

Physics (Class 12)

Chapter 1: ELECTRIC CHARGES AND FIELDS

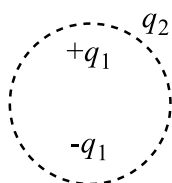
SKYLIMIT EDUCATION

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1. ELECTRIC CHARGES AND FIELDS

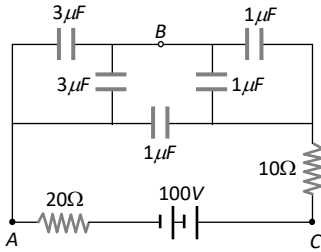
Single Correct Answer Type

- Five balls numbered 1,2,3,4,5 are suspended using separate threads. The balls (1,2),(2,4) and (4,1) show electrostatic attraction, while balls (2,3) and (4,5) show repulsion. Therefore, ball 1 must be
a) Negatively charged b) Positively charged c) Neutral d) Made of metal
- There are two charges $+1 \mu\text{C}$ and $+5 \mu\text{C}$. The ratio of the forces (force on one due to other) acting on them will be
a) 1:1 b) 1:2 c) 1:3 d) 1:4
- Consider the charge configuration and a spherical Gaussian surface as shown in the figure. When calculating the flux of the electric field over the spherical surface, the electric field will be due to

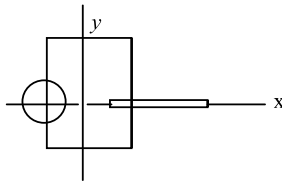


- a) q_2 b) Only the positive charges
c) All the charges d) $+q_1$ and $-q_1$
- Under the influence of the Coulomb field of charge $+Q$, a charge $-q$ is moving around it in an elliptical orbit. Fine out the correct statement(s)
a) The angular momentum of the charge $-q$ is constant
b) The linear momentum of the charge $-q$ is constant
c) The angular velocity of the charge $-q$ is constant
d) The linear speed of the charge $-q$ is constant
- The magnitude of electric field E in the annular region of a charged cylindrical capacitor
a) Is same throughout
b) Is higher near the outer cylinder than near the inner cylinder
c) Varies as $1/r$, where r is the distance from the axis
d) Varies as $1/r^2$, where r is the distance from the axis
- In a certain region of space, there exists a uniform electric field of $2 \times 10^2 \hat{k} \text{ Vm}^{-1}$. A rectangular coil of dimension $10 \text{ cm} \times 20 \text{ cm}$ is placed in $x - y$ plane. The electric flux through the coil is
a) Zero b) 30 Vm c) 40 Vm d) 50 Vm
- Two condensers of capacities $2C$ and C are joined in parallel and charged upto potential V . The battery is removed and the condenser of capacity C is filled completely with a medium of dielectric constant K . The p.d. across the capacitors will now be
a) $\frac{3V}{K+2}$ b) $\frac{3V}{K}$ c) $\frac{V}{K+2}$ d) $\frac{V}{K}$
- In the figure below, what is the potential difference between the points A and B and between B and C respectively in steady state





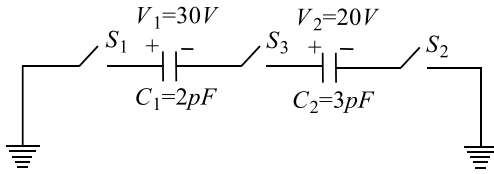
- a) $V_{AB} = V_{BC} = 100\text{ V}$
 b) $V_{AB} = 75\text{ V}, V_{BC} = 25\text{ V}$
 c) $V_{AB} = 25\text{ V}, V_{BC} = 75\text{ V}$
 d) $V_{AB} = V_{BC} = 50\text{ V}$
9. A disc of radius $\frac{a}{4}$ having a uniformly distributed charge 6 C is placed in the $x - y$ plane with its centre at $(\frac{-a}{2}, 0, 0)$. A rod of length a carrying a uniformly distributed charge 8 C is placed on the x -axis from $x = \frac{a}{4}$ to $x = \frac{5a}{4}$. Two point charges -7 C and 3 C are placed at $(\frac{a}{4}, \frac{-a}{4}, 0)$ and $(\frac{-3a}{4}, \frac{3a}{4}, 0)$ respectively. Consider a cubical surface formed by six surfaces $x = \pm \frac{a}{2}, y = \pm \frac{a}{2}, z = \pm \frac{a}{2}$. The electric flux through this cubical



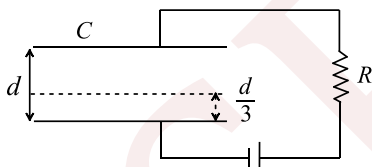
surface is

- a) $\frac{-2C}{\epsilon_0}$
 b) $\frac{2C}{\epsilon_0}$
 c) $\frac{10C}{\epsilon_0}$
 d) $\frac{12C}{\epsilon_0}$
10. In a region of space, the electric field is given by $\vec{E} = 8\hat{j} + 4\hat{j} + 3\hat{k}$. The electric flux through a surface of area of 100 units in $x - y$ plane is
 a) 800 units
 b) 300 units
 c) 400 units
 d) 1500 units
11. A wooden block performs SHM on a frictionless surface with frequency ν_0 . The block carries a charge $+Q$ on its surface. If now a uniform electric field \vec{E} is switched on as shown, then the SHM of the block will be
-
- a) of the same frequency and with shifted mean position
 b) of the same frequency and with same mean position
 c) of changed frequency and with shifted mean position
 d) of changed frequency and with same mean position
12. Three +ve charges of equal magnitude ' q ' are placed at the vertices of an equilateral triangle of side ' l '. How can the system of charges be placed in equilibrium?
 a) By placing a charge $Q = (-q/\sqrt{3})$ at the centroid of the triangle
 b) By placing a charge $Q = (q/\sqrt{3})$ at the centroid of the triangle
 c) By placing a charge $Q = q$ at a distance l from all the three charges
 d) By placing a charge $Q = -q$ above the plane of the triangle at a distance l from all the three charges
13. The surface density on a copper sphere is σ . The electric field strength on the surface of the sphere is
 a) σ
 b) $\sigma/2$
 c) $\sigma/2\epsilon_0$
 d) σ/ϵ_0
14. A point charge q_1 is moved along a circular path of radius r in the electric field of another point charge q_2 at the centre of the path. The work done by the electric field on the charge q_1 in half revolution is
 a) Zero
 b) Positive
 c) Negative
 d) None of these
15. For the circuit shown, which of the following statements is true





- a) With S_1 closed, $V_1 = 15 V, V_2 = 20 V$
 b) With S_3 closed $V_1 = V_2 = 25V$
 c) With S_1 and S_2 closed $V_1 = V_2 = 0$
 d) With S_1 and S_3 closed, $V_1 = 30V, V_2 = 20V$
16. A positive point charge $50 \mu\text{C}$ is located in the plane xy at a point with radius vector $\vec{r}_0 = 2\hat{i} + 3\hat{j}$. The electric field at vector \vec{E} at a point with radius vector $\vec{r} = 8\hat{i} - 5\hat{j}$, where r_0 and r are expressed in metre, is
 a) $(1.4\hat{i} - 2.6\hat{j})\text{kNC}^{-1}$ b) $(1.4\hat{i} + 2.6\hat{j})\text{kNC}^{-1}$ c) $(2.7\hat{i} - 3.6\hat{j})\text{kNC}^{-1}$ d) $(2.7\hat{i} + 3.6\hat{j})\text{kNC}^{-1}$
17. If an electron has an initial velocity in a direction different from that of a uniform electric field, the path of electron is
 a) A straight line b) A circle c) An ellipse d) A parabola
18. The dielectric constant K of an insulator can be
 a) -1 b) 0 c) 0.5 d) 5
19. A spherical conducting ball is suspended by a grounded conducting thread. A positive point charge is moved near the ball. The ball will
 a) Be attracted to the point charge and swing toward it
 b) Be repelled from the point charge and swing away from it
 c) Not be affected by the point charge
 d) None of these
20. Two neutrons are placed at some distance apart from each other. They will
 a) Attract each other b) Repel each other
 c) Neither attract nor repel each other d) Cannot say
21. A parallel plate capacitor C with plates of unit area and separation d is filled with a liquid of dielectric constant $K = 2$. The level of liquid is $\frac{d}{3}$ initially. Suppose the liquid level decreases at a constant speed V , the time constant as a function of time t is



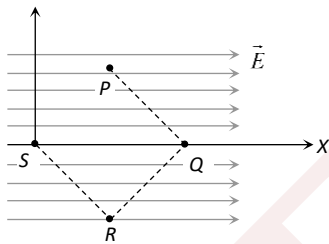
- a) $\frac{6\epsilon_0 R}{5d + 3Vt}$ b) $\frac{(15d + 9Vt)\epsilon_0 R}{2d^2 - 3dVt - 9V^2 t^2}$ c) $\frac{6\epsilon_0 R}{5d - 3Vt}$ d) $\frac{(15d - 9Vt)\epsilon_0 R}{2d^2 + 3dVt - 9V^2 t^2}$
22. It is required to hold equal charges q in equilibrium at the corners of a square. What charge when placed at the center of the square will do this?
 a) $-\frac{q}{2}(1 + 2\sqrt{2})$ b) $\frac{q}{2}(1 + 2\sqrt{2})$ c) $\frac{q}{4}(1 + 2\sqrt{2})$ d) $-\frac{q}{4}(1 + 2\sqrt{2})$
23. Two large vertical and parallel metal plates having a separation of 1 cm are connected to a DC voltage source of potential difference X . A proton is released at rest midway between the two plates. It is found to move at 45° to the vertical JUST after release. Then X is nearly
 a) $1 \times 10^{-5}V$ b) $1 \times 10^{-7}V$ c) $1 \times 10^{-9}V$ d) $1 \times 10^{-10}V$
24. Units of electric flux are
 a) NC^{-1}m^2 b) JC^{-1} c) V d) Vm
25. Two identical spheres with charges $4q, -2q$ kept some distance apart exert a force F on each other. If they are made to touch each other and replaced at their old positions, the force between them will be
 a) $\frac{1}{9}F$ b) $\frac{1}{8}F$ c) $\frac{9}{8}F$ d) $\frac{8}{9}F$



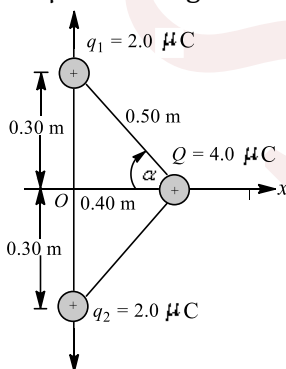
26. Two equal negative charge $-q$ are fixed at the fixed points $(0, a)$ and $(0, -a)$ on the Y -axis. A positive charge Q is released from rest at the point $(2a, 0)$ on the X -axis. The charge Q will
- Execute simple harmonic motion about the origin
 - Move to the origin and remain at rest
 - Move to infinity
 - Execute oscillatory but not simple harmonic motion
27. The dimensional formula of electric intensity is
- $MLT^{-2}A^{-1}$
 - $MLT^{-3}A^{-1}$
 - $ML^2T^{-3}A^{-1}$
 - $ML^2T^{-3}A^{-2}$
28. An electric line of force in the xy plane is given by equation $x^2 + y^2 = 1$. A particle with unit positive charge, initially at rest at the point $x = 1, y = 0$ in the xy plane
- Not move at all
 - Will move along straight line
 - Will move along the circular line of force
 - Information is insufficient to draw any conclusion
29. Which one of the following graphs shows the variation of electric field strength E which distance r from the center of a hollow conducting sphere?



30. Point charge q moves from point P to point S along the path $PQRS$ (figure shown) in a uniform electric field E pointing coparallel to the positive direction of the X -axis. The coordinates of the points P, Q, R and S are $(a, b, 0), (2a, 0, 0), (a, -b, 0)$ and $(0, 0, 0)$ respectively. The work done by the field in the above process is given by the expression

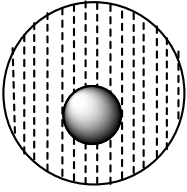


- qEa
 - $-qEa$
 - $qEa\sqrt{2}$
 - $qE\sqrt{[(2a)^2 + b^2]}$
31. In the figure, two equal positive point charges $q_1 = q_2 = 2.0 \mu\text{C}$ interact with a third point charge $Q = 4.0 \mu\text{C}$. The magnitudes as well as direction of the net force on Q is



- 0.23 N in $+x$ direction
 - 0.46 N in $-x$ direction
 - 0.23 N in $-x$ direction
 - 0.46 N in $-x$ direction
32. A spherical portion has been removed from a solid sphere having a charge distributed uniformly in its volume as shown in the figure. The electric field inside the emptied space is



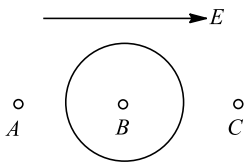


- a) Zero everywhere
b) Non-zero and uniform
c) Non-uniform
d) Zero only at its centre
33. A parallel plate capacitor of capacitance C is connected to a battery and is charged to a potential difference V . Another capacitor of capacitance $2C$ is connected to another battery and is charged to potential difference $2V$. The charging batteries are now disconnected and the capacitors are connected in parallel to each other in such a way that the positive terminal of one is connected to the negative terminal of the other. The final energy of the configuration is
- a) Zero
b) $\frac{25CV^2}{6}$
c) $\frac{3CV^2}{2}$
d) $\frac{9CV^2}{2}$
34. Three concentric metallic spherical shells of radii $R, 2R, 3R$, are given charges Q_1, Q_2, Q_3 , respectively. It is found that the surface charge densities on the outer surfaces of the shells are equal. Then, the ratio of the charges given to the shells, $Q_1: Q_2: Q_3$, is
- a) 1:2:3
b) 1:3:5
c) 1:4:9
d) 1:8:18
35. Two positive and equal charges are fixed at a certain distance. A third small charge is placed in between the two charges and it experiences zero net force due to the other two
- a) The equilibrium is stable if small charge is positive
b) The equilibrium is stable if small charges is negative
c) The equilibrium is always stable
d) The equilibrium is not stable
36. A disk of radius $a/4$ having a uniformly distributed charge $6C$ is placed in the $x - y$ plane with its centre at $(-a/2, 0, 0)$. A rod of length a carrying a uniformly distributed charge $8C$ is placed on the x -axis from $x = a/4$ to $x = 5a/4$. Two point charges $-7C$ and $3C$ are placed at $(a/4, -a/4, 0)$ and $(-3a/4, 3a/4, 0)$, respectively. Consider a cubical surface formed by six surfaces $x = \pm a/2, y = \pm a/2, z = \pm a/2$. The electric flux through this cubical surface is
-
- a) $\frac{-2C}{\epsilon_0}$
b) $\frac{2C}{\epsilon_0}$
c) $\frac{10C}{\epsilon_0}$
d) $\frac{12C}{\epsilon_0}$
37. Three charges $+Q_1 + Q_2$ and q are placed on a straight line such that q is somewhere in between $+Q_1$ and $+Q_2$. If this system of charges is in equilibrium, what should be the magnitude and sign of charge q ?
- a) $\frac{Q_1 Q_2}{(\sqrt{Q_1} + \sqrt{Q_2})^2}, +ve$
b) $\frac{Q_1 + Q_2}{2}, +ve$
c) $\frac{Q_1 Q_2}{(\sqrt{Q_1} + \sqrt{Q_2})^2}, -ve$
d) $\frac{Q_1 + Q_2}{2}, -ve$
38. Two particles of masses in the ratio 1:2, with charges in the ratio 1:1, are placed at rest in a uniform electric field. They are released and allowed to move for the same time. The ratio of their kinetic energies will be finally
- a) 2:1
b) 8:1
c) 4:1
d) 1:4
39. An electron of mass m_e initially at rest moves through a certain distance in a uniform electric field in time t_1 . A proton of mass m_p also initially at rest takes time t_2 to move through and equal distance in this uniform electric field. Neglecting the effect of gravity, the ratio of t_2/t_1 is nearly equal to



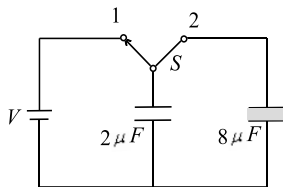
- a) 1 b) $(m_p/m_e)^{1/2}$ c) $(m_e/m_p)^{1/2}$ d) 1836

40. A dielectric in the form of a sphere is introduced into a homogeneous electric field. A, B and C are three points as shown in fig

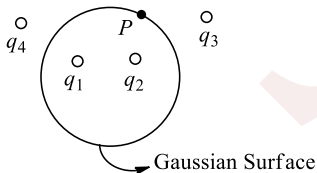


Then,

- a) Intensity at A increases while that at B and C decreases
 b) Intensity at A and B decreases, whereas intensity at C increases
 c) Intensity at A and C increases and that at B decreases
 d) Intensity at A, B and C decreases
41. In S.I. system, the value of ϵ_0 is
 a) $C^2N^{-1}m^{-2}$ b) $9 \times 10^9 C^2N^{-1}m^{-2}$
 c) $\frac{1}{9 \times 10^9} C^2N^{-1}m^{-2}$ d) $\frac{1}{4\pi \times 9 \times 10^9} C^2N^{-1}m^{-2}$
42. A $2\mu F$ capacitor is charged as shown in figure. The percentage of its stored energy dissipated after the switch S is turned to position 2 is

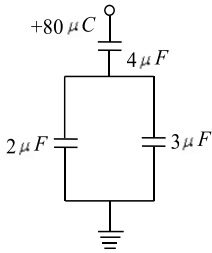


- a) 0% b) 20% c) 75% d) 80%
43. A positively charged ball hangs from a long silk thread. Electric field at a certain point (at the same horizontal level of ball) due to this charge is E . Let us put a positive test charge q_0 at this point and measure F/q_0 on this charge. Then, E
 a) $> F/q_0$ b) $< F/q_0$ c) $= F/q_0$ d) None of these
44. A cube of side 10 cm encloses a charge of $0.1\mu C$ at its center. Calculate the number of lines of force through each face of the cube
 a) 1.113×10^{11} b) 1.13×10^4 c) 1.13×10^9 d) 1883
45. Consider the Gaussian surface that surrounds part of the charge distribution shown in Fig. Then, the contribution to the electric field at point P arises from charges



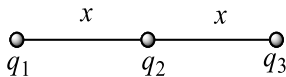
- a) q_1 and q_2 only b) q_3 and q_4 only c) q_1, q_2, q_3 and q_4 d) None of the above
46. In the given circuit, a charge of $+80 \mu C$ is given to the upper plate of the $4 \mu F$ capacitor. Then in the steady state, the charge on the upper plate of the $3 \mu F$ capacitor is





- a) $+32 \mu C$ b) $+40 \mu C$ c) $+48 \mu C$ d) $+80 \mu C$

47. Three charged particles are placed on a straight line as shown in the figure. q_1 and q_2 are fixed but q_3 can be moved. Under the action of the forces from q_1 and q_2 , q_3 is in equilibrium. What is the relation between q_1 and q_2 ?

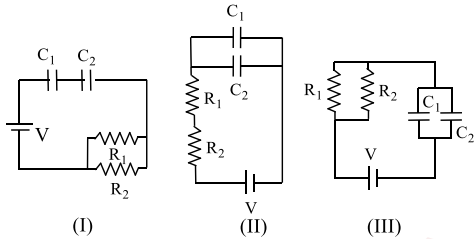


- a) $q_1 = 4q_2$ b) $q_1 = -q_2$ c) $q_1 = -4q_2$ d) $q_1 = q_2$

48. Given,

$$R_1 = 1\Omega, C_1 = 2\mu F$$

$$R_2 = 2\Omega, C_2 = 4\mu F$$



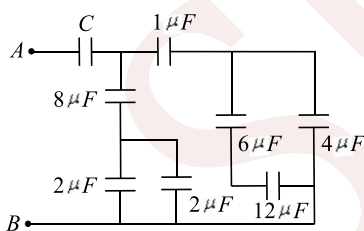
The time constant (in μs) for the circuits, I, II, III, are respectively

- a) 18, 18/9, 4 b) 18, 4, 8/9 c) 4, 8/9, 18 d) 8/9, 18, 4

49. In a region with a uniform electric field, the number of lines of force per unit area is E . If a spherical metallic conductor is placed in the area, the field inside the conductor will be

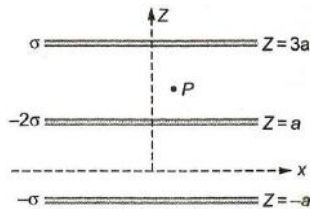
- a) Zero b) E c) More than E d) Less than E

50. In the following circuit, the resultant capacitance between A and B is $1\mu F$. Then value of C is



- a) $\frac{32}{11} \mu F$ b) $\frac{11}{32} \mu F$ c) $\frac{23}{32} \mu F$ d) $\frac{32}{23} \mu F$

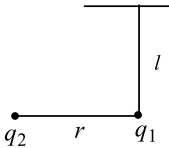
51. Three infinitely long charge sheets are placed as shown in figure. The electric field at point P is



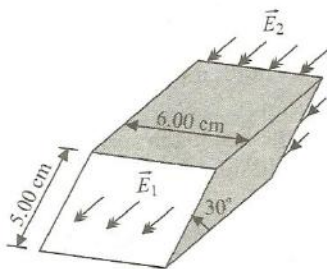
- a) $\frac{2\sigma}{\epsilon_0} \hat{k}$ b) $-\frac{2\sigma}{\epsilon_0} \hat{k}$ c) $\frac{4\sigma}{\epsilon_0} \hat{k}$ d) $-\frac{4\sigma}{\epsilon_0} \hat{k}$



52. A cylinder of radius R and length l is placed in a uniform electric field E parallel to the axis of the cylinder. The total flux over the curved surface of the cylinder is
 a) Zero b) $\pi R^2 E$ c) $2\pi R^2 E$ d) $E/\pi R^2$
53. Five point charges, each of value $+q$, are placed on five vertices of a regular hexagon of side L . The magnitude of the force on a point charge of value $-q$ coulomb placed at the centre of the hexagon is
 a) $\frac{1}{\pi\epsilon_0} \left(\frac{q}{L}\right)^2$ b) $\frac{2}{\pi\epsilon_0} \left(\frac{q}{L}\right)^2$ c) $\frac{1}{2\pi\epsilon_0} \left(\frac{q}{L}\right)^2$ d) $\frac{1}{4\pi\epsilon_0} \left(\frac{q}{L}\right)^2$
54. A system consists of a thin charged wire ring of radius r and a very long uniformly charged wire oriented along the axis of the ring, with one of its ends coinciding with the centre of the ring. The total charge on the ring is q and the linear charge density on the straight wire is λ . The interaction force between the ring and the wire is
 a) $\frac{\lambda q}{4\pi\epsilon_0 r}$ b) $\frac{\lambda q}{2\sqrt{2}\pi\epsilon_0 r}$ c) $\frac{2\sqrt{2}\lambda q}{\pi\epsilon_0 r}$ d) $\frac{4\lambda q}{\pi\epsilon_0 r}$
55. Three equal charges, each $+q$, are placed on the corners of an equilateral triangle. The electric field intensity at the centroid of the triangle is
 a) kq/r^2 b) $3kq/r^2$ c) $\sqrt{3}kq/r^2$ d) Zero
56. If the flux of the electric field through a closed surface is zero, then
 a) The electric field must be zero everywhere on the surface
 b) The total charge inside the surface must be zero
 c) The electric field must be uniform throughout the closed surface
 d) The charge outside the surface must be zero
57. An isolated charge q_1 of mass m is suspended freely by a thread of length l . Another charge q_2 is brought near it ($r \gg l$). When q_1 is in equilibrium, tension in thread will be



- a) mg b) $> mg$ c) $< mg$ d) None of these
58. A non-conducting ring of radius $0.5m$ carries a total charge of $1.11 \times 10^{-10} C$ distributed non-uniformly on its circumference producing an electric field \vec{E} everywhere in space. The value of the line integral $\int_{l=-\infty}^{l=0} -\vec{E} \cdot d\vec{l}$ ($l = 0$ being centre of the ring) in volt is
 a) $+2$ b) -1 c) -2 d) Zero
59. The electric field \vec{E}_1 at one face of a parallelepiped is uniform over the entire face and is directed out of the face. At the opposite face, the electric field \vec{E}_2 is also uniform over the entire face and is directed into that face (as shown in fig). The two faces in question are inclined at 30° from the horizontal, \vec{E}_1 and \vec{E}_2 (both horizontal) have magnitude of $2.50 \times 10^4 N/C$ and $7.00 \times 10^4 N/C$, respectively. Assuming that no other electric field lines cross the surfaces of the parallelepiped, the net charge contained within is



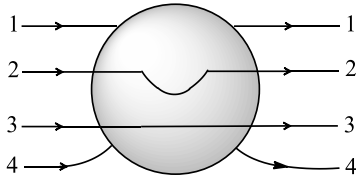
- a) $-67.5\epsilon_0 C$ b) $37.5\epsilon_0 C$ c) $105\epsilon_0 C$ d) $-105\epsilon_0 C$



60. Eight charges, $1 \mu\text{C}$, $-7 \mu\text{C}$, $-4 \mu\text{C}$, $10 \mu\text{C}$, $2 \mu\text{C}$, $-5 \mu\text{C}$, $-3 \mu\text{C}$ and $6 \mu\text{C}$, are situated at the eight corners of a cube of side 20 cm. A spherical surface of radius 80 cm encloses this cube. The centre of the sphere coincides with the centre of the cube. Then, the total outgoing flux from the spherical surface (in units of Vm) is

- a) $36\pi \times 10^3$ b) $684\pi \times 10^3$ c) Zero d) None of these

61. A metallic solid sphere is placed in a uniform electric field. The lines of force follow the path(s) shown in figure as



- a) 1 b) 2 c) 3 d) 4

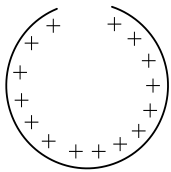
62. What is the largest charge a metal ball of 1 mm radius can hold? Dielectric strength of air is $3 \times 10^6 \text{Vm}^{-1}$

- a) 3 nC b) $1/3$ nC c) 2 nC d) $1/2$ nC

63. Under what conditions can the electric flux ϕ_E be found through a closed surface?

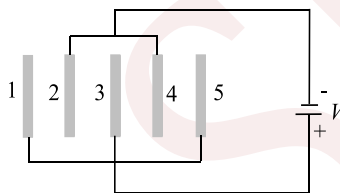
- a) If the magnitude of electric field is known everywhere on the surface
b) If the total charge inside the surface is specified
c) If the total charge outside the surface is specified
d) Only if the location of each point charge inside the surface is specified

64. A ring of charge with radius 0.5 m has 0.002 π m gap. If the ring carries a charge of +1C, the electric field at the centre is



- a) $7.5 \times 10^7 \text{NC}^{-1}$ b) $7.2 \times 10^7 \text{NC}^{-1}$ c) $6.2 \times 10^7 \text{NC}^{-1}$ d) $6.5 \times 10^7 \text{NC}^{-1}$

65. Five identical plates each of area A are joined as shown in the figure. The distance between the plates is d . The plates are connected to a potential difference of V volts. The charge on plates 1 and 4 will be



- a) $\frac{\epsilon_0 AV}{d}, \frac{2\epsilon_0 AV}{d}$ b) $\frac{-\epsilon_0 AV}{d}, \frac{2\epsilon_0 AV}{d}$ c) $\frac{\epsilon_0 AV}{d}, \frac{-2\epsilon_0 AV}{d}$ d) $\frac{-\epsilon_0 AV}{d}, \frac{-2\epsilon_0 AV}{d}$

66. Under the influence of the coulomb field of charge $+Q$, a charge $-q$ is moving around it in an elliptical orbit. Find out the correct statements(s).

