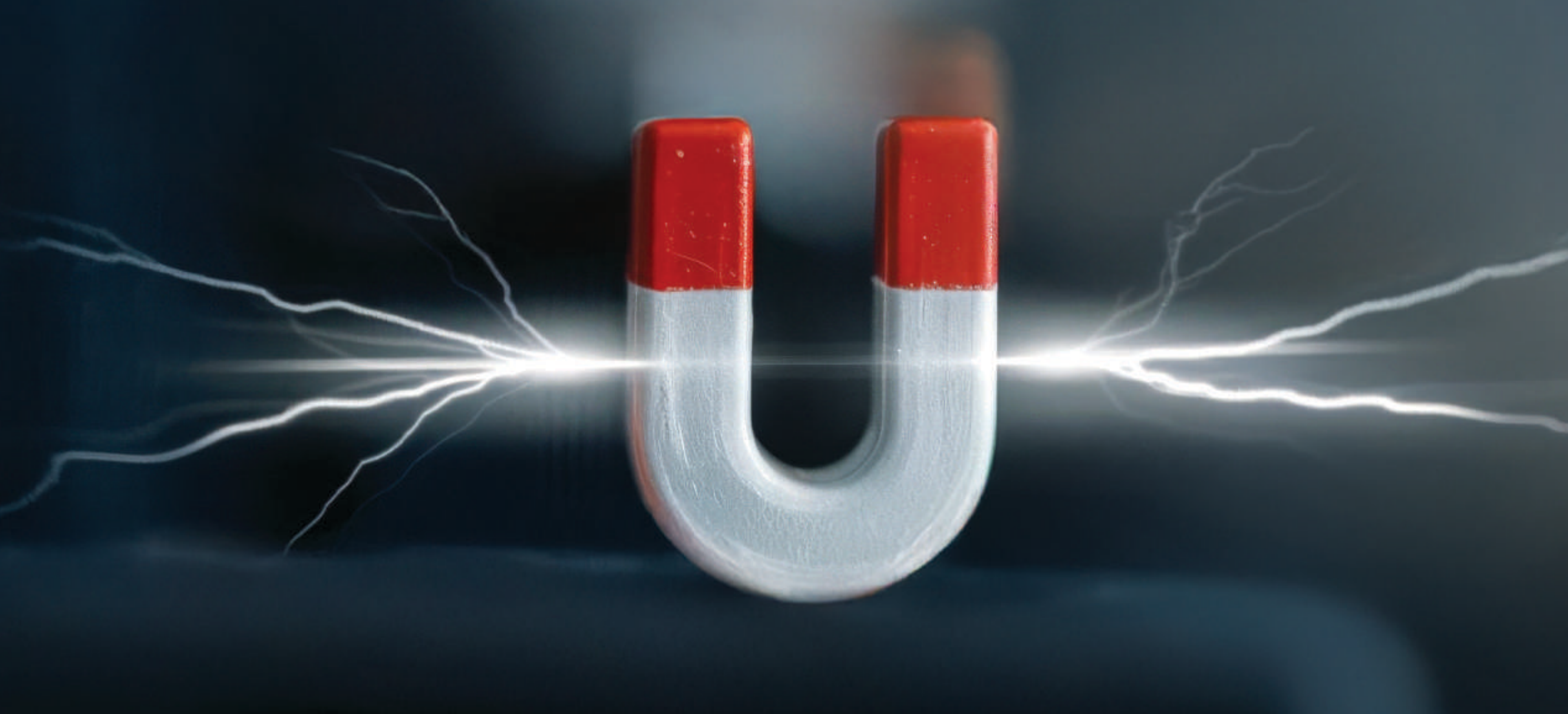
SPRINT

CRASH COURSE FOR NEET



Class XII

PHYSICS

CONTENTS

CHAPTER

1

Electrical Charges and Fields

- **Electric charge** is the property associated with a body or a particle due to which it is able to produce as well as experience the electric effects.

COULOMB'S LAW AND FORCE DUE TO MULTIPLE CHARGES

- $F = \frac{1}{4\pi \in_0 \in_r} \frac{q_1 q_2}{d^2}$

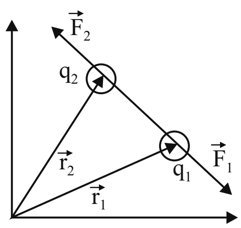
  $\in_0$ - permittivity of free space or vacuum or air.

  $\in_r$ - Relative permittivity or dielectric constant of the medium in which the charges are situated. $\in_r = \frac{\in}{\in_0}$

- $\in_0 = 8.857 \times 10^{-12} \frac{C^2}{Nm^2}$ or $\frac{\text{farad}}{\text{metre}}$,

  and $\frac{1}{4\pi \in_0} = 9 \times 10^9 \, Nm^2/C^2$

- Suppose the position vector of two charges q_1 and q_2 are $\vec{r_1}$ and $\vec{r_2}$, then electric force on charge q_1 due to q_2 is,



$$\vec{F_1} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{\left|\vec{r_2} - \vec{r_1}\right|^3} \left(\vec{r_1} - \vec{r_2}\right)$$

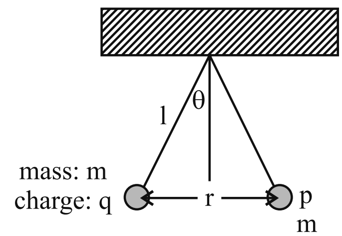
Similarly, electric force on q_2 due to charge q_1 is

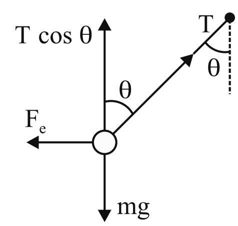
$$\vec{F_2} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{\left|\vec{r_2} - \vec{r_1}\right|^3} \left(\vec{r_2} - \vec{r_1}\right)$$

Here q_1 and q_2 are to be substituted with sign.

IDENTICAL CHARGES SUSPENDED FROM A COMMON POINT

Two small bodies are suspended from a common point by two strings both are equally charged and have the same mass m.





Using Coulomb's law

$F_e = k_c(qq/r^2)$

where $k_c = 9 \times 10^9 \, Nm^2/C^2$

Therefore

$k_c (qq / r^2) = mg \tan (\theta)$

If we wish to determine the charge on the bodies.

Equating the horizontal and vertical components of the forces,

$$k_c \frac{qq}{r^2} = mg \tan\theta$$

$$q = r\sqrt{\frac{mg \tan\theta}{k_c}}$$

ELECTRIC FIELD

- The space around an electric charge where the electric influence is felt is known as electric field.
- Electric field is a conservative field.

Motion of a Charged Particle in a Uniform Electric Field

A charged body of mass 'm' and charge 'q' is initially at rest in a uniform electric field of intensity E. The force acting on it is given by $F = Eq$.

- ❖ Here the direction of F is towards the direction of electric field if 'q' is +ve and opposite to the field if 'q' is –ve.
- ❖ The body travels in a straight line path with uniform acceleration, $a = \frac{F}{m} = \frac{Eq}{m}$ and initial velocity u = 0.

  At an instant of time t.

