V.

$\therefore V_{S2} = 3 \times -1.5 \times 10^{-9} \times 1.5 \times 10^{-9} (1 \times 1.5 \times 10^{-9} + 1)$

$= -6.75 \times 10^{-18}$ V.

(Ans)

(h) at S_1

$r_{q_1 S_1} = 1.5$ nm

$r_{q_3 S_1} = 1.5 + 3 = 4.5$ nm

$r_{q_2 S_1} = \sqrt{(1.5)^2 + (3)^2} = 3.354$ nm

$$\therefore V_{S1} = \frac{k q_1}{r_{q_1 S_1}} + \frac{k q_2}{r_{q_2 S_1}} + \frac{k q_3}{r_{q_3 S_1}}$$

$$= k\left(\frac{3 \times -1.6 \times 10^{-19}}{1.5 \times 10^{-9}} + \frac{2 \times -1.6 \times 10^{-19}}{3.354 \times 10^{-9}} + \frac{-5 \times -1.6 \times 10^{-19}}{4.5 \times 10^{-9}}\right)$$

$= -2.136$ V.

at s_2

$r_{q_2 s_2} = 1.5 \text{ nm}$

$r_{q_1 s_2} = \sqrt{(3)^2 + (1.5)^2} = 3.354 \text{ nm}$

$r_{q_3 s_2} = \sqrt{(3)^2 + (3+1.5)^2} = 5.4 \text{ nm}$

$$V_{s_2} = K\left(\frac{q_1}{r_{q_1 s_2}} + \frac{q_2}{r_{q_2 s_2}} + \frac{q_3}{r_{q_3 s_2}}\right)$$

$$= K\left(\frac{3\times -1.6\times10^{-19}}{3.354\times10^{-9}} + \frac{2\times -1.6\times10^{-19}}{1.5\times10^{-9}} + \frac{-5\times -1.6\times10^{-19}}{5.4\times10^{-9}}\right)$$

$= -1.872 \text{ V.}$

(Ans)

(i) $V_{net,s_1} = 6.75\times10^{-18} - 2.136 \text{ V}$

$= -2.136 \text{ V}$

$V_{net,s_2} = +6.75\times10^{-18} - 1.872 \text{ V}$

$= -1.872 \text{ V}$

(Ans)

(j) $r_{s1s2} = 3\,nm$

$$\therefore V_{s2}' = \frac{KP}{r_{s1s2}}$$

$$= \frac{8.987\times10^{9}\times1.6\times10^{-19}}{3\times10^{-9}}$$

$$= 0.479\ V$$

$$\therefore V_{net,s2}' = \cancel{V_{net}}\ V_{net,s2} + V_{s2}'$$

$$= 0.479 - 1.872\ V$$

$$= -1.3927\ V$$

$\therefore$ Potential energy,

$$\cancel{U = V_{s2}}$$

$$U = V_{net,s2}' \times P$$

$$= -1.3927\times1.6\times10^{-19}$$

$$= -2.23\times10^{-19}\ J$$

(Ans)