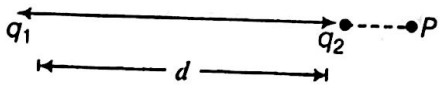
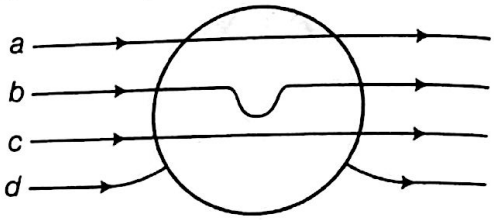
1 Mark Questions

1. Draw the pattern of electric field lines, when a point charge $-Q$ is kept near an uncharged conducting plate.
2. Draw a pattern of electric field lines due to two positive charges placed a distance d apart.
3. Draw the pattern of electric field lines due to an electric dipole
4. Why do the electrostatic field lines not form closed loop?
5. Two equal balls having equal positive charge q coulombs are suspended by two insulating strings of equal length. What would be the effect on the force when a plastic sheet is inserted between the two?
6. Why do the electric field lines never cross each other?
7. Why must electrostatic field at the surface of a charged conductor be perpendicular to every point on it?
8. Two point charges q_1 and q_2 are placed at a distance d apart as shown in the figure. The electric field intensity is zero at the point P on the line joining them as shown. Write two conclusions that you can draw from this.



9. Define dipole moment of an electric dipole. Is it a scalar quantity or a vector quantity?
10. Draw a plot showing the variation of electric field (E) with distance r due to a point charge q
11. A proton is placed in a uniform electric field directed along the positive X-axis. In which direction, will it tend to move?
12. In which orientation, a dipole placed in a uniform electric field is in (*i*) stable equilibrium (*ii*) unstable equilibrium?
13. Two point charges having equal charges separated by 1m distance experience a force of 8 N. What will be the force experienced by them, if they are held in water at the same distance? (Given, $K_{water} = 80$).
14. A metallic sphere is placed in a uniform electric field as shown in the figure. Which path is followed by electric field lines and why?



15. Point out whether the following statement is right or wrong.

    The mutual forces between two charges do not get affected by the presence of other charges

2 Marks Questions

16. Derive an expression for the electric field due to a dipole of dipole moment **p** at a point on its perpendicular bisector.
17. 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 $4\sqrt{3}$ N-m. Calculate the potential energy of the dipole if it has charge ± 8 nC.
18. An electric dipole of length 2 cm when placed with its axis making an angle of 60° with a uniform electric field, experiences a torque of $8\sqrt{3}$ N-m. Calculate the potential energy of the dipole if it has charge of ± 4 nC.

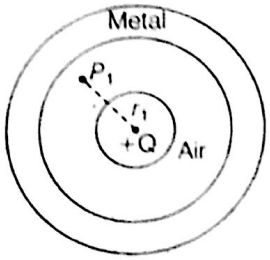
19. An electric dipole of length 1cm when placed with its axis making an angle of 60° with a uniform electric field, experiences a torque of $6\sqrt{3}$ N-m. Calculate the potential energy of the dipole, if it has charge ± 2 nC.

20. An electric dipole is placed in a uniform electric field E with its dipole moment p parallel to the field. Find

(i) the work done in turning the dipole till its dipole moment points in the direction opposite to E.

(ii) the orientation of the dipole for which the torque acting on it becomes maximum.

21. A small metal sphere carrying a charge $+Q$ is located at the centre of a spherical cavity in a large uncharged metallic spherical shell. Write the charges on the inner and outer surfaces of the shell. Write the expression for the electric field at the point P_1.



22. Point charge $(+Q)$ is kept in the vicinity of an uncharged conducting plate. Sketch electric field lines between the charge and the plate.

23. Two concentric metallic spherical shells of radii R and $2R$ are given charge Q_1 and Q_2 respectively. The surface charge densities on the outer surfaces of the shells are equal. Determine the ratio $Q_1:Q_2$.

24. Calculate the amount of work done in turning an electric dipole of dipole moment 3×10^{-8} C - m from its position of unstable equilibrium to the position of stable equilibrium in a uniform electric field of intensity 10^3 NC^{-1}.

25. Plot a graph showing the variation of Coulomb force (F) *versus* $1/r^2$, where r is the distance between the two charges of each pair of charges (1 μC, 2 μC) and (1 μC, – 3 μC). Interpret the graphs obtained.

