CHAPTER – 29
ELECTRIC FIELD AND POTENTIAL
EXERCISES

1. $\varepsilon_0 = \dfrac{\text{Coulomb}^2}{\text{Newton m}^2} = I^1M^{-1}L^{-3}T^4$

   $\therefore F = \dfrac{kq_1q_2}{r^2}$

2. $q_1 = q_2 = q = 1.0$ C distance between = 2 km = 1 × 10^3 m

   so, force = $\dfrac{kq_1q_2}{r^2}$ $F = \dfrac{(9\times10^9)\times1\times1}{(2\times10^3)^2} = \dfrac{9\times10^9}{2^2\times10^6}$ = 2,25 × 10^3 N

   The weight of body = mg = 40 × 10 N = 400 N

   So, $\dfrac{\text{wt of body}}{\text{force between charges}} = \left(\dfrac{2.25\times10^3}{4\times10^2}\right)^{-1} = (5.6)^{-1} = \dfrac{1}{5.6}$

   So, force between charges = 5.6 weight of body.

3. q = 1 C, Let the distance be χ

   F = 50 × 9.8 = 490

   $F = \dfrac{Kq^2}{\chi^2} \Rightarrow 490 = \dfrac{9\times10^9\times1^2}{\chi^2}$ or $\chi^2 = \dfrac{9\times10^9}{490}$ = 18.36 × 10^6

   $\Rightarrow \chi = 4.29\times10^3$ m

4. charges 'q' each, AB = 1 m

   wt, of 50 kg person = 50 × g = 50 × 9.8 = 490 N

   $F_C = \dfrac{kq_1q_2}{r^2}$ $\therefore \dfrac{kq^2}{r^2} = 490$ N

   $\Rightarrow q^2 = \dfrac{490\times r^2}{9\times10^9} = \dfrac{490\times1\times1}{9\times10^9}$

   $\Rightarrow q = \sqrt{54.4\times10^{-9}}$ = 23.323 × 10^{-5} coulomb ≈ 2.3 × 10^{-4} coulomb

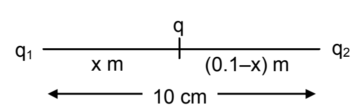
5. Charge on each proton = a= 1.6 × 10^{-19} coulomb

   Distance between charges = 10 × 10^{-15} metre = r

   Force = $\dfrac{kq^2}{r^2} = \dfrac{9\times10^9\times1.6\times1.6\times10^{-38}}{10^{-30}}$ = 9 × 2.56 × 10 = 230.4 Newton

6. $q_1 = 2.0\times10^{-6}$ $q_2 = 1.0\times10^{-6}$ r = 10 cm = 0.1 m

   Let the charge be at a distance x from q_1



   $F_1 = \dfrac{Kq_1q}{\chi^2}$ $F_2 = \dfrac{kqq_2}{(0.1-\chi)^2}$

   $= \dfrac{9.9\times2\times10^{-6}\times10^9\times q}{\chi^2}$

   Now since the net force is zero on the charge q. $\Rightarrow f_1 = f_2$

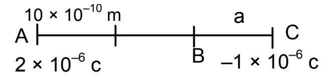
   $\Rightarrow \dfrac{kq_1q}{\chi^2} = \dfrac{kqq_2}{(0.1-\chi)^2}$

   $\Rightarrow 2(0.1-\chi)^2 = \chi^2 \Rightarrow \sqrt{2}\,(0.1-\chi) = \chi$

   $\Rightarrow \chi = \dfrac{0.1\sqrt{2}}{1+\sqrt{2}}$ = 0.0586 m = 5.86 cm ≈ 5.9 cm From larger charge

7. $q_1 = 2 \times 10^{-6}$ c $\quad$ $q_2 = -1 \times 10^{-6}$ c $\quad$ r = 10 cm = 10×10^{-2} m

Let the third charge be a $\quad$ so, $F_{-AC} = -F_{-BC}$



$$\Rightarrow \frac{kQq_1}{{r_1}^2} = \frac{-KQq_2}{{r_2}^2} \qquad \Rightarrow \frac{2 \times 10^{-6}}{(10+\chi)^2} = \frac{1 \times 10^{-6}}{\chi^2}$$

$$\Rightarrow 2\chi^2 = (10+\chi)^2 \Rightarrow \sqrt{2}\,\chi = 10 + \chi \Rightarrow \chi(\sqrt{2} - 1) = 10 \Rightarrow \chi = \frac{-10}{1.414-1} = 24.14 \text{ cm } \chi$$

So, distance = 24.14 + 10 = 34.14 cm from larger charge

8. Minimum charge of a body is the charge of an electron

Wo, $q = 1.6 \times 10^{-19}$ c $\quad$ $\chi = 1$ cm $= 1 \times 10^{-2}$ cm

$$\text{So, } F = \frac{kq_1q_2}{r^2} = \frac{9 \times 10^9 \times 1.6 \times 1.6 \times 10^{-19} \times 10^{-19}}{10^{-2} \times 10^{-2}} = 23.04 \times 10^{-38+9+2+2} = 23.04 \times 10^{-25} = 2.3 \times 10^{-24}$$

9. No. of electrons of 100 g water $= \frac{10 \times 100}{18} = 55.5$ Nos $\qquad$ Total charge = 55.5

No. of electrons in 18 g of $H_2O = 6.023 \times 10^{23} \times 10 = 6.023 \times 10^{24}$

No. of electrons in 100 g of $H_2O = \frac{6.023 \times 10^{24} \times 100}{18} = 0.334 \times 10^{26} = 3.334 \times 10^{25}$

Total charge $= 3.34 \times 10^{25} \times 1.6 \times 10^{-19} = 5.34 \times 10^{6}$ c

10. Molecular weight of $H_2O = 2 \times 1 \times 16 = 16$

No. of electrons present in one molecule of H_2O = 10

18 gm of H_2O has 6.023×10^{23} molecule

18 gm of H_2O has $6.023 \times 10^{23} \times 10$ electrons

100 gm of H_2O has $\frac{6.023 \times 10^{24}}{18} \times 100$ electrons

So number of protons $= \frac{6.023 \times 10^{26}}{18}$ protons (since atom is electrically neutral)

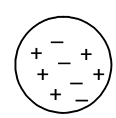
Charge of protons $= \frac{1.6 \times 10^{-19} \times 6.023 \times 10^{26}}{18}$ coulomb $= \frac{1.6 \times 6.023 \times 10^{7}}{18}$ coulomb

Charge of electrons = $= \frac{1.6 \times 6.023 \times 10^{7}}{18}$ coulomb

$$\text{Hence Electrical force} = \frac{9 \times 10^9 \left(\frac{1.6 \times 6.023 \times 10^7}{18}\right) \times \left(\frac{1.6 \times 6.023 \times 10^7}{18}\right)}{(10 \times 10^{-2})^2}$$

$$= \frac{8 \times 6.023}{18} \times 1.6 \times 6.023 \times 10^{25} = 2.56 \times 10^{25} \text{ Newton}$$

11. Let two protons be at a distance be 13.8 femi



$$F = \frac{9 \times 10^9 \times 1.6 \times 10^{-38}}{(14.8)^2 \times 10^{-30}} = 1.2 \text{ N}$$

12. F = 0.1 N

$r = 1$ cm $= 10^{-2}$ (As they rubbed with each other. So the charge on each sphere are equal)

$$\text{So, } F = \frac{kq_1q_2}{r^2} \Rightarrow 0.1 = \frac{kq^2}{(10^{-2})^2} \Rightarrow q^2 = \frac{0.1 \times 10^{-4}}{9 \times 10^9} \Rightarrow q^2 = \frac{1}{9} \times 10^{-14} \Rightarrow q = \frac{1}{3} \times 10^{-7}$$

