

$$\textcircled{1} \quad r = 0.05 \text{ m}$$

$$q = 4 \times 10^{-15} \text{ C}$$

$$q = n e$$

$$n = \frac{4 \times 10^{-15}}{1.6 \times 10^{-19}} = \frac{40}{16} \times 10^4$$

$$= 2.5 \times 10^4$$

$$\textcircled{2} \quad r = 9 \text{ cm} = 0.09 \text{ m}$$

$$q_1 = ?$$

$$q_2 = 100 \times 10^{-6} \text{ C}$$

$$F = \frac{1}{9} \text{ N}$$

$$F = 9 \times 10^9 \frac{q_1 q_2}{r^2}$$

$$\frac{1}{9} = \frac{9 \times 10^9 \times q_1 \times 10^{-4}}{(0.09)^2}$$

$$\frac{1}{9} \times \frac{9}{100} \times \frac{9}{100} \times \frac{1}{9 \times 10^5} = q_1$$

$$\therefore q_1 = 10^{-9} \text{ C}$$

(13)

$$q_1 = 8 \mu\text{C}$$

$$q_2 = -9 \mu\text{C}$$

$$r = 0.1 \text{ m}$$

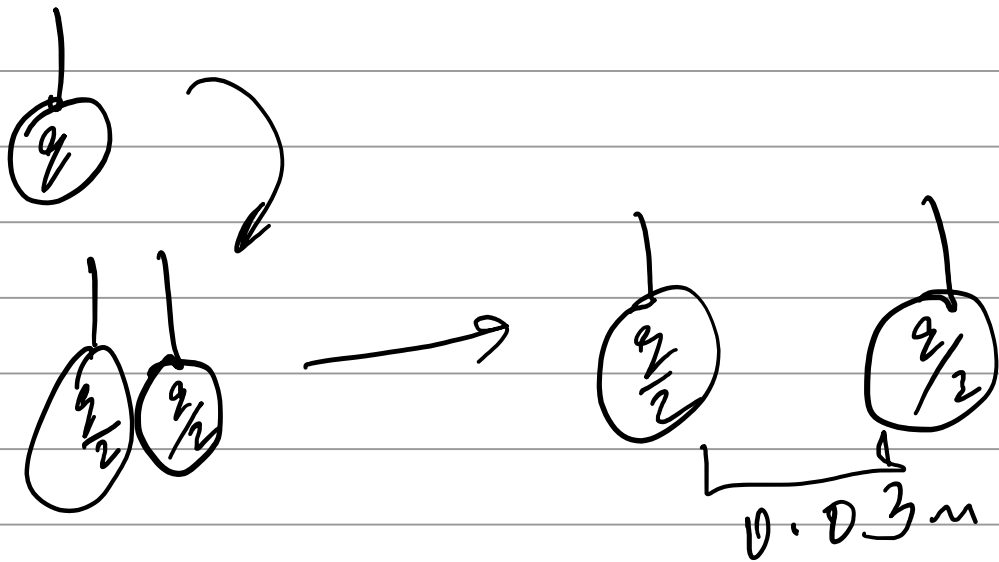
$$F = 9 \times 10^9 \frac{q_1 q_2}{r^2}$$

$$= \frac{9 \times 10^9 \times 8 \times 10^{-6} \times (-9) \times 10^{-6}}{(0.1)^2}$$

$$= -648 \times 10^{-1}$$

$$= -64.8 \text{ N}$$

(2)



$$F = 2.5 \times 10^{-4} \text{ N}$$

$$F = \frac{9 \times 10^9 \times q \cdot q/2}{r^2}$$

$$2.5 \times 10^{-4} = \frac{9 \times 10^9 \times \frac{q}{2} \cdot \frac{q}{2}}{(0.03)^2}$$

$$\frac{2.5 \times 10^{-4} \times 3 \times 3 \times 10^{-4} \times 2 \times 2}{9 \times 10^9} = q^2$$

$$25 \times 4 \times 10^{-18} = q^2$$

$$\therefore q = 10 \times 10^{-9} \text{ C} = 10^{-8} \text{ C}$$

(5)

$$q_1 + q_2 = 20 \mu\text{C}$$

$$F = 0.675 \text{ N}$$

$$r = 1 \text{ m}$$

$$F = 9 \times 10^9 \frac{q_1 q_2}{r^2}$$

$$0.675 = \frac{9 \times 10^9 \times q_1 (20 - q_1) \times 10^{-12}}{1^2}$$

$$q_1^2 - 20q_1 + \frac{0.675 \times 10^3}{9} = 0$$

$$q_1^2 - 20q_1 + 75 = 0$$

$$q_1^2 - 15q_1 - 5q_1 + 75 = 0$$

$$q_1 (q_1 - 15) - 5 (q_1 - 15) = 0$$

$$(q_1 - 5) (q_1 - 15) = 0$$

$$\therefore q_1 = 5 \mu\text{C} \quad \text{or} \quad 15 \mu\text{C}$$

$$q_2 = 15 \mu\text{C} \quad \text{or} \quad 5 \mu\text{C}$$

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$$q_1 = 3 \mu\text{C}$$

$$q_2 = 2 \mu\text{C}$$

$$F = 150 \times 10^{-5} \text{ N}$$

$$r = 0.04 \text{ m}$$

$$F = 9 \times 10^9 \frac{q_1 q_2}{r^2}$$

$$150 \times 10^{-5} = \frac{9 \times 10^9 \times 3 \mu\text{C} \times 2 \mu\text{C}}{(0.04)^2}$$

$$150 \times 10^{-5} \times \frac{4}{100} \times 4 \times \frac{1}{9 \times 10^9} \times \frac{1}{6} = x^2$$