26. Two identical metallic spherical shells A and B having charges $+4Q$ and $-10Q$ are kept a certain distance apart. A third identical uncharged sphere C is first placed in contact with sphere A and then with sphere B, then spheres A and B are brought in contact and then separated. Find the charge on the spheres A and B.

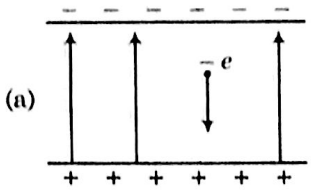
27. A dipole with a dipole moment of magnitude p is in stable equilibrium in an electrostatic field of magnitude E. Find the work done in rotating this dipole to its position of unstable equilibrium.

28. A dipole is present in an electrostatic field of magnitude 10^6 NC^{-1}. If the work done in rotating it from its position of stable equilibrium to its position of unstable equilibrium is 2×10^{-23} J, then find the magnitude of the dipole moment of this dipole.

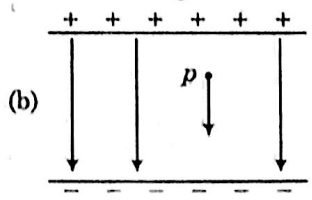
29. Deduce the expression for the electric field E due to a system of two charges q_1 and q_2 with position vectors $\mathbf{r}_1$ and $\mathbf{r}_2$ at a point r with respect to common origin.

3 Marks Questions

30. An electron falls through a distance of 1.5 cm in a uniform electric field of magnitude 2.0×10^4 N/C (Fig. a)



Calculate the time it takes to fall through this distance starting from rest.



If the direction of the field is reversed (Fig. b) keeping its magnitude unchanged, calculate the time taken by a proton to fall through this distance starting from rest.

31. (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 (a) stable, (b) unstable equilibrium in a uniform electric field.

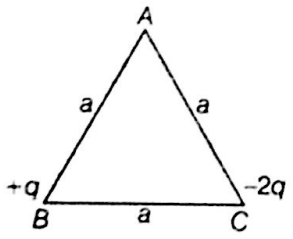
32. (i) Obtain the expression for the torque τ experienced by an electric dipole of dipole moment **p** in a uniform electric field, **E**.

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

33. A charge is distributed uniformly over a ring of radius a. Obtain an expression for the electric field intensity E at a point on the axis of the ring. Hence, show that for points at large distances from the ring, it behaves like a point charge.

34. An electric dipole of dipole moment **p** is placed in a uniform electric field **E**. Obtain the expression for the torque τ experienced by the dipole. Identify two pairs of perpendicular vectors in the expression

35. Two point charges $+q$ and $-2q$ are placed at the vertices B and C of an equilateral ΔABC of side a as given in the figure. Obtain the expression for



(i) the magnitude and

(ii) the direction of the resultant electric field at the vertex A due to these two charges.

36. Define the term electric dipole moment. Is it a scalar or vector? Deduce an expression for the electric field at a point on the equatorial plane of an electric dipole of length $2a$.

37. An electric dipole is kept in a uniform electric field. Derive an expression for the net torque acting on it and write its direction. State the conditions under which the dipole is in (i) stable equilibrium

(ii) unstable equilibrium.

38. Sketch the pattern of electric field lines due to

(i) a conducting sphere having negative charge on it.

(ii) an electric dipole

5 Marks Questions

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

(ii) 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.

40. (i) Derive an expression for the electric field E due to a dipole of length $2l$ at a point distant r from the centre of the dipole on the axial line.

(ii) Draw a graph of E *versus* r for $r >> l$.

(iii) If this dipole is kept in a uniform external electric field 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.

41. (i) Define torque acting on a dipole of dipole moment **p** placed in a uniform electric field **E**. Express it in the vector form and point out the direction along which it acts.

(ii) What happens if the field is non-uniform?

(iii) What would happen if the external field **E** is increasing (a) parallel to **p** and (b) anti-parallel to **p**?

1 Mark Questions

1. How does the electric flux due to a point charge enclosed by a spherical Gaussian surface get affected when its radius is increased?

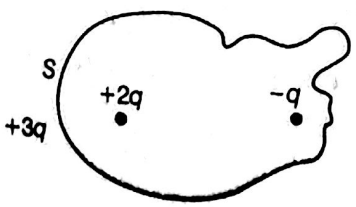
2. What is the electric flux through a cube of side 1 cm which encloses an electric dipole?