1.6×10^{-19} c $\qquad$ Carries by 1 electron $\qquad$ 1 c carried by $\frac{1}{1.6 \times 10^{-19}}$

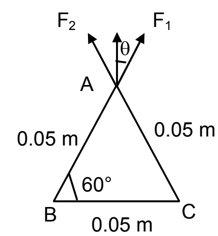
0.33×10^{-7} c carries by $\frac{1}{1.6 \times 10^{-19}} \times 0.33 \times 10^{-7} = 0.208 \times 10^{12} = 2.08 \times 10^{11}$

13. F = $\frac{kq_1q_2}{r^2}$ = $\frac{9\times10^9\times1.6\times1.6\times10^{-19}\times10^{-19}}{(2.75\times10^{-10})^2}$ = $\frac{23.04\times10^{-29}}{7.56\times10^{-20}}$ = 3.04 × 10^{-9}

14. Given: mass of proton = 1.67 × 10^{-27} kg = M_p
k = 9 × 10^9 Charge of proton = 1.6 × 10^{-19} c = C_p
G = 6.67 × 10^{-11} Let the separation be 'r'
Fe = $\frac{k(C_p)^2}{r^2}$, fg= $\frac{G(M_p)^2}{r^2}$
Now, Fe : Fg = $\frac{K(C_p)^2}{r^2}\times\frac{r^2}{G(M_p)^2}$ = $\frac{9\times10^9\times(1.6\times10^{-19})^2}{6.67\times10^{-11}\times(1.67\times10^{-27})^2}$ = 9 × 2.56 × 10^{38} ≈ 1,24 ×10^{38}

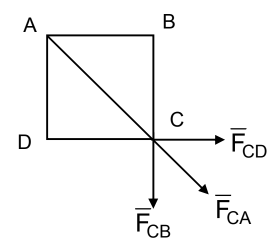
15. Expression of electrical force F = $C\times e^{\frac{-kr}{r^2}}$
Since e^{-kr} is a pure number. So, dimensional formulae of F = $\frac{\text{dimensional formulae of C}}{\text{dimensional formulae of } r^2}$
Or, $[MLT^{-2}][L^2]$ = dimensional formulae of C = $[ML^3T^{-2}]$
Unit of C = unit of force × unit of r^2 = Newton × m^2 = Newton–m^2
Since –kr is a number hence dimensional formulae of
k = $\frac{1}{\text{dimentional formulae of r}}$ = $[L^{-1}]$ Unit of k = m^{-1}

16. Three charges are held at three corners of a equilateral trangle.
Let the charges be A, B and C. It is of length 5 cm or 0.05 m
Force exerted by B on A = F_1 force exerted by C on A = F_2
So, force exerted on A = resultant F_1 = F_2



$\Rightarrow$ F = $\frac{kq_2}{r^2}$ = $\frac{9\times10^9\times2\times2\times2\times10^{-12}}{5\times5\times10^{-4}}$ = $\frac{36}{25}\times10$ = 14.4
Now, force on A = 2 × F cos 30° since it is equilateral Δ.
$\Rightarrow$ Force on A = 2 × 1.44 × $\sqrt{\frac{3}{2}}$ = 24.94 N.

17. $q_1 = q_2 = q_3 = q_4$ = 2 × 10^{-6} C
v = 5 cm = 5 × 10^{-2} m
so force on $\bar{c}$ = $\bar{F}_{CA}+\bar{F}_{CB}+\bar{F}_{CD}$



so Force along × Component = $\bar{F}_{CD}+\bar{F}_{CA}\cos45°+0$
= $\frac{k(2\times10^{-6})^2}{(5\times10^{-2})^2}+\frac{k(2\times10^{-6})^2}{(5\times10^{-2})^2}\frac{1}{2\sqrt{2}}$ = $kq^2\left(\frac{1}{25\times10^{-4}}+\frac{1}{50\sqrt{2}\times10^{-4}}\right)$
= $\frac{9\times10^9\times4\times10^{-12}}{24\times10^{-4}}\left(1+\frac{1}{2\sqrt{2}}\right)$ = 1.44 (1.35) = 19.49 Force along % component = 19.49
So, Resultant R = $\sqrt{Fx^2+Fy^2}$ = 19.49 $\sqrt{2}$ = 27.56

18. R = 0.53 A° = 0.53 × 10^{-10} m
F = $\frac{Kq_1q_2}{r^2}$ = $\frac{9\times10^9\times1.6\times1.6\times10^{-38}}{0.53\times0.53\times10^{-10}\times10^{-10}}$ = 82.02 × 10^{-9} N

19. Fe from previous problem No. 18 = 8.2 × 10^{-8} N Ve = ?
Now, M_e = 9.12 × 10^{-31} kg r = 0.53 × 10^{-10} m
Now, Fe = $\frac{M_ev^2}{r}$ $\Rightarrow v^2$ = $\frac{Fe\times r}{m_e}$ = $\frac{8.2\times10^{-8}\times0.53\times10^{-10}}{9.1\times10^{-31}}$ = 0.4775 × 10^{13} = 4.775 × 10^{12} m^2/s^2
$\Rightarrow$ v = 2.18 × 10^6 m/s

20. Electric force feeled by 1 c due to 1×10^{-8} c.

$F_1 = \dfrac{k \times 1 \times 10^{-8} \times 1}{(10 \times 10^{-2})^2} = k \times 10^{-6}$ N. electric force feeled by 1 c due to 8×10^{-8} c.

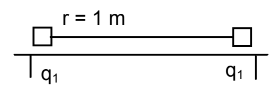
$F_2 = \dfrac{k \times 8 \times 10^{-8} \times 1}{(23 \times 10^{-2})^2} = \dfrac{k \times 8 \times \times 10^{-8} \times 10^2}{9} = \dfrac{28k \times 10^{-6}}{4} = 2k \times 10^{-6}$ N.

Similarly $F_3 = \dfrac{k \times 27 \times 10^{-8} \times 1}{(30 \times 10^{-2})^2} = 3k \times 10^{-6}$ N

So, $F = F_1 + F_2 + F_3 + \ldots\ldots + F_{10} = k \times 10^{-6}\,(1 + 2 + 3 + \ldots\ldots + 10)$ N

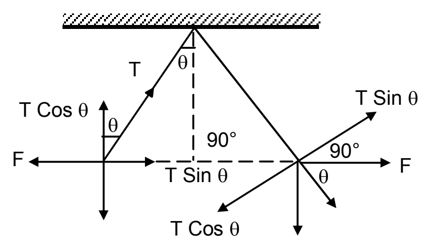
$= k \times 10^{-6} \times \dfrac{10 \times 11}{2} = 55k \times 10^{-6} = 55 \times 9 \times 10^9 \times 10^{-6}$ N $= 4.95 \times 10^3$ N

21. Force exerted $= \dfrac{kq_1^{\,2}}{r^2}$



$= \dfrac{9 \times 10^9 \times 2 \times 2 \times 10^{-16}}{1^2} = 3.6 \times 10^{-6}$ is the force exerted on the string

22. $q_1 = q_2 = 2 \times 10^{-7}$ c   m = 100 g
l = 50 cm $= 5 \times 10^{-2}$ m   d $= 5 \times 10^{-2}$ m



(a) Now Electric force

$F = K\dfrac{q^2}{r^2} = \dfrac{9 \times 10^9 \times 4 \times 10^{-14}}{25 \times 10^{-4}}$ N $= 14.4 \times 10^{-2}$ N = 0.144 N

(b) The components of Resultant force along it is zero, because mg balances T cos θ and so also.

