collegedunia

Class 12 Physics Chapterwise PYQs

2026 – 2003 | All CBSE Board Papers

Chapter-wise previous year questions, sorted by marks and year

Chapter 1: Electric Charges and Fields

Table of Contents

1-Mark Questions (70 questions · Section A · MCQ)

Q1. A particle of mass m and charge q starts from rest and moves in an electric field $\vec{E} = E_0\hat{i}$. After travelling a distance x in the field along the x-axis, the kinetic energy of the particle will be:

(A) qE_0x^2
(B) qE_0^2x
(C) q^2E_0x
(D) qE_0x

[2026 • Set 55-3-1]

Q2. An electric dipole $\vec{P} = 2qa\hat{i}$ is placed in x-y plane, centred at the origin. Let E_1 and E_2 be the magnitudes of electric field at a point distant r $(\gg a)$ from its centre, along its axis and on its equatorial plane, respectively. Then the value of $\left(\frac{E_1}{E_2}\right)$ is:

(A) $\frac{1}{4}$
(B) $\frac{1}{2}$
(C) 2
(D) 4

[2026 • Set 55-3-2]

Q3. An electric dipole with dipole moment $\vec{P} = (2{\cdot}54 \times 10^{-26}\ \text{C} \cdot \text{m})(2{\cdot}00\,\hat{i} + 3{\cdot}00\,\hat{j})$ is placed in an electric field $\vec{E} = (100\,\hat{i})$ N/C. An external agent turns the dipole until its electric dipole moment is $\vec{P} = (2{\cdot}54 \times 10^{-26}\ \text{C} \cdot \text{m})(-3{\cdot}00\,\hat{i} + 2{\cdot}00\,\hat{j})$. The work done by the agent is:

(A) $2{\cdot}54 \times 10^{-23}$ J
(B) $1{\cdot}27 \times 10^{-24}$ J
(C) $1{\cdot}02 \times 10^{-23}$ J
(D) $2{\cdot}29 \times 10^{-26}$ J

[2026 • Set 55-3-3]

Q4. Two small identical metallic balls having charges q and $-2q$ are kept far at a separation r. They are brought in contact and then separated at distance $\frac{r}{2}$. Compared to the initial force F, they will now:

(A) attract with a force $\frac{F}{2}$
(B) repel with a force $\frac{F}{2}$
(C) repel with a force F
(D) attract with a force F

[2026 • Set 55-5-1]

Q5. Two point charges $-Q$ and Q are located at points $(d, 0)$ and $(0, d)$ respectively, in x-y plane. The electric field $\vec{E}$ at the origin will be:

(A) $\frac{1}{4\pi\varepsilon_0}\frac{\sqrt{2}Q}{d^2}(\hat{i} - \hat{j})$
(B) $\frac{1}{4\pi\varepsilon_0}\frac{\sqrt{2}Q}{d^2}(\hat{i} + \hat{j})$
(C) $\frac{1}{4\pi\varepsilon_0}\frac{Q}{d^2}(-\hat{i} - \hat{j})$
(D) $\frac{1}{4\pi\varepsilon_0}\frac{Q}{d^2}(\hat{i} - \hat{j})$

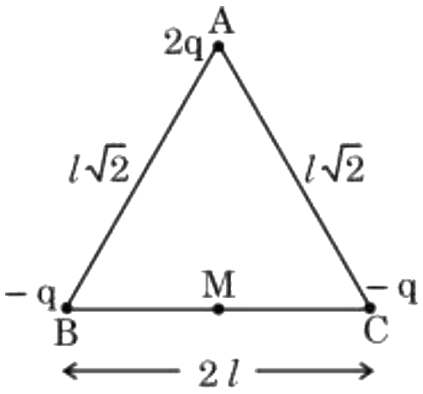
[2026 • Set 55-5-2]

Q6. An electron is moving with velocity $v_0\,\hat{i}$. If a uniform electric field $\vec{E} = E_0\,\hat{j}$ is set up in the region, the electron will:

(A) describe a circular path
(B) describe a helical path
(C) describe a parabolic path
(D) continue moving without any deviation

[2026 • Set 55-5-2]

Q7. The figure shows three point charges kept at the vertices of triangle ABC. The net electric field, due to this system of charges, at the midpoint M of base BC will be:



(A) $\frac{1}{4\pi\varepsilon_0}\frac{q}{l^2}$ pointing along MA

(B) $\frac{1}{4\pi\varepsilon_0}\frac{q}{l^2}$ pointing along AM

(C) $\frac{1}{2\pi\varepsilon_0}\frac{q}{l^2}$ pointing along AM

(D) Zero

[2026 • Set 55-5-3]

Q8. Figure shows variation of Coulomb force (F) acting between two point charges with $\frac{1}{r^2}$, r being the separation between the two charges (q_1, q_2) and (q_2, q_3). If q_2 is positive and least in magnitude, then the magnitudes of q_1, q_2 and q_3 are such that:

(A) $q_2 < q_3 < q_1$

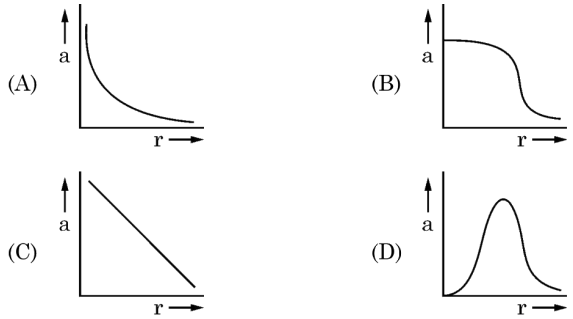
(B) $q_3 < q_2 < q_1$

(C) $q_1 < q_2 < q_3$

(D) $q_2 < q_1 < q_3$

[2025 • Set 55-1-1]

Q9. A charge Q is fixed in position. Another charge q is brought near charge Q and released from rest. Which of the following graphs is the correct representation of the acceleration of the charge q as a function of its distance r from charge Q?



(A) Option A (graph as shown)

(B) Option B (graph as shown)

(C) Option C (graph as shown)
(D) Option D (graph as shown)

[2025 • Set 55-1-3]

Q10. Two charges $-q$ each are placed at the vertices A and B of an equilateral triangle ABC. If M is the mid-point of AB, the net electric field at C will point along
(A) CA
(B) CB
(C) MC
(D) CM

[2025 • Set 55-2-1]

Q11. Which one of the following statements is correct? Electric field due to static charges is
(A) conservative and field lines do not form closed loops.
(B) conservative and field lines form closed loops.
(C) non-conservative and field lines do not form closed loops.
(D) non-conservative and field lines form closed loops.

[2025 • Set 55-2-1]

Q12. Two identical point charges are placed at the two vertices A and B of an equilateral triangle of side ℓ. The magnitude of the electric field at the third vertex P is E. If a hollow conducting sphere of radius $(\ell/4)$ is placed at P, the magnitude of the electric field at point P now becomes
(A) 2E
(B) E
(C) $\frac{E}{2}$
(D) zero

[2025 • Set 55-2-2]

Q13. Consider two identical dipoles D_1 and D_2. Charges $-q$ and q of dipole D_1 are located at (0, 0) and (a, 0) and that of dipole D_2 at (0, a) and (0, 2a) in x-y plane, respectively. The net dipole moment of the system is
(A) $qa(\hat{i}+\hat{j})$
(B) $-qa(\hat{i}+\hat{j})$
(C) $qa(\hat{i}-\hat{j})$
(D) $-qa(\hat{i}-\hat{j})$

[2025 • Set 55-2-3]

Q14. An electric dipole of dipole moment 1.0×10^{-12} Cm lies along x-axis. An electric field of magnitude 2.0×10^4 N C^{-1} is switched on at an instant in the region. The unit vector

along the electric field is $\frac{4}{5}\hat{i} + \frac{3}{5}\hat{j}$. The magnitude of the torque acting on the dipole at that instant is :

(A) 0.5×10^{-8} Nm

(B) 1.0×10^{-8} Nm

(C) 2.0×10^{-8} Nm

(D) 4.0×10^{-8} Nm

[2025 • Set 55-4-2]

Q15. Two point charges Q and $-q$ are held 'r' distance apart in free space. A uniform electric field E is applied in the region perpendicular to the line joining the two charges. Which one of the following angles will the direction of the net force acting on charge $-q$ make with the line joining Q and $-q$?

(A) $\tan^{-1}\frac{4\pi\varepsilon_0 Er^2}{Q}$

(B) $\cot^{-1}\frac{4\pi\varepsilon_0 Er^2}{Q}$

(C) $\tan^{-1}\frac{QE}{4\pi\varepsilon_0 r^2}$

(D) $\cot^{-1}\frac{QE}{4\pi\varepsilon_0 r^2}$

[2025 • Set 55-4-3]

Q16. A particle of mass m and charge q moving with velocity $v\,\hat{i}$ is subjected to a uniform electric field $E\,\hat{j}$. The particle will initially have a tendency to move in a circle of radius:

(A) $\left(\frac{mv^2}{qE}\right)$ in x-y plane

(B) $\frac{mv^2}{qE}$ in x-z plane

(C) $\frac{mv^2}{qE}$ in x-y plane

(D) $\left(\frac{mv^2}{qE}\right)$ in y-z plane

[2025 • Set 55-6-3]

Q17. A thin plastic rod is bent into a circular ring of radius R. It is uniformly charged with charge density λ. The magnitude of the electric field at its centre is:

(A) $\frac{\lambda}{2\varepsilon_0 R}$

(B) Zero

(C) $\frac{\lambda}{4\pi\varepsilon_0 R}$

(D) $\frac{\lambda}{4\varepsilon_0 R}$

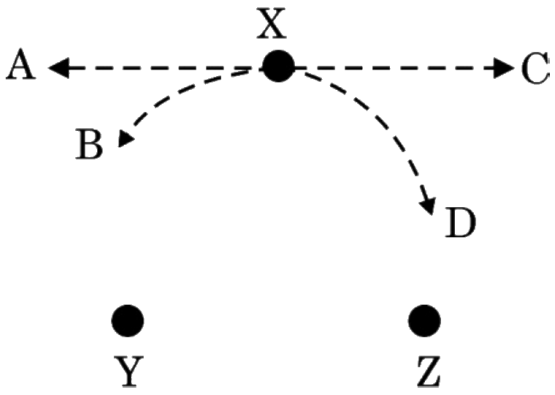
[2024 • Set 55-1-1]