$$\frac{135}{976} \times 10^{-17} = x^2$$

$$\frac{135}{976} \times \frac{1}{10} = 10^{-16} = x^2$$

$$\frac{1}{3 \times 2} = 10^{-8} = x$$

$$\therefore q_1 = 3 = 0.5 \times 10^{-8} \text{ C}$$

$$q_2 = 2 = 0.33 \times 10^{-8} \text{ C}$$

$$\textcircled{7} \quad r = 0.05 \text{ m}$$

$$q_1 = 5 \mu\text{C}$$

$$q_2 = 0.5 \mu\text{C}$$

$$F = ?$$

$$F = 9 \times 10^9 \frac{q_1 q_2}{r^2} = 9 \times 10^9 \frac{5 \times 10^{-6} \times 0.5 \times 10^{-6}}{0.05^2}$$

$$= \frac{9 \times 5 \times 5 \times 10^{-4}}{25 \times 10^{-4}} = 9 \text{ N}$$

$$F_{r=3} = \frac{9 \text{ N}}{3} = 3 \text{ N} \quad \left( \because F = \frac{9 \times 10^9 q_1 q_2}{k r^2} \right)$$

$$\textcircled{8} \quad q_1 = 70 \mu\text{C}$$

$$q_2 = 80 \mu\text{C}$$

$$r = 0.25 \text{ m}$$

$$F = 201.6 \text{ N}$$

$$k = ?$$

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

$$201.6 = \frac{q_1 q_2}{k (25 \times 10^{-2})^2}$$

$$201.6 = \frac{9 \times 10^9 \cdot 70 \times 10^{-6} \times 80 \times 10^{-6}}{k (25 \times 10^{-2})^2}$$

$$201.6 = \frac{9 \times 7 \times 8 \times 10^3}{k \times 625}$$

$$\therefore k = \frac{9 \times 7 \times 8 \times 10000}{625 \times 2016} = 4$$



$$\textcircled{9} \quad F = 9 \times 10^{-5} \text{ N (air)}$$

$$F_k = 4 \times 10^{-5} \text{ N (medium)}$$

$$F_k = \frac{F}{k}$$

$$\therefore k = \frac{9 \times 10^{-5}}{4 \times 10^{-5}} = 2.25$$

10

$$q = 0.1 \mu\text{C}$$

$$E = ? \text{ at } r = 0.2 \text{ m}$$

$$E = 9 \times 10^9 \frac{q}{r^2}$$

$$= 9 \times 10^9 \times \frac{0.1 \times 10^{-6}}{0.2^2}$$

$$= \frac{9}{4} \times 10^{9-6-1+2}$$

$$= 2.25 \times 10^4 \text{ N/C}$$

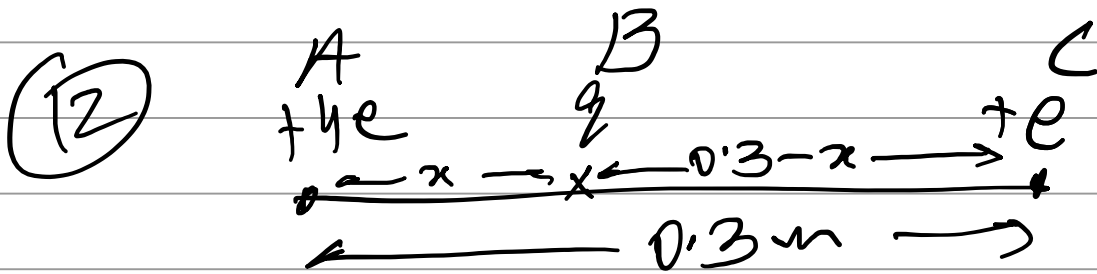
11

$$q = 5 \mu C$$

$$F = 10 \times 10^{-4} N$$

$$E = ?$$

$$E = \frac{F}{q} = \frac{10 \times 10^{-4}}{5 \times 10^{-6}} = 200 N/C$$



at A Assumng  $q$  is  $-ve$

$$F_{AB} = F_{AC}$$

Not Reqd.

$$9 \times 10^9 \times \frac{4e \cdot q}{x^2} = 9 \times 10^9 \cdot \frac{4e \cdot e}{0.3^2}$$

$$\therefore \frac{q}{x^2} = \frac{e}{0.09} \quad \text{--- (i)}$$

at B  $F_{BA} = F_{BC}$  [NOTE:  $F_{BA}$  towards left  
 $F_{BC}$  towards right]

$$9 \times 10^9 \times \frac{q \cdot 4e}{x^2} = 9 \times 10^9 \times \frac{q \cdot e}{(0.3 - x)^2}$$