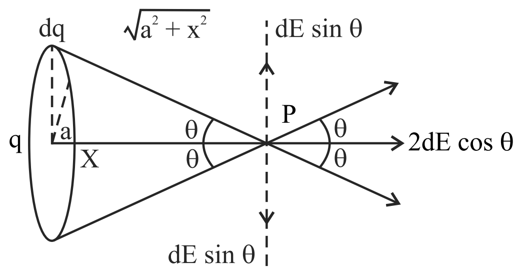
  Its final velocity, $v = u + at = \left(\frac{Eq}{m}\right)t$

  Displacement $s = ut + \frac{1}{2}at^2 = \frac{1}{2}\left(\frac{Eq}{m}\right)t^2$

  Momentum, $P = mv = (Eq)t$ $[\because mv = F \times t]$

  Kinetic energy, $K.E = \frac{1}{2}mv^2 = \frac{1}{2}\left(\frac{E^2q^2}{m}\right)t^2$

Electric Field at the Axis of a Circular Uniformly Charged Ring



Intensity of electric field at a point P that lies on the axis of the ring at a distance x from its centre is $E = \frac{1}{4\pi\varepsilon_0}\frac{qx}{\left(x^2 + R^2\right)^{3/2}}$

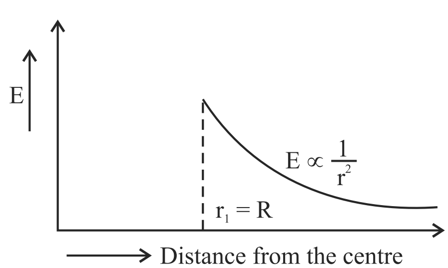
Where R is the radius of the ring. The electric field is maximum at $x = \pm\frac{R}{\sqrt{2}}$

Electric Field due to a Charged Spherical Conductor (Spherical Shell)

- ❖ Outside the shell: $E = \frac{1}{4\pi\epsilon_0} \times \frac{q}{r^2}$

  On the shell: $E = \frac{\sigma}{\epsilon_0} = \frac{1}{4\pi\epsilon_0}\frac{q}{R^2}$

  Inside the shell: E = 0



Electric Field due to a Uniformly Charged Non–conducting Sphere

At any point inside the sphere:

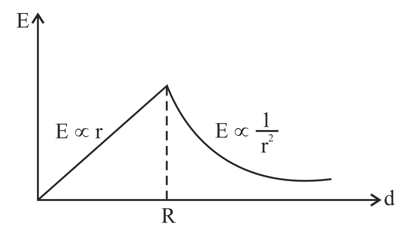
$$E = \frac{1}{4\pi\varepsilon_0}\frac{Qr}{R^3} \text{ for } r < R$$

On the surface of the sphere:

$$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{R^2}$$

At any point outside the sphere:

$$E = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}$$



ELECTRIC DIPOLE

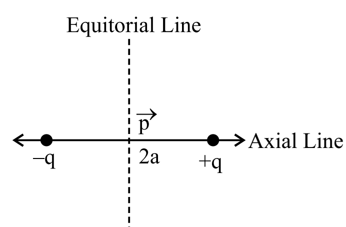
An electric dipole is a pair of equal and opposite point charges q and $-q$ separated by a distance $2a$.

Electric Dipole Moment ($\vec{p}$)

It is defined as the product of magnitude of either charge and the distance between the two charges.

$\vec{p} = q(2\vec{a})$

Dipole moment $\vec{p}$ always points from –q to +q.



Electric Dipole

Electric Field due to a Dipole at a Point Lying on the Axial Line (End on Position)

$$E_{axial} = \frac{1}{4\pi\varepsilon_0}\frac{2pr}{\left(r^2 - a^2\right)^2}$$

Direction of the electric field is in the direction of the dipole moment.

In case of a short dipole ($r >> a$).

$$E_{axial} = \frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}$$

Electric Field due to a Dipole at a Point Lying on the Equatorial Line (Broad side on Position)

$$E_{\text{equatorial}} = \frac{1}{4\pi\varepsilon_0}\frac{p}{\left(r^2+a^2\right)^{3/2}}$$

Direction of the electric field is opposite to the direction of dipole moment.

In case of short dipole ($r >> a$),

$$E_{\text{equatorial}} = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^3}$$

Electric Field due to a Short Dipole at any Point

Which is at a distance r from the dipole

$$E = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^3}\sqrt{1+3\cos^2\theta}$$

Torque on a Dipole Placed in a Uniform Electric Field

$$\vec{\tau} = \vec{p}\times\vec{E}$$

$\Rightarrow \tau = pE\sin\theta$, it is maximum for $\theta = 90°$ & minimum for $\theta = 0, 180°$

Potential Energy of a Dipole Placed in a Uniform Electric Field

The potential energy of a dipole in a uniform electric field is $U = -PE\cos\theta$

$\Rightarrow U = -\vec{P}.\vec{E}$

GAUSS'S LAW

According to Gauss's law, "the net electric flux through any closed surface is equal to the net charge enclosed by it divided by ε_0". Mathematically, it can be written as

$$\phi_E = \oint \vec{E}\cdot\overrightarrow{dS} = \frac{q}{\varepsilon_0}$$

If electric charge is placed inside a gaussion surface then the electric flux coming out of the surface can be calculated using the equation.

$$\phi_E = \oint \vec{E}\cdot\overrightarrow{dS} = \frac{q}{\varepsilon_0}$$

Where, E is the electric field and dS is the surface area.

Continuous Charge Distribution

Linear charge distribution: $\lambda = \frac{q}{\ell}$

Where λ = linear charge density.

Surface charge distribution: $\sigma = \frac{q}{A}$

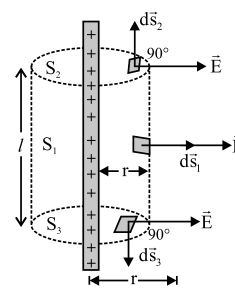
where σ = surface charge density.

Volume charge distribution: $\rho = \frac{q}{V}$

where ρ = volume charge density.

Applications of Gauss's Law

1. Electric field due to an infinitely long charged wire.



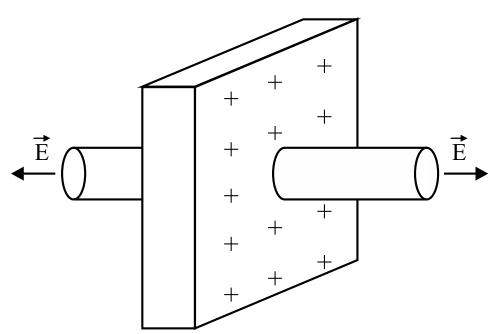
Using Gauss law, $\phi_E = \oint \vec{E}\cdot\overrightarrow{dS} = \frac{q}{\varepsilon_0}$

$$E.2\pi rl = \frac{\lambda l}{\varepsilon_0}$$

$$\Rightarrow E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

2. Electric field due to thin conducting sheet $\vec{E} = \frac{\sigma}{2\varepsilon_0}$, where σ is charge per unit area.

3. Electric field due to thick conducting sheet is $\vec{E} = \frac{\sigma}{\varepsilon_0}$.



LEVEL-1

1. Electric charge of any system is
   (*a*) Zero or neutral
   (*b*) Half integral multiple of the least amount of charge
   (*c*) Integral multiple of least amount of charge
   (*d*) One third of the least amount of charge

2. An electric dipole of moment p is placed in the position of stable equilibrium in uniform electric field of intensity E. This is rotated through an angle θ from the initial position. The potential energy of the electric dipole in the final position is
   (*a*) – pE cos θ (*b*) pE (1 – cos θ)
   (*c*) pE cos θ (*d*) pE sin θ

3. Two charged particles having charge 2×10^{-8}C each are joined by an insulating string of length 1m and the system is kept on a smooth horizontal table, what is the tension in the string?
   (*a*) 3.6×10^{-6}N (*b*) 4.5×10^{-6}N
   (*c*) 4×10^{-7}N (*d*) 3×10^{-4}N

4. How many electrons must be removed from a piece of metal to give it a positive charge of 1×10^{-7}C?
   (*a*) 6.25×10^{-11}
   (*b*) 6.25×10^{-12}
   (*c*) 6.25×10^{11}
   (*d*) 6.25×10^{13}

5. Three charges q_1, q_2, q_3 each equal to q are placed at the vertices of an equilateral triangle of side ℓ. What will be the force on a charge Q placed at the centroid of triangle?
   (*a*) 4N (*b*) 5N
   (*c*) 10N (*d*) Zero

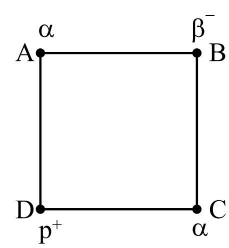
6. Which one of the following is not a property of electrostatic field lines?
   (*a*) Two lines cannot cross each other
   (*b*) Field line starts from negative and ends at positive charge
   (*c*) They cannot form closed loop
   (*d*) None of the above

7. Pick the correct statement from the following
   (*a*) If a point has a charge then the electric field is continuous at the point
   (*b*) Continuous electric field at every point
   (*c*) Continuous electric field at a point if a charge is present at the point
   (*d*) Electric field is discontinuous if a negative charge is present at a point

8. Electric field at the equator of a dipole is E. If strength and distance is now doubled then the electric field will be
   (*a*) E/2 (*b*) E/8
   (*c*) E/4 (*d*) E

9. An electron of mass m and charge q is accelerated from rest in a uniform electric field of strength E. The velocity acquired by it as it travels a distance ℓ is
   (*a*) $\sqrt{\frac{2Eq\ell}{m}}$ (*b*) $\sqrt{\frac{2E\ell}{m\ell}}$
   (*c*) $\sqrt{\frac{2Em}{q\ell}}$ (*d*) $\sqrt{\frac{Eq}{m\ell}}$

10. Four charged particles are placed at the vertices of square as shown in the figure. An electron that is free to move is placed at the exact centre of the square. In which direction will the electron move?