- a) The angular momentum of the charge $-q$ is constant
b) The linear momentum of the charge $-q$ is constant
c) The angular velocity of the charge $-q$ is constant
d) The linear speed of the charge $-q$ is constant

67. Positive electric flux are from a closed surface indicates that electric lines of force are directed

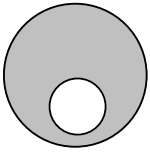
- a) Outward b) Inward c) Outward or inwards d) None of these

68. A charge q is placed at the centre of the line joining two equal charges Q . The system of the three charges will be in equilibrium, if q is equal to

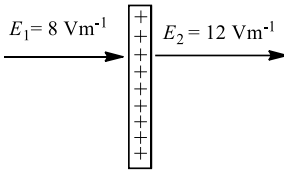


- a) $-\frac{Q}{2}$ b) $-\frac{Q}{4}$ c) $+\frac{Q}{4}$ d) $+\frac{Q}{2}$

69. A spherical portion has been removed from a solid sphere having a charge distributed uniformly in its volume in the figure. The electric field inside the emptied space is

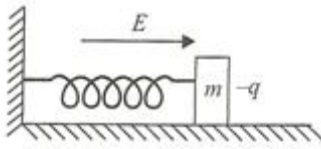


- a) Zero everywhere b) Non-zero and uniform
c) Non-uniform d) Zero only at its center
70. A solid sphere of radius R has a charge Q distributed in its volume with a charge density $\rho = kr^a$, where k and a are constants and r is the distance from its centre. If the electric field at $r = \frac{R}{2}$ is $\frac{1}{8}$ times that at $r = R$, find the value of a .
- a) 2 b) 3 c) 2.5 d) 0.2
71. Two point charges Q_1 and Q_2 are 3 m apart, and their sum of charges is $10 \mu\text{C}$. If force of attraction between them is 0.075 N , then the values of Q_1 and Q_2 , respectively, are
- a) $5 \mu\text{C}, 5 \mu\text{C}$ b) $15 \mu\text{C}, -5 \mu\text{C}$ c) $5 \mu\text{C}, 15 \mu\text{C}$ d) $-15 \mu\text{C}, 5 \mu\text{C}$
72. The electric field on two sides of a large charged plate is shown in fig. The charge density on the plate in S. I. units is given by (ϵ_0 is the permittivity of free space in S.I. units)

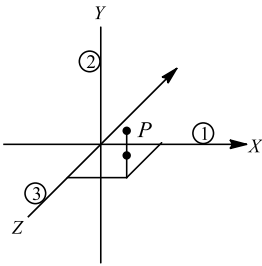


- a) $2\epsilon_0$ b) $4\epsilon_0$ c) $10\epsilon_0$ d) Zero
73. Consider a neutral conducting sphere. A positive point charge is placed outside the sphere. The net charge on the sphere is then
- a) Negative and distributed uniformly over the surface of the sphere
b) Negative and appears only at the point on the sphere closest to the point charge
c) Negative and distributed non-uniformly over the entire surface of the sphere
d) Zero
74. A surface encloses an electric dipole. The net flux through the surface is
- a) Zero b) Positive c) Negative d) Infinite
75. Four identical charges Q are fixed at the four corners of a square of side a . The electric field at a point P located symmetrically at a distance $a/\sqrt{2}$ from the centre of the square is
- a) $\frac{Q}{2\sqrt{2}\pi\epsilon_0 a^2}$ b) $\frac{Q}{\sqrt{2}\pi\epsilon_0 a^2}$ c) $\frac{2\sqrt{2}Q}{\pi\epsilon_0 a^2}$ d) $\frac{\sqrt{2}Q}{\pi\epsilon_0 a^2}$
76. Positive and negative point charges of equal magnitude are kept at $(0,0,\frac{a}{2})$ and $(0,0,-\frac{a}{2})$, respectively. The work done by the electric field when another positive point charge is moved from $(-a, 0, 0)$ to $(0, a, 0)$ is
- a) Positive b) Negative
c) Zero d) Depends on the path connecting the initial and final positions
77. A block of mass m containing a net negative charge $-q$ is placed on a frictionless horizontal table and is connected to a wall through an unstretched spring of spring constant k as shown. If horizontal electric field E parallel to the spring is switched on, then the maximum compression of the spring is

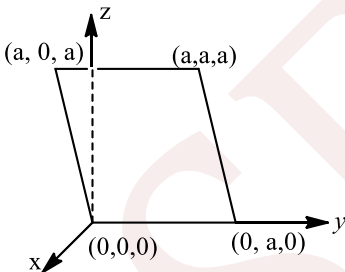




- a) $\sqrt{qE/k}$ b) $2qE/k$ c) qE/k d) Zero
78. Two charges $Q_1 = 18 \mu\text{C}$ and $Q_2 = -2 \mu\text{C}$ are separated by a distance R and Q_1 is to the left of Q_2 . The distance of the point where the net electric field is zero is
a) Between Q_1 and Q_2 b) Left of Q_1 at $R/2$ c) Right of Q_2 at R d) Right of Q_2 at R
79. Find the electric field vector at $P(a, a, a)$ due to three infinitely long lines of charges along the x -, y - and z -axis, respectively. The charge density, i.e., charge per unit length of each wire is λ



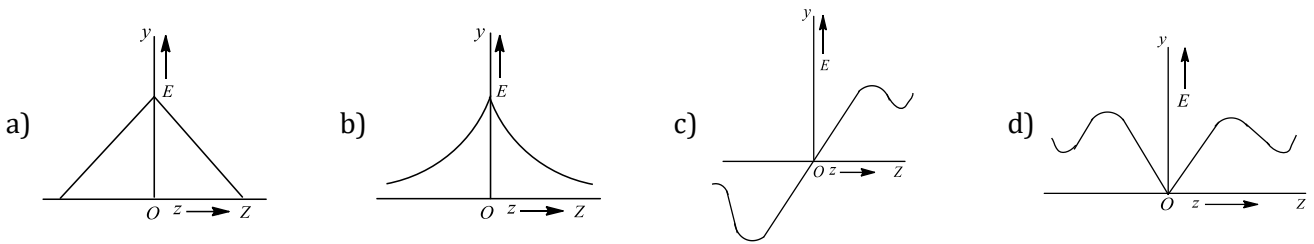
- a) $\frac{\lambda}{3\pi\epsilon_0 a}(\hat{i} + \hat{j} + \hat{k})$ b) $\frac{\lambda}{2\pi\epsilon_0 a}(\hat{i} + \hat{j} + \hat{k})$ c) $\frac{\lambda}{2\sqrt{2}\pi\epsilon_0 a}(\hat{i} + \hat{j} + \hat{k})$ d) $\frac{\sqrt{2}\lambda}{\pi\epsilon_0 a}(\hat{i} + \hat{j} + \hat{k})$
80. An insulated sphere of radius R has a uniform volume charge density ρ . The electric field at a point P inside the sphere at a distance r from the center is
a) $\frac{R\rho}{3\epsilon_0}$ b) $\frac{r\rho}{3\epsilon_0}$ c) Zero d) $\frac{2}{3}\left(\frac{r\rho}{\epsilon_0}\right)$
81. Consider an electric field $\mathbf{E} = E_0 \hat{x}$, where E_0 is a constant. The flux through the shaded area (as shown in the figure) due to this field is



- a) $2E_0 a^2$ b) $\sqrt{2}E_0 a^2$ c) $E_0 a^2$ d) $\frac{E_0 a^2}{\sqrt{2}}$
82. A hollow metallic sphere of radius 10 cm is given a charge of $3.2 \times 10^{-9} \text{C}$. The electric intensity at a point 4 cm from the centre is
a) $9 \times 10^{-9} \text{NC}^{-1}$ b) 288NC^{-1} c) 2.88NC^{-1} d) Zero
83. An oil drop, carrying six electronic charges and having a mass of $1.6 \times 10^{-12} \text{g}$, falls with some terminal velocity in a medium. What magnitude of vertical electric field is required to make the drop move upwards with the same speed as it was formerly moving downwards with? Ignore buoyancy
a) 10^5NC^{-1} b) 10^4NC^{-1} c) $3.3 \times 10^4 \text{NC}^{-1}$ d) $3.3 \times 10^5 \text{NC}^{-1}$
84. Electric charges A and B repel each other. Electric charges B and C also repel other. If A and C are held close together, they will
a) Attract b) Repel c) Not affect each other d) None of these



85. A circular ring carries a uniformly distributed positive charge and lies in $X - Y$ plane with centre at origin of coordinate system. If at a point $(0, 0, z)$ the electric field is E , then which of the following graphs is correct?

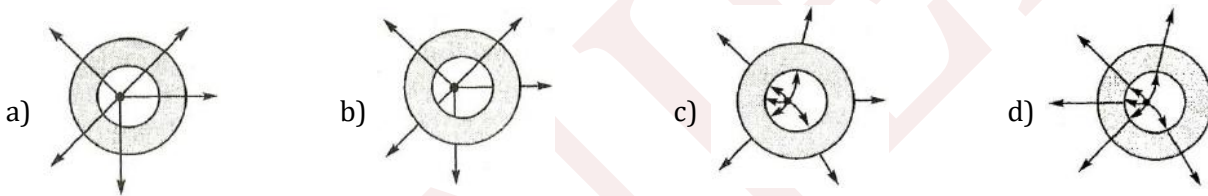


86. If one penetrates a uniformly charged spherical cloud, electric field strength
 a) Decreases directly as the distance from the centre
 b) Increases directly as the distance from the centre
 c) Remains constant
 d) None of the above

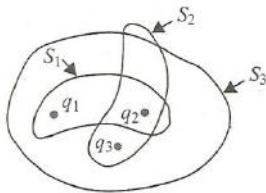
87. The electric potential V at any point $O(x, y, z)$ all in metres) in space is given by $V = 4x^2$ volt. The electric field at the point $(1m, 0, 2m)$ in volt/metre is

- a) 8 along negative $C -$ axis
 b) 8 along positive $X -$ axis
 c) 16 along negative $X -$ axis
 d) 16 along positive $Z -$ axis

88. A metallic shell has a point charge q kept inside its cavity. Which one of the following diagrams correctly represents the electric lines or forces?

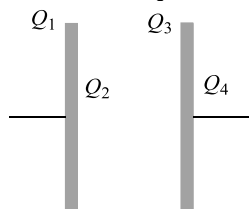


89. Three charges of $q_1 = 1 \times 10^{-6}C$, $q_2 = 2 \times 10^{-6}C$ and $q_3 = -3 \times 10^{-6}C$ have been placed as shown. Then, the net electric flux will be maximum for the surface



- a) S_1
 b) S_2
 c) S_3
 d) Same for all three

90. In an isolated parallel plate capacitor of capacitance C , the four surface have charges Q_1, Q_2, Q_3 and Q_4 as shown. The potential difference between the plates is



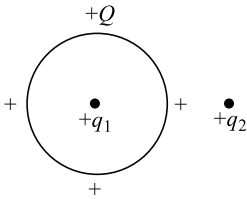
- a) $\frac{Q_1 + Q_2 + Q_3 + Q_4}{2C}$
 b) $\frac{Q_2 + Q_3}{2C}$
 c) $\frac{Q_2 - Q_3}{2C}$
 d) $\frac{Q_1 + Q_4}{2C}$

91. A cylinder of length L and radius b has its axis coincident with the $x -$ axis. The electric field in this region is $\vec{E} = 200\hat{i}$. Find the flux through the left end of cylinder.

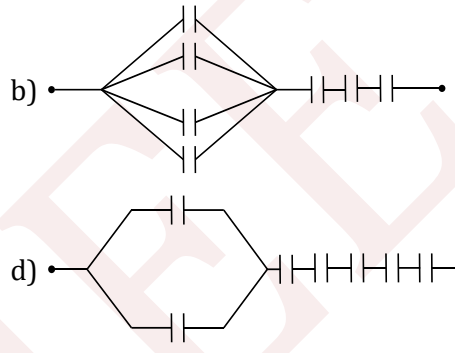
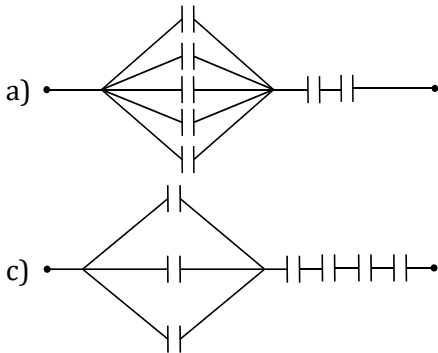
- a) 0
 b) $200 \pi b^2$
 c) $100 \pi b^2$
 d) $-200 \pi b^2$



92. A thin metallic spherical shell contains a charge Q on its surface. A point charge q_1 is placed at the centre of the shell and another charge q_2 is placed outside the shell. All the three charges are positive. Then, the force on charge q_1 is



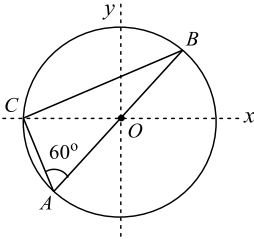
- a) Towards right b) Towards left c) Zero d) None of these
93. Seven capacitors each of capacity $2\mu F$ are to be so connected to have an equivalent capacity $\frac{10}{11}\mu F$. Which will be the necessary figure as shown



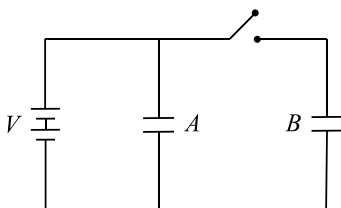
94. A long, hollow conducting cylinder is kept coaxially inside another long, hollow conducting cylinder of larger radius. Both the cylinders are initially electrically neutral.
- a) A potential difference appears between the two cylinders when a charge density is given to the inner cylinder
 b) A potential difference appears between the two cylinders when a charge density is given to the outer cylinder
 c) No potential difference appears between the two cylinders when a uniform line charge is kept along the axis of the cylinders
 d) No potential difference appears between the two cylinders when same charge density is given to both the cylinders
95. Consider a neutral conducting sphere. A positive point charge is placed outside the sphere. The net charge on the sphere is then
- a) negative and distributed uniformly over the surface of the sphere
 b) negative and appears only at the point on the sphere closest to the point charge
 c) Negative and distributed non-uniformly over the entire surface of the sphere
 d) Zero
96. A certain charge ' Q ' is to be divided into two parts q and $Q - q$. What is the relationship ' Q ' and ' q ' if the two parts, placed at a given distance ' r ' apart, are to have the maximum Coulomb repulsion?
- a) $q = Q/2$ b) $q = Q/3$ c) $q = 2Q/2$ d) $q = Q/4$
97. Positive and negative point charges of equal magnitude are kept at $(0, 0, \frac{a}{2})$ and $(0, 0, -\frac{a}{2})$, respectively. The work done by the electric field when another positive point charge is moved from $(-a, 0, 0)$ to $(0, a, 0)$ is
- a) Positive
 b) Negative
 c) Zero



- d) Depends on the path connecting the initial and final positions
98. Electric lines of force
- Exist everywhere
 - Exist only in the immediate vicinity of electric charges
 - Exist only when both positive and negative charges are near one another
 - Are imaginary
99. A force of 2.25 N acts on a charge of 15×10^{-4} C. Calculate the intensity of electric field at the point
- 1500 NC^{-1}
 - 150 NC^{-1}
 - 15000 NC^{-1}
 - None of these
100. Consider a system of three charges $\frac{q}{3}$, $\frac{q}{3}$ and $-\frac{2q}{3}$ placed at points A, B and C, respectively, as shown in the figure. Take O to be the centre of the circle of radius R and angle $CAB = 60^\circ$

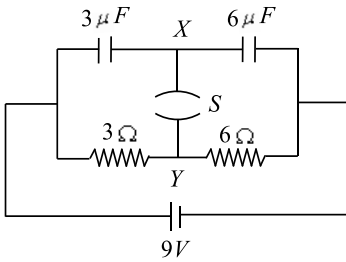


- The electric field at point O is $\frac{q}{8\pi\epsilon_0 R^2}$ directed along the negative x -axis
 - The Potential energy of the system is zero
 - The magnitude of the force between the charges at C and B is $\frac{q^2}{54\pi\epsilon_0 R^2}$
 - The potential at point O is $\frac{q}{12\pi\epsilon_0 R}$
101. Two point charges $+q$ and $-q$ are held fixed at $(-d, 0)$ and $(d, 0)$ respectively of a (X, Y) coordinate system. Then
- E at all points on the Y - axis is along \hat{i}
 - The electric field \vec{E} at all points on the X -axis has the same direction
 - Dipole moment is $2qd$ directed along \hat{i}
 - Work has to be done in bringing a test charge from infinity to the origin
102. Choose the correct statement:
- The total charge of the universe is constant
 - The total number of the charged particles is constant
 - The total positive charge of the universe remains constant
 - The total negative charge of the universe remains constant
103. Figure given below shows two identical parallel plate capacitors connected to a battery with switch S closed. The switch is now opened and the free space between the plate of capacitors is filled with a dielectric of dielectric constant 3. What will be the ratio of total electrostatic energy stored in both capacitors before and after the introduction of the dielectric



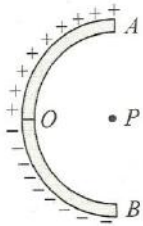
- 3 : 1
 - 5 : 1
 - 3 : 5
 - 5 : 3
104. A circuit is connected as shown in the figure with the switch S open. When the switch is closed, the total amount of charge that flows from Y to X is





- a) 0 b) $54 \mu C$ c) $27 \mu C$ d) $81 \mu C$

105. A thin glass rod is bent into a semicircle of radius r . A charge $+Q$ is uniformly distributed along the upper half and a charge $-Q$ is uniformly distributed along the lower half, as shown in Fig. The electric field E at P , the centre of the semicircle, is



- a) $\frac{Q}{\pi^2 \epsilon_0 r^2}$ b) $\frac{2Q}{\pi^2 \epsilon_0 r^2}$ c) $\frac{4Q}{\pi^2 \epsilon_0 r^2}$ d) $\frac{Q}{4\pi^2 \epsilon_0 r^2}$

106. A uniformly charged thin spherical shell of radius R carries uniform surface charge density of σ per unit area. It is made of two hemispherical shells, held together by pressing them with force F (see figure). F is proportional to



- a) $\frac{1}{\epsilon_0} \sigma^2 R^2$ b) $\frac{1}{\epsilon_0} \sigma^2 R$ c) $\frac{1}{\epsilon_0} \frac{\sigma^2}{R}$ d) $\frac{1}{\epsilon_0} \frac{\sigma^2}{R^2}$

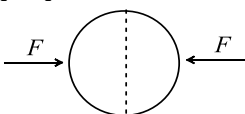
107. Two small spheres each having the charge $+Q$ are suspended by insulating threads of length L from a hook. This arrangement is taken in space where there is no gravitational effect, then the angle between the two suspensions and the tension in each will be

- a) $180^\circ, \frac{1}{4\pi\epsilon_0} \frac{Q^2}{(2L)^2}$ b) $90^\circ, \frac{1}{4\pi\epsilon_0} \frac{Q^2}{L^2}$ c) $180^\circ, \frac{1}{4\pi\epsilon_0} \frac{Q^2}{2L^2}$ d) $180^\circ, \frac{1}{4\pi\epsilon_0} \frac{Q^2}{L^2}$

108. A particle of mass m and charge $-q$ moves diametrically through a uniformly charged sphere of radius R with total charge Q . The angular frequency of the particle's simple harmonic motion, if its amplitude $< R$, is given by

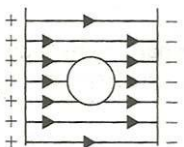
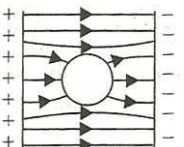
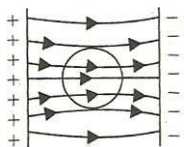
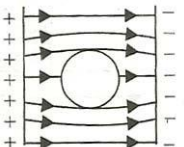
- a) $\sqrt{\frac{1}{4\pi\epsilon_0} \frac{qQ}{mR}}$ b) $\sqrt{\frac{1}{4\pi\epsilon_0} \frac{qQ}{mR^2}}$ c) $\sqrt{\frac{1}{4\pi\epsilon_0} \frac{qQ}{mR^3}}$ d) $\sqrt{\frac{1}{4\pi\epsilon_0} \frac{m}{qQ}}$

109. A uniformly charged thin spherical shell of radius R carries uniform surface charge density of σ per unit area. It is made of two hemispherical shells, held together by pressing them with force F (see figure). F is proportional to

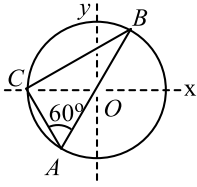


- a) $\frac{1}{\epsilon_0} \sigma^2 R^2$ b) $\frac{1}{\epsilon_0} \sigma^2 R$ c) $\frac{1}{\epsilon_0} \frac{\sigma^2}{R}$ d) $\frac{1}{\epsilon_0} \frac{\sigma^2}{R^2}$



110. Three identical spheres, each having a charge q and radius R , are kept in such a way that each touches the other two. The magnitude of the electric force on any sphere due to other two is
- a) $\frac{1}{4\pi\epsilon_0} \left(\frac{q}{R}\right)^2$ b) $\frac{\sqrt{3}}{4\pi\epsilon_0} \left(\frac{q}{R}\right)^2$ c) $\frac{\sqrt{3}}{16\pi\epsilon_0} \left(\frac{q}{R}\right)^2$ d) $\frac{\sqrt{5}}{16\pi\epsilon_0} \left(\frac{q}{R}\right)^2$
111. Three concentric metallic spherical shells of radii $R, 2R, 3R$ given charges Q_1, Q_2, Q_3 respectively. It is found that the surface charge densities on the outer surfaces of the shells are equal. Then, the ratio of the charges given to the shells, $Q_1:Q_2:Q_3$ is
- a) 1:2:3 b) 1:3:5 c) 1:4:9 d) 1:8:18
112. A solid sphere of radius R has a charge Q distributed in its volume with a charge density $\rho = kr^a$, where k and a are constants and r is the distance from its centre. If the electric field at $r = \frac{R}{2}$ is $\frac{1}{8}$ times that at $r = R$, find the value of a
- a) 3 b) 5 c) 2 d) Both (a) and (b)
113. An α particle is situated in an electric field of strength $15 \times 10^4 \text{ NC}^{-1}$. Force acting on it is
- a) $4.8 \times 10^{-12} \text{ N}$ b) $4.8 \times 10^{-14} \text{ N}$ c) $48 \times 10^{-14} \text{ N}$ d) None of these
114. Which of the following statement(s) is/are correct
- a) If the electric field due to a point charge varies as $r^{-2.5}$ instead of r^{-2} , then the Gauss law will still be valid
- b) The Gauss law can be used to calculate the field distribution around an electric dipole
- c) If the electric field between two point charges is zero somewhere, then the sign of the two charges is the same
- d) The work done by the external force in moving a unit positive charge from point A at potential V_A is $(V_B - V_A)$
115. Three equal charges, each $+q$, are placed on the corners of an equilateral triangle of side a . Then, the coulomb force experienced by one charge due to the rest of the two is
- a) kq^2/a^2 b) $2kq^2/a^2$ c) $\sqrt{3}kq^2/a^2$ d) Zero
116. A spherical shell of radius $R = 1.5 \text{ cm}$ has a charge $q = 20 \mu\text{C}$ uniformly distributed over it. The force exerted by one half over the other half is
- a) Zero b) 10^{-2} N c) 500 N d) 2000 N
117. A particle of mass m carrying a positive charge q moves simple harmonically along x -axis under the action of a varying electric field E directed along x -axis. The motion of the particle is confined between $x = 0$ and $x = 2l$. The angular frequency of the motion is ω . Then, which of the following is correct?
- a) $qE = -m\omega^2(x - l)$
- b) $qE = m\omega^2(x - l)$
- c) Electric field to the right of origin is directed along +ve x - axis for all values of x
- d) Electric field to the right of origin is directed along -ve x -axis for all values of x
118. An uncharged metal sphere is placed between two equal and oppositely charged metal plates. The nature of lines of force will be
- a)  b)  c)  d) 
119. Consider a system of three charges $\frac{q}{3}, \frac{q}{3}$ and $-\frac{2q}{3}$ placed at point A, B and C respectively, as shown in the figure. Take O to be the centre of the circle of radius R and angle $CAB = 60^\circ$.