$$\frac{4}{x^2} = \frac{1}{(0.3 - x)^2}$$

$$0.36 - 2.4x + 4x^2 = x^2$$

$$3x^2 - 2.4x + 0.36 = 0$$

$$100x^2 - 80x + 12 = 0$$

$$25x^2 - 20x + 3 = 0$$

$$25x^2 - 15x - 5x + 3 = 0$$

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$$(5x - 1)(5x - 3) = 0$$

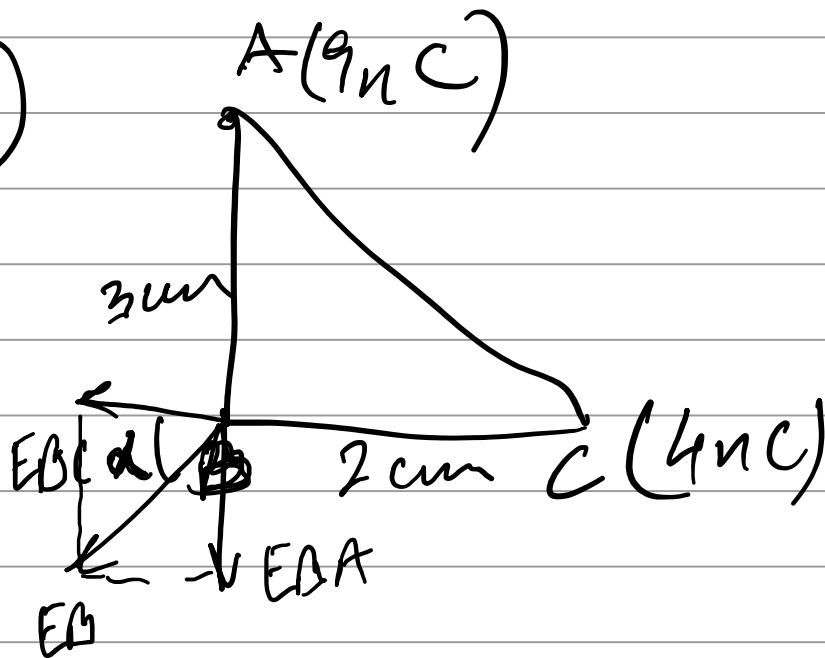
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An Intellectual Development  
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13

$$V = 200V$$
$$d = 2cm = 0.02m$$
$$E = ?$$

$$E = \frac{V}{d} = \frac{200}{0.02} = 10^4 \text{ V/m}$$

(14)



$$E_{BA} = \frac{9 \times 10^9 \times 9 \times 10^{-9}}{0.03^2}$$

$$= 9 \times 10^4 \text{ N/C}$$

$$E_{BC} = \frac{9 \times 10^9 \times 4 \times 10^{-9}}{0.02^2}$$

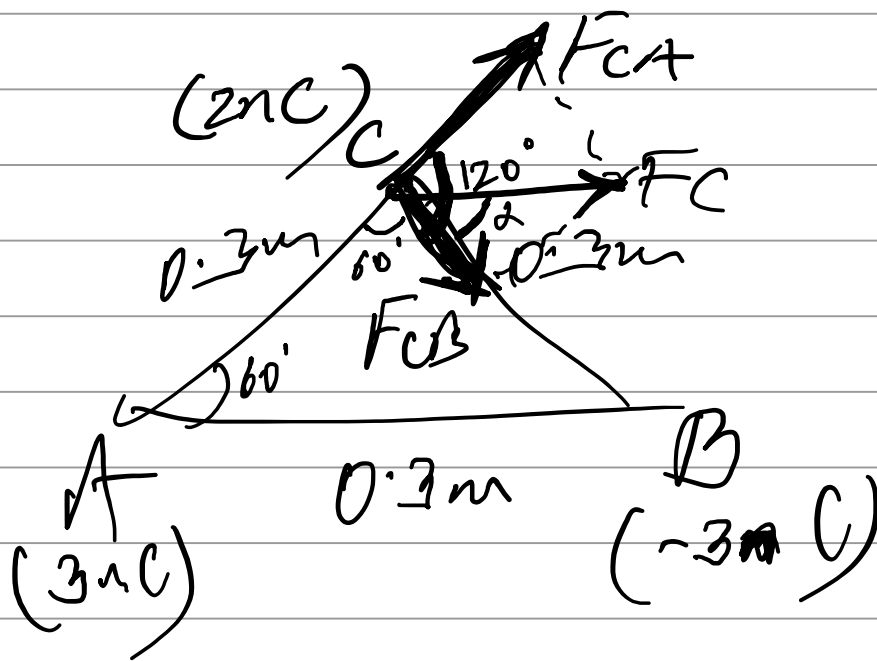
$$= 9 \times 10^4 \text{ N/C}$$

$$E_B = \sqrt{(9 \times 10^4)^2 + (9 \times 10^4)^2}$$

$$= 9\sqrt{2} \times 10^4 \text{ N/C} = 12.736 \times 10^4 \text{ N/C}$$

$$\alpha = 45^\circ$$

(15)



$$F_{CA} = \frac{9 \times 10^9 \times 3 \times 10^{-9} \times 2 \times 10^{-7}}{0.3^2}$$

$$= 6 \times 10^{-7} \text{ N}$$

$$F_{CB} = \frac{9 \times 10^9 \times 3 \times 10^{-9} \times 2 \times 10^{-7}}{0.3^2}$$

