DPP - Daily Practice Problems

Name :

Date :

Start Time :

End Time :

PHYSICS 33

SYLLABUS : Electrostatics-2 (Electric potential and potential difference, equipotential surfaces, electric dipole)

Max. Marks : 104 **Time : 60 min.**

GENERAL INSTRUCTIONS

- The Daily Practice Problem Sheet contains 26 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.
- You have to evaluate your Response Grids yourself with the help of solution booklet.
- Each correct answer will get you 4 marks and 1 mark shall be deduced for each incorrect answer. No mark will be given/ deducted if no bubble is filled. Keep a timer in front of you and stop immediately at the end of 60 min.
- The sheet follows a particular syllabus. Do not attempt the sheet before you have completed your preparation for that syllabus. Refer syllabus sheet in the starting of the book for the syllabus of all the DPP sheets.
- After completing the sheet check your answers with the solution booklet and complete the Result Grid. Finally spend time to analyse your performance and revise the areas which emerge out as weak in your evaluation.

DIRECTIONS (Q.1-Q.19) : There are 19 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which ONLY ONE choice is correct.

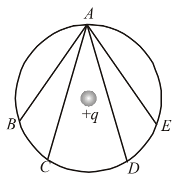
Q1. In the electric field of a point charge q, a certain charge is carried from point A to B, C, D and E. Then the work done by electric force is

(a) least along the path AB

(b) least along the path AD

(c) zero along all the paths AB, AC, AD and AE

(d) least along AE



Q2. Four equal charges Q are placed at the four corners of a square of each side 'a'. Work done in removing a charge $-Q$ from its centre to infinity is

(a) 0 (b) $\frac{\sqrt{2}Q^2}{4\pi\epsilon_0 a}$ (c) $\frac{\sqrt{2}Q^2}{\pi\epsilon_0 a}$ (d) $\frac{Q^2}{2\pi\epsilon_0 a}$

Q3. A particle A has charge $+q$ and a particle B has charge $+4q$ with each of them having the same mass m. When allowed to fall from rest through the same electric potential difference, the ratio of their speed $\frac{v_A}{v_B}$ will become

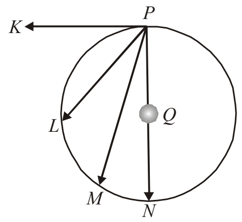
(a) 2 : 1 (b) 1 : 2

(c) 1 : 4 (d) 4 : 1

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ

Space for Rough Work

Q4. In the figure the charge Q is at the centre of the circle. Work done (by electrostatic force on q) is maximum when another charge q is taken from point P to (consider both the charges to be positive)



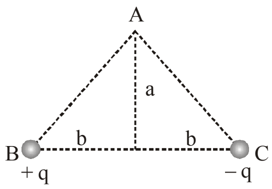
(a) K (b) L (c) M (d) N

Q5. How much kinetic energy will be gained by an α- particle in going from a point at 70V to another point at 50V ?
(a) 40 eV (b) 40 keV (c) 40 MeV (d) 0 eV

Q6. Ten electrons are equally spaced and fixed around a circle of radius R. Relative to $V = 0$ at infinity, the electrostatic potential V and the electric field E at the centre C are
(a) $V \neq 0$ and $\vec{E} \neq 0$ (b) $V \neq 0$ and $\vec{E} = 0$
(c) $V = 0$ and $\vec{E} = 0$ (d) $V = 0$ and $\vec{E} \neq 0$

Q7. The displacement of a charge Q in the electric field $\vec{E} = e_1\hat{i} + e_2\hat{j} + e_3\hat{k}$ is $\vec{r} = a\hat{i} + b\hat{j}$. The work done is
(a) $Q(ae_1 + be_2)$ (b) $Q\sqrt{(ae_1)^2 + (be_2)^2}$
(c) $Q(e_1 + e_2)\sqrt{a^2 + b^2}$ (d) $Q\left(\sqrt{e_1^2 + e_2^2}\right)(a+b)$

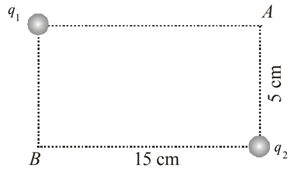
Q8. As shown in the figure, charges $+q$ and $-q$ are placed at the vertices B and C of an isosceles triangle. The potential at the vertex A is



