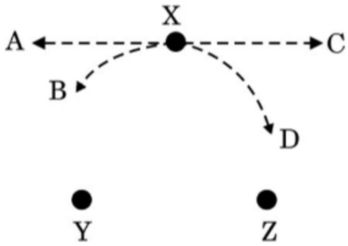
Class XII

PHYSICS CH 1&2

Class 12 - Physics

Section A

1. 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: **[1]**



a) C
b) A
c) D
d) B

2. Two infinitely long parallel conducting plates having surface charge densities $+\sigma$ and $-\sigma$ respectively are separated by a small distance. The medium between the plates is a vacuum. If ε_0 is the dielectric permittivity of vacuum, then the electric field in the region between the plates is **[1]**

a) 0 Vm^{-1}
b) $\frac{\sigma}{\varepsilon_0}$ Vm^{-1}
c) $\frac{2\sigma}{\varepsilon_0}$ Vm^{-1}
d) $\frac{\sigma}{2\varepsilon_0}$ Vm^{-1}

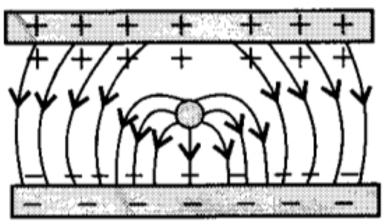
3. Which of the following is deflected by electric field? **[1]**

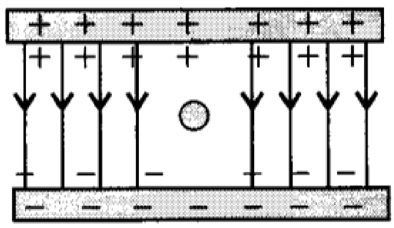
a) γ-rays
b) Neutrons
c) α-particles
d) X-rays

4. SI unit of permittivity is **[1]**

a) $C^2m^2N^{-1}$
b) $C^2m^{-2}N^{-1}$
c) $C^{-1}m^2N^{-2}$
d) $C^2m^2N^2$

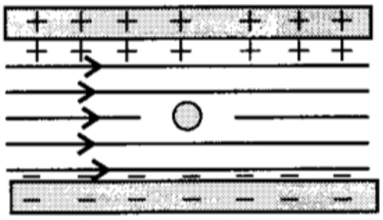
5. Which of the diagrams correctly represents the electric field between two charged plates if a neutral conductor is placed in between the plates? **[1]**

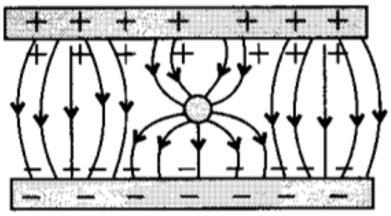
a) 

b) 

c)

d)





6. A charged cloud system produces an electric field in the air near the earth's surface. A particle of charge -2×10^{-9} C is acted on by a downward electrostatic force of 3×10^{-6} N when placed in this field. The gravitational and electrostatic force, respectively, exerted on a proton placed in this field are **[1]**

a) 1.64×10^{-26} N, 1.5×10^{3} N

b) 1.64×10^{-26} N, 2.4×10^{-16} N

c) 1.56×10^{-18} N, 2.4×10^{-16} N

d) 1.5×10^{3} N, 2.4×10^{-16} N

7. 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: **[1]**

a) $\frac{\lambda}{4\varepsilon_0 \mathrm{R}}$

b) Zero

c) $\frac{\lambda}{2\varepsilon_0 R}$

d) $\frac{\lambda}{4\pi\varepsilon_0 \mathrm{R}}$

8. The capacitors, each of $4\mu\mathrm{F}$ are to be connected in such a way that the effective capacitance of the combination is $6\mu\mathrm{F}$. This can be achieved by connecting **[1]**

a) Two of them connected in parallel and the combination in series to the third.

b) Two of them connected in series and the combination in parallel to the third.