Q18. A charged sphere of radius r has surface charge density σ. The electric field on its surface is E. If the radius of the sphere is doubled, keeping charge density the same, the ratio of the electric field on the old sphere to that on the new sphere will be:

(A) 1
(B) $\frac{1}{2}$
(C) $\frac{1}{4}$
(D) 4

[2024 • Set 55-1-2]

Q19. Three small charged spheres X, Y and Z carrying charges $+q$, $-q$ and $+q$ respectively are placed equidistant from each other, as shown in the figure. The spheres Y and Z are held in place. Initially X is also held in place, but is otherwise free to move. When X is released, the path followed by it will be:



(A) A
(B) B
(C) C
(D) D

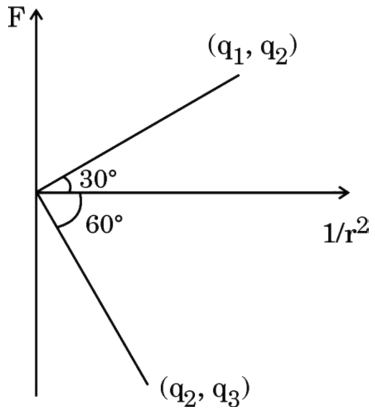
[2024 • Set 55-1-3]

Q20. Two charged particles P and Q, having the same charge but different masses m_P and m_Q, start from rest and travel equal distances in a uniform electric field $\vec{E}$ in time t_P and t_Q respectively. Neglecting the effect of gravity, the ratio $\frac{t_P}{t_Q}$ is:

(A) $\frac{m_P}{m_Q}$
(B) $\frac{m_Q}{m_P}$
(C) $\sqrt{\frac{m_P}{m_Q}}$
(D) $\sqrt{\frac{m_Q}{m_P}}$

[2024 • Set 55-2-1]

Q21. Coulomb force F versus $\frac{1}{r^2}$ graphs for two pairs of point charges (q_1 and q_2) and (q_1 and q_3) are shown in the figure. The ratio of charges $\frac{q_2}{q_3}$ is:



(A) $\sqrt{3}$
(B) $\frac{1}{\sqrt{3}}$
(C) $\frac{\sqrt{3}}{2}$
(D) $\frac{2}{\sqrt{3}}$

[2024 • Set 55-2-3]

Q22. An isolated conductor, with a cavity, has a net charge $+Q$. A point charge $+q$ is inside the cavity. The charges on the cavity wall and the outer surface are respectively:

(A) 0 and Q
(B) $-q$ and $Q-q$
(C) $-q$ and $Q+q$
(D) 0 and $Q-q$

[2024 • Set 55-3-2]

Q23. Two identical small conducting balls B_1 and B_2 are given $-7\,\text{pC}$ and $+4\,\text{pC}$ charges respectively. They are brought in contact with a third identical ball B_3 and then separated. If the final charge on each ball is $-2\,\text{pC}$, the initial charge on B_3 was

(A) $-2\,\text{pC}$
(B) $-3\,\text{pC}$
(C) $-5\,\text{pC}$
(D) $-15\,\text{pC}$

[2024 • Set 55-4-1]

Q24. An electric dipole of dipole moment $\vec{p}$ is kept in a uniform electric field $\vec{E}$. The amount of work done to rotate it from the position of stable equilibrium to that of unstable equilibrium will be

(A) $2pE$

(B) $-2pE$
(C) pE
(D) zero

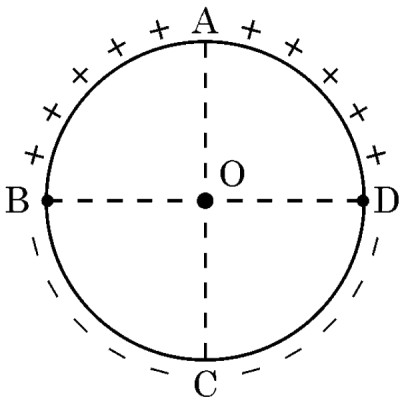
[2024 • Set 55-4-3]

Q25. An infinite long straight wire having a charge density λ is kept along $y'y$ axis in x-y plane. The Coulomb force on a point charge q at a point $P(x, 0)$ will be

(A) attractive and $\frac{\lambda q}{2\pi\varepsilon_0 x}$
(B) repulsive and $\frac{\lambda q}{2\pi\varepsilon_0 x}$
(C) attractive and $\frac{\lambda q}{\pi\varepsilon_0 x}$
(D) repulsive and $\frac{\lambda q}{\pi\varepsilon_0 x}$

[2024 • Set 55-4-3]

Q26. For Questions 13 to 16, two statements are given — one labelled Assertion (A) and other labelled Reason (R). Select the correct answer to these questions from the options as given below: (A) If both Assertion (A) and Reason (R) are true and Reason (R) is correct explanation of Assertion (A). (B) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of Assertion (A). (C) If Assertion (A) is true but Reason (R) is false. (D) If both Assertion (A) and Reason (R) are false. Assertion (A): Equal amount of positive and negative charges are distributed uniformly on two halves of a thin circular ring as shown in figure. The resultant electric field at the centre O of the ring is along OC. Reason (R): It is so because the net potential at O is not zero.



(A) Both Assertion (A) and Reason (R) are true and Reason (R) is correct explanation of Assertion (A).
(B) Both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of Assertion (A).
(C) Assertion (A) is true but Reason (R) is false.
(D) Both Assertion (A) and Reason (R) are false.

[2024 • Set 55-5-1]

Q27. A point charge situated at a distance 'r' from a short electric dipole on its axis, experiences a force $\vec{F}$. If the distance of the charge is '$2r$', the force on the charge will be:

(A) $\frac{F}{16}$

(B) $\frac{F}{8}$

(C) $\frac{F}{4}$

(D) $\frac{F}{2}$

[2023 • Set 55-1-1]

Q28. The magnitude of the electric field due to a point charge object at a distance of 4.0 m is 9 N/C. From the same charged object the electric field of magnitude, 16 N/C will be at a distance of

(A) 1 m

(B) 2 m

(C) 3 m

(D) 6 m

[2023 • Set 55-2-1]

Q29. An isolated point charge particle produces an electric field $\vec{E}$ at a point 3 m away from it. The distance of the point at which the field is $\frac{\vec{E}}{4}$ will be

(A) 2 m

(B) 3 m

(C) 4 m

(D) 6 m

[2023 • Set 55-2-2]

Q30. An electric dipole of dipole moment 2×10^{-8} C m in a uniform electric field experiences a maximum torque of 6×10^{-4} N m. The magnitude of electric field is

(A) 2.2×10^{2} V m^{-1}

(B) 1.2×10^{4} V m^{-1}

(C) 3.0×10^{4} V m^{-1}

(D) 4.2×10^{2} V m^{-1}

[2023 • Set 55-2-3]

Q31. An electron experiences a force $(1.6 \times 10^{-16}\,\text{N})\,\hat{i}$ in an electric field $\vec{E}$. The electric field $\vec{E}$ is:

(A) $(1.0 \times 10^{3}\,\text{N/C})\,\hat{i}$

(B) $-(1.0 \times 10^{3}\,\text{N/C})\,\hat{i}$

(C) $(1.0 \times 10^{-3}\,\text{N/C})\,\hat{i}$

(D) $-(1.0 \times 10^{-3}\,\text{N/C})\,\hat{i}$

[2023 • Set 55-3-1]

Q32. Which one of the following is not a scalar quantity?

(A) Electric field
(B) Voltage
(C) Resistivity
(D) Power

[2023 • Set 55-3-1]

Q33. An infinitely long uniformly charged wire produces an electric field of $1.8 \times 10^4\,\text{N C}^{-1}$ at a distance of $1.0\,\text{cm}$. The linear charge density on the wire is:

(A) $1.12 \times 10^{-1}\,\text{C m}^{-1}$
(B) $3.08 \times 10^{-2}\,\text{C m}^{-1}$
(C) $1.0 \times 10^{-2}\,\text{C m}^{-1}$
(D) $1.0 \times 10^{-7}\,\text{C m}^{-1}$

[2023 • Set 55-3-2]

Q34. Two charges q_1 and q_2 are placed at the centres of two spherical conducting shells of radius r_1 and r_2 respectively. The shells are arranged such that their centres are $d\,[> (r_1 + r_2)]$ distance apart. The force on q_2 due to q_1 is:

(A) $\dfrac{1}{4\pi\varepsilon_0}\dfrac{q_1 q_2}{d^2}$
(B) $\dfrac{1}{4\pi\varepsilon_0}\dfrac{q_1 q_2}{(d - r_1)^2}$
(C) Zero
(D) $\dfrac{1}{4\pi\varepsilon_0}\dfrac{q_1 q_2}{[d - (r_1 + r_2)]^2}$

[2023 • Set 55-4-1]

Q35. Case Study: Electrostatics deals with the study of forces, fields and potentials arising from static charges. Force and electric field, due to a point charge is basically determined by Coulomb's law. For symmetric charge configurations, Gauss's law, which is also based on Coulomb's law, helps us to find the electric field. A charge/a system of charges like a dipole experience a force/torque in an electric field. Work is required to be done to provide a specific orientation to a dipole with respect to an electric field.

(a) Consider a uniformly charged thin conducting shell of radius R. Plot a graph showing the variation of $|\vec{E}|$ with distance r from the centre, for points $0 \le r \le 3R$.

[2023 • Set 55-4-1]

Q36. A point charge q is kept at a distance r from an infinitely long straight wire with charge density λ. The magnitude of the electrostatic force experienced by charge q is:

(A) Zero
(B) $\frac{q\lambda}{2\pi\varepsilon_0 r}$
(C) $\frac{q\lambda}{4\pi\varepsilon_0 r}$
(D) $\frac{q\lambda}{\varepsilon_0 r^2}$

[2023 • Set 55-4-2]

Q37. A particle of mass m and charge $-q$ is moving with a uniform speed v in a circle of radius r, with another charge q at the centre of the circle. The value of r is:
(A) $\frac{q^2}{4\pi\varepsilon_0 m}\left(\frac{1}{v}\right)^2$
(B) $\frac{q^2}{4\pi\varepsilon_0 m}\left(\frac{1}{v}\right)$
(C) $\frac{m}{4\pi\varepsilon_0}\left(\frac{q}{v}\right)^2$
(D) $\frac{m}{4\pi\varepsilon_0}\left(\frac{q}{v}\right)$

[2023 • Set 55-4-3]

Q38. An electric dipole of length 2 cm is placed at an angle of 30° with an electric field 2×10^5 N/C. If the dipole experiences a torque of 8×10^{-3} Nm, the magnitude of either charge of the dipole, is
(A) $4\,\mu C$
(B) $7\,\mu C$
(C) $8\,mC$
(D) $2\,mC$

[2023 • Set 55-5-1]

Q39. A charge Q is placed at the centre of a cube. The electric flux through one of its face is
(A) $\frac{Q}{\varepsilon_0}$
(B) $\frac{Q}{2\varepsilon_0}$
(C) $\frac{Q}{6\varepsilon_0}$
(D) $\frac{Q}{3\varepsilon_0}$

[2023 • Set 55-5-2]

Q40. If the net electric flux through a closed surface is zero, then we can infer
(A) no net charge is enclosed by the surface.
(B) uniform electric field exists within the surface.
(C) electric potential varies from point to point inside the surface.