F = mg = T sin θ

(c) Tension on the string

T sin θ = F   T cos θ = mg

$\text{Tan}\,\theta = \dfrac{F}{mg} = \dfrac{0.144}{100 \times 10^{-3} \times 9.8} = 0.14693$

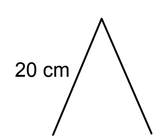
But T cos θ $= 10^2 \times 10^{-3} \times 10 = 1$ N

$\Rightarrow T = \dfrac{1}{\cos\theta} = \sec\theta$

$\Rightarrow T = \dfrac{F}{\sin\theta}$,

Sin θ = 0.145369 ; Cos θ = 0.989378;

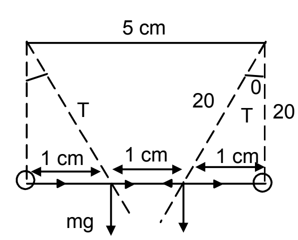
23. $q = 2.0 \times 10^{-8}$ c   n= ?   T = ? $\text{Sin}\,\theta = \dfrac{1}{20}$



Force between the charges

$F = \dfrac{Kq_1q_2}{r^2} = \dfrac{9 \times 10^9 \times 2 \times 10^{-8} \times 2 \times 10^{-8}}{(3 \times 10^{-2})^2} = 4 \times 10^{-3}$ N

$mg \sin\theta = F \Rightarrow m = \dfrac{F}{g\sin\theta} = \dfrac{4 \times 10^{-3}}{10 \times (1/20)} = 8 \times 10^{-3} = 8$ gm

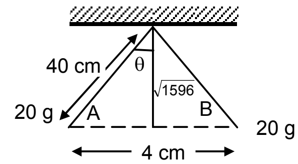


$\text{Cos}\,\theta = \sqrt{1 - \text{Sin}^2\theta} = \sqrt{1 - \dfrac{1}{400}} = \sqrt{\dfrac{400 - 1}{400}} = 0.99 \approx 1$

So, T = mg cos θ

Or $T = 8 \times 10^{-3}\ 10 \times 0.99 = 8 \times 10^{-2}$ M

24. T Cos θ = mg …(1)
T Sin θ = Fe …(2)



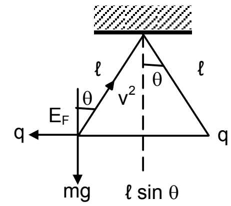
Solving, (2)/(1) we get, tan θ = $\frac{Fe}{mg} = \frac{kq^2}{r} \times \frac{1}{mg}$

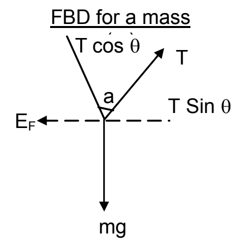
$$\Rightarrow \frac{2}{\sqrt{1596}} = \frac{9\times10^9 \times q^2}{(0.04)^2 \times 0.02 \times 9.8}$$

$$\Rightarrow q^2 = \frac{(0.04)^2 \times 0.02 \times 9.8 \times 2}{9\times10^9 \times \sqrt{1596}} = \frac{6.27\times10^{-4}}{9\times10^9 \times 39.95} = 17 \times 10^{-16} c^2$$

$$\Rightarrow q = \sqrt{17\times10^{-16}} = 4.123 \times 10^{-8}\ c$$

25. Electric force = $\frac{kq^2}{(\ell \sin Q + \ell \sin Q)^2} = \frac{kq^2}{4\ell^2 \sin^2}$





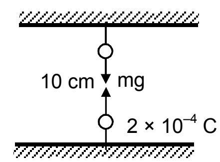
So, T Cos θ = ms (For equilibrium) T sin θ = Ef

Or tan θ = $\frac{Ef}{mg}$

$$\Rightarrow mg = Ef \cot\theta = \frac{kq^2}{4\ell^2 \sin^2\theta}\cot\theta = \frac{q^2 \cot\theta}{\ell^2 \sin^2\theta 16\pi E_0}$$

or m = $\frac{q^2 \cot\theta}{16\pi E_0 \ell^2 \mathrm{Sin}^2\theta g}$ unit.

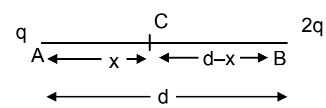
26. Mass of the bob = 100 g = 0.1 kg
So Tension in the string = 0.1 × 9.8 = 0.98 N.
For the Tension to be 0, the charge below should repel the first bob.



$\Rightarrow F = \frac{kq_1q_2}{r^2}$ T – mg + F = 0 ⇒ T = mg – f T = mg

$$\Rightarrow 0.98 = \frac{9\times10^9 \times 2\times10^{-4} \times q_2}{(0.01)^2} \Rightarrow q_2 = \frac{0.98\times1\times10^{-2}}{9\times2\times10^5} = 0.054 \times 10^{-9}\ N$$

27. Let the charge on C = q
So, net force on c is equal to zero



So $F_{AC} + F_{BA} = 0$, But $F_{AC} = F_{BC} \Rightarrow \frac{kqQ}{x^2} = \frac{k2qQ}{(d-x)^2}$

$\Rightarrow 2x^2 = (d-x)^2 \Rightarrow \sqrt{2}\,x = d - x$

$$\Rightarrow x = \frac{d}{\sqrt{2}+1} = \frac{d}{(\sqrt{2}+1)} \times \frac{(\sqrt{2}-1)}{(\sqrt{2}-1)} = d(\sqrt{2}-1)$$

For the charge on rest, $F_{AC} + F_{AB} = 0$

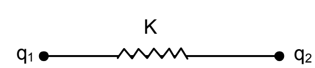
$$(2.414)^2 \frac{kqQ}{d^2} + \frac{kq(2q)}{d^2} = 0 \Rightarrow \frac{kq}{d^2}[(2.414)^2 Q + 2q] = 0$$

$\Rightarrow 2q = -(2.414)^2\ Q$

$$\Rightarrow Q = \frac{2}{-(\sqrt{2}+1)^2} q = -\left(\frac{2}{3+2\sqrt{2}}\right) q = -(0.343)\ q = -(6 - 4\sqrt{2})$$

28. K = 100 N/m ℓ = 10 cm = 10^{-1} m q = 2.0×10^{-8} c Find ℓ = ?

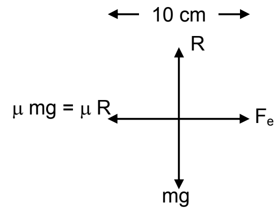
Force between them F = $\frac{kq_1q_2}{r^2} = \frac{9\times10^9 2\times10^{-8} \times 2\times10^{-8}}{10^{-2}} = 36 \times 10^{-5}$ N



So, F = – kx or x = $\frac{F}{-K} = \frac{36\times10^{-5}}{100} = 36 \times 10^{-7}$ cm = 3.6×10^{-6} m

29. $q_A = 2 \times 10^{-6}$ C $\quad M_b = 80$ g $\quad \mu = 0.2$

Since B is at equilibrium, So, Fe = μR



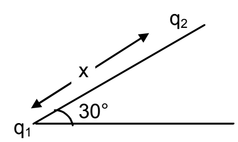
$\Rightarrow \frac{Kq_Aq_B}{r^2} = \mu R = \mu m \times g$

$\Rightarrow \frac{9\times10^9\times2\times10^{-6}\times q_B}{0.01} = 0.2 \times 0.08 \times 9.8$

$\Rightarrow q_B = \frac{0.2\times0.08\times9.8\times0.01}{9\times10^9\times2\times10^{-6}} = 8.7 \times 10^{-8}$ C $\qquad$ Range = $\pm 8.7 \times 10^{-8}$ C

30. $q_1 = 2 \times 10^{-6}$ c $\qquad$ Let the distance be r unit

$\therefore F_{repulsion} = \frac{kq_1q_2}{r^2}$



For equilibrium $\frac{kq_1q_2}{r^2}$ = mg sin θ

$\Rightarrow \frac{9\times10^9\times4\times10^{-12}}{r^2} = m \times 9.8 \times \frac{1}{2}$

$\Rightarrow r^2 = \frac{18\times4\times10^{-3}}{m\times9.8} = \frac{72\times10^{-3}}{9.8\times10^{-1}} = 7.34 \times 10^{-2}$ metre

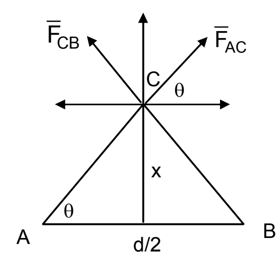
$\Rightarrow r = 2.70924 \times 10^{-1}$ metre from the bottom.