3. What is the flux due to electric field $\mathbf{E} = 3\times10^3\,\hat{\mathbf{i}}\,\mathrm{NC}^{-1}$ through a square of side 10 cm, when it is held normal to $\mathbf{E}$?

4. Two charges of magnitudes $-2Q$ and $+Q$ are located at points $(a, 0)$ and $(4a, 0)$, respectively. What is the electric flux due to these charges through a sphere of radius $3a$ with its centre at the origin?

5. 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?

6. 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?



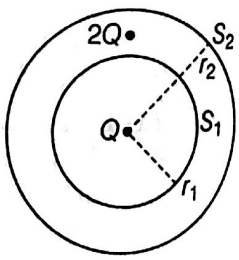
2 Marks Questions

7. Given a uniform electric field $\mathbf{E} = 5\times10^3\,\hat{\mathbf{i}}\ \mathrm{NC}^{-1}$, find the flux of this field through a square of 10 cm on a side whose plane is parallel to the YZ-plane. What would be the flux through the same square if the plane makes an angle of 30° with the X-axis?

8. Given a uniform electric field $\mathbf{E} = 2\times10^3\,\hat{\mathbf{i}}\ \mathrm{NC}^{-1}$, find the flux of this field through a square of side 20 cm, whose plane is parallel to the YZ-plane. What would be the flux through the same square, if the plane makes an angle of 30° with the X-axis?

9. Given a uniform electric field $\mathbf{E} = 4\times10^3\,\hat{\mathbf{i}}\ \mathrm{NC}^{-1}$. Find the flux of this field through a square of 5 cm on a side whose plane is parallel to the YZ-plane. What would be the flux through the same square if the plane makes an angle of 30° with the X-axis?

10. A sphere S_1 of radius r_1 encloses a net charge Q.



If there is another concentric sphere S_2 of radius $r_2 (r_2 > r_1)$ enclosing charge $2Q$, find the ratio of the electric flux through S_1 and S_2. How will the electric flux through sphere S_1 change if a medium of dielectric constant K is introduced in the space inside S_2 in place of air?

11. 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

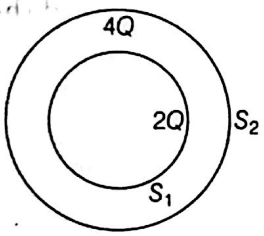
12. Show that the electric field at the surface of a charged conductor is given by $E = \frac{\sigma}{\varepsilon_0}\hat{n}$, where σ is the surface charge density and $\hat{n}$ is a unit vector normal to the surface in the outward direction.

13. 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.

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

(ii) Write the expression for the electric field at a point to $x > R_2$ from the centre of the shell.

14. 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 spheres S_1change if a medium of dielectric constant ε_r is introduced in the space inside S_1 in place of air? Deduce the necessary expression.



3 Marks Questions

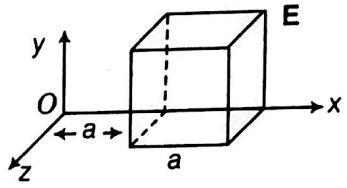
15. Two large charged plane sheets of charge densities σ and -2σ C/m^2 are arranged vertically with a separation of d between them. Deduce expressions for the electric field at points (i) to the left of the first sheet, (ii) to the right of the second sheet and (iii) between the two sheets.

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

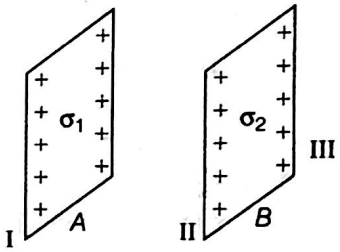
(a) A charge q is placed at the centre of the shell. Find out the surface charge density on the inner and outer surfaces of the shell.

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

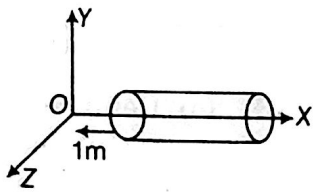
17. Define electric flux and write its SI unit. The electric field components in the figure shown are $E_x = \alpha x$, $E_y = 0$, $E_z = 0$, where $\alpha = \frac{100\text{N}}{\text{Cm}}$. Calculate the charge within the cube, assuming $a = 0.1$ m.



18. Two infinitely large plane thin parallel sheets having surface charge densities σ_1 and $\sigma_2 (\sigma_1 > \sigma_2)$ are shown in the figure. Write the magnitudes and directions of the net fields in the regions marked II and III.