- a) The electric field at point O is $\frac{q}{8\pi\epsilon_0 R^2}$ directed along the negative x -axis
 b) The potential energy of the system is zero
 The magnitude of the force between the charges at C and B is
 c) $\frac{q^2}{54\pi\epsilon_0 R^2}$
 The potential at point O is
 d) $\frac{q}{12\pi\epsilon_0 R}$

120. Electric field near a straight wire carrying a steady current is

- a) Proportional to the distance from the wire
 b) Proportional to inverse square of the distance from the wire
 c) Inversely proportional to the distance from the wire
 d) Zero

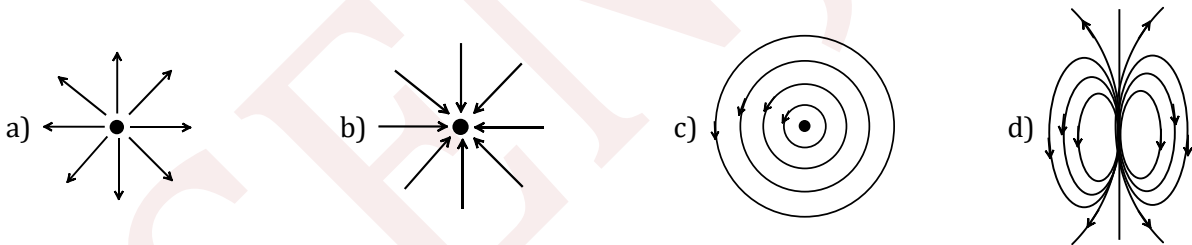
121. A flat, square surface with sides of length L is described by the equations

$$x = L, 0 \leq y \leq L, 0 \leq z \leq L$$

The electric flux through the square due to a positive point charge q located at the origin ($x = 0, y = 0, z = 0$) is

- a) $\frac{q}{4\epsilon_0}$ b) $\frac{q}{6\epsilon_0}$ c) $\frac{q}{24\epsilon_0}$ d) $\frac{q}{48\epsilon_0}$

122. Which of the field patterns given below is valid for electric field as well as for magnetic field



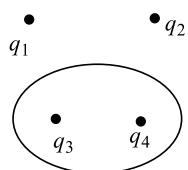
123. Number of electric lines of force from 0.5C of positive charge in a dielectric medium of dielectric constant 10 is

- a) 5.65×10^9 b) 1.13×10^{11} c) 9×10^9 d) 8.85×10^{-12}

124. If a body is charged by rubbing it, its weight

- a) Always decreases slightly b) Always increases slightly
 c) May increase slightly or may decrease slightly d) Remains precisely the same

125. Fig. shows four charges q_1, q_2, q_3, q_4 fixed in space. Then, the total flux of electric field through a closed surface S , due to all charges q_1, q_2, q_3 and q_4 , is



- a) Not equal to the total flux through S due to q_3 and q_4
 b) Equal to the total flux through S due to q_3 and q_4



- c) Zero if $q_1 + q_2 = q_3 + q_4$
d) Twice the total flux through S due to q_3 and q_4 if $q_1 + q_2 = q_3 + q_4$

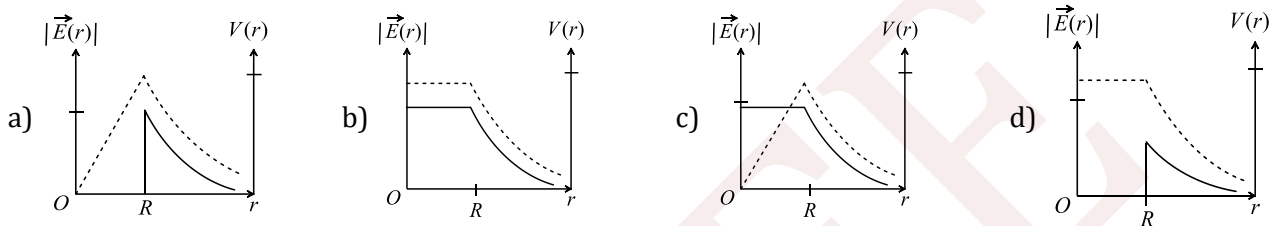
126. Two point charges at certain distance apart in air repel each other with a force F . A glass plate is introduced between the charges. The force becomes F_1 , where

- a) $F_1 < F$ b) $F_1 = F$ c) $F_1 > F$ d) Data is insufficient

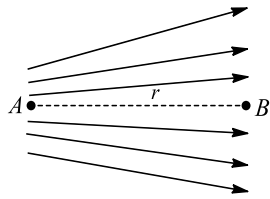
127. Two point charges repel each other with a force of 100 N. One of the charges is increased by 10% and the other is reduced by 10%. The new force of repulsion at the same distance would be

- a) 100 N b) 121 N c) 99 N d) None of these

128. Consider a thin spherical shell of radius R with its centre at the origin, carrying uniform positive surface charge density. The variation of the magnitude of the electric field $|\vec{E}(r)|$ and the electric potential $V(r)$ with the distance r from the centre, is best represented by which graph



129. Figure shows the electric lines of force emerging from a charged body. If the electric fields at A and B are E_A and E_B , respectively, and if the distance between A and B is r , then

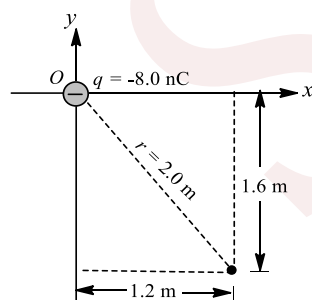


- a) $E_A > E_B$ b) $E_A < E_B$ c) $E_A = E_B/r$ d) $E_A = E_B/r^2$

130. If on the concentric hollow spheres of radii r and $R (> r)$ the charge Q is distributed such that their surface densities are same then the potential at their common centre is

- a) $\frac{Q(R^2 + r^2)}{4\pi\epsilon_0(R + r)}$ b) $\frac{QR}{R + r}$ c) Zero d) $\frac{Q(R + r)}{4\pi\epsilon_0(R^2 + r^2)}$

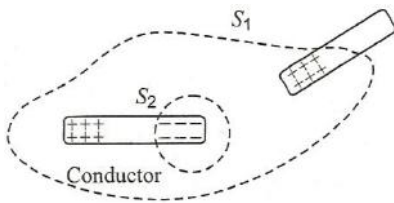
131. A point charge $q = -8.0$ nC is located at the origin. The electric field (in NC^{-1}) vector at the point $x = 1.2$ m, $y = -1.6$ m as shown in Fig. is



- a) $-14.4\hat{i} + 10.8\hat{j}$ b) $-14.4\hat{i} - 10.8\hat{j}$ c) $-10.8\hat{i} + 14.4\hat{j}$ d) $-10.8\hat{i} - 14.4\hat{j}$

132. Charge on an originally uncharged conductor is separated by holding a positively charged rod very closely nearby, as in fig. Assume that the induced negative charge on the conductor is equal to the positive charge q on the rod. Then, flux through surface S_1 is





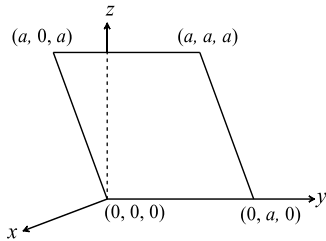
- a) Zero b) q/ϵ_0 c) $-q/\epsilon_0$ d) None of these
133. Six charges, three positive and three negative of equal magnitude are to be placed at the vertices of a regular hexagon such that the electric field at O is double the electric field when only one positive charge of same magnitude is placed at R . Which of the following arrangements of charges is possible for P, Q, R, S, T and U respectively?
-
- a) $+, -, +, -, -, +$ b) $+, -, +, -, +, -$ c) $+, +, -, +, -, -$ d) $-, +, +, -, +, -$
134. The electric flux from a cube of edge l is ϕ . If edge of the cube is made $2l$ and charge enclosed is halved, its value will be
- a) 4ϕ b) 2ϕ c) $\phi/2$ d) ϕ
135. Two particles A and B (B is right of A) have charges $8 \times 10^{-6} \text{ C}$ and $-2 \times 10^{-6} \text{ C}$, respectively, are held fixed with separation of 20 cm . Where should a third charged particle be placed so that it does not experience a net electric force
- a) 5 cm right of B b) 5 cm left of A c) 20 cm left of A d) 20 cm right of B
136. Consider two concentric spherical surfaces S_1 with radius a and S_2 with radius $2a$, both centred on the origin. There is a charge $+q$ at the origin, and no other charges. Compare the flux ϕ_1 through S_1 with the flux ϕ_2 through S_2
- a) $\phi_1 = 4\phi_2$ b) $\phi_1 = 2\phi_2$ c) $\phi_1 = \phi_2$ d) $\phi_1 = \phi_2/2$
137. A point charge of $100 \mu\text{C}$ is placed at $3\hat{i} + 4\hat{j} \text{ m}$. Find the electric field intensity due to this charge at a point located at $9\hat{i} + 12\hat{j} \text{ m}$
- a) 8000 Vm^{-1} b) 9000 Vm^{-1} c) 2250 Vm^{-1} d) 4500 Vm^{-1}
138. Dimensions of ϵ_0 are
- a) $M^{-1}L^{-3}T^4A^2$ b) $M^0L^{-3}T^3A^3$ c) $M^{-1}L^{-3}T^3A$ d) $M^{-1}L^{-3}TA^2$
139. A long, hollow conducting cylinder is kept coaxially inside another long, hollow conducting cylinder of larger radius. Both the cylinders are initially electrically neutral
- a) A potential difference appears between the two cylinders when a charge density is given to the inner cylinder
- b) A potential difference appears between the two cylinders when a charge density is given to the outer cylinder
- c) No potential difference appears between the two cylinders when a uniform line charge is kept along the axis of the cylinders
- d) No potential difference appears between the two cylinders when same charge density is given to both the cylinders
140. When a soap bubble is charged, its size
- a) Increases
- b) Decreases
- c) Remains the same
- d) Increases if it is given positive charge and decreases if it is given negative charge



141. Five point charges, $+q$ each, are placed at the five vertices of a regular hexagon. The distance of centre of the hexagon from any of the vertices is a . The electric field at the center of the hexagon is

- a) $\frac{q}{4\pi\epsilon_0 a^2}$ b) $\frac{q}{8\pi\epsilon_0 a^2}$ c) $\frac{q}{16\pi\epsilon_0 a^2}$ d) Zero

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



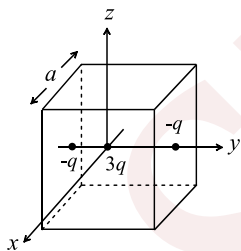
- a) $2E_0 a^2$ b) $\sqrt{2}E_0 a^2$ c) $E_0 a^2$ d) $\frac{E_0 a^2}{\sqrt{2}}$

143. A parallel plate capacitor of plate area A and plate separation d is charged to potential V and then the battery is disconnected. A slab of dielectric constant k is then inserted between the plates of the capacitors so as to fill the space between the plates. If Q, E and W denote respectively, the magnitude of charge on each plate, the electric field between the plates (after the slab is inserted) and work done on the system in question in the process of inserting the slab, then state incorrect relation from the following

- a) $Q = \frac{\epsilon_0 AV}{d}$ b) $W = \frac{\epsilon_0 AV^2}{2kd}$ c) $E = \frac{V}{kd}$ d) $W = \frac{\epsilon_0 AV^2}{2d} \left(1 - \frac{1}{k}\right)$

Multiple Correct Answers Type

144. A cubical region of side a has its centre at the origin. It encloses three fixed point charges, $-q$ at $(0, -a/4, 0)$, $+3q$ at $(0, 0, 0)$ and $-q$ at $(0, +a/4, 0)$. Choose the correct option(s)



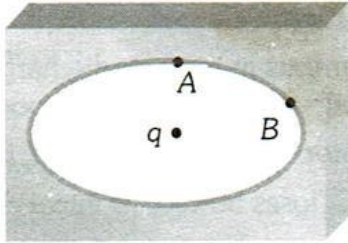
- a) The net electric flux crossing the plane $x = +a/2$ is equal to the net electric flux crossing the plane $x = -a/2$
- b) The net electric flux crossing the plane $y = +a/2$ is more than the net electric flux crossing the plane $y = -a/2$
- c) The net electric flux crossing the entire region is $\frac{q}{\epsilon_0}$
- d) The net electric flux crossing the plane $z = +a/2$ is equal to the net electric flux crossing the plane $x = +a/2$

145. A positively charged thin metal ring of radius R is fixed in the xy - plane with its centre at the O . A negatively charged particle P is released from rest at the point $(0, 0, z_0)$, where $z_0 > 0$. Then the motion of P is

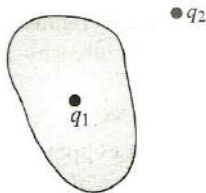
- a) Periodic for all values of z_0 satisfying $0 < z_0 < \infty$
- b) Simple harmonic for all values of satisfying $0 < z_0 < R$



- c) Approximately simple harmonic provided $z_0 \ll R$
 d) Such that P crosses O and continues to move along the negative z – axis towards $z = -\infty$
146. An ellipsoidal cavity is carved within a perfect conductor. A positive charge q is placed at the centre of the cavity. The points A and B are on the cavity surface as shown in the figure. Then



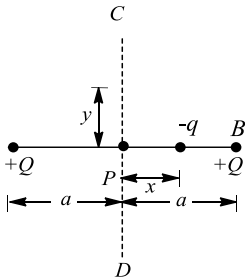
- a) Electric field near A in the cavity = Electric field near B in the cavity
 b) Charge density at A = Charge density at B
 c) Potential at A = Potential at B
 d) Total electric field flux through the surface of the cavity is q/ϵ_0
147. A parallel plate capacitor is charged to a potential difference of $50V$. It is discharged through a resistance. After 1 second, the potential difference between plates becomes $40V$. Then
- a) Fraction of stored energy after 1 second is $\frac{16}{25}$
 b) Potential difference between the plates after 2 seconds will be $32V$
 c) Potential difference between the plates after 2 seconds will be $20V$
 d) Fraction of stored energy after 1 second is $\frac{4}{5}$
148. Consider Gauss's law $\oint \vec{E} \cdot d\vec{s} = \frac{q}{\epsilon_0}$



- Then for the situation shown in fig. at the Gaussian surface
- a) \vec{E} due to q_2 would be zero
 b) \vec{E} due to both q_1 and q_2 would be non-zero
 c) ϕ due to both q_1 and q_2 would be non-zero
 d) ϕ due to q_2 would be zero
149. A few electric field lines for a system of two charges Q_1 and Q_2 fixed at two different points on the x –axis are shown in the figure. These lines suggest that
-
- a) $|Q_1| > |Q_2|$
 b) $|Q_1| < |Q_2|$
 c) at a finite distance to the left of Q_1 the electric field is zero
 d) at a finite distance to the right of Q_2 the electric field is zero
150. Which one statement is correct? A parallel plate air condenser is connected with a battery. Its charge, potential, electric field and energy are Q_0, V_0, E_0 and U_0 respectively. In order to fill the complete space between the plates a dielectric slab is inserted, the battery is still connected. Now the corresponding values Q, V, E and U are in relation with the initially stated as
- a) $Q > Q_0$
 b) $V > V_0$
 c) $E > E_0$
 d) $U > U_0$

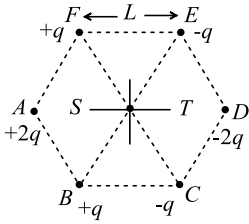


151. 10 C charge is given to conducting spherical shell and a -3 C points charge is placed inside the shell. For this arrangement, find the correct statement(s)
- The charge on the inner surface of the shell will be $+3C$ and it can be distributed uniformly or non-uniformly
 - The charge on the inner surface of the shell will be $+3C$ and its distribution would be uniform
 - The net charge on the outer surface of the shell will be $+7C$ and its distribution can be uniform or non-uniform
 - The net charge on the outer surface of the shell will be $+7C$ and its distribution would be uniform
152. A spherical metal shell A of radius R_A and a solid metal sphere B of radius $R_B (< R_A)$ are kept far apart and each is given charge $+Q$. Now they connected by a thin metal wire. Then
- $E_A^{\text{inside}} = 0$
 - $Q_A > Q_B$
 - $\frac{\sigma_A}{\sigma_B} = \frac{R_B}{R_A}$
 - $E_A^{\text{on surface}} < E_B^{\text{on surface}}$
153. For the arrangement shown in Fig., the two positive charges, $+Q$ each, are fixed. Mark out the correct statement(s) regarding a third charged particle q placed at midpoint P that can be displaced along or perpendicular to the line connecting the charges



- The particle will perform S.H.M. for $x \ll a$
 - The particle will oscillate about P but not harmonically for any x
 - The particle will perform S.H.M. for $y \ll a$
 - The particle will oscillate about P but not harmonically for y comparable to a
154. A metallic sheet is inserted between the plates of a parallel plate capacitor. The capacitance of the capacitor
- Increases
 - Is independent of the position of the sheet
 - Is maximum when the metal sheet is in the middle
 - Is maximum when the metal sheet touches one of the capacitor plates
155. A parallel plate capacitor is charged and the charging battery is then disconnected. If the plates of the capacitor are moved farther apart by means of insulating handles, then which of the following is correct
- The charge on the capacitor increases
 - The voltage across the plates increases
 - The capacitance increases
 - The electrostatic energy stored in the capacitor increases
156. Six point charges are kept at the vertices of a regular hexagon of side L and centre O , as shown in the figure. Given that $K = \frac{1}{4\pi\epsilon_0} \frac{q}{L^2}$, which of the following statement (s) is (are) correct





- a) The electric field at O is $6K$ along OD b) The potential at O is zero
 c) The potential at all points on the line PR is same d) The potential at all points on the line ST is same

157. Which of the following statement (s) is/are correct?

a) If the electric field due to a point charge varies as $r^{-2.5}$ instead of r^{-2} , then the Gauss's law will still be valid

b) The Gauss's law can be used to calculate the field distribution around an electric dipole

c) If the electric field between two point charges is zero somewhere, then the sign of the two charges is the same

d) The work done by the external force in moving a unit positive charge from point A at potential V_A to point B at potential V_B is $(V_B - V_A)$

158. Capacitor C_1 of capacitance 1 microfarad and capacitor C_2 of capacitance 2 microfarad are separately charged fully by a common battery. The two capacitors are then separately allowed to discharge through equal resistors at time $t = 0$

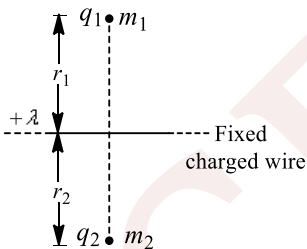
a) The current in each of the two discharging circuits is zero at $t = 0$

b) The currents in the two discharging circuits are equal but not zero

c) The currents in the two discharging circuits at $t = 0$ are unequal

d) Capacitor C_1 , loses 50% of its initial charge sooner than C_2 loses 50% of its initial charge

159. For the arrangement shown in Fig., the two point charges are in equilibrium. The infinite wire is fixed in the horizontal plane and the two point charges are placed one above and the other below the wire



Considering the gravitational effect of the earth, the nature of q_1 and q_2 can be

a) $q_1 \rightarrow +ve, q_2 \rightarrow +ve$ b) $q_1 \rightarrow +ve, q_2 \rightarrow -ve$ c) $q_1 \rightarrow -ve, q_2 \rightarrow -ve$ d) $q_1 \rightarrow -ve, q_2 \rightarrow +ve$

160. For Gauss's law, mark out the correct statements(s)

If we displace the enclosed charges (within a Gaussian surface) without crossing the boundary, then

a) both \vec{E} and ϕ remain same

b) If we displace the enclosed charges without crossing the boundary, then \vec{E} changes but ϕ remains the same

c) If charge crosses the boundary, then both \vec{E} and ϕ would change

d) If charge crosses the boundary, then ϕ changes but \vec{E} remains the same

161. A few electric field lines for a system of two charges Q_1 and Q_2 fixed at two different points on the $x - axis$ are shown in the figure. These lines suggest that



d) Range of motion of the particle can be less than, greater than or equal to
 $(u^2 \sin 2\theta)/g$

166. A dielectric slab of thickness d is inserted in a parallel plate capacitor whose negative plate is at $x = 0$ and positive plate is at $x = 3d$. The slab is equidistant from the plates. The capacitor is given some charge. As one goes from 0 to $3d$

- a) The magnitude of the electric field remains the same
- b) The direction of the electric field remains the same
- c) The electric potential increases continuously
- d) The electric potential increases at first, then decreases and again increases

Assertion - Reasoning Type

This section contain(s) 0 questions numbered 167 to 166. Each question contains STATEMENT 1 (Assertion) and STATEMENT 2 (Reason). Each question has the 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

- a) Statement 1 is True, Statement 2 is True; Statement 2 is correct explanation for Statement 1
- b) Statement 1 is True, Statement 2 is True; Statement 2 is **not** correct explanation for Statement 1
- c) Statement 1 is True, Statement 2 is False
- d) Statement 1 is False, Statement 2 is True

167

Statement 1: A molecule having intrinsic dipole moment is called polar molecule.

Statement 2: Centre of positive charge does not coincide with the negative charge in a polar molecule.

168

Statement 1: If three capacitors of capacitances $C_1 < C_2 < C_3$ are connected in parallel and in series then their equivalent capacitance $C_p > C_s$.

Statement 2: $\frac{1}{C_p} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ and $C_s = C_1 + C_2 + C_3$

169

Statement 1: If three capacitors of capacitance $C_1 < C_2 < C_3$ are connected in parallel then their equivalent capacitance $C_p > C_3$

Statement 2: $\frac{1}{C_p} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

170

Statement 1: A positive point charge initially at rest in a uniform electric field starts moving along electric lines of forces. (Neglect all other forces except electric forces)

Statement 2: A point charge released from rest in an electric field always moves along the lines of force

171

Statement 1: A charged capacitor is disconnected from a battery. Now if its plate are separated farther, the potential energy will fall



Statement 2: Energy stored in a capacitor is equal to the work done in charging it

172

Statement 1: A small metal ball of mass m is suspended from a thread of length l between the plates of a large capacitor. If a charge $+q$ is placed on the ball and the upper plate is positively charged then time period of the ball increases.

Statement 2: Time period of the ball is given by $T = 2\pi \frac{\sqrt{l}}{g - \frac{1}{\epsilon} \frac{q^2}{m}}$

173

Statement 1: The electric field due to a dipole on its axis line at a distance r is E . then, electric field due to the same dipole on the equatorial line and at the same distance will be $\frac{E}{2}$

Statement 2: Electric field due to dipole varies inversely as the squares of distance.

174

Statement 1: For practical purpose, the earth is used as a reference at zero potential in electrical circuits

Statement 2: The electrical potential of a sphere of radius R with charge Q uniformly distributed on the surface is given by $\frac{Q}{4\pi\epsilon_0 R}$

175

Statement 1: When charges are shared between any two bodies, no charge is really lost, but some loss of energy does occur

Statement 2: Some energy disappears in the form of heat, sparking *etc*

176

Statement 1: If a point charge is rotated in a circle around another charge at the centre of circle, the work done by electric field will be zero

Statement 2: Work done is equal to dot product of force and displacement

177

Statement 1: Mass of ion is slightly differed from its element

Statement 2: Ion is formed, when some electrons are removed or added so mass changes

178

Statement 1: A parallel plate capacitor is connected across battery through a key. A dielectric slab of constant K is introduced between the plates. The energy which is stored becomes K times

Statement 2: The surface density of charge on the plate remains constant or unchanged

179

Statement 1: For the situation shown in fig., if we displace the charge q within the conducting shell, then nature of distribution of charge on the outer surface of the shell not change



180 **Statement 2:** Any conduction shell divides the entire space into two regions (inside and outside the shell), which are independent to each other in term of electric field

Statement 1: When a neutral body acquires +ve charge, its mass decreases

Statement 2: A body acquires +ve charge when it loses electrons

181

Statement 1: Electric lines of force cross each other

Statement 2: Electric field at a point superimposes to give one resultant electric field

182

Statement 1: Conductors having equal positive charge and volume, must also have same potential

Statement 2: Potential depends only on charge and volume of conductor

183

Statement 1: On going away from a point charge or a small electric dipole, electric field decreases at the same rate in both the cases

Statement 2: Electric field is inversely proportional to square of distance from the charge or an electric dipole

184

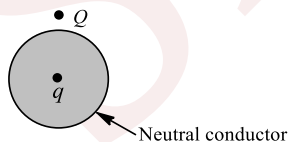
Statement 1: The coulomb's force is the dominating force in the universe.

Statement 2: The coulomb's force is the weaker than the gravitational force.

185

Statement 1: Electric field on the surface of a conductor is more at the sharp corners

Statement 2: Surface charge density on conductor's surface is inversely proportional to the radius of curvature



186

Statement 1: Two similarly charged bodies may attract each other

Statement 2: When charge on one body (Q) is much greater than that on another (q) and they are close enough to each other, then force of attraction between Q and induced charges exceeds the force of repulsion between Q and q

187

Statement 1: Annihilation of electron and positron is an example of decay of charges



Statement 2: In the process of annihilation an electron and a positron combine to give gamma ray

188

Statement 1: Displacement current goes through the gap between the plates of a capacitor when the charge of the capacitor does not change

Statement 2: The displacement current arises in the region in which the electric field and hence the electric flux does not change with time

189

Statement 1: The force with which one plate of a parallel plate capacitor is attracted towards the other plate is equal to square of surface density per ϵ_0 per unit area

Statement 2: The electric field due to one charged plate of the capacitor at the location of the other is equal to surface density per ϵ_0

190

Statement 1: Dielectric breakdown occurs under the influence of an intense light beam

Statement 2: Electromagnetic radiations exert pressure

191

Statement 1: Upon displacement of charges within a closed surface, \vec{E} at any point on the surface does not change

Statement 2: The flux crossing through a closed surface is independent of the location of charge within the surface

192

Statement 1: A metallic shield in form of a hollow shell may be built to block an electric field

Statement 2: In a hollow spherical shield, the electric field inside it is zero at every point

193

Statement 1: When a charge ' q ' is take from the centre of the surface of the sphere its potential energy changes by $\frac{q\rho}{3\epsilon_0}$

Statement 2: The electric field at a distance r ($r < R$) from the centre of the sphere is $\frac{\rho r}{3\epsilon_0}$

194

Statement 1: The tyres of aircraft's are slightly conducting

Statement 2: If a conductor is connected to ground, the extra charge induced on conductor will flow to ground

195

Statement 1: A bird perches on a high power line and nothing happens to the bird

Statement 2: The level of bird is very high from the ground

196



Statement 1: If Gaussian surface does not enclose any charge, then \vec{E} at any point on the Gaussian surface must be zero

Statement 2: No net charge is enclosed by Gaussian surface, so net flux passing through the surface is zero

197

Statement 1: \vec{E} in outside vicinity of a conductor depends only on the local charge density σ and it is independent of the other charges present anywhere on the conductor

Statement 2: \vec{E} in outside vicinity of a conductor is given by σ/ϵ_0

198

Statement 1: A point charge is brought in an electric field. The field at a nearby point will increase, whatever be the nature of the charge

Statement 2: The electric field is independent of the nature of charge

199

Statement 1: A number of capacitors are connected in series with each other. If U_1 U_2 U_3 be the energy stored in them respectively then total energy stored is $U_1 + U_2 + U_3 + \dots$

Statement 2: Potential energy is the scalar quantity.