31. Force on the charge particle 'q' at 'c' is only the x component of 2 forces

So, $F_{on\ c} = F_{CB} \sin\theta + F_{AC} \sin\theta$ $\qquad$ But $|\overline{F}_{CB}| = |\overline{F}_{AC}|$

$= 2 F_{CB} \sin\theta = 2\frac{KQq}{x^2+(d/2)^2}\times\frac{x}{\left[x^2+d^2/4\right]^{1/2}} = \frac{2k\theta qx}{(x^2+d^2/4)^{3/2}} = \frac{16kQq}{(4x^2+d^2)^{3/2}}x$

For maximum force $\frac{dF}{dx} = 0$



$\frac{d}{dx}\left(\frac{16kQqx}{(4x^2+d^2)^{3/2}}\right) = 0 \Rightarrow K\left[\frac{(4x^2+d^2)-x\left[3/2\left[4x^2+d^2\right]^{1/2}8x\right]}{[4x^2+d^2]^3}\right] = 0$

$\Rightarrow \frac{K(4x^2+d^2)^{1/2}\left[(4x^2+d^2)^3-12x^2\right]}{(4x^2+d^2)^3} = 0 \Rightarrow (4x^2+d^2)^3 = 12x^2$

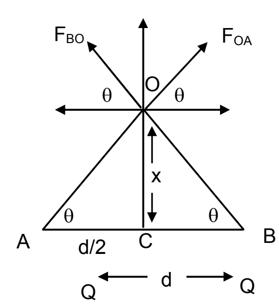
$\Rightarrow 16x^4 + d^4 + 8x^2d^2 = 12x^2 \qquad d^4 + 8x^2d^2 = 0$

$\Rightarrow d^2 = 0 \qquad d^2 + 8x^2 = 0 \qquad \Rightarrow d^2 = 8x^2 \;\Rightarrow d = \frac{d}{2\sqrt{2}}$

32. (a) Let Q = charge on A & B Separated by distance d

q = charge on c $\qquad$ displaced $\perp$ to –AB

So, force on 0 = $\overline{F}_{AB} + \overline{F}_{BO}$



But $F_{AO} \cos\theta = F_{BO} \cos\theta$

So, force on '0' in due to vertical component.

$\overline{F} = F_{AO} \sin\theta + F_{BO} \sin\theta \qquad |F_{AO}| = |F_{BO}|$

$= 2\frac{KQq}{(d/2^2+x^2)}\sin\theta \qquad F = \frac{2KQq}{(d/2)^2+x^2}\sin\theta$

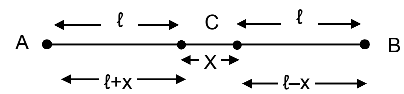
$= \frac{4\times2\times kQq}{(d^2+4x^2)}\times\frac{x}{[(d/2)^2+x^2]^{1/2}} = \frac{2kQq}{[(d/2)^2+x^2]^{3/2}}x$ = Electric force $\Rightarrow F \propto x$

(b) When x << d $\quad F = \dfrac{2kQq}{[(d/2)^2 + x^2]^{3/2}}x \quad x<<d$

$\Rightarrow F = \dfrac{2kQq}{(d^2/4)^{3/2}}x \Rightarrow F \propto x \qquad a = \dfrac{F}{m} = \dfrac{1}{m}\left[\dfrac{2kQqx}{[(d^2/4)+\ell^2]}\right]$

So time period $T = 2\pi\sqrt{\dfrac{\ell}{g}} = 2\pi\sqrt{\dfrac{\ell}{a}}$

33. $F_{AC} = \dfrac{KQq}{(\ell+x)^2} \qquad F_{CA} = \dfrac{KQq}{(\ell-x)^2}$



Net force $= KQq\left[\dfrac{1}{(\ell-x)^2} - \dfrac{1}{(\ell+x)^2}\right]$

$= KQq\left[\dfrac{(\ell+x)^2-(\ell-x)^2}{(\ell+x)^2(\ell-x)^2}\right] = KQq\left[\dfrac{4\ell x}{(\ell^2-x^2)^2}\right]$

x<<< l = d/2 neglecting x w.r.t. ℓ $\qquad$ We get

net $F = \dfrac{KQq4\ell x}{\ell^4} = \dfrac{KQq4x}{\ell^3} \qquad$ acceleration $= \dfrac{4KQqx}{m\ell^3}$

Time period $= 2\pi\sqrt{\dfrac{\text{displacement}}{\text{acceleration}}} = 2\pi\sqrt{\dfrac{xm\ell^3}{4KQqx}} = 2\pi\sqrt{\dfrac{m\ell^3}{4KQq}}$

$= \sqrt{\dfrac{4\pi^2 m\ell^3 4\pi\varepsilon_0}{4Qq}} = \sqrt{\dfrac{4\pi^3 m\ell^3\varepsilon_0}{Qq}} = \sqrt{4\pi^3 md^3\varepsilon_0 8Qq} = \left[\dfrac{\pi^3 md^3\varepsilon_0}{2Qq}\right]^{1/2}$

34. $F_e = 1.5 \times 10^{-3}$ N, $\qquad q = 1 \times 10^{-6}$ C, $\; F_e = q \times E$

$\Rightarrow E = \dfrac{F_e}{q} = \dfrac{1.5\times10^{-3}}{1\times10^{-6}} = 1.5 \times 10^3$ N/C

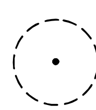
35. $q_2 = 2 \times 10^{-6}$ C, $\quad q_1^2 = -4 \times 10^{-6}$ C, $\quad$ r = 20 cm = 0.2 m
(E_1 = electric field due to q_1, $\qquad E_2$ = electric field due to q_2)

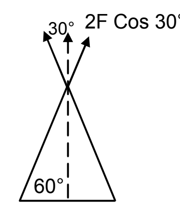
$\Rightarrow \dfrac{(r-x)^2}{x^2} = \dfrac{-q_2}{q_1} \Rightarrow \dfrac{(r-1)^2}{x} = \dfrac{-q_2}{q_1} = \dfrac{4\times10^{-6}}{2\times10^{-6}} = \dfrac{1}{2}$

$\Rightarrow \left(\dfrac{r}{x}-1\right) = \dfrac{1}{\sqrt{2}} = \dfrac{1}{1.414} \Rightarrow \dfrac{r}{x} = 1.414 + 1 = 2.414$

$\Rightarrow x = \dfrac{r}{2.414} = \dfrac{20}{2.414} = 8.285$ cm

36. $EF = \dfrac{KQ}{r^2}$

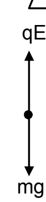




5 N/C $= \dfrac{9\times10^9\times Q}{4^2}$

$\Rightarrow \dfrac{4\times20\times10^{-2}}{9\times10^9} = Q \Rightarrow Q = 8.88 \times 10^{-11}$

37. m = 10, $\quad mg = 10 \times 10^{-3}$ g $\times 10^{-3}$ kg, $\quad q = 1.5 \times 10^{-6}$ C
But qE = mg $\Rightarrow (1.5 \times 10^{-6})\,E = 10 \times 10^{-6} \times 10$



$\Rightarrow E = \dfrac{10\times10^{-4}\times10}{1.5\times10^{-6}} = \dfrac{100}{1.5} = 66.6$ N/C

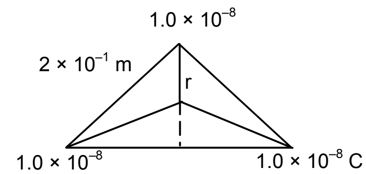
$= \dfrac{100\times10^3}{1.5} = \dfrac{10^{5+1}}{15} = 6.6 \times 10^3$

38. q = 1.0 × 10^{-8} C, ℓ = 20 cm

E = ? V = ?