   (*a*) It will move toward A (*b*) It will move toward B
   (*c*) It will move toward C (*d*) It will move toward D

11. The electric field inside a spherical shell of uniform surface charge density is
   (*a*) Zero
   (*b*) Constant less than zero
   (*c*) Directly proportional to the distance from the centre
   (*d*) None of the above

12. An electric charge q is placed at the center of a cube of side ℓ. The electric flux on one of its faces will be
   (*a*) $\frac{6q}{\varepsilon_o}$ (*b*) $\frac{q}{\varepsilon_o}$
   (*c*) $\frac{q}{6\varepsilon_o}$ (*d*) $\frac{2}{3}\frac{q}{\varepsilon_o}$

13. Five electric dipoles of charge 'q' each are placed into the shell. What will be the amount of electric flux associated with shell?
   (*a*) $5q\varepsilon_o$ (*b*) $\frac{10q}{\varepsilon_o}$
   (*c*) Zero (*d*) $\frac{5q}{\varepsilon_o}$

14. In a region, the intensity of an electric field is given by $E = 8\hat{i} + 8\hat{j} + \hat{k}$ in NC^{-1}. The electric flux through a surface S = $10\hat{i}$ m^2 in the region is

(*a*) 10 Nm^2C^{-1} (*b*) 80 Nm^2C^{-1}
(*c*) 8 Nm^2C^{-1} (*d*) None

15. A charge q is located at the center of a cube. The electric flux through any two consecutive faces will be

(*a*) $\frac{\pi q}{6(4\pi\varepsilon_o)}$ (*b*) $\frac{q}{6(4\pi\varepsilon_o)}$
(*c*) $\frac{2\pi q}{6(4\pi\varepsilon_o)}$ (*d*) $\frac{4\pi q}{3(4\pi\varepsilon_o)}$

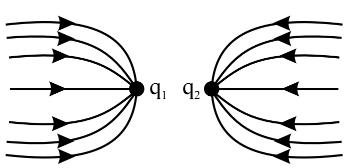
16. Two large metal plates are placed parallel to each other. The inner surfaces of plates are charge by $+\sigma$ and $-\sigma$ (Cm^{-2}). The outer surfaces are neutral. The electric field in the region between the plates and outside the plates is

(*a*) $\frac{2\sigma}{\varepsilon_0}, \frac{\sigma}{\varepsilon_0}$ (*b*) $\frac{\sigma}{\varepsilon_0}$, zero
(*c*) $\frac{2\sigma}{\varepsilon_0}$, zero (*d*) zero, $\frac{2\sigma}{\varepsilon_0}$

17. If the electric flux entering and leaving an enclosed surface respectively are ϕ_1 & ϕ_2 the electric charge inside the surface will be

(*a*) $\frac{\phi_2 - \phi_1}{\varepsilon_o}$ (*b*) $\frac{\phi_2 + \phi_1}{\varepsilon_o}$
(*c*) $(\phi_1 - \phi_2)\,\varepsilon_o$ (*d*) $\varepsilon_o(\phi_2 - \phi_1)$

18. The given figure shows electric lines of force due to two charges q_1 and q_2. What are the signs of the two charges?



(*a*) q_1 is positive but q_2 is negative
(*b*) q_1 is negative but q_2 is positive
(*c*) Both are negative
(*d*) Both are positive

19. A charge q is placed in an uniform electric field E. If it is released, then the K.E. of the charge after travelling distance y will be

(*a*) qEy (*b*) 2qEy
(*c*) $\frac{eEy}{2}$ (*d*) $\sqrt{eEy}$

20. Two identical spheres with charges 4q, –2q kept some distance apart exert a force F on each other. If they are made to touch each other and replaced at their old positions, the force between them will be

(*a*) $\frac{1}{8}$F (*b*) $\frac{9}{8}$F
(*c*) $\frac{8}{9}$F (*d*) $\frac{1}{9}$F

21. One million electrons are added to a glass rod. The total charge on the rod is

(*a*) 10^{-13} C (*b*) -1.6×10^{-13} C
(*c*) $+1.6 \times 10^{-12}$ C (*d*) 10^{-12} C

22. A force of 4N is acting between two charges in air. If the space between them is completely filled with glass ($\varepsilon_r = 8$), then the new force will be

(*a*) 2N (*b*) 5N
(*c*) 0.2N (*d*) 0.5N

23. Two identical metal spheres possess +60C and –20C of charges. They are brought in contact and then separated by 10 cm. The force between them is

(*a*) 36×10^{13} N
(*b*) 36×10^{14} N
(*c*) 36×10^{12} N
(*d*) 3.6×10^{12} N

24. Charges on two spheres are +10μC and –5μC respectively. They experience a force F. If each of them is given an additional charge +2μC then new force between them keeping the same distance is

(*a*) 18F (*b*) $\frac{F}{25}$
(*c*) $\frac{18F}{25}$ (*d*) $\frac{25}{18}$F

25. Total charge Q is broken in two parts Q_1 & Q_2 and they are placed at a distance R from each other. The maximum force of repulsion between them will occur when

(*a*) $Q_2 = \frac{Q}{R},\ Q_1 = Q - \frac{Q}{R}$
(*b*) $Q_2 = \frac{Q}{4},\ Q_1 = Q - \frac{2Q}{R}$
(*c*) $Q_2 = \frac{Q}{4},\ Q_1 = Q - \frac{3Q}{4}$
(*d*) $Q_2 = \frac{Q}{2},\ Q_1 = Q - \frac{Q}{2}$

26. Two charges each of 1μC are at $P\left(2\hat{i} + 3\hat{j} + \hat{k}\right)$m and $Q\left(\hat{i} + \hat{j} - \hat{k}\right)$m. Then the force between them is

(*a*) 100N (*b*) 10N
(*c*) 10^4 dyne (*d*) 100 dyne

27. Two charges of +200μC and –200μC are placed at the corners B and C of an equilateral triangle ABC of side 0.1 m. The force on a charge of 5μC placed at A is

(*a*) 1800 N (*b*) $1200\sqrt{3}$N
(*c*) $600\sqrt{3}$N (*d*) 900 N

28. Two point charges –q and $\frac{q}{2}$ are situated at the origin and at the point (a, 0, 0) respectively. The point along the x-axis where the electric field vanishes is

(*a*) $x=\frac{a}{\sqrt{2}}$ (*b*) $x=\sqrt{2}\,a$

(*c*) $x=\frac{\sqrt{2}\,a}{\sqrt{2}-1}$ (*d*) $x=\frac{\sqrt{2}\,a}{\sqrt{2}+1}$

29. The magnitude of force exerted by a uniform electric field on an electron having mass m_e and proton of mass m_p are represented as F_e and F_p respectively are related as

(*a*) $F_p = F_e$ (*b*) $\frac{F_e}{F_p}=\frac{m_e}{m_p}$

(*c*) $\frac{F_e}{F_p}=\frac{m_p}{m_c}$ (*d*) $\frac{F_e}{F_p}=\frac{m_e^2}{m_p^2}$

30. Two charges of 50μC and 100μC are separated by a distance of 0.6m. The intensity of electric field at a point midway between them is

(*a*) $50\times10^6\ \text{V/m}$ (*b*) $5\times10^6\ \text{V/m}$

(*c*) $10\times10^6\ \text{V/m}$ (*d*) $10\times10^{-6}\ \text{V/m}$

31. Two point charges Q and –3Q are placed some distance apart. If the electric field at the location of Q is $\vec{E}$, the field at the location of -3Q is