(D) charge is present inside the surface.

[2020 • Set 55-1-1]

Q41. An electric dipole placed in a non-uniform electric field can experience

(A) a force but not a torque.
(B) a torque but not a force.
(C) always a force and a torque.
(D) neither a force nor a torque.

[2020 • Set 55-1-2]

Q42. A point charge is situated at an axial point of a small electric dipole at a large distance from it. The charge experiences a force F. If the distance of the charge is doubled, the force acting on the charge will become

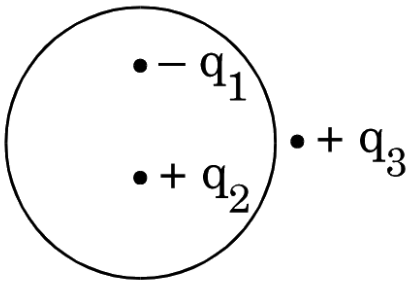
(A) $2F$
(B) $F/2$
(C) $F/4$
(D) $F/8$

[2020 • Set 55-1-3]

Q43. If the electric flux entering and leaving a closed surface in air are ϕ_1 and ϕ_2 respectively, the net electric charge enclosed within the surface is _____.

[2020 • Set 55-2-1]

Q44. Electric flux through a spherical surface shown in the figure, is _____.



[2020 • Set 55-2-2]

Q45. The electric flux emerging out from 1 C charge is

(A) $\frac{1}{\varepsilon_0}$
(B) 4π
(C) $\frac{\varepsilon_0}{4\pi}$
(D) ε_0

[2020 • Set 55-3-1]

Q46. An electric dipole consisting of charges $+q$ and $-q$ separated by a distance r, is kept symmetrically at the centre of an imaginary sphere of radius $R(>r)$. Another point charge Q is also kept at the centre of the sphere. The net electric flux coming out of the sphere will be

(A) $\frac{1}{4\pi\varepsilon_0}(2q+Q)$

(B) $\frac{Q}{\varepsilon_0}$

(C) $\frac{2q+Q}{\varepsilon_0}$

(D) $\frac{2q}{\varepsilon_0}$

[2020 • Set 55-3-2]

Q47. Two large conducting spheres carrying charges Q_1 and Q_2 are kept with their centres r distance apart. The magnitude of electrostatic force between them is not exactly $\frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}$ because

(A) these are not point charges.

(B) charge distribution on the spheres is not uniform.

(C) charges on spheres will shift towards the centres of their respective spheres.

(D) charges will shift towards the portions of the spheres which are closer and facing towards each other.

[2020 • Set 55-3-3]

Q48. Fill in the blank with appropriate answer. Torque acting on an electric dipole placed in an electric field is maximum when the angle between the electric field and the dipole moment is _____.

[2020 • Set 55-4-1]

Q49. The physical quantity having SI unit $\mathrm{NC^{-1}\,m}$ is _____ .

[2020 • Set 55-5-1]

Q50. The electric flux through a closed Gaussian surface depends upon

(A) Net charge enclosed and permittivity of the medium

(B) Net charge enclosed, permittivity of the medium and the size of the Gaussian surface

(C) Net charge enclosed only

(D) Permittivity of the medium only

[2020 • Set 55-5-1]

Q51. Draw the pattern of electric field lines, when a point charge $-Q$ is kept near an uncharged conducting plate.

[2019 • Set 55-1-1]

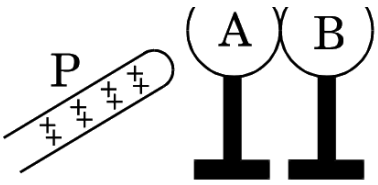
Q52. Draw the pattern of electric field lines due to an electric dipole.

[2019 • Set 55-2-2]

Q53. Draw a pattern of electric field lines due to two positive charges placed a distance d apart.

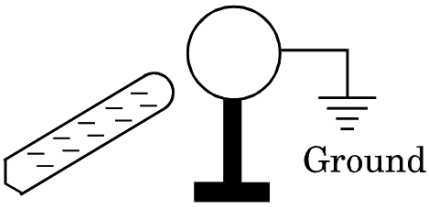
[2019 • Set 55-2-3]

Q54. Two metallic spheres A and B kept on insulating stands are in contact with each other. A positively charged rod P is brought near the sphere A as shown in the figure. The two spheres are separated from each other, and the rod P is removed. What will be the nature of charges on spheres A and B?



OR

A metal sphere is kept on an insulating stand. A negatively charged rod is brought near it, then the sphere is earthed as shown. On removing the earthing, and taking the negatively charged rod away, what will be the nature of charge on the sphere? Give reason for your answer.



[2019 • Set 55-3-1]

Q55. Two identical conducting balls A and B have charges $-Q$ and $+3Q$ respectively. They are brought in contact with each other and then separated by a distance d apart. Find the nature of the Coulomb force between them.

OR

A metallic spherical shell has an inner radius R_1 and outer radius R_2. A charge Q is placed at the centre of the shell. What will be the surface charge density on the (i) inner surface, and (ii) outer surface of the shell?

[2019 • Set 55-4-1]

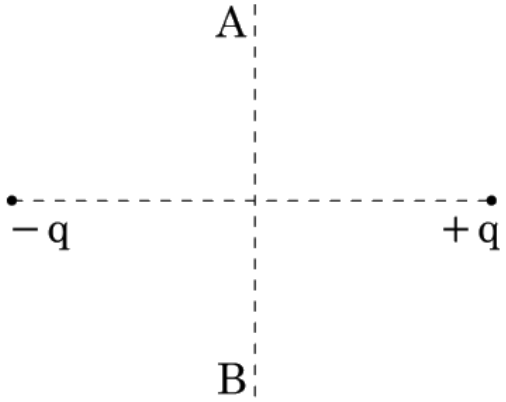
Q56. Why is the direction of the electric field due to a charged conducting sphere at any point perpendicular to its surface?

[2019 • Set 55-5-2]

Q57. Why can the interior of a conductor have no excess charge in the static situation?

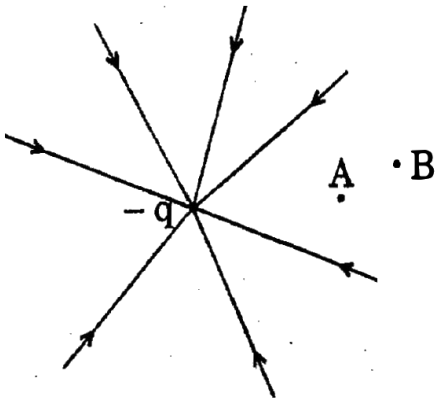
[2019 • Set 55-5-3]

Q58. A charge q is moved from a point A above a dipole of dipole moment p to a point B below the dipole in equatorial plane without acceleration. Find the work done in the process.



[2016]

Q59. The field lines of a negative point charge are as shown in the figure. Does the kinetic energy of a small negative charge increase or decrease in going from B to A?



[2015]

Q60. What is the electric flux through a cube of side 1 cm which encloses an electric dipole?

[2015]

Q61. Why do the electric field lines never cross each other ?

[2014]

Q62. A charge q is placed at the centre of a cube of side l. What is the electric flux passing through each face of the cube?

[2012]

Q63. Why should electrostatic field be zero inside a conductor?

[2012]

Q64. Define dipole moment of an electric dipole. Is it a scalar or a vector?

[2012]

Q65. Why must electrostatic field be normal to the surface at every point of a charged conductor?

[2012]

Q66. Define electric dipole moment. Write its S.I. unit.

[2011]

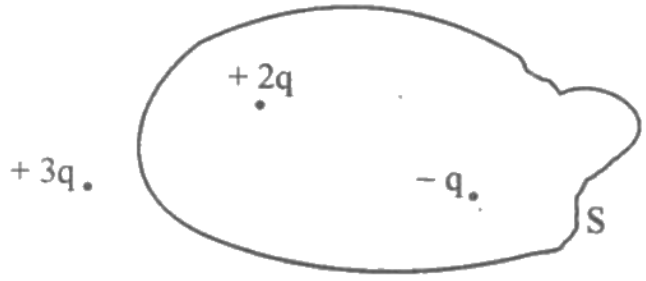
Q67. Two insulated charged copper spheres A and B of identical size have charges q_A and q_B respectively. A third sphere C of the same size but uncharged is brought in contact with the first and then in contact with the second and finally removed from both. What are the new charges on A and B?

[2011 • Set 55-2-1]

Q68. In which orientation, a dipole placed in a uniform electric field is in (i) stable, (ii) unstable equilibrium?

[2010]

Q69. Figure shows three point charges, $+2q$, $-q$ and $+3q$. Two charges $+2q$ and $-q$ are enclosed within a surface 'S'. What is the electric flux due to this configuration through the surface 'S'?



[2010]

Q70. An electric dipole of dipole moment 20×10^{-6} C · m is enclosed by a closed surface. What is the net flux coming out of the surface?

[2005]

2-Mark Questions (32 questions · Section B · VSA)

Q1. An electric dipole consists of two point charges $+1\,\mu C$ and $-1\,\mu C$, held 10 cm apart. It is subjected to a uniform electric field of 100 N/C. Calculate the amount of work done in turning the dipole from its position of stable equilibrium to the position of unstable equilibrium, in the field.

[2026 • Set 55-4-1]

Q2. An electric dipole consists of point charges $-1.0\,\text{pC}$ and $+1.0\,\text{pC}$ located at $(0, 0)$ and $(3\,\text{mm}, 4\,\text{mm})$ respectively in $x - y$ plane. An electric field $\vec{E} = \left(\frac{2 \times 10^5\,\text{V}}{\text{m}}\right)\hat{i}$ is switched on in the region. Find the torque $\vec{\tau}$ acting on the dipole.