(a) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{2q}{\sqrt{a^2+b^2}}$
(b) Zero
(c) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{\sqrt{a^2+b^2}}$
(d) $\frac{1}{4\pi\varepsilon_0}\cdot\frac{(-q)}{\sqrt{a^2+b^2}}$

Q9. Two electric charges $12\,\mu C$ and $-6\,\mu C$ are placed 20 cm apart in air. If there will be a point P on the line joining these charges and outside the region between them, at which the electric potential is zero, then the distance of P from $-6\,\mu C$ charge is
(a) 0.10 m (b) 0.15 m (c) 0.20 m (d) 0.25 m

Q10. In the rectangle shown below, the two corners have charges $q_1 = -5\ \mu C$ and $q_2 = +2.0\ \mu C$. The work done by external agent in moving a charge $q = +3.0\ \mu C$ slowly from B to A is (Take $1/4\pi\varepsilon_0 = 10^{10}\,Nm^2/C^2$)



(a) 2.8 J
(b) 3.5 J
(c) 4.5 J
(d) 5.5 J

Q11. Electric charges q, q, $-2q$ are placed at the corners of an equilateral triangle ABC of side l. The magnitude of electric dipole moment of the system is
(a) ql (b) $2ql$ (c) $\sqrt{3}ql$ (d) $4ql$

Q12. A charge (–q) and another charge (+Q) are kept at two points A and B respectively. Keeping the charge (+Q) fixed at B, the charge (–q) at A is moved to another point C such that ABC forms an equilateral triangle of side l. The net work done by electrostatic field in moving the charge (–q) is
(a) $\frac{1}{4\pi\epsilon_0}\frac{Qq}{l}$ (b) $\frac{1}{4\pi\epsilon_0}\frac{Qq}{l^2}$
(c) $\frac{1}{4\pi\epsilon_0}Qql$ (d) zero

Q13. In an hydrogen atom, the electron revolves around the nucleus in an orbit of radius 0.53×10^{-10}m. Then the electrical potential produced by the nucleus at the position of the electron is
(a) –13.6V (b) –27.2V (c) 27.2V (d) 13.6V

Q14. Point charge $q_1 = 2\mu C$ and $q_2 = -1\mu C$ are kept at points $x = 0$ and $x = 6$ respectively. Electrical potential will be zero at points
(a) $x = 2$ and $x = 9$ (b) $x = 1$ and $x = 5$
(c) $x = 4$ and $x = 12$ (d) $x = -2$ and $x = 2$

RESPONSE GRID					
	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ
	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ
	14. ⓐⓑⓒⓓ				

Space for Rough Work

Q15. The distance between H^+ and Cl^- ions in HCl molecule is 1.28 Å. What will be the potential due to this dipole at a distance of 12 Å on the axis of dipole

(a) 0.13 V (b) 1.3 V (c) 13 V (d) 130 V

Q16. Two identical thin rings each of radius R metres are coaxially placed at a distance R metres apart. If Q_1 coulomb and Q_2 coulomb are respectively the charges uniformly spread on the two rings, the work done by external agent in moving a charge q slowly from the centre of ring with charge Q_1 to that of other is

(a) zero (b) $\frac{q(Q_2-Q_1)(\sqrt{2}-1)}{\sqrt{2}.4\pi\epsilon_0 R}$

(c) $\frac{q\sqrt{2}(Q_1+Q_2)}{4\pi\epsilon_0 R}$ (d) $\frac{q(Q_1+Q_2)(\sqrt{2}+1)}{4\pi\epsilon_0 R}$

Q17. Identical point charges, each having $+q$ charge, are fixed at each of the points $x=x_0, x=3x_0,\ x=5x_0$ .... infinite, on the x-axis and a identical point charges, each having $-q$ charge, are fixed at each of the points $x=2x_0, x=4x_0, x=6x_0$ .... infinite. Here x_0 is a positive constant. Potential at the origin due to the above system of charges is

(a) 0 (b) $\frac{q}{8\pi\epsilon_0 x_0 \ln 2}$

(c) ∞ (d) $\frac{q\ln 2}{4\pi\epsilon_0 x_0}$

Q18. A uniform electric field pointing in positive x - direction exists in a region. Let A be the origin, B be the point on the $x-$axis at $x=+1$ cm and C be the point on the $y-$axis at $y=+1$ cm. Then the potentials at the points A, B and C satisfy