(*a*) $\vec{E}$ (*b*) $2\vec{E}$

(*c*) $+\frac{\vec{E}}{3}$ (*d*) $-\frac{\vec{E}}{3}$

32. A mass m carrying a charge q is suspended from a string and placed in a uniform horizontal electric field of intensity E. The angle made by the string with the vertical in the equilibrium position is

(*a*) $\theta=\tan^{-1}\frac{\text{mg}}{\text{Eq}}$ (*b*) $\theta=\tan^{-1}\frac{\text{m}}{\text{Eq}}$

(*c*) $\theta=\tan^{-1}\frac{\text{Eq}}{\text{m}}$ (*d*) $\theta=\tan^{-1}\frac{\text{Eq}}{\text{mg}}$

33. Two charges of 10 μ C and –90 μ C are separated by a distance of 24 cm. Electrostatic field strength from the smaller charge is zero at a distance of

(*a*) 12 cm (*b*) 24 cm

(*c*) 36 cm (*d*) 48 cm

34. A proton of mass 'm' charge 'e' is released from rest in a uniform electric field of strength 'E'. The time taken by it to travel a distance 'd' in the field is

(*a*) $\sqrt{\frac{2de}{mE}}$ (*b*) $\sqrt{\frac{2dm}{Ee}}$

(*c*) $\sqrt{\frac{2dE}{me}}$ (*d*) $\sqrt{\frac{2Ee}{dm}}$

35. A particle of mass m and charge q is thrown at a speed u against a uniform electric field E. How much distance will it travel before coming to rest?

(*a*) $mu^2/2qE$ (*b*) $2mu^2/qE$

(*c*) $mqE/2u^2$ (*d*) mu/qE

36. Two equal and opposite charges of masses m_1 & m_2 are accelerated in a uniform electric field through the same distance. What is the ratio of magnitudes of their accelerations if their ratio of masses is $\frac{m_1}{m_2}=0.5$.

(*a*) $\frac{a_1}{a_2}=0.5$ (*b*) $\frac{a_1}{a_2}=1$

(*c*) $\frac{a_1}{a_2}=2$ (*d*) $\frac{a_1}{a_2}=3$

37. There is an electric field E in x-direction. If the work done in moving a charge of 0.2 C through a distance of 2m along a line making an angle of 60° with x-axis is 4J, the value of E is

(*a*) $2\sqrt{3}$ N/C (*b*) 5 N/C

(*c*) 4 N/C (*d*) 20 N/C

38. A charge of 4×10^{-9}C is distributed uniformly over the circumference of a conducting ring of radius 0.3 m. Calculate the field intensity at a point on the axis of the ring at 0.4m from its center and also at the center?

(*a*) 112N/C, 2N/C (*b*) 112N/C, 3N/C

(*c*) 115.2N/C, Zero (*d*) 113.2N/C, Zero

39. An oil drop having a mass of 4.8×10^{-10}g and charge of 30×10^{-18}C stands still between two charged horizontal plates separated by a distance of 1cm. If now polarity of the plates is changed, instantaneous acceleration of the drop is ($g = 10\ m/s^2$)

(*a*) $10\ m/s^2$ (*b*) $15\ m/s^2$

(*c*) $25\ m/s^2$ (*d*) $20\ m/s^2$

40. A charged oil drop is suspended in uniform field of 3×10^4 V/m. So that it neither falls nor rises. The charge on the drop will be ($m = 9.9\times10^{-15}$ kg) ($g = 10\ m/s^2$)

(*a*) 3.3×10^{-18}C (*b*) 3.2×10^{-18}C

(*c*) 1.6×10^{-18}C (*d*) 4.8×10^{-18}C

41. Electric flux emanating through a surface element ds = $5\,\hat{i}$ placed in an electric field E = $4\hat{i}+4\hat{j}+4\hat{k}$ is

(*a*) 10 units (*b*) 20 units

(*c*) 4 units (*d*) 16 units

42. A ball having a charge –100e is placed at the centre of a hollow spherical shell which has a net charge of –20e. What is the charge on the shell's outer surface?

(*a*) + 80e (*b*) –20e

(*c*) –100e (*d*) –120e

43. A sphere S_1 of radius R, encloses a total charge q. If there is another concentric sphere S_2 of radius 2R and there be no additional charges between S_1 and S_2. What is the ratio of electric flux through S_1 and S_2?

(*a*) 1.5 (*b*) 2
(*c*) 1 (*d*) 0.5

44. An electric dipole is along a uniform electric field. If it is deflected by 60°, work done by an agent is 2×10^{-19} J. Then the work done by an agent if it is deflected by 30° further is

(*a*) 2.5×10^{-19} J (*b*) 2×10^{-19} J
(*c*) 4×10^{-19} J (*d*) 2×10^{-16} J

45. An electric dipole is placed along the x-axis at the origin O. A point P is at a distance of 20 cm from this origin such that OP makes an angle $\pi/3$ with the x-axis. If the electric field at point P makes an angle θ with the x-axis the value of θ would be

(*a*) $\pi/3$ (*b*) $2\pi/3$
(*c*) $\tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$ (*d*) $\pi/3 + \tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$

46. An electric dipole, when held at 60° with respect to a uniform electric field of 10^7 NC^{-1} experience a torque of 12×10^{-20} N–m. What is the value of dipole moment?

(*a*) 1.4×10^{-26} C–m (*b*) 8×10^{-27} C–m
(*c*) 3×10^{-26} C–m (*d*) 1.3×10^{-27} C–m

47. An electric dipole of moment p is lying along a uniform electric field E. The work done in rotating the dipole by 180° is

(*a*) $\sqrt{2}$pE (*b*) pE
(*c*) 2 pE (*d*) $\frac{pE}{\sqrt{2}}$

48. A pendulum bob carries a negative charge $-q$. A positive charge $+q$ is held at the point of support. Then, the time period of the bob is

(*a*) Greater than $2\pi\sqrt{\frac{L}{g}}$ (*b*) Less than $2\pi\sqrt{\frac{L}{g}}$
(*c*) Equal to $2\pi\sqrt{\frac{L}{g}}$ (*d*) Equal to $2\pi\sqrt{\frac{2L}{g}}$

49. The electric intensity outside a charged sphere of radius R at a distance $r(r > R)$ is

(*a*) $\frac{\sigma R^2}{\varepsilon_0 r^2}$ (*b*) $\frac{\sigma r^2}{\varepsilon_0 R^2}$
(*c*) $\frac{\sigma r}{\varepsilon_0 R}$ (*d*) $\frac{\sigma R}{\varepsilon_0 r}$

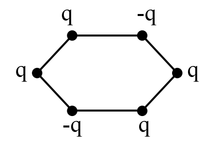
50. Which of the following law gives existence of force between two charged particles?

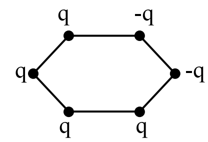
(*a*) Coulomb's law (*b*) Biot-savart's law
(*c*) Ohm's law (*d*) All of these

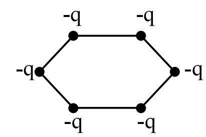
51. A charge q is placed at the center of the line joining two equal charges Q. Three charges are in equilibrium then what will be the value of 'q'?