200

Statement 1: If the distance between parallel plates of a capacitor is halved and dielectric constant is made three times, then the capacitance becomes 6 times

Statement 2: Capacity of the capacitor does not depend upon the nature of the material

201

Statement 1: Charge is quantized because only integral number of electrons can be transferred

Statement 2: There is no possibility of transfer of some fraction of electron

202

Statement 1: If a proton and an electron are placed in the same uniform electric field. They experience different acceleration

Statement 2: Electric force on a test charge is independent of its mass

203

Statement 1: For a charged particle moving from point P to point Q , the net work done by an electrostatic field on the particle is independent of the path connecting point P to point Q

Statement 2: The net work done by a conservative force on an object moving along a closed loop is zero

204

Statement 1: The coulomb force is the dominating force in the universe

Statement 2: The coulomb force is weaker than the gravitational force



205

Statement 1: Surface of a symmetrical conductor can be treated as equipotential surface

Statement 2: Charges can easily flow in a conductor

206

Statement 1: The surface charge densities of two spherical conductors of different radii are equal. Then the electric field intensities near their surface are also equal

Statement 2: Surface charge density is equal to charge per unit area

207

Statement 1: Electrons move away from a low potential to high potential region

Statement 2: Because electrons have negative charge

208

Statement 1: A and B are two conducting spheres of same radius A being solid and B hollow. Both are charged to the same potential. Then charge A = charge B

Statement 2: Potentials on both are same.

209

Statement 1: If a point charge q is placed in front of an infinite grounded conducting plane surface, the point charge will experience a force

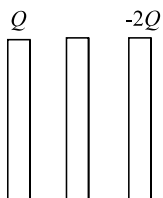
Statement 2: This force is due to the induced charge on the conducting surface which is at zero potential

Matrix-Match Type

This section contain(s) 0 question(s). Each question contains Statements given in 2 columns which have to be matched. Statements (A, B, C, D) in **columns I** have to be matched with Statements (p, q, r, s) in **columns II**.

210. Three identical metal plates with large surface areas are kept plate parallel to each other as shown in Fig. The left most plate is given charge Q , the rightmost given charge $-2Q$ and the middle one remains neutral.

Then



Column-I

Column- II

- | | |
|---|---|
| <p>(A) i. The charge appearing on outer surface of the rightmost plate</p> <p>(B) ii. The charge appearing on outer surface of the leftmost plate</p> | <p>(p) $+\frac{Q}{2}$</p> <p>(q) $-\frac{Q}{2}$</p> |
|---|---|



- (C) iii. The charge appearing on left surface of the middle plate (r) $-\frac{3Q}{2}$
 (D) iv. The charge appearing on right surface of the middle plate (s) $\frac{3Q}{2}$

CODES :

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

211. Match Column I with Column II

Column-I

Column- II

- | | |
|---|-------------------------|
| (A) Force on an electron in an atom | (p) Gravitational force |
| (B) Force between a proton and a neutron inside nucleus | (q) Strong force |
| (C) Force between a proton and a proton inside nucleus | (r) Coulomb force |
| (D) Conservative force | (s) Electric force |

CODES :

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

212. Electric field due to

Column-I

Column- II

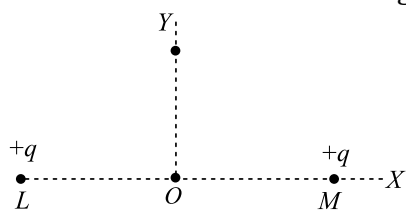
- | | |
|--|----------------------------------|
| (A) i. Infinite plane sheet of charge | (p) 0 |
| (B) ii. Infinite conducting plane sheet of uniform thickness | (q) $\frac{\sigma}{2\epsilon_0}$ |
| (C) iii. Non-conducting charged solid sphere at its surface | (r) $\frac{R\rho}{3\epsilon_0}$ |
| (D) iv. Non-conducting charged solid sphere at its centre | (s) $\frac{\sigma}{\epsilon_0}$ |



CODES :

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

213. In Fig. 1.130, charges, each $+q$, are fixed at L and M . O is the midpoint of distance LM . X - and Y - axes are as shown. Consider the situations given in column I and match them with the information in Column II:



Column-I

Column- II

- | | |
|---|---|
| (A) Let us place a charge $+q$ at O , displace it slightly along X -axis and release. Assume that it is allowed to move only along X -axis. At position O , | (p) Force on the charge is zero |
| (B) Place a charge $-q$ at O . Displace it slightly along X -axis and release. Assume that it is allowed to move only along X -axis. At position O , | (q) Potential energy of the system is maximum |
| (C) Place a charge $+q$ at O . Displace it slightly along Y -axis and release. Assume that it is allowed to move only along Y -axis. At position O , | (r) Potential energy of the system is minimum |
| (D) Place a charge $-q$ at O . Displace it slightly along Y -axis and release. Assume that it is allowed to move only along Y -axis. At position O , | (s) The charge is in equilibrium |

CODES :

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



214.

Column-I

Column- II

(A) ϵ_0

(p) 1

(B) K

(q) $[M^1L^1T^{-2}]$

(C) E

(r) $[M^{-1}L^{-3}T^4A^2]$

(D) F

(s) $[M^1L^1T^{-3}A^{-1}]$

CODES :

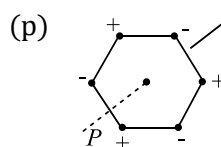
	A	B	C	D
a)	B	a	d	c
b)	c	a	d	b
c)	b	d	c	a
d)	d	a	c	b

215. Six point charges, each of the same magnitude q , are arranged in different manners as shown in Column II. In each case, a point M and a line PQ passing through M are shown. Let E be the electric field and V be the electric potential at M (potential at infinity is zero) due to the given charge distribution when it is at rest. Now, the whole system is set into rotation with a constant angular velocity about the line PQ . Let B be the magnetic field at M and μ be the magnetic moment of the system in this condition. Assume each rotation charge to be equivalent to a steady current

Column-I

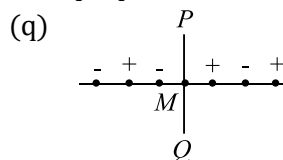
Column- II

(A) $E = 0$



Charges are at the corners of a regular hexagon. M is at the centre of the hexagon. PQ is perpendicular to the plane of the hexagon

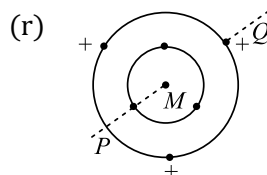
(B) $V \neq 0$



Charges are on a line perpendicular to PQ at equal intervals. M is the mid-point between the two innermost charges

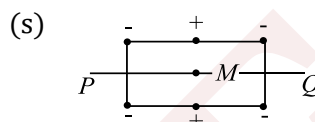


(C) $B = 0$

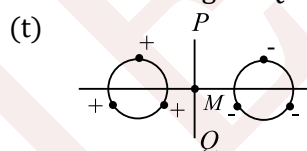


Charges are placed on two coplanar insulating rings at equal intervals. M is the common centre of the rings. PQ is perpendicular to the plane of the rings

(D) $\mu \neq 0$



Charges are placed at the corners of a rectangle of sides a and $2a$ and at the mid points of the longer sides. M is at the centre of the rectangle. PQ is parallel to the longer sides



Charges are placed on two coplanar, identical insulating rings at equal intervals. M is the mid-point between the centres of the rings. PQ is perpendicular to the line joining the centres and coplanar to the rings

CODES :

	A	B	C	D
a)	P,r,s	r,s	p,q,t	r,s
b)	r,s	p,q,t	r,s	p,r,
c)	p,q,t	r,s	r,s	p,r,s
d)	r,s	p,r,s	r,s	p,q,t

216. Match the facts given in Column I with the system given in Column II:

Column-I

Column- II

- | | |
|-------------------------|--------------------|
| (A) Charge cannot exist | (p) Without charge |
| (B) Mass can exist | (q) Without mass |
| (C) Charge is | (r) Not conserved |



(D) Mass is

(s) Conserved

CODES :

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

217. Match the forces given in Column I with the properties given in Column II:

Column-I	Column- II
(A) Electric force of nucleus of electron	(p) Conservative
(B) Your weight, i.e., the force that earth exerts on you	(q) Action reaction force
(C) Force between earth and sun	(r) Depends on the nature of medium between the interacting objects
(D) Repulsive force between two protons	(s) Principle of superposition applies provided that other forces, which are acting on the object, are also of this nature

CODES :

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

Linked Comprehension Type

This section contain(s) 33 paragraph(s) and based upon each paragraph, multiple choice questions have to be answered. Each question has atleast 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

Paragraph for Question Nos. 218 to -218

Consider a block of conducting material of resistivity ρ shown in the figure. Current I enters at A and leaves from D . We apply superposition principle to find voltage. ΔV developed between B and C . The calculation is done in the following steps

- Take current I entering from A and assume it to spread over a hemispherical surface in the book.
- Calculate field $E(r)$ at distance r from A by using Ohm's law $E = \rho J$, where J is the current per unit area at r .
- From the r dependence of $E(r)$ obtain the potential $V(r)$ at r .



(iv) Repeat (i), (ii) and (iii) for current I leaving D and superpose results for A and D .

218. ΔV measured between B and C is

a) $\frac{\rho l}{\pi a} - \frac{\rho l}{\pi(a+b)}$

b) $\frac{\rho l}{a} - \frac{\rho l}{(a+b)}$

c) $\frac{\rho l}{2\pi a} - \frac{\rho l}{2\pi(a+b)}$

d) $\frac{\rho l}{2\pi(a-b)}$

Paragraph for Question Nos. 219 to - 219

Two small identical conducting balls A and B of charges of $+10\mu\text{C}$ and $+30\mu\text{C}$, respectively, are kept at a separation of 50 cm. These balls have been connected by a wire for a short time

219. The final charge on each of the balls A and B will be

a) $10\mu\text{C}$ and $30\mu\text{C}$, respectively

b) $20\mu\text{C}$ on each ball

c) $30\mu\text{C}$ and $10\mu\text{C}$, respectively

d) $-40\mu\text{C}$ and $80\mu\text{C}$, respectively

Paragraph for Question Nos. 220 to - 220

Two free point charges A and B having charges $+q$ and $+4q$, respectively, are a distance l apart. A third charge is so placed that the entire system is in equilibrium

220. The third charge should be placed

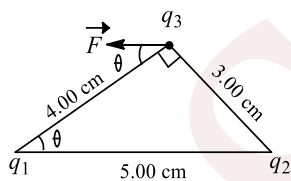
a) Left of A at a distance $l/3$ from A

b) Right of A at a distance $l/3$ from B

c) Between A and B at a distance $2l/3$ from A

d) Between A and B at a distance $l/3$ from A

Paragraph for Question Nos. 221 to - 221



Three charges are placed as shown in Fig. The magnitude of q_1 is $2.00\mu\text{C}$, but its sign and the value of the charge q_2 are not known. Charge q_3 is $+4.00\mu\text{C}$, and the net force on q_3 is entirely in the negative x -direction

221. As per the condition given in the problem, the sign of q_1 and q_2 will be

a) $+, +$

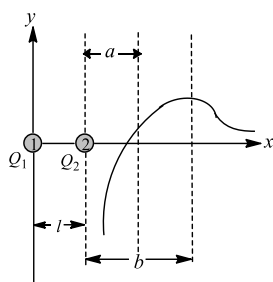
b) $+, -$

c) $-, +$

d) $-, -$

Paragraph for Question Nos. 222 to - 222





Two point like charges Q_1 and Q_2 are positioned at points 1 and 2. The field intensity to the right of the charge Q_2 on the line that passes through the two charges varies according to a law that is represented schematically in Fig. The field intensity is assumed to be positive if its direction coincides with the positive direction on the x -axis. The distance between the charges is l

222. The sign of each charge Q_1 and Q_2 is

- a) +, - b) -, + c) +, + d) -, -

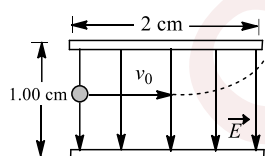
Paragraph for Question Nos. 223 to - 223

Four equal positive charges, each of value Q , are arranged at the four corners of a square of diagonal $2a$. A small body of mass m carrying a unit positive charge is placed at a height h above the centre of the square

223. What should be the value of Q in order that this body may be in equilibrium?

- a) $\pi\epsilon_0 \frac{mg}{2h} (h^2 + 2a^2)^{3/2}$ b) $\pi\epsilon_0 \frac{mg}{h} (h^2 + a^2)^{3/2}$
c) $\pi\epsilon_0 \frac{2mg}{h} (h^2 + 2a^2)^{3/2}$ d) $\pi\epsilon_0 \frac{mg}{2h} (h^2 - a^2)^{3/2}$

Paragraph for Question Nos. 224 to - 224



An electron is projected with an initial speed $v_0 = 1.60 \times 10^6 \text{ ms}^{-1}$ into the uniform field between the parallel plates as shown in Fig. Assume that the field between the plates is uniform and directed vertically downwards, and that the field outside the plates is zero. The electron enters the field at a point midway between the plates. Mass of electron = $9.1 \times 10^{-31} \text{ kg}$

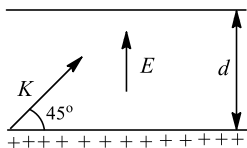
224. If the electron just misses the upper plate, the time of flight of electron up to this instant is

- a) $1.25 \times 10^{-9} \text{ s}$ b) $32.5 \times 10^{-6} \text{ s}$ c) $1.25 \times 10^{-8} \text{ s}$ d) $32.5 \times 10^{-8} \text{ s}$

Paragraph for Question Nos. 225 to - 225



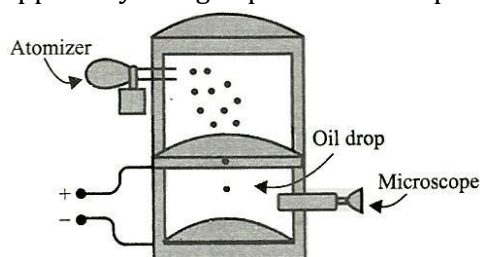
An electron is projected as shown in Fig., with kinetic energy k , at an angle $\theta = 45^\circ$ between two charged plates. Ignore the gravity



225. The magnitude of the electric field, so that the electron just fails to strike the upper plate is
 a) K/qd b) $2K/qd$ c) $K/2qd$ d) Infinite

Paragraph for Question Nos. 226 to - 226

In 1909, Robert Millikan was the first to find the charge of an electron in his now-famous oil-drop experiment. In that experiment, tiny oil drops were sprayed into a uniform electric field between a horizontal pair of oppositely charged plates. The drops were observed with a magnifying



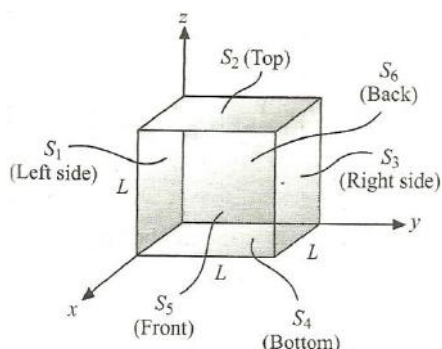
eyepiece, and the electric field was adjusted so that the upward force on some A negatively charged oil drop was just sufficient to balance the downward force of gravity. That is, when suspended upward force qE just equalled mg . Millikan accurately measured the charges on many oil drops and found the values to be whole number multiples of $1.6 \times 10^{-19} \text{C}$ – the charge of the electron. For this, he won the Noble prize

226. If a drop of mass $1.08 \times 10^{-14} \text{kg}$ remains stationary in an electric field of $1.68 \times 10^5 \text{NC}^{-1}$, then the charge of this drop is
 a) $6.40 \times 10^{-19} \text{C}$ b) $3.2 \times 10^{-19} \text{C}$ c) $1.6 \times 10^{-19} \text{C}$ d) $4.8 \times 10^{-19} \text{C}$

Paragraph for Question Nos. 227 to - 227

The cube as shown in fig has sides of length $L = 10.0 \text{ cm}$. The electric field is uniform, has a magnitude $E = 4.00 \times 10^3 \text{NC}^{-1}$, and is parallel to the xy -plane at an angle of 37° measured from the $+x$ -axis towards the $+y$ -axis





227. The surface that have zero flux are

- a) S_1 and S_3 b) S_5 and S_6 c) S_2 and S_4 d) S_1 and S_1

Paragraph for Question Nos. 228 to - 228

A cube sides of length $L = 0.300$ m. It is placed with one corner at the origin as shown in fig. The electric field is not uniform, but is given by $\vec{E} = (-5.00\text{NC}^{-1})x\hat{i} + (3.00\text{NC}^{-1})z\hat{k}$

228. The surface that have zero flux are

- a) S_2, S_4 and S_5 b) S_1, S_3, S_4 and S_6 c) S_1, S_2 and S_3 d) S_2, S_3 and S_4

Paragraph for Question Nos. 229 to - 229

A cube has sides of length L . It is placed with one corner at the origin as shown in fig. The electric field is uniform and given by $\vec{E} = -B\hat{i} + C\hat{j} - D\hat{k}$, where B, C and D are positive constants

229. The flux passing through the different surfaces (match the table is)

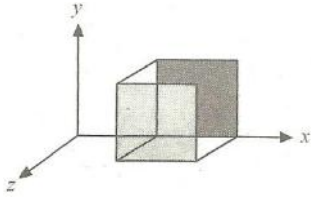
Surface	Flux
(i) S_1	(m) BL^2
(ii) S_2	(n) $-BL^2$
(iii) S_3	(o) CL^2
(iv) S_4	(p) $-CL^2$
(v) S_5	(q) DL^2
(vi) S_6	(r) $-DL^2$

- a) (i, p), (ii, r), (iii, o), (iv, q), (v, n), (vi, m) b) (i, r), (ii, p), (iii, q), (iv, n), (v, m), (vi, o)
c) (i, m), (ii, n), (iii, o), (iv, p), (v, q), (vi, r) d) (i, r), (ii, q), (iii, p), (iv, o), (v, n), (vi, m)

Paragraph for Question Nos. 230 to - 230

A cube of side a is placed such that the nearest face which is parallel to the $y - z$ plane is at a distance ' a ' from the origin. The electric field components are $E_x = \alpha x^{1/2}, E_y = E_z = 0$





230. The flux ϕ_E through the cube is

- a) $\sqrt{2}\alpha a^{5/2}$ b) $-\alpha a^{5/2}$ c) $(\sqrt{2} - 1)\alpha a^{5/2}$ d) Zero

Paragraph for Question Nos. 231 to - 231

A hollow conducting ball has a single positive charge $+q$ fixed at the centre. The ball has no net charge

231. The charge on the inner of the ball is

- a) $+2q$ b) $+q$ c) $-q$ d) 0

Paragraph for Question Nos. 232 to - 232

Suppose that a net charge $+q$ is placed on the ball in the previous question; the point charge remains at its centre

232. The charge on the inner surface of the ball is

- a) $+2q$ b) $+q$ c) $-q$ d) 0

Paragraph for Question Nos. 233 to - 233

The positive charge at the centre of the ball in problem 13-14 is moved off centre and closer to the inner surface, but it does not touch the inner surface

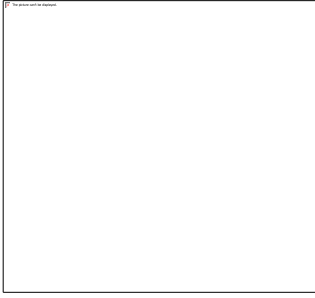
233. The total charge on the inner surface of the ball will

- a) Increase
b) Decrease
c) Remain the same
d) Change, depending on how close the ball gets to the inner surface

Paragraph for Question Nos. 234 to - 234

A small conducting spherical shell with inner radius a and outer radius b is concentric with a larger conducting spherical shell with inner radius c and outer radius d (as shown in fig). The inner shell has total charge $+2q$ and the outer shell has charge $+4q$. Calculate the electric field in terms of q and the distance r from the common centre of the two shells for





234. $r < a$

a) Zero

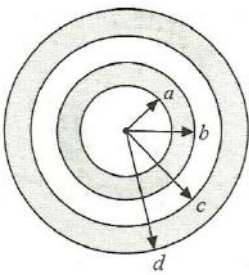
b) $\frac{1}{4\pi\epsilon_0} \frac{2q}{r^2}$

c) $-\frac{1}{4\pi\epsilon_0} \frac{6q}{r^2}$

d) $\frac{1}{4\pi\epsilon_0} \frac{q}{r^2}$

Paragraph for Question Nos. 235 to - 235

A small conducting spherical shell with inner radius a and outer radius b is concentric with a larger conducting spherical shell with inner radius c and outer radius d (as shown in fig). The inner shell has total charge $+2q$ and the outer shell has charge $+4q$. Calculate the electric field in terms of q and the distance r from the common centre of the two shells for



235. Inner surface of the small shell is

a) Zero

b) $2q$

c) $-2q$

d) $6q$

Paragraph for Question Nos. 236 to - 236

Consider the previous problem, let the outer shell have charge $-4q$. As in the above problem, the inner shell has charge $+2q$. Calculate the electric field in terms of q and the distance r from the common centre of the two shells for

236. $r < a$

a) Zero

b) $\frac{1}{4\pi\epsilon_0} \frac{2q}{r^2}$

c) $-\frac{1}{4\pi\epsilon_0} \frac{2q}{r^2}$

d) $\frac{1}{4\pi\epsilon_0} \frac{6q}{r^2}$

Paragraph for Question Nos. 237 to - 237

According to problem what is the total charge on the



237. Inner surface of the small shell?

- a) Zero b) $2q$ c) $-2q$ d) $6q$

Paragraph for Question Nos. 238 to - 238

Consider the above problem, let the outer shell have charge $-2q$. As in the above problem, the inner shell has charge $+2q$. Calculate the electric field in terms of q and the distance r from the common centre of two shells for:

238. $r < a$

- a) Zero b) $\frac{1}{4\pi\epsilon_0} \frac{2q}{r^2}$ c) $-\frac{1}{4\pi\epsilon_0} \frac{2q}{r^2}$ d) $\frac{1}{4\pi\epsilon_0} \frac{6q}{r^2}$

Paragraph for Question Nos. 239 to - 239

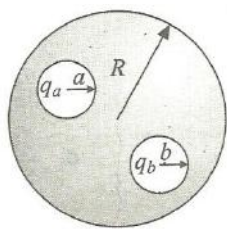
In the previous problem, the total charge on the

239. Inner surface of the small shell is

- a) Zero b) $2q$ c) $-2q$ d) $4q$

Paragraph for Question Nos. 240 to - 240

Two spherical cavities of radii a and b are hollowed out from the interior of a neutral conducting sphere of radius R . At the centre of each cavity, a point charge is placed. Call these charges q_a and q_b



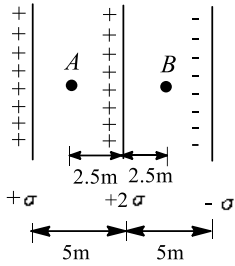
240. Match the table

(i) σ_a	(m) $\frac{q_a + q_b}{4\pi R^2}$
(ii) σ_b	(n) $\frac{-q_a}{4\pi a^2}$
(iii) σ_R	(o) $\frac{-q_b}{4\pi b^2}$

- a) (i, o), (ii, n), (iii, m) b) (i, n), (ii, o), (iii, m) c) (i, m), (ii, o), (iii, n) d) (i, n), (ii, m), (iii, o)

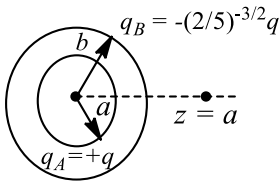
Paragraph for Question Nos. 241 to - 241





Find the ratio of the net electric field at point A to that at point B

247. Two concentric rings, one of radius 'a' and the other of radius 'b', have the charges +q, and $-(2/5)^{-3/2}q$, respectively, as shown in the figure



Find the ratio b/a if a charge particle placed on the axis at $z = a$ is in equilibrium

248. A cube of side $l = 1$ m has one corner at the origin of coordinates and extends along the positive x, y and z -axes. Suppose the electric field in this region is given by $\vec{E} = (2 + 3y)\hat{j}$. The charge inside the cube is $W\epsilon_0$. Find W
249. There is an electric field E in $+x$ direction. If work done by electric field in moving a charge 0.2 C through a distance of 2 m along a line making an angle of 60 degree with x -axis is 1.0J, what is the value of E in N/C?
250. A solid sphere of radius R has a charge Q distributed in its volume with a charge density $\rho = kr^a$, where k and a are constants and r is the distance from its centre. If the electric field at $r = R/2$ is $1/8$ times that at $r = R$, find the value of a
251. Two particles of masses m and $2m$ having same charges q each are placed in a uniform electric field E and allowed to move for the same time. Find the ratio of their kinetic energies
252. An electric field is given by $\vec{E} = (y\hat{i} + x\hat{j})N/C$. Find the work done (in J) by electric field in moving a 1C charge from $\vec{r}_A = (2\hat{i} + 2\hat{j})m$ to $\vec{r}_B = (4\hat{i} + \hat{j})m$



1. ELECTRIC CHARGES AND FIELDS

: ANSWER KEY :

1) c	2) a	3) c	4) a	141) a	142) c	143) d	1) c
5) c	6) c	7) a	8) c	a,c,d	2) a,c	3) c,d	4) c
9) a	10) b	11) d	12) a	a,b			
13) d	14) a	15) d	16) c	5) b,d	6) a,d	7) a,d	8) c
17) d	18) d	19) a	20) a	a,d			
21) a	22) d	23) c	24) a	9) a,b,c,d	10) c,d	11) a,b	12) c
25) b	26) d	27) b	28) c	b,d			
29) d	30) b	31) b	32) b	13) a,b,c	14) c,d	15) b,d	16) c
33) c	34) b	35) d	36) a	b,c			
37) c	38) a	39) b	40) c	17) b,c	18) a,d	19) a,b,c,d	20) c
41) d	42) d	43) a	44) d	a,c			
45) c	46) c	47) c	48) d	21) a,c	22) a,b,c	23) b,c	1) a
49) a	50) d	51) b	52) a	2) a	3) c	4) c	2) c
53) d	54) a	55) d	56) b	5) e	6) d	7) c	8) b
57) b	58) a	59) a	60) c	9) b	10) a	11) a	12) c
61) d	62) b	63) b	64) b	13) a	14) a	15) e	16) d
65) c	66) b	67) a	68) b	17) d	18) d	19) a	20) a
69) b	70) a	71) b	72) b	21) e	22) d	23) d	24) b
73) d	74) a	75) b	76) c	25) d	26) a	27) d	28) b
77) b	78) d	79) b	80) b	29) c	30) d	31) d	32) d
81) c	82) d	83) c	84) b	33) b	34) b	35) a	36) b
85) c	86) a	87) a	88) c	37) b	38) d	39) a	40) b
89) a	90) c	91) d	92) c	41) a	42) a	43) a	1) b
93) a	94) a	95) d	96) a	2) d	3) a	4) a	2) c
97) c	98) d	99) a	100) c	5) b	6) a	7) a	8) c
101) a	102) a	103) c	104) c	1) c	2) b	3) d	4) c
105) a	106) a	107) a	108) c	5) a	6) b	7) c	8) c
109) a	110) c	111) b	112) c	9) a	10) c	11) b	12) a
113) b	114) c	115) c	116) d	13) c	14) c	15) c	16) c
117) a	118) b	119) c	120) d	17) a	18) a	19) a	20) a
121) c	122) c	123) a	124) c	21) a	22) a	23) b	24) a
125) b	126) a	127) c	128) d	1) 1	2) 3	3) 1	4) 6
129) a	130) d	131) c	132) b	5) 0	6) 2	7) 3	8) 5
133) d	134) c	135) d	136) c	9) 2	10) 2	11) 0	
137) b	138) a	139) a	140) a				



1. ELECTRIC CHARGES AND FIELDS

: HINTS AND SOLUTIONS :

- 1 (c)
1 2 3 4 5
+ - +

If 1 is positively charged, then 2 should be negatively charged, then 4 should be positively charged. Now, 1 and 4 cannot attract. It means ball 1 should be neutral (2 and 4 cannot be neutral because they are showing repulsion with 3 and 5, respectively)

- 2 (a)
Newton's third law

- 3 (c)
At any point over the spherical Gaussian surface, net electric field is the vector sum of electric fields due to $+q_1$, $-q_1$ and q_2 . Don't confuse with the electric flux which is zero (net) passing over the Gaussian surface as the net charge enclosing the surface is zero.

