PHYSICS

BOOKS - GK PUBLICATIONS PHYSICS (HINGLISH)

ELECTROSTATICS

Illustrative Example

1. Given a cube with point charges q on each of its vertices. Calculate the force exerted on any of the charges due to rest of the 7 charges.

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2. Two particles, each having a mass of 5 g and charge. 1.0×10^{-7} C, stay in limiting equilibrium on a horizontal. table with a separation of

10 cm between them. The coefficient of friction between each particle and the table. is the same. Find the value of this coefficient.

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3. Two particles A and B having charges q and 2q respectively are placed on a smooth table with a separtion d. A third partcle C is to be clamped on the table in such a way that the particles A and B remain at rest on the table undeer electrical forces. What should at rest on the table under electrical forces. What should be the charge on C and where should it clamped?

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4. Charges $5.0 \times^{-7} C$ and $1.0 \times 10^{-7} C$ are held fixed at the three cornners A, B, C of an equilateral

. charge at C due to the rest two.

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5. A particle a having a charge of $5.0 \times 10^{-7} C$ is fixed in. a vertical wall. A second particle B of mass 100 g and. having equal charge is supended by a silk thread. of length 30 cm form the wall. The point of suspension is. 30 cm above the particle A. Find the angle of the thread. with the vertical when it stays in equilibrium.

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6. Ten positively charged particles are kept fixed on the x-axis at points x=10cm, 20cm, 30cm, ..., 100cm. The first particle has a charge $1.0 \times 10^{-8} C$, the second 8×10^{-8} C, the third $27 \times 10(-8)$C and so on. The tenth particle has a charge $1000 \times 10^{-8} C$. find the magnitude of the electric force acting on a 1 C charge placed at the origin.

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7. Two positive charges q_1 and q_2 are located at the points with redius vectors r_1 and r_2. Find a negative charge q_s and a radius vector r_s of the point at which it has to be placed for the force acting on each of the three charges to be equal to zero.

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8. Three small balls, each of mass 10 gm are suspended separately from common point. by silk threads, each one meter long. The balls are identically charged and hang at the corners of an equilateral triangle of side 0.1. metre. Find the charge on each ball?

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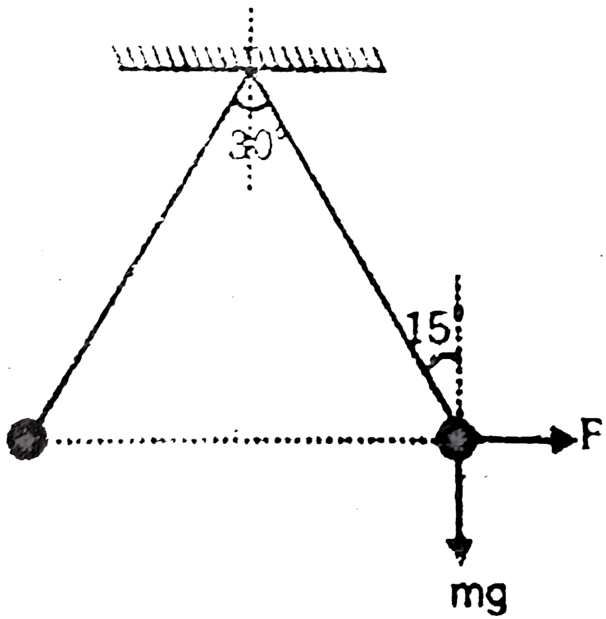
9. Two identically charged spheres are suspended by strings of equal length. The strings make an angle of 30° with each other. When suspended in a liquid of density $0.8g/cc$ the angle remains same. What is the dielectric constant of liquid. Density of sphere $= 1.6g/cc$



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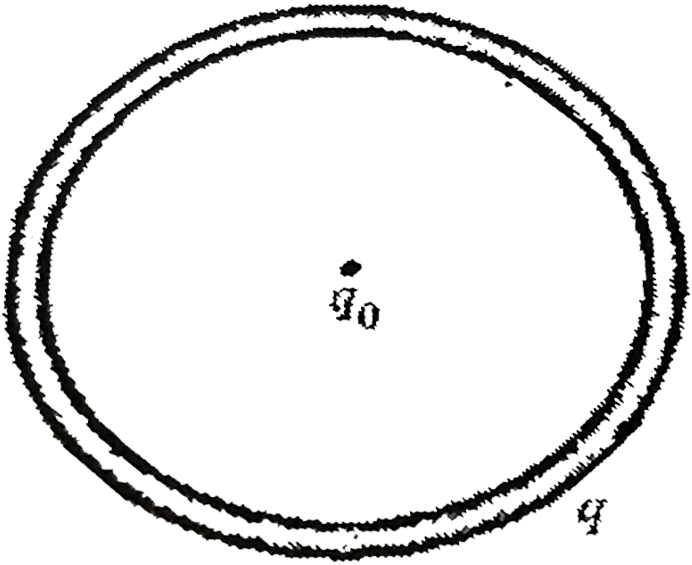
10. A ring of radius R with a uniformly distributed charge q as shown in figure. A charge q_0, is now placed at the centre of the ring. Find the increment in-the tension in ring.



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11. Four small particles charged with equal positive charges Q each are arranged at the four corners of a horizontal square of side a. A unit positive charge mass m is placed at a point P, at a height h above the centre of the square. What should be the magnitude of charge Q in order that the unit charge remain in equilibrium

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12. Two small particles charged with equal positive charges Q each, are fixed apart at a distance 2a. Another small particle having a charge q lies midway between the fixed charges. Show that

(i) For small displacement (relative to a) along line joining the fixed charges, the middle charge executes SHM'if it is +ve and

(ii) For small lateral displacement, it executes SHM ifit is-ve. Compare the frequencies of oscillation in the two cases

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13. A wooden ball covered with an aluminimum foil having a mass m hangs by a fine silk thread l metre long in a horizontal electric field E. When the ball is given an electric charge q coulomb, it stands out d metre from the vertical line passing through !he · suspension point of thread. Show that the electric field is given by

$$E = \frac{mgd}{\sqrt{l^2 - d^2}}$$

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14. A particle of mass m and charge q is thrown with initial velocity v_0 at an angle with the horizontal. In space there exist an electric field of strength E at angle β with the downward vertical away from the point of projection. Find the time of flight and range of projectile on horizontal ground

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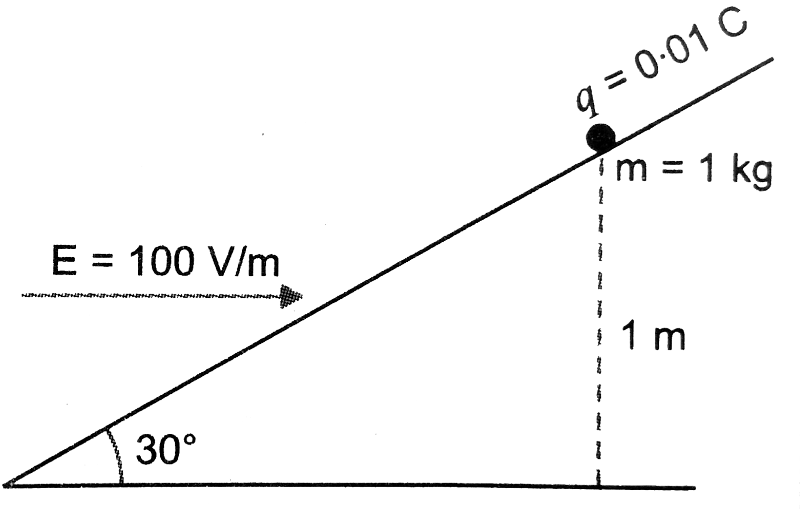
15. An inclinded plane making an angle of 30° with the horizontal electric field of $100Vm^{-1}$ as shown in Figure. A particle of mass $1kg$ and charge $0 \cdot 01C$ is allowed to slide down from rest from a height of $1m$. If the coefficient of friction is 0.2, find time taken by the particle to reach the bottom.



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16. A ball of mass m with a charge q can rotate in a vertical plane at the end of a string of length l in a uniform electrostatic field whose lines of force are directed upwards. What horizontal velocity must be imparted to the ball in the upper position so that the tension in the string in the lower position of the ball is 1.5 times than the weight of the ball?

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17. A simple pendulum has a bob of mass m = 40 gm and a positive charge $q = 4 \times 10^{-6} C$. It makes 20 oscillation in 4.5 s. A vertical upward electric field of magnitude $E = 2.5 \times 10^4 N/C$ is switched on in space. How much time will the simple pendulum will now take to complete 20 oscillation.

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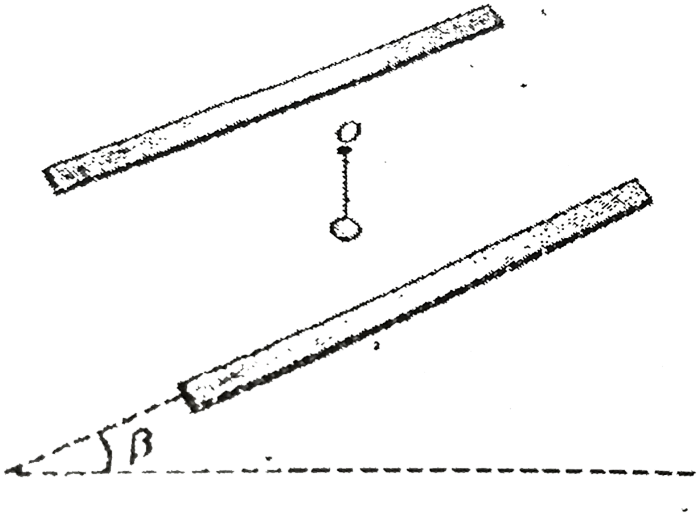
18. A bob of mass m carrying a positive charge q is suspended from a light insulating string of length l inside a parallel plate capacitor with its plates making an angle β with the horizontal as shown in figure. The plates of the capacitor are connected with a battery to establish an electric field E between the plates with its upper plate negatively charged. Find the period of small oscillations of the pendulum and the angle between the thread and vertical in equilibrium position of

the bob



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19. A rectangular tank of mass m_0 and charge Q is placed over a smooth horizontal floor. A horizontal electric field£ exist in the region. Rain drops are falling vertically in the tank at the constant rate of n drops per second. Mass of each drop is m. Find velocityoftank as function of time.

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20. Four particles each having a charge q are placed on the four vertices of a regular pentagon. The distance of each comer from !be centre is 'a'. Find the electric field at the centre of pentagon.

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21. In the given arrangement of a charged square frame made up of four wires 1, 2, 3 and 4 charged witb the linear charge density as mentioned in figure. Find electric field at centre due to this frame

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22. A system consits fo a thin charged wire ring of radius R and a very long uniformly charged thread oriented along the axis of the ring, with one of its ends coinciding with the centre of the ring. The total charge of the ring, with one of the ring so equal to q. The charge of the thread (per unit length) is equal to λ. Find the interaction froce between the ring and the thread.

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23. A point charge q is located at the centre fo a thin ring of radius R with uniformly distributed charge $-q$, find the magnitude of the electric field strength vectro at the point lying on the axis of the ring at a distance x from its centre, if $x > > R$.

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24. A thin fixed of radius 1 metre has a positive charge 1×10^{-5} coulomb uniformly distributed over it. A particle of mass 0.9 gm and having a negative charge of 1×10^{-6} coulomb is placed on the axis at a distance of 1cm from the centre of the ring. Show that the motion of the negatively charged particle is approaximately simple harmonic. Calculate the time period of oscillations.

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25. A clock face has charges $-q, -2q, , \ldots . -12q$ fixed at the position of the corresponding numerals on the dial. The clock hands do not disturb the net field due to point charges. At what time does the hour hand point in the direction of the electric field at the centre of the dial.

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26. Consider the classical model of an electron such that a nucleus of charge +e is uniformly distributed within a sphere of radius2Å. An electron of charge -e at a radial distance 1Å moves inside this sphere. Find the force a!tracting the electron on to the centre of the sphere.

Calculate the frequency with which the electron would oscillate about the centre of the sphere, if released from rest at this radial distance.

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27. A positive charge q is placed in front of conducting solid cube at a distance d from its centre. Find the electric field at the centre of the cube due to the charges appearing on its surface.

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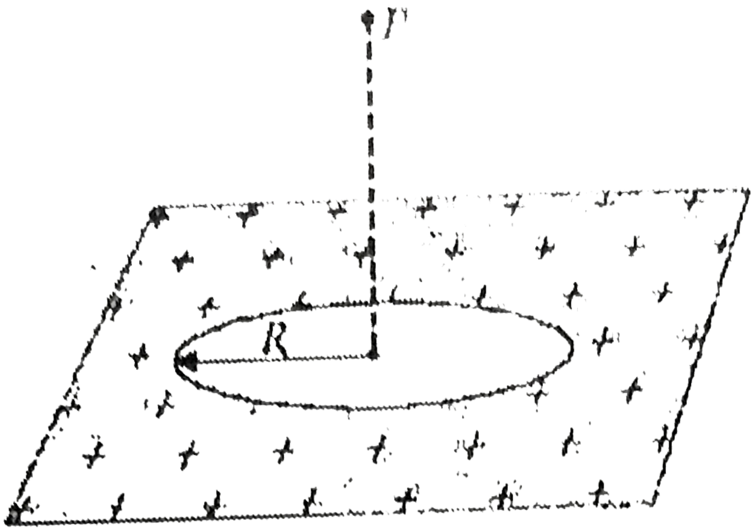
28. A large nonconducting surface has a uniform charge density σ. A small circular hole ofradius R is cut in the middle of the sheet, as shown in figure. Ignore fringing of the field lines around all edges calculate the electric field at' pointP, a distancez from the centre of the hole along its axis.



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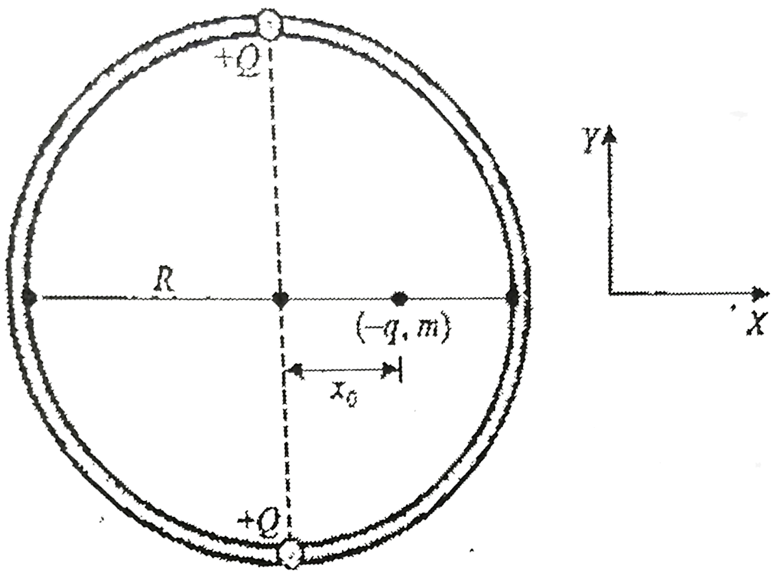
29. A thin insulating wire is stretched·along the diameter of an. insulated circular hoop of radius R. A small bead of mass m and charge-q is threaded onto the wire. Two small identical charges are tied to the hoop at points opposite to each other, so that the diameter passing through them is perpendicular to the thread as shown in figure. The bead is released at a point which.is located at a distance x_0 from the centre of the hoop. Assume that $x_0 < < R$.

(a) What is the resultant force acting on the charged bead?

(b) Describe the motion of the bead after it is released X

(c) Use the assumption that $\frac{x}{R} < < 1$ to obtain an approximate equation of motion, and find the displacement and velocity of the bead as functions of time

(d) When will the velocity of the bead will bcome zero for the first time?



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30. An infinitely long cylindrical shell ofinner radius r_1 and outer radius r_2 is charged in its volume with a volume charge density which varies with distance from axis of cylinder as $p = blrC / m^3$ which C is a positive constant and r is the distance from axis of cylinder. Find the electric field intensity at a point P at a distance x from axis of cylinder

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31. An infinitely long cylindrical surface density $\sigma = \sigma_0 \cos \varphi$. Where φ is the polar angle of the cylindrical coordinate system whose z axis coincides with the axis of the given surface. Find the magnitude and direction of the electric field strength vector on the z axis.

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32. A thin nonconducting ring of radius R has a linear charge density $\lambda = \lambda_0 \cos\varphi$, where λ_0 is a constant , ϕ is the azimutahl angle. Find the magnitude of the electric field strength

(a) at the centre of the ring ,

(b) on the axis of the ring as a function of the distance x from its centre. Investegation the obtained function at $x > \; > R$.

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33. A ball of radius R carries a positive charge whose volume density depends only on a separation r from the ball's centre as $\rho = \rho_0(1 - r/R)$, where ρ_0 is a constant. Asumming the permittivites of the ball and the enviroment to be equal to unity find :

(a) the magnitude of the electric field strength as a function of the distance r both inside and outside the ball :

(b) the maximum intensity $E_{\max}$ and the corresponding distance r_m.

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34. A point charge $q_1 = 4.00nC$ is placed at the origin, and a second point charge $q_2 = -3.00nC$, placed on the x-axis at x = + 20.0 cm. A third point charge $q_3 = 2.00nC$ is placed on the X-axis between q_1, and q_2. (Take as zero the potential energy of the three charges when they are infinitely far apart).

(a) What is the potential energy of the system of the three charges if q_3 is placed at x= + 10.0 cm?

(b) Where should q_3 be placed to make the potential energy of the system equal to zero?

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35. A particle of mass $400mg$ and charged with $5 \times 10^{-9}C$ is moving directly towards a fixed positive point charge of magnitude $10^{-8}C$. When it is at a distance of 10 cm from the fixed positive point charge it has a velocity of 50 cm/s. At what distance from the fixed point charge will the particle come momentarily to rest ? Is the acceleration constant during the motion ?

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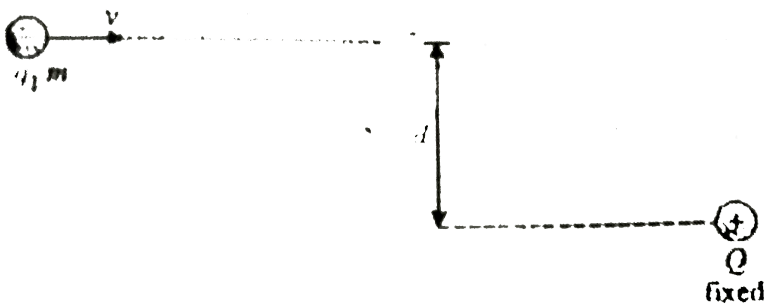
36. Figure shows a charge +Q clamped at a point in free space. From a large distance another charge particle of charge -q an.d mass m is thrown toward +Q with an impact parameter d as shown with speed v. Find the distance of closest approach of the two particles.



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37. A particle of mass 40 mg and carrying a charge $5 \times 10^{-9} C$ is moving directly towards a fixed positive point charge on magnitude $10^{-8} C$. When it is at a distance of 10 cm from the fixed positive point charge it has a velocity of $50 cms^{-1}$ at what distance from the fixed point charge will the particle come momentarily to rest ? Is the acceleration constant during motion?

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38. Three point charges q, 2q and 8q are to be placed on a

. 9cm long straight line. Find the

. positions where the charges shouldbe placed such that the potential energy

. of this sysrem is minimum. In this situation, what is the

. electric field at the charge q due to the other two charges?

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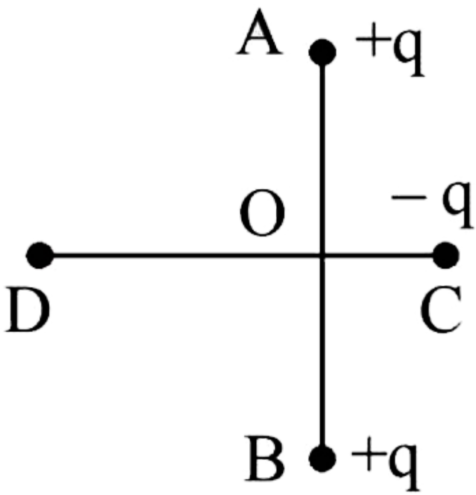
39. Two fixed, equal, positive charges, each of magnitude 5×10^{-5} coul are located at points A and B separated by a distance of 6m. An equal and opposite charge moves towards them along the line COD, the perpendicular bisector of the line AB.

The moving charge, when it reaches the point C at a distance of 4m from O, has a kinetic energy of 4 joules. Calculate the distance of the farthest point D which the negative charge will reach before returning towards C.



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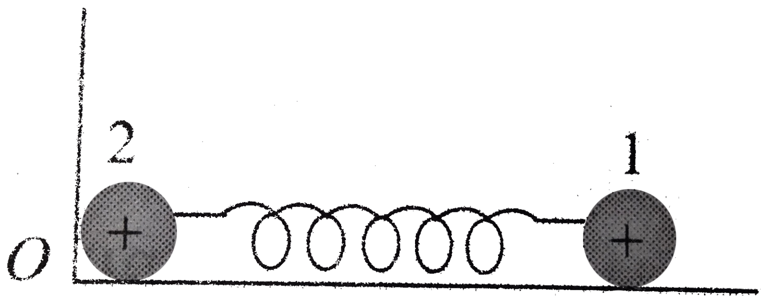
40. Two small identical balls lying on a horizontal plane are connected by a weightless spring. One ball (ball 2) is fixed at O, and the other (ball 1) is free. The balls are charged identically as a result of which the spring length increases $\eta = 2$ times. Determine the change in frequency.



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41. A small particle has charge $-5.00\mu C$ and mass $2.00 \times 10 - 4$ kg. It moves from point A where the electric potential is $V_A = +200V$. to point B, where the electric potential is $V_B = +800V$. The electric force is the only force acting on the particle. The particle has speed

$5.00\frac{m}{s}$ at point A. What is its speed at point B? is it moving faster or slower at B than at A. Explain,

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42. A particle having a charge$+3 \times 10^{-9C}$ is placed in a uniform electric field directed toward left. It is released from rest and moves a distance of 5 cm after which its kinetic energy is found to be $4.5 \times 10^{-5} J.$

(a) Calcnalate the work done by the electrical force on the particle

(b) Calculate the magnitude of the electric field.

(c) Calculate the potential of starting point with respect to the end point of particle's motion.

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43. An electric field $\overrightarrow{E} = \overrightarrow{I} Ax$ exists in the space, where $A = 10Vm^{-2}$. Take the potential at (10m, 20m) to be zero. Find the potential at the origin.

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44. Find V_{ba}, if $12J$ of work has to be done against an electric field to take a charge of 10^{-2} C from a to b.

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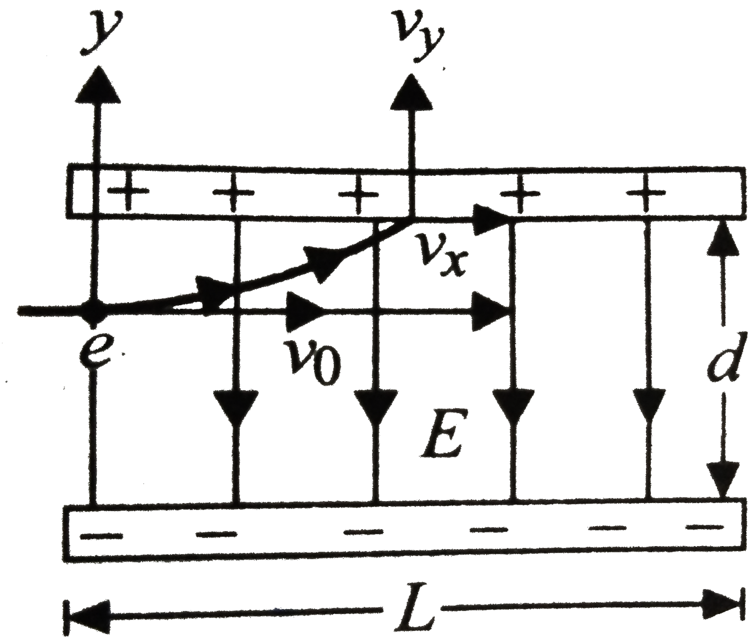
45. A particle of mass 9×10^{-31} kg having a negative charge of $1.6 \times 10^{-19}C$ is projected horizontally with a velocity of $10^6 ms^{-1}$ into a region between two infinite horizontal parallel plates of metal. The distance between the plates is $d = 0.3cm$ and the particle enters 0.1cm below the top plate, THe top and bottom plates are connected, respectively to the positive and negative terminal of a 30V

battery. Find the components of the velocity of the particle just before it hits one of the plates.



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46. There are two large parallel metallic plates S_1 and S_2 carrying surface charge densities σ_1 and σ_2 respectively $(\sigma_1 > \sigma_2)$ placed at a distance d apart in vacuum. Find the work done by the electric field in moving a point charge q at distance $a(a < d)$ from S_1 towards S_2 along a line making an angle $\pi / 4$ with the normal to the plates.