$$= 6 \times 10^{-7} \text{ N}$$

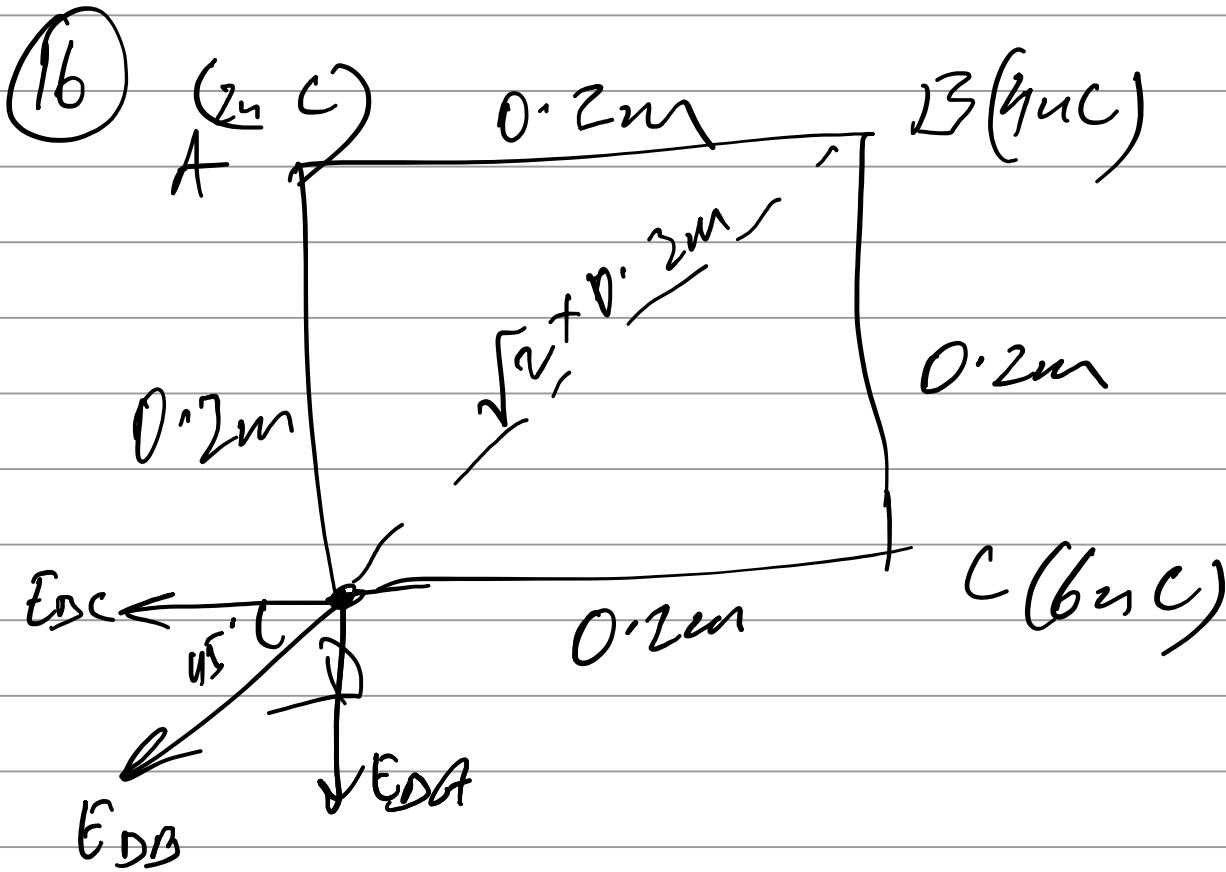
$$\therefore F_C = \sqrt{F_{CA}^2 + F_{CB}^2 + 2F_{CA} \cdot F_{CB} \cos 120^\circ}$$

$$= \sqrt{(6 \times 10^{-7})^2 + (6 \times 10^{-7})^2 - \frac{2 \times 6 \times 10^{-7} \times 6 \times 10^{-7}}{2}}$$

$$= 6 \times 10^{-7} \text{ N}$$

$$\alpha = \tan^{-1} \left( \frac{F_{CA} \sin 120^\circ}{F_{CB} + F_{CA} \cos 120^\circ} \right) = \tan^{-1} \left( \frac{\frac{\sqrt{3}}{2}}{1 - \frac{1}{2}} \right)$$

$$\alpha = \underline{\underline{60^\circ}}$$



$$E_{BC} = \frac{9 \times 10^9 \times 6 \times 10^{-9}}{0.2^2} = \frac{2700}{2} \text{ N/C}$$

$$E_{DA} = \frac{9 \times 10^9 \times 2 \times 10^{-9}}{0.2^2} = \frac{900}{2} \text{ N/C}$$

$$E_{DB} = \frac{9 \times 10^9 \times 4 \times 10^{-9}}{(\sqrt{2} \times 0.2)^2} = \frac{900}{2} \text{ N/C}$$

$$E_x = \frac{2700}{2} + \frac{900}{2\sqrt{2}} = 1668.25 \text{ N/C} \quad E_x = E_{BC} + E_{DB} \cos 45^\circ$$

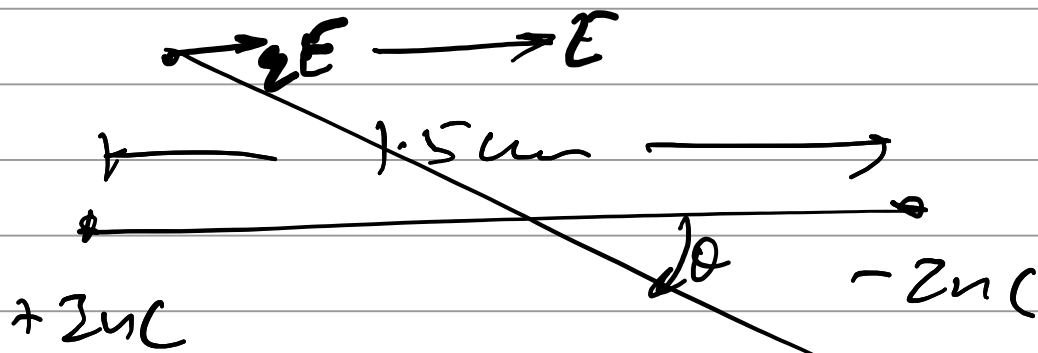
$$E_y = \frac{900}{2} + \frac{900}{2\sqrt{2}} = 768.20 \text{ N/C} \quad E_y = E_{DA} + E_{DB} \sin 45^\circ$$

$$E_D = \sqrt{E_x^2 + E_y^2} = 1836.62 \text{ N/C}$$

$$\alpha = \tan^{-1} \left( \frac{E_y}{E_x} \right) = 24^\circ 43'$$



(17)