- 4 (a)
Torque about Q of charge $-q$ is zero, so angular momentum charge $-q$ is constant, but distance between charges is changing, so force is changing, so speed and velocity are changing

- 5 (c)
The magnitude of electric field in the annular region of a charged cylindrical capacitor is given by $E = \frac{1}{2\pi\epsilon_0 r} \lambda$ where λ is the charge per unit length and r is the distance from the axis of the cylinder. Thus $E \propto \frac{1}{r}$

- 6 (c)
 $\vec{E} = 2000\hat{k}$, $\vec{A} = 10 \times 20 \times 10^{-4}\hat{k}$
 $\phi = \vec{E} \cdot \vec{A} = 40 \text{ Vm}$

- 7 (a)
 $q_1 = 2CV$, $q_2 = CV$
Now condenser of capacity C is filled with dielectric K , therefore $C_2 = KC$

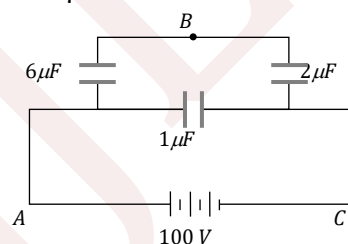
As charge is conserved

$$\begin{aligned} \therefore q_1 + q_2 &= (C'_2 + 2C)V' \Rightarrow V' = \frac{3CV}{(K+2)C} \\ &= \frac{3V}{K+2} \end{aligned}$$

- 8 (c)
 $C_{eq} = \frac{(3+3) \times (1+1)}{(3+3) + (1+1)} + 1 = \left(\frac{6 \times 2}{6+2}\right) + 1$
 $= \frac{5}{2} \mu F$

$$\therefore Q = C \times V = \frac{5}{2} \times 100 = 250 \mu C$$

Charge in $6\mu F$ branch = $VC = \left(\frac{6 \times 2}{6+2}\right) 100 = 150 \mu C$



$$V_{AB} = \frac{150}{6} = 25V \text{ and } V_{BC} = 100 - V_{AB} = 75V$$

- 9 (a)
Total enclosed charge as already shown in

$$\begin{aligned} q_{net} &= \frac{6C}{2} + \frac{8C}{4} - 7C \\ &= -2C \end{aligned}$$

From Gauss-theorem, net flux,

$$\Phi_{net} = \frac{q_{net}}{\epsilon_0} = \frac{-2C}{\epsilon_0}$$

- 10 (b)
 $\vec{E} = 8\hat{i} + 4\hat{j} + 3\hat{k}$, $\vec{A} = 100\hat{k}$

- 11 (d)
Frequency or time period of SHM depends on variable forces. It does not depend on constant external force. Constant external force can only change the mean position. For example, in the given question mean position is at natural length



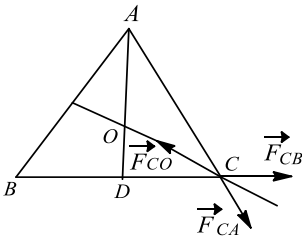
of spring in the absence of electric field. Whereas in the presence of electric field mean position will be obtained after a compression of x_0 . Where x_0 is given by

$$kx_0 = QE$$

$$x_0 = \frac{QE}{k}$$

12 (a)

To keep the system in equilibrium, net force experienced by charges at 'A', 'B' and 'C' should be zero. For this, another charge of opposite sign should be placed at the centroid of the triangle. Let this charge be '-Q'



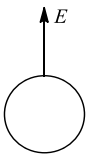
$$AD = l \cos 30^\circ = \frac{l\sqrt{3}}{2}, AO = \frac{2}{3}AD = \frac{l}{\sqrt{3}}$$

$$2 = |\vec{F}_{CA}| \cos 30^\circ = |\vec{F}_{CO}|$$

$$2 \times \frac{1}{4\pi\epsilon_0} \times \frac{q^2}{l^2} \times \frac{\sqrt{3}}{2} = \frac{1}{4\pi\epsilon_0} \frac{Qq}{(l/\sqrt{3})^2} \Rightarrow Q = -\frac{q}{\sqrt{3}}$$

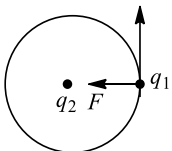
13 (d)

Electric field at any point near the surface of an arbitrary conductor is $E = \sigma/\epsilon_0$, where σ is the surface charge density at that point



14 (a)

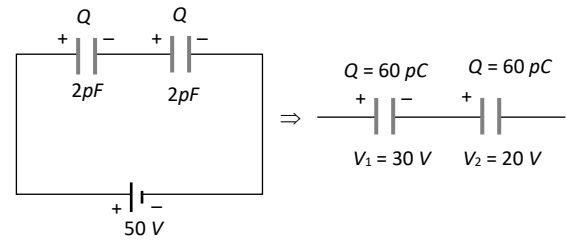
Work done is zero, because force applied by q_2 on q_1 is always perpendicular to the velocity of q_1



15 (d)

Charges on capacitors are $Q_1 = 30 \times 2 = 60\mu C$ and $Q_2 = 20 \times 3 = 60\mu C$ or $Q_1 = Q_2 = Q$ (say)

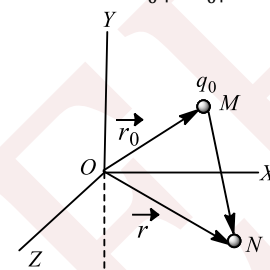
The situation is similar as the two capacitors in series are first charged with a battery of emf 50 V and then disconnected



\therefore when S_3 is closed $V_1 = 30V$ and $V_2 = 20V$

16 (c)

$$\text{As } \vec{E} = \frac{1}{4\pi\epsilon_0} \frac{q}{|\vec{r} - \vec{r}_0|^3} (\vec{r} - \vec{r}_0)$$



$$\vec{MN} = \vec{r} - \vec{r}_0 = (8\hat{i} - 5\hat{j}) - (2\hat{i} + 3\hat{j}) = (6\hat{i} - 8\hat{j})$$

$$|\vec{r} - \vec{r}_0| = \sqrt{6^2 + 8^2} = 10 \text{ m}$$

$$\vec{E} = 9 \times 10^9 \times \frac{50 \times 10^{-6}}{(10)^3} (6\hat{i} - 8\hat{j}) = (2.7\hat{i} - 3.6\hat{j}) \text{ kNC}^{-1}$$

17 (d)

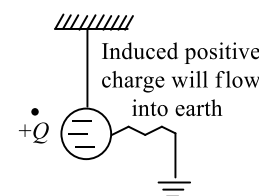
We can compare this situation with that of a mass moving as a projectile

18 (d)

Dielectric constant of a material is $K \geq 1$

19 (a)

Due to induced negative charge, there will be attraction



20 (a)

There will be gravitational attraction between the neutrons

21 (a)

Time constant $\tau = RC$



$$C = \frac{C_1 C_2}{C_1 + C_2} = \frac{\left(\frac{A\epsilon_0}{d-x}\right) \left(\frac{KA\epsilon_0}{x}\right)}{\frac{A\epsilon_0}{d-x} + \frac{KA\epsilon_0}{x}}$$

$$C = \frac{KA\epsilon_0}{x + K(d-x)} \Rightarrow x = \frac{d}{3} - Vt$$

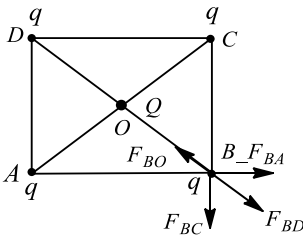
$$\tau = \frac{RKA\epsilon_0}{\frac{d}{3} - Vt + K\left(d - \frac{d}{3} + Vt\right)}$$

$$A = 1, K = 2, \tau = \frac{3 \times 2R\epsilon_0}{d - 3Vt + 6d - 2d + 6Vt} = \frac{6R\epsilon_0}{5d + 3Vt}$$

22 (d)

$$AC = \sqrt{2}l = BD$$

$$\Rightarrow BO = \frac{1}{\sqrt{2}}$$

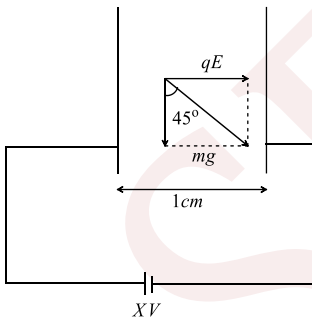


$$F_{BO} = F_{BD} + (F_{BA} + F_{BC}) \cos 45^\circ$$

Solving, we get

$$Q = \frac{q}{4}(1 + 2\sqrt{2}), Q \text{ should be negative of } q$$

23 (c)



$$mg = qE$$

$$1.67 \times 10^{-27} \times 10 = 1.6 \times 10^{-19} \times \frac{X}{0.01}$$

$$X = \frac{1.67}{1.6} \times 10^{-9} V \Rightarrow X = 1 \times 10^{-9} V$$

24 (a)

$$\phi = E = \text{NC}^{-1}\text{m}^2$$

25 (b)

When spheres are touched and separated, charge is

$$q' = \frac{4q - 2q}{2} = \frac{2q}{2} = q$$

From Coulomb's law

$$F = \frac{1}{4\pi\epsilon_0} \frac{(4q)(-2q)}{r} \quad \dots (i)$$

When made to touch

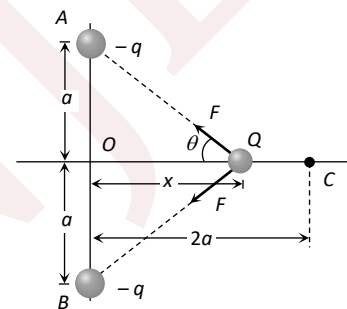
$$F' = \frac{1}{4\pi\epsilon_0} \frac{q^2}{r} \quad \dots (ii)$$

From Eqs. (i) and (ii), we get

$$F' = \frac{F}{8}$$

26 (d)

By symmetry of problem the components of force on Q due to charges at A and B along y -axis will cancel each other while along x -axis will add up and will be along CO . Under the action of this force charge Q will move towards O . If at any time charge Q is at a distance x from O . Net force on charge Q



$$F_{net} \Rightarrow 2F \cos \theta$$

$$= 2 \frac{1}{4\pi\epsilon_0} \frac{-qQ}{(a^2 + x^2)} \times \frac{x}{(a^2 + x^2)^{1/2}}$$

$$i.e., F_{net} = -\frac{1}{4\pi\epsilon_0} \cdot \frac{2qQx}{(a^2 + x^2)^{3/2}}$$

As the restoring force F_{net} is not linear, motion will be oscillatory (with amplitude $2a$) but not simple harmonic

27 (b)

$$E = \frac{F}{q} = \frac{MLT^{-2}}{AT} = MLA^{-1}T^{-3}$$

28 (c)

Charge will move along the circular line of force because $x^2 + y^2 = 1$ is the equation of circle in xy -plane

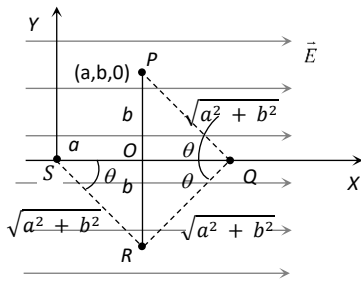
29 (d)

Inside a hollow conductor, electric field is zero. At surface, it is maximum and then decreases



30 (b)

As electric field is a conservative field

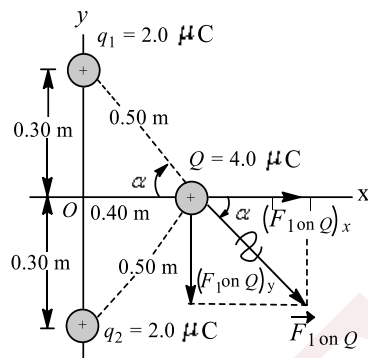


Hence the work done does not depend on path

$$\begin{aligned} \therefore W_{PQRS} &= W_{POS} = W_{PO} + W_{OS} \\ &= Fb \cos 90^\circ + Fa \cos 180^\circ = 0 + qEa(-1) \\ &= -qEa \end{aligned}$$

31 (b)

$$\begin{aligned} F_{\text{net}} &= 2|F_{31}| \cos \alpha \\ &= 2 \times \frac{1}{4\pi\epsilon_0} \times \frac{2 \times 4 \times 10^{-12}}{(0.5)^2} \times \frac{4}{5} = 0.46 \text{ N} \end{aligned}$$



32 (b)

Inside the cavity, field at any point is uniform and non-zero.

33 (c)

$$\begin{aligned} \text{Total charge} &= (2C)(2V) + (C)(-V) = 3CV \\ \therefore \text{Common potential} &= \frac{3CV}{3C} = V \\ \therefore \text{Energy} &= \frac{1}{2}(3C)(V)^2 = \frac{3}{2}CV^2 \end{aligned}$$

34 (b)

Due to induction net charges on outer surfaces of spheres are as shown

$$\begin{aligned} \sigma &= \frac{Q_1}{4\pi R^2} = \frac{Q_1 + Q_2}{4\pi(2R)^2} = \frac{Q_1 + Q_2 + Q_3}{4\pi(3R)^2} \\ \Rightarrow Q_1 &= \frac{Q_1 + Q_2}{4} = \frac{Q_1 + Q_2 + Q_3}{9} \\ \Rightarrow Q_2 &= 3Q_1 \text{ and } Q_3 = 5Q_1 \\ \therefore Q_1 : Q_2 : Q_3 &= 1 : 3 : 5 \end{aligned}$$

35 (d)

The equilibrium can be stable only if on displacing the small charge slightly in any direction, the forces act on it in such a way so as to bring back the charge to its equilibrium position

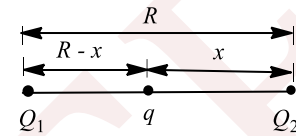
36 (a)

Half disk (charge $3C$), and fourth part of rod (charge $2C$) and charge of $-7C$ are inside the cubical surface, so net charge inside the surface = $3 + 2 - 7 = -2C$

$$\therefore \text{Flux through the surface } \phi = \frac{1}{\epsilon_0}(Q) = \frac{-2C}{\epsilon_0}$$

37 (c)

Force on Q_2 is zero (q should be -ve)



$$\Rightarrow \frac{kQ_1Q_2}{R^2} = \frac{kqQ_2}{x^2} \Rightarrow \frac{x}{R} = \sqrt{\frac{q}{Q_1}}$$

$$\text{Force on } q \text{ is Zero: } \frac{kQ_1q}{(R-x)^2} = \frac{kqQ_2}{x^2}$$

$$\Rightarrow \frac{R-x}{x} = \frac{\sqrt{Q_1}}{\sqrt{Q_2}}$$

$$\Rightarrow \frac{R}{x} = \frac{\sqrt{Q_1} + \sqrt{Q_2}}{\sqrt{Q_2}} \Rightarrow \frac{\sqrt{Q_1}}{\sqrt{q}} = \frac{\sqrt{Q_1} + \sqrt{Q_2}}{\sqrt{Q_2}}$$

$$\Rightarrow q = \frac{Q_1Q_2}{(\sqrt{Q_1} + \sqrt{Q_2})^2}$$

38 (a)

As charge on both particles is same, so electric force acting on them will be same. Since the particles are allowed to move for the same time, their final momentum will be same. Because Change in momentum = impulse = force \times time

$$\text{So, from KE} = \frac{p^2}{2m}, \text{ we have } \text{KE} \propto \frac{1}{m}$$

$$\frac{\text{KE}_1}{\text{KE}_2} = \frac{m_2}{m_1} = 2:1$$

39 (b)

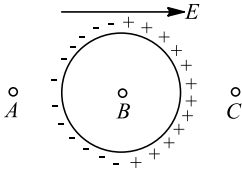
$$\text{For electron } s = \frac{eE}{m_e} \times t_1^2, \text{ For proton } s = \frac{eE}{m_p} \times t_2^2$$

$$\therefore \frac{t_2^2}{t_1^2} = \frac{m_p}{m_e} \Rightarrow \frac{t_2}{t_1} = \sqrt{\frac{m_p}{m_e}} = \left(\frac{m_p}{m_e}\right)^{1/2}$$

40 (c)

The dielectric gets polarized as shown. Induced charges will also contribute in electric field



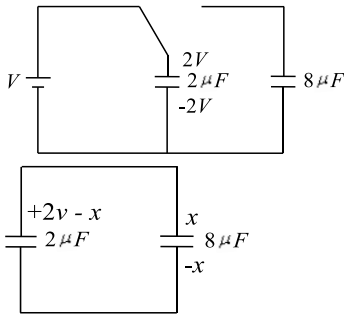


So, intensity at points A and C will increase and at B intensity will decrease

41 (d)

$$k = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9, \epsilon_0 = \frac{1}{4\pi \times 9 \times 10^9} \text{C}^2\text{N}^{-1}\text{m}^{-2}$$

42 (d)



$$U_i = \frac{1}{2}(2)V^2, V_{\text{common}} = \frac{V}{5}$$

$$U_f = \frac{1}{2}(2+8)\left(\frac{V}{5}\right)^2$$

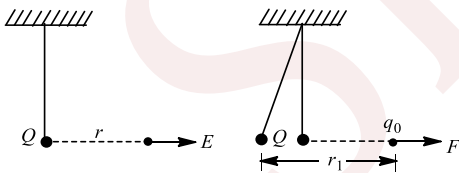
$$\frac{U_i - U_f}{U_i} \times 100$$

$$= \frac{V^2 - \frac{V^2}{5}}{V^2} \times 100$$

$$\frac{4}{5} \times 100 = 80\%$$

43 (a)

$$E = \frac{kQ}{r^2} \text{ (i)}$$



$$F = \frac{kQq_0}{r_1^2} \Rightarrow \frac{F}{q_0} = \frac{kQ}{r_1^2} \text{ (ii)}$$

As $r_1 > r$, so from Eqs (i) and (ii), we get $E > F/q_0$

44 (d)

$$\frac{q}{6\epsilon_0} = \frac{0.1 \times 10^{-6}}{6 \times 8.85 \times 10^{-12}} = 1883$$

45 (c)

Electric field at any point on Gaussian surface is due to all charges present inside or outside the surface

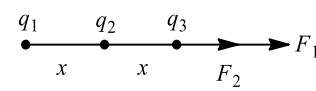
46 (c)

$$q_3 = \frac{C_3}{C_2 + C_3} \cdot Q$$

$$q_3 = \frac{3}{3+2} \times 80 = \frac{3}{5} \times 80 = 48 \mu\text{C}$$

47 (c)

Net force on q_3 : $F_1 + F_2 = 0$



$$\Rightarrow \frac{kq_1q_3}{(2x)^2} + \frac{kq_2q_3}{x^2} = 0 \Rightarrow q_1 = -4q_2$$

48 (d)

$$\tau_1 = RC \left(\frac{1 \times 2}{1+2} \right) \times \left(\frac{2 \times 4}{2+4} \right) = \frac{2}{3} \times \frac{8}{6} = 8/9 \mu\text{s}$$

$$\tau_2 = RC = (1+2)(2+4) = 3 \times 6 = 18 \mu\text{s}$$

$$\tau_3 = \left(\frac{1 \times 2}{1+2} \right) (2+4) = \frac{2}{3} \times 6 = 4 \mu\text{s}$$

49 (a)

Inside a conductor, electric field is zero. Because applied field is cancelled by field produced due to induced charges

50 (d)

$12\mu\text{F}$ and $6\mu\text{F}$ are in series and again are in parallel with $4\mu\text{F}$.

Therefore, resultant of these three will be

$$= \frac{12 \times 6}{12+6} + 4 = 4 + 4 = 8\mu\text{F}$$

This equivalent system is in series with $1\mu\text{F}$

Its equivalent capacitance = $\frac{8 \times 1}{8+1} = \frac{8}{9}\mu\text{F}$... (i)

Equivalent of $8\mu\text{F}$, $2\mu\text{F}$ and $2\mu\text{F}$

$$= \frac{4 \times 8}{4+8} = \frac{32}{12} = \frac{8}{3}\mu\text{F} \text{ ... (ii)}$$

(i) and (ii) are in parallel and are in series with C

$$\therefore \frac{8}{9} + \frac{8}{3} = \frac{32}{9} \text{ and } C_{eq} = 1 = \frac{\frac{32}{9} \times C}{\frac{32}{9} + C} \Rightarrow C = \frac{32}{23}\mu\text{F}$$

51 (b)

All the three plates will produce electric field at P along negative z-axis. Hence,

$$E_p = \left[\frac{\sigma}{2\epsilon_0} + \frac{2\sigma}{2\epsilon_0} + \frac{\sigma}{2\epsilon_0} \right] (-\hat{k})$$

$$= -\frac{2\sigma}{\epsilon_0} \hat{k}$$

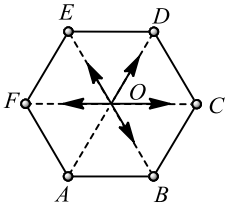
52 (a)



At any point on the curved surface, E and area vector are perpendicular to each other

53 (d)

If there had been a sixth charge $+q$ at the remaining vertex of hexagon, force due to all the six charges on $-q$ at O will be zero



Now if f is the force due to the sixth charge and F due to the remaining five charges, then

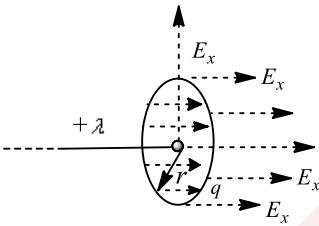
$$\vec{F} + \vec{f} = 0, \text{ i.e., } \vec{F} = -\vec{f}$$

$$|\vec{F}| = |\vec{f}| = \frac{1}{4\pi\epsilon_0} \frac{q \times q}{L^2} = \frac{1}{4\pi\epsilon_0} \left(\frac{q}{L}\right)^2$$

54 (a)

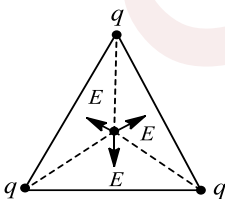
Net force $F_{\text{net}} = qE_x$

$$F = q \frac{\lambda}{4\pi\epsilon_0} = \frac{\lambda q}{4\pi\epsilon_0 r}$$



55 (d)

Each charge will produce the same magnitude of intensity, say E , at the centroid. These are directed at angles of 120° with each other. So, their vector sum will be zero



56 (b)

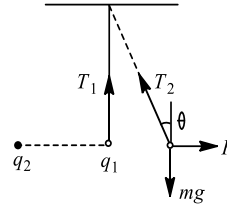
$$\phi = \frac{q_{\text{in}}}{\epsilon_0} \Rightarrow 0 = \frac{q_{\text{in}}}{\epsilon_0} \Rightarrow q_{\text{in}} = 0$$

57 (b)

Initial tension: $T_1 = mg$

Final tension: $T_2 \cos \theta = mg$

$$\Rightarrow T_2 = \frac{mg}{\cos \theta}$$



Obviously, $T_2 > mg$

Here we have assumed θ to be small so that F is almost horizontal

58 (a)

$\int_{-\infty}^0 -\vec{E} \cdot d\vec{l} = \text{potential at centre of non-conducting ring}$

$$= \frac{1}{4\pi\epsilon_0} \times \frac{q}{r} = \frac{9 \times 10^9 \times 1.11 \times 10^{-10}}{0.5} = 2 \text{ volt}$$

59 (a)

To find the charge enclosed, we need the flux through the parallelepiped:

$$\begin{aligned} \Phi_1 &= AE_1 \cos 60^\circ \\ &= (0.0500 \text{ m})(0.0600 \text{ m})(2.50 \\ &\quad \times 10^4 \text{ NC}^{-1}) \cos 60^\circ \\ &= 37.5 \text{ Nm}^2\text{C}^{-1} \end{aligned}$$

$$\begin{aligned} \Phi_2 &= AE_2 \cos 120^\circ \\ &= (0.0500 \text{ m})(0.0600 \text{ m})(7.00 \\ &\quad \times 10^4 \text{ NC}^{-1}) \cos 120^\circ \\ &= -105 \text{ Nm}^2\text{C}^{-1} \end{aligned}$$