c) All three in series

d) All three in parallel

9. A point charge q_0 is moving along a circular path of radius a, with a point charge -Q at the centre of the circle. The kinetic energy of q_0 is **[1]**

a) $\frac{q_0 Q}{4\pi\epsilon_0 a}$

b) $\frac{\mathrm{q}_0 \mathrm{Q}}{4\pi\epsilon_0 \mathrm{a}^2}$

c) $\frac{q_0 Q}{8\pi\epsilon_0 a}$

d) $\frac{\mathrm{q}_0 \mathrm{Q}}{8\pi\epsilon_0 \mathrm{a}^2}$

10. A series combination of n_1 capacitors, each of value C_1 is charged by a source of potential difference 4V. When another parallel combination of n_2 capacitors, each of value C_2, is charged by a source of potential difference V, it has the same (total) energy stored in it, as the first combination has. The value of C_2, in terms of C_1, is then: **[1]**

a) $\frac{2C_1}{n_1 n_2}$

b) $2\frac{n_2}{n_1}C_1$

c) $16\frac{n_2}{n_1}C_1$

d) $\frac{16C_1}{n_1 n_2}$

11. An uncharged capacitor with a solid dielectric is connected to a similar air capacitor charged to a potential of V_0. If the common potential after sharing of charges becomes V, then the dielectric constant of the dielectric must be: **[1]**

a) $\frac{V}{V_0}$

b) $\frac{V_0}{V}$

c) $\frac{(V_0 - V)}{V}$

d) $\frac{(V_0 - V)}{V_0}$

12. **Assertion:** Net electric field inside a conductor is zero. **[1]**

Reason: Total positive charge equals to total negative charge in a charged conductor.

a) Assertion and reason both are correct

b) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

13. **Assertion (A):** If the bob of a simple pendulum is kept in a horizontal electric field, its period of oscillation will remain the same. **[1]**

Reason (R): If the bob is charged and kept in a horizontal electric field, then the time period will be decreased.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

14. **Assertion (A):** The force between the plates of a parallel plate capacitor is proportional to the charge on it. **[1]**

Reason (R): Electric force is equal to charge per unit area.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

15. **Assertion:** A spherical equipotential surface is possible for a point charge. **[1]**

Reason: A spherical equipotential surface is not possible inside a spherical capacitor.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

16. Deduce the dimensional formula for the proportionality constant k in Coulomb's law. **[1]**

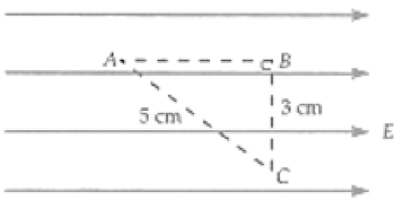
17. A sphere S_1 of radius r_1 enclosing a charge Q_1 is surrounded by another concentric sphere S_2 of radius r_2 ($r_2 > r_1$). If there is a charge $-Q_2$ in the space between S_1 and S_2, find the ratio of electric flux through S_1 and S_2. **[1]**

18. 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. **[1]**

19. An electrostatic field line cannot be discontinuous. Why **[1]**

20. Two point charges +q and +4q are separated by a distance of 6a. Find the point on the line joining the two charges where the electric field is zero. **[1]**

21. Three points A, B and C lie in a uniform electric field (E) of 5×10^3 NC^{-1} as shown in the figure. Find the potential difference between A and C. **[1]**

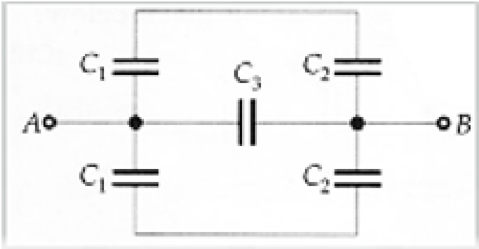


22. A parallel plate capacitor has a capacity of $6\mu F$ in air and $60\mu F$ when dielectric medium is introduced. What is dielectric constant of medium? **[1]**