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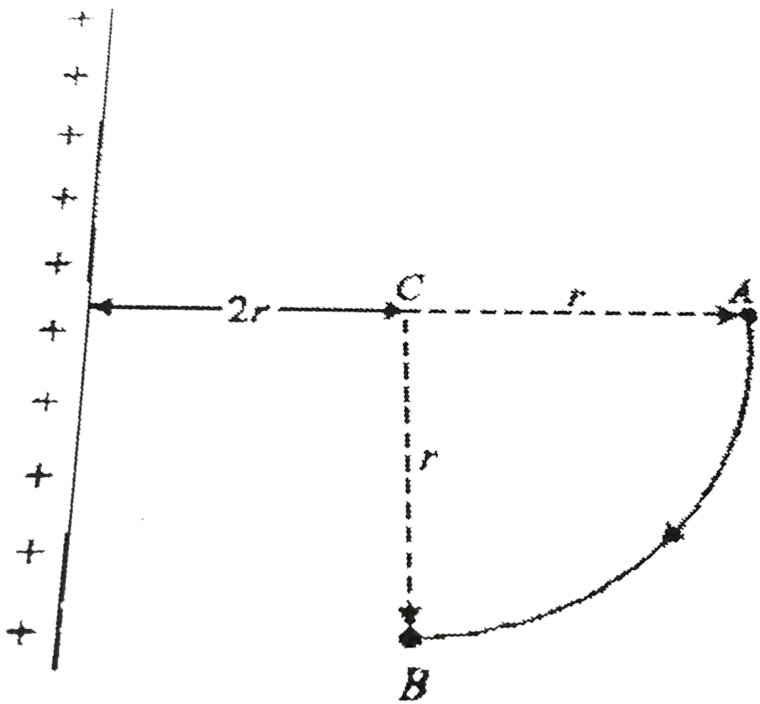
47. A charge q_0 is transported from point A to B along the arc AB with centre at C as shown in figure near a long charged wire with linear density A. lying in the same plane. Find the work done in doing so.



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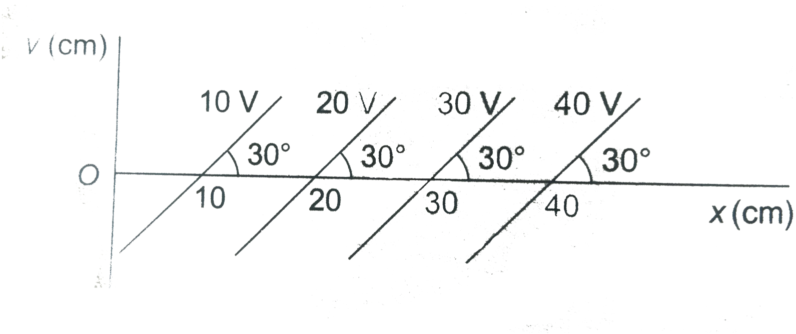
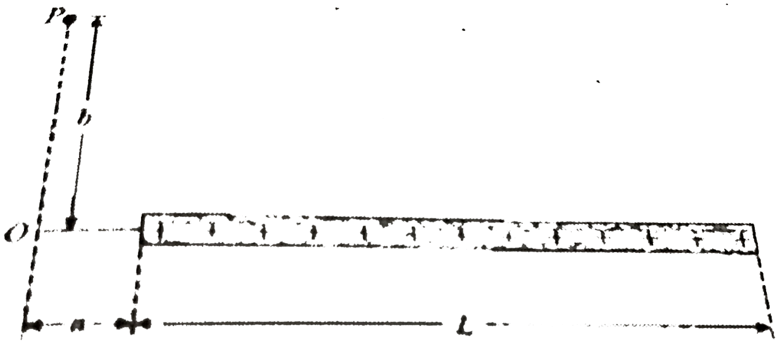
48. Some equipotential surfaces are shown in figure . The magnitude and direction of electric field is



49. Calculate the potential due to a thin uniformly charged rod of length L at the poiot P shown in figure. The lioear charge density of the rod is $\lambda C / m$



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50. Two charges $-2Q$ abd Q are located at the points with coordinates $(-3a, 0)$ and $(+3a, 0)$ respectively in the x-y plane. (i) Show that all points in the x-y plane where the electric potential due to the charges is zero, on a circle. Find its radius and the location of its centre (ii) Give the expression V(x) at a general point on the x-axis and sketch the function V(x) on the whole x-axis. (iii) If a particle of charge +q starts from rest at the centre of the circle, shown by a short quantitative argument that the particle eventually crosses the circle. Find its speed when it does so.

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51. There is an infinite straight chain of alternating charges q and -q. The distance between the two neighbouring charges is equal to a. Find the interaction energy of any charge with all the other charges.

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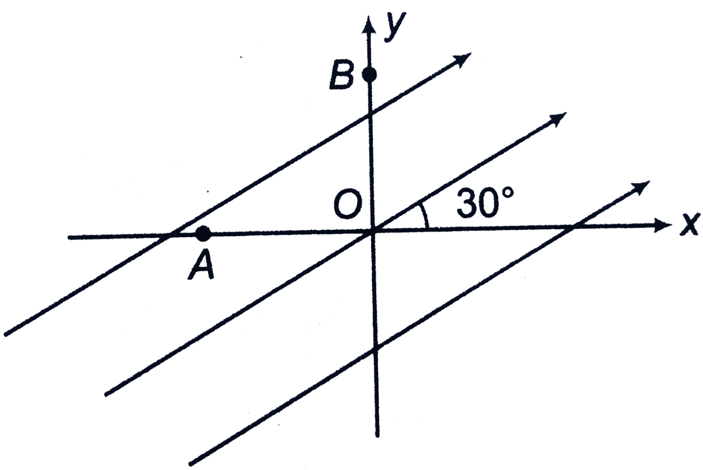
52. A uniform electric field of $100 V / m$ is directed at 3° with the positive x-axis as shown in figure. Find the potential difference V_{BA} if $OA = 2$m and $OB = 4m$.



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53. The potential at a point in space depends only upon the x-coordinate and it is given as

$V = \frac{1000}{x} + \frac{1500}{x^2} + \frac{500}{x^3}$ Determine the electric field strength at point where $x = 1m$.

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54. Determine the electric field strength vector in a region if in space the potential of this field depends on x and y coordinates as $V = a(x^2 - y^2)$.

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55. A charge Q is distributed over two concentric hollow spheres of radii r and $R(> r)$ such that the surface charge densities are equal. Find the potential at the common centre.

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56. A conducting liquid bubble of radius a and thickness $t(t < \; < a)$ is charged to potential V. If the bubble collapses to a droplet , find the potential on the droplet .

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57. Find the electric field potentail and strength at the centre of a hemisphere fo raidus R ahcged uniformly with the the surface density σ.

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58. On a thin rod oflength $l = 1m$, lying along the x-axis with one end at the origin x = 0, there is uniformly distributed charge per unit length $\lambda = Kx$, where K =constant $= 10^{-9} cm^{-2}$ Find the work done in displacing a charge $q = 1000 \mu C$ from a point $(0, \sqrt{0.44m} \text{to} (0, Im))$.

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59. A spherical drop of water carrying a charge of $3 \times 10^{-10} C$ has potential of 500V at its surface. When two such drops having same charge and radius combine to from a single spherical drop, what is the potential at the surface of the new drop?

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60. Find the potential of an isolated ball-shaped conductor with a charge q of radius R_1 surrounded by an adjacent concentric layer of dielectric with dielectric constant k and outer radius R_2

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61. Three concentric spherical metallic shells A, B and C of radii a, b and c (a lt b ltc) have surface charge densities σ, $-\sigma$ and σ respectively.

`(i) Find the potential of the three shells A, B and C.

(ii) If the shells A and C are at the same potential, obtain the relation between the radii a, b and c.

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62. A short electric dipole is situated at the origin of coordinate axis with its axis along x-axis and equator along y-axis. It is found that the magnitudes of the electric intensity and electric potential due to the dipole are equal at a point distance $r = \sqrt{5}m$ from origin. Find the position vector of the point in first quadrant.

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63. Prove that the frequency of oscillation of an electric dipole of moment p and rotational inertia I for small amplitudes about its equilibrium position in a uniform electric field strength E is $\frac{1}{2\pi}\sqrt{\left(\frac{pE}{I}\right)}$

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64. A particle of mass m and charge $+q$ is located midway between two fixed charged particles each having a charge $+q$ and at a distance 2L apart. Assuming that the middle charge moves along the line joining the fixed charges, calculate the frequency of oscillation when it is displaced slightly.

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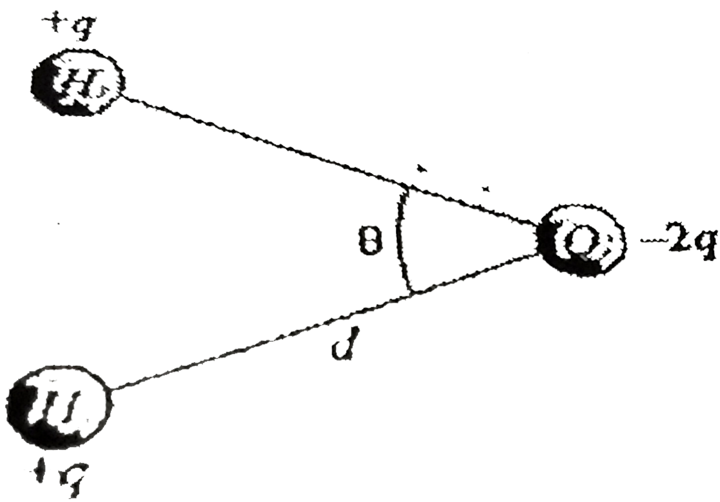
65. A water molecule is placed at a distance l from the line carrying linear charge density λ . Find the maximum force exerted on the water molecule. The shape of water molecule and the partial charges on Hand O atoms are shown in figure



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66. Two thin parallel threads carry a uniform charge with linear densities λ and $-\lambda$. The distance between the threads is equal to l. Find the potential of the electric field and the magnitude of its strength vector at the distance $r > \; > l$ at the angle θ to the vector 1 (fig).

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67. Show that, for a given dipole, V & E cannot have the same magnitude at distance less than 2m from the dipole. Suppose that the distance is $\sqrt{5}m$, determine the directions along which V & E are equal in magnitude.

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68. A closed cylinder is placed in uniform electric field E parallel to the axis of the cylinder. Find electric flux passing through cylinder.

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69. The electric field in a region is given by $E = a\hat{i} + b\hat{j}$. Hence as and b are constants. Find the net flux passing through a square area of side I parallel to y-z plane.

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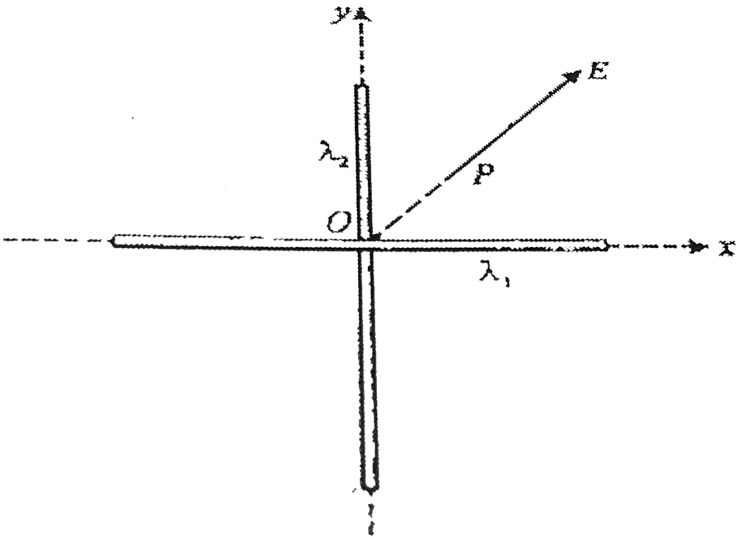
70. Two mutually perpendicular infinite wires along x-axis and y-axis carry charge densities λ_1 and λ_2 (see figure). The 1 electric line of force at P is along the line $y = \frac{1}{\sqrt{3}}x$, where P is also a point lying on the same line, then find λ_1 / λ_2



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71. Find the electric flux coming out from one race of a cube of edge a, centre of which a point charge q is placed

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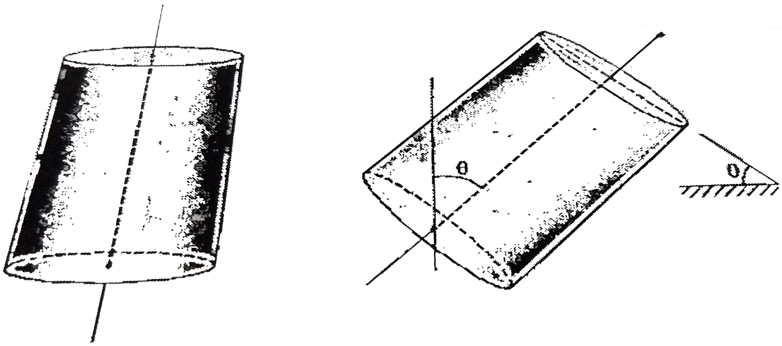
72. The cylinder of previous example is now tilted by an angle θ from vertica. Find the flux crossing the cylinder.



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73. The electric fields in a region is given by $\overrightarrow{E} = E_0 \frac{x}{L} \hat{i}$,Find the charge contained inside a cubical volume bounded by the surface $x = 0, x = L, y = 0, y = L, z = 0, z = L.$

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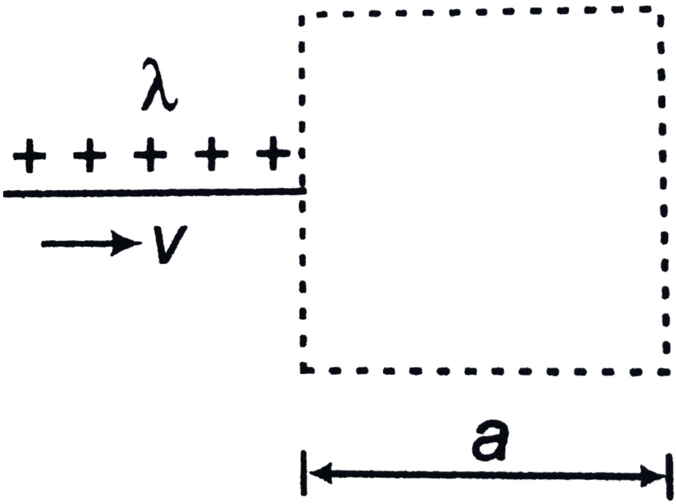
74. Figure shows an imaginary cube of side a. A uniformly charged rod of length a moves towards right at a constant speed v. At $t = 0$ the right end of the just touches the left face of the cube. Plot a graph between electric flux passing through the cube versus time.



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75. The field potentail in a certain region of space depends only on the x coordinate as $\varphi = -ax^2 + b$, where a and b are constants. Find the distribution of the space charge $\rho(x)$.

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76. The electrostatic potential inside a charged spherical ball is given by $\phi = ar^2 + b$ where r is the distance from the centre and a, b are constants. Then the charge density inside the ball is:

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77. The intensity of an electric field depends only on the coordinates x and y as follows,

$E = \frac{a\left(x\hat{i} + y\hat{j}\right)}{x^2 + y^2}$ where, a is constant and $\hat{i}$ and $\hat{j}$ are the unit vectors of the x and y axes. Find the charges within a sphere of radius R with the centre at the origin.

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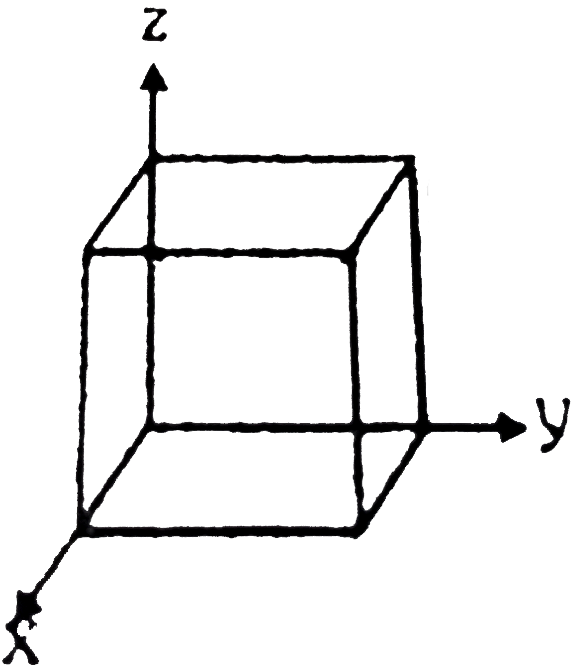
78. Electric field in a region is given by $\overrightarrow{E} = -4x\hat{i} + 6y\hat{j}$. The charge enclosed in the cube of side $1m$ oriented as shown in the diagram is given by $\alpha \in_0$. Find the value of α.



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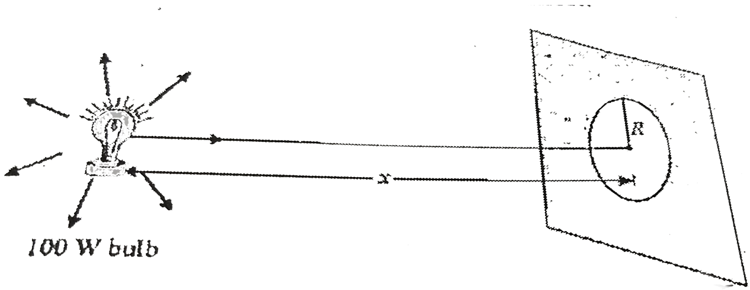
79. A point light source of $100W$ is placed at a distance x from the centre ofa hole ofradius R in a sheet as shown in figure, Find the power passing through the hole in sheet



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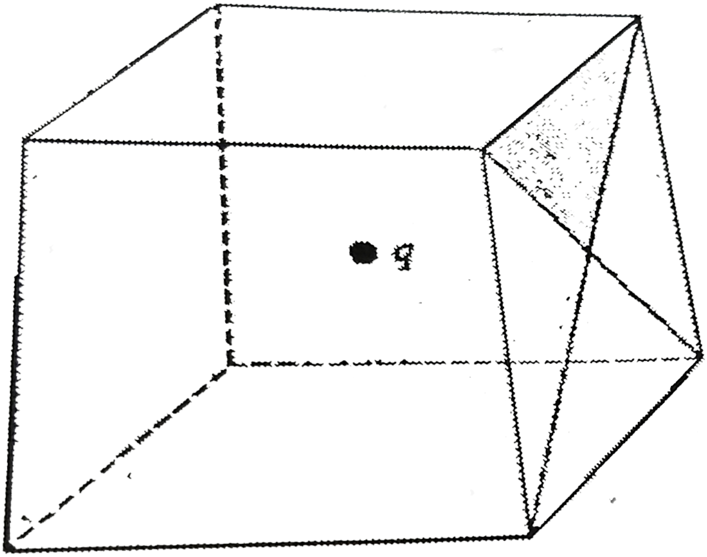
80. A point charge q is placed at the centre of the cubical box. Find, (a) total flux associated with the box (b) flux emerging through each face of the box (c) flux throngh shaded area of surface



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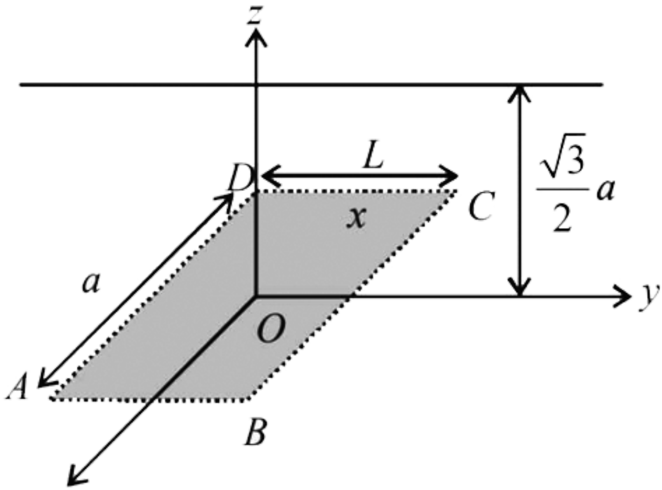
81. An infinity long uniform line charge distribution of charge per unit length λ lies parallel to the y-axis in the $y-z$ plane at $z=\frac{\sqrt{3}}{2}$ a(see figure). If the magnitude of the flux of the electric field through the rectangular surface ABCD lying in the $x-y$ plane with its centre at the origin is $\frac{\lambda L}{\neq \psi lon_0}$ ($\varepsilon_0 =$ permittivity of free space), then the value of n is



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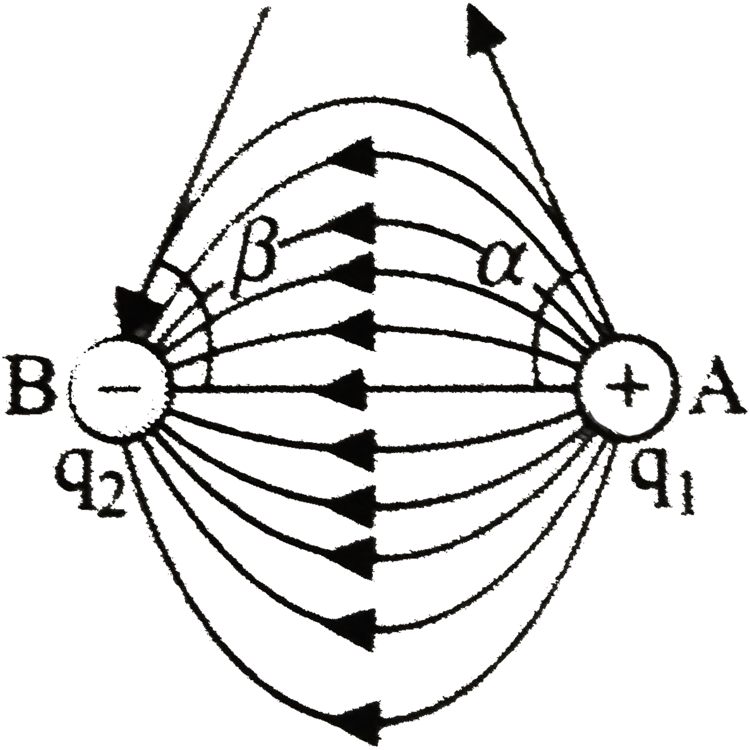
82. Two charges $+q_1$ and $-q_2$ are placed at A and B respectively. A line of force emanates from q_1 at an angle α with the line AB. At what angle will it terminate at $-q_2$?



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83. A point charge q is placed on the top of a cone of semi vertex angle θ. Show that the electric flux through the base of cone is $\frac{q(1-\cos\theta)}{2\varepsilon_0}$

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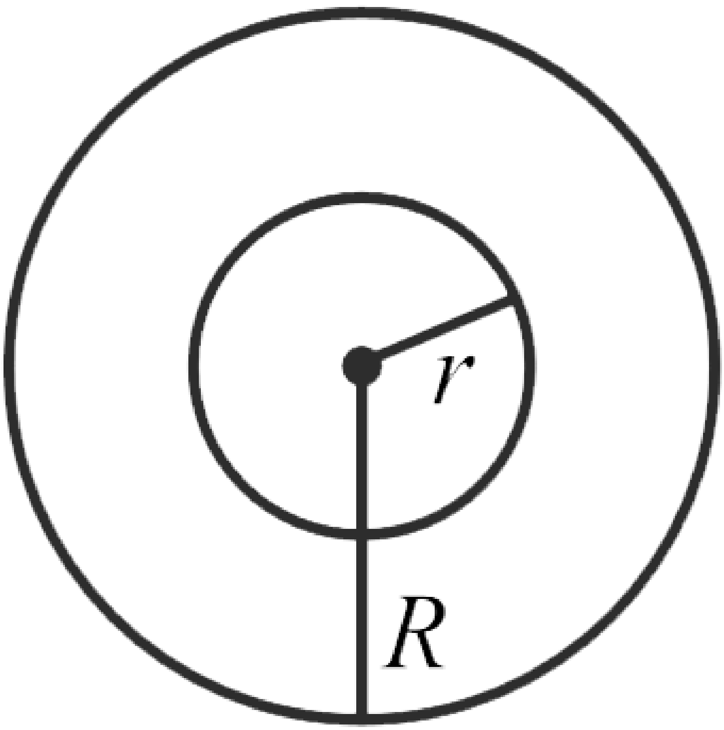
84. A soap bubble of radius r is formed inside another soap bubble of radius $R(> r)$. The atmospheric pressure is P_0 and surface tension of the soap solution is T. Calculate change in radius of the smaller bubble if the outer bubble bursts. Assume that the axcees pressure inside a bubble is small compared to P_0.



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85. A soap bubble of radius r and surface tension T is given a potential V. Show that the new radius R of the bubble is related with the initial radius by the equation $P(R^3 - r^3) + 4T(R^2 - r^2) = \frac{\in_0 V^2 R}{2}$ where P is the atmospheric pressure.

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86. The minimum strength of a uniform electric field which can tear a conducting uncharged thin-walled sphere into two parts is known to be E_0. Determine the minimum electric field strength E_1 required to tear the sphere of twice as large radius if the thickness ofits walls is the same as in the former case.

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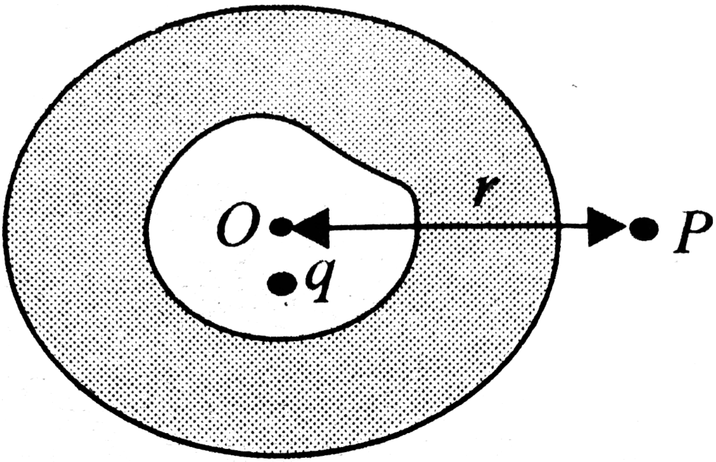
87. The point charge q is within the cavity of an electrically neutral conducting shell whose outer surface has spherical shape. Find the potential V at a point P lying outside the shell at distance r from the center O of the outer sphere.



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88. A charge Q is placed at the centre of an uncharged, hollow metallic sphere of radius a. (a) Find the surface charge density on the inner surface and on the outer surface. (b) If a charge q is put on the sphere, what would be the surface charge densities on the inner and the outer surface? (c) Find the electric field inside the sphere at a distance x from the centre in the situations (a) and (b).