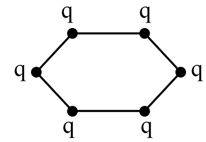
(*a*) $\frac{Q}{4}$ (*b*) $\frac{-Q}{4}$
(*c*) Q (*d*) $\frac{-Q}{8}$

52. In which of the following cases the electric field at the centre is not zero?

(*a*) 

(*b*) 

(*c*) 

(*d*) 

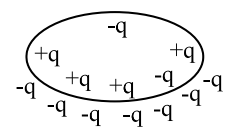
53. The insulation of air vanishes when the electric field is 5×10^5 V/m. The maximum charge that can be given to a sphere of radius 3m is approximately

(*a*) 5 μC (*b*) 500 μC
(*c*) 10 μC (*d*) 1 μC

54. Electric field intensity at a point in between two parallel sheets with like charges of same surface charge densities (σ) is

(*a*) $\frac{\sigma}{2\varepsilon_0}$ (*b*) $\frac{3\sigma}{\varepsilon_0}$
(*c*) $\frac{2\sigma}{\varepsilon_0}$ (*d*) Zero

55. The flux of electric field due to these charges through the surface S is



(*a*) $\frac{2q}{\varepsilon_0}$ (*b*) $\frac{3q}{\varepsilon_0}$
(*c*) $\frac{-5q}{\varepsilon_0}$ (*d*) $q\varepsilon_o$

56. Gauss law is valid for

(*a*) Square lamina (*b*) Disc
(*c*) Shell (*d*) None of these

57. Electric field at the equator of a dipole is E. If strength of electric dipole moment and distance is now doubled then the electric field will be

(*a*) E/2 (*b*) E/8
(*c*) E/4 (*d*) E

58. Dipole is placed parallel to the electric field. If W is the work done in rotating the dipole by 60°, then work done in rotating it by 180° is

(*a*) 2W (*b*) 3W
(*c*) 4W (*d*) W/2

LEVEL-2

Statement Based MCQs

Directions: These questions consist of two statements each, printed as Statement-I and Statement-II. While answering these questions, you are required to choose any one of the following four responses.
(*a*) Both Statement-I and Statement-II are correct.
(*b*) Both Statement-I and Statement-II are incorrect.
(*c*) Statement-I is correct and Statement-II is incorrect.
(*d*) Statement-I is incorrect and Statement-II is correct.

1. **Statement-I:** If a point charge q is placed in front of an infinite grounded conducting plane surface, the point charge will experience a force.
   Statement-II: The force on the point charge in front of the conducting plane surface is due to the induced charge on the conducting surface which is at zero potential.
2. **Statement-I:** When charges are shared between two bodies, there occurs no loss of charge, but there does occur a transformation of energy.
   Statement-II: In case of sharing of charges conservation of energy fails.
3. **Statement-I:** On going away from a point charge or a small electric dipole, electric field decreases at the same rate in both the cases.
   Statement-II: Tangent at any point of electric line of force gives the direction of electric field
4. **Statement-I:** The surface charge densities of two spherical conductors of different radii are equal. Then the electric field intensities near their surface are also equal.
   Statement-II: Surface charge density is equal to charge per unit area.
5. **Statement-I:** If a conducting medium is placed between two charges, then electric force between them becomes zero.
   Statement-II: When a dielectric medium is placed between two charges, then force between the two charges is reduced.

Assertion & Reason MCQs

Directions: These questions consist of two statements each, printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following four responses.
(*a*) If both Assertion and Reason are True and the Reason is a correct explanation of the Assertion.
(*b*) If both Assertion and Reason are True but Reason is not a correct explanation of the Assertion.
(*c*) If Assertion is True but the Reason is False.
(*d*) If Assertion is False but Reason is True.

6. **Assertion:** Charge is invariant.
   Reason: Charge does not depend on speed or frame of reference.
7. **Assertion:** The lightning conductor at the top of a building has sharp pointed ends.
   Reason: The surface charge density at sharp points is very high resulting in of electric wind.
8. **Assertion:** A metallic shield in form of a hollow shell may be built to block an electric field.
   Reason: In a hollow spherical shield, the electric field inside it is zero at every point.
9. **Assertion:** Two protons repel each other.
   Reason: Like charges repel each other while unlike charges attract each other.

Rank Booster MCQs

10. Two charged spheres separated by a distance *R* exert a force *F* on each other. If they are immersed in a liquid of dielectric constant 5 then what is the new force between them

    (*a*) $\frac{F}{5}$ (*b*) F
    (*c*) $5F$ (*d*) $\frac{F}{2}$

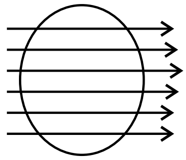
11. The distance between a proton and electron both having a charge 1.6×10^{-19} C of a hydrogen atom is 10^{-12} metre. The value of intensity of electric field produced on electron due to proton will be

    (*a*) 14.4×10^{14} N/C
    (*b*) 12.2×10^{14} N/C
    (*c*) 11.4×10^{14} N/C
    (*d*) 13.2×10^{14} N/C

12. Two point charges of 30 μC and 40 μC are 20 cm apart from each other. Where will be the electric field zero on the line joining the charges from 30 μC charge?

    (*a*) $\frac{20\sqrt{3}}{\sqrt{2}+1}$ cm (*b*) $\frac{20\sqrt{3}}{\sqrt{3}+2}$ cm
    (*c*) $\frac{20\sqrt{3}}{\sqrt{5}}$ cm (*d*) 5 cm

13. A circular disc of radius 'r' is placed along the plane of paper. A uniform electric field $\vec{E}$ is also present in the plane of paper. What amount of electric flux is associated with it?



(*a*) $E\pi r^2$ (*b*) Zero

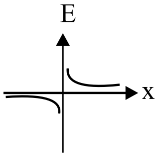
(*c*) $2E\pi r$ (*d*) $\frac{\pi r^2 q}{E}$

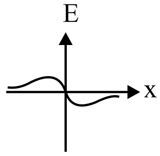
14. An electric dipole of length 1 cm is placed with the axis making an angle of 30° to an electric field of strength $10^4 NC^{-1}$. If it experiences a torque of $10\sqrt{2}$ Nm, the potential energy of the dipole is

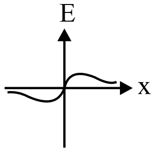
(*a*) 0.245 J (*b*) 2.45×10^{-4} J

(*c*) 0.0245 J (*d*) 24.5 J

15. A ring shaped conductor with radius a carries a net positive charge q uniformly distributed on it. A point P is situated at a distance x from its centre. Which of the following graph shows the correct variation of electric field (E) with distance (x)?

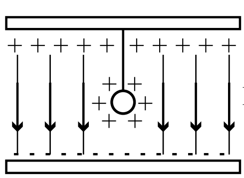
(*a*) 

(*b*) 

(*c*) 

(*d*) None of these

16. If a positively charged pendulum is oscillating in a uniform electric field as shown in diagram. Its frequency compared to that when it was uncharged



(*a*) Will increase

(*b*) Will decrease

(*c*) Will not change

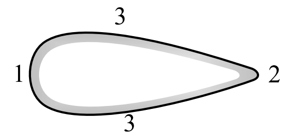
(*d*) Will first increase and then decrease

17. 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*) $\sqrt{3}q\ell$ (*b*) $\sqrt{2}q\ell$

(*c*) $q\ell$ (*d*) $2q\ell$

18. Consider a non-spherical conductor shown in the figure which is given a certain amount of positive charge. The charge distributes itself on the surface such that the charge densities are σ_1, σ_2 and σ_3 at the region 1, 2 and 3 respectively. Then



(*a*) $\sigma_1 > \sigma_2 > \sigma_3$ (*b*) $\sigma_2 > \sigma_3 > \sigma_1$

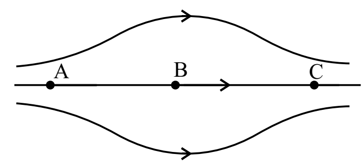
(*c*) $\sigma_3 > \sigma_1 > \sigma_2$ (*d*) $\sigma_2 > \sigma_1 > \sigma_3$

19. A particle having charge q and mass m is projected with velocity $\vec{v} = 2i - 3j$ in a uniform electric field $\vec{E} = E_0\hat{j}$. Change in momentum $|\Delta\vec{P}|$ during any time interval t is given by?