23. Define the term potential energy for charge q at a distance r in an external field. **[1]**

24. What happens if the plates of a charged capacitor are suddenly connected by a conducting wire? **[1]**

25. Find the equivalent capacitance of the combination shown in Fig. between points A and B. **[1]**



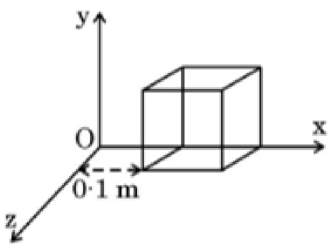
Section B

26. Two-point charges $q_1 = 5 \times 10^{-6}$ C and $q_2 = 3 \times 10^{-6}$ C are located at positions (1m, 3m, 2m) and (3m, 5m, 1m) respectively. Find the forces $\overrightarrow{F_{12}}$ and $\overrightarrow{F_{21}}$ using the vector form of Coulomb's law. **[2]**

27. **[2]**
    a. 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.
    b. How is the field directed if
        i. the sheet is positively charged,
        ii. negatively charged?

28. Define electric field intensity. Write its SI unit. Write the magnitude and direction of electric field intensity due to an electric dipole of length 2a at the midpoint of the line joining the two charges. **[2]**

29. A cube of side 0.1 m is placed, as shown in the figure, in a region where electric field $\vec{E} = 500 \times \hat{\imath}$ exists. Here x is in meters and E in N^{-1}. Calculate: **[2]**
    a. the flux passing through the cube, and
    b. the charge within the cube.

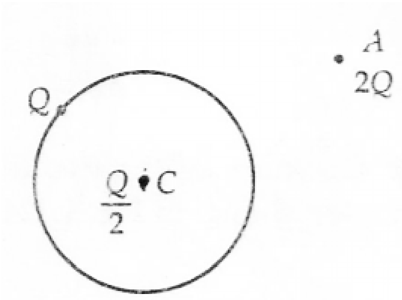


30. A spherical conducting shell of inner radius r_1 and outer radius r_2 has a charge Q. **[2]**
    a. A charge q is placed at the centre of the shell. Find out the surface charge density on the inner and outer surfaces of the shell.
    b. Is the electric field inside a cavity (with no charge) zero; independent of the fact whether the shell is spherical or not? Explain.

31. State the superposition principle for electrostatic force on a charge due to a number of charges. **[2]**

32. Two point charges having equal charges separated by 1 metre 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? **[2]**
(Given, $K_{water} = 80$).

33. A thin metallic spherical shell of radius R carries a charge Q on its surface. A point charge $\frac{Q}{2}$ is placed at its centre C and another charge +2Q is placed outside the shell at a distance x from the centre as shown in Fig. **[2]**



Find:

i. the force on the charge at the centre of the shell and at the point A.
ii. the electric flux through the shell.

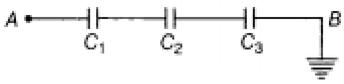
34. Plot a graph showing the variation of coulomb force (F) versus $\left(\frac{1}{r^2}\right)$, where r is the distance between the two charges of each pair of charges: (1 μC, 2 μC) and (2 μC, -3 μC). Interpret the graphs obtained. **[2]**

35. Write the vector form of force acting between two charges q_1 and q_2 having $\overrightarrow{r_1}$ and $\overrightarrow{r_2}$ as their position vectors respectively. **[2]**

36. A slab of material of dielectric constant K has the same area as that of the plates of a parallel plate capacitor, but has the thickness $\frac{d}{2}$, where d is the separation between the plates. Find out the expression for its capacitance when the slab is inserted between the plates of the capacitor. **[2]**

37. A capacitor of unknown capacitance is connected across a battery of V volt. A charge of 360 μC is stored in it. When the potential across the capacitor is reduced by 120 V, the charge stored in the capacitor becomes 120 μC. Calculate V and the unknown capacitance. What would have been the charge on the capacitor if the voltage were increased by 120 V? **[2]**