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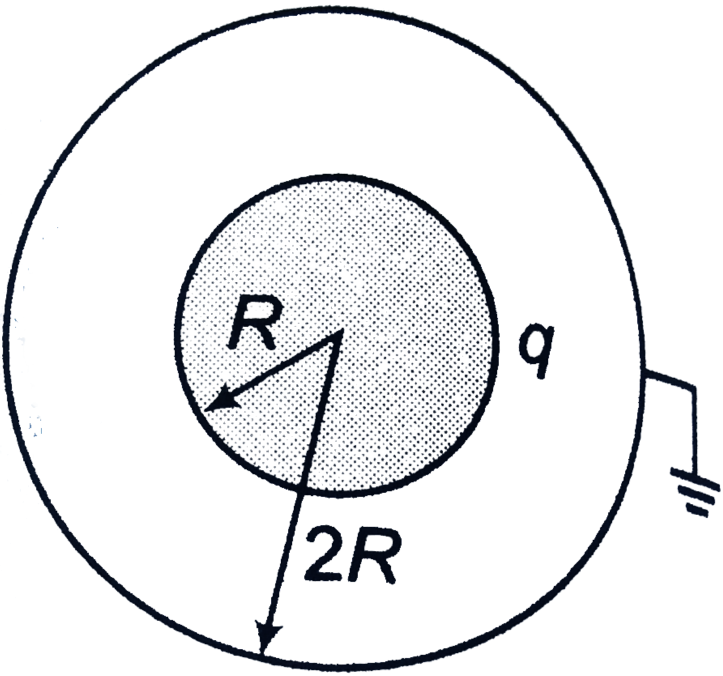
89. A charge q is distributed uniformly on the surface of a sold sphere of radius R. It covered by a concentric hollow conduction sphere of radius $2R$. Find the charges inner and outer surface of hollow sphere if it is earthed.



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90. There are four concentric shells A,B, C and D of radii a, $2a$, $3a$ and $4a$ respectively. Shells B and D are given charges $+q$ and $-q$ respectively. Shell C is now earthed. The potential difference $V_A - V_C$ is $k = \left(\frac{1}{4\pi\varepsilon_0}\right)$

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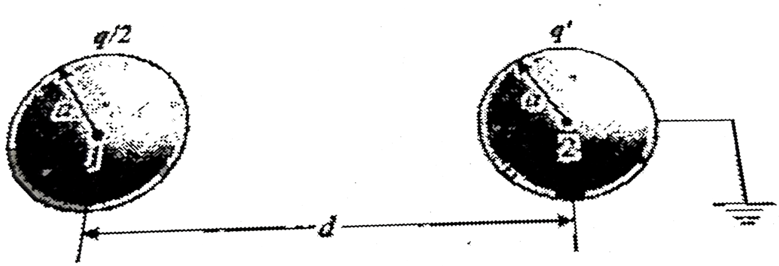
91. There are two uncharged identical metallic spheres of radius a, separated a distance d. A charged metallic sphere (charge q) of sarue radius is brought and touches sphere 1. After some time it is moved away to a far off distance. After this, the sphere 2 is earthed. Find the charge on sphere 2.



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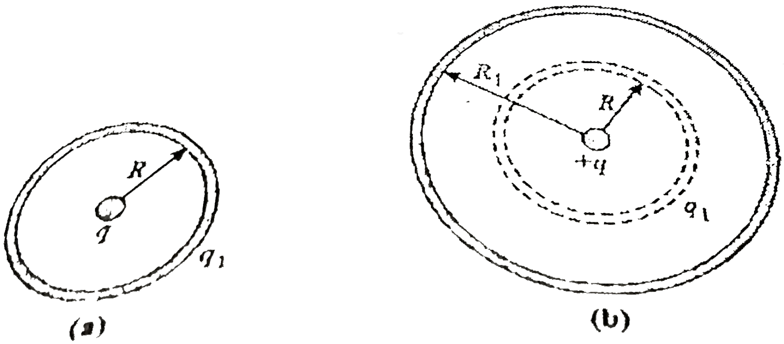
92. Figure (a) shows a shall of radius R having charge q_1 uniformly distributed over it. A point charge q is placed at the centre of shell. Find amount of work required to increase the radius of shell from R to R_1 as shown in figure (b).



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93. Find the electrostatic energy stored in a cylindrical shell of length l, inner radius a and outer radius b, coaxial with a uniformly charged wire with linear charge density $\lambda C / m$.

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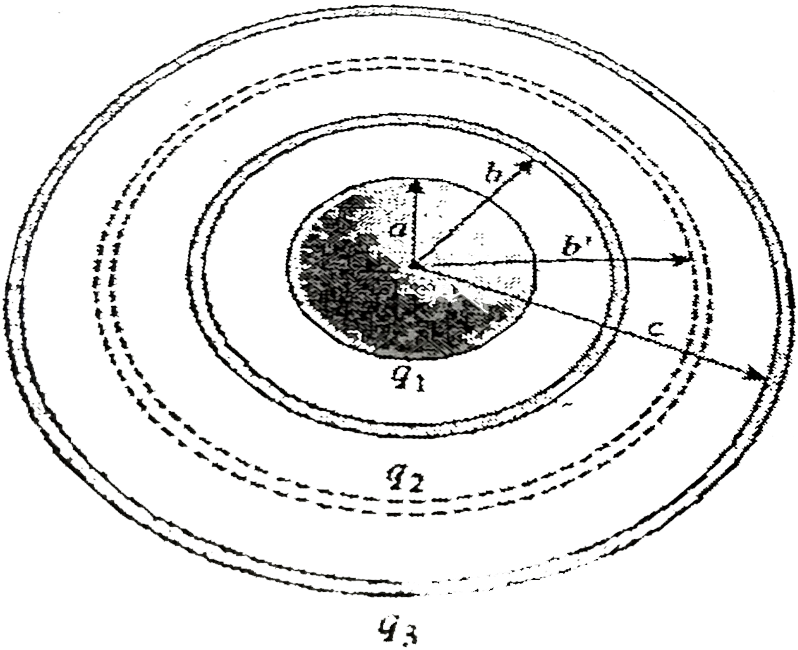
94. Three shells are shown carrying charge q_1, q_2 and q_3 and of radii a, band c respectively. If the middle shell expands from radius b to

$b'(b' < c)$. Find the work done by electric field in process.



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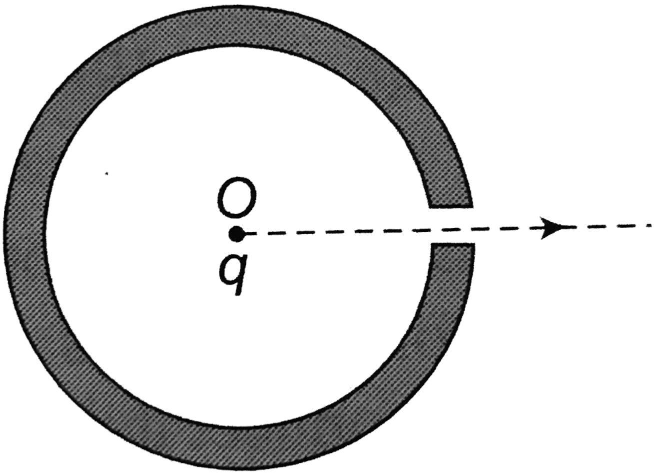
95. A point charge q is located at the centre O of a spherical uncharged coducting layer provided with small orifice. The inside and outside radii of the layer are equal to a and b respectively. The amount of work that has to be performed to slowly transfer the charge q from teh point O through the orifice and into infinity is



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Partice Exercise 1.1

1. Two identical pith balls are charged by rubbing against each other. They are suspended from a horizontal rod through two strings of length 20 cm each, the separation between the susjpension points being 5 cm. in equilibrium, the separation between the balls in 3 cm.

Find the mass of each ball and the tension in the strings. the charge on each ball gas a magnitude $2.0 \times 10^{-8} C$.

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Partice Exercise

1. Two positively charged small particles, each of mass $1.7 \times 10^{-27} kg$ and carrying a charge of $1.6 \times 10^{-19} C$ are placed apart at a separation r. If each one experiences a repulsive force equal to its weight find their separation. [0.117 m]

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2. Two particles (free to move) with charges $+q$ and $+4q$ are a distance L apart. A third charge is placed so that the entire system is in equilibrium.

(a) Find the location, magnitude and sign of the third charge.

(b) Show that the equilibrium is unstable.

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3. A charge Q is to be divided on two objects. What shouold. be the values of the charges on the objects so that the. force between the objects can be maximum?.

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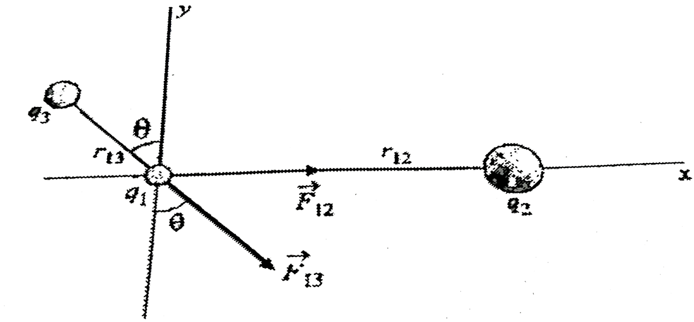
4. Three charges q_1, q_2 and q_3 are shown in figure . Determine the net force acting on charge q_1 . The charges and separation are given as $q_1 = -1.0 \times 10^{-6} C, q_2 = +3.0 \times 10^{-6} C,$ and

$q_3 = -2.0 \times 10^{-6} C, r_{12} = 15 cm, r_{13} = 10 cm$ and $\theta = 30^{\circ}$.



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5. Three Charges of magnitude $100 \mu C$ are placed at the corners A, Band C ofan equilateral triangle of side 4m. If the charge at A and Care positive and the one at point B is negative, what is the magnitude and direction of total force acting on charge at C? $[5.625 N]$

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6. Two negative charges of a unit magnitude and a positive charge q are placed along a straight line. At what position and value of q will the system be in equilibrium? (Negative charges are fixed).

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7. A charges Q is placed at each of the two opposite corners of a square. A charge q is placed to each of the other two corners. If the resultant force on each charge q is zero, then

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8. Two balls of the same radius and weight are suspended on threads so that their surface are in contact. A charge of $q_0 = 4 \times 10^{-7} C$ is given to the balls which makes them repel each other and diverge to an angle of 60°. Find the mass of the balls if the distance of balls from the point of suspension to the centre of ball is 20cm. Find the density of the material of the balls if the angle of divergence becomes 54° when the balls are immersed in kerosene of density $800 kgm^{-3}$ dielectric constant ofkerosene is $\varepsilon_r = 2\left[1.592g, 255K / gm^3\right]$

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9. Two equal positive point charges are separated by a distance 2a. A point test charge is located in a plane which is normal to the line joining these charges and midway between them.

(a) Calculate the radius r of the circle of symmetry in this plane for which the force on the test charge has a maximum value.

(b) What is the direction of this force, assuming a positive test charge ? [at $\sqrt{2}$, radial and away from the center]

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10. Consider a fixed charge Q and another charge q is placed at a distance x_0 from Q on a smooth plane surface. Find the velocity of charge q as a function of x.

$$\left[\left[\frac{Qq}{2\pi \in_0 m}\left\{\frac{1}{x_0}-\frac{1}{x}\right\}\right]^{\frac{1}{2}}\right]$$

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11. A positive point charge $50\mu C$ is located in the plane xy at a point with radius vector $\overrightarrow{r}_0 = 2\hat{i} + 3\hat{j}$. The electric field vector $\overrightarrow{E}$ at a point with radius vector $\overrightarrow{r} = 8\hat{i} - 5\hat{j}$, where r_0 and r are expressed in meter, is

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12. Four point charges, each of $+q$, are rigidly fixed at the four corners of a square planar soap film of side 'a'. The surface tension of the soap film is γ. The system of charges and planar film are in equilibrium, and $a = k\left[\frac{q^2}{\gamma}\right]^{1/N}$, where 'K' is a constant. Then N is

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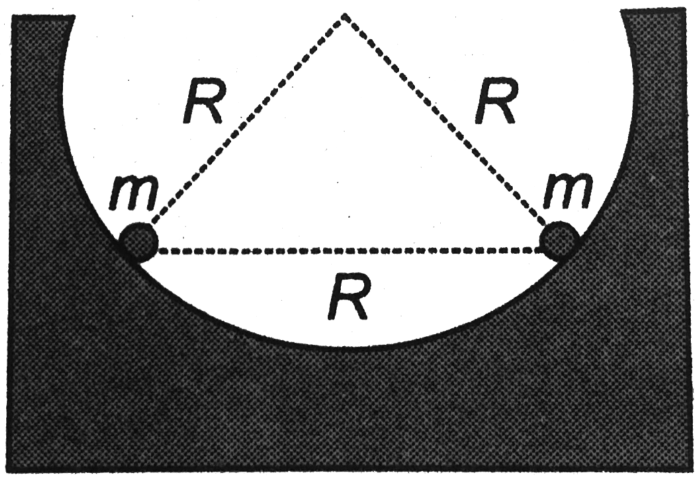
13. Two identical beads each have a mass m and charge q. When placed in a hemispherical bowl of radius R with frictionless, non-conducting walls, the beads move, and at equilibrium they area distance R apart (figure). Determine the charge on each bead.



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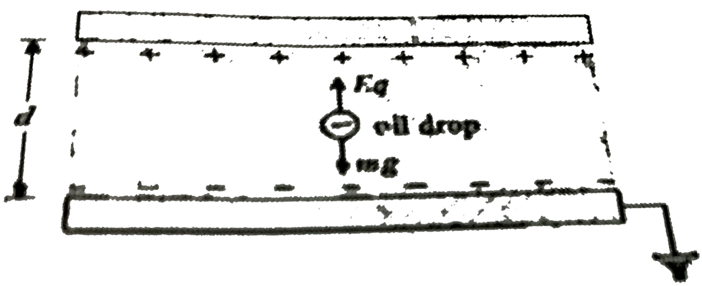
14. Two horizontal parallel conducting plates are kept at a separation $d = 1.5 \times 10^{-2} m$ apart one above the other in air as shown in figure. The upper plate is maintained at a positive potential of $1.5kV$ while the other plate is earthed which maintains it at zero potential. Calculate the number of electrons which must be attached to a small oil drop of mass $m = 4.9 \times 10^{-15} kg$ between the plates to maintain it at rest. Consider density of air is negligible in comparison with that ofoil. If the potential of above plate is suddenly changed to $-l.5kV$, what will be the initial acceleration of the charged drop? Also calculate the terminal velocity of the drop if its radius is $r = 5.0 \times 10^{-6} m$ and the coefficient of viscosity of air is $\eta = 1.8x10 - \; - 5N - s/m^2 \left[3, 2g, 5.7 \times 10^{-5} m/s^2\right]$



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15. A uniform electric field of intensity $E = 10^6 V / m$ exist in vertically downwards direction in a region. A particle of mass m = 0.01 kg andcharge $q = 10^{-6} C$ is suspended byan inextensible thread oflength $I = 1m$. The particle is displaced slightly from its mean position and released. Calculate the time period ofits oscillation. What minimum velocity should be given to the particle at rest from its equilibrium position so that it completes a full circle in vertical plane? Calculate the maximum and minimum tension in the thread in its circular motion in vertical plane. $[0.6s, 23.42m / s, 6.59N, 0]$

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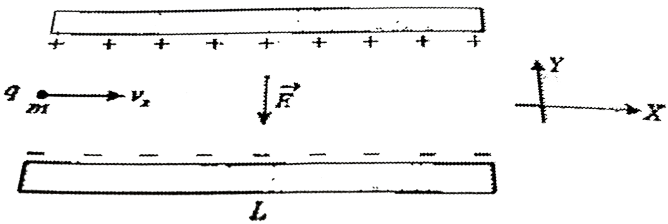
16. Figure shows an assembly of deflecting plates A and B ofan ink-jet printer which causes moving ink droplets to deflect at desired displacements by continuously varying electric field between the plates. An ink drop with a mass $m = 1.3 \times 10^{-10} kg$ and a negative charge of magnitude $q = 1.5xx10^{-13}C$ enters the region between the plates, initially moving along the x-axis with speed $v_x, = 18m/s$. The length of plates is $L = 1.6cm$. The plates are connected with a varying voltage and thus produce an electric field at all points between them. Assume that field $\overrightarrow{E}$ for some duration is constant and it is acting in downward direction as shown and has a magnitude of $E = I.4 \times 10^6 N/C$, find the vertical deflection of the drop at the far edge ofthe plate? As the gravitational force on the drop is very small relative to the electrostatic force acting on the drop, it can be neglected for this analysis. $[6.4 \times 10^{-4}m]$



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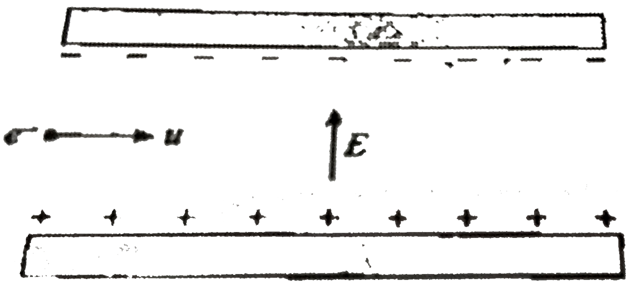
17. A uniform electric field E is established between two parallel charged plates as shown in figure. An electron enter the field symmetrically between the plates with a speed u. The length of each plate is l. if the electron does not stricke any of the plates, find the angle of deviation of the electron as it comes out of the field at the outer end of plates. $\left[\tan^{-1}\left(\frac{eEl}{\mu^2}\right)\right]$



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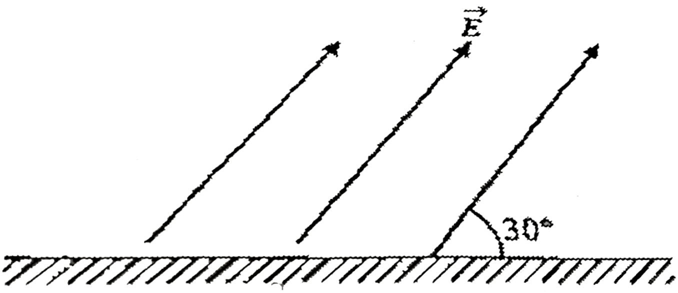
18. In a region an electric field is setu!l with its strength $E = 15N/C$ and it makes an angle of 30° with the horizontal plane as shown in figure. A ball having a charge 2C, mass 3kg and coefficient of restitution with ground 0.5 is projected at an angle of 30° with the horizontal along the direction of electric field with speed 20 m/s. Find the horizontal distance travelled by ball from first hit with the ground to the second time when it hits the ground. $[70\sqrt{3}m]$



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19. In a hydrogen atom an electron of mass $9.1 \times 10^{-31} jg$ revolves about a proton in circular orbit of radius 0.53Å. Calculate the radial acceleration and angular velocity of electron. $[8.9 \times 10^{22} m / s^2, 4.1 \times 10^{16} s^{-1}]$

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20. An electron is released with a velocity of $5 \times 10^{6} ms^{-1}$ in an electric field of $10^{3} NC^{-1}$ which has been applied so as to oppose its motion. What distance would the electron travel and how much time could it take before it is brought to rest?

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21. A particle is unchanged and is thrown vertically upward from ground level with a speed of $5\sqrt{5}$ m//s in a region of space having uniform electric field As a result, it attains a maximum height h. The particle is then given a positive charge +q and reaches the same maximum height h when thrown vertically upward with a speed of $13m/s$ Finally the particle is given a negative charge -q Ignoring air resistance determine the speed (in m//s) with which the negatively charged particle must be thrown vertically upward, so that it attains exactly the same maximum height h.

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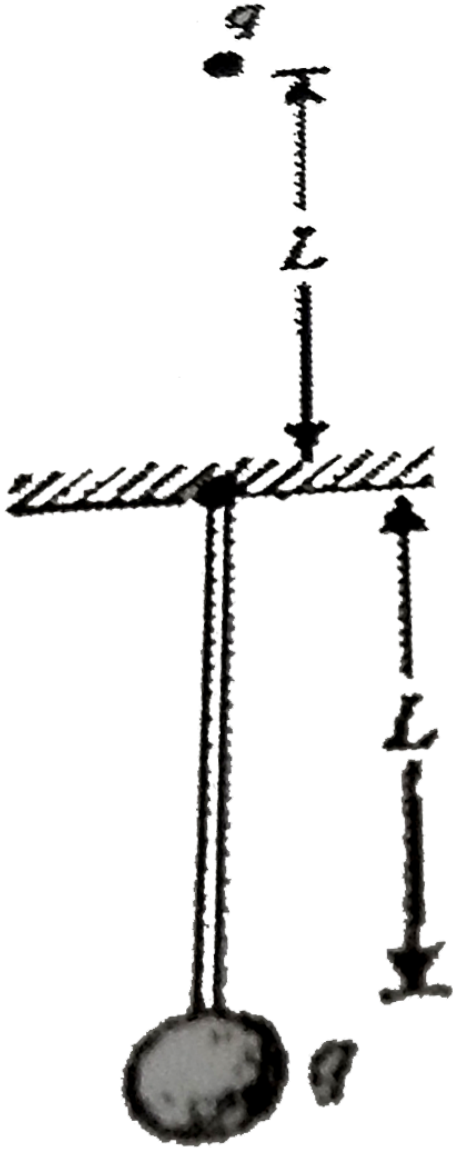
22. A particle of charge q and mass m is suspended from a point on the wall by a rigid massless rod oflength $L = 3/m$ as shown. Above the point of suspension another particle is clamped which has a charge -q at a distance L .from point of suspension. On slight displacement from the mean position, the suspended particle is observed to executes SHM. Find the time period of SHM. (For calculations consider $Kq^2 = 2mgL^2$ and $g = \pi^2$) $[4s]$



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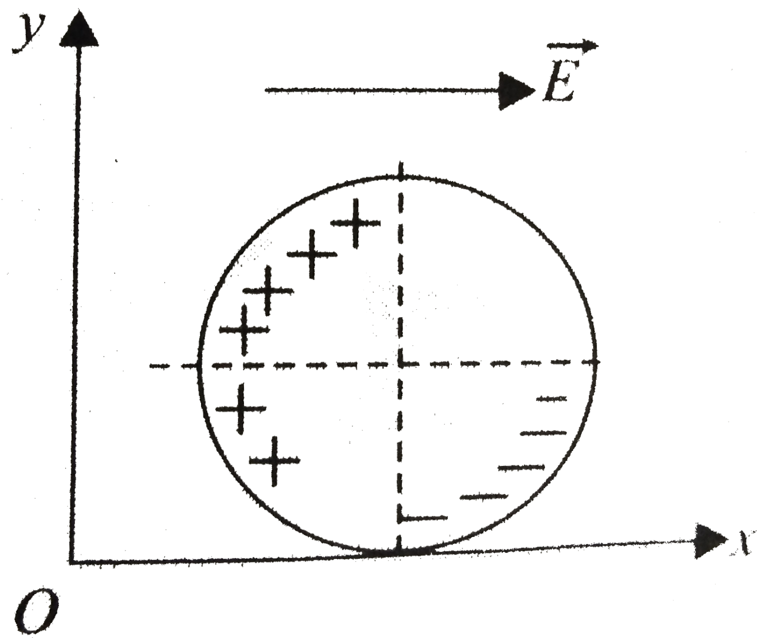
23. A nonconducting ring of mass m and radius R, with charge per unit length λ is shown in fig. It is then placed on a rough nonconducting horizontal plane. At time t=0, a uniform electric field $\overrightarrow{E} = E_0 \hat{i}$ is switched on and the ring starts rolling without sliding. Determine the friction force (magnitude and direction) acting on the ring.



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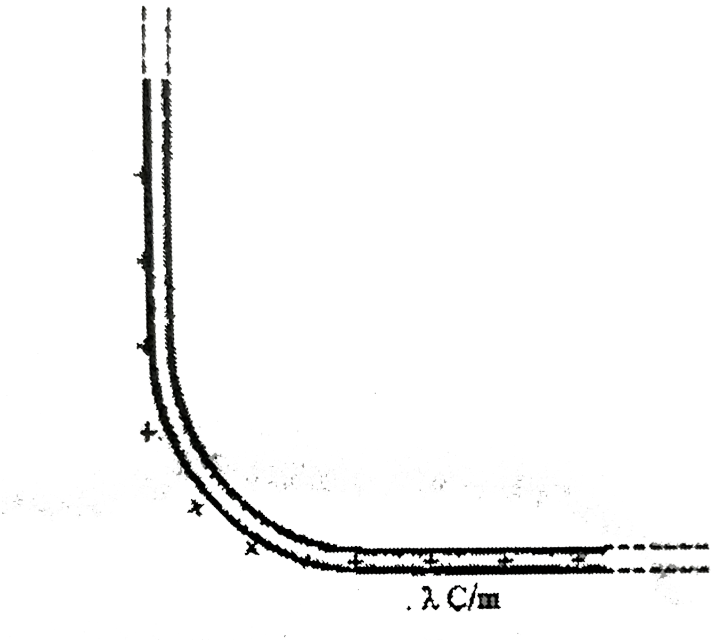
24. In the given arrangement find electric field at C. Complete wire is uniformly charged at linear charge density λ. $\left[\frac{\lambda}{2\sqrt{2} \in_0 R}\right]$



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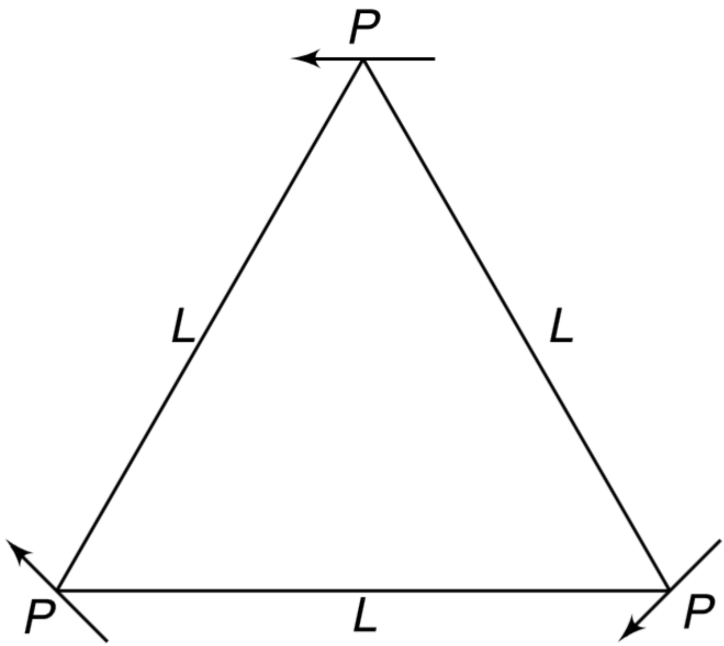
25. A thin half ring of radius $R = 20cm$ is uniformly charged with a total charge $q = 0.70nC$.Find the magnitude of the electric field strength at the curvaite centre of this half-ring.