So, the total flux is

$$\begin{aligned} \Phi &= \Phi_1 + \Phi_2 = (37.5 - 105) \text{ Nm}^2\text{C}^{-1} \\ &= -67.5 \text{ Nm}^2\text{C}^{-1} \end{aligned}$$

$$q = \Phi \epsilon_0 = (-67.5 \text{ Nm}^2/\text{C}) \epsilon_0 = -5.97 \times 10^{-10} \text{ C}$$

There must be a net charge (negative) in the parallelepiped since there is a net flux flowing into the surface. Also, there must be an external field, otherwise all lines would point towards the slab

60 (c)

$$1 - 7 - 4 + 10 + 2 - 5 - 3 + 6 = 0$$

Sum of all the charges is zero, so net flux is zero

61 (d)

The electric field is always perpendicular to the surface of a conductor and field lines never cross the conducting surface

62 (b)

Dielectric strength means the maximum electric field which a medium can bear. Here, if field becomes more than this, then the charge will start leaking from the metal ball. so,



$$E = \frac{kQ}{R^2} \Rightarrow Q = \frac{ER^2}{k} = \frac{3 \times 10^6 \times (0.001)^2}{9 \times 10^9} = 1/3 \text{ nC}$$

63 (b)

We should know the total charge inside. There is a no contribution in the flux due to outside charges. Also, we should know both magnitude and direction of electric field at any point on the surface

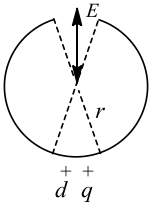
64 (b)

Charge on the element opposite to the gap is

$$dq = \frac{Q}{2\pi r} (0.002\pi)$$

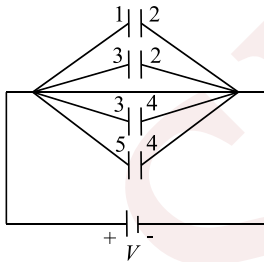
$$= \frac{1}{2\pi(0.5)} \times \frac{2\pi}{1000} = 2 \times 10^{-3} \text{ C}$$

$$E = \frac{9 \times 10^9 \times 2 \times 10^{-3}}{(0.5)^2} = 7.2 \times 10^7 \text{ NC}^{-1}$$



65 (c)

The given circuit can be redrawn as follows. All capacitors are identical and each having capacitance $C = \frac{\epsilon_0 A}{d}$



|Charge on each capacitor| = |Charge on each plate|

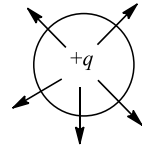
$$= \frac{\epsilon_0 A}{d} V$$

Plate 1 is connected with positive terminal of battery so charge on plate 4 will be $+\frac{\epsilon_0 A}{d} \cdot V$

Plate 4 comes twice and it is connected with negative terminal of battery, so charge on plate 4 will be $-\frac{2\epsilon_0 A}{d} V$

67 (a)

Outgoing flux is taken as +ve



Positive flux

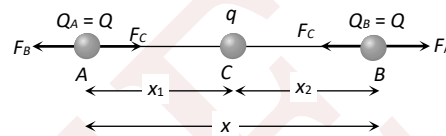
68

(b)

Suppose in the following figure, equilibrium of charge B is considered. Hence for it's equilibrium

$$|F_A| = |F_C|$$

$$\Rightarrow \frac{1}{4\pi\epsilon_0} \frac{Q^2}{4x^2} = \frac{1}{4\pi\epsilon_0} \frac{qQ}{x^2} \Rightarrow q = \frac{-Q}{4}$$



Short trick : For such type of problem the magnitude of middle charge can be determined if either of the extreme charge is in equilibrium by using the following formula

If charge A is in equilibrium then $q = -Q_B \left(\frac{x_1}{x}\right)^2$

If charge B is in equilibrium then $q = -Q_A \left(\frac{x_2}{x}\right)^2$

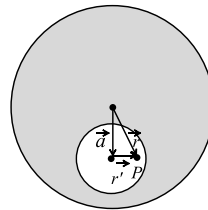
If the whole system is in equilibrium then use either of the above formula

69

(b)

a = distance between centre of both spheres

By principle of superposition the net electric field at point P



$$\vec{E} = \frac{\rho \vec{r}}{3\epsilon_0} - \frac{\rho \vec{r}''}{3\epsilon_0}$$

$$\therefore \vec{r} - \vec{r}'' = \vec{a}$$

$$\therefore \vec{E} = \frac{\rho \vec{a}}{3\epsilon_0} = \text{uniform}$$

70

(a)

From Gauss' theorem,

$$E \propto \frac{q}{r^2} \quad (q = \text{charge enclosed})$$



$$\frac{E_2}{E_1} = \frac{q_2}{q_1} = \frac{r_1^2}{r_2^2}$$

$$8 = \frac{\int_0^R (4\pi r^2) kr^a dr}{\int_0^{R/2} (4\pi r^2) kr^a dr} \times \frac{\left(\frac{R}{2}\right)^2}{(R)^2}$$

Solving this equation we get, $a = 2$

71 (b)

Given $Q_1 + Q_2 = 10$

And $\frac{kQ_1Q_2}{r^2} = -0.075$

$$\Rightarrow \frac{9 \times 10^9 Q_1 Q_2 \times 10^{-12}}{(3)^2} = -0.075 \quad (i)$$

(Here, we have multiplied by 10^{-12} because we have considered Q_1 and Q_2 to be in μC)

$$\Rightarrow Q_1 Q_2 = -75 \quad (ii)$$

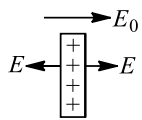
Solving Eqs. (i) and (ii), we get $Q_1 = 15 \mu\text{C}$, $Q_2 = -5 \mu\text{C}$

72 (b)

From the figure, it is clear that the plate is placed in an external electric field. Let the electric field due to plate be E , and E_0 is the external electric field

$$\therefore E_0 + E = 12 \text{ Vm}^{-1}$$

$$E_0 - E = 8 \text{ Vm}^{-1}$$



Solving equations, $E = 2 \text{ Vm}^{-1}$ and $E_0 = 10 \text{ Vm}^{-1}$

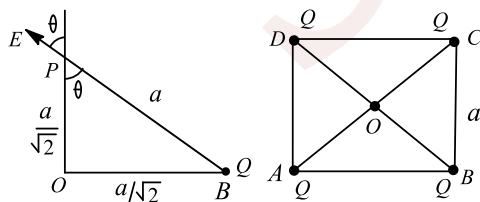
Now, electric field due to plate $= \frac{\sigma}{2\epsilon_0} = 2$

$$\therefore \sigma = 4\epsilon_0$$

74 (a)

Because net charge enclosed by the surface is zero

75 (b)



$$E_{\text{net}} = 4E \cos \theta = \frac{4}{4\pi\epsilon_0} \frac{Q}{a^2} \frac{1}{\sqrt{2}} = \frac{Q}{\sqrt{2}\pi\epsilon_0 a^2}$$

77 (b)

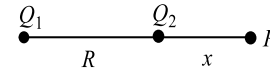
Force on the block: $F = qE$ towards left

Let spring be compressed maximum by x . Then

$$Fx = \frac{1}{2} kx^2 \Rightarrow qEx = \frac{1}{2} kx^2 \Rightarrow x = \frac{2qE}{k}$$

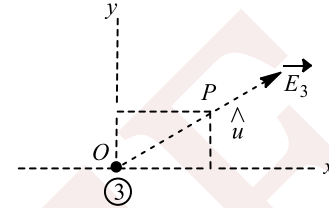
78 (d)

$$\frac{kQ_2}{x^2} = \frac{kQ_1}{(x+R)^2} \Rightarrow x = \frac{R}{2}$$



79 (b)

Let us consider the electric field due to wire (3) only



$$\begin{aligned} \vec{E}_3 &= E\hat{u} \\ &= \frac{\lambda}{2\pi\epsilon_0(a^2 + a^2)^{1/2}} (\hat{i} \cos 45^\circ + \hat{j} \cos 45^\circ) \\ &= \frac{\lambda}{2\sqrt{2}\pi\epsilon_0 a \sqrt{2}} (\hat{i} + \hat{j}) \\ &= \frac{\lambda}{4\pi\epsilon_0 a} (\hat{i} + \hat{j}) \end{aligned}$$

Similarly, electric field due to wires (1) and (2)

$$\vec{E}_1 = \frac{\lambda}{4\pi\epsilon_0 a} (\hat{j} + \hat{k}) \text{ and } \vec{E}_2 = \frac{\lambda}{4\pi\epsilon_0 a} (\hat{i} + \hat{k})$$

$$\vec{E}_{\text{net}} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 = \frac{\lambda}{2\pi\epsilon_0 a} (\hat{i} + \hat{j} + \hat{k})$$

80 (b)

$$E = \frac{kQR}{R^3} = \frac{1}{4\pi\epsilon_0} \frac{(4/3)\pi R^3 \rho r}{R^3} = \frac{\rho r}{3\epsilon_0}$$

81 (c)

Electric flux, $\phi = \mathbf{E} \cdot \mathbf{S}$

$$\text{Or } \phi = ES \cos \theta$$

Here, θ is the angle between \mathbf{E} and \mathbf{S} . In this question $\theta = 45^\circ$, because \mathbf{S} is perpendicular to surface.

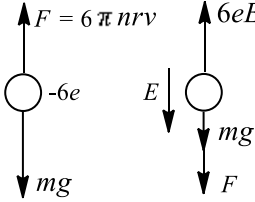
$$E = E_0$$

$$S = (\sqrt{2}a)(a) = \sqrt{2}a^2$$

$$\therefore \phi = (E_0)(\sqrt{2}a^2) \cos 45^\circ = E_0 a^2$$

\therefore Correct option is (C).



- 82 (d)
At any point inside the conductor, net electric field is zero
- 83 (c)
For the first case: $F = mg$
For the second case: $F + mg = 6eE \Rightarrow 2mg = 6eE$
- 
- $\Rightarrow E = \frac{mg}{3e} = \frac{1.6 \times 10^{-15} \times 10}{3 \times 1.6 \times 10^{-19}} = 3.3 \times 10^4 \text{NC}^{-1}$
- 84 (b)
A and B have like charges, and B and C have like charges. So, A and C also have like charges. Hence, they also repel each other
- 85 (c)
The following two arguments shall lead us to the right choice
i. Electric field at the centre of the ring is zero
ii. Electric field is directed away from the ring
- 86 (a)
Inside a uniformly charged solid sphere: $E \propto r$
- 87 (a)
The electric potential $V(x, y, z) = 4x^2 \text{ volt}$
Now $\vec{E} = -\left(\hat{i} \frac{\partial V}{\partial x} + \hat{j} \frac{\partial V}{\partial y} + \hat{k} \frac{\partial V}{\partial z}\right)$
Now $\frac{\partial V}{\partial x} = 8x$, $\frac{\partial V}{\partial y} = 0$ and $\frac{\partial V}{\partial z} = 0$
Hence $\vec{E} = -8x\hat{i}$, so at point $(1m, 0, 2m)$
 $E = -8\hat{i} \text{ volt/metre}$ or 8 along negative X-axis
- 88 (c)
Electric field is zero everywhere inside a metal (conductor) i.e., field lines do not enter a metal plus these are perpendicular to a metal surface (equipotential surface).
- 89 (a)
Charge inside $S_1 = q_1 + q_2 = 3 \times 10^{-6} \text{C}$
Charge inside $S_2 = q_2 + q_3 = -1 \times 10^{-6} \text{C}$
Charge inside $S_3 = 0$
Charge inside S_1 is greatest. So, flux through S_1 is maximum
- 90 (c)

Plane conducting surfaces facing each other must have equal and opposite charge densities. Here as the plate areas are equal, $Q_2 = -Q_3$.

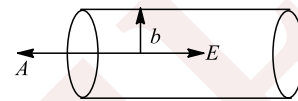
The charge on a capacitor means the charge on the inner surface of the positive plate [Here it is Q_2]

Potential difference between the plates

$$= \frac{\text{charge}}{\text{capacitance}} = \frac{Q_2}{C} = \frac{2Q_2}{2C}$$

$$= \frac{Q_2 - (-Q_2)}{2C} = \frac{Q_2 - Q_3}{2C}$$

- 91 (d)
 $\phi = EA \cos \theta = E\pi b^2 \cos 180^\circ = -200\pi b^2$



- 92 (c)
Electric field is zero inside the shell due to the outside charges
- 94 (a)
There will be an electric field between two cylinders (using Gauss theorem). This electric field will produce a potential difference.
- 95 (d)
Charge will be induced in the conducting sphere, but net charge on it will be zero
- 96 (a)
 $F = \frac{1}{4\pi\epsilon_0} \frac{q(Q-q)}{r^2}$
For the force to be maximum:
 $\frac{dF}{dq} = \frac{1}{4\pi\epsilon_0 r^2} \frac{d}{dq} [Qq - q^2] = 0 \Rightarrow q = \frac{Q}{2}$
And $\frac{d^2F}{dq^2}$ is negative at $q = \frac{Q}{2}$
Hence, force will be maximum if $q = Q/2$
- 97 (c)
 $A \equiv (-a, 0, 0) B \equiv (0, a, 0)$

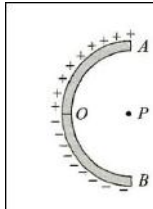
Point charge is moved from A to B



Charge flowing through the switch = increase in charge on the system consisting of right plate of $3\mu F$ and left plate of $6\mu F = (-9 + 36) = 27\mu C$

105 (a)

Take PO as the x -axis and PA as the y -axis. Consider two elements EF and $E'F'$ of width $d\theta$ at angular distance θ above and below PO , respectively



The magnitude of the field at P due to either element is

$$dE = \frac{1}{4\pi\epsilon_0} \frac{rd\theta \times Q/(\pi r/2)}{r^2} = \frac{Q}{2\pi^2\epsilon_0 r^2} d\theta$$

Resolving the fields, find that the components along PO sum up to zero and hence, the resultant field is along PB

Therefore, field at P due to pair of elements = $2dE \sin \theta$

$$E = \int_0^{\pi/2} 2dE \sin \theta$$

$$= 2 \int_0^{\pi/2} \frac{Q}{2\pi\epsilon_0 r^2} \sin \theta d\theta = \frac{Q}{\pi^2\epsilon_0 r^2}$$

106 (a)

Electrical force per unit area

$$= \frac{1}{2} \epsilon_0 E^2$$

$$= \frac{1}{2} \epsilon_0 \left(\frac{\sigma}{\epsilon_0}\right)^2 = \frac{\sigma^2}{2\epsilon_0}$$

Projected area = πR^2

\therefore Net electrical force

$$= \left(\frac{\sigma^2}{2\epsilon_0}\right) (\pi R^2)$$

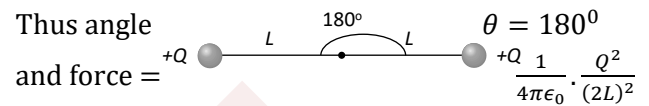
In equilibrium, this force should be equal to the applied force.

$$\therefore F = \frac{\pi\sigma^2 R^2}{2\epsilon_0}$$

$$\text{Or } F \propto \frac{\sigma^2 R^2}{\epsilon_0}$$

107 (a)

The position of the balls in the satellite will become as shown below because it is gravitation free space



108 (c)

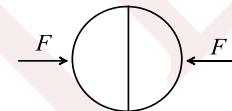
$$F = \frac{kQrq}{R^3} = -ma$$

$$a = -\left(\frac{Qq}{4\pi\epsilon_0 mR^3}\right) r \Rightarrow a = -\omega^2 r$$

$$\omega = \sqrt{\frac{Qq}{4\pi\epsilon_0 mR^3}}$$

109 (a)

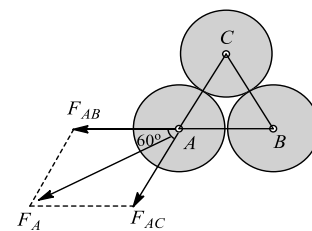
Electrostatic repulsive force;



$$F_{ele} = \left(\frac{\sigma^2}{2\epsilon_0}\right) \pi R^2; F = F_{ele} = \frac{\sigma^2 \pi R^2}{2\epsilon_0}$$

110 (c)

For external points, a charged sphere behaves as if the whole of its charge is concentrated at its centre



Force on A due to B ,

$$F_{AB} = \frac{1}{4\pi\epsilon_0} \frac{q^2}{(2R)^2} = \frac{1}{4\pi\epsilon_0} \frac{q^2}{4R^2} \text{ along } \overrightarrow{BA}$$

And force on A due to C ,

$$F_{AC} = \frac{1}{4\pi\epsilon_0} \frac{q^2}{(2R)^2} = \frac{1}{4\pi\epsilon_0} \frac{q^2}{4R^2} \text{ along } \overrightarrow{CA}$$

Now as angle between BA and CA is 60° and

$$|F_{AB}| = |F_{AC}| = F$$

$$\therefore F_A = \sqrt{F^2 + F^2 + 2F \cdot F \cdot \cos 60^\circ} = \sqrt{3}F$$

$$F_A = \frac{1}{4\pi\epsilon_0} \frac{\sqrt{3}}{4} \left(\frac{q}{R}\right)^2$$



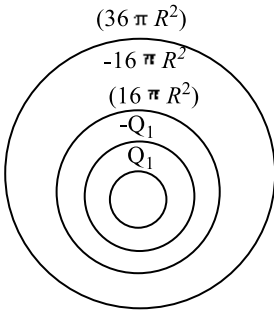
111 (b)

$$Q_1 = \sigma(4\pi R^2) = 4\pi\sigma R^2$$

$$Q_2 = 16\pi\sigma R^2 - Q_1 = 12\pi\sigma R^2$$

$$Q_3 = 36\pi\sigma R^2 = 16\pi\sigma R^2 + 20\pi\sigma R^2$$

$$Q_1 : Q_2 : Q_3 = 1 : 3 : 5$$



112 (c)

$$\rho = Kr^a, E\left(r = \frac{R}{2}\right) = \frac{1}{8}E(r = R)$$

$$\frac{q_{\text{enclosed}}}{4\pi\epsilon_0(R/2)^2} = \frac{1}{8} \frac{Q}{4\pi\epsilon_0 R^2}$$

$$32 q_{\text{enc.}} = Q$$

$$q_{\text{enc.}} = \int_0^{R/2} Kr^a 4\pi r^2 dr = \frac{(4\pi K)}{a+3} \left(\frac{R}{2}\right)^{a+3}$$

$$Q = \frac{4\pi K}{(a+3)} R^{a+3} \Rightarrow \frac{Q}{q_{\text{enc.}}} = 2^{a+3} \Rightarrow 2^{a+3} = 32$$

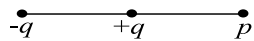
$$\Rightarrow a = 2$$

113 (b)

$$F = Eq = 15 \times 10^4 \times 2 \times 1.6 \times 10^{-19} \\ = 4.8 \times 10^{-14} \text{ N}$$

114 (c)

$$\phi = \int E ds = \frac{Kq}{r^2} 4\pi r^2 = \frac{q}{\epsilon_0}$$

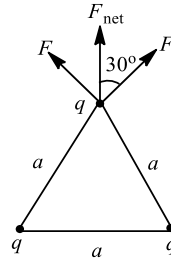


$$W_{\text{ext}} = q(V_B - V_A)$$

Comment : (d) is not correct answer because it is not given that charge is moving slowly

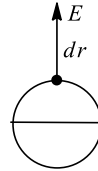
115 (c)

$$F_{\text{net}} = 2F \cos 30^\circ \\ = \frac{2kq^2 \sqrt{3}}{a^2} = \frac{\sqrt{3}kq^2}{a^2}$$



116 (d)

$$\phi = \vec{E} \cdot \vec{A} = 300 \text{ units}$$



$$E = \frac{\sigma}{2\epsilon_0}$$

$$F = E dr = \frac{\sigma dA \sigma}{2\epsilon_0}$$

$$P = \frac{F}{dA} = \frac{\sigma^2}{2\epsilon_0}$$

$$\text{Force} = P \pi R^2 = \frac{\sigma^2}{2\epsilon_0} \pi R^2$$

$$= \frac{Q^2}{16\pi^2 R^4} \frac{\pi R^2}{2\epsilon_0} = \frac{Q^2}{32\epsilon_0 R^2} \\ = \frac{(20 \times 10^{-6})^2 \times 9 \times 10^9}{8(1.5 \times 10^{-2})^2} = 2000 \text{ N}$$

117 (a)

Mean position : $x = l$

$$F = -k(x - l) \Rightarrow \text{where } k = m\omega^2$$

$$\text{Or } qE = -m\omega^2(x - l) \Rightarrow \text{At } x = l, E = 0$$

To the right of $x = l$, E is -ve, so towards left and to the left of $x = l$, E is +ve

118 (b)

There is no electric field inside a conductor, and at surface line of forces are perpendicular to the conductor at any point

119 (c)

Distance

$$BC = AB \sin 60^\circ = (2R) \frac{\sqrt{3}}{2} = \sqrt{3}R$$

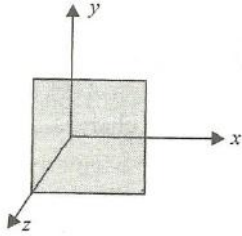
$$\therefore |F_{BC}| = \frac{1}{4\pi\epsilon_0} \frac{\left(\frac{q}{3}\right) \left(\frac{2q}{3}\right)}{(\sqrt{3}R)^2} = \frac{q^2}{54\pi\epsilon_0 R^2}$$

120 (d)



Net charge on a current carrying wire will be zero at any time. Because when current flows through a wire, the amount of charge entering from one end is equal to the amount of charge leaving the other end

121 (c)



Imagine a charge q at the centre of a cube of edge length $2L$. Then

$$\phi = \frac{q}{\epsilon_0}$$

Here, the square is one 24th of the surface area of the imaginary cube, so it intercepts 1/24 of the flux. That is,

$$\Phi = \frac{q}{24\epsilon_0}$$

122 (c)

True for induced electric field and magnetic field

123 (a)

$$\frac{Q}{K\epsilon_0} = \frac{0.5}{10 \times 8.85 \times 10^{-12}} = 5.65 \times 10^9$$

124 (c)

The body may slightly get charged either negatively or positively

125 (b)

Net flux is due to charges inside S only

126 (a)

Glass plate will act like a dielectric

127 (c)

$$100 = kq_1q_2/r^2 \text{ and } F = k(1.1q_1)(0.9q_2)/r^2$$

$$\Rightarrow \frac{F}{100} = 0.99 \Rightarrow F = 99 \text{ N}$$

129 (a)

Strength of electric intensity is more if field lines are closer

130 (d)

$$q_1 + q_2 = Q \text{ and } \frac{q_1}{4\pi r^2} = \frac{q_2}{4\pi R^2} \text{ [Given]}$$

$$q_1 = \frac{QR^2}{R^2+r^2} \text{ and } q_2 = \frac{QR^2}{R^2+r^2}$$

Potential at common centre

$$\frac{1}{4\pi\epsilon_0} \left(\frac{Qr^2}{(R^2+r^2)r} + \frac{QR^2}{(R^2+r^2)R} \right)$$

$$= \frac{Q(R+r)}{4\pi\epsilon_0(R^2+r^2)}$$

131 (c)

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

$$\hat{r} = \frac{\vec{r}}{r} = \frac{(1.2-0)\hat{i} + (-1.6-0)\hat{j}}{\sqrt{(1.2)^2 + (1.6)^2}}$$

$$= \frac{1}{2}(1.2\hat{i} - 1.6\hat{j})$$

$$\vec{E} = 9 \times 10^9 \times \frac{(-8 \times 10^{-9})}{2^2} \times \left[\frac{1}{2}(1.2\hat{i} - 1.6\hat{j}) \right]$$

$$= -10.8\hat{i} + 14.4\hat{j}$$

132 (b)

Net charge on the conductor will be zero. So, net charge inside S_1 will be the charge on the rod.

Hence, flux through S_1 is q/ϵ_0

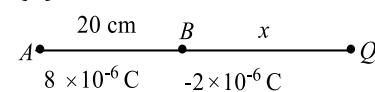
133 (d)

According to option (d) the electric field due to P and S and due to Q and T add to zero. While due to U and R will be added up. Hence the correct option is (d).