(*a*) $\sqrt{13}$ m (*b*) qE_0t

(*c*) $\frac{qE_0t}{m}$ (*d*) Zero

20. The figure shows some of the electric field lines corresponding to an electric field. The figure suggests



(*a*) $E_A > E_B > E_C$

(*b*) $E_A = E_B = E_C$

(*c*) $E_A = E_C > E_B$

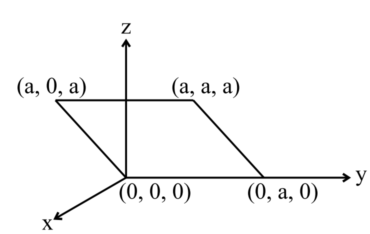
(*d*) $E_A > E_C > E_B$

21. The electric field due to an electric dipole at a distance *r* from its centre in axial position is *E*. If the dipole is rotated through an angle of 90° about its perpendicular axis, the electric field at the same point will be

(*a*) E (*b*) $\frac{E}{4}$

(*c*) $\frac{E}{2}$ (*d*) $2E$

22. Consider an electric field $\vec{E} = E_0\hat{x}$, where E_0 is a constant. The flux through the shaded area (as shown in the figure) due to this field is



(*a*) $2E_0a^2$ (*b*) $\sqrt{2}E_0a^2$

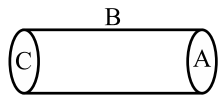
(*c*) E_0a^2 (*d*) $\frac{E_0a^2}{\sqrt{2}}$

23. Two parallel line charges $+\lambda$ and $-\lambda$ are placed with a separation distance R in free space. The net electric field exactly mid way between the two line charge is

(*a*) Zero (*b*) $\frac{2\lambda}{\pi\varepsilon_o R}$

(*c*) $\frac{\lambda}{\pi\varepsilon_o R}$ (*d*) $\frac{1}{2\pi\varepsilon_o R}$

24. A hollow cylinder has a charge *q C* within it. If ϕ is the electric flux in unit of voltmeter associated with the curved surface *B*, the flux linked with the plane surface *A* in unit of voltmeter will be



(*a*) $\frac{1}{2}\left(\frac{q}{\varepsilon_0}-\phi\right)$ (*b*) $\frac{q}{2\varepsilon_0}$

(*c*) $\frac{\phi}{3}$ (*d*) $\frac{q}{\varepsilon_0}-\phi$

25. Two identical charged spheres of material density ρ, suspended from the same point by inextensible strings of equal length make an angle θ between the strings. When suspended in a liquid of density σ the angle θ remains the same. The dielectric constant k of the liquid is

(*a*) $\frac{\rho}{\rho-\sigma}$ (*b*) $\frac{\rho-\sigma}{\rho}$

(*c*) $\frac{\rho}{\rho+\sigma}$ (*d*) $\frac{\rho+\sigma}{\rho}$

26. A charge particle q_1 is at position (2, –1, 3). The electrostatic force on another charged particle q_2 at (0, 0, 0) is

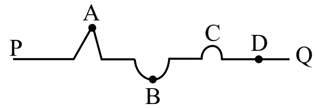
(*a*) $\frac{q_1\, q_2}{56\pi\in_0}(2\hat{i}-\hat{j}+3\hat{k})$

(*b*) $\frac{1}{4\pi\in_0}\frac{q_1\, q_2}{(\sqrt{14})^3}(-2\hat{i}+\hat{j}-3\hat{k})$

(*c*) $\frac{q_1\, q_2}{56\pi\in_0}(\hat{j}-2\hat{i}-3\hat{k})$

(*d*) $\frac{q_1\, q_2}{56\sqrt{14}\,\pi\in_0}(2\hat{i}-\hat{j}+3\hat{k})$

27. A conductor *PQ* as shown in figure is charged. σ_A, σ_B, σ_C and σ_D are surface charge densities of points *A*, *B*, *C* and *D* respectively



(*a*) $\sigma_A < \sigma_B < \sigma_C < \sigma_D$ (*b*) $\sigma_A = \sigma_B = \sigma_C > \sigma_D$

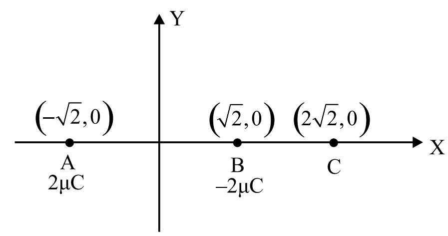
(*c*) $\sigma_A > \sigma_C > \sigma_B > \sigma_D$ (*d*) $\sigma_A = \sigma_B = \sigma_C = \sigma_D$

28. A charged particle of charge q and mass m is released from rest in an uniform electric field E. Neglecting the effect of gravity, the kinetic energy of the charged particle after time 't' seconds is

(*a*) $\frac{Eqm}{t}$ (*b*) $\frac{E^2q^2t^2}{2m}$

(*c*) $\frac{2E^2t^2}{mq}$ (*d*) $\frac{Eq^2m}{2t^2}$

29. Two point charges 2μC and – 2μC are placed at point A and B as shown in figure. Find out electric field intensity at point C. All the distances are measured in meter.



(*a*) $-8000\hat{i}$ N/C (*b*) $-800\hat{i}$ N/C

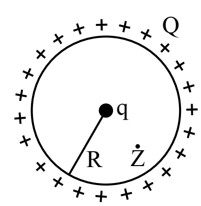
(*c*) $800\hat{i}$ N/C (*d*) $+8000\hat{i}$ N/C

30. Eight charges, 1μC, –7μC, –4μC, 10μC, 2μC, –5μC, –3μC and 6μC are situated at the eight corners of a cube of side 20 cm. A spherical surface of radius 80 cm encloses this cube. The centre of the sphere coincides with the centre of the cube. Then the total outgoing flux from the spherical surface (in unit of volt meter) is

(*a*) $36\pi \times 10^3$ (*b*) $684\pi \times 10^3$

(*c*) Zero (*d*) None of these

31. A positive charge Q is uniformly distributed along a circular ring of radius R. A small test charge q is placed at the centre of the ring as shown in figure. Then



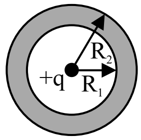
(*a*) If q > 0, and is displaced away from the centre in the plane of the ring, it will be pushed back towards the centre

(*b*) If q < 0 and is displaced away from the centre in the plane of the ring, it will never return to the centre and will continue moving till it hits the ring

(*c*) If q < 0 it will perform SHM for small displacement along the axis

(*d*) All of the above

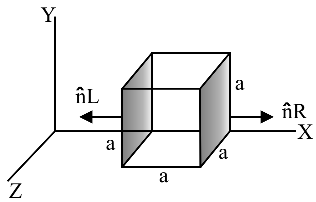
32. A metallic spherical shell has an inner radius R_1 and outer radius R_2. A charge is placed at the centre of the spherical cavity. The surface charge density on the inner surface is



(a) $\frac{q}{4\pi R_1^2}$ (b) $\frac{-q}{4\pi R_1^2}$

(c) $\frac{q^2}{4\pi R_2^2}$ (d) $\frac{q}{4\pi R_2^2}$

33. The electric field components in the given figures are $E_x = \alpha x^{1/2}$, $E_y = E_z = 0$ in which $\alpha = 800 N\ C^{-1}\ m^{-1/2}$. The charge within the cube is if net flux through the cube is $1.04\ N\ m^2C^{-1}$ (assume a = 0.1 m)

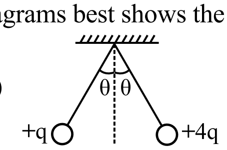


(a) 9.21×10^{-12} C (b) 9.21×10^{12} C

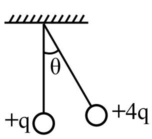
(c) 6.97×10^{-12} C (d) 7.45×10^{12} C

34. Two metal spheres of same mass are suspended from a common point by a light insulating string. The length of each string is same. The sphere are given electric charges +q on one end and +4q on the other. Which of the following diagrams best shows the resulting positions of sphere?