26. Three short electric dipoles, each of dipole moment P, are placed at the vertices of an equilateral triangle of side length L. Each dipole has its moment oriented parallel to the opposite side of the triangle as shown in the fig. Find the electric field and potential at the centroid of the triangle



27. A whin wire ring of radius r carries charge q. Find the magnitude of the electric field strength on the axis of the ring as a function of distance l from its centre. Investigate the obtained function at $l > > r$. Find the maximum strength magnitude and the corresponding distance l. Draw the appoximate polt of the function. $E(l)$.

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28. A circular wire-loop of radius a carries a total charge Q distributed uniformly over its length . A small length dL of the wire is cut off. Find the electric field at the centre due to remaining wire.

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29. An electron is constrained to move along the central axis of a ring ofradius R having uniformly distributed charge q. Show that the electrostatic force exerted on the electron can cause itto oscillate through the centre of the ring with an angular frequency of $\omega = \sqrt{(eq/4\pi\varepsilon_0 mR^3)}$, where m is the mass of the electron

$$\left[\sqrt{\frac{qe}{4\pi \in_0 mR^3}}\right]$$

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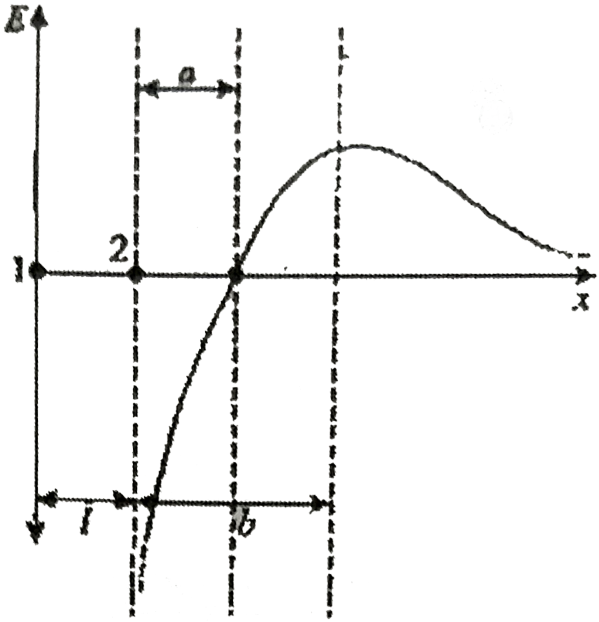
30. Two point charges Q_1 and Q_2 are positioned at points I and 2. The field intensity to the right of the charge Q_2 on the line that passes through the two charges varies according to a law that is represented in the figure. The field intensity is assumed to be positive if its direction coincides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



(a) Find the sign of each charge

(b) Find the ratio of the absolute values of the charges $\left|\frac{Q_1}{Q_2}\right|$

(c) Find the value of b where the field intensity is maximum

[(a) Q_2 is negative and Q_1 is positive (b) $\left(\frac{l+a}{a}\right)^2$, (c) $\frac{l}{\left(\frac{l+a}{a}\right)^{2/3}-1}$]

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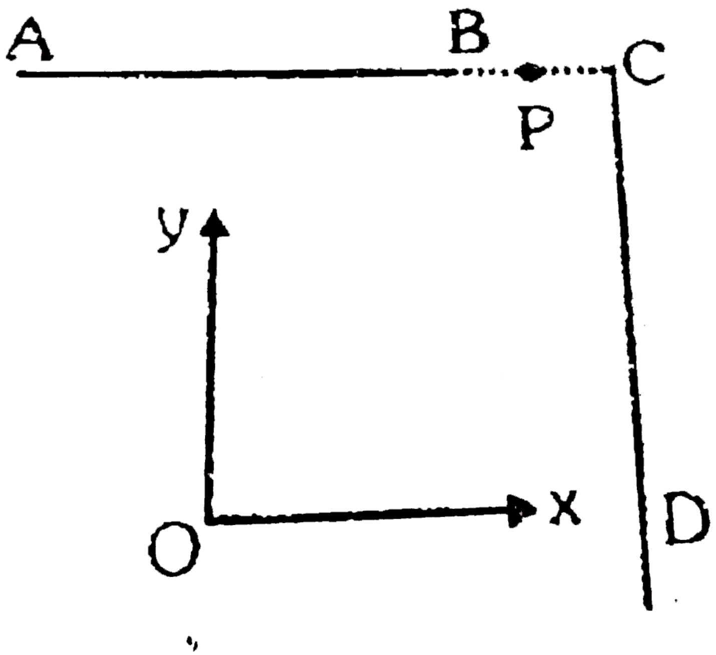
31. Two wires AB & CD, each $1m$ length, carry a total charge of 0.2 microcoulomb each and are placed as shown in figure. The ends B & C are separated 1 m distance. Determine the value of electric intensity at the point P in the vector form.Note P is the mid point of BC.



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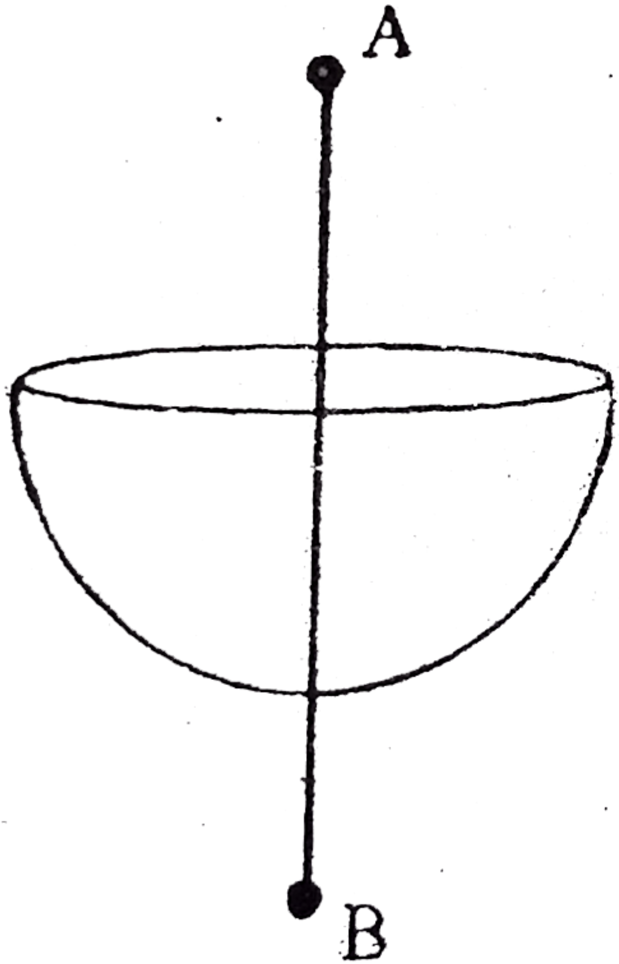
32. The diagram shows a uniformly charged hemisphere of radius R. It has volume charge density rho. If the electric field at a point 2R distance above its center is E then what is the electric field at the point which is 2R below its center?



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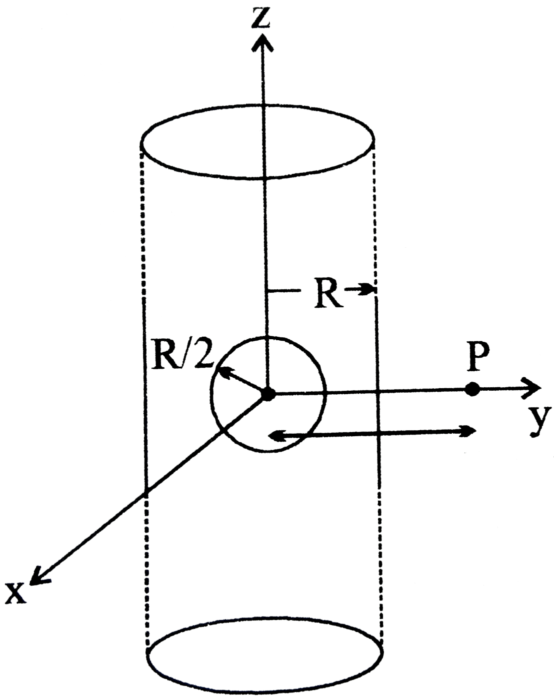
33. An infinitely long solid cylinder of radius R has a uniform volume charge density ρ. It has a spherical cavity of radius $R/2$ with its centre on the axis of cylinder, as shown in the figure. The magnitude of the electric field at the point P, which is at a distance $2R$ form the axis of the cylinder, is given by the expression $\frac{23rR}{16ke_0}$. The value of k is .



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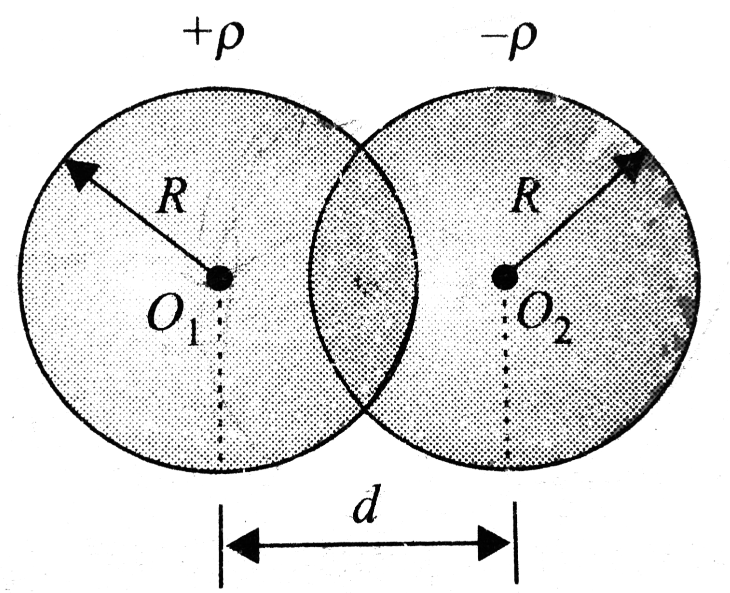
34. There are two nonconducting spheres having uniform volume charge densities ρ and $-\rho$. Both spheres have equal radius R. The spheres are now laid down such that they overlap as shown in Fig.2.125. Take $\overrightarrow{d} = \overrightarrow{O_1O_2}$.



The electric field $\overrightarrow{E}$ in the overlapped region is

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35. Suppose the surface charge density over a sphere of radius R depends on a polar angle θ as $\sigma = \sigma_0 \cos\theta$, where σ_0 is a positive constant. Show that such a charge distribution can be represented ~s a result ofa small relative shift of two uniformly · charged balls of radius R whose charges are equal in magnitude and opposite in sign. Resorting to this representation, find the electric field strength vector inside the given sphere. $\left[\frac{\sigma_0}{3 \in_0}\right]$

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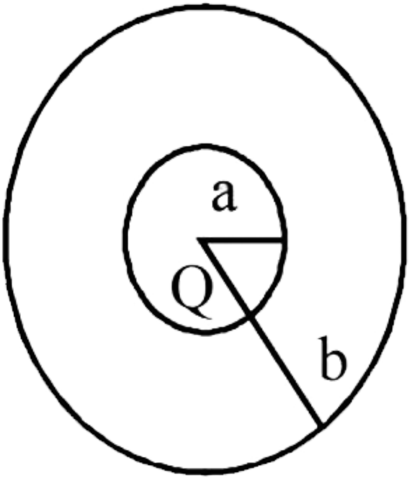
36. The region between two concentric spheres of radii 'a' and 'b', respectively (see figure), have volume charge density $\rho = \frac{A}{r}$, where A is a constant and r is the distance from the centre. At the centre of the spheres is a point charge Q. The value of A such that the electric field in the region between the spheres will be constant, is:



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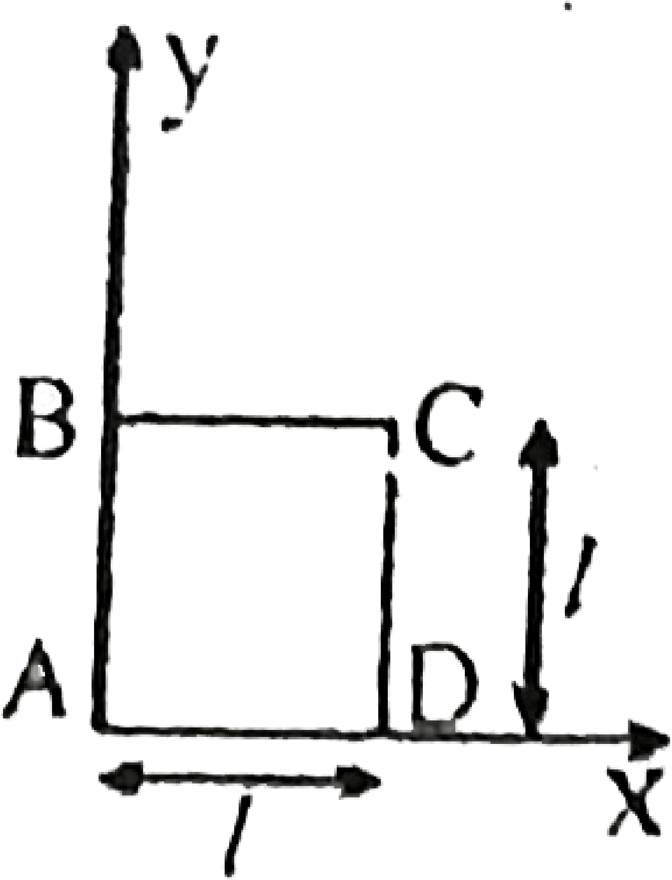
37. A square loop of side 'l' each side having uniform linear charge density 'lambda' is placed in 'xy' lane as shown in the figure There exists a non uniform electric field $\vec{E} = \frac{a}{l}(x + l)\hat{i}$ where a and l are constants and x is the position of the point from origin along x-axis. Find the resultant electric force on the loop (in Newtons) if

$l = 10cm \lambda = 20\mu C / m$ and $a = 5 \times 10^5 N / C$.



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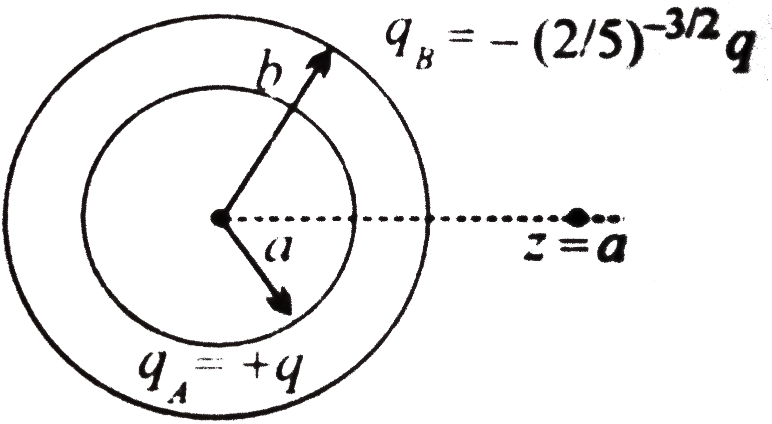
38. Two concentric rings, one of radius a and the other of radius b, have the charges +q, and $-(2/5)^{-3/2}q$, respectively as shown in fig.



Find the rario b/a if a charge particle palaced on the axis at z =a is i equilibrium.

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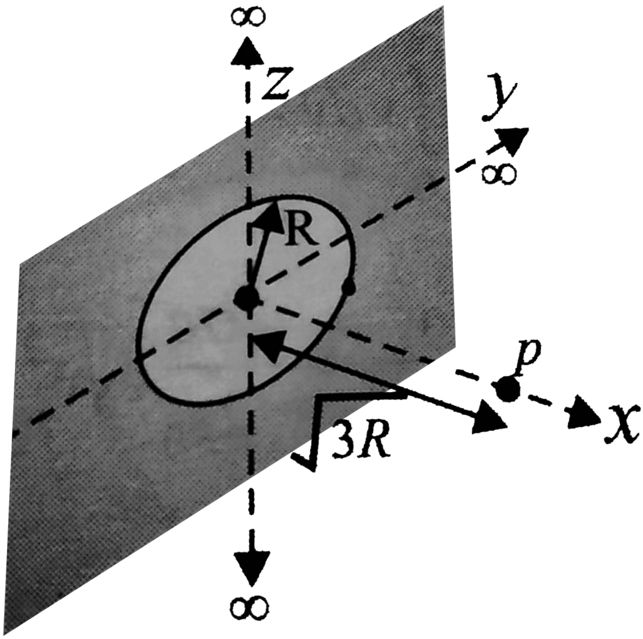
39. An infinite dielectric sheet having charge density σ has a hole of radius R in it. An electron is released from point P on the axis of the hole at a distance $\sqrt{3}R$ from the center. Find the speed with which it crosses the plane of the sheet.



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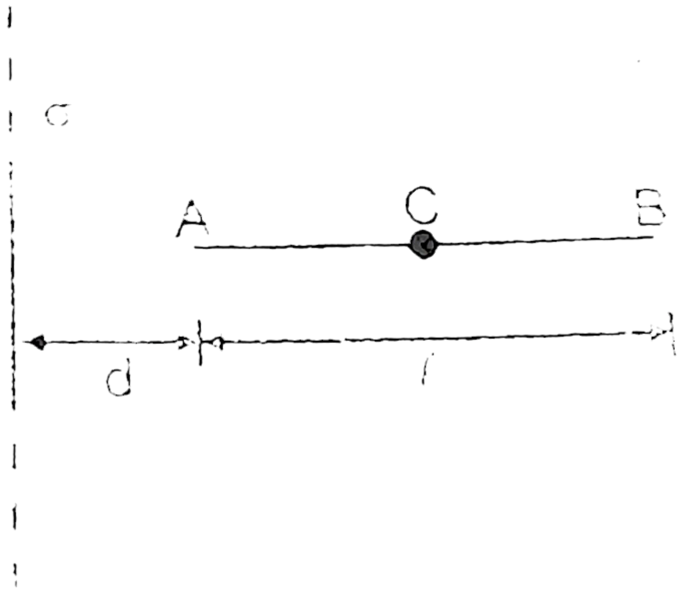
40. A uniform rod AB of mass m and length l is hinged at its mid point C. The left half (AC) of the rod has linear charge density $-\lambda$ and the right half (CB) has $+\lambda$ where λ is constant. A large non conducting sheet of uniform surface charge density σ is also present near the rod. Initially the rod is kept perpendicular to the sheet. The end A of the rod is initialy at a distance d. Now the rod is rotated by a small angle in the plane of the paper and released. Prove that the rod will perform SHM and find its time period.



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41. Two particles each charged with a charge +q are clamped on they axis at the points (0, a) and (0, - a). If a positively charged particle of charge q_0 and mass m is slightly displaced from origin in the direction ofnegativex-axis.

(a) What will be its speed at infinity?

(b) If the particle is projected towards the left along the x-axis from a point at a large distance on the right of the origin with a velocity half that acquired in part (a), at what distance from origin will it come to rest ?

$$\left[\sqrt{\frac{2Kqq_0}{ma}}, \sqrt{15}a\right]$$

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42. An infinite number of charges each equal to q are placed along the x-axis at $x = 1m, x = 2m, x = 4m, x = 8m$, ... and so on. Find the potential and electric field at the point x = 0 due to this set of charges. What will be potential and electric field ifin the above set up if the consecutive charge have opposite sign?

$$\left[\frac{q}{2\pi \in_0}, \frac{q}{3\pi \in_0}, \frac{q}{6\pi \in_0}, \frac{q}{5\pi \in_0}\right]$$

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43. A particle having a charge of $1.6x10^{-19}C$ enters midway between the two plates of a parallel plate capacitor. The initial velocity of particle is parallel to the plates. A potential difference of300 Vis applied between the two plates. lfthe length of the plates is 10 cm and they are separated by 2 cm, calculate the greatest initial velocity for which the particle will not be able to come out of the plates. The mass of the particle is $12 \times 10^{-24}kg$

$\left[10^4 m/s\right]$

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44. A circular ring of radius R with uniform positive charge density λ per unit length is located in the y-z plane with its centre at the origin O. A particle of mass m and positive charge q is projected from the point P $\left(R\sqrt{3}, 0, 0\right)$ on the positive x-axis directly towards O, with an initial speed v. Find the smallest (non-zero) value of the speed v such that the particle does not return to P.

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45. Two thin wire rings each having radius R are placed at distance d apart with their axes coinciding. The charges on the two are $+Q$ and $-Q$. The potential difference between the centre so the two rings is

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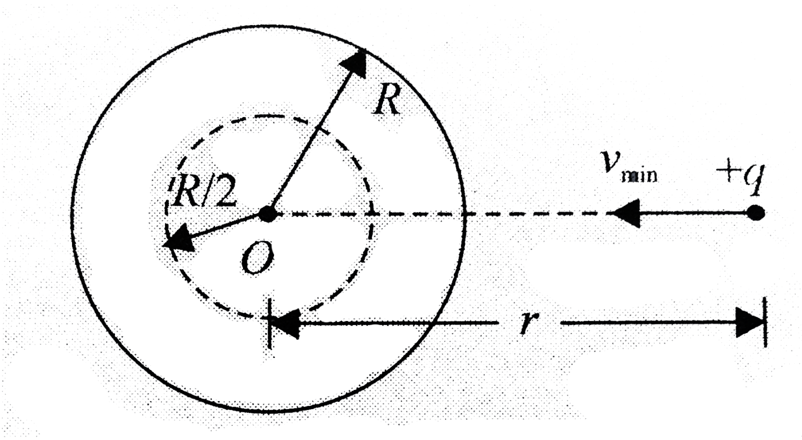
46. A positive charge Q is uniformly distributed throughout the volume of a dielectric sphere of radius R. A point mass having charge +q and mass m is fired toward the center of the sphere with velocity v from a point at distance $r(r > R)$ from the center of the sphere. Find the minimum velocity v so that it can penetrate $(R/2)$ distance of the sphere. Neglect any resistance other than electric interaction.

Charge on the small mass remains constant throughout the motion.



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47. The electric potential at surface of thin non-conducting sheet with charge density σ is V_0. Show that the electric potential at a distance x from infinite sheet can be written as

$$V = V_0 - \frac{\sigma}{2\,\epsilon_0}x$$

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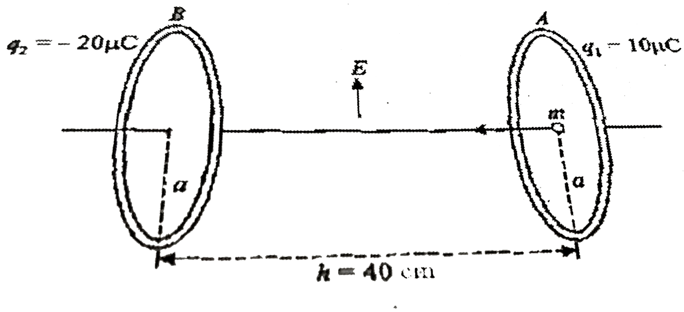
48. Two identical circular rings A and B of radius 30 cm are placed coaxially with their axes horizontal in a uniform electric field $E. = 10^5 N/C$ directed vertically upward as shown in figure. Distance between centres ofthese rings A and B is40cm. Ring A has a positive charge $10\mu C$ while ring B has a negative charge of magnitude $20\mu C$. A particle of mass $100g$ and carrying a positive charge $10\mu C$ is released from rest at the centre of the ring A. Calculate its velocity when it has moved a distanceof40cm. Take $g = 10m/s^2$



$[6\sqrt{2}m/s]$

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49. A non-conducting disc of radius a and uniform positive surface charge density σ is placed on the ground, with its axis vertical. A particle of mass m and positive charge q is dropped, along the axis of the disc, from a height H with zero initial velocity. The particle has $q/m = 4 \in_0 g/\sigma$

(a) Find the value of H if the particle just reaches the disc.

(b) Sketch the potential energy of the particle as a function of its height and find its equilibrium position.

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50. Determine the potential $\phi(x, y, z)$ of an electrostatic field $\overrightarrow{E} = ay\hat{i} + (ax + bz)\hat{j} + by\hat{k}$, where a and b are constants, $\hat{i}$, $\hat{j}$ are the unit vectors of the axes x,y,z. $[-y(ax+bz)+$ constant]

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51. Find the potential difference between points a and b in and electric field of which strength in the region is given by the vector as

$\overrightarrow{E} = \left(2\hat{i} + 3\hat{j} + 4\hat{k}\right)N/C$

The position vectors of points a and b are given as

$\overrightarrow{r}_a = \left(\hat{i} - 2\hat{j} + \hat{k}\right)m$ and $\overrightarrow{r}_b = \left(2\hat{i} + \hat{j} - 2\hat{j}k\right)m[-1V]$

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52. Consider a spherical surface of radius 4 m cenred at the origin. Point charges +q and - 2q are fixed at points A(2 m, 0,0) and B(8 m, 0, 0), respectively. Show that every point on the shperical surface is at zero potential.