(a) $V_A < V_B$ (b) $V_A > V_B$ (c) $V_A < V_C$ (d) $V_A > V_C$

Q19. A point Q lies on the perpendicular bisector of an electrical dipole of dipole moment p. If the distance of Q from the dipole is r (much larger than the size of the dipole), then electric field at Q is proportional to

(a) P^{-1} and r^{-2} (b) p and r^{-2}

(c) P^2 and r^{-3} (d) p and r^{-3}

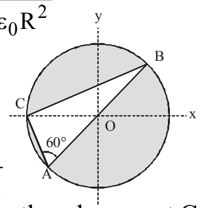
DIRECTIONS (Q.20-Q.21) : In the following questions, more than one of the answers given are correct. Select the correct answers and mark it according to the following codes:

Codes :

(a) 1, 2 and 3 are correct **(b)** 1 and 2 are correct

(c) 2 and 4 are correct **(d)** 1 and 3 are correct

Q20. Consider a system of three charges $\frac{q}{3}, \frac{q}{3}$ and $-\frac{2q}{3}$ placed at point A, B and C respectively, as shown in the figure. Take O to be the centre of the circle of radius R and angle CAB = 60°. Choose the **incorrect** options



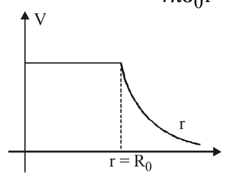
(1) The electric field at point O is $\frac{q}{8\pi\varepsilon_0 R^2}$ directed along the negative x-axis

(2) The potential energy of the system is zero

(3) The potential at point O is $\frac{q}{12\pi\varepsilon_0 R}$

(4) The magnitude of the force between the charges at C and B is $\frac{q^2}{54\pi\varepsilon_0 R^2}$

Q21. For spherical symmetrical charge distribution, variation of electric potential with distance from centre is given in diagram. Given that : $V=\frac{q}{4\pi\varepsilon_0 R_0}$ for $r \le R_0$ and $V=\frac{q}{4\pi\varepsilon_0 r}$ for $r \ge R_0$



Then which option (s) are correct :

(1) Total charge within $2R_0$ is q

(2) Total electrostatic energy for $r \le R_0$ is non-zero

(3) At $r = R_0$ electric field is discontinuous

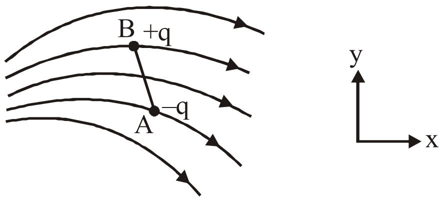
(4) There will be no charge anywhere except at $r < R_0$.

DIRECTIONS (Q.22-Q.23) : Read the passage given below and answer the questions that follows :

An electric dipole (AB) consisting of two particles of equal and opposite charge and same mass is released in an electric field. In the figure field lines are without considering effect of field of dipole.

RESPONSE GRID					
	15. ⓐⓑⓒⓓ	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ	19. ⓐⓑⓒⓓ
	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ			

Space for Rough Work



Q22. The centre of mass of the dipole
- (a) Has no acceleration
- (b) Has acceleration with positive x and y components
- (c) Has acceleration with positive x component and negative y component
- (d) Has acceleration with negative x component and positive y component

Q23. Angular acceleration of the dipole, immediately after it is released
- (a) is zero
- (b) is clockwise
- (c) is anticlockwise
- (d) cannot be determined from the given information.

DIRECTIONS (Q. 24-Q.26) : Each of these questions contains two statements: Statement-1 (Assertion) and Statement-2 (Reason). Each of these questions has four alternative choices, only one of which is the correct answer. You have to select the correct choice.

- (a) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
- (b) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.
- (c) Statement -1 is False, Statement-2 is True.
- (d) Statement -1 is True, Statement-2 is False.

Q24. Statement -1 : A bird perches on a high power line and nothing happens to the bird.
Statement -2 : The level of bird is very high from the ground.

Q25. Statement -1 : Electrons move away from a low potential to high potential region.
Statement- 2 : Because electrons have negative charge

Q26. Statement -1 : Surface of a symmetrical conductor can be treated as equipotential surface.
Statement -2 : Charges can easily flow in a conductor.