[2024 • Set 55-1-1]

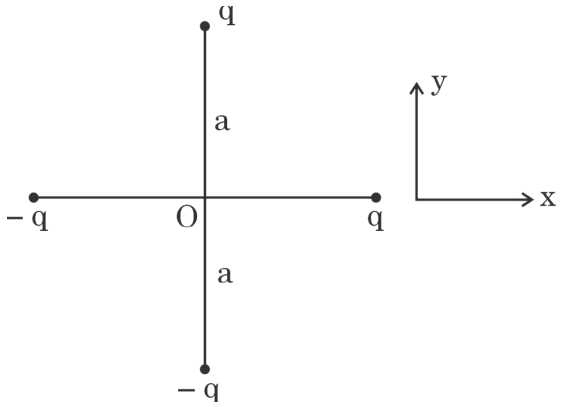
Q3. Four point charges of $1\,\mu$C, $-2\,\mu$C, $1\,\mu$C and $-2\,\mu$C are placed at the corners A, B, C and D respectively, of a square of side $30\,$cm. Find the net force acting on a charge of $4\,\mu$C placed at the centre of the square.

[2024 • Set 55-5-1]

Q4. Three point charges, $1\,\mu$C each, are kept at the vertices of an equilateral triangle of side $10\,$cm. Find the net electric field at the centroid of triangle.

[2024 • Set 55-5-1]

Q5. Two identical dipoles are arranged in x-y plane as shown in the figure. Find the magnitude and the direction of net electric field at the origin O.



[2023 • Set 55-4-1]

Q6. (c) An electric dipole of dipole moment of 6×10^{-7} C-m is kept in a uniform electric field of 10^4 N/C such that the dipole moment and the electric field are parallel. Calculate the potential energy of the dipole.

OR

(c) An electric dipole of dipole moment $\vec{p}$ is initially kept in a uniform electric field $\vec{E}$ such that $\vec{p}$ is perpendicular to $\vec{E}$. Find the amount of work done in rotating the dipole to a position at which $\vec{p}$ becomes antiparallel to $\vec{E}$.

[2023 • Set 55-4-1]

Q7. Use Gauss's law to obtain the expression for electric field due to a uniformly charged infinite plane thin sheet.

[2023 • Set 55-4-2]

Q8. Use Gauss's law to obtain the expression for electric field due to a thin infinitely long straight uniformly charged wire.

[2023 • Set 55-4-3]

Q9. Depict the orientation of an electric dipole in (a) stable and (b) unstable equilibrium in an external uniform electric field. Write the potential energy of the dipole in each case.

[2023 • Set 55-5-1]

Q10. An electric dipole of dipole moment $(\vec{p})$ is kept in a uniform electric field $\vec{E}$. Show graphically the variation of torque acting on the dipole (τ) with its orientation (θ) in the field. Find the orientation in which torque is (i) zero and (ii) maximum.

[2023 • Set 55-5-2]

Q11. Derive the expression for the torque acting on an electric dipole, when it is held in a uniform electric field. Identify the orientation of the dipole in the electric field, in which it attains a stable equilibrium.

OR

Obtain the expression for the energy stored in a capacitor connected across a dc battery. Hence define energy density of the capacitor.

[2020 • Set 55-5-1]

Q12. Five point charges, each of charge $+q$ are placed on five vertices of a regular hexagon of side l. Find the magnitude of the resultant force on a charge $-q$ placed at the centre of the hexagon.

OR

A simple pendulum consists of a small sphere of mass m suspended by a thread of length l. The sphere carries a positive charge q. The pendulum is placed in a uniform electric field of strength E directed vertically downwards. Find the period of oscillation of the pendulum due to the electrostatic force acting on the sphere, neglecting the effect of the gravitational force.

[2019 • Set 55-3-1]

Q13. Apply Gauss's law to show that for a charged spherical shell, the electric field outside the shell is, as if the entire charge were concentrated at the centre.

OR

Two large parallel plane sheets have uniform charge densities $+\sigma$ and $-\sigma$. Determine the electric field (i) between the sheets, and (ii) outside the sheets.

[2019 • Set 55-4-1]

Q14. Derive an expression for the torque acting on an electric dipole of dipole moment $\vec{p}$ placed in a uniform electric field $\vec{E}$. Write the direction along which the torque acts.

OR

Derive an expression for the electric field at a point on the axis of an electric dipole of dipole moment $\vec{p}$. Also write its expression when the distance $r >>$ the length 'a' of the dipole.

[2019 • Set 55-5-1]

Q15. Derive an expression for the work done in rotating a dipole from the angle θ_0 to θ_1 in a uniform electric field E.

[2016]

Q16. Given a uniform electric field $\vec{E} = 5 \times 10^3\,\hat{i}\,\mathrm{N/C}$, find the flux of this field through a square of 10 cm on a side whose plane is parallel to the y-z plane. What would be the flux through the same square if the plane makes a 30° angle with the x-axis ?

[2014]

Q17. An electric dipole of length 4 cm, when placed with its axis making an angle of 60° with a uniform electric field, experiences a torque of $4\sqrt{3}$ Nm. Calculate the potential energy of the dipole, if it has charge $+8$ nC.

[2014]

Q18. A spherical conducting shell of inner radius r_1 and outer radius r_2 has a charge 'Q'. A charge 'q' is placed at the centre of the shell.

(a) What is the surface charge density on the (i) inner surface, (ii) outer surface of the shell?

(b) Write the expression for the electric field at a point $x > r_2$ from the centre of the shell.

[2012]

Q19. Show that the electric field at the surface of a charged conductor is given by $\vec{E} = \dfrac{\sigma}{\varepsilon_0}\,\hat{n}$, where σ is the surface charge density and $\hat{n}$ is a unit vector normal to the surface in the outward direction.

[2012]

Q20. An electric dipole is held in a uniform electric field.

(i) Show that the net force acting on it is zero.

(ii) The dipole is aligned parallel to the field. Find the work done in rotating it through the angle of $180°$.

[2012]

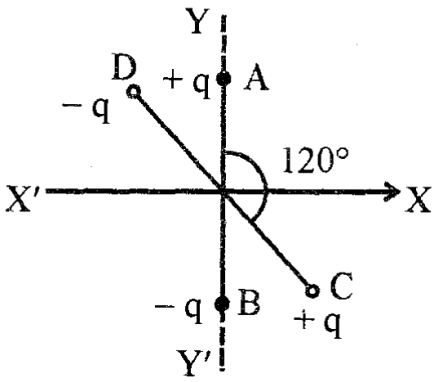
Q21. Plot a graph showing the variation of coulomb force (F) versus $\left(\frac{1}{r^2}\right)$, where r is the distance between the two charges of each pair of charges: $(1\ \mu C,\ 2\ \mu C)$ and $(2\ \mu C,\ -3\ \mu C)$. Interpret the graphs obtained.

[2011]

Q22. A thin straight infinitely long conducting wire having charge density λ is enclosed by a cylindrical surface of radius r and length l, its axis coinciding with the length of the wire. Find the expression for the electric flux through the surface of the cylinder.

[2011]

Q23. Two small identical electrical dipoles AB and CD, each of dipole moment p, are kept at an angle of 120° as shown in the figure. What is the resultant dipole moment of this combination? If this system is subjected to electric field $\vec{E}$ directed along $+X$ direction, what will be the magnitude and direction of the torque acting on this?



[2011 • Set 55-1-1]

Q24. Calculate the amount of work done in rotating a dipole, of dipole moment 3×10^{-8} C m, from its position of stable equilibrium to the position of unstable equilibrium, in a uniform electric field of intensity 10^4 N/C.

[2011 • Set 55-2-1]

Q25. Define electric flux. Write its S.I. unit. A charge q is enclosed by a spherical surface of radius R. If the radius is reduced to half, how would the electric flux through the surface change?

[2009]

Q26. Derive an expression for the torque acting on an electric dipole, which is held in a uniform electric field, when the axis of the dipole makes an angle θ with the electric field.

[2008]

Q27. The electric field E due to a point charge at any point near it is defined as $E = \lim_{q \to 0} \frac{F}{q}$, where q is the test charge and F is the force acting on it. What is the physical significance

of $\lim_{q \to 0}$ in this expression? Draw the electric field lines of a point charge Q when (i) $Q > 0$ and (ii) $Q < 0$.

[2007]

Q28. Define electric flux. Write its S.I. units. A spherical rubber balloon carries a charge that is uniformly distributed over its surface. As the balloon is blown up and increases in size, how does the total electric flux coming out of the surface change? Give reason.

[2007]

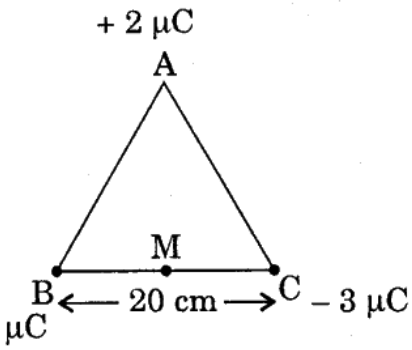
Q29. The electric field and electric potential at any point due to a point charge kept in air is $20\ \text{NC}^{-1}$ and $10\ \text{JC}^{-1}$ respectively. Compute the magnitude of this charge.

[2006]

Q30. Define 'electric line of force' and give its two important properties.

[2005]

Q31. Three point charges of $+2\ \mu$C, $-3\ \mu$C and $-3\ \mu$C are kept at the vertices A, B and C respectively of an equilateral triangle of side 20 cm as shown in the figure. What should be the sign and magnitude of the charge to be placed at the mid-point (M) of side BC so that the charge at A remains in equilibrium?



[2005]

Q32. Mention any two properties of electric lines of force. Sketch them for an isolated positive point charge.

[2003]

3-Mark Questions (33 questions · Section C · SA)

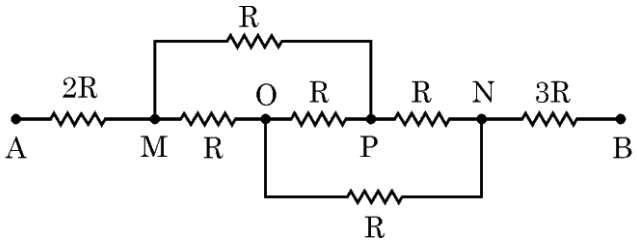
Q1. (a) Using Gauss's law, deduce an expression for electric field at a point due to a uniformly charged infinite plane thin sheet.

(b) Two large thin plane sheets, each having surface charge density σ, are held close and parallel to each other in air. What is the net electric field at a point (i) inside and (ii) outside, the sheets?