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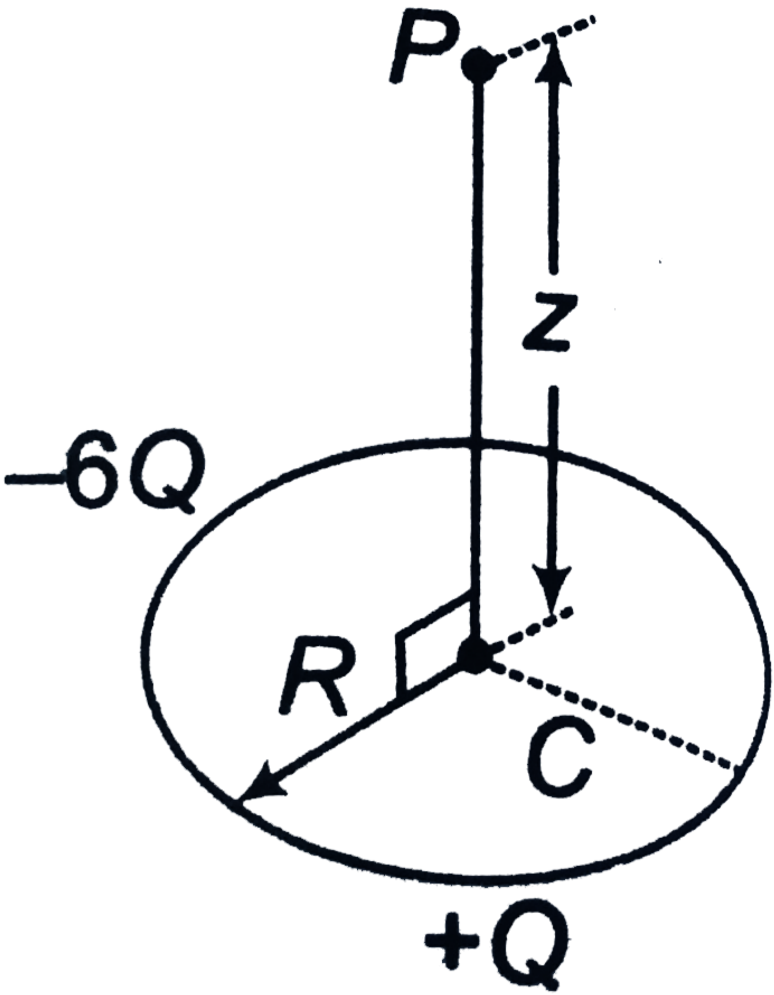
53. A plastic rod has been formed into a circle of radius R. It has a positive charge $+Q$ uniformly distributed along one-quarter of its circumference and a negative charge of $-6Q$ uniformly distributed along the rest of the circumference (figure). With V = 0 at infinity, what is the electric potential $-6Q$

(a) at the centre C of the circle and

(b) at point P, which is on the central axis of the circle at distance z from the centre?



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54. A ring of radius R is having two charges q and $2q$ distributed on its two half parts. The electric potentiasl at a point on its axis at a distance of $2\sqrt{2}R$ from its centre is $\left(k = \frac{1}{4\pi\varepsilon_0}\right)$

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55. A spherical oil drop, radius 10^{-4} cm has on it at a certain a total charge of 40 electrons. Calculate the energy that would be required to place an additional electron on the drop.

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56. Three charges 0.1 coulomb each are placed on the corners of an equilateral triangle of side $1m$. If the energy is supplied to this system at the rate of $1kW$ how much time would be required to move one to the charges on to the midpoint of the line joining the two ?

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57. A system consists of two concentric spheres, with the inside sphere of radius a carrying a positive charge q_1. What charge q_2 has to be diposited on the outsie sphere of radius b to reduce the potentail φ depend in this case on a distance r from the centre of the system ? Draw teh appoximate plot of this dependence.

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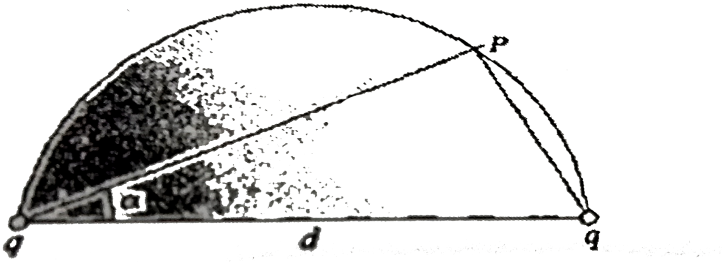
58. At the end points of a line sigment of a length of $d = \frac{\sqrt{337}}{84}m$ there are two identical positive electric charges q. What is the ratio of the electric field strength and the electric potential magnitudes is

SI units at a point located by an angle $a = 37^{\circ}$ on the circle drawn around the line segment as a diameter?



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59. A conducting sphere S_1 of radius r is attached to an insulating handle. Another conduction sphere S_2 of radius R is mounted on an insulating stand. S_2 is initially uncharged. S_1 is given a charge Q brought into contact with S_2 and removed. S_1 is recharge such that the charge on it is again Q and it is again brought into contact with S_2 and removed. This procedure is repeated n times.

a. Find the electrostatic energy of S_2 after n such contacts with S_1.

b. What is the limiting value of this energy as $n \rightarrow \infty$?

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60. A uniform disc of radius R is charged with a uniform surface charge density σ. Find the electric potential due to the charges on the disc at a point on its edge. $\left[\frac{\sigma R}{\pi \in_0}\right]$

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61. A dielectric cylinder of radius a is infinitely long. It is non-uniformly charged such that volume charge density ρ varies directly as the distance from the cylinder. Calculate the electric field intensity due to it at a point located at a distance r from the axis of the cylinder. Given that ρ is zero at the axis and it is equal to ρ on the surface of cylinder. Also calculate the potential difference between the axis and the surface. $\left[\frac{\rho r^2}{3 \in_0 a}, \frac{\rho a^2}{9 \in_0}\right]$

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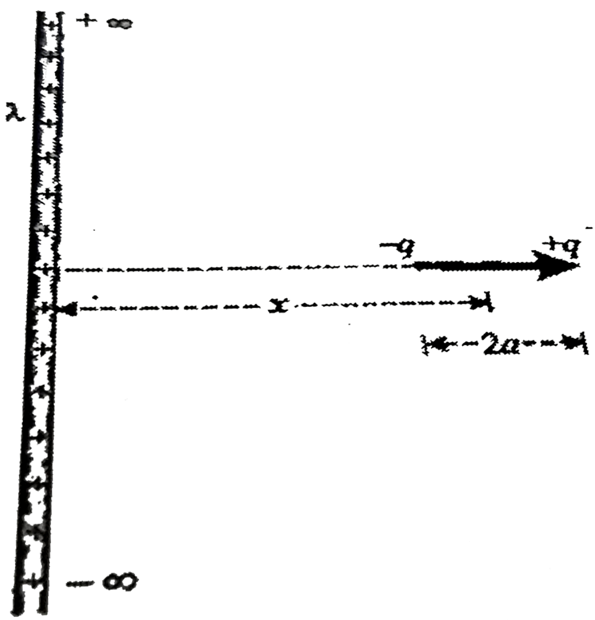
62. In figure-, an electric dipole is placed at a distance x from an infinitely long rod of linear charge density λ.

(a) Find the net force acting on the dipole

(b) What is the work done in rotating the dipole through 180°

(c) If the dipole is slightly rotated about its equilibrium position, find the time period of oscillation. Assume that the dipole is linearly restrained.

$$\left[(a)\frac{\lambda aq}{\pi \in_0 x^2}, (b)\frac{2\lambda aq}{\pi \in_0 x}, (c)2\pi\sqrt{\frac{2\pi \in_0 mx^2a}{\lambda q}}\right]$$



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63. Two point dipoles $p\hat{k}$ and $\frac{P}{2}\hat{k}$ are located at (0, 0, 0) and (1m, 0, 2m) respectively. Find the resultant electric field due to the two dipoles at the point M(1m, 0, 0)

$$\left[-\left(\frac{7P}{32\pi \in_0}\right)\hat{k}\right]$$

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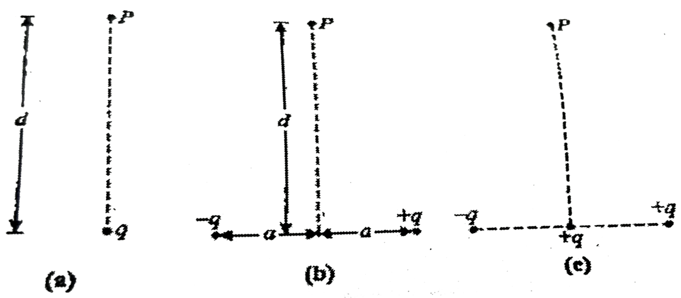
64. Find the magnitude of the electric field at the point P in the configuration shown in figure- 1.219 (a), (b) and (c) for $d > > a$ take 2qa=P.

$$\left[(a)\frac{q}{4\pi \in_0 d^2}, (b)\frac{2q}{2\pi \in_0 d^3}, (c)\frac{q}{4\pi \in_0 d^2}\sqrt{1+\frac{4a^2}{d^2}}\right]$$



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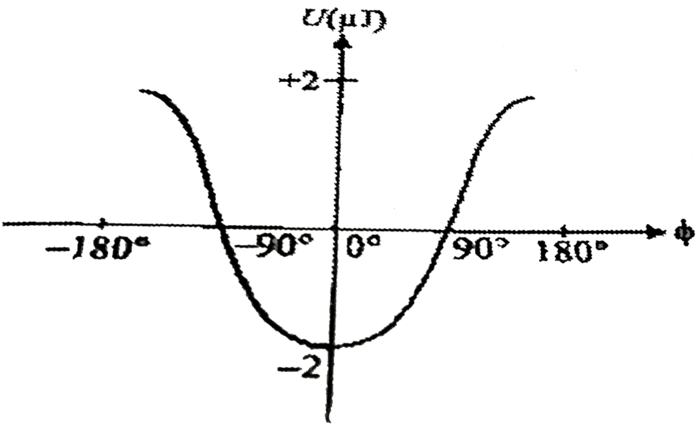
65. The graph in figure-shows the potential energy of an electric dipole that oscillates between $\pm 60^\circ$. What is the kinetic energy of dipole when it is aligned with the field?

$[1 \mu J]$



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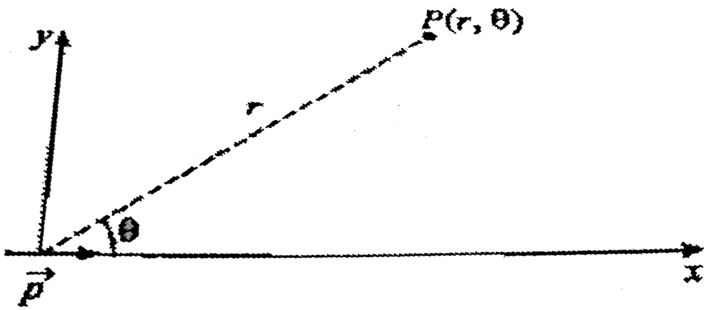
66. An electric dipole with dipole moment P oriented in the positive direction of z-axis is located at the origin of a three dimensional coordinate system. Find the projections of electric field E_x and E_y of the electric field strength vector at a point $P(r, \theta)$. Aslo find out the angle θ at which electric field vector is perpendicular to the dipole moment.

$$\left[\frac{P}{4\pi \in_0 r^3}\left(3\cos^3\theta - 1\right), \frac{3p\sin\theta\cos\theta}{4\pi \in_0 r^3}, \cos^{-1}\left(\frac{1}{\sqrt{3}}\right)\right]$$



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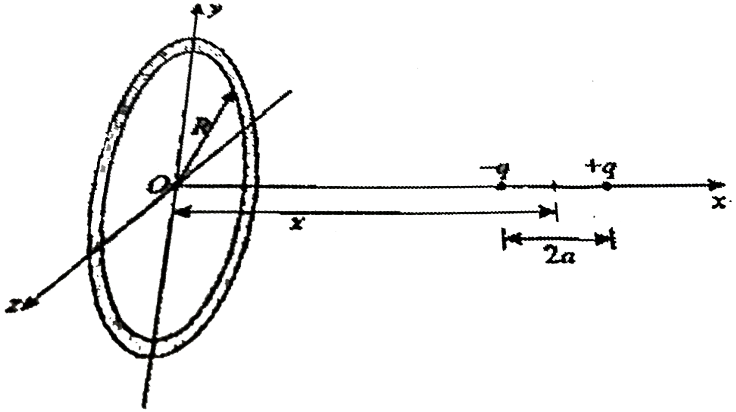
67. An electric dipole is placed at a distance x from centre O on the axis of a charged ring of radius R and charge Q uniformly distributed over it.

(a) Find the net force acting on the dipole

(b) What is the work done in rotating the dipole through 180°?

$$\left[(a)\frac{aqQ}{2\pi\varepsilon_0}\left(\frac{R^2-2x^2}{(R^2+x^2)^{3/2}}\right),(b)\frac{aqQx}{\pi\varepsilon_0(R^2+x^2)^{3/2}}\right]$$



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68. A dipole with an electric moment p is located at a distance r from a along thread charge uniformly with a linear density λ. Find the force F acting on the dipole if the vector p is oriented

(a) along the thread

(b) along the radius vector r

(c) at the right angles to the thread and the radius vector r.

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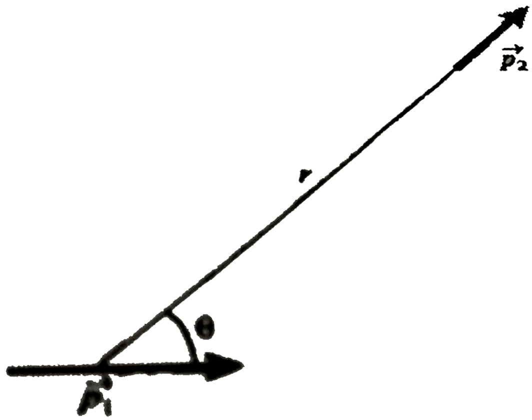
69. Two short electric dipoles are placed as shown in figure. Find the potential energy of electric interaction between these dipoles.

$\left[-\dfrac{Kp_1p_2\cos\theta}{r^3}\right]$



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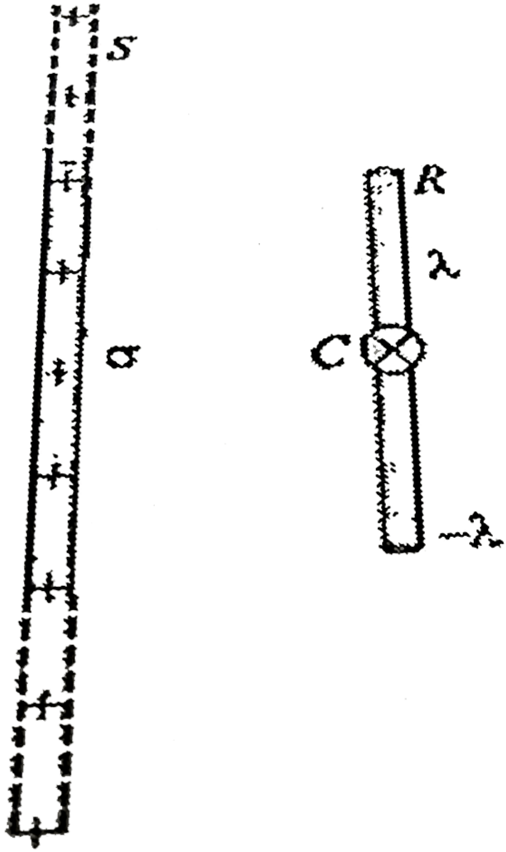
70. In the figure shown S is a large nonconducting sheet of uniform charge density σ. A rod R of length l and mass 'm' is parallel to the sheet and hinged at its point. The linear charge densities on the upper and lower half of the rod are shown in the figure. Find the angular acceleration of the rod just after it is released

$$\left[\frac{3\sigma\lambda}{2m\in_0}\right]$$



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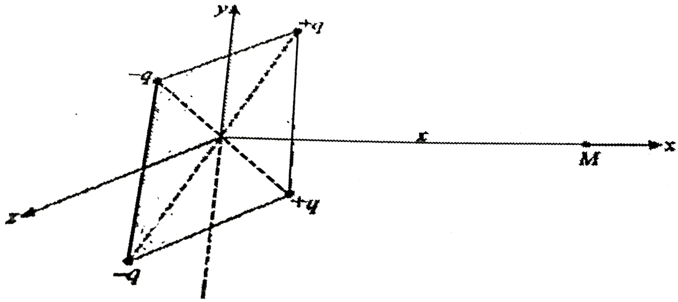
71. Point charges q and -q located at the vertices of a square with diagonals 2l as shown in figure. Find the magnitude of the electric field at a point located symmetrically with respect to the vertices of the square at a distance x from its centre. Consider $x > > l_0$

$$\left[-\frac{ql}{\sqrt{2}\pi\varepsilon_0 x^3}\right]$$



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72. Two point charges q and $-q$ are separated by a distance $2l$. Find the flux strength vector across the circle of radius R placed with its centre coinciding with the of line joining the two charges in the perpendicular plane.

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73. A charge q_0 is distributed uniformly on a ring of radius R. A sphere of equal radius R constructed with its centre on the circumference of the ring. Find the electric flux through the surface of the sphere.

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74. An electric field given by $\vec{E} = 4\hat{i} + 3(y^2 + 2)\hat{j}$ pierces a gaussian cube of side 1m placed at origin such that one of its corners is at origin and rest of sides are along positive side of coordinate axis. Find the magnitude of net charge enclosed within the cube

$[3 \in_0]$

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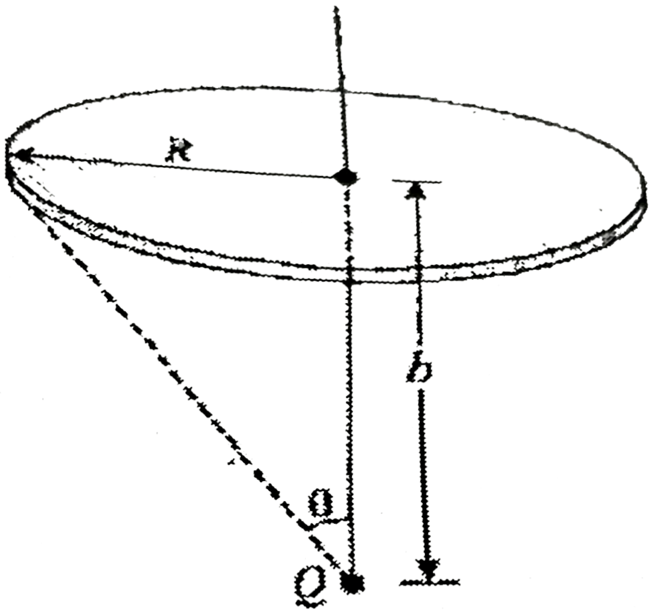
75. A point charge q is located on the axis of a disc of radius R at a distance b from the plane of the disc as shown in figure 1.295 What should be the radius of the disc if one fourth of the total electric flux form the charge passes through the disc.



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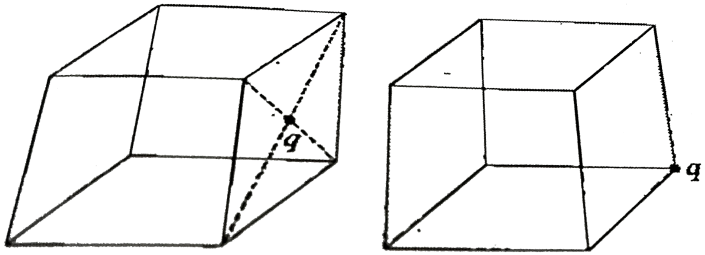
76. Find the electric flux through a cubical surface due to a point charge q placed (a) at centre of one face (b) corner of the cubical box as shown in figures -1.296 below in case (b) find the flux through each face of the cube



$$\left[\frac{q}{2\in_0}, \frac{q}{8\in_0}, \frac{q}{24\in_0}, 0\right]$$

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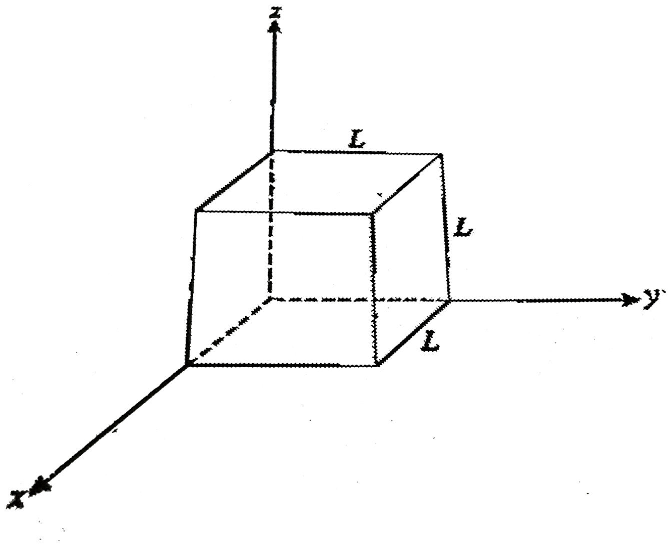
77. A cube has sides of length L=0.2 m It is placed with one corner at the origin as shown in figure The electric field in uniform and given by $\overrightarrow{E} = \left(2.5\hat{i} - 4.2\hat{j}\right)N/C$ .Find the electric flux through the entire cube.



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78. For a spherically symmetrical charge distribution electric field at a distance r from the centre of sphere is $\overrightarrow{E} = kr^2\hat{r}$ where k is a constant what will be the volume charge density at a distance r from the centre of sphere?

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79. A non-conducting spherical ball of radius R contains a spherically symmetric charge with volume charge density $\rho = kr^2$ where r is the distance form the centre of the ball and n is a constant what should be n such that the electric field inside the ball is directly proportional to square of distance from the centre?

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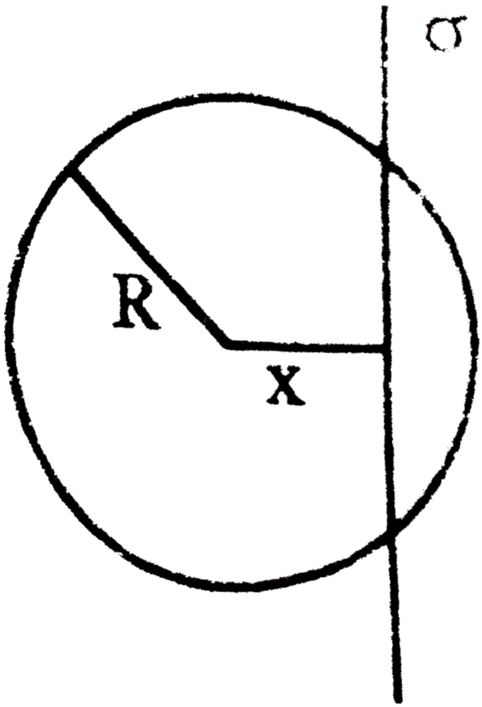
80. An infinite, uniformly charged sheet with surface charge density σ cuts through a spherical Gaussian surface of radius R at a distance X from its center, as shown in the figure. The electric flux Φ through the Gaussian surface is .



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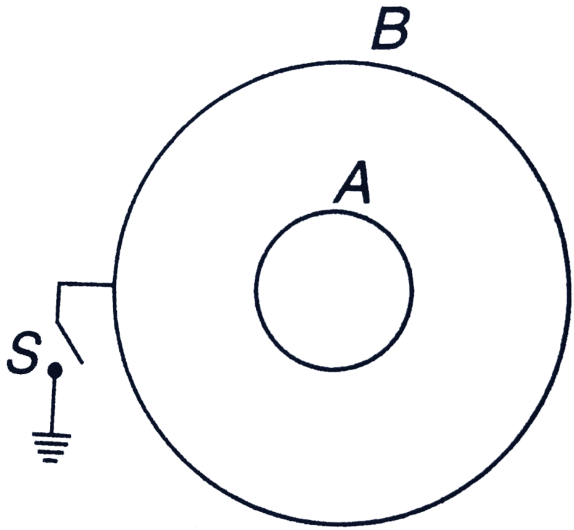
81. Initially the spheres A and B are at potentials V_A and V_B. Find the potential of A when sphere B is earthed.



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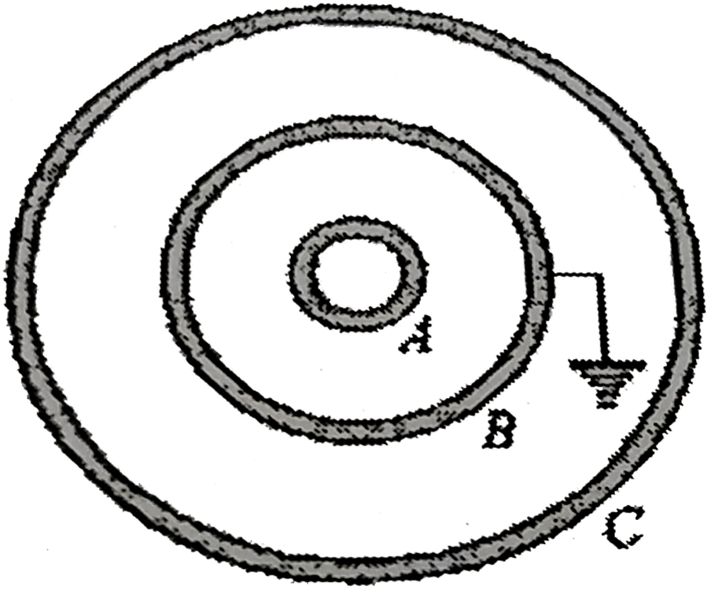
82. Figure shows three concentric thin conducting spherical shells A, B and C of radii R, 2R and 3R. The shell B is earthed A and C are given charges q and 2q respectively. Find the charges appearing on all the surface of A,B and C.