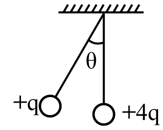
(a)



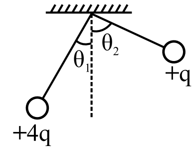
(b)



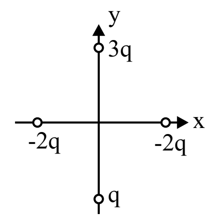
(c)



(d)



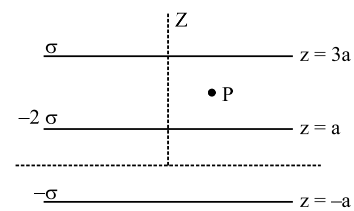
35. 4 charges are placed each at a distance 'a' from origin. The dipole moment of configuration is



(a) $2qa\hat{j}$ (b) $3qa\hat{j}$

(c) $2aq[\hat{i} + \hat{j}]$ (d) None of these

36. Three infinitely long charge sheets are placed as shown in the figure



The electric field at point P is

(a) $\frac{2\sigma}{\varepsilon_0}\hat{k}$ (b) $-\frac{2\sigma}{\varepsilon_0}\hat{k}$

(c) $\frac{4\sigma}{\varepsilon_0}\hat{k}$ (d) $-\frac{4\sigma}{\varepsilon_0}\hat{k}$

Past 5 Years Questions

1. Two identical charged conducting spheres *A* and *B* have their centres separated by a certain distance. Charge on each sphere is *q* and the force of repulsion between them is *F*. *A* third identical uncharged conducting sphere is brought in contact with sphere *A* first and then with *B* and finally removed from both. New force of repulsion between spheres *A* and *B* (Radii of *A* and *B* are negligible compared to the distance of separation so that for calculating force between them they can be considered as point charges) is best given as: **(2025)**

(a) $\frac{3F}{5}$ (b) $\frac{2F}{3}$

(c) $\frac{F}{2}$ (d) $\frac{3F}{8}$

2. A metal cube of side 5 cm is charged with 6 μC. The surface charge density on the cube is **(2024 Re)**

(a) $0.125 \times 10^{-3}\ C\ m^{-2}$ (b) $0.25 \times 10^{-3}\ C\ m^{-2}$

(c) $4 \times 10^{-3}\ C\ m^{-2}$ (d) $0.4 \times 10^{-3}\ C\ m^{-2}$

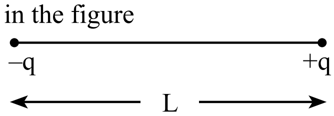
3. An electric dipole is placed at an angle of 30° with an electric field of intensity 2×10^5 NC^{-1}. It experiences a torque equal to 4 Nm. Calculate the magnitude of charge on the dipole, if the dipole length is 2 cm. **(2023)**

(*a*) 2 mC (*b*) 8 mC
(*c*) 6 mC (*d*) 4 mC

4. If $\oint_s \vec{E} \cdot \vec{dS} = 0$ over a surface, then: **(2023)**

(*a*) the electric field inside the surface is necessarily uniform.
(*b*) the number of flux lines entering the surface must be equal to the number of flux lines leaving it.
(*c*) the magnitude of electric field on the surface is constant.
(*d*) all the charges must necessarily be inside the surface.

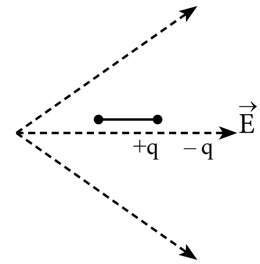
5. Two point charges –q and +q are placed at a distance of L, as shown in the figure



The magnitude of electric field intensity at a distance R (R >> L) varies as **(2022)**

(*a*) $\frac{1}{R^6}$ (*b*) $\frac{1}{R^2}$
(*c*) $\frac{1}{R^3}$ (*d*) $\frac{1}{R^4}$

6. A dipole is placed in an electric field as shown. In which direction will it move? **(2021)**



(*a*) Towards the **right** as its potential energy will **decrease**.
(*b*) Towards the **left** as its potential energy will **decrease**.
(*c*) Towards the **right** as its potential energy will **increase**.
(*d*) Towards the **left** as its potential energy will **increase**.

Answer Key

Level–1

1. (*c*)	2. (*b*)	3. (*a*)	4. (*c*)	5. (*d*)	6. (*b*)	7. (*d*)	8. (*c*)	9. (*a*)	10. (*d*)
11. (*a*)	12. (*c*)	13. (*c*)	14. (*b*)	15. (*d*)	16. (*b*)	17. (*d*)	18. (*c*)	19. (*a*)	20. (*a*)
21. (*b*)	22. (*d*)	23. (*a*)	24. (*c*)	25. (*d*)	26. (*d*)	27. (*d*)	28. (*c*)	29. (*a*)	30. (*b*)
31. (*c*)	32. (*d*)	33. (*a*)	34. (*b*)	35. (*a*)	36. (*c*)	37. (*d*)	38. (*c*)	39. (*d*)	40. (*a*)
41. (*b*)	42. (*d*)	43. (*c*)	44. (*b*)	45. (*d*)	46. (*a*)	47. (*c*)	48. (*c*)	49. (*a*)	50. (*a*)
51. (*b*)	52. (*b*)	53. (*b*)	54. (*d*)	55. (*a*)	56. (*c*)	57. (*c*)	58. (*c*)		

Level–2

1. (*a*)	2. (*c*)	3. (*d*)	4. (*a*)	5. (*a*)	6. (*a*)	7. (*a*)	8. (*a*)	9. (*a*)	10. (*a*)
11. (*a*)	12. (*b*)	13. (*b*)	14. (*d*)	15. (*c*)	16. (*a*)	17. (*a*)	18. (*d*)	19. (*b*)	20. (*c*)
21. (*c*)	22. (*c*)	23. (*b*)	24. (*a*)	25. (*a*)	26. (*b*)	27. (*c*)	28. (*b*)	29. (*a*)	30. (*c*)
31. (*d*)	32. (*b*)	33. (*a*)	34. (*a*)	35. (*a*)	36. (*b*)				

Past 5 Years Questions

1. (*d*)	2. (*d*)	3. (*a*)	4. (*b*)	5. (*c*)	6. (*a*)

Explanation

Level–1

1. (*c*) Charge is always quantized, so electric charge of any system is integral multiple of least amount of charge.
$q = ne$

2. (*b*) To orient the dipole at any angle θ from its initial position, work has to be done on the dipole from $\theta = 0°$ to θ
∴ Potential energy = $pE(1 - \cos\theta)$

3. (*a*) $q_1 = q_2 = 2 \times 10^{-8}C$, $r = 1$ m
Tension in the string will be equal to the force between the charges.
According to Coulomb's law,

$$F = \frac{Kq_1q_2}{r^2}$$

$$= \frac{9\times10^9\times\left(2\times10^{-8}\right)^2}{(1)^2}$$

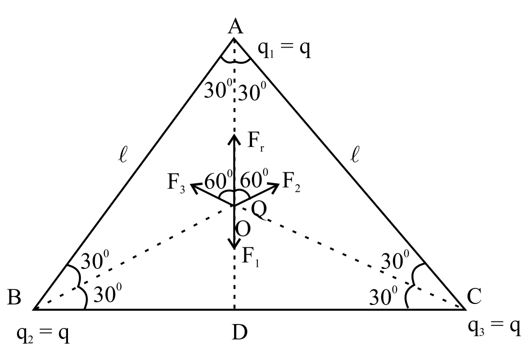
$$= \frac{9\times10^9\times4\times10^{-16}}{1}$$

$= 36 \times 10^{-7}N = 3.6 \times 10^{-6}N$

4. (*c*) According to quantisation of charge,
$q = ne$

$$n = \frac{q}{e} = \frac{1\times10^{-7}}{1.6\times10^{-19}} = 6.25\times10^{11}$$

5. (*d*)



$$\frac{AD}{AB} = \cos 30°$$

$$AD = \frac{\ell\sqrt{3}}{2}$$

Distance AO of centroid from A is

$$AO = \frac{2}{3}AD = \frac{2}{3}\times\frac{\ell\sqrt{3}}{2} = \frac{\ell}{\sqrt{3}}$$

Similarly BO and CO are equal to $\frac{\ell}{\sqrt{3}}$

Force on Q at O due to charge q placed at A

$$F_1 = \frac{kQq}{\left(\ell/\sqrt{3}\right)^2} = \frac{3KQq}{\ell^2} \text{ along AO}$$

Similarly, $F_2 = F_3 = \frac{3KQq}{\ell^2}$ along BO and along CO respectively.

Angle between F_2 and F_3 is 120^o

According to parallelogram law

$$F_r = \sqrt{F_2^2 + F_3^2 + 2F_2F_3\cos 120^o} \quad [\because F_1 = F_2 = F_3 = F]$$

$$F_r = \sqrt{F^2 + F^2 + 2F^2\left(\frac{-1}{2}\right)} = F$$

Force due to charge q at A is equal and opposite to the resultant force F. So the net force experienced is Zero.

6. (*b*) Field line starts from positive and ends at negative charge.

7. (*d*) If the point has a charge then the electric field is discontinuous at the point.