134 (c)

$$\phi = \frac{q}{\epsilon_0} \rightarrow \text{Independent of dimensions}$$

135 (d)



Let the third charge Q be placed at a distance x to the right of B . Then

$$\frac{kQ \times 8 \times 10^{-6}}{(20+x)^2} = \frac{k(2 \times 10^{-6})}{x^2}$$

$$\Rightarrow x = 20 \text{ cm}$$

136 (c)

Flux through both will be the same as net charge enclosed by both is same

137 (b)

$$\vec{r} = (9-3)\hat{i} + (12-4)\hat{j} = 6\hat{i} + 8\hat{j}$$

$$\Rightarrow r = \sqrt{6^2 + 8^2} = 10 \text{ m}$$

$$E = \frac{9 \times 10^9 \times 100 \times 10^{-6}}{10^2} = 9000 \text{ Vm}^{-1}$$

138 (a)

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

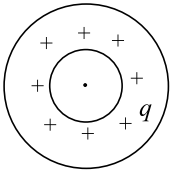


$$[\epsilon_0] = \frac{[q^2]}{[Fr^2]} = \frac{(\text{current} \times \text{time})^2}{MLT^{-2}L^2}$$

$$= \frac{A^2T^2}{MLT^{-2}L^2} = M^{-1}L^{-3}T^4A^2$$

139 (a)

When a charge density is given to inner cylinder an electric field will be produced between the inner and outer cylinder. Hence a potential difference will appear between the two cylinders

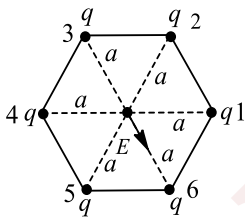


140 (a)

When we charge a soap bubble, there will be either net positive or net negative charge on the bubble. Due to the repulsion between like charges, size of the bubble will tend to increase

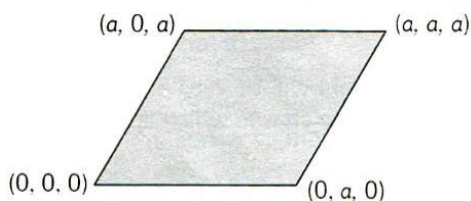
141 (a)

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



Suppose the charge is present at the sixth vertex also, then electric field at centre would be zero. Now, if charge is not present at this vertex, the electric field at centre would be because of other five charges, which would be equal and opposite to the field produced due to single charge at the sixth vertex

142 (c)



$$\text{Flux} = [E_0 \cos 45^\circ] \times \text{area}$$

$$= \frac{E_0}{\sqrt{2}} \times a \times \sqrt{2}a = E_0 a^2$$

143 (d)

After inserting the dielectric slab

$$\text{New capacitance } C' = K \cdot C = \frac{K\epsilon_0 A}{d}$$

$$\text{New potential difference } V' = \frac{V}{K}$$

$$\text{New charge } Q' = C'V' = \frac{\epsilon_0 AV}{d}$$

$$\text{New electric field } E' = \frac{V'}{d} = \frac{V}{Kd}$$

Work done (W) = Final energy - Initial energy

$$W = \frac{1}{2}C'V'^2 - \frac{1}{2}CV^2 = \frac{1}{2}(KC)\left(\frac{V}{K}\right)^2 - \frac{1}{2}CV^2$$

$$= \frac{1}{2}CV^2\left(\frac{1}{K} - 1\right) = -\frac{1}{2}CV^2\left(1 - \frac{1}{K}\right)$$

$$= -\frac{\epsilon_0 AV^2}{2d}\left(1 - \frac{1}{K}\right) \text{ so } |W| = \frac{\epsilon_0 AV^2}{2d}\left(1 - \frac{1}{K}\right)$$

144 (a,c,d)

Position of all the charges are symmetric about the planes $x = \frac{+a}{2}$ and $x = \frac{-a}{2}$. So net electric flux through them will be same

Similarly flux through $y = \frac{+a}{2}$ is equal to flux through

$$y = \frac{-a}{2}$$

$$\phi = \frac{q_{in}}{\epsilon_0} = \frac{3q - q - q}{\epsilon_0} = \frac{q}{\epsilon_0}$$

By symmetry flux through $z = \frac{+a}{2}$ is equal to flux through $x = \frac{+a}{2}$

145 (a,c)

$$\text{Here, } E = \frac{1}{4\pi\epsilon_0} \cdot \frac{Qz_0}{(R^2 + z_0^2)^{3/2}}$$

Where Q is the charge on ring and z_0 is the distance of the point from origin

$$\text{Then } F = qE = \frac{-Qqz_0}{4\pi\epsilon_0(R^2 + z_0^2)^{3/2}}$$

When charge $-q$ crosses origin, force is again towards centre *i. e.*, motion is periodic

Now if $z_0 \ll R$

$$\therefore F = -\frac{1}{4\pi\epsilon_0} \cdot \frac{Qqz_0}{R^3} \Rightarrow F \propto -z_0 \text{ i. e., motion is S.H.M}$$

146 (c,d)

Under electrostatic condition, all points lying on the conductor are in same potential. Therefore, potential at A = potential at B

From gauss's theorem, total flux through the surface of the cavity will be q/ϵ_0

Note : Instead of an elliptical cavity, if it would had been a spherical cavity then options (a) and (b) were also correct



147 (a,b)

By using

$$V = V_0 e^{-t/CR} \Rightarrow 40 = 50 e^{-1/CR} \Rightarrow e^{-1/CR} = 4/5$$

Potential difference after 2 sec

$$V' = V_0 e^{-2/CR} = 50(e^{-1/CR})^2 = 50\left(\frac{4}{5}\right)^2 = 32V$$

Fraction of energy after 1 sec

$$= \frac{\frac{1}{2}C(V_f)^2}{\frac{1}{2}C(V_i)^2} = \left(\frac{40}{50}\right)^2 = \frac{16}{25}$$

148 (b,d)

In L.H.S. of Gauss's law, \vec{E} is due to all point charges present in space and ϕ depends only on the enclosed charges

149 (a,d)

From the behaviour of electric lines, we can say that Q_1 is positive and Q_2 is negative. Further, $|Q_1| > |Q_2|$.

At some finite distance to the right of Q_2 , electric field will be zero. Because electric field due to Q_1 is towards right (away from Q_1) and due to Q_2 is towards left (towards Q_2). But since magnitude of Q_1 is more, the two fields may cancel each other because distance of that point from Q_1 will also be more.

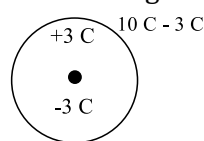
\therefore The correct options are (a) and (d).

150 (a,d)

Capacitance will be increased when a dielectric is introduced in the capacitor but potential difference will remain the same because battery is still connected. So according to $q = CV$, charge will increase i. e., $Q > Q_0$ and $U = \frac{1}{2}QV_0$, $U_0 = \frac{1}{2}Q_0V_0 \Rightarrow Q > Q_0$ so $U > U_0$

151 (a,d)

Due to induction, charges on various faces are as shown in fig

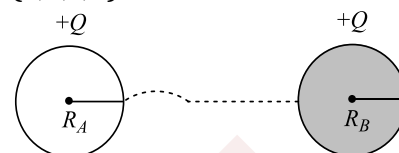


Charge on the inner surface of the shell = +3C

Net charge on the outer surface of the shell = -3 C + 10 C = +7 C

Distribution of charge on the inner surface would be uniform if charge is placed at the centre, otherwise non-uniform. On outer surface, charge would be always uniformly distributed as the displacement of inside charges does not affect the distribution of the outer charge

152 (a,b,c,d)



$$Q_A + Q_B = 2Q \quad \dots(i)$$

$$\frac{KQ_A}{R_A} = \frac{KQ_B}{R_B} \quad \dots(ii)$$

$$(i) \text{ and } (ii) \Rightarrow Q_A = Q_B \left(\frac{R_A}{R_B}\right)$$

$$\&Q_B \left(1 + \frac{R_A}{R_B}\right) = 2Q \Rightarrow Q_B = \frac{2Q}{\left(1 + \frac{R_A}{R_B}\right)} = \frac{2QR_B}{R_A + R_B}$$

$$\&Q_A = \frac{2QR_A}{R_A + R_B} \Rightarrow Q_A > Q_B$$

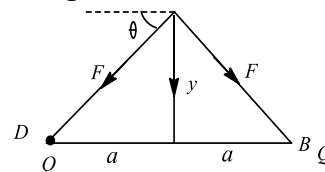
$$\frac{\sigma_A}{\sigma_B} = \frac{Q_A/4\pi R_A^2}{Q_B/4\pi R_B^2} = \frac{R_B}{R_A} \quad [\text{using (ii)}]$$

$$E_A = \frac{\sigma_A}{\epsilon_0} \&E_B = \frac{\sigma_B}{\epsilon_0} \quad [\because \sigma_A < \sigma_B]$$

$$\Rightarrow E_A < E_B \quad (\text{at surface})$$

153 (c,d)

The particle will oscillate or perform SHM if equilibrium is a stable one. For negative charge, equilibrium is stable if the particles are displaced along CD and unstable for displacement along AB



For $y \ll a$, in displaced position, net resultant force towards equilibrium position is

$$F_{\text{res}} = 2F \sin \theta = \frac{2 \times Q}{4\pi\epsilon_0(a^2 + y^2)} \times \frac{y}{(a^2 + y^2)^{1/2}} \\ = \frac{2Qy}{4\pi\epsilon_0 a^3} [a \gg y]$$

$F_{\text{res}} \propto y$, so SHM for $y \ll a$

For $y = a$, there would be restoring force, but F is not proportional to y

So, there is oscillatory motion but not SHM

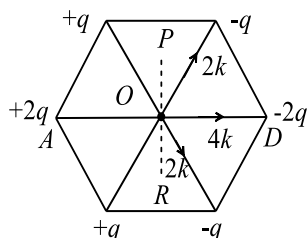
155 (b,d)

Battery is disconnected, hence charge remains conserved. The plates are pulled apart, so capacity



will decrease on account of increase of voltage.
Now capacity decreases, hence energy will increase as charge is constant
Thus, (b) and (d) are correct

156 (a,b,c)



$$E_0 = 6K \text{ (along } OD)$$

$$V_0 = 0$$

Potential on line PR is zero

157 (c,d)

If charges are of opposite signs then the two fields are along the same direction. So, they cannot be zero. Hence, the charges should be of same sign.

Therefore, option (c) is correct.

Further, work done by external force = change in potential energy.

$$\therefore W_{A \rightarrow B} = q(\Delta V) = (+1)(V_B - V_A)$$

$$\text{or } W_{A \rightarrow B} = V_B - V_A$$

Therefore, option (d) is also correct.

\therefore Correct options are (c) and (d).

158 (b,d)

Options (b) and (d) are correct

The time constants are

$$\tau_1 = R \cdot C_1 \quad C_1 = 1\mu f$$

$$\tau_2 = R \cdot C_2 \quad C_2 = 2\mu f$$

Hence, $\tau_1 < \tau_2$

Thus, as per the discharging eqn. $q = q_0 e^{-t/RC}$

$\therefore C_1$ will loose charge earlier

$$\text{Hence, } \frac{\tau_1}{\tau_2} = \frac{1}{2}$$

Hence, C_1 lose 50% of charge initially present earlier than C_2

Hence, (d) is correct

Now initially, the current depend on V and R , i.e.,

$$I = I_0 e^{-t/RC} \text{ and at } t = 0 \quad I = I_0 = \frac{V}{R}$$

Hence, for both the capacitor the initial current will be same. Hence (b) is correct

159 (b,c)

Just draw the FBD of both charge particles and see whether force can be zero or not on the particle.

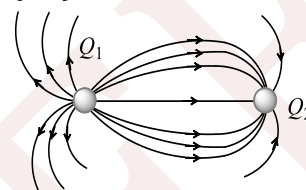
At least, one force should be opposite to others

160 (b,c)

ϕ crossing through Gaussian surface does not depend on the location of charge, while \vec{E} depends on it

If q crosses the boundary, then q_{enclosed} changes and hence the flux and \vec{E} also change

161 (a,d)



From the figure, it can be observed that Q_1 is positive, Q_2 is negative

Number of lines on Q_1 is greater and number of lines is directly proportional to magnitude of charge

So, $|Q_1| > |Q_2|$

Electric field will be zero to the right of Q_2 as it has small magnitude and opposite sign to that of Q_1

162 (a,b,c,d)

The potential shown is for charged spherical conductor

163 (a,c)

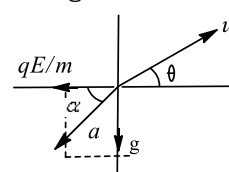
For non-conducting solid sphere $E_{in} \propto r$ and $E_{out} \propto \frac{1}{r^2}$ i.e. for $r < R$; E increases as r increases and for $R < r < \infty$; E decreases as r increases

165 (a,b,c)

$$\text{Along } X\text{-axis, } u_x = u \cos \theta \Rightarrow a_x = -\frac{qE}{m}$$

$$\text{Along } Y\text{-axis, } u_y = u \sin \theta \Rightarrow a_y = -g$$

Equation of motion along X - and Y -axes would be as follows: a is resultant acceleration. If a is opposite to u , i.e., $\alpha = \theta$, then the path will be a straight line. For $\alpha \neq \theta$, the path will be parabolic



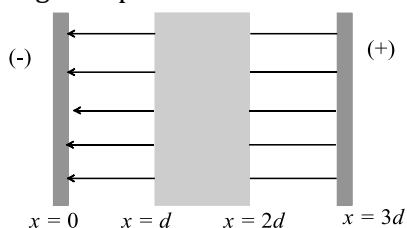
Time of flight remains unchanged as vertical motion is not affected by \vec{E} . Range of particle in the present case is always less than =

$$\frac{u^2 \sin 2\theta}{g} \text{ whatever may be the value of } E$$

$$R = x_t = T = u \cos \theta \times \frac{2u \sin \theta}{g} - \frac{1}{2} \times \frac{qE}{m} \left[\frac{2u \sin \theta}{g} \right]^2 < \frac{u^2 \sin 2\theta}{g}$$

166 (b,c)

Even after introduction of dielectric slab, direction of electric field will be perpendicular to the plates and directed from positive plate to negative plate



Further, magnitude of electric field in air = $\frac{\sigma}{\epsilon_0}$

Magnitude of electric field in dielectric = $\frac{\sigma}{K\epsilon_0}$

Similarly electric lines always flows from higher to lower potential, therefore, electric potential increases continuously as we move from $x = 0$ to $x = 3d$

167 (a)

A polar molecular has intrinsic dipole moment or permanent dipole moment, so it is called an electric dipole. In a polar molecule, the centers of positive and negative charges do not coincide with each other because of asymmetric shape of molecule.

168 (a)

In series combination

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

In parallel combination

$$C_p = C_1 + C_2 + C_3$$

Thus, it is obvious that

$$C_p > C_s$$

169 (c)

Equivalent capacitance of parallel combination is

$$C_p = C_1 + C_2 + C_3$$

170 (c)

If the field lines are curved, then the charge particle does not exactly follow the curved path

171 (e)

Battery is disconnected from the capacitor

$$\text{So } Q = \text{constant. Energy} = \frac{Q^2}{2C} = \frac{Q^2 d}{2\epsilon_0 A}$$

$$\Rightarrow \text{Energy} \propto d$$

172 (d)

Figure shows the forces on the metal ball, when the upper plate of the capacitor is positively charged.

If E is strength of the electric field between the plates, then apparent weight of the ball

Diagram

$$mg' = mg + qE$$

$$\text{or } g' = g + \frac{qE}{m}$$

The period of oscillation of the ball is given by

$$T = 2\pi \sqrt{\frac{1}{g}} = 2\pi \sqrt{\frac{1}{g + qE/m}}$$

Since, $g + qE/m > g$, the time period of the ball will decrease.

173 (c)

We know that for an electric dipole,

$$E_{axial} = \frac{1}{4\pi\epsilon_0} \left(\frac{2p}{r^3} \right) \dots \dots (i)$$

$$\text{And } E_{equatorial} = \frac{1}{4\pi\epsilon_0} \left(\frac{p}{r^3} \right) \dots \dots (ii)$$

Hence, from Eqs. (i) and (ii)

$$\frac{E_{axial}}{2} = E_{equatorial}$$



Hence. $E_{equatorial} = \frac{E}{2}$

Reason is false as electric field due to dipole varies inversely as cube of distance i.e., $E \propto \frac{1}{r^3}$.

174 (b)

Statement 1 is true by information

Statement 2 is true by formula. But statement 2 is not the explanation of statement 1

175 (b)

Charge is always conserved but energy is lost in the term of heat

176 (a)

Force by electric field will be perpendicular to the displacements

178 (c)

In the given case $V = V_0$ [constant]

Energy stored in the capacitor $= \frac{1}{2} CV^2$

$C \rightarrow KC$, so energy stored will become A times

$Q = CV$, so Q will become K times

\therefore Surface charge density $\sigma' = \frac{Kq}{A} = K\sigma_0$

179 (a)

Statement II is true and according to that distribution of charge on the outer surface is not affected by the inside location of the charges

180 (a)

A body can be charged by the transfer of electrons only

181 (e)

If electric lines of forces cross each other, then the electric field at the point of intersection will have two direction simultaneously which is not possible physically

182 (d)

Electric potential of a charged conductor depends not only on the amount of charge and volume but also on the shape of the conductor. Hence if their

shapes are different, they may have different electric potential

183 (d)

The rate of decrease of electric field is different in the two cases. In case of a point charge, it decreases as $1/r^2$ but in the case of electric dipole it decreases more rapidly, as $E \propto 1/r^3$

184 (d)

Gravitational force is the dominating force in nature not coulomb's force. Gravitational force is the weakest force.

185 (a)

From $\sigma \propto 1/R$ and electric field at the conductor's surface, $E = \sigma/\epsilon_0$. We can say that Statement I is correct and Statement II is correct explanation for it

186 (a)

Reason truly explains the assertion. However, if charges are point, no induction will take place and they will never attract

187 (e)

It is an example of conservation of charges

188 (d)

Displacement current is not the current produced due to charge carries but it is due to varying electric flux with time. It is the current in the sense that it produces a magnetic field. The displacement current is given by

$$I_d = \epsilon_0 \frac{d\phi_\epsilon}{dt}$$

It will happen when charge on capacitor does not remain constant but changes with time

189 (d)

The electric field due to one charged plate at the location of the other is $E = \sigma/2\epsilon_0$ and the force per unit area is $F = \sigma E = \sigma^2/2\epsilon_0$

191 (d)

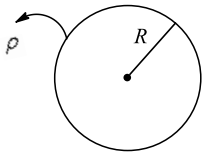


Due to displacement of charges within closed surface, \vec{E} at any point may change. But net flux crossing the surface will not change

192 (a)

In a hollow spherical shield, the charge is present only on its surface but charge is zero at every point inside the hollow sphere. Hence, the metallic shield in form of hollow shell may be built to block an electric field

193 (d)



$$U_c = \frac{3KQ}{2R}q, U_s = \frac{KQ}{R}q$$

$$\therefore \Delta U = \frac{KQ}{2R}q$$

$$= \frac{1}{4\pi\epsilon_0} \cdot \frac{1}{2R} \rho \frac{4\pi R^3}{3} q = \frac{\rho R^2 q}{6\epsilon_0}$$

194 (b)

During take off and landing, the friction between tyres and the run way may cause electrification of tyres. Due to conducting nature of tyre, the charge so collected is conducted to a ground and electrical sparking is avoided

195 (c)

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

196 (d)

\vec{E} at any point on the Gaussian surface may be due to outside charges also

197 (d)

\vec{E} in outside vicinity of the conductor's surface depends on all the charges present in the space, but expression $\vec{E} = \sigma/\epsilon_0$

198 (d)

Electric field at the nearby point will be resultant of existing field and field due to the charge brought. It may increase or decrease if the charge is positive or negative depending on the position of the point with respect to the charge brought

199 (b)

The total energy stored in series combination of capacitors is the sum of energies stored in the individual capacitors *i.e.*, $U=U_1 + U_2 + U_3 + \dots$ is also true that potential energy is the scalar quantity.

200 (b)

By the formula capacitance of a capacitor

$$C_1 = \epsilon_0 \times \frac{KA}{d} \propto \frac{K}{d}$$

$$\text{Hence, } \frac{C_1}{C_2} = \frac{K_1}{d_1} \times \frac{d_2}{K_2} = \frac{K}{d} \times \frac{d/2}{3K} = \frac{1}{6} \text{ or } C_2 = 6C_1$$

Again for capacity of a capacitor $C = \frac{Q}{V}$

Therefore, capacity of a capacitor does not depend upon the nature of the material of the capacitor

201 (a)

Both the assertion and the reason are true, and the reason is the correct explanation of the assertion

202 (b)

Electron and proton have same amount of charge so they have same coulomb force. They have different accelerations because they have different masses $\left[a = \frac{F}{m} \right]$

Therefore, both assertion and reason are true and reason is not the correct explanation of the assertion



204 (d)

Gravitational force is the dominating force in nature and not coulomb's force. Gravitational force is the weakest force. Also, Coulomb's force \gg gravitational force

205 (a)

Potential is constant on the surface of a sphere so it behaves as an equipotential surface

206 (b)

As $\sigma_1 = \sigma_2$ [Given]

$\therefore \frac{q_1}{4\pi r_1^2} = \frac{q_2}{4\pi r_2^2}$, or $\frac{q_1}{q_2} = \frac{r_1^2}{r_2^2}$ [Let r_1 and r_2 be two different radii]

Then the ratio of electric field intensities near the surface of spherical conductor,

$$\frac{E_1}{E_2} = \frac{q_1}{4\pi\epsilon_0 r_1^2} \times \frac{4\pi\epsilon_0 r_2^2}{q_2} = \frac{q_1}{q_2} \times \frac{r_2^2}{r_1^2} = 1 \text{ i.e. } E_1 = E_2$$

207 (a)

Electron has negative charge, in electric field negative charge moves from lower potential to higher potential

208 (a)

Let Q_A and Q_B be the charges on the solid and the hollow conducting spheres respectively and R be the radius of each sphere. When charge is given to a solid conducting sphere, it appears on the outer surface. For the calculation of electric field or potential due to a sphere (Whether hollow or solid) at a point on or outside the sphere, the charge behaves as if it is concentrated at the center of the sphere. If V_A and V_B are potential of two spheres, then

$$V_A = \frac{1}{4\pi\epsilon_0} \frac{Q_A}{R} \text{ or } V_B = \frac{1}{4\pi\epsilon_0} \frac{Q_B}{R}$$

Since, $V_A = V_B$

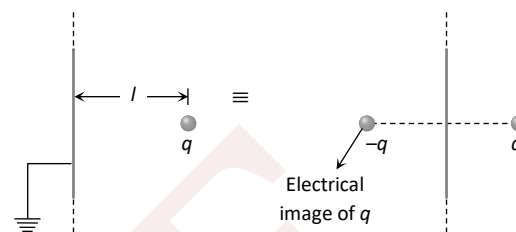
$$\Rightarrow Q_A = Q_B$$

209 (a)

This is the concept of electric image

If we are asked to find the force between an infinite earthed conductor and a point charge q placed at perpendicular distance l from the earthed conductor (see figure), then we proceed as follows

Firstly, the conductor being earthed implies $V = 0$



So, we redraw the situation in which we replace the conductor and introduce an **IMAGE** charge $-q$ as shown

The force between the two charges (object charge q and image charge $-q$) is the electrostatic force between the infinite grounded conductor and q

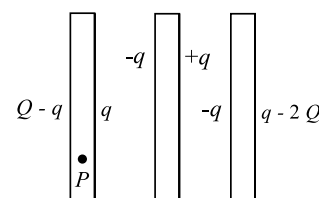
$$\text{So, } F = \frac{1}{4\pi\epsilon_0} \frac{q^2}{(2l)^2} \Rightarrow F = \frac{1}{4\pi\epsilon_0} \frac{q^2}{4l^2} \text{ [attractive in nature]}$$

210 (b)

Distribution of charge on different surfaces of the plates has been shown

Take a point P on the leftmost plate. The electric field is

$$E = \frac{Q - q}{2A\epsilon_0} - \frac{q}{2A\epsilon_0} + \frac{q}{2A\epsilon_0} - \frac{q}{2A\epsilon_0} + \frac{q}{2A\epsilon_0} - \frac{(q - 2Q)}{2A\epsilon_0} = 0$$



(Inside a conductor, $E = 0$)

$$\text{So, } Q - q - q + 2Q = 0$$



Or $2q = 3Q \Rightarrow q = \frac{3Q}{2}$

The charge appearing on the outer surface of the rightmost plate is

$$q - 2Q = \frac{3Q}{2} - 2Q = -\frac{Q}{2}$$

The charge on the outer surface of the leftmost plate is

$$Q - q = Q - \frac{3Q}{2} = -\frac{Q}{2}$$

Charge appearing on the middle plate is $-q$ and $+q$

i.e. $-\frac{3Q}{2}$ and $+\frac{3Q}{2}$

Note: We see that charge appearing on each of the outer surfaces is half of the total sum of charge on all three plates

211 (d)

Electrostatic forces or the Coulombic force exists between the charged bodies. Gravitational force exists between all bodies. Strong force exists between particles inside the nucleus

212 (a)

i. Infinite conducting plane sheet of charge is $\sigma/2\epsilon_0$

ii. Infinite conducting plane sheet of uniform thickness is σ/ϵ_0

iii. Non-conducting charged solid sphere at its surface is $R\rho/3\epsilon_0$

iv. Non-conducting charged solid sphere at its centre is zero

213 (a)

In case of stable equilibrium, the potential energy is minimum and in case of unstable equilibrium, potential energy is maximum

Cases (i) and (ii) are the cases of stable equilibrium, hence answer are (a),(c),and

(d). Cases (ii) and (iii) are the cases of unstable equilibrium. Hence, the answer are (a),(b) and (d)

214 (b)

$$\epsilon_0 \propto \frac{q_1 q_2}{Fr^2} \Rightarrow [\epsilon_0] = [M^{-1}L^{-3}T^4A^2]$$

k = Dimensionless

$$E = \frac{F}{q} \Rightarrow [E] = [M^1L^1T^{-2}Q^{-1}]$$

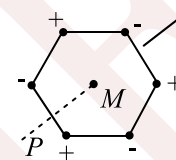
$$= [M^1L^1T^{-2}A^{-1}T^{-1}]$$

$$= [M^1L^1T^{-3}A^{-1}]s$$

$$[F] = [M^1L^1T^{-2}]$$

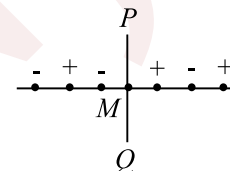
215 (a)

(p)



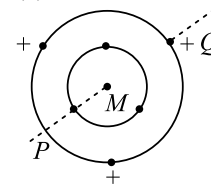
By symmetry an $E = 0, V = 0, B = 0$
 $\mu = \text{NIA}$ but $I_{\text{effective}} = 0$, So, $\mu = 0$

(q)



$E \neq 0, V = 0$ Since $I_{\text{effective}} = 0$
 $\Rightarrow B = 0$ and $\mu = 0$

(r)



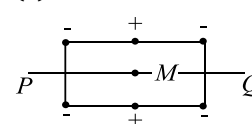
$E = 0$ (By Symmetry)

$V \neq 0$ (Since distances are different)

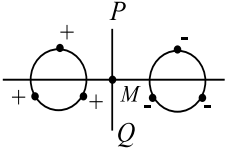
$B \neq 0$ (Since Radius is different)

$\mu \neq 0$

(s)



$E = 0$ (By Symmetry)
 $V \neq 0$ (Since distances are different)
 $B \neq 0$
 $\mu \neq 0$
(t)



$E \neq 0, V = 0, \mu = 0, B = 0$ and given each rotating charge to be equivalent to a steady current so $B = 0$ so $(t \rightarrow C)$ and it was not given that each rotating charge to be equivalent to steady current then $B \neq 0$

216 (a)

Charge always needs mass to reside. Mass may or may not be charged. Charge is a conserved quantity but mass is not