38. Calculate the potential difference and the energy stored in the capacitor C_2 in the circuit shown in the figure. Given potential at *A* is 90 V, C_1 = 20 μF, C_2 = 30 μF and C_3 = 15μF. **[2]**



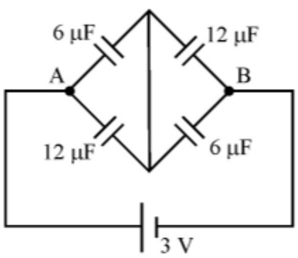
39. A parallel plate capacitor of capacitance C is charged to a potential V by a battery. Without disconnecting the battery, the distance between the plates is tripled and a dielectric medium of k = 10 is introduced between the plates of the capacitor. Explain giving reasons, how will the following be affected: **[2]**

i. the capacitance of the capacitor,
ii. charge on the capacitor,
iii. the energy density of the capacitor.

40. a. A parallel plate capacitor (C_1) having charge Q is connected, to an identical uncharged capacitor C_2 in series. What would be the charge accumulated on the capacitor C_2? **[2]**

b. Three identical capacitors each of capacitance 3 μF are connected in turn in series and in parallel combination to the common source of V volt. Find out the ratio of the energies stored in two configurations.

41. Find the total charge stored in the network of capacitors connected between A and B as shown in figure. **[2]**



42. Find out the expression for the potential energy of a system of three charges q_1 , q_2 and q_3 located at r_1 , r_2 and r_3 with respect to the common origin O. **[2]**

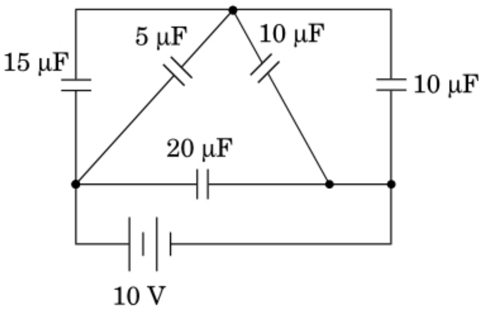
43. A 100 μF capacitor is charged by a 12 V battery. **[2]**

a. How much electrostatic energy is stored by the capacitor?

b. The capacitor is disconnected from the battery and connected in parallel to another uncharged 100 μF capacitor. What is the electrostatic energy stored by the system?

44. An air-filled parallel plate capacitor with plate separation 1 mm has a capacitance of 20 pF. It is charged to $4.0\mu C$. Calculate the amount of work done to pull its plates to a separation of 5 mm. Assume the charge on the plates remains the same. **[2]**

45. The figure shows a network of five capacitors connected to a 10 V battery. Calculate the charge acquired by the 5 μF capacitor. **[2]**



Section C

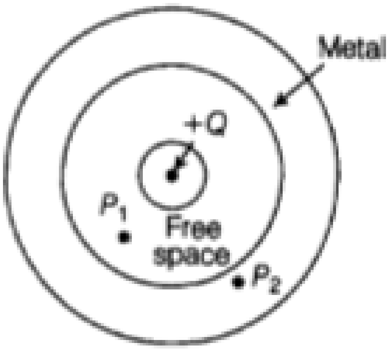
46. An electric dipole consists of two opposite charges each of magnitude 1 μC separated by 2 cm. The dipole is placed in an external electric field of $105 NC^{-1}$. Find **[3]**

i. the maximum torque exerted by the field on the dipole

ii. the work which the external agent will have to do in turning the dipole through 180° starting from the position 0 = 0°

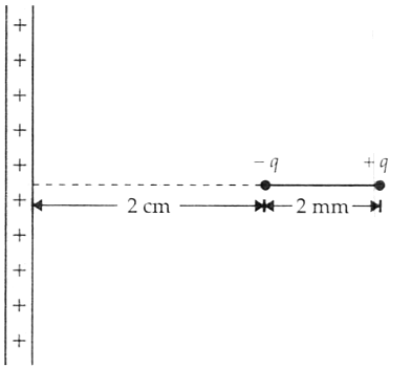
47. Define electric flux. Write its SI unit. **[3]**

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.