RESPONSE GRID					
	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ	26. ⓐⓑⓒⓓ

DAILY PRACTICE PROBLEM SHEET 33 - PHYSICS			
Total Questions	26	Total Marks	104
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	26	Qualifying Score	42
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

Space for Rough Work

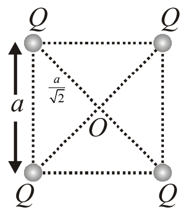
DAILY PRACTICE PROBLEMS

PHYSICS SOLUTIONS

33

1. **(c)** *ABCDE* is an equipotential surface, on equipotential surface no work is done in shifting a charge from one place to another.

2. **(c)** Potential at centre O of the square



$$V_0 = \left(\frac{Q}{4\pi\varepsilon_0(a/\sqrt{2})}\right)$$

Work done in shifting (– Q) charge from centre to infinity

$$W = -Q(V_\infty - V_0) = QV_0$$

$$= Q.\frac{4\sqrt{2}Q}{4\pi\varepsilon_0 a} = \frac{\sqrt{2}Q^2}{\pi\varepsilon_0 a}$$

3. **(b)** Using

$$v = \sqrt{\frac{2QV}{M}} \Rightarrow v \propto \sqrt{Q} \Rightarrow \frac{v_A}{v_B} = \sqrt{\frac{Q_A}{Q_B}} = \sqrt{\frac{q}{4q}} = \frac{1}{2}$$

4. **(a)** Work done in moving a charge from P to L, P to M and P to N is zero while it is $q\,(V_P - V_k) > 0$ for motion from P to k.

5. **(a)** $KE = q(V_1 - V_2) = 2\times(70-50)\Omega = 40\ eV$

6. **(a)** The electric potential $V(x,y,z) = 4x^2\ volt$

Now $\vec{E} = -\left(\hat{i}\frac{\partial V}{\partial x} + \hat{j}\frac{\partial V}{\partial y} + \hat{k}\frac{\partial V}{\partial z}\right)$

Now $\frac{\partial V}{\partial x} = 8x, \frac{\partial V}{\partial y} = 0$ and $\frac{\partial V}{\partial z} = 0$

Hence $\vec{E} = -8\hat{i}$, so at point $(1m, 0, 2m)$

$\vec{E} = -8x\hat{i}$ *volt/meter* or 8 along negative X - axis.

7. **(b)** Electric fields due to electrons on same line passing through centre cancel each other while electric potential due to each electron is negative at centre C. Therefore, at centre $\vec{E} = 0, V \pm 0$

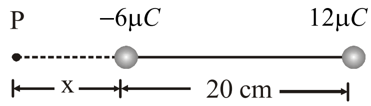
8. **(a)** By using $W = Q(\vec{E}.\Delta\vec{r})$

$$\Rightarrow W = Q[(e_1\hat{i} + e_2\hat{j} + e_3\hat{k}).(a\hat{i} + b\hat{j})] = Q(e_1 a + e_2 b)$$

9. **(b)** Potential at A= Potential due to $(+q)$ charge + Potential due to (– q) charge

$$= \frac{1}{4\pi\varepsilon_0}.\frac{q}{\sqrt{a^2+b^2}} + \frac{1}{4\pi\varepsilon_0}\frac{(-q)}{\sqrt{a^2+b^2}} = 0$$

10. **(c)** Point P will lie near the charge which is smaller in magnitude *i.e.* $-6\mu C$. Hence potential at P



$$V = \frac{1}{4\pi\varepsilon_0}\frac{(-6\times10^{-6})}{x} + \frac{1}{4\pi\varepsilon_0}\frac{(12\times10^{-6})}{(0.2+x)} = 0 \Rightarrow x = 0.2m$$

11. **(a)** Work done $W = q^{-6}(V_A - V_B)$; where

$q = 3\times10^{-6}$ coulomb where

$$V_A = 10^{10}\left[\frac{(-5\times10^{-6})}{15\times10^{-2}} + \frac{2\times10^{-6}}{5\times10^{-2}}\right] = \frac{1}{15}\times10^6\ volt$$