Since it forms an equipotential surface.

So the electric field at the centre is <u>Zero</u>.

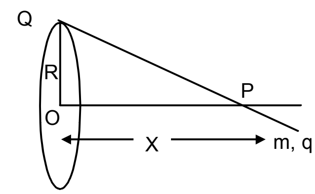


$$r = \frac{2}{3}\sqrt{(2\times10^{-1})^2-(10^{-1})^2} = \frac{2}{3}\sqrt{4\times10^{-2}-10^{-2}}$$

$$= \frac{2}{3}\sqrt{10^{-2}(4-1)} = \frac{2}{3}\times10^{-2}\times1.732 = 1.15\times10^{-1}$$

$$V = \frac{3\times9\times10^{9}1\times10^{-8}}{1\times10^{-1}} = 23\times10^{2} = 2.3\times10^{3}\text{ V}$$

39. We know : Electric field 'E' at 'P' due to the charged ring



$$= \frac{KQx}{(R^2+x^2)^{3/2}} = \frac{KQx}{R^3}$$

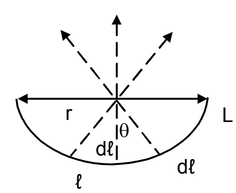
Force experienced 'F' = Q × E = $\frac{q\times K\times Qx}{R^3}$

Now, amplitude = x

$$\text{So, } T = 2\pi\sqrt{\frac{x}{KQqx/mR^3}} = 2\pi\sqrt{\frac{mR^3x}{KQqx}} = 2\pi\sqrt{\frac{4\pi\varepsilon_0 mR^3}{Qq}} = \sqrt{\frac{4\pi^2\times4\pi\varepsilon_0 mR^3}{qQ}}$$

$$\Rightarrow T = \left[\frac{16\pi^3\varepsilon_0 mR^3}{qQ}\right]^{1/2}$$

40. λ = Charge per unit length = $\frac{Q}{L}$



dq_1 for a length dl = λ × dl

Electric field at the centre due to charge = $k\times\frac{dq}{r^2}$

The horizontal Components of the Electric field balances each other. Only the vertical components remain.

∴ Net Electric field along vertical

$$d_E = 2\,E\cos\theta = \frac{Kdq\times\cos\theta}{r^2} = \frac{2kCos\theta}{r^2}\times\lambda\times dl \qquad \left[\text{but } d\theta = \frac{d\ell}{r} = d\ell = rd\theta\right]$$

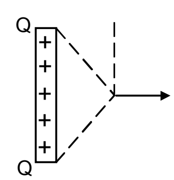
$$\Rightarrow \frac{2k\lambda}{r^2}Cos\theta\times rd\theta = \frac{2k\lambda}{r}Cos\theta\times d\theta$$

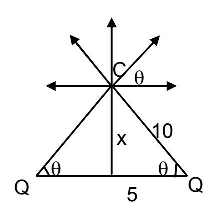
$$\text{or } E = \int_0^{\pi/2}\frac{2k\lambda}{r}Cos\theta\times d\theta = \int_0^{\pi/2}\frac{2k\lambda}{r}Sin\theta = \frac{2k\lambda l}{r} = \frac{2K\theta}{Lr}$$

but L = πR $\Rightarrow$ r = $\frac{L}{\pi}$

$$\text{So } E = \frac{2k\theta}{L\times(L/\pi)} = \frac{2k\pi\theta}{L^2} = \frac{2}{4\pi\varepsilon_0}\times\frac{\pi\theta}{L^2} = \frac{\theta}{2\varepsilon_0 L^2}$$

41. G = 50 μC = 50 × 10^{-6} C



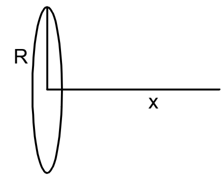


We have, E = $\frac{2KQ}{r}$ for a charged cylinder.

$$\Rightarrow E = \frac{2\times9\times10^{9}\times50\times10^{-6}}{5\sqrt{3}} = \frac{9\times10^{-5}}{5\sqrt{3}} = 1.03\times10^{-5}$$

42. Electric field at any point on the axis at a distance x from the center of the ring is

$E = \dfrac{xQ}{4\pi\varepsilon_0(R^2+x^2)^{3/2}} = \dfrac{KxQ}{(R^2+x^2)^{3/2}}$



Differentiating with respect to x

$\dfrac{dE}{dx} = \dfrac{KQ(R^2+x^2)^{3/2} - KxQ(3/2)(R^2+x^2)^{11/2}2x}{(r^2+x^2)^3}$

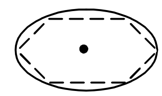
Since at a distance x, Electric field is maximum.

$\dfrac{dE}{dx} = 0 \Rightarrow KQ\ (R^2 + x^2)^{3/2} - Kx^2\ Q3(R^2 + x^2)^{1/2} = 0$

$\Rightarrow KQ\ (R^2 + x^2)^{3/2} = Kx^2\ Q3(R^2 + x^2)^{1/2} \Rightarrow R^2 + x^2 = 3\ x^2$

$\Rightarrow 2\ x^2 = R^2 \ \Rightarrow x^2 = \dfrac{R^2}{2} \ \Rightarrow x = \dfrac{R}{\sqrt{2}}$

43. Since it is a regular hexagon. So, it forms an equipotential surface. Hence the charge at each point is equal. Hence the net entire field at the centre is Zero.



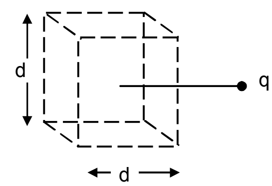
44. Charge/Unit length = $\dfrac{Q}{2\pi a} = \lambda$; Charge of $d\ell$ = $\dfrac{Qd\ell}{2\pi a}$ C

Initially the electric field was ‘0’ at the centre. Since the element ‘$d\ell$’ is removed so, net electric field must $\dfrac{K \times q}{a^2}$ Where q = charge of element $d\ell$

$E = \dfrac{Kq}{a^2} = \dfrac{1}{4\pi\varepsilon_0} \times \dfrac{Qd\ell}{2\pi a} \times \dfrac{1}{a^2} = \dfrac{Qd\ell}{8\pi^2\varepsilon_0 a^3}$

45. We know,

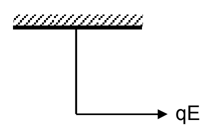
Electric field at a point due to a given charge



‘E’ = $\dfrac{Kq}{r^2}$ Where q = charge, r = Distance between the point and the charge

So, ‘E’ = $\dfrac{1}{4\pi\varepsilon_0} \times \dfrac{q}{d^2}$ [$\therefore$ r = ‘d’ here]

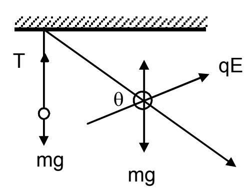
46. E = 20 kv/m = 20 × 10^3 v/m, m = 80 × 10^{-5} kg, c = 20 × 10^{-5} C