217 (c)

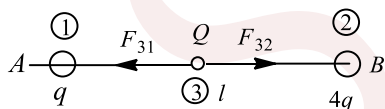
Electrostatic force and gravitational force are conservative, action-reaction forces. Also, electrostatic force depends upon the nature of the medium between interacting objects. The principle of superposition is applicable, irrespective of the nature of force

219 (b)

Charge on each ball = $\frac{10+30}{2} = 20 \mu\text{C}$

$$F = 9 \times 10^9 \times \frac{(20 \times 10^{-6})^2}{(0.50)^2} = 14.4 \text{ N}$$

220 (d)



For system to be in equilibrium net force on each charge should be zero, hence the third charge should be negative and it should be placed near q between (1) and (2). For equilibrium of (3), we have

$$\frac{1}{4\pi\epsilon_0} \frac{qQ}{x^2} = \frac{1}{4\pi\epsilon_0} \frac{Q4q}{(l-x)^2} \Rightarrow x = \frac{l}{3}$$

For equilibrium of (1), we have

$$\frac{1}{4\pi\epsilon_0} \frac{q4q}{l^2} = \frac{1}{4\pi\epsilon_0} \frac{Qq}{x^2}$$

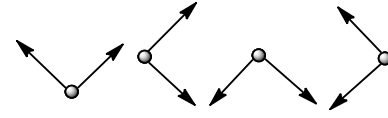
$$Q = 4q \left(\frac{x}{l}\right)^2 = 4q \left(\frac{1}{3}\right)^2 = \frac{4q}{9} \Rightarrow Q = \frac{4q}{9}$$

Q should be negative of q , otherwise the resultant force on q cannot be zero

221 (c)

The four possible force diagrams are as follows:
Only the last picture can result in an electric field in the $-ve$ x -direction

$$q_1 = -2.00 \mu\text{C}, q_3 = +4.00 \mu\text{C} \text{ and } q_2 > 0$$



$$E_y = 0 = \frac{1}{4\pi\epsilon_0} \frac{q_1}{(0.0400\text{m})^2} \sin \theta$$

$$- \frac{1}{4\pi\epsilon_0} \frac{q_2}{(0.0300\text{m})^2} \cos \theta$$

$$\Rightarrow q_2 = \frac{9}{16} q_1 \frac{\sin \theta}{\cos \theta} = \frac{9}{16} q_1 \frac{3/5}{4/5} = \frac{27}{64} q_1 = 0.843 \mu\text{C}$$

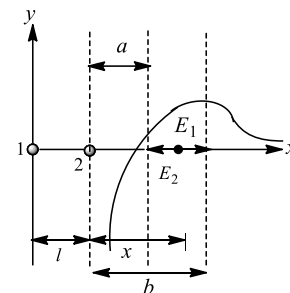
$$F_3 = q_3 E_x = q_3 \frac{1}{4\pi\epsilon_0} \left(\frac{q_1}{0.00165} + \frac{q_2}{0.00095} \right) = 56.25 \text{ N}$$

222 (a)

Electric field at (2) tends to $-\infty$, hence the charge at (2) should be negative. There is a neutral point to the right of charges. This is possible only when the charge at (1) should be positive

Hence, Q_1 is positive and Q_2 is negative

At neutral point, $\vec{E}_1 = \vec{E}_2$



$$\frac{1}{4\pi\epsilon_0} \frac{Q_1}{(a+l)^2} = \frac{1}{4\pi\epsilon_0} \frac{Q_2}{a^2} \Rightarrow \frac{Q_1}{Q_2} = \left(\frac{a+l}{a}\right)^2$$

Electric field at any position to the right of charges

$$E = E_1 - E_2 = \frac{1}{4\pi\epsilon_0} \frac{Q_1}{(l+x)^2} - \frac{1}{4\pi\epsilon_0} \frac{Q_2}{x^2}$$

For the maximum value of E

$$\frac{dE}{dx} = 0 \Rightarrow \frac{d}{dx} \left[\frac{1}{4\pi\epsilon_0} \frac{Q_1}{(l+x)^2} - \frac{1}{4\pi\epsilon_0} \frac{Q_2}{x^2} \right] = 0$$

$$Q_1 \frac{(-2)}{(l+x)^3} - Q_2 \frac{(-2)}{x^3} = 0$$



$$\frac{Q_1}{(l+x)^3} = \frac{Q_2}{x^3} \Rightarrow \left(\frac{l+x}{x}\right)^3 = \frac{Q_1}{Q_2}$$

$$\frac{l+x}{x} = \left(\frac{Q_1}{Q_2}\right)^{1/3} \Rightarrow \frac{l}{x} = \left(\frac{Q_1}{Q_2}\right)^{1/3} - 1$$

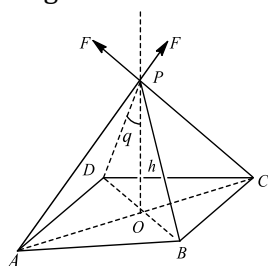
$$x = \frac{l}{\left(\frac{Q_1}{Q_2}\right)^{1/3} - 1}$$

223 (b)

$$OA = OB = OC = OD = a$$

The magnitude of the electric force due to each charge is $\frac{1}{4\pi\epsilon_0} \frac{q}{a^2+h^2}$

The components of the force perpendicular to OP sum up to zero because of the symmetrical distribution of charges about OP . Hence, the resultant force at P is upward along OP . The magnitude of the force is given by



$$F_{\text{up}} = 4 \times \frac{1}{4\pi\epsilon_0} \frac{q}{h^2+a^2} \cos \theta$$

$$= \frac{q}{\pi\epsilon_0(h^2+a^2)} \frac{h}{\sqrt{h^2+a^2}} = \frac{qh}{\pi\epsilon_0(h^2+a^2)^{3/2}}$$

$$F_{\text{down}} = \text{weight} = mg$$

$$\text{For equilibrium, } mg = \frac{qh}{\pi\epsilon_0(h^2+a^2)^{3/2}}$$

$$\Rightarrow Q = \pi\epsilon_0 \frac{mg}{h} (h^2+a^2)^{3/2}$$

Yes, this is a stable equilibrium as it will regain its position if displaced a little

224 (c)

Passing between the charged plates, the electron feels a force upward and just misses the top plate. The distance it travels in the y-direction is 0.005 m

$$\text{Time of flight} = t = \frac{0.0200 \text{ m}}{1.60 \times 10^6 \text{ m/s}}$$

$$= 1.25 \times 10^{-8} \text{ s}$$

and the initial y-velocity is zero

$$\text{Now, } y = v_{0y}t + \frac{1}{2}at^2$$

$$\text{So, } 0.005 \text{ m} = \frac{1}{2}a(1.25 \times 10^{-8} \text{ s})^2$$

$$\Rightarrow a = 6.40 \times 10^{13} \text{ ms}^{-2}$$

$$\text{But also, } a = \frac{F}{m} = \frac{eE}{m_e}$$

$$E = \frac{(9.1 \times 10^{-31} \text{ kg})(6.40 \times 10^{13} \text{ ms}^{-2})}{1.60 \times 10^{-19} \text{ C}}$$

$$= 364 \text{ NC}^{-1}$$

Since the portion is more massive, it will accelerate less, and NOT hit the plates. To find the vertical displacement when it exists the plates, we use the kinematic equations again:

$$y = \frac{1}{2}at^2 = \frac{1}{2} \frac{eE}{m_p} (1.25 \times 10^{-8} \text{ s})^2$$

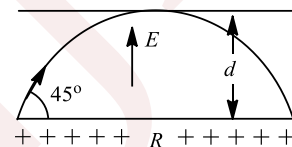
$$= 2.73 \times 10^{-6} \text{ m}$$

As mentioned in (b), the proton will not hit one of the plates because although the electric force felt by the proton is the same as the electron felt, a smaller acceleration results for the more massive proton

The acceleration produced by the electric force is much greater than g; it is reasonable to ignore gravity

225 (c)

$$d = \frac{u^2 \sin^2 \theta}{2a}, a = \frac{qE}{m}$$



$$d = \frac{mu^2 \sin^2 45^\circ}{2qE}$$

$$d = \frac{K}{2qE} \Rightarrow E = \frac{K}{2dq}$$

$$R = \frac{u^2}{a} = \frac{2d}{\sin^2 \theta} = 4d$$

226 (a)

$$qE = mg \Rightarrow q \times 1.68 \times 10^5 = 1.08 \times 10^{-14} \text{ g}$$

$$\Rightarrow q = 6.40 \times 10^{-19} \text{ C}$$

$$q = ne \Rightarrow 6.4 \times 10^{-19} = n \times 1.6 \times 10^{-19} \Rightarrow n = 4$$

227 (c)

$$\Phi = \vec{E} \cdot \vec{A} = EA \cos \theta, \text{ where, } \vec{A} = A\hat{n}$$

$$\hat{n}_{S_1} = -\hat{j}(\text{left}), \Phi_{S_1}$$

$$= -(4$$

$$\times 10^3 \text{ NC}^{-1}(0.1 \text{ m})^2 \cos(90^\circ$$

$$- 37^\circ)$$

$$= -24 \text{ Nm}^2\text{C}^{-1}$$

$$\hat{n}_{S_2} = +\hat{k}(\text{top})$$

$$\Phi_{S_2} = -(4 \times 10^3 \text{ NC}^{-1})(0.1 \text{ m})^2 \cos 90^\circ = 0$$



$$\begin{aligned}\hat{n}_{S_3} &= +\hat{j}(\text{right}), \\ \Phi_{S_3} &= +(4 \times 10^3 \text{NC}^{-1})(0.1 \text{ m})^2 \cos(90^\circ - 37^\circ) \\ &= +24 \text{Nm}^2 \text{C}^{-1} \\ \hat{n}_{S_4} &= -\hat{k}(\text{bottom}), \\ \Phi_{S_4} &= (4 \times 10^3 \text{NC}^{-1})(0.1 \text{ m})^2 \cos 90^\circ = 0 \\ \hat{n}_{S_5} &= +\hat{i}(\text{front}), \\ \Phi_{S_5} &= +(4 \times 10^3 \text{NC}^{-1})(0.1 \text{ m})^2 \cos 37^\circ \\ &= 32 \text{Nm}^2 \text{C}^{-1} \\ \hat{n}_{S_6} &= -\hat{i}(\text{back}), \\ \Phi_{S_6} &= -(4 \times 10^3 \text{NC}^{-1})(0.1 \text{ m})^2 \cos 37^\circ \\ &= -32 \text{Nm}^2 \text{C}^{-1}\end{aligned}$$

As the field is uniform, so the total flux through the cube must be zero; any flux entering the cube must also leave it

228 (b)

$$\begin{aligned}\text{For } S_1: \vec{A} &= L^2(-\hat{j}), \vec{E} = -5x\hat{i} + 3z\hat{k} \\ \text{Here } \vec{E} \perp \vec{A}, \text{ so } \phi_{S_1} &= 0 \\ \text{For } S_2: \vec{A} &= L^2\hat{k}, \vec{E} = -5x\hat{i} + 3L\hat{k} \\ \text{Here } -5x\hat{i} \text{ is perpendicular to } \vec{A}, \text{ so no flux due to} \\ \text{this component} \\ \phi_{S_2} &= (3L\hat{k}) \cdot L^2\hat{k} = 3L^3 = 81 \times 10^{-3} \text{Nm}^2 \text{C}^{-1} \\ \text{For } S_3: \vec{A} &= L^2\hat{j}, \vec{E} = -5x\hat{i} + 3z\hat{k} \\ \text{Here } \vec{E} \perp \vec{A}, \text{ so } \phi_{S_3} &= 0 \\ \text{For } S_4: \vec{A} &= -L^2\hat{k}, \vec{E} = -5x\hat{i} + 0\hat{k} (\because z = 0) \\ \text{Here } \vec{E} \perp \vec{A}, \text{ so } \phi_{S_4} &= 0 \\ \text{For } S_5: \vec{A} &= L^2\hat{i}, \vec{E} = -5L\hat{i} + 3z\hat{k} \\ \text{No flux due to } 3z\hat{k} \text{ component} \\ \phi_{S_5} &= (-5L\hat{i}) \cdot L^2\hat{i} = -5L^3 \\ &= -135 \times 10^{-3} \text{Nm}^2 \text{C}^{-1} \\ \text{For } S_6: \vec{A} &= -L^2\hat{i}, \vec{E} = 0\hat{i} + 3z\hat{k} (\because x = 0) \\ \text{Here } \vec{E} \perp \vec{A}, \text{ so } \phi_{S_6} &= 0 \\ \text{Total flux through the cube is} \\ \phi &= \phi(S_1 + S_2 + S_3 + S_5 + S_6) \\ &= 81 \times 10^{-3} - 135 \times 10^{-3} \\ &= -54 \times 10^{-2} \text{Nm}^2 \text{C}^{-1}\end{aligned}$$

$$\text{Now } \phi = \frac{q_{\text{in}}}{\epsilon_0} \Rightarrow q_{\text{in}} = \phi \epsilon_0 = -0.054 \epsilon_0 \text{C}$$

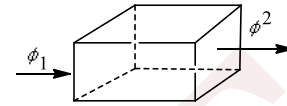
229 (a)

$$\begin{aligned}\text{Given that } \vec{E} &= -B\hat{i} + C\hat{j} - D\hat{k}, \Phi = \vec{E} \cdot \vec{A}, \\ \text{Edge length } L, \text{ and} \\ \hat{n}_{S_1} &= -\hat{j} \Rightarrow \Phi_1 = \vec{E} \cdot A\hat{n}_{S_1} = -CL^2 \\ \hat{n}_{S_2} &= +\hat{k} \Rightarrow \Phi_2 = \vec{E} \cdot A\hat{n}_{S_2} = -DL^2 \\ \hat{n}_{S_3} &= +\hat{j} \Rightarrow \Phi_3 = \vec{E} \cdot A\hat{n}_{S_3} = +CL^2\end{aligned}$$

$$\begin{aligned}\hat{n}_{S_4} &= -\hat{k} \Rightarrow \Phi_4 = \vec{E} \cdot A\hat{n}_{S_4} = +DL^2 \\ \hat{n}_{S_5} &= +\hat{i} \Rightarrow \Phi_5 = \vec{E} \cdot A\hat{n}_{S_5} = -BL^2 \\ \hat{n}_{S_6} &= -\hat{i} \Rightarrow \Phi_6 = \vec{E} \cdot A\hat{n}_{S_6} = +BL^2 \\ \text{Total flux is } \sum_{i=1}^6 \Phi_i &= 0\end{aligned}$$

230 (c)

$$\begin{aligned}\phi_1 &= -E_1 a^2 = -\alpha a^{1/2} a^2 = -\alpha a^{5/2} \\ \text{and } \phi_2 &= E_2 a^2 = \alpha (2a)^{1/2} a^2 = \sqrt{2} \alpha a^{5/2} \\ \phi_{\text{net}} &= (\sqrt{2} - 1) \alpha a^{5/2}\end{aligned}$$

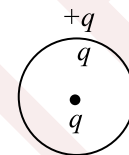


Using the Gauss theorem, we get

$$\begin{aligned}\phi &= \frac{q_{\text{in}}}{\epsilon_0} \\ \Rightarrow q_{\text{in}} &= \phi \epsilon_0 = (\sqrt{2} - 1) \epsilon_0 \alpha a^{5/2}\end{aligned}$$

231 (c)

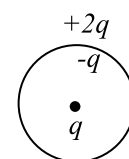
Induced charge on the inner surface will be equal and opposite to the charge placed at the centre



Equal amount of opposite charge as that of the inner surface will be induced on the outer surface while net charge is zero on that ball

232 (c)

The extra given charge will reside on the outer surface



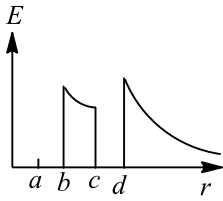
233 (c)

As far as the net charge induced on the inner and outer surface is concerned, it does not depend upon the location of point charge within the ball

234 (a)

$$\begin{aligned}\text{i. } r < a. E &= 0, \text{ since } Q = 0 \\ \text{ii. } a < r < b. E &= 0, \text{ since } Q = 0 \\ \text{iii. } b < r < c. \text{ Since } Q &= +2q, E = \frac{1}{4\pi\epsilon_0} \frac{2q}{r^2},\end{aligned}$$





iv. $c < r < d$. $E = 0$, since $Q = 0$

v. $r > d$. $E = \frac{1}{4\pi\epsilon_0} \frac{6q}{r^2}$, since $Q = +6q$

235 (a)

i. Small shell inner surface : $Q = 0$

ii. Small shell outer surface : $Q = +2q$

iii. Large shell inner surface : $Q = -2q$

iv. Large shell outer surface : $Q = +6q$

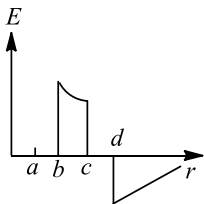
236 (a)

i. $r < a$. $E = 0$, since charge enclosed is zero

ii. $a < r < b$. $E = 0$, since charge enclosed is zero

iii. $b < r < c$. $E = \frac{1}{4\pi\epsilon_0} \frac{2q}{r^2}$, since charge enclosed is $+2q$

iv. $c < r < d$. $E = 0$, since charge enclosed is zero



v. $r > d$. $E = -\frac{1}{4\pi\epsilon_0} \frac{2q}{r^2}$, since charge enclosed is $-2q$

237 (a)

i. Small shell inner surface : $Q = 0$

ii. Small shell outer surface : $Q = +2q$

iii. Large shell inner surface : $Q = -2q$

iv. Large shell outer surface : $Q = -2q$

238 (a)

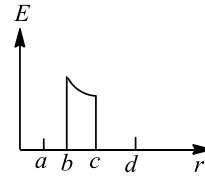
i. $r < a$. $E = 0$, since the charge enclosed is zero

ii. $a < r < b$. $E = 0$, since the charge enclosed is zero

iii. $b < r < c$. $E = \frac{1}{4\pi\epsilon_0} \frac{2q}{r^2}$, since the charge enclosed is $2q$

iv. $c < r < d$. $E = 0$, since the net charge enclosed is zero

v. $r > d$. $E = 0$, since the net charge enclosed is zero



239 (a)

i. Small shell inner surface : $Q = 0$

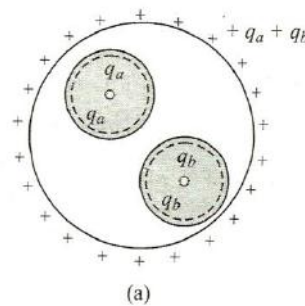
ii. Small shell outer surface : $Q = +2q$

iii. Large shell inner surface : $Q = -2q$

iv. Large shell outer surface : $Q = 0$

240 (b)

i. $\sigma_A = \frac{-q_a}{4\pi a^2}$, $\sigma_B = \frac{-q_b}{4\pi b^2}$, $\sigma_R = \frac{q_a + q_b}{4\pi R^2}$



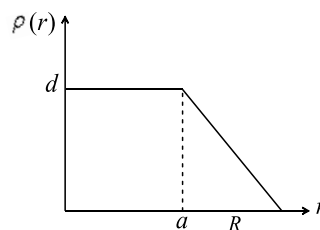
ii. $E = \frac{1}{4\pi\epsilon} \frac{q_a + q_b}{r^2}$

iii. $E_a = \frac{1}{4\pi\epsilon} \frac{q_b}{r^2}$

241 (a)

Electric field at $r = R$

$E = \frac{KQ}{R^2}$; $Q = \text{Total charge within the nucleus} = Ze$



So $E = \frac{KZe}{R^2}$

So electric field is independent of a

242 (1)

Consider a coplanar and concentric ring of radius x and radial thickness dx

Its area $ds = 2\pi x dx$

Distance of every point of this ring from the point charge is

$$r = \sqrt{a^2 + x^2}$$

Electric field at circumference of this ring is



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

Electric flux passing through this ring is

$$d\phi = \vec{E} \cdot \vec{ds} = (Eds \cos \theta)$$

$$d\phi = \left(\frac{1}{4\pi\epsilon_0} \frac{q}{(a^2 + x^2)} \right) 2\pi c dx \left(\frac{a}{\sqrt{(a^2 + x^2)}} \right)$$

Hence, total flux passing through this ring is

$$\begin{aligned} \phi &= \int_{x=0}^{x=R} \frac{aq}{2\epsilon_0} \frac{xdx}{(a^2 + x^2)^{3/2}} \\ &= \frac{qa}{2\epsilon_0} \left[\frac{1}{a} - \frac{1}{\sqrt{a^2 + R^2}} \right] \end{aligned}$$

Putting the values, we get

$$\phi = 1 \times 10^5 \text{ N/C}$$

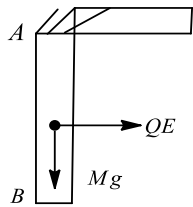
243 (3)

Electric field on the surface of the sphere should not exceed $3.0 \times 10^6 \text{ N/C}$. Therefore,

$$\begin{aligned} 9 \times 10^9 \times \frac{q}{(3 \times 10^{-3})^2} &= 3.0 \times 10^6 \Rightarrow q \\ &= 3 \times 10^{-9} \text{ C} \end{aligned}$$

244 (1)

After turning through 90° , the rod comes at rest momentarily. So there is no change in KE. Net work done by all the forces should be zero



$$QE \frac{L}{2} - Mg \frac{L}{2} = 0 \Rightarrow E = \frac{Mg}{Q}$$

245 (6)

$$E_1 = \frac{\rho \cdot R^2}{\epsilon_0 \cdot 4R}$$

$$E_2 = \frac{1}{4\pi\epsilon_0} \cdot \frac{\rho \cdot \frac{4}{3}\pi \cdot \frac{R^3}{8}}{(2R)^2}$$

$$E_1 - E_2 = \frac{\rho R}{4\epsilon_0} - \frac{\rho \cdot R}{\epsilon_0 \cdot 24 \times 4}$$

$$= \frac{\rho R}{4\epsilon_0} \left[1 - \frac{1}{24} \right]$$

$$= \frac{23\rho R}{96\epsilon_0} = \frac{23\rho R}{16k\epsilon_0}$$

$$\Rightarrow k = 6$$

246 (0)

Electric field at point A will be zero and at B will be non-zero. So the required ratio is 0

247 (2)

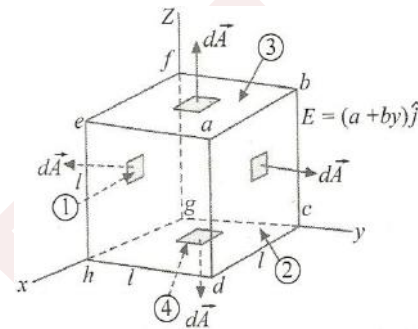
For the equilibrium of charge at $z = a$, the net electric field at this point due to both the ring should be zero

$$E_A + E_B = 0 \Rightarrow \frac{kq_A a}{(a^2 + a^2)^{3/2}} + \frac{kq_B a}{(b^2 + a^2)^{3/2}} = 0$$

Put the values and solve to get $b/a = 2$

248 (3)

The faces $adhe$, $bcgf$, $cdhg$ and $abfe$ will contribute zero flux because the area vector is normal to the electric field for these faces



$$\begin{aligned} \text{Flux through face } efgh, \phi_1 &= \int \vec{E} \cdot d\vec{A} \\ &= a(j) \cdot l^2(-j) = -al^2 \end{aligned}$$

As the field at the face $efgh$ (that lies in the yz plane, $y = 0$) is $E = a\hat{j}$ and area vector is $l^2(-\hat{j})$ (direction outwards normal)

Flux through face $abcd$:

$$\phi_2 = (a + bl)\hat{j} \cdot l^2\hat{j} = (al^2 + bl^3), \text{ for this } y = l$$

Net flux through the cube = $\phi_1 + \phi_2 = bl^3$

$$\text{From Gauss's law, } \phi = \frac{Q_{\text{enclosed}}}{\epsilon_0}$$

$$Q_{\text{enclosed}} = \epsilon_0 \phi = \epsilon_0 bl^3$$

After substituting the values $l = 1\text{ m}$ and $b = 3$, we get

$$Q_{\text{enclosed}} = \epsilon_0 \phi = 3\epsilon_0$$

249 (5)

$$\begin{aligned} W &= qE \times s \cos \theta \Rightarrow 1 = 0.2 E \times 2 \cos 60^\circ \\ &\Rightarrow E = 5 \text{ NC}^{-1} \end{aligned}$$

250 (2)

$$\rho = kr^a$$

$$E \left(r = \frac{R}{2} \right) = \frac{1}{8} E(r = R)$$

$$\frac{q_{\text{enclosed}}}{4\pi\epsilon_0 (R/2)^2} = \frac{1}{8} \frac{Q}{4\pi\epsilon_0 R^2}$$

$$32q_{\text{enclosed}} = Q$$

$$q_{\text{enclosed}} = \int_0^{R/2} kr^a 4\pi r^2 dr = \frac{4\pi k}{(a+3)} \left(\frac{R}{2} \right)^{(a+3)}$$



$$Q = \frac{4\pi k}{(a+3)} R^{(a+3)}$$

$$\frac{Q}{q_{\text{enclosed}}} = 2^{a+3} \Rightarrow 2^{a+3} = 32 \Rightarrow a = 2$$

251 (2)

$$a_1 = \frac{qE}{m} \text{ and } a_2 = \frac{qE}{2m} \Rightarrow a_1 = 2a_2$$

$$K_1 = \frac{1}{2} m_1 v_1^2 = \frac{1}{2} m_1 (a_1 t)^2, K_2 = \frac{1}{2} m_2 v_2^2 \\ = \frac{1}{2} m_2 (a_2 t)^2$$

$$\frac{K_1}{K_2} = \frac{m_1 a_1^2}{m_2 a_2^2} = \frac{m}{2m} \times \frac{4}{1} = \frac{2}{1}$$

252 (0)

$$W = q \int_{\vec{r}_A}^{\vec{r}_B} \vec{E} \cdot d\vec{r} = 1 \times \int_{(2,2)}^{(4,1)} (E_x dx + E_y dy)$$

$$= 1 \times \int_{(2,2)}^{(4,1)} (y dx + x dy) = \int_{(2,2)}^{(4,1)} d(xy)$$

$$= [xy]_{(2,2)}^{(4,1)} = 4 \times 1 - 2 \times 2 = 0$$

SENJEE