OR

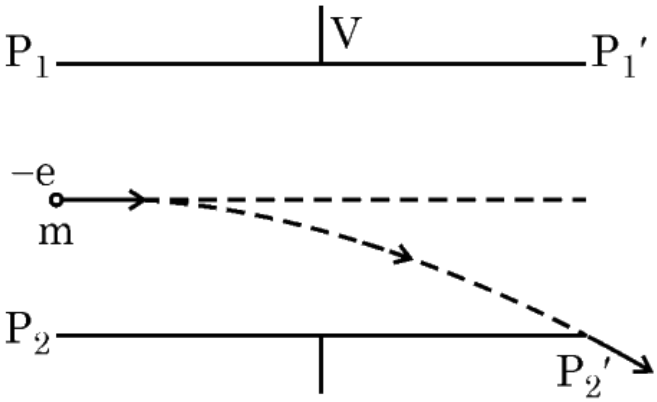
(a) Obtain the condition of balance of a Wheatstone bridge.

(b) Find net resistance of the network of resistors connected between A and B, as shown in figure.



[2026 • Set 55-1-1]

Q2. Figure shows a narrow beam of electrons entering with a velocity of 3×10^7 m/s, symmetrically through the space between two parallel horizontal plates P_1P_1' and P_2P_2' kept 2 cm apart.



If each plate is 3 cm long, calculate the potential difference V applied between the plates so that the beam just strikes the end P_2'.

[2026 • Set 55-1-1]

Q3. Two point charges $q_1 = 2.5 \times 10^{-7}$ C and $q_2 = -2.5 \times 10^{-7}$ C are located at points $(0, 0, -15\,\text{cm})$ and $(0, 0, 15\,\text{cm})$ respectively. Find:

(a) the electric dipole moment of the system, and

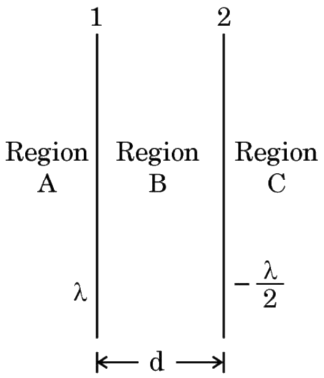
(b) the magnitude and direction of electric field at the origin $(0, 0, 0)$.

[2026 • Set 55-5-3]

Q4. (a) Two small solid metal balls A and B of radii R and $2R$ having charge densities 2σ and 3σ respectively are kept far apart. Find the charge densities on A and B after they are connected by a conducting wire.

OR

(b) Two infinitely long straight wires '1' and '2' are placed d distance apart, parallel to each other, as shown in the figure. They are uniformly charged having charge densities λ and $-\frac{\lambda}{2}$ respectively. Locate the position of the point from wire '1' at which the net electric field is zero and identify the region in which it lies.



[2025 • Set 55-5-1]

Q5. An electric field $\vec{E}$ given by: $\vec{E} = 100\,\hat{i}$ N/C for $x > 0$ $\vec{E} = -100\,\hat{i}$ N/C for $x < 0$ exists in a region. A right circular cylinder of length 10 cm and radius 2 cm, is placed in the region such that its axis coincides with x-axis and its two faces are at $x = -5$ cm and $x = 5$ cm. Calculate:

(a) the net outward flux through the cylinder, and

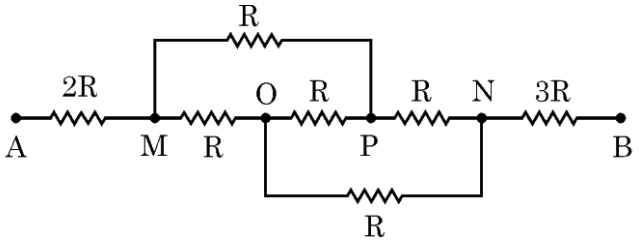
(b) the net charge inside the cylinder.

[2025 • Set 55-7-3]

Q6. A cube of side 0.1 m is placed, as shown in the figure, in a region where electric field $\vec{E} = 500\,x\,\hat{i}$ exists. Here x is in metres and E in NC^{-1}. Calculate:

(a) the flux passing through the cube, and

(b) the charge within the cube.



[2024 • Set 55-1-1]

Q7. Derive an expression for potential energy of an electric dipole $\vec{p}$ in an external uniform

electric field $\vec{E}$. When is the potential energy of the dipole (1) maximum, and (2) minimum?

[2024 • Set 55-1-1]

Q8. (a) Define the term 'electric flux' and write its dimensions.

(b) A plane surface, in shape of a square of side $1\,\text{cm}$ is placed in an electric field $\vec{E} = (100\,\text{N/C})\hat{i}$ such that the unit vector normal to the surface is given by $\hat{n} = 0.8\hat{i} + 0.6\hat{k}$. Find the electric flux through the surface.

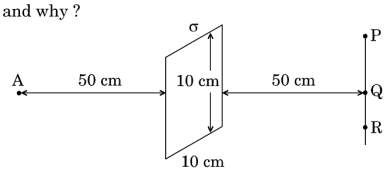
[2024 • Set 55-5-1]

Q9. (a) A uniformly charged large plane sheet has charge density $\sigma = \left(\frac{1}{18\pi}\right) \times 10^{-9}\,\text{C/m}^2$. Find the electric field at point A which is $50\,\text{cm}$ from the sheet.

(b) Consider a straight line with three points P, Q and R, placed $50\,\text{cm}$ from the charged sheet on the right side as shown in the figure. At which of these points, does the magnitude of the electric field due to the sheet remain the same as that at point A and why?

(a) A uniformly charged large plane sheet has charge density $\sigma = \left(\frac{1}{18\pi}\right) \times 10^{-15}\ \text{C/m}^2$. Find the electric field at point A which is 50 cm from the sheet.

Consider a straight line with three points P, Q and R, placed 50 cm from the charged sheet on the right side as shown in the figure. At which of these points, does the magnitude of the electric field due to the sheet remain the same as that at point A and why ?



(b) Two small identical conducting spheres carrying charge 10 μC and – 20 μC when

[2021]

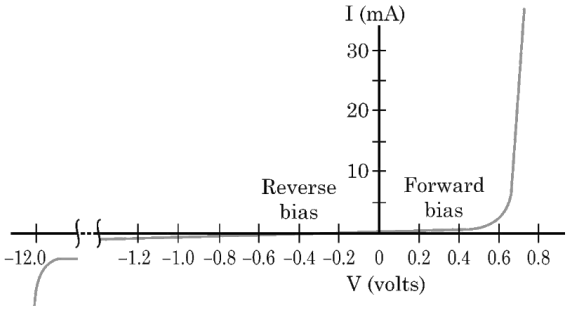
Q10. Two small identical conducting spheres carrying charge $10\,\mu\text{C}$ and $-20\,\mu\text{C}$ when separated by a distance of r, experience a force F each. If they are brought in contact and then separated to a distance of $\frac{r}{2}$, what is the new force between them in terms of F?

[2021]

Q11. Two small identical electric dipoles AB and CD, each of dipole moment $\vec{p}$ are kept at an angle of $120°$ to each other in an external electric field $\vec{E}$ pointing along the x-axis as shown in the figure. Find the

(a) dipole moment of the arrangement, and

(b) magnitude and direction of the net torque acting on it.



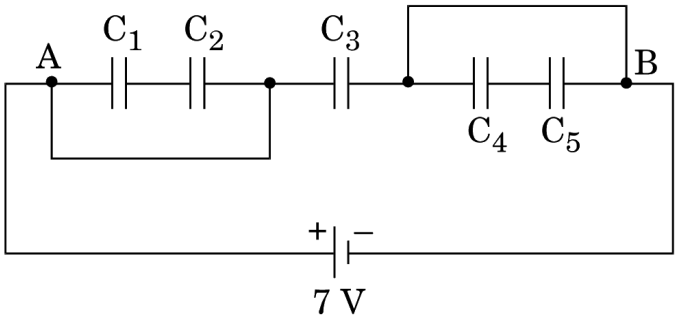
OR

In the figure given below, find the

(a) equivalent capacitance of the network between points A and B. Given: $C_1 = C_5 = 8\ \mu$F, $C_2 = C_3 = C_4 = 4\ \mu$F.

(b) maximum charge supplied by the battery, and

(c) total energy stored in the network.



[2020 • Set 55-2-1]

Q12. (a) Two electric field lines cannot cross each other. Also, they cannot form closed loops. Give reasons.

(b) A particle of charge $2\ \mu$C and mass 1.6 g is moving with a velocity $4\hat{i}$ m s^{-1}. At $t = 0$ the particle enters in a region having an electric field $\vec{E}$ (in NC^{-1}) $= 80\hat{i} + 60\hat{j}$. Find the velocity of the particle at $t = 5$ s.

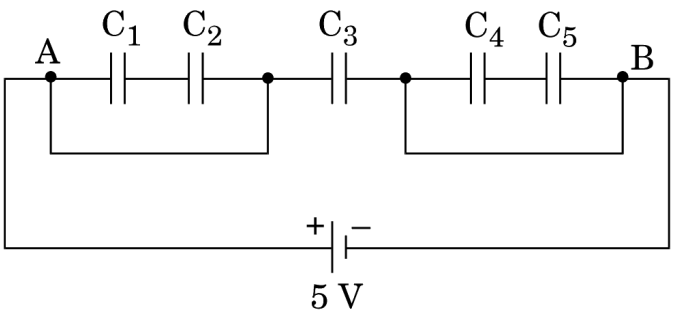
OR

In the figure given below, find the

(a) equivalent capacitance of the network between points A and B. Given: $C_1 = C_5 = 4\ \mu$F, $C_2 = C_3 = C_4 = 2\ \mu$F.

(b) maximum charge supplied by the battery, and

(c) total energy stored in the network.



[2020 • Set 55-2-2]

Q13. A hollow conducting sphere of inner radius r_1 and outer radius r_2 has a charge Q on its surface. A point charge $-q$ is also placed at the centre of the sphere.

(a) What is the surface charge density on the (i) inner and (ii) outer surface of the sphere?

(b) Use Gauss' law of electrostatics to obtain the expression for the electric field at a point lying outside the sphere.

OR

(a) An infinitely long thin straight wire has a uniform linear charge density λ. Obtain the expression for the electric field E at a point lying at a distance x from the wire, using Gauss' law.

(b) Show graphically the variation of this electric field E as a function of distance x from the wire.