$\tan\theta = \left(\dfrac{qE}{mg}\right)^{-1}$ [T Sin θ = mg, T Cos θ = qe]

$\tan\theta = \left(\dfrac{2\times10^{-8}\times20\times10^3}{80\times10^{-6}\times10}\right)^{-1} = \left(\dfrac{1}{2}\right)^{-1}$

$1 + \tan^2\theta = \dfrac{1}{4} + 1 = \dfrac{5}{4}$ [$\cos\theta = \dfrac{1}{\sqrt{5}}$, $\sin\theta = \dfrac{2}{\sqrt{5}}$]



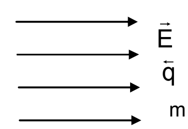
$T\sin\theta = mg \Rightarrow T \times \dfrac{2}{\sqrt{5}} = 80 \times 10^{-6} \times 10$

$\Rightarrow T = \dfrac{8\times10^{-4}\times\sqrt{5}}{2} = 4\times\sqrt{5}\times10^{-4} = 8.9 \times 10^{-4}$

47. Given

u = Velocity of projection, $\vec{E}$ = Electric field intensity

q = Charge; m = mass of particle



We know, Force experienced by a particle with charge ‘q’ in an electric field $\vec{E}$ = qE

$\therefore$ acceleration produced = $\dfrac{qE}{m}$

As the particle is projected against the electric field, hence deceleration = $\frac{qE}{m}$

So, let the distance covered be 's'

Then, $v^2 = u^2 + 2as$ [where a = acceleration, v = final velocity]

Here $0 = u^2 - 2 \times \frac{qE}{m} \times S \Rightarrow S = \frac{u^2 m}{2qE}$ units

48. m = 1 g = 10^{-3} kg, u = 0, q = 2.5×10^{-4} C ; E = 1.2×10^4 N/c ; S = 40 cm = 4×10^{-1} m

a) $F = qE = 2.5 \times 10^{-4} \times 1.2 \times 10^4 = 3$ N

So, $a = \frac{F}{m} = \frac{3}{10^{-3}} = 3 \times 10^3$

$E_q = mg = 10^{-3} \times 9.8 = 9.8 \times 10^{-3}$ N

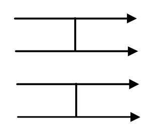
b) $S = \frac{1}{2}at^2$ or $t = \sqrt{\frac{2a}{g}} = \sqrt{\frac{2 \times 4 \times 10^{-1}}{3 \times 10^3}} = 1.63 \times 10^{-2}$ sec

$v^2 = u^2 + 2as = 0 + 2 \times 3 \times 10^3 \times 4 \times 10^{-1} = 24 \times 10^2 \Rightarrow v = \sqrt{24 \times 10^2} = 4.9 \times 10 = 49$ m/sec

work done by the electric force w = $F \rightarrow td = 3 \times 4 \times 10^{-1} = 12 \times 10^{-1} = 1.2$ J

49. m = 100 g, q = 4.9×10^{-5}, $F_g = mg$, $F_e = qE$

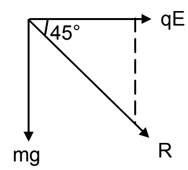
$\vec{E} = 2 \times 10^4$ N/C



So, the particle moves due to the et resultant R

$R = \sqrt{F_g{}^2 + F_e{}^2} = \sqrt{(0.1 \times 9.8)^2 + (4.9 \times 10^{-5} \times 2 \times 10^4)^2}$

$= \sqrt{0.9604 + 96.04 \times 10^{-2}} = \sqrt{1.9208} = 1.3859$ N



$\tan\theta = \frac{F_g}{F_e} = \frac{mg}{qE} = 1$ So, $\theta = 45°$

∴ Hence path is straight along resultant force at an angle 45° with horizontal

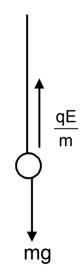
Disp. Vertical = (1/2) × 9.8 × 2 × 2 = 19.6 m

Disp. Horizontal = S = (1/2) $at^2 = \frac{1}{2} \times \frac{qE}{m} \times t^2 = \frac{1}{2} \times \frac{0.98}{0.1} \times 2 \times 2 = 19.6$ m

Net Dispt. = $\sqrt{(19.6)^2 + (19.6)^2} = \sqrt{768.32} = 27.7$ m

50. m = 40 g, q = 4×10^{-6} C

Time for 20 oscillations = 45 sec. Time for 1 oscillation = $\frac{45}{20}$ sec



When no electric field is applied, $T = 2\pi\sqrt{\frac{\ell}{g}} \Rightarrow \frac{45}{20} = 2\pi\sqrt{\frac{\ell}{10}}$

$\Rightarrow \frac{\ell}{10} = \left(\frac{45}{20}\right)^2 \times \frac{1}{4\pi^2} \Rightarrow \ell = \frac{(45)^2 \times 10}{(20)^2 \times 4\pi^2} = 1.2836$

When electric field is not applied,

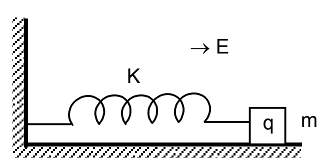
$T = 2\pi\sqrt{\frac{\ell}{g-a}}$ [$a = \frac{qE}{m} = 2.5$] $= 2\pi\sqrt{\frac{1.2836}{10-2.5}} = 2.598$

Time for 1 oscillation = 2.598

Time for 20 oscillation = 2.598 × 20 = 51.96 sec ≈ 52 sec.

51. F = qE, F = –Kx

Where x = amplitude



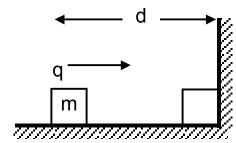
$qE = -Kx$ or $x = \frac{-qE}{K}$

52. The block does not undergo. SHM since here the acceleration is not proportional to displacement and not always opposite to displacement. When the block is going towards the wall the acceleration is along displacement and when going away from it the displacement is opposite to acceleration.

Time taken to go towards the wall is the time taken to goes away from it till velocity is

$d = ut + (1/2)\, at^2$

$\Rightarrow d = \frac{1}{2} \times \frac{qE}{m} \times t^2$



$\Rightarrow t^2 = \frac{2dm}{qE} \Rightarrow t = \sqrt{\frac{2md}{qE}}$

$\therefore$ Total time taken for to reach the wall and com back (Time period)

$= 2t = 2\sqrt{\frac{2md}{qE}} = \sqrt{\frac{8md}{qE}}$

53. E = 10 n/c, S = 50 cm = 0.1 m

$E = \frac{dV}{dr}$ or, V = E × r = 10 × 0.5 = 5 cm

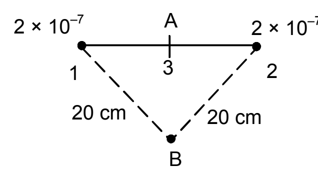
54. Now, $V_B - V_A$ = Potential diff = ? Charge = 0.01 C

Work done = 12 J Now, Work done = Pot. Diff × Charge

$\Rightarrow$ Pot. Diff = $\frac{12}{0.01}$ = 1200 Volt

55. When the charge is placed at A,

$E_1 = \frac{Kq_1q_2}{r} + \frac{Kq_3q_4}{r}$



$= \frac{9 \times 10^9 (2 \times 10^{-7})^2}{0.1} + \frac{9 \times 10^9 (2 \times 10^{-7})^2}{0.1}$

$= \frac{2 \times 9 \times 10^9 \times 4 \times 10^{-14}}{0.1}$ = 72 × 10^{-4} J

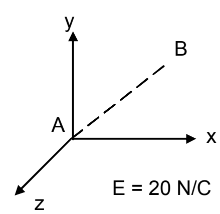
When charge is placed at B,

$E_2 = \frac{Kq_1q_2}{r} + \frac{Kq_3q_4}{r} = \frac{2 \times 9 \times 10^9 \times 4 \times 10^{-14}}{0.2}$ = 36 × 10^{-4} J

Work done = $E_1 - E_2$ = (72 – 36) × 10^{-4} = 36 × 10^{-4} J = 3.6 × 10^{-3} J

56. (a) A = (0, 0) B = (4, 2)

$V_B - V_A$ = E × d = 20 × $\sqrt{16}$ = 80 V



(b) A(4m, 2m), B = (6m, 5m)

$\Rightarrow V_B - V_A$ = E × d = $20 \times \sqrt{(6-4)^2}$ = 20 × 2 = 40 V

(c) A(0, 0) B = (6m, 5m)

$\Rightarrow V_B - V_A$ = E × d = $20 \times \sqrt{(6-0)^2}$ = 20 × 6 = 120 V.