48. An electric dipole consists of charges $\pm 2 \times 10^{-8}$ C, separated by a distance of 2 mm. It is placed near a long line charge of density 4.0×10^{-4} Cm^{-1}, as shown in Fig., such that the negative charge is at a distance of 2 cm from **[3]**

the line charge. Calculate the force acting on the dipole.

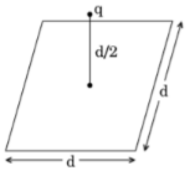


49. Using Gauss' law, obtain the expression for the electric field due to uniformly charged spherical shell of radius R at a point outside the shell. Draw a graph showing the variation of electric field with r, for r > R and r < R. **[3]**

50. 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. **[3]**

51. Define electric flux. Is it a scalar or a vector quantity? **[3]**

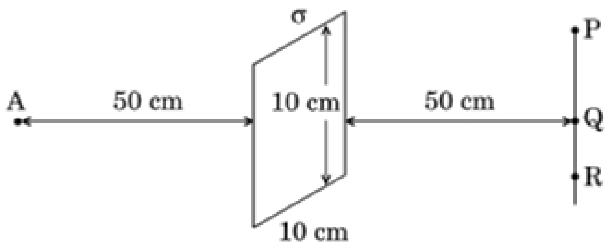
A point charge q is at a distance of $\frac{d}{2}$ directly above the centre of a square of side d, as shown in the figure. Use Gauss' law to obtain the expression for the electric flux through the square.



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.

52. Obtain the expression for the torque τ experienced by an electric dipole of dipole moment p in a uniform electric field, E. What will happen, if the field were not uniform? **[3]**

53. **[3]**
   a. A uniformly charged large plane sheet has charge density $\sigma = \left(\frac{1}{18\pi}\right) \times 10^{-15}\,\mathrm{C/m^2}$. 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?



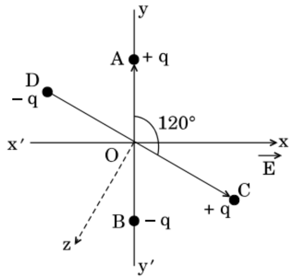
   b. Two small identical conducting spheres carrying charge 10 μC and -20 μC when separated by a distance of r, experience a force F each. If they are brought in contact and then separated to a distance of $\frac{r}{2}$, what is the new force between them in terms of F?

54. **[3]**
   a. Two electric field lines cannot cross each other. Also, they cannot form closed loops. Give reasons.
   b. A particle of charge 2 μC and mass 1.6 g is moving with a velocity 4 $\hat{i}$ ms^{-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.

55. Two small identical electric dipoles AB and CD, each of dipole moment $\vec{p}$ are kept at an angle of 120^{o} to each other in an external electric field $\vec{E}$ pointing along the x-axis as shown in the figure. Find the **[3]**

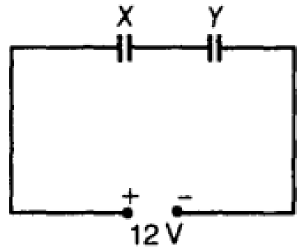
a. dipole moment of the arrangement, and

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



56. Two charges q_1 and q_2 are placed at (0, 0, d) and (0, 0, -d) respectively. Find locus of points where the potential a zero. **[3]**

57. Two parallel plate capacitors *X* and *Y* have the same area of the plates and same separation between them. *X* has air between the plates while *Y* contains a dielectric medium of $\varepsilon_r = 4$. **[3]**



i. Calculate the capacitance of each capacitor if equivalent of the combination is 4 μF.

ii. Calculate the potential difference between the plates of X and Y.

iii. What is the ratio of electrostatic energy stored in X and Y?