$$\theta = 30^\circ$$

$$E = 5000 \text{ N/C}$$

$$Z = ?$$

$$qE$$

$$2d = 1.5 \text{ cm}$$

$$Z = pE \sin \theta$$

$$= q(2d) E \sin \theta$$

$$= 2 \times 10^{-9} \times 1.5 \times 10^{-2} \times 5000 \times \frac{1}{2}$$

$$= 7500 \times 10^{-11} \text{ Nm}$$

$$= 7.5 \times 10^{-8} \text{ Nm}$$

18

$$q = 2 \mu\text{C}$$

$$2l = 1.75 \text{ mm}$$

$$\tau_{\text{max}} = 3 \times 10^{-3} \text{ N/m}$$

$$E = ?$$

$$\tau_{\text{max}} = \rho E$$

$$\left[ \theta = 90^\circ \right. \\ \left. \sin \theta = 1 \right]$$

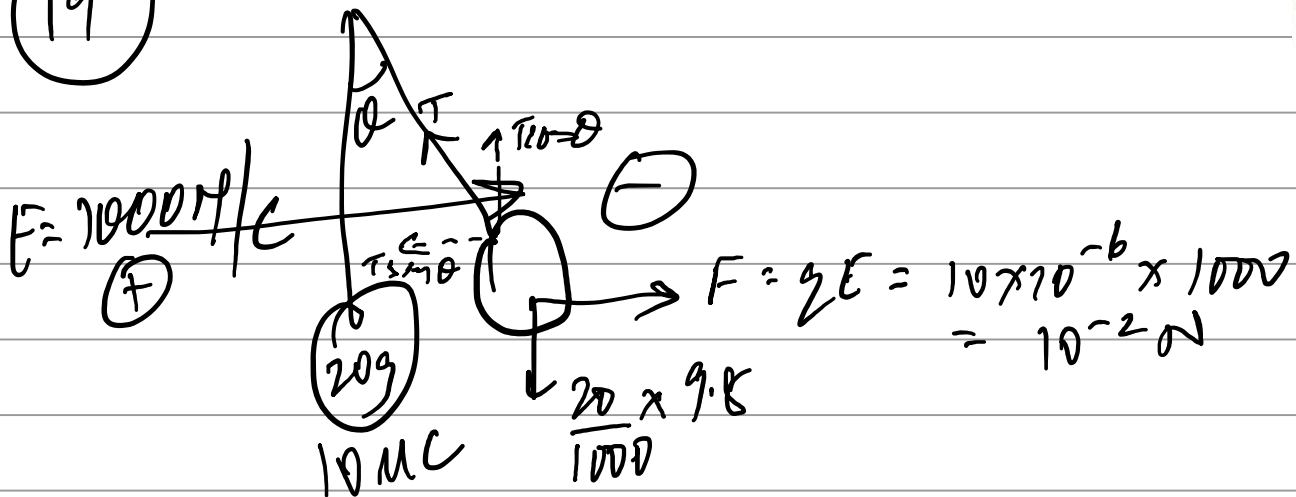
$$3 \times 10^{-3} = q (2l) E$$

$$\frac{3 \times 10^{-3}}{2 \times 10^{-6} \times 1.75 \times 10^{-3}} = E$$

$$\therefore E = \frac{6}{7} \times 10^6 \text{ N/C}$$

$$= 0.8571 \times 10^6 \text{ N/C}$$

19



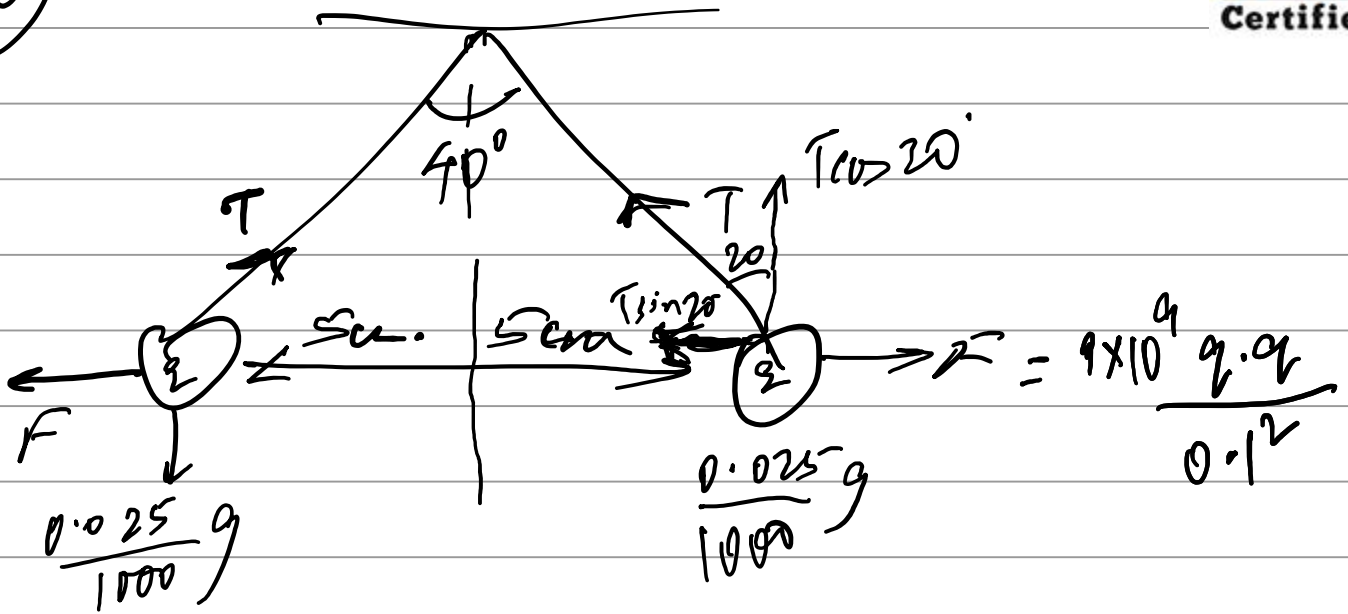
$$T \sin \theta = 10^{-2} \quad \text{--- (i)}$$

$$T \cos \theta = \frac{19.6}{100} \quad \text{--- (ii)}$$

$$\therefore \tan \theta = \frac{1}{19.6} \quad \Rightarrow \theta = 2.55^\circ$$

$$\text{Sub in (i)} \quad T = \frac{1}{100 \times \sin 2.55^\circ} = 0.2 \text{ N}$$