[2020 • Set 55-4-1]

Q14. Derive an expression for the electric field due to a dipole of dipole moment $\vec{p}$ at a point on its perpendicular bisector.

[2019 • Set 55-1-3]

Q15. Two large charged plane sheets of charge densities σ and -2σ C/m^2 are arranged vertically with a separation of d between them. Deduce expressions for the electric field at points (i) to the left of the first sheet, (ii) to the right of the second sheet, and (iii) between the two sheets.

OR

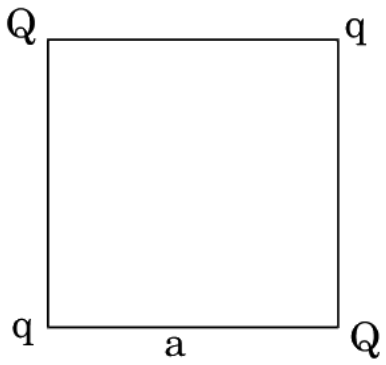
A spherical conducting shell of inner radius r_1 and outer radius r_2 has a charge Q.

(a) A charge q is placed at the centre of the shell. Find out the surface charge density on the inner and outer surfaces of the shell.

(b) Is the electric field inside a cavity (with no charge) zero; independent of the fact whether the shell is spherical or not? Explain.

[2019 • Set 55-2-1]

Q16. Four point charges Q, q, Q and q are placed at the corners of a square of side 'a' as shown in the figure.



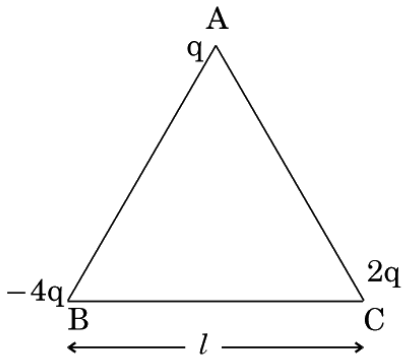
Find the

(a) resultant electric force on a charge Q, and

(b) potential energy of this system.

[2018]

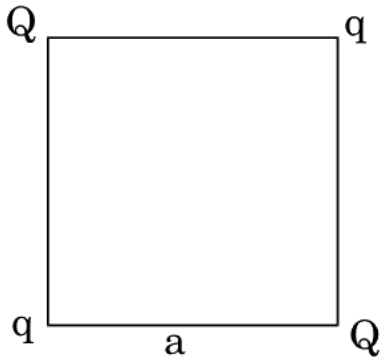
Q17. (a) Three point charges q, $-4q$ and $2q$ are placed at the vertices of an equilateral triangle ABC of side 'l' as shown in the figure. Obtain the expression for the magnitude of the resultant electric force acting on the charge q.



(b) Find out the amount of the work done to separate the charges at infinite distance.

[2018]

Q18. Four point charges Q, q, Q and q are placed at the corners of a square of side 'a' as shown in the figure.



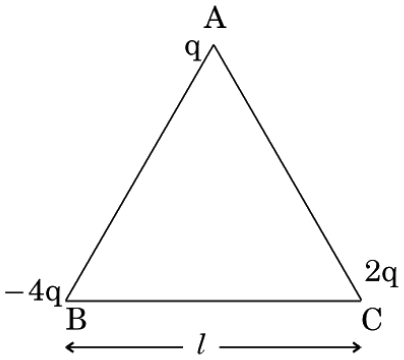
Find the

(a) resultant electric force on a charge Q, and

(b) potential energy of this system.

OR

(a) Three point charges q, −4q and 2q are placed at the vertices of an equilateral triangle ABC of side 'l' as shown in the figure. Obtain the expression for the magnitude of the resultant electric force acting on the charge q.



(b) Find out the amount of the work done to separate the charges at infinite distance.

[2018]

Q19. (i) Derive the expression for electric field at a point on the equatorial line of an electric dipole.

(ii) Depict the orientation of the dipole in (i) stable, (ii) unstable equilibrium in a uniform electric field.

[2017]

Q20. (i) Obtain the expression for the torque $\vec{\tau}$ experienced by an electric dipole of dipole moment $\vec{p}$ in a uniform electric field, $\vec{E}$.

(ii) What will happen if the field were not uniform?

[2017]

Q21. A long charged cylinder of linear charge density $+\lambda_1$ is surrounded by a hollow coaxial conducting cylinder of linear charge density $-\lambda_2$. Use Gauss's law to obtain expressions for the electric field at a point (i) in the space between the cylinders, and (ii) outside the larger cylinder.

[2017]

Q22. Define electric flux. Write its SI unit. Using Gauss's law, deduce an expression for electric field intensity due to an infinitely long straight uniformly charged wire.

[2017]

Q23. Using Gauss's law in electrostatics, deduce an expression for electric field intensity due to a uniformly charged infinite plane sheet. If another identical sheet is placed parallel to it, show that there is no electric field in the region between the two sheets.

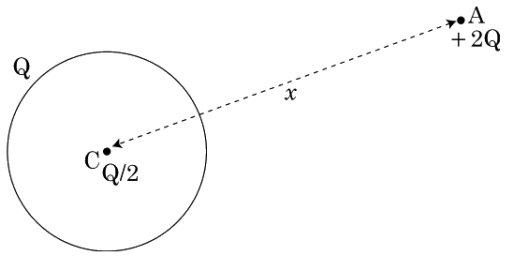
[2017]

Q24. A thin metallic spherical shell of radius R carries a charge Q on its surface. A point charge $Q/2$ is placed at the centre C and another charge $+2Q$ is placed outside the shell at A at a distance x from the centre as shown in the figure.

(i) Find the electric flux through the shell.

(ii) State the law used.

(iii) Find the force on the charges at the centre C of the shell and at the point A.



[2016]

Q25. Find the electric field intensity due to a uniformly charged spherical shell at a point (i) outside the shell and (ii) inside the shell. Plot the graph of electric field with distance from the centre of the shell.

[2016]

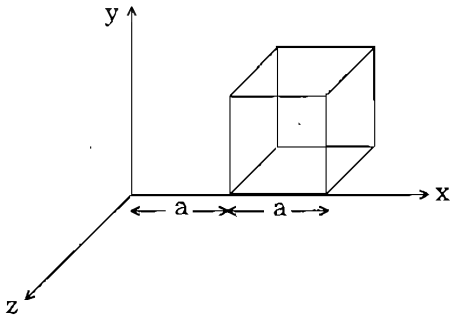
Q26. Derive an expression for the electric field intensity at a point on the equatorial line of an electric dipole of dipole moment $\vec{P}$ and length $2a$. What is the direction of this field?

[2016]

Q27. State Gauss's law in electrostatics. A cube with each side 'a' is kept in an electric field given by $\vec{E} = Cx\,\hat{i}$, (as is shown in the figure) where C is a positive dimensional constant. Find out

(i) the electric flux through the cube, and

(ii) the net charge inside the cube.



[2012]

Q28. Using Gauss's law obtain the expression for the electric field due to a uniformly charged thin spherical shell of radius R at a point outside the shell. Draw a graph showing the variation of electric field with r, for $r > R$ and $r < R$.

[2011 • Set 55-1-1]

Q29. A thin conducting spherical shell of radius R has charge Q spread uniformly over its surface. Using Gauss's law, derive an expression for an electric field at a point outside the shell. Draw a graph of electric field $E(r)$ with distance r from the centre of the shell for $0 \leq r \leq \infty$.

[2009]

Q30. State Gauss's theorem in electrostatics. Apply this theorem to derive an expression for electric field intensity at a point near an infinitely long straight charged wire.

[2007]

Q31. What is electric flux? Write its S.I. units. Using Gauss's theorem, deduce an expression for the electric field at a point due to a uniformly charged infinite plane sheet.

[2006]

Q32. An electric dipole is held in a uniform electric field. (i) Using a suitable diagram, show that it does not undergo any translatory motion, and (ii) derive an expression for the torque acting on it and specify its direction.

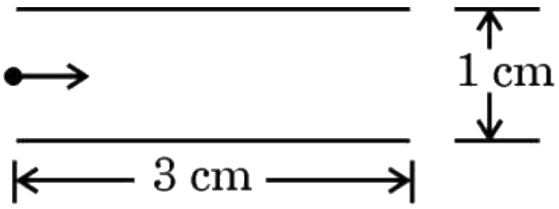
[2005]

Q33. State Gauss' theorem in electrostatics. Using this theorem, derive the expression for the electric field intensity at any point outside a uniformly charged thin spherical shell.

[2004]

4-Mark Questions (1 questions · Section D · Case Study)

Q1. A beam of electrons moving horizontally with a velocity of 3×10^7 m/s enters a region between two plates as shown in the figure. A suitable potential difference is applied across the plates such that the electron beam just strikes the edge of the lower plate.



Answer the following questions based on the above:

(a) How long does an electron take to strike the edge?

(b) What is the shape of the path followed by the electron and why?

(c) Find the potential difference applied.

OR

(c) Find the magnitude and direction of the magnetic field which should be created in the space between the plates so that the electron beam goes straight undeviated.

[2023 • Set 55-3-1]

5-Mark Questions (33 questions · Section E · Long Answer)

Q1. (a) An electric dipole consists of two point charges q and $-q$ separated by a distance $2a$. Derive an expression for the electric field $\vec{E}$ due to this dipole at a point distant r from the centre of the dipole on the equatorial plane. Write the expression for the electric field at a far off point, i.e. $r >> a$.

(b) A dipole is placed in x-y plane such that charges q and $-q$ are located at $x = a$ and $x = b$ respectively. There exists an electric field $\vec{E} = 2x\,\hat{i}$ N/C in the region. Calculate the force $\vec{F}$ and torque $\vec{\tau}$ experienced by the dipole.

OR

(a) Two cells of emf E_1 and E_2 with internal resistances r_1 and r_2 respectively, are connected in parallel by connecting their positive terminals together and negative terminals together. Deduce an expression for equivalent emf and equivalent internal resistance of the combination.

(b) A parallel combination, as stated in (a) above, of two cells of emfs E and $3E$ and internal resistances R each is connected across a resistance $2R$. Find the current that flows through resistance $2R$.

[2026 • Set 55-1-1]

Q2. (i) Two infinitely long straight wires having linear charge densities $-\lambda$ and 3λ are held vertically parallel to each other, distance r apart in free space. Find the nature and magnitude of the force/length exerted by one wire on the other.