8. (*c*) $E = \frac{kp}{r^3} \Rightarrow E \propto \frac{p}{r^3} \Rightarrow \frac{E_1}{E} = \frac{2}{8} \Rightarrow E_1 = \frac{E}{4}$

9. (*a*) $u = 0, a = \frac{qE}{m}$, $s = \ell$ $v = ?$

$$v^2 = u^2 + 2as$$

$$v^2 = 0 + \frac{2qE\ell}{m} \Rightarrow v = \sqrt{\frac{2qE\ell}{m}}$$

10. (*d*) Net force on the electron will be zero along the diagonal AC. It will move towards D due to attraction by the proton.

11. (*a*) Because charge is present on the outer surface of the shell. Hence, electric field is zero inside the shell.

12. (*c*) A cube have 6 faces so flux through one face is given by gauss law

$$\phi = \frac{q}{\varepsilon_o} \text{ (for the cube)}$$

$$\Rightarrow \phi = \frac{q}{6\varepsilon_o} \text{ (for each faces)}$$

13. (*c*) Total charge into the shell is zero because a dipole composed of negative and positive charge.
So, $q_{net} = 5(-q + q) = 0$

$$\phi = \frac{q}{\varepsilon_o} = \text{zero}$$

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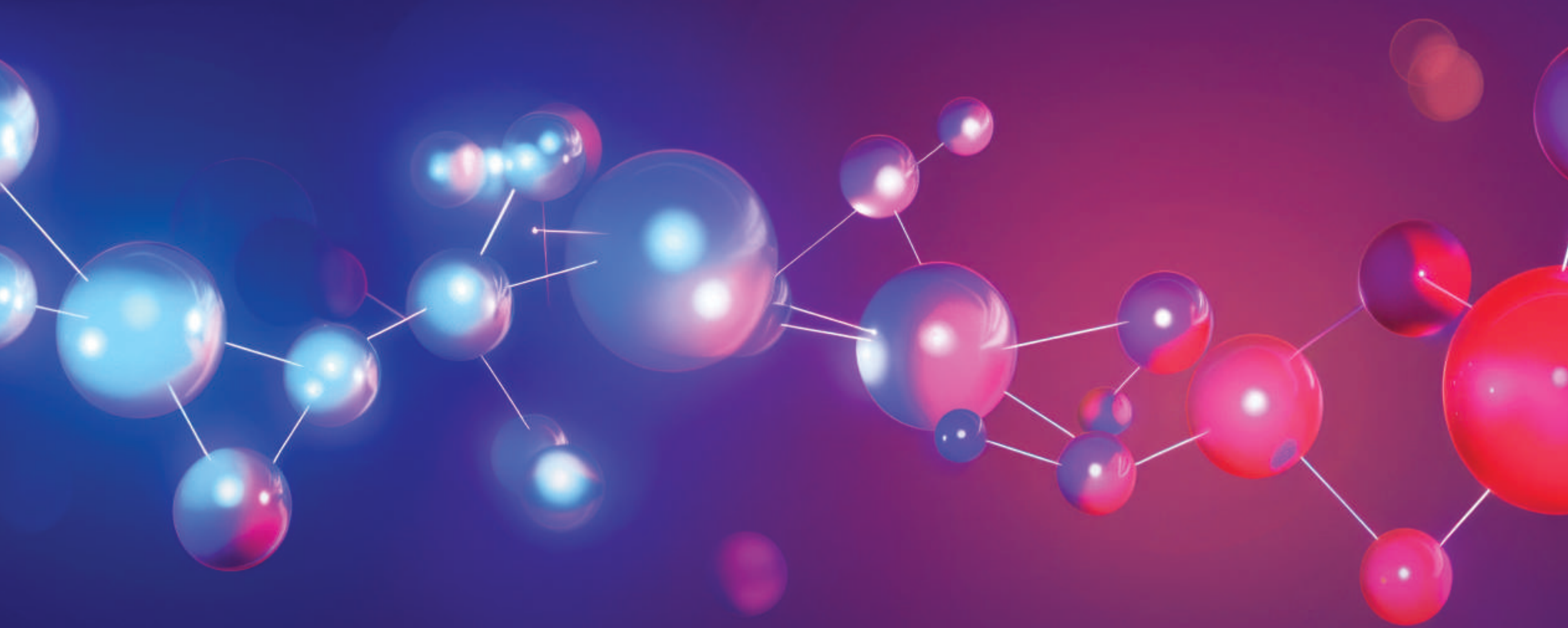

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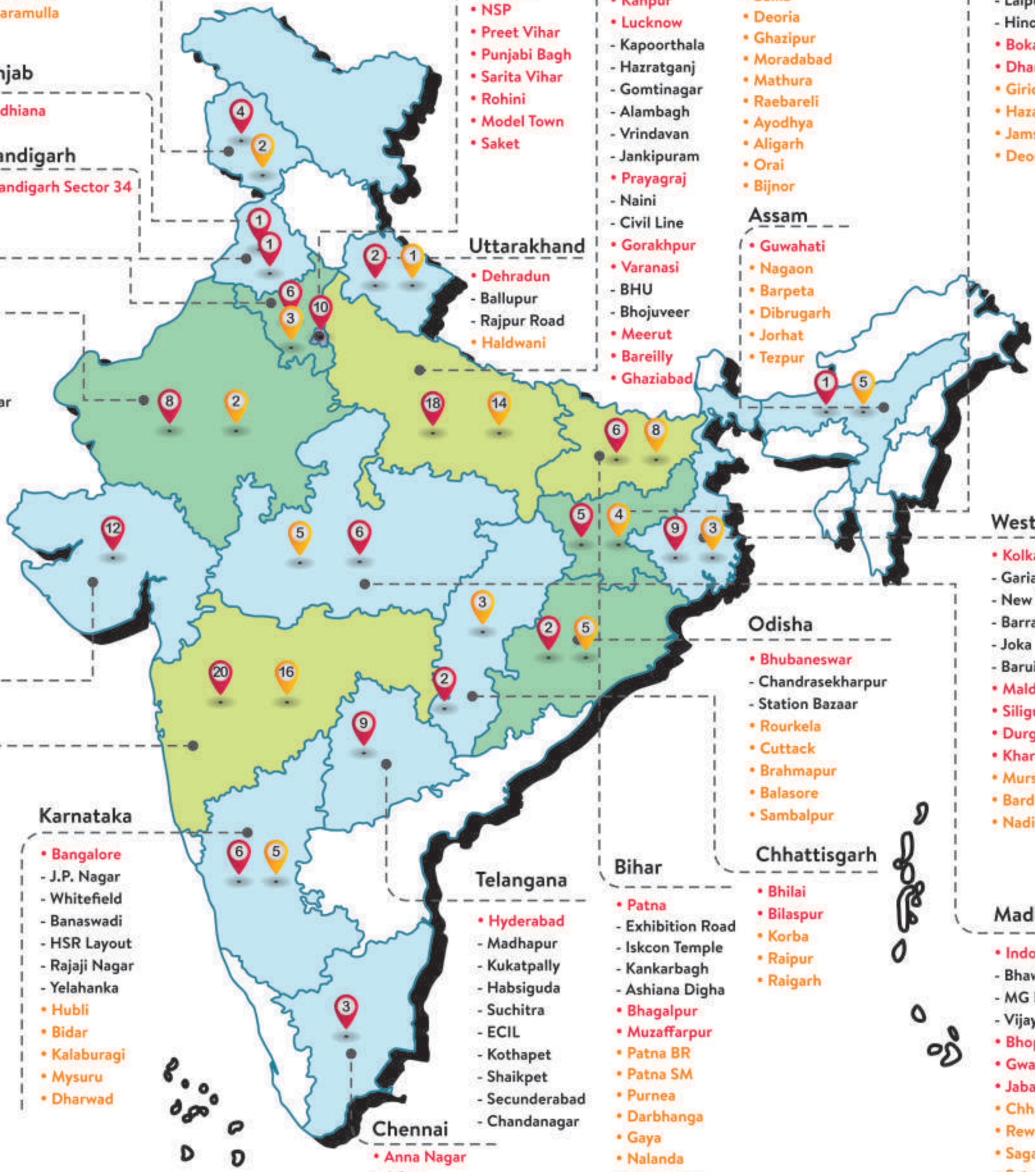

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ISBN 978-93-7153-686-8

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