(A  
20)



$$T \sin 20 = F \quad \text{--- (i)}$$

$$T \cos 20 = \frac{0.025}{1000} \times 9.8$$

$$\therefore T = 0.0002607 \text{ N}$$

Sub. in (i)

$$0.0002607 \sin 20 = \frac{9 \times 10^{-9} q \cdot q}{0.1^2}$$

$$\therefore q = 9.953 \text{ nC}$$

(2)

$$q = 8 \mu\text{C}$$

$$2l = 5 \times 10^{-3} \text{ m}$$

$$r = 0.2 \text{ m}$$

$$E_{axis} = ?$$

$$E_{eq} = ?$$

$$E_{axis} = \frac{1}{4\pi\epsilon_0} \frac{2qr}{(r^2 - l^2)^2}$$

$$\because r \gg l$$

$$\begin{aligned} \therefore E_{axis} &= \frac{9 \times 10^9 \times 2 \times 8 \times 10^{-6} \times 5 \times 10^{-3}}{(0.2)^3} \\ &= 90000 \text{ N/C} \end{aligned}$$

$$E_{eq} = \frac{1}{4\pi\epsilon_0} \frac{q}{(r^2 + l^2)^{3/2}}$$

$$\because r \gg l$$

$$\begin{aligned} E_{eq} &= \frac{9 \times 10^9 \times 8 \times 10^{-6} \times 5 \times 10^{-3}}{(0.2)^3} \\ &= 45000 \text{ N/C} \end{aligned}$$

22

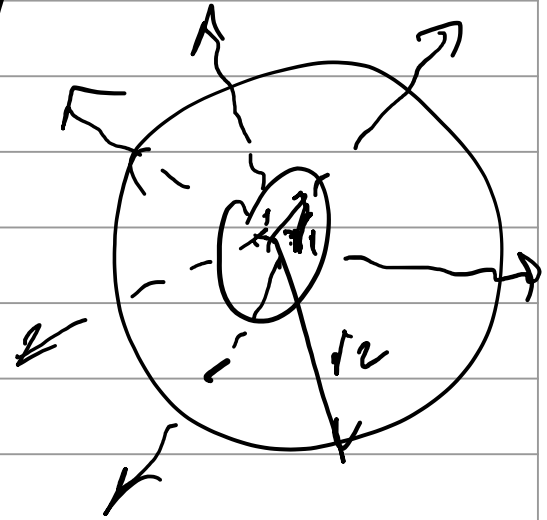
$$\phi_1 = 12000 \text{ Wm}^2/\text{C}$$

$$r_1 = 0.15 \text{ m}$$

$$\phi_2 = ?$$

$$r_2 = 15 \text{ cm}$$

$$q = ?$$



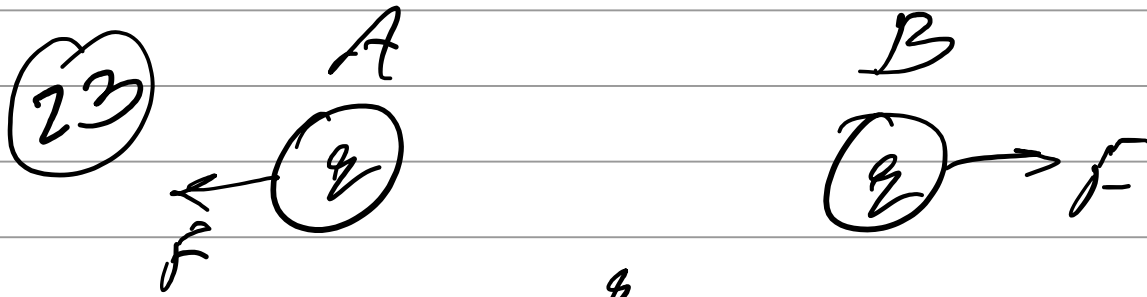
$$E_{\text{sphere}} = 9 \times 10^9 \frac{q}{r^2}$$

$$\phi = E \cdot A$$

$$12000 = 9 \times 10^9 \frac{q}{r^2} \times 4\pi r^2$$

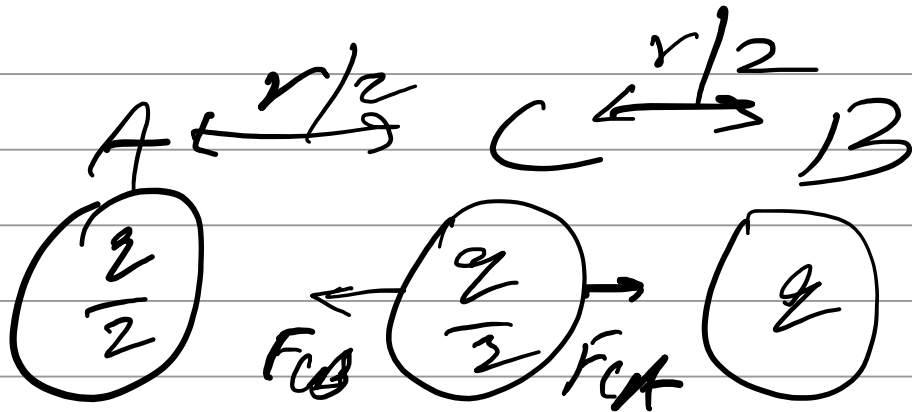
$$\therefore q = \frac{12000}{9 \times 10^9 \times 4\pi} = 1.061 \times 10^{-7} \text{ C}$$