57. (a) The Electric field is along x-direction

Thus potential difference between (0, 0) and (4, 2) is,

$\delta V = -E \times \delta x$ = – 20 × (40) = – 80 V

Potential energy $(U_B - U_A)$ between the points = $\delta V \times q$

= – 80 × (–2) × 10^{-4} = 160 × 10^{-4} = 0.016 J.

(b) A = (4m, 2m) B = (6m, 5m)

$\delta V = -E \times \delta x$ = – 20 × 2 = – 40 V

Potential energy $(U_B - U_A)$ between the points = $\delta V \times q$

= – 40 × (–2 × 10^{-4}) = 80 × 10^{-4} = 0.008 J

(c) A = (0, 0) B = (6m, 5m)

$\delta V = -E \times \delta x$ = – 20 × 6 = – 120 V

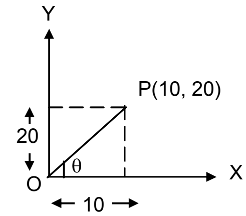
Potential energy $(U_B - U_A)$ between the points A and B

= $\delta V \times q$ = – 120 × (–2 × 10^{-4}) = 240 × 10^{-4} = 0.024 J

58. E = $\left(\hat{i}20 + \hat{j}30\right)$ N/CV = at (2m, 2m) r = (2i + 2j)

So, V= $-\vec{E}\times\vec{r}$ = –(i20 + 30J) (2 $\hat{i}$ + 2j) = –(2 × 20 + 2× 30) = – 100 V

59. E = $\vec{i}$ × Ax = 100 $\vec{i}$



$\int_v^0 dv = -\int E \times d\ell$ V = $-\int_0^{10} 10x \times dx = -\int_0^{10} \frac{1}{2} \times 10 \times x^2$

0 – V = $-\left[\frac{1}{2}\times 1000\right]$ = – 500 ⇒ V = 500 Volts

60. V(x, y, z) = A(xy + yz + zx)

(a) A = $\frac{\text{Volt}}{m^2} = \frac{ML^2T^{-2}}{ITL^2}$ = $[MT^{-3}I^{-1}]$

(b) E = $-\frac{\delta V\hat{i}}{\delta x} - \frac{\delta V\hat{j}}{\delta y} - \frac{\delta V\hat{k}}{\delta z} = -\left[\frac{\delta}{\delta x}[A(xy+yz+zx) + \frac{\delta}{\delta y}[A(xy+yz+zx) + \frac{\delta}{\delta z}[A(xy+yz+zx)\right]$

= $-\left[(Ay + Az)\hat{i} + (Ax + Az)\hat{j} + (Ay + Ax)\hat{k}\right] = -A(y+z)\hat{i} + A(x+z)\hat{j} + A(y+x)\hat{k}$

(c) A = 10 SI unit, r = (1m, 1m, 1m)

E = –10(2) $\hat{i}$ – 10(2) $\hat{j}$ – 10(2) $\hat{k}$ = – 20 $\hat{i}$ – 20 $\hat{j}$ – 20 $\hat{k}$ = $\sqrt{2o^2 + 20^2 + 20^2}$ = $\sqrt{1200}$ = 34.64 ≈ 35 N/C

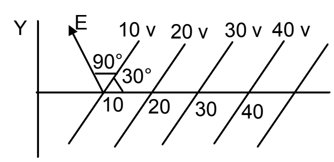
61. $q_1 = q_2 = 2 \times 10^{-5}$ C

Each are brought from infinity to 10 cm a part d = 10×10^{-2} m

So work done = negative of work done. (Potential E)

P.E = $\int_\infty^{10} F \times ds$ P.E. = $K \times \frac{q_1q_2}{r} = \frac{9\times10^9 \times 4\times10^{-10}}{10\times10^{-2}}$ = 36 J

62. (a) The angle between potential E dℓ = dv



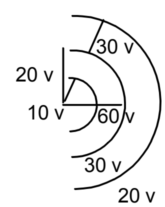
Change in potential = 10 V = dV

As E = ⊥r dV (As potential surface)

So, E dℓ = dV ⇒ E dℓ Cos(90° + 30°) = – dv

⇒ E(10× 10^{-2}) cos 120° = – dV

⇒ E = $\frac{-dV}{10\times10^{-2}\text{Cos}120°} = -\frac{10}{10^{-1}\times(-1/2)}$ = 200 V/m making an angle 120° with y-axis



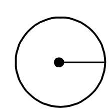
(b) As Electric field intensity is ⊥r to Potential surface

So, E = $\frac{kq}{r^2}r = \frac{kq}{r} \Rightarrow \frac{kq}{r}$ = 60 v q = $\frac{6}{K}$

So, E = $\frac{kq}{r^2} = \frac{6\times k}{k\times r^2}$ v.m = $\frac{6}{r^2}$ v.m

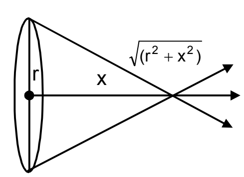
63. Radius = r So, 2πr = Circumference

Charge density = λ Total charge = 2πr × λ



Electric potential = $\frac{Kq}{r} = \frac{1}{4\pi\varepsilon_0} \times \frac{2\pi r\lambda}{(x^2+r^2)^{1/2}} = \frac{r\lambda}{2\varepsilon_0(x^2+r^2)^{1/2}}$

So, Electric field = $\frac{V}{r}$Cosθ

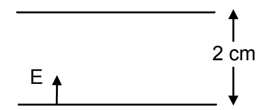


= $\frac{r\lambda}{2\varepsilon_0(x^2+r^2)^{1/2}} \times \frac{1}{(x^2+r^2)^{1/2}}$

= $\frac{r\lambda}{2\varepsilon_0(x^2+r^2)^{1/2}} \times \frac{x}{(x^2+r^2)^{1/2}} = \frac{r\lambda x}{2\varepsilon_0(x^2+r^2)^{3/2}}$

64. $\vec{E}$ = 1000 N/C

(a) $V = E \times d\ell = 1000 \times \dfrac{2}{100} = 20$ V



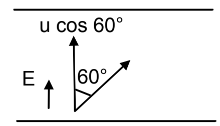
(b) u = ? $\vec{E}$ = 1000, = 2/100 m

$a = \dfrac{F}{m} = \dfrac{q \times E}{m} = \dfrac{1.6 \times 10^{-19} \times 1000}{9.1 \times 10^{-31}} = 1.75 \times 10^{14}\ m/s^2$

$0 = u^2 - 2 \times 1.75 \times 10^{14} \times 0.02 \Rightarrow u^2 = 0.04 \times 1.75 \times 10^{14} \Rightarrow u = 2.64 \times 10^6$ m/s.

(c) Now, U = u Cos 60° V = 0, s = ?