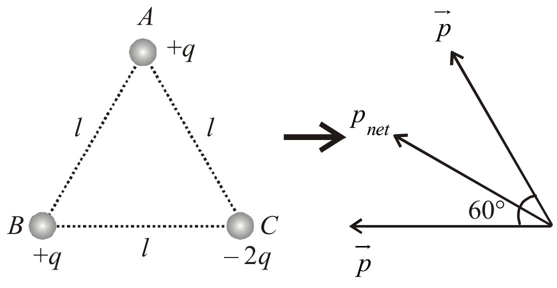
and $V_B = 10^{10}\left[\frac{(2\times10^{-6})}{15\times10^{-2}} - \frac{5\times10^{-6}}{5\times10^{-2}}\right]$

$$= -\frac{13}{15}\times10^6\ volt$$

$$\therefore W = 3\times10^{-6}\left[\frac{1}{15}\times10^6 - \left(\frac{13}{15}\times10^6\right)\right]$$

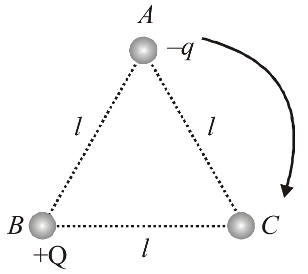
$= 2.8$ J

12. **(c)**



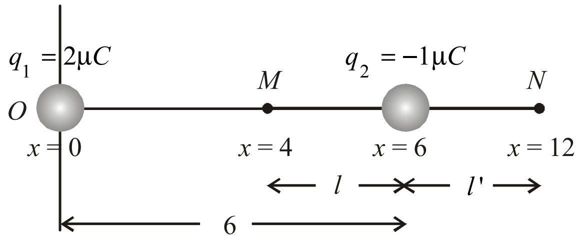
$$P_{net} = \sqrt{p^2 + p^2 + 2pp\cos 60^\circ} = \sqrt{3}p = \sqrt{3}\,ql(\because p = ql)$$

13. **(d)** According to figure, potential at A and C are both equal to kQ. Hence work done in moving $-q$ charge from A to C $= -q(V_A - V_C) = 0$



14. **(c)** $V = k \times \frac{Q}{r} = 9\times10^9 \times \frac{(+1.6\times10^{-19})}{0.53\times10^{-10}} = 27.2V$

15. **(c)** Potential will be zero at two points



At internal point (M) :

$$\frac{1}{4\pi\varepsilon_0}\times\left[\frac{2\times10^{-6}}{(6-l)}+\frac{(-1\times10^{-6})}{l}\right]=0$$

$\Rightarrow l = 2$

So distance of M from origin;

$x = 6 - 2 = 4$

At exterior point (N):

$$\frac{1}{4\pi\varepsilon_0}\times\left[\frac{2\times10^{-6}}{(6-l')}+\frac{(-1\times10^{-6})}{l'}\right]=0$$

$\Rightarrow l' = 6$

So distance of N from origin, $x = 6 + 6 = 12$

16. **(a)** $V = V_{AB} + V_{BC} + V_{CD}$

$$= \frac{k.5Q_0}{R} + \frac{k.(-2Q_0)}{R} + \frac{k.(3Q_0)}{R}$$

$$= \frac{6kQ_0}{R}$$

$$= \frac{3Q_0}{2\pi\in_0 R}$$

17. **(a)** $V = 9\times10^9 . \frac{p}{r^2}$

$$= 9\times10^9 \times \frac{(1.6\times10^{-19})\times1.28\times10^{-10}}{(12\times10^{-10})^2} = 0.13V$$

18. **(b)** $W = q(V_{02} - V_{01})$

where $V_{01} = \frac{Q_1}{4\pi\varepsilon_0 R} + \frac{Q_2}{4\pi\varepsilon_0 R\sqrt{2}}$

and $V_{02} = \frac{Q_2}{4\pi\varepsilon_0 R} + \frac{Q_1}{4\pi\varepsilon_0 R\sqrt{2}}$

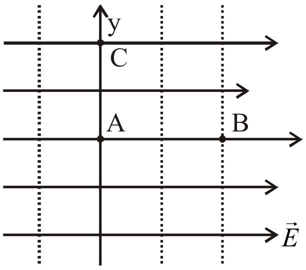
$$\Rightarrow W = q(V_{02} - V_{01}) = \frac{q(Q_2 - Q_1)}{4\pi\varepsilon_0 R}\frac{(\sqrt{2}-1)}{\sqrt{2}}$$