$$\phi_2 = \phi_1 = 12000 \text{ Wb}$$



$$F = 9 \times 10^9 \frac{q \cdot q}{r^2}$$

$$\frac{4 \times 10^{-5}}{9 \times 10^9} = \frac{q^2}{r^2} \quad \dots (1)$$



$$F_{CB} = 9 \times 10^9 \frac{\frac{q}{2} \cdot q}{(r/2)^2}$$

$$= 18 \times 10^9 \times \frac{q^2}{r^2}$$

$$F_{CA} = 9 \times 10^9 \times \frac{\frac{q}{2} \cdot \frac{q}{2}}{(r/2)^2} = 9 \times 10^9 \frac{q^2}{r^2}$$

$$F_c = F_{cB} - F_{cA}$$

$$= \frac{9^2}{1^2} \times 10^9 (18 - 9)$$

$$= 9 \times 10^9 \frac{9^2}{1^2}$$

using (1)

$$F_c = 9 \times 10^9 \frac{\times 4 \times 10^{-5}}{9 \times 10^9}$$

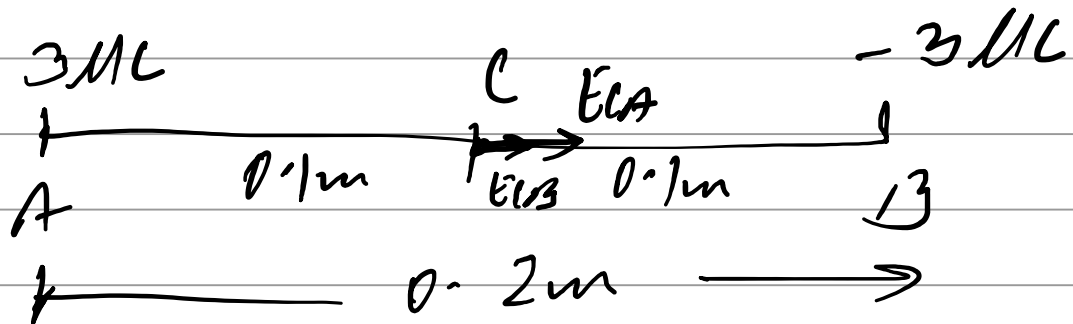
$$= 4 \times 10^{-5} \text{ N}$$



(24)

$$q = 3 \mu\text{C}$$

$$r = 0.2 \text{ m}$$



$$E_C = E_{CA} + E_{CB}$$

$$= 9 \times 10^9 \times \frac{3 \times 10^{-6}}{0.1^2} + 9 \times 10^9 \times \frac{3 \times 10^{-6}}{0.1^2}$$

$$= 54 \times 10^5 = 5.4 \times 10^6 \text{ N/C}$$

$$F = qE = 1.5 \times 10^{-9} \times 5.4 \times 10^6$$

$$= 0.0081 \text{ N}$$

$$= 8.1 \times 10^{-3} \text{ N}$$

(25)

$$E = 3.5 \times 10^3 \text{ V/m}$$

$$d = 0.05 \text{ m}$$

$$V = ?$$

$$E = \frac{V}{d} \quad \therefore V = 3.5 \times 10^3 \times 0.05$$

$$= 175 \text{ V}$$

(26)

$$p = 3 \times 10^{-10} \text{ m}$$

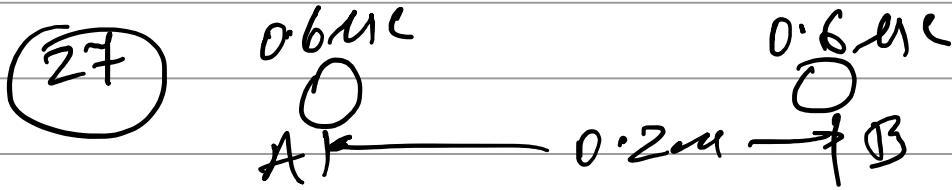
$$E = 6 \times 10^4 \text{ N/C}$$

$$\theta = 30^\circ$$

$$Z = pE \sin \theta$$

$$= 3 \times 10^{-10} \times 6 \times 10^4 \sin 30^\circ$$

$$= 9 \times 10^{-6} \text{ N}\cdot\text{m}$$



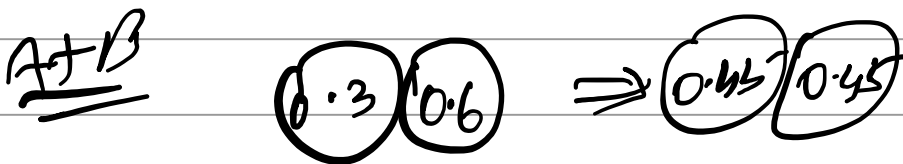
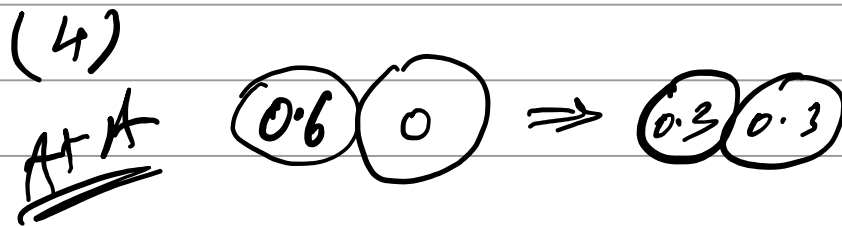
$$(1) F = 9 \times 10^9 \times \frac{0.6 \times 10^{-6} \times 0.6 \times 10^{-6}}{0.2^2}$$