[inner surface $(A)0, (B)-q, (C)\frac{4}{3}q$

Outer surface $(A)q, (B)-\frac{4}{3}q, (C)\frac{2}{3}q$]

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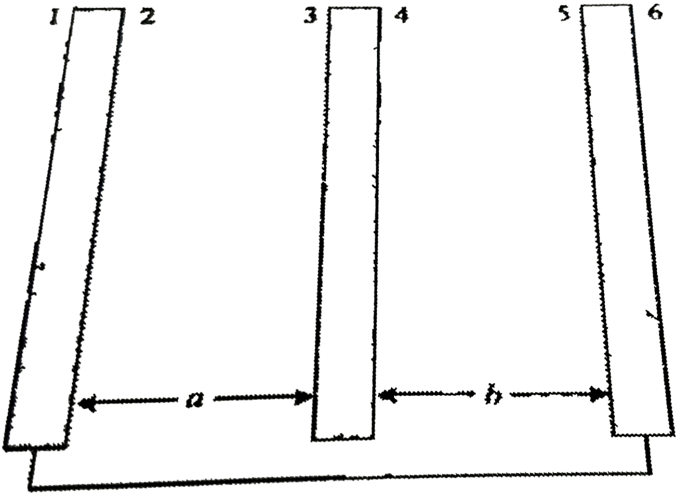
83. Three identical metallic plates are kept parallel to one another at a separation of a and b The outer plates are connected by a thin conducting wire and a charge Q is placed on the central plate Find final charges on all the surfaces of the three plates.



$$\left[faces(1)\frac{Q}{2}, (2) - \frac{Qb}{a+b}, (3)\frac{Qb}{a+b}, (4)\frac{Qa}{a+b}, (5) - \frac{Qa}{a+b}, (6)\frac{Q}{3}\right]$$

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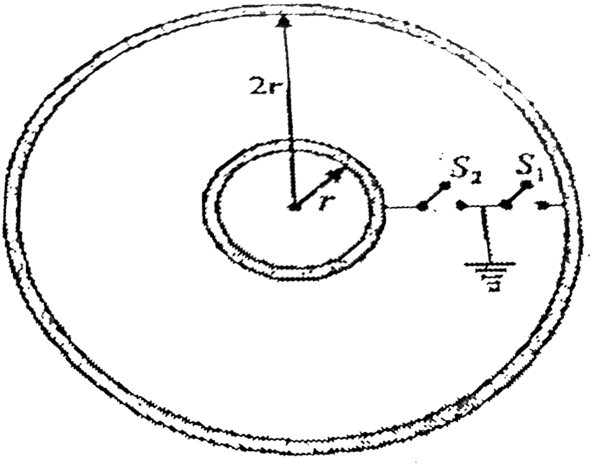
84. There are two concentration conducting spherical shells of radii r and 2r initially a charge Q is given to the inner shell Now, switch S_1 is closed and opened then S_2 is closed and opened and the process is repeated n times for both the keys alternatively. Find the final potential difference between the shells.



$$\left[\frac{1}{2^{n+1}}\left[\frac{Q}{4\pi\varepsilon_0}r\right]\right]$$

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85. An electrometer is charged to 3 kV. Then the electrometer is touched with a neutral metal ball, mounted on an isulating rod and then the metal ball is taken away and earthed The process is done for 10 times and finally the electrometer reads 1.5 kV. After this, at least how many times must the above process be repeated in order that the electrometer reads less than 1 kV?

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86. When an uncharged conducting ball of radius R is placed in an external uniform electric field, a surface charge densityh $\sigma = \sigma_0 \cos\theta$ is induced on the ball's surface charge (here σ_0 is a constant, θ is a polar angle). Find the magnitude of the resultant electric force acting on an induced charge of the same sign.

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87. A point charge q is located at the centre of the spherical layers of uniform isotropic dielectric with relative permittivity K.The inside radius of the layer is equal to a and the outside radius is equal to b .The electrostatic energy inside the dielectric layer is

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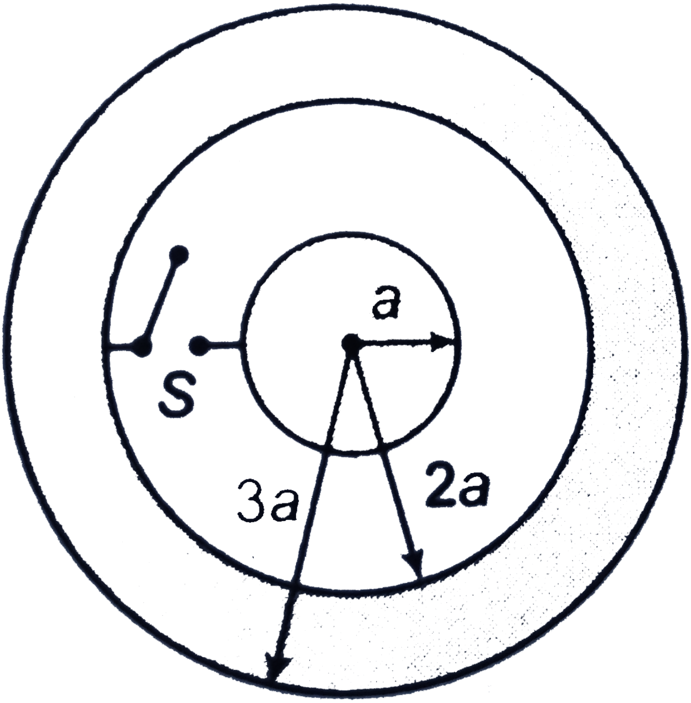
88. A solid conducting sphere of radius a having a charge q is surrounded by a concentric conducting spherical shell of inner radius $2a$ and outer radius $3a$ as shown in figure. Find the amount of heat porduced when switch is closed $\left(k = \frac{1}{4\pi\varepsilon_0}\right)$



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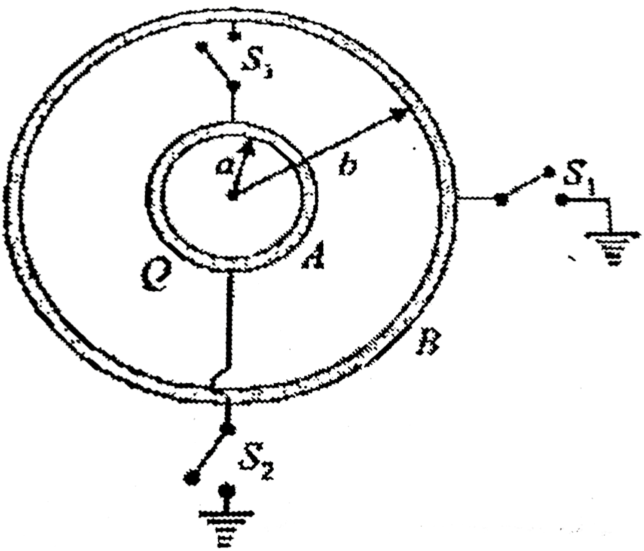
89. The figure shows a conducting sphere 'A' of radius 'a' which is surrounded by a neutral conducting spherical shell B of radius 'b' $(> a)$ Initially switches S_1, S_2 and S_3 are open and sphere 'A' carries a charge Q.



First the switch $'S_1'$ is closed to connect the shell B with the ground and then opened Now the switch $'S_2'$ is closed so that the sphere 'A' is grounded and then S_2 is opened Finally, the switch $'S_3'$ is closed to connect the spheres together. Find the heat(in Joule) which is produced after closing the switch S_3 [Consider $b = 4cma = 2cm$ and $Q = 8\mu c$]

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90. A long cylindrical shell of length l and radius a is given a uniformly distributed charge Q on its surface. If the shell is expanded uniformly to a radius b, find the work done by electrical forces in the process of expansion.

$$\left[\frac{\lambda^2 l}{4\pi \in_0} ln\left(\frac{b}{a}\right)\right]$$

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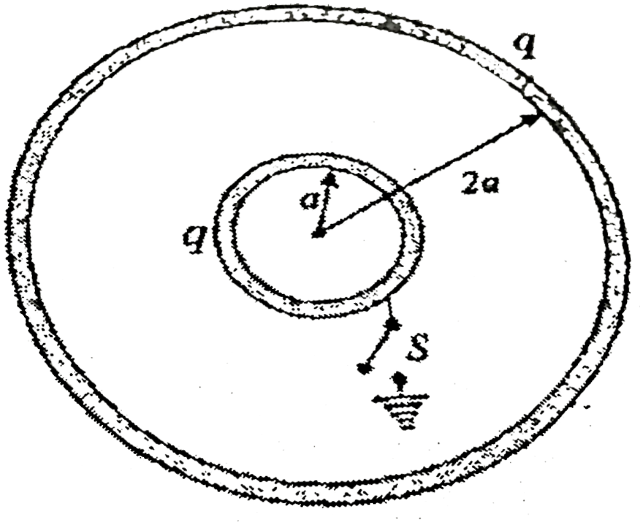
91. In a system of two concentric spherical conducting shells charge q is given to both inner and outer shells as shown in figure 1.361. Inner shell is connected to earth by a switch Find the amount of heat produced when switch is closed



$\left[\frac{5Kq^2}{8a}\right]$

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92. Two uniformly charged solid spheres A and B of radii a and b with charges q_1 and q_2 are kept at a separation r. Find the work done in disassembling the whole system into very small particles and displace the particles to infinite separation.

$\left[\frac{3}{5}\frac{Kq_1^2}{a}+\frac{3}{5}\frac{Kq_2^2}{b}+\frac{Kq_1q_2}{r}\right]$

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93. Two uniformly charged concentric sperical shells are of radii a and b respectively. The charges on the two shells are q_1 and q_2 Find the work required in expanding the outer shell of radius b to increase its radius to infinity

$$\left[-\frac{Kq_2^2}{2b}+\frac{Kq_1q_2}{b}\right]$$

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Partice Exercise 1.2

1. A block of mass m containing a net positive charge q is placed on a smooth horizontal table which terminates in a vertical wall as shown in figure(29-E2). The distance of the bolck from the wall is d. A horizontal electric field E to towards right is switched on. Assuming elastic collisions find the time period of the resulting oscillatory motion. Is it a simple harmonic motion?

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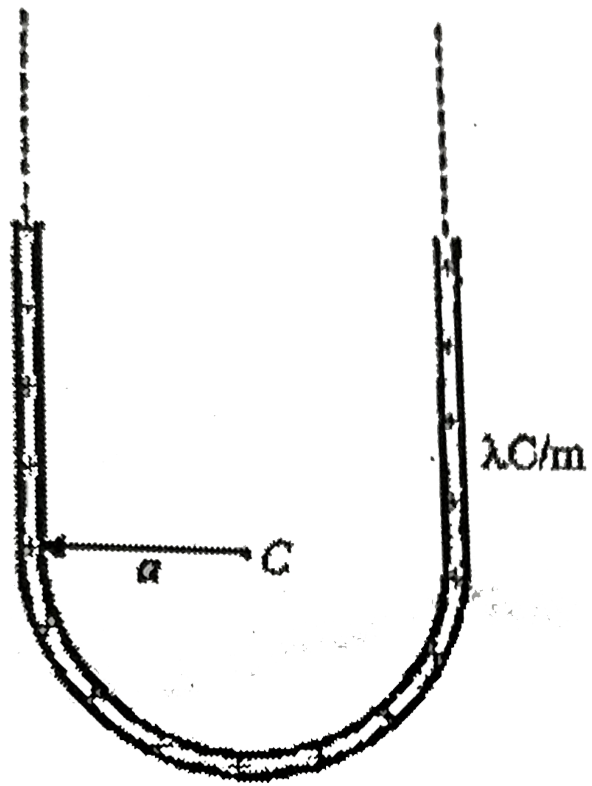
Partice Exercise 1.3

1. In the given arrangement find the electric field at C in the figure. Here the U-shaped wire is uniformly charged with linear charge density λ. [0]



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Partice Exercise 1.4

1. 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 $r = R$, find the value of a.

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Partice Exercise 1.5

1. Four particles with charges $+q, +q, -q, -q$ are placed respectively at the comers. A, B, C, D of a sqµare of side 'a' arranged in given order. Calculate the electric potential and intensity at point 0, the center of the square. If E and Fare the midpoints of the sides BC and CD respectively, what will be the work done in displacing a charge Qfrmil OtoE and from Oto F?

$$\left[0, \ -\frac{4KqQ}{a}\left(\frac{\sqrt{5}-1}{\sqrt{5}}\right)\right]1$$

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Partice Exercise 1.6

1. Two concentric spheres of radii R and $2R$ are charged. The inner sphere has a charge if $1\mu C$ and the outer sphere has a charge of $2\mu C$ of the same sigh. The potential is $9000V$ at a distance $3R$ from the common centre. The value of R is

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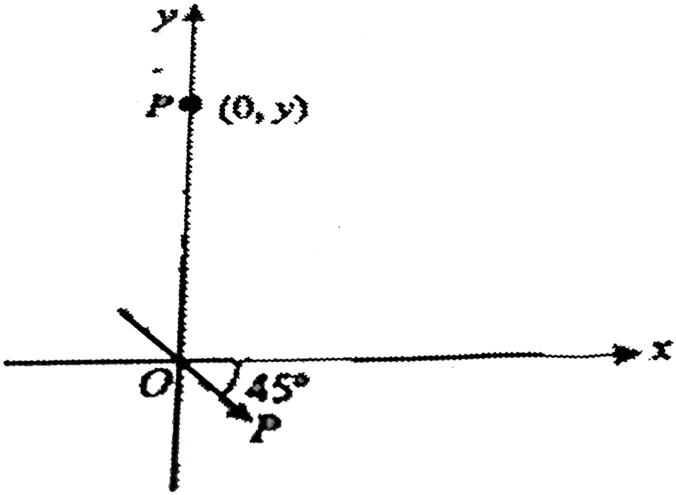
Partice Exercise 1.7

1. A dipole is placed at origin of coordinate system as shown in figure, find the electric field at point P(0,y).

$$\left[\frac{KP}{\sqrt{2}y^3}\left(-\hat{i}-2\hat{j}\right)\right]$$



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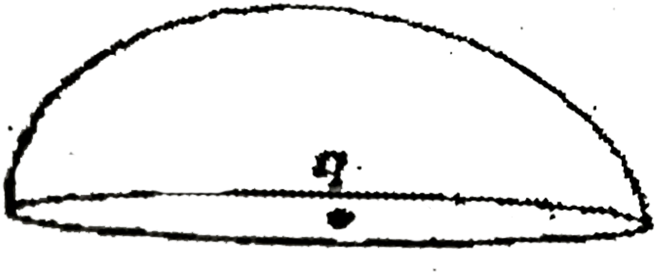
Partice Exercise 1.8

1. Find flux through the hemispherical cup due to the charge q placed as shown in figure -



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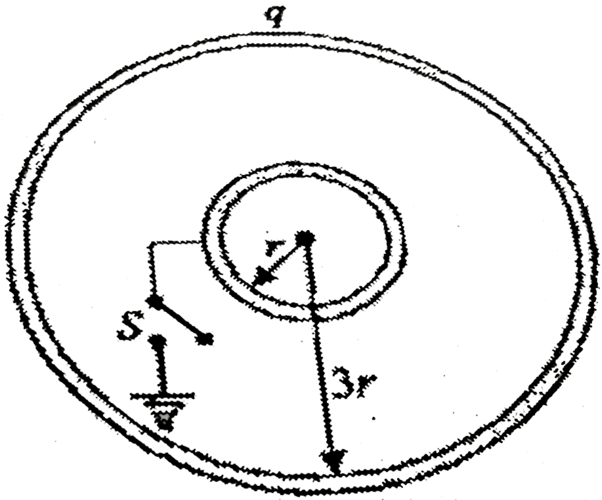
Partice Exercise 1.9

1. Figure - shows two conducting thin concentric shells of radii r and 3r The outer shell carries charge q where as inner shell is uncharged. Find the charge that will flow from inner shell to earth after the switch S is closed.



$\left[+\frac{q}{3}\right.$ charge will flow inner shell to earth]

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Partice Exercise 1.10

1. One thousand similar electrified raindrops merge into one so that their total charge remains unchanged Find the change in the total electric energy of the drops, assuming that the drops are spherical and that small drops are at large distance from one another [Energy increase by 100 times]

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Discussion Question

1. Two identical metallic spheres of exactly equal masses are taken. One is given a poistive charge Q coulombs and the other an equal negative charge. Their masses after charging are different.

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2. It is said that the separaton between the two charges forming an electric dipole should be small. Small compered to what?

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3. A point charge q is placed in a cavity in a metal block. If a charge Q is brought outside the metal, will the charge q feel an electric force?

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4. An electron and a proton are freely situated in an electric field. Will the electric forces on them be equal? Will their acceleration be equal? Explain with reason.

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5. Is there any lower limit to the electric force between two

. particles placed at a separation of 1 cm?

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6. Can two equipotential surfaces cut each other?

Watch Video Solution

7. Why the electric field at the outer surface of a hollow charged conductor is normal to the surface?

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8. Can a gravitational field be added vectorially to an

. electric field to get a total field?

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9. Why does a phonograph record attract dust particles just after it is cleaned?

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10. A spherical shell made of plastic, contains a charge Q distributed uniformly over its surface. What is the electric field inside the shell? If the shell is hammered to deshape it without altering the charge. Will the field inside be changed? What happend if the shell is made of a metal?

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11. How can the whole charge ofa conductor be transferred to another isolated conductor ?

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12. Does the force on a charge due to another charge depend

. on the charges present nearby?

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13. A charged particale is free to move in an electric field. Will it always move along an electric line of force ?

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14. Two point charges+ q and-q are placed at distanced apart. What are the points at which the resultant field is parallel to the line joining the two charges ?

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15. A point charge is taken from a point A to a point B in an electric field. Does the work done by the electric field depend on the path of the charge ?

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16. A positive charge +q is located at a point. What is the work done if a unit positive charge is carried once around this charge along a circle ofradius r about :

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17. A rubber balloon is given a charge. Q distributed uniformly over its surface. Is the field inside the balloon zero everywhere if the balloon does not have a spherical surface?

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18. Two small balls having equal poistive charges Q(coulomb) on each are suspended by two insulating strings of equal length L(metre) from a hook fixed to a stand. The whole set up is taken in a satellite into space where there is no gravity (state of weightlessness). The angle between the two strings is...............and the tenison in each string is...................newtons.

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19. The number of electrons in an insulator is of the same order as the number of electrons in a conductor. What is then the basic difference between a conductor and an insulator ?

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20. No work is done in taking a positive charge from one point to other inside a positive charged metallic sphere, while outside the sphere work is done in taking the charge from one point to other (towards the sphere). Explain.

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21. A small plane area is rotated in an electric field. In which orientation of the area is the flux of electric field through the area maximum? In which orientation is it zero.?

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22. When a charged comb is brought near a small piece of paper, it attracts the piece. Does the paper, it attracts the piece. Does the paper become charged when the conb is brought near it ?

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23. A circular ring of radius r made of a nonconducting material is placed with its axis parallel to a uniform electric field. The ring is rotated about a diameter through180^0. Does the flux of electric field change? If yes, does it decrease of increase?

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24. A charge Q is uniformly distributed on a thin spherical shell. What is the field at the centre of the shell? If a point charge is brought close to the shell, will the field at the centre change? Does your answer depend on whether the shell is conducting or nonconducting?

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25. One going away from a point charge, the electric field due to the charge decreases. This is also true for a small electric-dipole. Does the electric field decreases at the same rate in both cases ?

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Conceptual MCQs single option correct

1. A soap bubble is given a negative charge, then its radius

A. Decrease

B. Increase

C. Remains unchanged

D. Nothing can be predicted as information is insufficient

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2. A given charge is situated at a certain distance from an electric dipole in the end-on position experiences a force F If the distance of the charge is doubled, the force acting on the charge will be

A. 2F

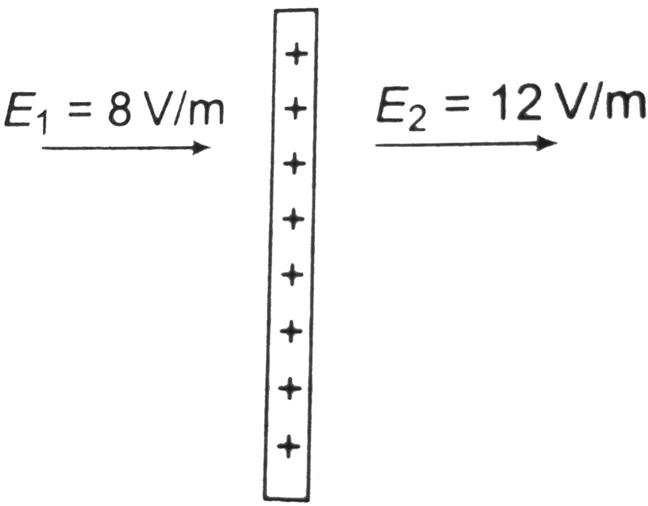
B. F/2

C. F/4

D. F/8

Watch Video Solution

3. The electric field on two sides of a thin sheet of charge is shown in the figure. The charge density on the sheet is



A. $2\varepsilon_0$

B. $4\varepsilon_0$

C. $10\varepsilon_0$

D. Zero

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4. Three identical charges are placed at corners of a equilateral triangel of side l. If force between any two charges is F, the work required to double the dimensiions of triangle is

A. $-3Fl$

B. 3Fl

C. $(-3/2)Fl$

D. $(3/2)Fl$

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5. Three concentric conducting sphereical shells carry charges $+4Q$ on the inner shell $-2Q$ on the middle shel and $+6Q$ on the outer shell. The charge on the inner surface of the outer shell is

A. 0

B. 4Q

C. $-Q$

D. $-2Q$

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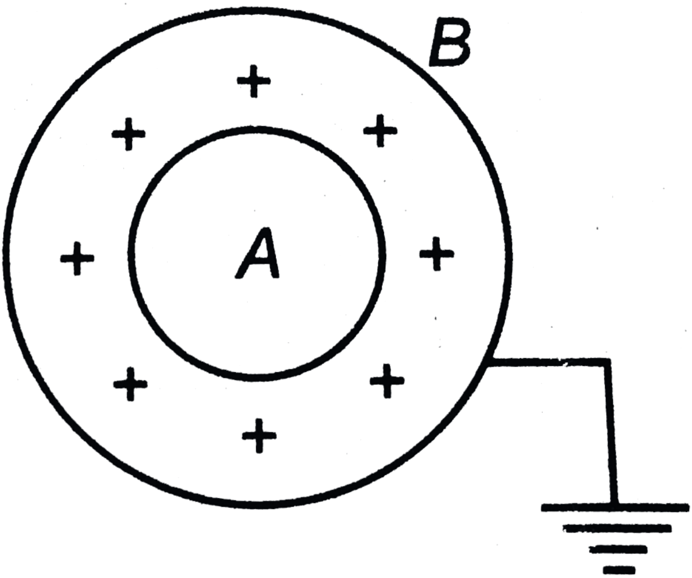
6. A and B are two concentric spherical shells. If A is given a charge $+q$ while B is earthed as shown in figure then



A. Charge on the outer surface of shell B is zero

B. The charge on B is equal and opposite to that of A

C. The field inside A and outside B is zero

D. All of the above

Answer: D

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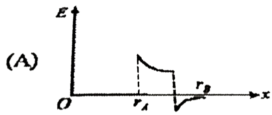
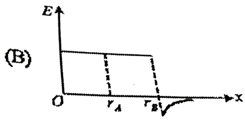
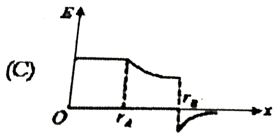
7. Two concentric conducting thin spherical shells A andB having radii rA and $r8(r_8 > r_A)$ are charged to Q_A and $-Q_B(|Q_B| > |Q_A|)$. The electric field strength along a line passing through the centre varies with the distance x as :

A. 

B. 

C. 