58. Define an equipotential surface. Draw equipotential surfaces **[3]**

a. in case of a single point charge

b. in a constant electric field in Z-direction. Why the equipotential surfaces about a single charge are not equidistant?

c. Can electric field exist tangential to an equipotential surface? Give reason.

59. a. Draw the equipotential surfaces corresponding to a uniform electric field in the z-direction. **[3]**

b. Derive an expression for the electric potential at any point along the axial line of an electric dipole.

60. a. Define the S.I. unit of capacitance. **[3]**

b. Obtain an expression for the capacitance of a parallel plate capacitor.

c. Derive the expression for the effective capacitance of a series combination of n-capacitors.

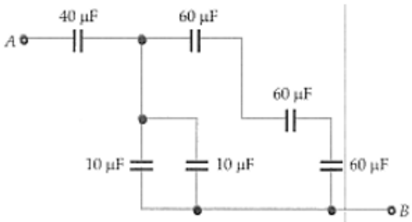
61. Two capacitors of unknown capacitances C_1 and C_2 are connected first in series and then in parallel across a battery of 100 V. If the energy stored in the two combinations is 0.045 J and 0.25 J respectively, determine the values of q and C_2. Also, calculate the charge on each capacitor in parallel combination. **[3]**

62. The plates of a parallel plate capacitor have an area of 90 cm^2 each and are separated by 2.5 mm. The capacitor is charged by connecting it to a 400 V supply. **[3]**

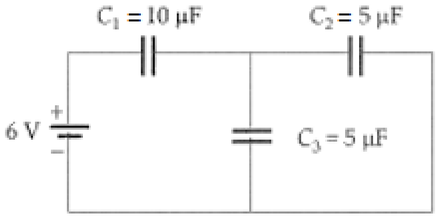
a. How much electrostatic energy is stored by the capacitor?

b. View this energy as stored in the electrostatic field between the plates, and obtain the energy per unit volume u. Hence arrive at a relation between u and the magnitude of electric field E between the plates.

63. Find the equivalent capacitance of the combination of capacitors between points A and B as shown in Fig. Also calculate the total charge that flows in the circuit when a 100 V battery is connected between points A and B. **[3]**



64. Three capacitors C_1, C_2 and C_3 are connected ’ to a 6 V battery, as shown in Fig. Find the charges on the three capacitors. **[3]**



65. Seven capacitors each of capacitance 2μF are connected in a configuration to obtain an effective capacitance $\frac{10}{11}\mu$F. Suggest a suitable combination to achieve the desired result. **[3]**

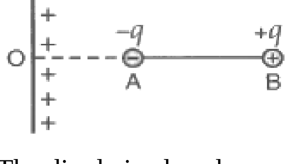
Section D

66. **[5]**
   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 $\leq$ R and r $\geq$ R.
   b. Two-point charges of + 1 μC and + 4 μC are kept 30 cm apart. How far from the + 1 μC charge on the line joining the two charges, will the net electric field be zero?

67. **[5]**
   a. Using Gauss’ law, obtain expressions for the electric field (i) inside, and (ii) outside a positively charged spherical shell.
   b. Show graphically variation of the electric field as a function of the distance r from the centre of the sphere.
   c. A square plane sheet of side 10 cm is inclined at an angle of 30^o with the direction of a uniform electric field of 200 NC^{-1}. Calculate the electric flux passing through the sheet.