$$= 81 \times 10^{-3} \text{ N}$$

$$(2) F' = 81 \times 10^{-3} \times \frac{2 \times 2}{2^2}$$

$$= 81 \times 10^{-3} \text{ N}$$

$$(3) F_k = \frac{81 \times 10^{-3}}{5} = 16.2 \times 10^{-3} \text{ N}$$

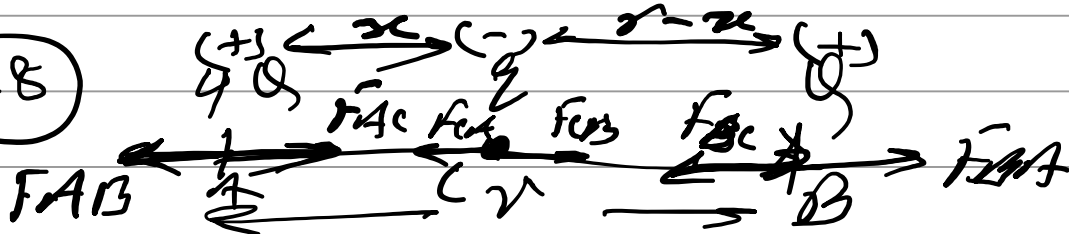


0.3 μm                      0.45 μm  
○                                      ○  
← 0.2 μm →

$$F = 9 \times 10^9 \times \frac{0.3 \times 10^{-6} \times 0.45 \times 10^{-6}}{0.2^2}$$

$$= 0.0304 \text{ N}$$

(28)



$g$  has to be the

$$F_{AB} = F_{AC}$$

$$9 \times 10^9 \times \frac{40 \cdot 40}{r^2} = 9 \times 10^9 \times \frac{40 \cdot 9}{x^2}$$

$$\frac{4}{r^2} = \frac{9}{x^2}$$

$$x^2 = \frac{9r^2}{4}$$

$$F_{CA} = F_{CB}$$

$$9 \times 10^9 \times \frac{9 \cdot 40}{x^2} = 9 \times 10^9 \times \frac{9 \cdot 9}{(r-x)^2}$$

$$\frac{4}{x^2} = \frac{1}{(r-x)^2}$$

$$2r - 2x = x$$

$$\frac{2r}{3} = x \quad (i)$$

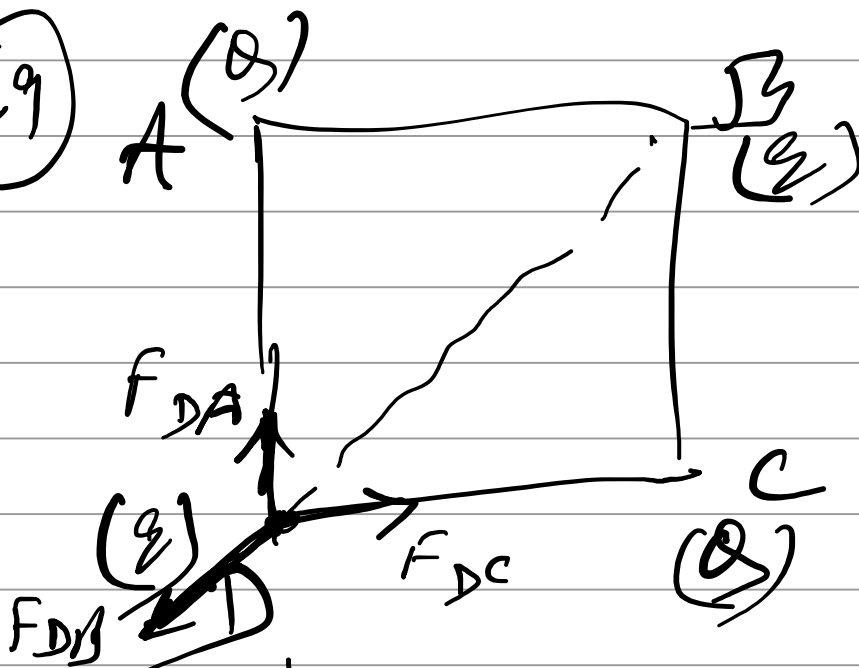
Using (i)

$$\frac{4r^2}{9} = \frac{9r^2}{4}$$

$$\therefore g = \frac{40}{9}$$

$$\text{Ans: } \frac{-40}{9}$$

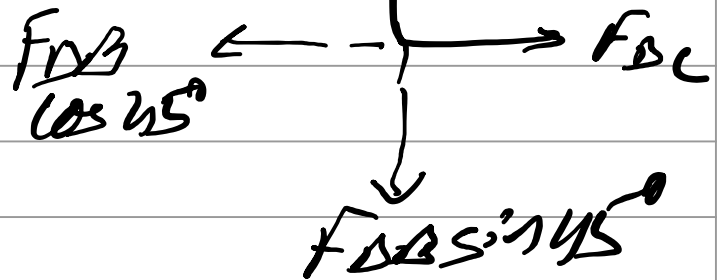
(29)



$\because$  Net force of  $q$  is zero  $\therefore q$  k  $q$  have to be opp. sign. let take  $q$  as -ve &  $Q$  as +ve & mark the forces at D.

$$\therefore F_{DC} = F_{DB} \cos 45^\circ$$

$$\frac{q \times 10^9 \times q \cdot Q}{r^2} = \frac{q \times 10^9 \times Q^2}{(\sqrt{2}l)^2} \cdot \frac{1}{\sqrt{2}}$$



$$Q = \frac{q}{2\sqrt{2}}$$

$$\therefore \boxed{Q = -2\sqrt{2}q}$$