D. None of these

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8. Electric potential at a point P, r distance away due to a point charge q kept at point A is V. If twice of this charge is distributed uniformly on the surface of a hollow sphere of radius 4r with centre at point A the potential at P now is

A. V

B. V/2

C. V/4

D. V/8

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9. There is a point charge +q inside a hollow sphere and a point charge -q just outside its surface. The total flux passing through the surface of sphere is :

A. $-\frac{q}{\epsilon_0}$

B. $\frac{q}{\epsilon_0}$

C. $\frac{2q}{\epsilon_0}$

D. zero

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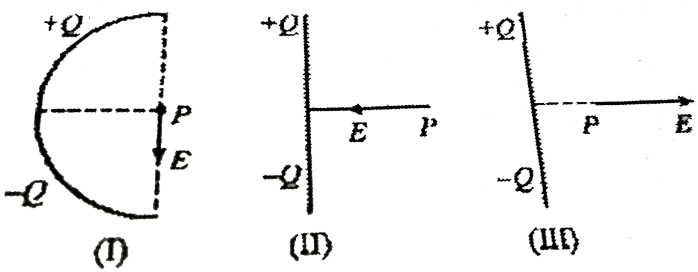
10. The figure shows three non condncting rods, one circular and two straight. Each has a uniform charge of magnitude Q distributed on its one half and -Q on its other half as shown in the figure-1.364. Which of these correctly represents the direction of field at point P :



A. I

B. II

C. III

D. I and II

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11. A conducting spherical shell having inner radius a and outer radius b carries a net charge Q. If a point charge q is placed at the centre of this shell, then the surface charge density on the outer surface of the shell is given as:

A. $\dfrac{Q-p}{4\pi b^2}$

B. $\dfrac{Q+q}{4\pi b^2}$

C. $\dfrac{Q-q}{4\pi b^2}$

D. Zero

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12. If a unit positive charge is taken from one point to another over an equipotential surface ,then

A. Work is done on the charge

B. Work is done by the charge

C. Work on the charge is constant

D. No work is done

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13. Ten electrons are qually spaced and fixed around a circle of radius R. Relative to $V = 0$ at infinity, the electrostatic potential V and the electric field E at the centre C are

A. $V \neq 0 \text{and} \overrightarrow{E} \neq 0$

B. $V \neq 0 \text{and} \overrightarrow{E} = 0$

C. $V = 0 \text{ and } \overrightarrow{E} = 0$

D. $V = 0 \text{and} \overrightarrow{E} \neq 0$

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14. Let $P(r) = \frac{Q}{\pi R^4} r$ be the charge density distribution for a solid sphere of radius R and total charge Q. For a point 'p' inside the sphere at distance r_1 from the centre of the sphere, the magnitude of electric field is:

A. $\dfrac{Q}{4\pi \in_0 r_1^2}$

B. $\dfrac{Qr_1^2}{4\pi \in_0 R^4}$

C. $\dfrac{Qr_1^2}{3\pi \in_0 R^4}$

D. 0

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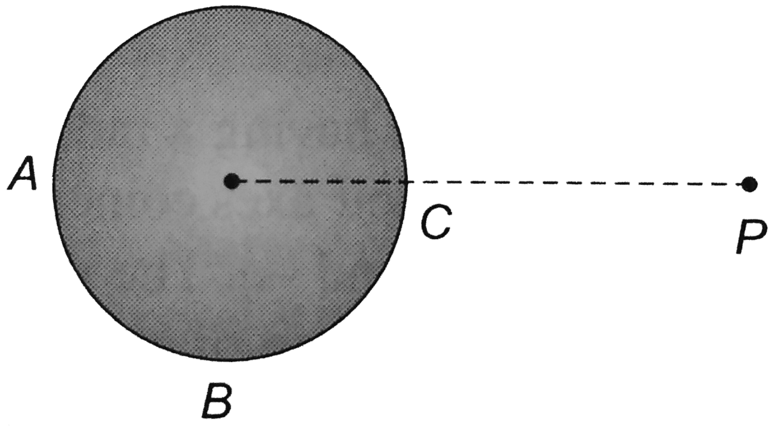
15. A hollow conducting sphere is placed in an electric field produced by a point charge placed at P as shown in figure.

Let V_A, V_B, V_C be the potentials at points A, B and C respectively.

Then



A. $V_C > V_B$

B. $V_B < V_C$

C. $V_A > V_B$

D. $V_A = V_C$

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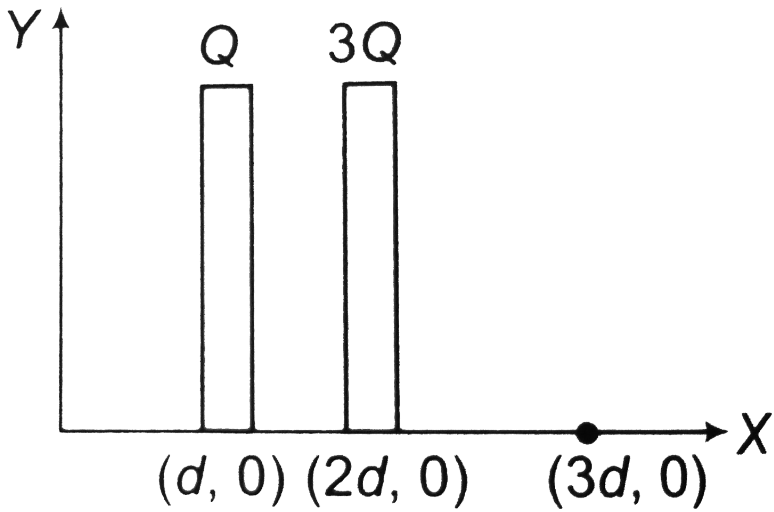
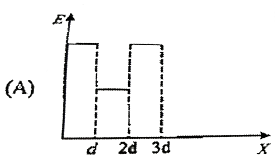
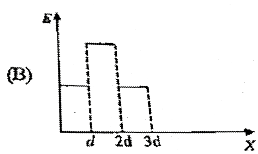
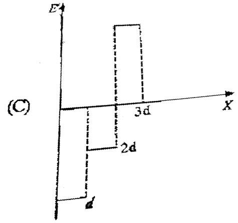
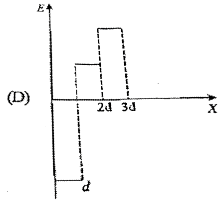
16. Two very large thin conducting plates having same cross sectional area are placed as shown in figure. They are carrying chaerges Q and $3Q$, respectivley. The variation of electric field as as function at x(for $x = 0$ to $x = 3d$) will be best represented as by



A. 

B. 

C. 

D. 

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17. A conducting shell S_1 having a charge Q is surrounded by an uncharged concentric conducting spherical shell S_2.

Let the potential difference between S_1 and that S_2 be V. If the shell S_2 is now given a charge $-3Q$, the new potential difference between the same two shells is

A. V

B. 2V

C. 4V

D. $-2V$

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18. For a given surface the Gauss's law is stated as $\oint \vec{E} \,.\, d\vec{A} = 0$.

From this we can conclude that

A. E is necessarily zero on the surface

B. E is perpendicular to the surface at every point

C. The total flux through the surface is zero

D. The flux is only going out of the surface

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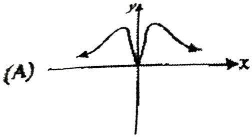
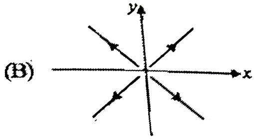
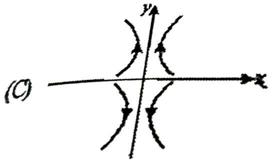
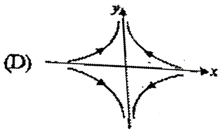
19. The potential field depends on the x - and y - coordinates as $V = x^2 - y^2$. The corresponding electric field lines in x y plane are as.

A. 

B. 

C. 

D. 

20. Conisder a neutral conducting sphere. A poistive point charge is placed outisde 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

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21. One metallic sphere A is given positive charge whereas another identical metallic sphere B of exactly same mass as of A is given equal amount of negative charge. Then

A. Mass of A and mass of B still remain equal

B. Mass of A increases

C. Mass of B decreases

D. Mass of B increases

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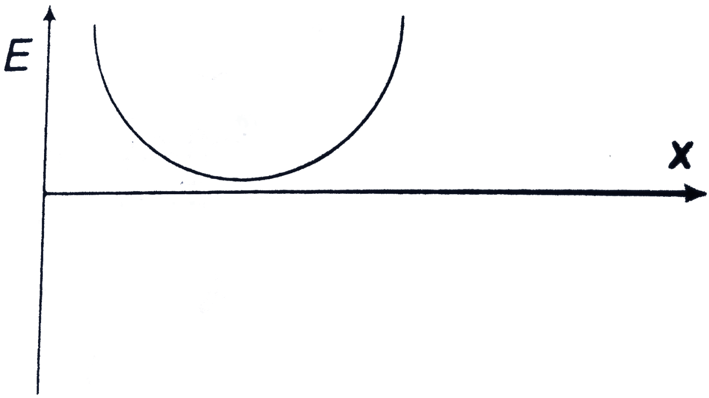
22. Two point charges a and b whose magnitude are same, positioned at a certain distance along the positive x-axis from each other a is at origin. Graph is drawn between electrical field strength and distance x from a. E is taken positive if it is along the line joining from a to b

Fro the graph it ca be decided that



A. a is positive, b is negative

B. a and b both are positive

C. a and b boih are negative

D. a is negative, b is positive

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23. Two spheres A and B of radius 'a' and 'b' respectively are at same electric potential. The ratio of the surface charge densities of A and

B is

A. $\frac{a}{b}$

B. $\frac{b}{a}$

C. $\frac{a^2}{b^2}$

D. $\frac{b^2}{a^2}$

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24. A long, hollow conducting cylinder is kept coaxially inisde 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 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.

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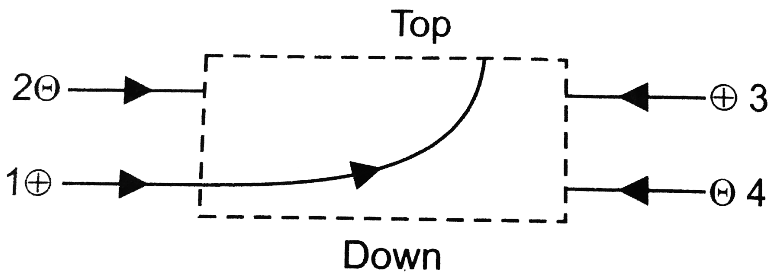
25. The figure shows the path of a positively charged particle 1 through a rectangualr region of unifrom electric field as shown in the figure. What is the direction of electric field and the direction of deflection of particles $2, 3$ and 4 ?



A. Top, down, top, down

B. Top, down, down, top

C. Down, top, top, down

D. Down, top, down, down

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26. The force experienced by a unit positive point charge when placed in an electric field is called ?

A. Potential of electric field at that point

B. Moment of electric field at that point

C. Intensity of electric field at that point

D. Capacity of electric field at that point

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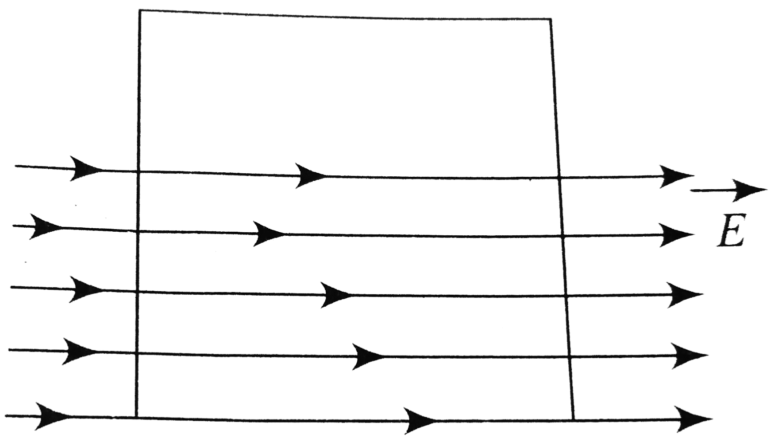
27. A square surface of side Lm is in the plane of the paper. A uniform electric field $\overrightarrow{E}(V/m)$, also in the plane of the paper, is limited only to the lower half of the square surface (see figure). The electric flux in SI units associated with the surface is:



A. Zero

B. EL^2

C. $EL^2 / 2 \in_0$

D. $EL^2 / 2$

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28. A positively charged disc is placed on a horizontal plane. A charged particle is released from a certain height on its axis. The particle just reaches the centre of the disc. Select the correct alternative.

A. Particle has negative charge on it

B. Total potential energy (gravitational+ electrostatic) of the particle first increases then decreases

C. Total potential energy of the particle first decreases then increases

D. Total potential energy of the particle continuously decreases

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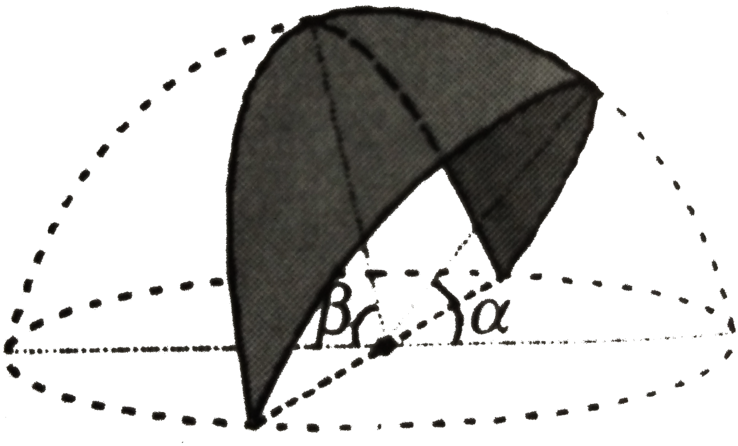
29. The electric field intensity at the center of a uniformly charged hemispherical shell is E_0. Now two portions of the hemisphere are cut from either side, and the remaining portion is shown in fig. If $\alpha = \beta = \pi / 3$, then the electric field intensity at the center due to the remaining portion is



A. $\frac{E_0}{3}$

B. $\frac{E_0}{6}$

C. $\frac{E_0}{2}$

D. Information insufficient

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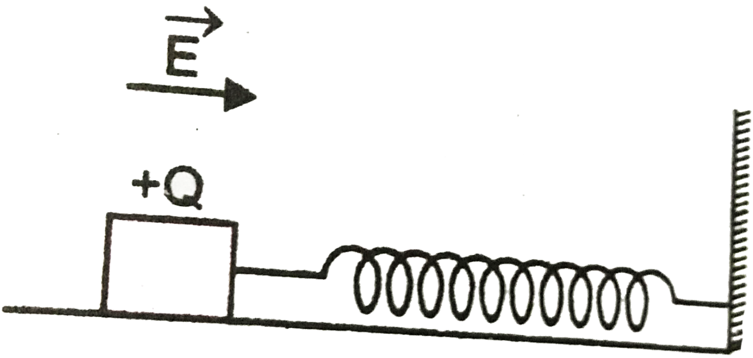
30. A wooden block performs SHM on a frictionless surface with frequency, v_0. The block carries a charge $+Q$ on its surface. If now a uniform electric field $\vec{E}$ is switched on as shwon in figure., then the SHM of the block will be



A. Of the same frequency and with shifted mean position

B. Of the same frequency and with the same mean position.

C. Of changed frequency and with shifted mean position.

D. Of changed frequency and with the same mean position.

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31. Two equal positive charges are kept at points A and B. The electric potential at the points between A and B (exculding these points) is studid while moving from A to b. The potential

A. Continuously increases

B. Continuously decreases

C. Increases then decreases

D. Increases then decreases

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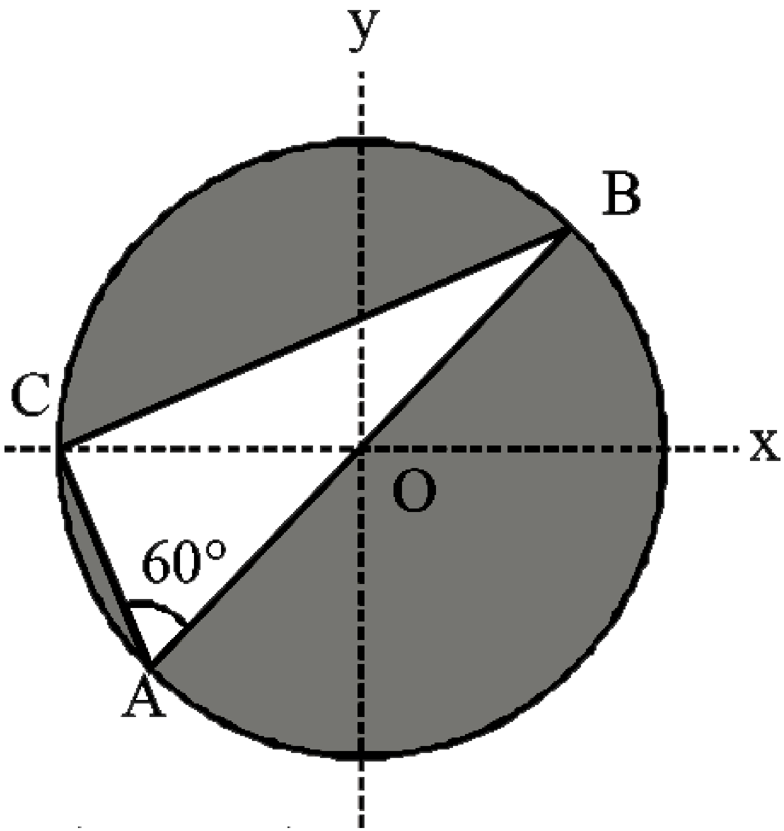
32. Consider a system of three charges $\frac{q}{3}, \frac{q}{3}$ and $-\frac{2q}{3}$ placed ar point A,B and C respectively, as shown in the figure. Take O to be the centre of the circle of radius R and angle $CAB = 60^{\circ}$. Choose the incorrect options



(1) The electric field at point O is $\frac{q}{8\pi\varepsilon_0 R^2}$ directed along the negative x-axis

(2) The potential energy of the system is zero

(3) The potential at point O is $\frac{q}{12\pi\varepsilon_0 R}$

(4) The magnitude of the force between the charges at C and B is $\frac{q^2}{54\pi\varepsilon_0 R^2}$

A. The electric field at point O is $\frac{q}{8\pi \in_0 R^2}$ directed along the negative x-axis.

B. The potential energy of the system is zero.

C. The magnitude of the force between the charges at C and B is $\frac{q^2}{54\pi \in_0 R^2}$

D. The potential at point O is $\frac{q}{12\pi \in_0 R}$

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33. A solid conducting sphere having a charge Q is surrounded by an uncharged concentric conducting hollow spherical shell. Let the potential difference between the surface of the solid sphere and that of the outer surface of the hollow shell be V. If the shell is now given a charge of $-3Q$, the new potential difference between the same two surfaces is :

A. V

B. 2V

C. 4V

D. $-2V$

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34. Charges Q and -2Q are placed at some distance. The locus of points in the plane of the charges where the potential is zero will be :

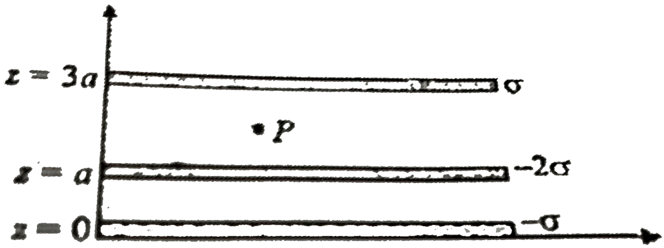
A. A Strainght line

B. A circle

C. A parabola

D. An ellispse

35. Three infinite long charged sheets of charge densities $-\sigma, \ -2\sigma$ and σ are placed parallel to,y-plane at z= 0, z= a, z= 3a. Electric field at point Pis given as :



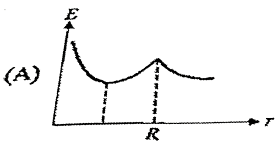
A. $-\dfrac{2\sigma}{\in_0}\hat{k}$

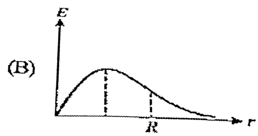
B. $\dfrac{2\sigma}{\in_0}\hat{k}$

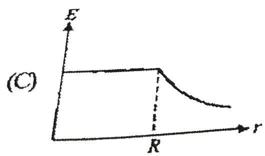
C. $\dfrac{-4\sigma}{\in_0}\hat{k}$

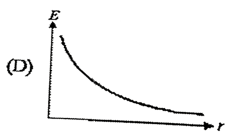
D. $\dfrac{4\sigma}{\in_0}\hat{k}$

36. A spherical insulator of radius R is charged uniformly with a charge Q throughout its volume and contains a point charge $\frac{Q}{16}$ located at its centre. Which of the following graphs best represent quanlitatively, the variation of electric field intensity E with distance r from the centre.

A. 

B. 

C. 

D. 

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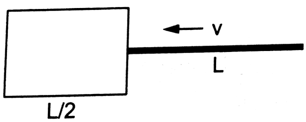
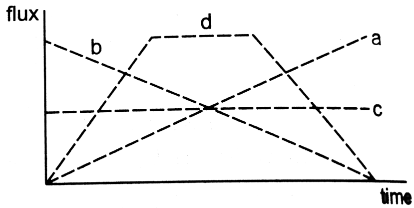
37. Figure shown an imaginary cube of edge L/2. A uniformly Charged rod of length L moves towards left at a small but constant speed v. At t=0, the left end just touches the centre of the cube opposite it. Which of the graphs shown in figure represents the flux of the electic field through the cube as the rod goes through it?





A. I

B. II

C. III

D. IV

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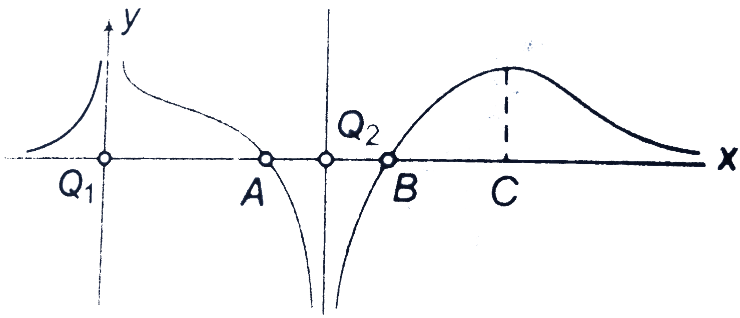
38. The curve represents the distribution of potential along the staight line joining the two charges Q_1 and Q_2 (separated by a distance r) then which of the following statements are correct?



1. $|Q_1| > |Q_2|$

2. Q_1 is positive in nature

3. A and B are equilibrium points

4. C is a point of unstabkle equilibrium

A. I and 2

B. I,2 and 3

C. I,2 and 4

D. l,2,3and4

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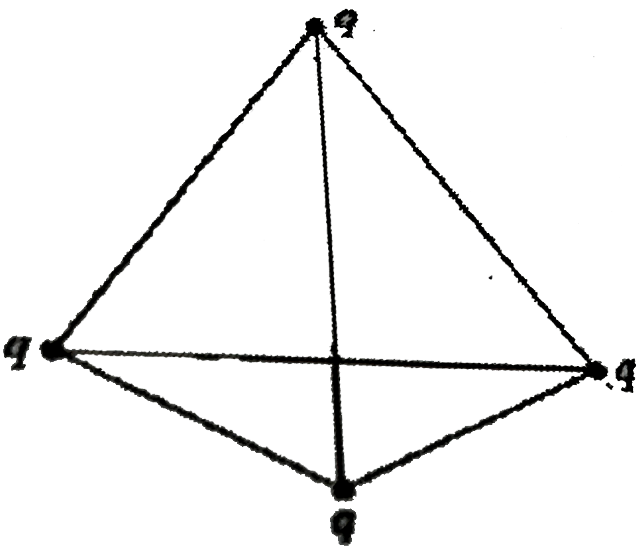
39. Four similar point charges q are located at the vertices of (C) a tetrahedron with an edge a. The energy of the interaction of Four similar point charges q are located at the vertices of (C) a tetrahedron with an edge a. The energy of the interaction of



A. $\frac{6q^2}{4\pi\varepsilon_0 a}$

B. $\frac{4q^2}{4\pi\varepsilon_0 a}$

C. $\frac{3q^2}{4\pi\varepsilon_0 a}$

D. $\frac{q^2}{4\pi\varepsilon_0 a}$

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40. A positively charged ball hangs from a long silk thread. Electric filed 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 charges. then E

A. $> F/q_0$

B. $= F/q_0$

C. $< F/q_0$

D. Can not be estimated

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41. A particle of charge $-q$ and mass m moves in a circular orbits of radius r about a fixed charge $+Q$.The relation between the radius of the orbit r and the time period T is

A. $r = \frac{Qq}{16\pi^2 \varepsilon_0 m} T^2$

B. $r^3 = \frac{Qq}{16\pi^3 \varepsilon_0 m} T^2$

C. $r^2 = \frac{Qq}{16\pi^3 \varepsilon_0 m} T^3$

D. $r^2 = \frac{Qq}{4\pi^3 \varepsilon_0 m} T^3$

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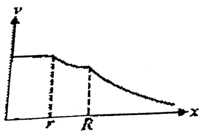
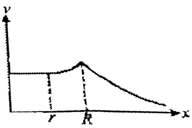
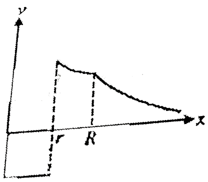
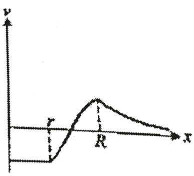
42. Two concentric spherical shells of radii r and $R(r < R)$ have surface charge densities $-\sigma$ and $+\sigma$ respectively. The variation ofelectric potential V with distance x from the centre O of the shells plotted. Which of the following graphs best depict the variation qualitatively?