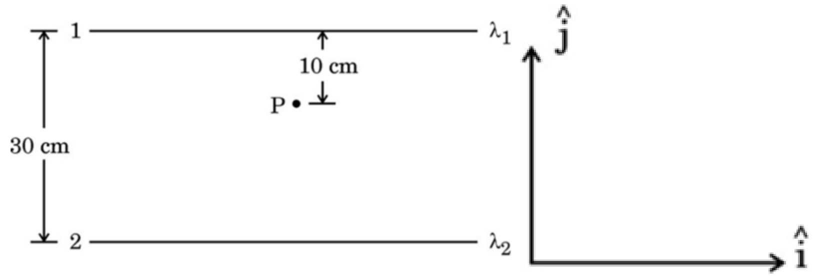
68. Define the term electric field intensity. Write its SI unit. Derive an expression for the electric field intensity at a point on the axis of an electric dipole. **[5]**

69. **[5]**
   a. Using Gauss' theorem, obtain an expression for the electric field intensity at a point at a distance r from an infinitely long uniformly charged straight wire.
   b. An electric dipole AB consists of charges ± 5 nC and separated by a distance of 2×10^{-3} m [Fig].

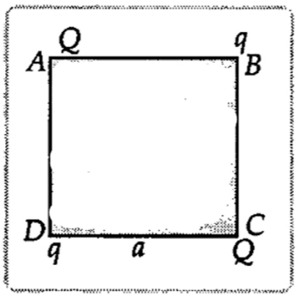


The dipole is placed near a long line charge having linear charge density 4.5×10^{-4} Cm^{-1}, such that the negative charge is at a distance OA = 2·5 cm from the line charge. Find the force acting on the dipole.

70. **[5]**
   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.



71. Four point charges Q, q, Q and q are placed at the corners of a square of side **a** as shown in the figure. **[5]**



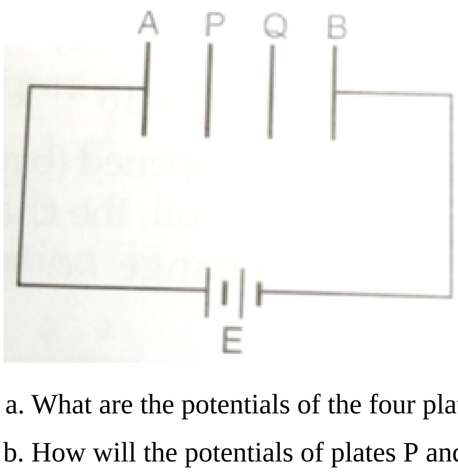
Find the

i. Resultant electric force on a charge Q, and
ii. Potential energy of this system.

72. a. Derive the expression for the electric potential due to an electric dipole at a point on its axial line. **[5]**
b. Depict the equipotential surfaces due to an electric dipole.

73. a. Derive the expression for the capacitance of a parallel plate capacitor having plate area A and plate separation d. **[5]**
b. Two charged spherical conductors of radii R_1 and R_2 when connected by a conducting wire acquire charges q_1 and q_2 respectively. Find the ratio of their surface charge densities in terms of their radii.

74. Two parallel metal plates P and Q are inserted at equal distances into a plane capacitor as shown in fig. Plates A and B of the capacitor are connected to a battery of e.m.f. V. **[5]**



a. What are the potentials of the four plates?
b. How will the potentials of plates P and Q and the intensities of the fields in each of the three spaces change after plates P and Q have been connected by a wire?
c. What will happen to the charges on plates A and B, when plates P and Q are connected with a wire?
d. Will there be charges on the plates P and Q after connecting them with a wire?

75. i. An electric dipole (dipole moment $\overrightarrow{p} = p\hat{i}$), consisting of charges $-q$ and q, separated by distance $2a$, is placed along the x-axis, with its centre at the origin. Show that the potential V, due to this dipole, at a point $x, (x >> a)$ is equal to $\frac{1}{4\pi\varepsilon_0} \cdot \frac{\overrightarrow{p} \cdot \hat{i}}{x^2}$. **[5]**

ii. Two isolated metallic spheres S_1 and S_2 of radii 1 cm and 3 cm respectively are charged such that both have the same charge density $\left(\frac{2}{\pi} \times 10^{-9}\right) C/m^2$. They are placed far away from each other and connected by a thin wire. Calculate the new charge on sphere S_1.