[2026 • Set 55-3-1]

Q3. (ii) A small hollow conducting sphere of radius r_1 is given a charge Q. It is surrounded by a concentric conducting spherical shell of inner radius r_2 and outer radius r_3, having charge $-3Q$. If a point charge $2q$ were kept at the centre, find: (I) the electric flux through a concentric spherical Gaussian surface of radius x for (1) $x < r_1$, and (2) $r_1 < x < r_2$. (II) electric field at a point distant x from the centre for (1) $x > r_3$, and (2) $r_1 < x < r_2$. (III) surface charge density on the inner surface of (1) sphere, and (2) shell.

[2026 • Set 55-3-1]

Q4. (i) What is difference between an open surface and a closed surface? Draw elementary surface vector $d\vec{S}$ for a spherical surface S.

(ii) Define electric flux through a surface. Give the significance of a Gaussian surface. A charge outside a Gaussian surface does not contribute to total electric flux through the surface. Why?

(iii) A small spherical shell S_1 has point charges $q_1 = -3\ \mu$C, $q_2 = -2\ \mu$C and $q_3 = 9\ \mu$C inside it. This shell is enclosed by another big spherical shell S_2. A point charge Q is placed in between the two surfaces S_1 and S_2. If the electric flux through the surface S_2 is four times the flux through surface S_1, find charge Q.

[2025 • Set 55-2-1]

Q5. (a) (i) Two point charges $+q$ and $-q$ are held at $(a, 0)$ and $(-a, 0)$ in x-y plane. Obtain an expression for the net electric field due to the charges at a point $(0, y)$. Hence, find electric field at a far off point $(y \gg a)$. (ii) Three point charges of -2 nC, -1 nC, and $+5$ nC are kept at the vertices A, B and C of an equilateral triangle of side 0.2 m. Find the total amount of work done in shifting the charges from A to A_1, B to B_1 and C to C_1. Here A_1, B_1 and C_1 are the midpoints of sides AB, BC and CA, respectively.

OR

(b) (i) Show that Gauss's theorem is consistent with Coulomb's law. Using it, derive an expression for the electric field due to a uniformly charged thin spherical shell of radius r at a point at a distance y from the centre of the shell such that (I) $y > r$, and (II) $y < r$. (ii) A point charge of $+2$ nC is kept at the origin of a three-dimensional coordinate system. Find the type and magnitude of the charge which

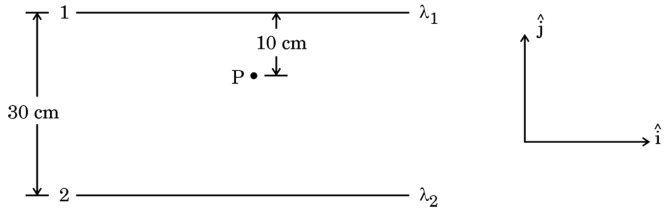
should be kept at $(0, 0, -6\,\text{m})$ so that the potential due to the system becomes zero at $(0, 0, 2\,\text{m})$.

[2025 • Set 55-4-1]

Q6. (a) (i) Obtain an expression for the electric potential due to a small dipole of dipole moment $\vec{p}$, at a point $\vec{r}$ from its centre, for much larger distances compared to the size of the dipole. (ii) Three point charges q, 2q and nq are placed at the vertices of an equilateral triangle. If the potential energy of the system is zero, find the value of n.

OR

(b) (i) State Gauss's Law in electrostatics. Apply this to obtain the electric field $\vec{E}$ at a point near a uniformly charged infinite plane sheet. (ii) Two long straight wires 1 and 2 are kept as shown in the figure. The linear charge density of the two wires are $\lambda_1 = 10\ \mu C/m$ and $\lambda_2 = -20\ \mu C/m$. Find the net force $\vec{F}$ experienced by an electron held at point P.



[2024 • Set 55-2-1]

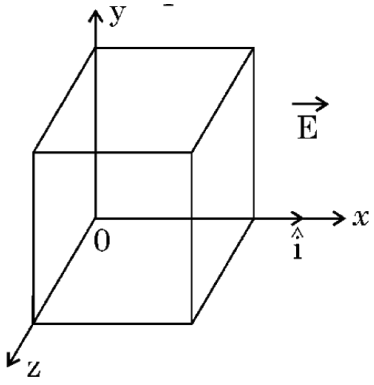
Q7. (i) A charge $+Q$ is placed on a thin conducting spherical shell of radius R. Use Gauss's theorem to derive an expression for the electric field at a point lying (i) inside and (ii) outside the shell.

(ii) Show that the electric field for same charge density (σ) is twice in case of a conducting plate or surface than in a nonconducting sheet.

[2024 • Set 55-3-1]

Q8. (i) Using Gauss's law, show that the electric field $\vec{E}$ at a point due to a uniformly charged infinite plane sheet is given by $\vec{E} = \dfrac{\sigma}{2\varepsilon_0}\hat{n}$ where symbols have their usual meanings.

(ii) Electric field $\vec{E}$ in a region is given by $\vec{E} = (5x^2 + 2)\hat{i}$, where E is in N/C and x is in meters. A cube of side $10\,\text{cm}$ is placed in the region as shown in figure. Calculate (1) the electric flux through the cube, and (2) the net charge enclosed by the cube.



[2024 • Set 55-4-1]

Q9. (i) A thin spherical shell of radius R has a uniform surface charge density σ. Using Gauss' law, deduce an expression for electric field (i) outside and (ii) inside the shell.

(ii) Two long straight thin wires AB and CD have linear charge densities $10\,\mu$C/m and $-20\,\mu$C/m, respectively. They are kept parallel to each other at a distance 1 m. Find magnitude and direction of the net electric field at a point midway between them.

[2024 • Set 55-5-1]

Q10. (i) State Coulomb's law in electrostatics and write it in vector form, for two charges.

(ii) 'Gauss's law is based on the inverse-square dependence on distance contained in the Coulomb's law.' Explain.

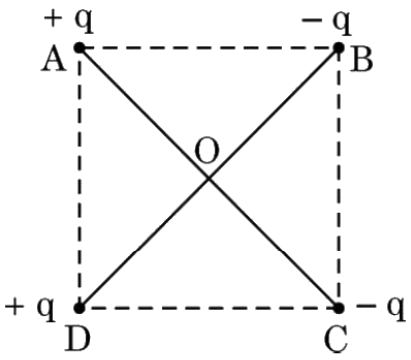
(iii) Two charges A (charge q) and B (charge $2q$) are located at points $(0, 0)$ and (a, a) respectively. Let $\hat{i}$ and $\hat{j}$ be the unit vectors along x-axis and y-axis respectively. Find the force exerted by A on B, in terms of $\hat{i}$ and $\hat{j}$.

[2023 • Set 55-1-1]

Q11. (i) Derive an expression for the electric field at a point on the equatorial plane of an electric dipole consisting of charges q and $-q$ separated by a distance $2a$.

(ii) The distance of a far off point on the equatorial plane of an electric dipole is halved. How will the electric field be affected for the dipole?

(iii) Two identical electric dipoles are placed along the diagonals of a square $ABCD$ of side $\sqrt{2}$ m as shown in the figure. Obtain the magnitude and direction of the net electric field at the centre (O) of the square.



[2023 • Set 55-1-1]

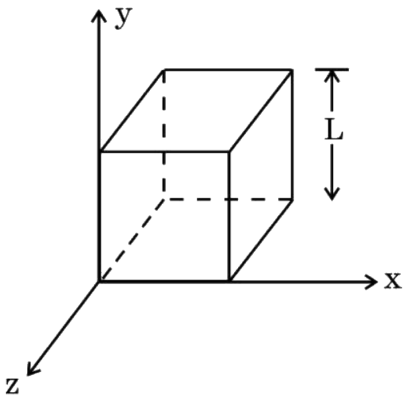
Q12. **(i)** Use Gauss' law to obtain an expression for the electric field due to an infinitely long thin straight wire with uniform linear charge density λ.

(ii) An infinitely long positively charged straight wire has a linear charge density λ. An electron is revolving in a circle with a constant speed v such that the wire passes through the centre, and is perpendicular to the plane, of the circle. Find the kinetic energy of the electron in terms of magnitudes of its charge and linear charge density λ on the wire.

(iii) Draw a graph of kinetic energy as a function of linear charge density λ.

[2023 • Set 55-2-1]

Q13. (a) **(i)** Define electric flux and write its SI unit. (ii) Use Gauss' law to obtain the expression for the electric field due to a uniformly charged infinite plane sheet. (iii) A cube of side L is kept in space, as shown in the figure. An electric field $\vec{E} = (Ax + B)\,\hat{i}$ exists in the region. Find the net charge enclosed by the cube.



OR

(b) **(i)** Define electric potential at a point and write its SI unit. (ii) Two capacitors are connected in series. Derive an expression of the equivalent capacitance of the combination. (iii) Two point charges $+q$ and $-q$ are located at points $(3a, 0)$ and $(0, 4a)$ respectively in x-y plane. A third charge Q is kept at the origin. Find the

value of Q, in terms of q and a, so that the electrostatic potential energy of the system is zero.

[2023 • Set 55-3-1]

Q14. Using Gauss law, derive expression for electric field due to a spherical shell of uniform charge distribution σ and radius R at a point lying at a distance x from the centre of shell, such that

(i) $0 < x < R$, and

(ii) $x > R$.

[2020 • Set 55-1-1]

Q15. An electric field is uniform and acts along $+x$ direction in the region of positive x. It is also uniform with the same magnitude but acts in $-x$ direction in the region of negative x. The value of the field is $E = 200\,\text{N/C}$ for $x > 0$ and $E = -200\,\text{N/C}$ for $x < 0$. A right circular cylinder of length $20\,\text{cm}$ and radius $5\,\text{cm}$ has its centre at the origin and its axis along the x-axis so that one flat face is at $x = +10\,\text{cm}$ and the other is at $x = -10\,\text{cm}$. Find:

(i) The net outward flux through the cylinder.

(ii) The net charge present inside the cylinder.

[2020 • Set 55-1-1]

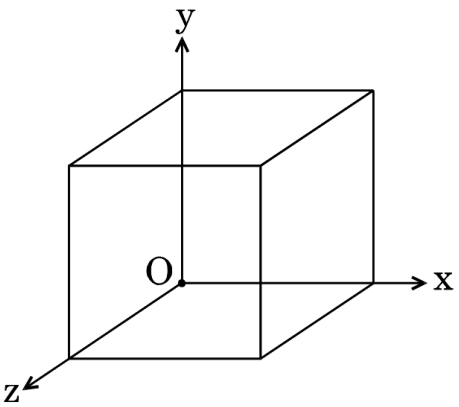
Q16. (a) Use Gauss's law to show that due to a uniformly charged spherical shell of radius R, the electric field at any point situated outside the shell at a distance r from its centre is equal to the electric field at the same point, when the entire charge on the shell were concentrated at its centre. Also plot the graph showing the variation of electric field with r, for $r < R$ and $r \geq R$.