19. **(d)** $V = \frac{q}{4\pi\varepsilon_0 x_0}\left[1+\frac{1}{3}+\frac{1}{5}+...\right] - \frac{q}{4\pi\varepsilon_0 x_0}\left[\frac{1}{2}+\frac{1}{4}+\frac{1}{6}+...\right]$

$$= \frac{q}{4\pi\varepsilon_0 x_0}\left[1-\frac{1}{2}+\frac{1}{3}-\frac{1}{4}+...\right] = \frac{q}{4\pi\varepsilon_0 x_0}\log_e 2$$

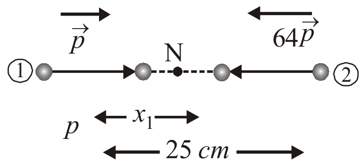
20. **(b)** Potential decreases in the direction of electric field. Dotted lines are equipotential surfaces

$\therefore V_A = V_C$ and $V_A > V_B$



21. **(d)** $E_{equatorial} = \frac{kp}{r^3}$ i.e. $E \propto p$ and $E \propto r^{-3}$

22. **(a)** Suppose neutral point N lies at a distance x from dipole of moment p or at a distance x^2 from dipole of 64 p.



At N |E.F. due to dipole①| = |E.F. due to dipole②|

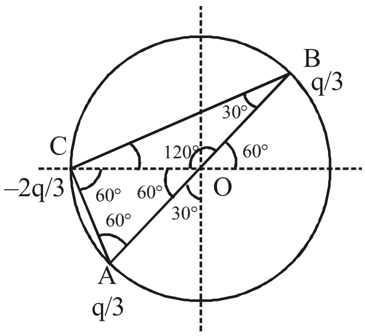
$$\Rightarrow \frac{1}{4\pi\varepsilon_0}.\frac{2p}{x^3} = \frac{1}{4\pi\varepsilon_0}.\frac{2(64p)}{(25-x)^3}$$

$$\Rightarrow \frac{1}{x^3} = \frac{64}{(25-x)^3} \Rightarrow x = 5 \text{ cm.}$$

23. **(a).** $BC = 2R\sin\left(\frac{120}{2}\right) = \sqrt{3}R$

Electric field at O $= \frac{1}{4\pi\varepsilon_0 R}\left(\frac{2q/3}{R^2}\right) = \frac{q}{6\pi\varepsilon_0 R^2}$

along negative X-axis.



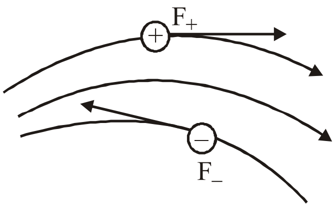
The potential energy of the system is non zero
Force between B & C

$$= \left| \frac{1}{4\pi\varepsilon_0} \frac{(q/3)(-2q/3)}{(\sqrt{3}R)^2} \right| = \frac{q^2}{54\pi\varepsilon_0 R^2}$$

Potential at $O = \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{3}+\frac{q}{3}-\frac{2q}{3}\right) = 0$

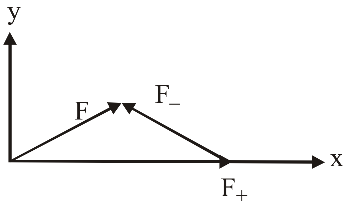
24. (d) The given graph is of charged conducting sphere of radius R_0. The whole charge q distributes on the surface of sphere

25 (b), 26 (b), 27 c



$(F_+ > F_- \text{ as } E_+ > E_-)$

Net force F :



Net torque immediately after it is released ⇒ clockwise
A body cannot exert force on itself.

28. **(d)** When the bird perches on a single high power line, no current passes through its body because its body is at equipotential surface i.e., there is no potential difference. While when man touches the same line, standing bare foot on ground the electrical circuit is completed through the ground. The hands of man are at high potential and his feet's are at low potential. Hence large amount of current flows through the body of the man and person therefore gets a fatal shock.

29. **(a)** Electron has negative charge, in electric field negative charge moves from lower potential to higher potential.

30. **(b)** Potential is constant on the surface of a sphere so it behaves as an equipotential surface. Free charges (electrons) are available in conductor. The two statements are independent.