$a = 1.75 \times 10^{14}\ m/s^2$ $V^2 = u^2 - 2as$



$\Rightarrow s = \dfrac{(u\text{Cos}60°)^2}{2 \times a} = \dfrac{\left(2.64 \times 10^6 \times \frac{1}{2}\right)^2}{2 \times 1.75 \times 10^{14}} = \dfrac{1.75 \times 10^{12}}{3.5 \times 10^{14}} = 0.497 \times 10^{-2} \approx 0.005\ m \approx 0.50$ cm

65. E = 2 N/C in x-direction

(a) Potential aat the origin is O. $dV = -E_x\,dx - E_y\,dy - E_z\,dz$

$\Rightarrow V - 0 = -2x \Rightarrow V = -2x$

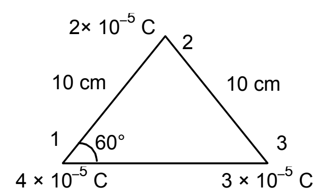
(b) $(25 - 0) = -2x \Rightarrow x = -12.5$ m

(c) If potential at origin is 100 v, $v - 100 = -2x \Rightarrow V = -2x + 100 = 100 - 2x$

(d) Potential at ∞ IS 0, $V - V' = -2x \Rightarrow V' = V + 2x = 0 + 2\infty \Rightarrow V' = \infty$

Potential at origin is ∞. No, it is not practical to take potential at ∞ to be zero.

66. Amount of work done is assembling the charges is equal to the net potential energy



So, P.E. = $U_{12} + U_{13} + U_{23}$

$= \dfrac{Kq_1q_2}{r_{12}} + \dfrac{Kq_1q_3}{r_{13}} + \dfrac{Kq_2q_3}{r_{23}} = \dfrac{K \times 10^{-10}}{r}[4 \times 2 + 4 \times 3 + 3 \times 2]$

$= \dfrac{9 \times 10^9 \times 10^{-10}}{10^{-1}}(8 + 12 + 6) = 9 \times 26 = 234$ J

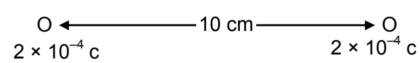
67. K.C. decreases by 10 J. Potential = 100 v to 200 v.

So, change in K.E = amount of work done

$\Rightarrow 10J = (200 - 100)\ v \times q_0 \Rightarrow 100\ q_0 = 10$ v

$\Rightarrow q_0 = \dfrac{10}{100} = 0.1$ C

68. m = 10 g; $F = \dfrac{KQ}{r} = \dfrac{9 \times 10^9 \times 2 \times 10^{-4}}{10 \times 10^{-2}}$ $F = 1.8 \times 10^{-7}$



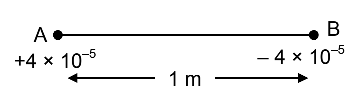
$F = m \times a \Rightarrow a = \dfrac{1.8 \times 10^{-7}}{10 \times 10^{-3}} = 1.8 \times 10^{-3}\ m/s^2$

$V^2 - u^2 = 2as \Rightarrow V^2 = u^2 + 2as$

$V = \sqrt{0 + 2 \times 1.8 \times 10^{-3} \times 10 \times 10^{-2}} = \sqrt{3.6 \times 10^{-4}} = 0.6 \times 10^{-2} = 6 \times 10^{-3}$ m/s.

69. $q_1 = q_2 = 4 \times 10^{-5}$; s = 1m, m = 5 g = 0.005 kg

$F = K\dfrac{q^2}{r^2} = \dfrac{9 \times 10^9 \times (4 \times 10^{-5})^2}{1^2} = 14.4$ N



Acceleration 'a' = $\dfrac{F}{m} = \dfrac{14.4}{0.005} = 2880\ m/s^2$

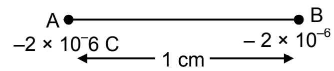
Now u = 0, s = 50 cm = 0.5 m, $a = 2880\ m/s^2$, V =?

$V^2 = u^2 + 2as \Rightarrow V^2 = = 2 \times 2880 \times 0.5$

$\Rightarrow V = \sqrt{2880} = 53.66$ m/s ≈ 54 m/s for each particle

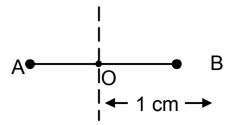
70. E = 2.5 × 104 P = 3.4×10^{-30} τ = PE sin θ
= P × E × 1 = $3.4 \times 10^{-30} \times 2.5 \times 10^{4} = 8.5 \times 10^{-26}$

71. (a) Dipolemoment = q × ℓ



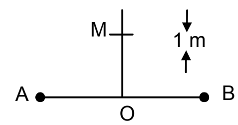
(Where q = magnitude of charge ℓ = Separation between the charges)
= $2 \times 10^{-6} \times 10^{-2}$ cm = 2×10^{-8} cm

(b) We know, Electric field at an axial point of the dipole



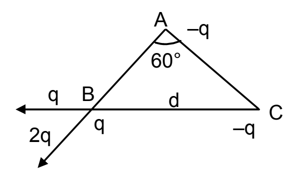
$$= \frac{2KP}{r^3} = \frac{2 \times 9 \times 10^9 2 \times 10^{-8}}{(1 \times 10^{-2})^3} = 36 \times 10^7 \text{ N/C}$$

(c) We know, Electric field at a point on the perpendicular bisector about 1m away from centre of dipole.



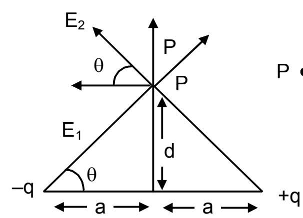
$$= \frac{KP}{r^3} = \frac{9 \times 10^9 2 \times 10^{-8}}{1^3} = 180 \text{ N/C}$$

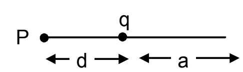
72. Let –q & –q are placed at A & C
Where 2q on B So length of A = d
So the dipole moment = (q × d) = P
So, Resultant dipole moment



P= $[(qd)^2 + (qd)^2 + 2qd \times qd \text{ Cos } 60°]^{1/2} = [3 q^2d^2]^{1/2} = \sqrt{3}$ qd = $\sqrt{3}$ P

73. (a) P = 2qa
(b) E_1 Sin θ = E_2 sin θ Electric field intensity
= E_1 Cos θ + E_2 Cos θ = 2 E_1 Cos θ

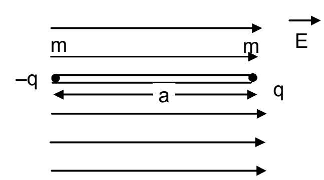




$$E_1 = \frac{Kqp}{a^2 + d^2} \text{ so } E = \frac{2KPQ}{a^2 + d^2} \frac{a}{(a^2 + d^2)^{1/2}} = \frac{2Kq \times a}{(a^2 + d^2)^{3/2}}$$

When a << d $$= \frac{2Kqa}{(d^2)^{3/2}} = \frac{PK}{d^3} = \frac{1}{4\pi\varepsilon_0} \frac{P}{d^3}$$

74. Consider the rod to be a simple pendulum.
For simple pendulum T = $2\pi\sqrt{\ell / g}$ (ℓ = length, q = acceleration)
Now, force experienced by the charges



F = Eq Now, acceleration = $\frac{F}{m} = \frac{Eq}{m}$

Hence length = a so, Time period = $2\pi\sqrt{\frac{a}{(Eq/m)}} = 2\pi\sqrt{\frac{ma}{Eq}}$

75. 64 grams of copper have 1 mole 6.4 grams of copper have 0.1 mole
1 mole = No atoms 0.1 mole = (no × 0.1) atoms
= $6 \times 10^{23} \times 0.1$ atoms = 6×10^{22} atoms
1 atom contributes 1 electron 6×10^{22} atoms contributes 6×10^{22} electrons.

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