19. A hollow cylindrical box of length 1 m and area of cross -section 25 cm^2 is placed in a three-dimensional coordinate system as shown in the figure. The electric field in the region is given by $E = 50\,x\hat{i}$, where E is in NC^{-1} and x is in metre.



Find

(i) net flux through the cylinder.

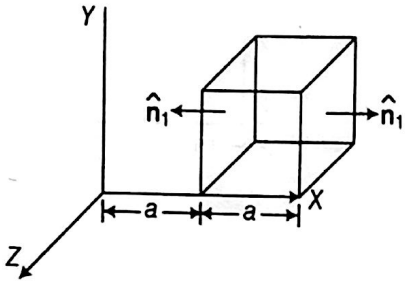
(ii) charge enclosed by the cylinder.

20. (i) State Gauss's law.

(ii) A thin straight infintely long conducting wire of linear charge

density λ is enclosed by a cylindrical surface of radius r and length l. Its axis coinciding with the length of the wire. Obtain the expression for the electric field, indicating its direction, at a point on the surface of the cylinder.

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



(i) the electric flux through the cube.

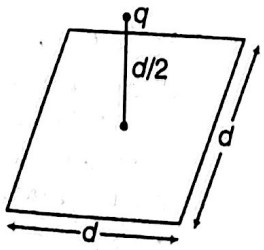
(ii) the net charge inside the cube.

22. Using Gauss' law, obtain the expression for the electric field due to uniformly charged 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 $r < R$

5 Marks Questions

23. (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.

24. (a) Use Gauss' law to derive the expression for the electric field (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.

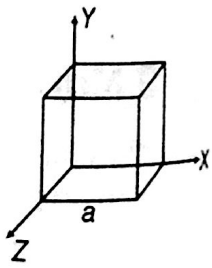
(c) Find the work done in bringing a charge q from perpendicular distance r_1 to $r_2 (r_2 > r_1)$

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

(ii) 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.

26. (i) An electric dipole of dipole moment p consists of point charges $+q$ and $-q$ separated by a distance $2a$ apart. Deduce the expression for the electric field **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 **p** . Hence, show that in the limit $x >> a, \mathbf{E} \longrightarrow 2\mathbf{p}/(4\pi\varepsilon_0 x^3)$.

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

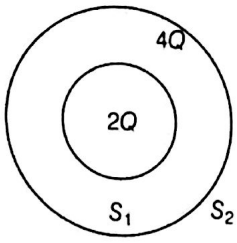


27. (i) Define electric flux. Write its SI unit. Gauss' law in electrostatics is true for any closed surface, no matter what its shape or size is. Justify this statement with the help of a suitable example.

(ii) Use Gauss' law to prove that the electric field inside a uniformly charged spherical shell is zero.

28. (a) Deduce the expression for the torque acting on a dipole of dipole moment p in the presence of uniform electric field 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 changes, if a medium of dielectric L is introduced in the space inside S_1 in place of air? Deduce the necessary expression



29. Using Gauss' law, deduce the expression for the electric field due to a uniformly charged spherical conducting shell of radius R at a point

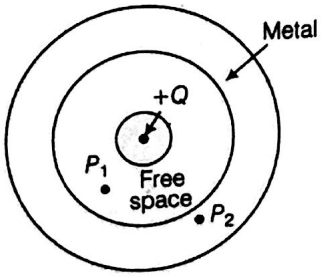
(i) outside the shell (ii) inside the shell.

Plot a graph showing variation of electric field as a function of $r > R$ and $r < R$.

(r being the distance from the centre of the shell)

30. (i) Define electric flux. Write its SI unit.

(ii) A small metal sphere carrying charge $+Q$ is located at the centre of a spherical cavity inside a large uncharged metallic spherical shell as shown in the figure.Use Gauss' law to find the expressions for the electric field at points P_1 and P_2.



31. (i) Define electric flux. Write its SI unit.

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

How is the field directed if

(a) the sheet is positively charged?

(b) negatively charged?

32. (i) State Gauss' law. Use it to deduce the expression for the electric field due to a uniformly charged thin spherical shell at points

(a) inside the shell and

(b) outside the shell.

(ii) Two identical metallic spheres A and B having charges $+4Q$ and $-10Q$ are kept a certain distance apart. A third identical uncharged sphere C is first placed in contact with sphere A and then with sphere B. Then, spheres A and B are brought in contact and then separated. Find the charges on the spheres A and B.