(b) Two point charges of $+1\ \mu$C and $+4\ \mu$C are kept 30 cm apart. How far from the $+1\ \mu$C charge on the line joining the two charges, will the net electric field be zero?

OR

(a) Two point charges q_1 and q_2 are kept r distance apart in a uniform external electric field $\vec{E}$. Find the amount of work done in assembling this system of charges.

(b) A cube of side 20 cm is kept in a region as shown in the figure. An electric field $\vec{E}$ exists in the region such that the potential at a point is given by $V = 10x + 5$, where V is in volt and x is in m.



Find the (i) electric field $\vec{E}$, and (ii) total electric flux through the cube.

[2020 • Set 55-2-1]

Q17. (a) An electric dipole of dipole moment $\vec{P}$ is placed in a uniform electric field $\vec{E}$ at an angle θ with it. Derive the expression for torque $(\vec{\tau})$ acting on it. Find the orientation of the dipole relative to the electric field for which torque on it is (i) maximum, and (ii) half of maximum.

(b) Two point charges $q_1 = +1\,\mu$C and $q_2 = +4\,\mu$C are placed 2 m apart in air. At what distance from q_1 along the line joining the two charges, will the net electric field be zero?

OR

(a) Derive an expression for the energy stored in a parallel plate capacitor of capacitance C when charged up to voltage V. How is this energy stored in the capacitor?

(b) A capacitor of capacitance $1\,\mu$F is charged by connecting a battery of negligible internal resistance and emf 10 V across it. Calculate the amount of charge supplied by the battery in charging the capacitor fully.

[2020 • Set 55-3-1]

Q18. (a) Write two important characteristics of equipotential surfaces.

(b) A thin circular ring of radius r is charged uniformly so that its linear charge density becomes λ. Derive an expression for the electric field at a point P at a distance x from it along the axis of the ring. Hence, prove that at large distances ($x \gg r$), the ring behaves as a point charge.

OR

(a) State Gauss's law on electrostatics and derive an expression for the electric field due to a long straight thin uniformly charged wire (linear charge density λ) at a point lying at a distance r from the wire.

(b) The magnitude of electric field (in NC^{-1}) in a region varies with the distance r (in m) as $E = 10r + 5$ By how much does the electric potential increase in moving from point at $r = 1$ m to a point at $r = 10$ m.

[2020 • Set 55-5-1]

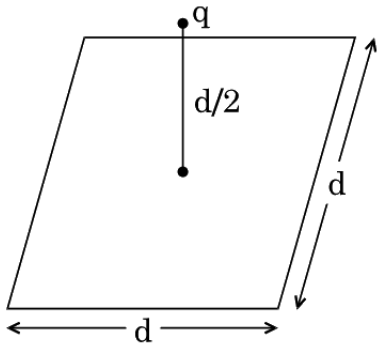
Q19. Derive an expression for the electric field at any point on the equatorial line of an electric dipole.

[2019 • Set 55-1-1]

Q20. Two identical point charges, q each, are kept 2 m apart in air. A third point charge Q of unknown magnitude and sign is placed on the line joining the charges such that the system remains in equilibrium. Find the position and nature of Q.

[2019 • Set 55-1-1]

Q21. (a) Define electric flux. Is it a scalar or a vector quantity ? A point charge q is at a distance of $d/2$ directly above the centre of a square of side d, as shown in the figure. Use Gauss' law to obtain the expression for the electric flux through the square.



(b) If the point charge is now moved to a distance 'd' from the centre of the square and the side of the square is doubled, explain how the electric flux will be affected.

[2018]

Q22. (a) Use Gauss' law to derive the expression for the electric field $(\vec{E})$ due to a straight uniformly charged infinite line of charge density λ C/m.

(b) Draw a graph to show the variation of E with perpendicular distance r from the line of charge.

(c) Find the work done in bringing a charge q from perpendicular distance r_1 to r_2 $(r_2 > r_1)$.

[2018]

Q23. (a) Derive an expression for the electric field $\vec{E}$ due to a dipole of length '$2a$' at a point distant r from the centre of the dipole on the axial line.

(b) Draw a graph of E versus r for $r >> a$.

(c) If this dipole were kept in a uniform external electric field $\vec{E_0}$, diagrammatically represent the position of the dipole in stable and unstable equilibrium and write the expressions for the torque acting on the dipole in both the cases.

[2017]

Q24. (a) Use Gauss's theorem to find the electric field due to a uniformly charged infinitely large plane thin sheet with surface charge density σ.

(b) An infinitely large thin plane sheet has a uniform surface charge density $+\sigma$. Obtain the expression for the amount of work done in bringing a point charge q from infinity to a point, distant r, in front of the charged plane sheet.

[2017]

Q25. (i) Use Gauss's law to find the electric field due to a uniformly charged infinite plane sheet. What is the direction of field for positive and negative charge densities?

(ii) Find the ratio of the potential differences that must be applied across the parallel and series combination of two capacitors C_1 and C_2 with their capacitances in the ratio $1 : 2$ so that the energy stored in the two cases becomes the same.

OR

(i) If two similar large plates, each of area A having surface charge densities $+\sigma$ and $-\sigma$ are separated by a distance d in air, find the expressions for

(a) field at points between the two plates and on outer side of the plates. Specify the direction of the field in each case.

(b) the potential difference between the plates.

(c) the capacitance of the capacitor so formed. (ii) Two metallic spheres of radii R and $2R$ are charged so that both of these have same surface charge density σ. If they are connected to each other with a conducting wire, in which direction will the charge flow and why?

[2016]

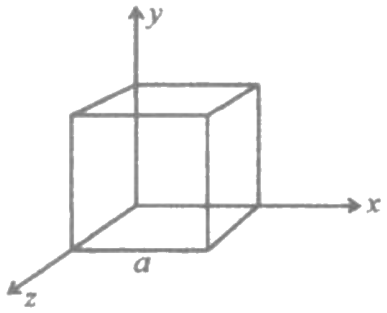
Q26. (a) "The outward electric flux due to charge $+Q$ is independent of the shape and size of the surface which encloses it." Give two reasons to justify this statement.

(b) Two identical circular loops '1' and '2' of radius R each have linear charge densities $-\lambda$ and $+\lambda$ C/m respectively. The loops are placed coaxially with their centres $R\sqrt{3}$ distance apart. Find the magnitude and direction of the net electric field at the centre of loop '1'.

[2015]

Q27. (a) An electric dipole of dipole moment $\vec{p}$ consists of point charges $+q$ and $-q$ separated by a distance $2a$ apart. Deduce the expression for the electric field $\vec{E}$ due to the dipole at a distance x from the centre of the dipole on its axial line in terms of the dipole moment $\vec{p}$. Hence show that in the limit $x \gg a$, $\vec{E} \to 2\vec{p}/(4\pi\varepsilon_0 x^3)$.

(b) Given the electric field in the region $\vec{E} = 2x\hat{i}$, find the net electric flux through the cube and the charge enclosed by it.



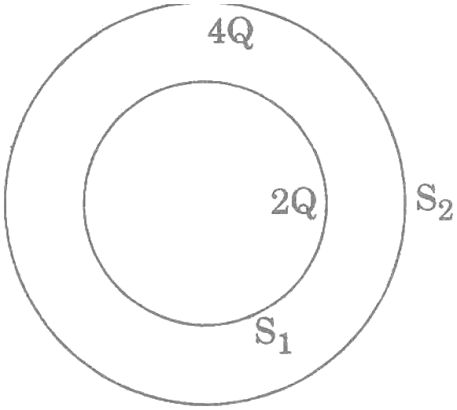
[2015]

Q28. Draw a labelled diagram of Van de Graaff generator. State its working principle to show how by introducing a small charged sphere into a larger sphere, a large amount of charge can be transferred to the outer sphere. State the use of this machine and also point out its limitations.

OR

(a) Deduce the expression for the torque acting on a dipole of dipole moment $\vec{p}$ in the presence of a uniform electric field $\vec{E}$.

(b) Consider two hollow concentric spheres, S_1 and S_2, enclosing charges $2Q$ and $4Q$ respectively as shown in the figure. (i) Find out the ratio of the electric flux through them. (ii) How will the electric flux through the sphere S_1 change if a medium of dielectric constant 'ε_r' is introduced in the space inside S_1 in place of air ? Deduce the necessary expression.



[2014]

Q29. Explain the principle of a device that can build up high voltages of the order of a few million volts. Draw a schematic diagram and explain the working of this device. Is there any restriction on the upper limit of the high voltages set up in this machine? Explain.

OR

(a) Define electric flux. Write its S.I. units.

(b) Using Gauss's law, prove that the electric field at a point due to a uniformly charged infinite plane sheet is independent of the distance from it.

(c) How is the field directed if (i) the sheet is positively charged, (ii) negatively charged?

[2012]

Q30. State Gauss' theorem in electrostatics. Apply it to find the electric field strength at a point near a long straight conductor carrying electric charge.

[2010]

Q31. What is the magnitude of a point electric charge chosen so that the electric field due to it at a point 50 cm away has magnitude $2.0\ \mathrm{N\,C^{-1}}$?

[2010]

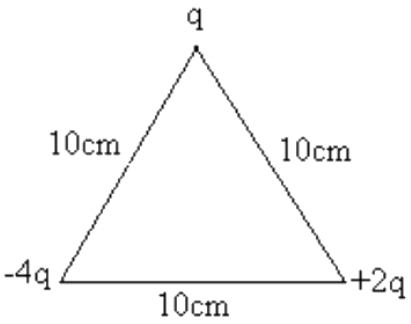
Q32. (a) Using Gauss' law, derive an expression for the electric field intensity at any point outside a uniformly charged thin spherical shell of radius R and charge density $\sigma\ C/m^2$. Draw the field lines when the charge density of the sphere is (i) positive, (ii) negative.

(b) A uniformly charged conducting sphere of $2.5\ m$ in diameter has a surface charge density of $100\ \mu C/m^2$. Calculate the (i) Charge on the sphere (ii) Total electric flux passing through the sphere

[2008]

Q33. (a) Derive an expression for the torque experienced by an electric dipole kept in a uniform electric field.

(b) Calculate the work done to dissociate the system of three charges placed on the vertices of a triangle as shown.



[2008]