A. (A) 

B. (B) 

C. (C) 

D. (D) 

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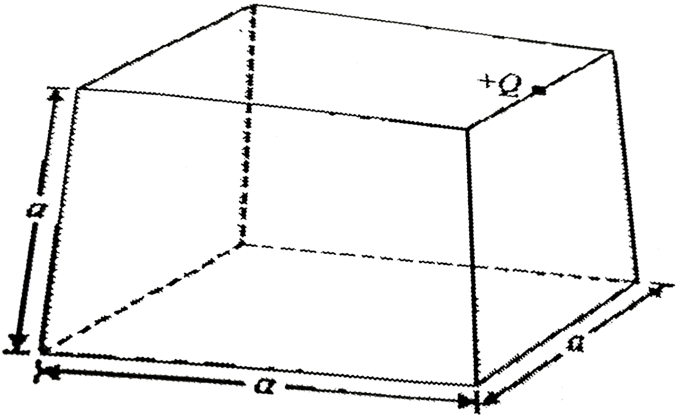
43. In figure $+Q$ charge is located at one of the edge of the cube as shown in figure-1.376. Then electric flux through cube due to $+Q$ charge is given as



A. $\frac{+Q}{\varepsilon_0}$

B. $\frac{+Q}{2\varepsilon_0}$

C. $\frac{+Q}{4\varepsilon_0}$

D. $\frac{+Q}{8\varepsilon_0}$

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44. Two equal negative charges $-q$ are fixed at points $(0, -a)$ and $(0, a)$ on y-axis. A poistive charge Q is released from rest at point $(2a, 0)$ on the x-axis. The charge Q will

A. Execute simple harmonic motion about the origin

B. Move to the origin and remains at rest

C. Move to infinity

D. Execute oscillatory but not simple harmonic motion.

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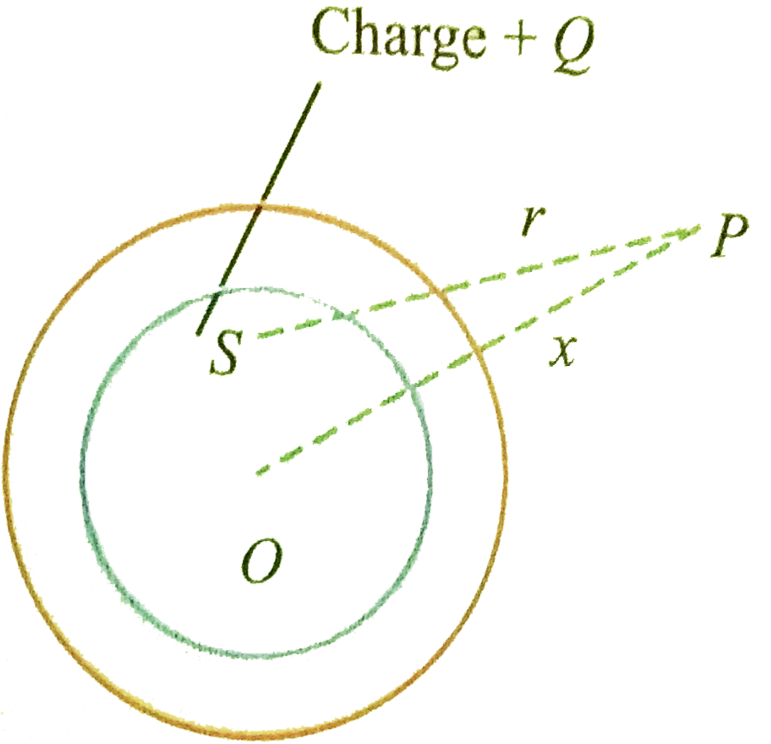
45. The adjacent diagram shows a charge $+Q$ held on an insulating support S and enclosed by a hollow spherical conductor,O represent the center of the spherical conductors and P is a point such that

$OP = x$ and $SP = r$ .The electric field at point P will be



A. $\frac{Q}{4\pi \in_0 x^2}$

B. $\frac{Q}{4\pi \in_0 r^2}$

C. 0

D. None of these

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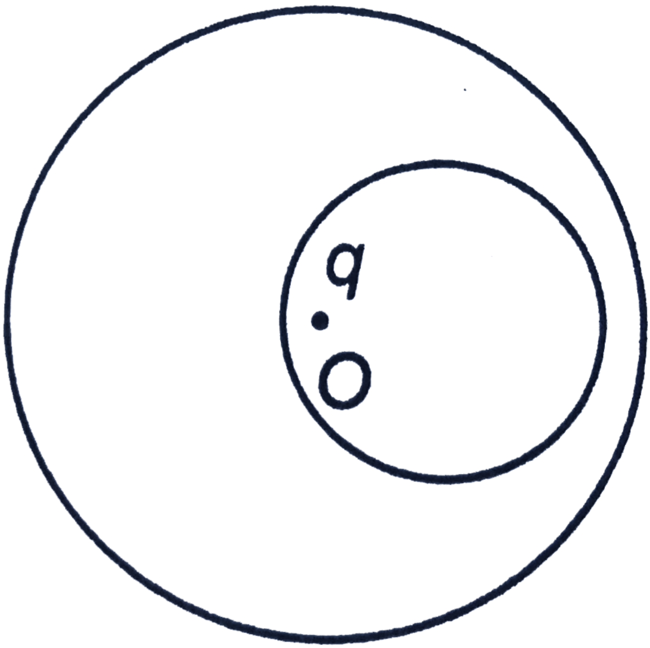
46. A charge q is placed at O in the cavity in a sphereical uncharged conductor. Points S is outside the conductor. If q is displaced from O towards S (still remaining within the cavity)



A. Electric field at S will increase

B. Electric field at S will decrease

C. Electric field at S will first increase and then decrease

D. Electric field at S will not change

Answer: D

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47. Two pith balls having charge 3_q and 2_q are placed at distance of a from each other. For what value of charge transferred from 1^{st} ball to 2^{nd} ball, force between balls becomes maximum?

A. $\frac{q}{2}$

B. $\frac{5q}{2}$

C. $7q$

D. q

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48. The insulated spheres of radii R_1 and R_2 having charges Q_1 and Q_2 respectively are connected to each other. There is

A. No change in the energy of the system

B. An increase in the energy of the system

C. Always a decrease in the energy of the system

D. A decrease in energy of the system unless $Q_1R_2 = Q_2R_1$

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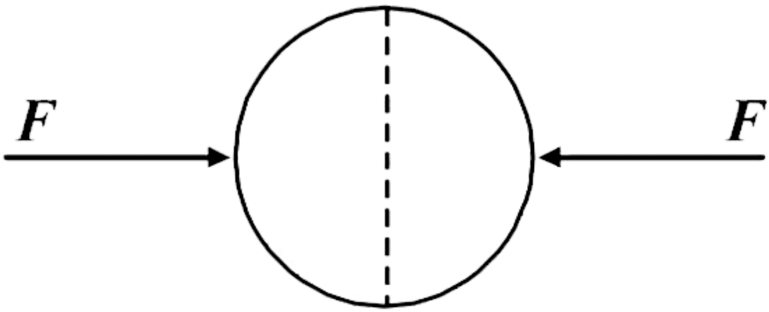
49. A uniformly charged thin spherical shell of radius R carries uniform surface charge denisty of $isgma$ per unit area. It is made of two hemispherical shells, held together by presisng them with force

F(see figure). F is proportional to



A. $\alpha^2 R^2$

B. $\alpha^2 R$

C. $\dfrac{\alpha^2}{R}$

D. $\dfrac{\alpha^2}{R^2}$

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50. A sphere of radius R carries charge density p proportional to the square of the distance from the centre such that $p = Cr^2$, where C is a positive constant. At a distance R/2 from the centre, the magnitude of the electric field is :

A. $A/(4 \in_0)$

B. $AR^3/(40 \in_0)$

C. $AR^3/(24 \in_0)$

D. $AR^3/(5 \in_0)$

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51. Two point charges, each with a charge of $+1\mu C$, lie at some finite distance apart. On which of the segments of an infinite line going through the charges is there a point, a finite distance away from the charges, where the electric potential is zero, assuming that it vanishes at infinity?

A. Between the charges only

B. On either side outside the system

C. Impossible to tell without knowing the distance between to tell without knowing the distance between

D. Nowhere

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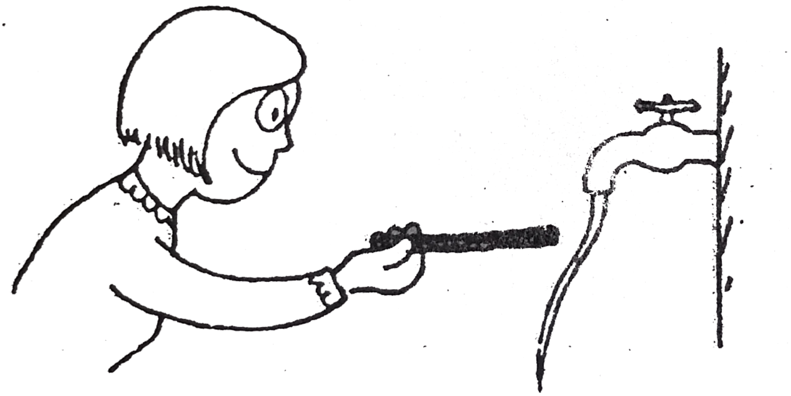
52. In normal cases thin stream of water bends toward a negatively charged rod. When a positively charged rod is placed near the stream, it will bend in the



A. opposite direction

B. same direction

C. It won't bend at all

D. Can't be predicted

Answer: B

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53. How does the electric field strength vary when we enter and move inside a uniformly charged spherical cloud?

A. Increases inversely as the square of the distance from the center.

B. Decreases inversely as the square of the distance from the center

C. Increases directly as the distance from the center.

D. Decreases directly as the distance from the centre

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54. On an imaginary planet the acceleration due to gravity is same as that on Earth but there is also a downward electric field that is uniform close to the planet's surface. A ball of mass m carrying a charge q is thrown upward at a speed v and hits the ground after an interval t, What is the magnitude of potential difference between the starting point and top point of the trajectory?

A. $\frac{mv}{2q}\left(v-\frac{\text{gt}}{2}\right)$

B. $\frac{mv}{q}\left(v-\frac{\text{gt}}{2}\right)$

C. $\frac{mv}{2q}(v-\text{gt})$

D. $\frac{2mv}{q}(v-\text{gt})$

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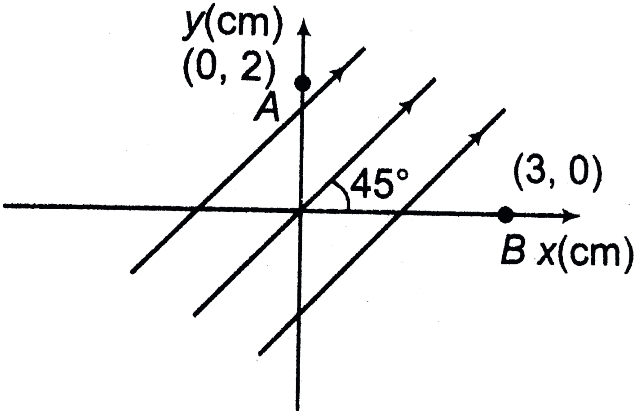
55. A uniform electric field of $400\frac{V}{m}$ is directed at 45° above the x-axis as shown in the figure. The potential difference $V_A - V_B$ is given by



A. 0

B. 4V

C. $6.4V$

D. $2.8V$

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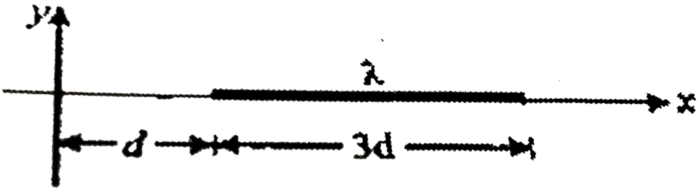
56. A continuous line of charge oflength 3d lies along the x-axis, extending from $x + d$ to$x + 4d$. the line carries a uniform linear charge density λ.



In terms of d,λ and any necessary physical constants, find the magnitude of the electric field at the origin:

A. $\lambda / 5\pi \in_0 d$

B. $\lambda / 4\pi \in_0 d$

C. $3\lambda / 16\pi \in_0 d$

D. $3\lambda / 8\pi \in_0 d$

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57. Electric charge are distributed in a small vouume. The flux of the electric field through a spherical surface of rasius 10cm surrounding the total charge is 25 V m. The flux over a concentric sphere of radius 20 cm will be

A. $25V - m$

B. $50V - m$

C. $I00V - m$

D. $200V - m$

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58. Three concentric metallic spherical shells A, B and C of radii a, b and $c(a < b < c)$ have surface charge densities $-\sigma$, $+\sigma$and $-\sigma$ respectively ,the potential of shell A is

A. $(a+b+c)\frac{\alpha}{\varepsilon_0}$

B. $\left(\frac{a^2}{b}-b+c\right)\frac{\alpha}{\varepsilon_0}$

C. $\left(\frac{a^2}{b} - \frac{b^2}{c} + c\right)\frac{\alpha}{\varepsilon_0}$

D. $\frac{\alpha c}{\varepsilon_0}$

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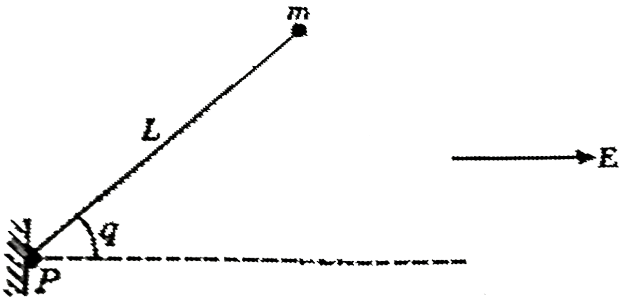
59. A particle of mass m and charge q is attached to a light rod oflength L. The rod cau rotate freely in the plane of paper about the other end, which is hinged at P, the.entire assembly lies in an uniform electric field E acting in the plane of paper ·as shown in the figure-. The rod is released from rest when it makes an angle 9 with the electric field direction. Determine the speed oft he particle when the rod becomes parallel to the electric field:



A. $\left(\frac{2qEL(1-\cos\theta)}{2m}\right)^{1/2}$

B. $\left(\frac{2qEL(1-\sin\theta)}{m}\right)^{1/2}$

C. $\left(\frac{qEL(1-\cos\theta)}{2m}\right)^{1/2}$

D. $\left(\frac{2qEL\cos\theta}{m}\right)^{1/2}$

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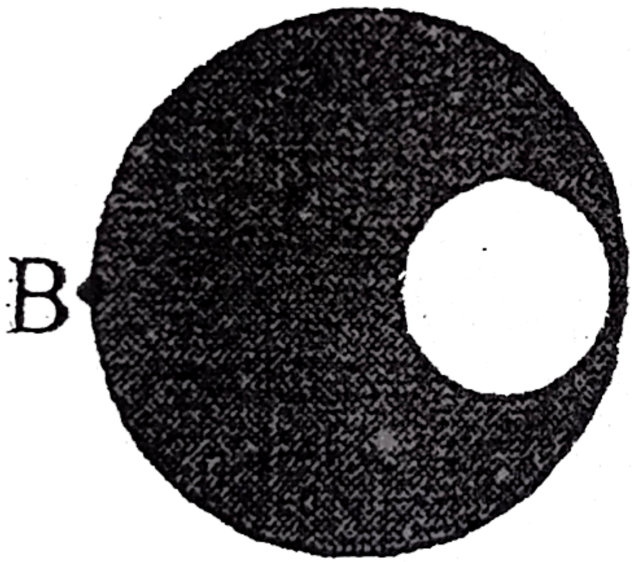
60. A positively charged sphere of radius r_0 carries a volume charge density ρ_E (Figure). A spherical cavity of radius $r_0/2$ is then scooped out and left empty, as shown. What is the direction and magnitude of the electric field at point B?



A. $\frac{17\rho r_0}{54 \in_0}$ left

B. $\frac{\rho r_0}{6 \in_0}$ left

C. $\frac{17\rho r_0}{54 \in_0}$ right

D. $\frac{\rho r_0}{6 \in_0}$ right

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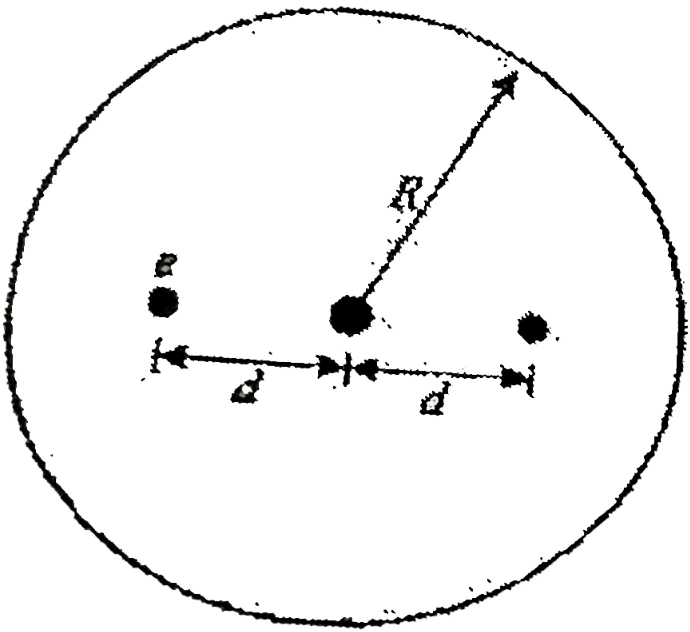
61. Using Thomson's model of the atom, consider an atom consisting of two electrons, each of charge $-e$, embedded in a sphere ofcharge + 2e and radius R. In equilibrium each electron is at distanced from the centre of the atom. What is equilibrium separation between electrons ?



A. R

B. R//2

C. R//3

D. R//4

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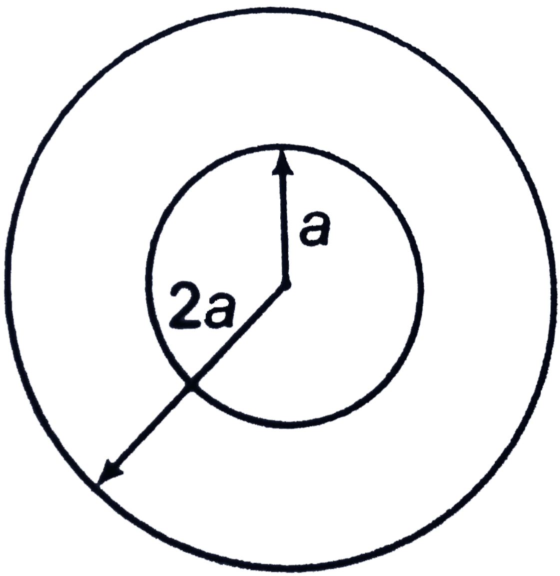
62. If the electric potential of the inner shell is $10V$ and that of the outer shel is $5V$, then the potential at the centre will be



A. 10V

B. 5V

C. 15V

D. zero

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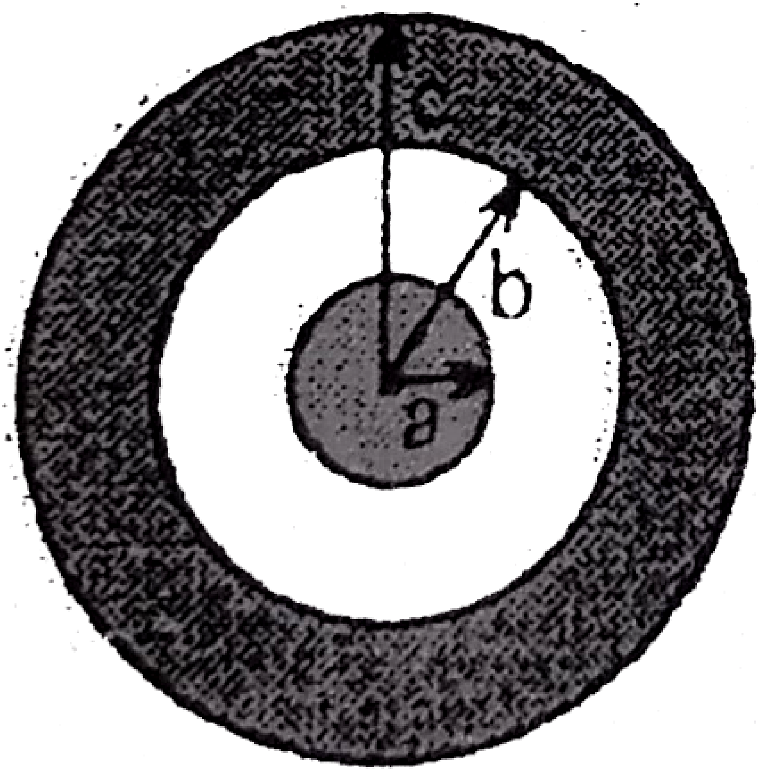
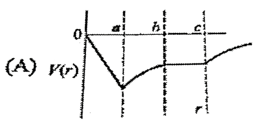
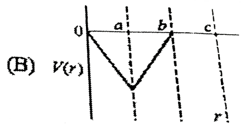
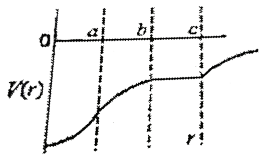
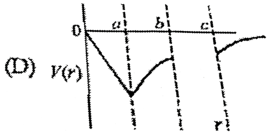
63. A nonconducting sphere with radius a is concentric with and surrounded by a conducting spherical shell with inner radius b and outer radius c. The inner sphere has a negative charge uniformly distributed throughout its volume, while the spherical shell has no net charge. The potential V (r) as a function of distance from the center is given by



A. 

B. 

C. 

D. 

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64. A charged particle q is shot from a large distance twoards another charged particle Q which is fixed, with speed v. It approaches Q up to as closed distance r and then returns. If q were given a speed 2v, the distasnce of approach would be

A. r

B. 2r

C. $r/2$

D. $r/4$

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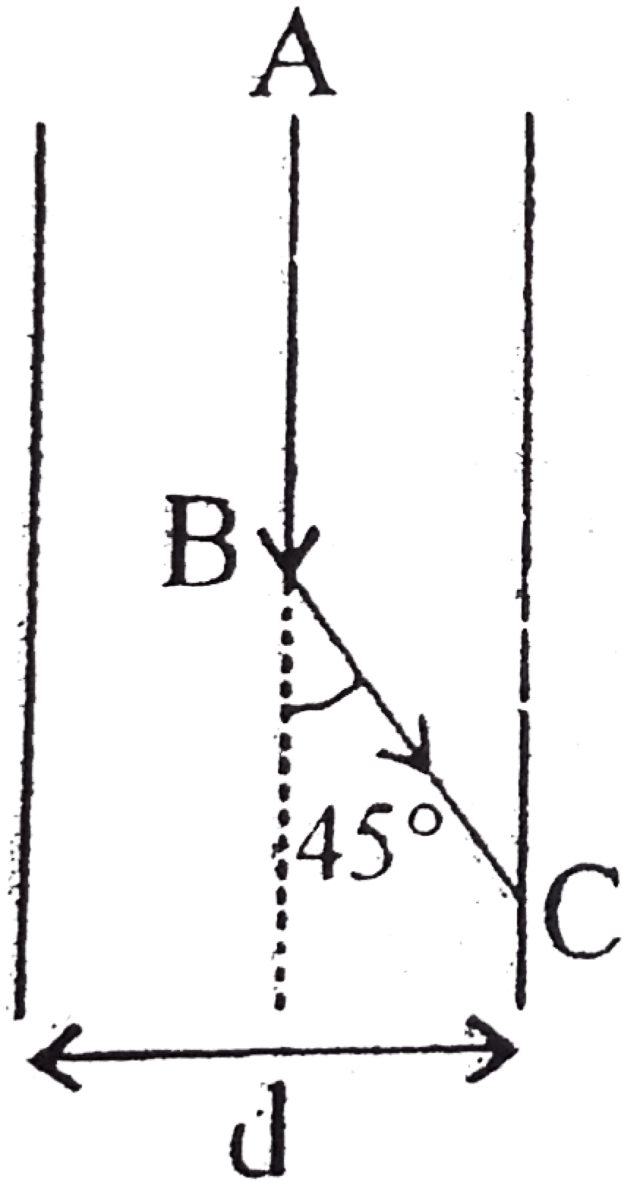
65. A sphere carrying a charge of Q having weight w falls under gravity between a pair of vertical plates at a distance of d from each other. When a potential difference V is applied between the plates the acceleration of sphere changes as shown in the figure, to along line BC. The value of Q is



A. $\frac{w}{V}$

B. $\frac{w}{2V}$

C. $\frac{wd}{V}$

D. $\frac{\sqrt{2}wd}{V}$

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66. Let $E_1(r)$, $E_2(r)$ and $E_3(r)$ be the respectively electric field at a distance r from a point charge Q, an infinitely long wire with constant linear charge density λ, and an infinite plane with uniform surface charge density σ. If $E_1(r_0) = E_2(r_0) = E_3(r_0)$ at a given distance r_0, then

A. $Q = 4\sigma\pi r_0^2$

B. $r_0 = \frac{\lambda}{2\pi\sigma}$

C. $E_1(r_0/2) = 2E_3(r_0/2)$

D. $E_2(r_0/2) = 4E_3(r_0/2)$

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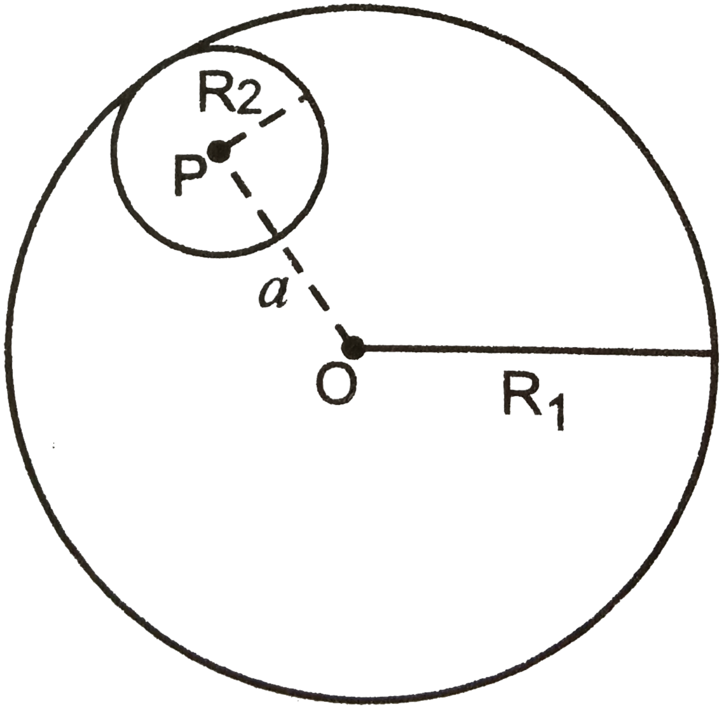
67. Consider a uniform spherical charge distribution of radius R_1 centred at the origin O. In this distribution a spherical cavity of radius R_2, centred at P with distance $OP = a = R_1 - R_2$ (fig) is made.If the electric field inside the cavity at position $\overrightarrow{r}$, then the correct statement is



A. E is uniform, its magnitude is independent of R_2 but its direction depends on r.

B. E is uniform, its magnitude depends on R_2 and its direction depends on r

C. E is uniform, its magnitude is independent of a but its direction depends on a.

D. Eis uniform and both its magnitude and direction depend on magnitude and direction of a

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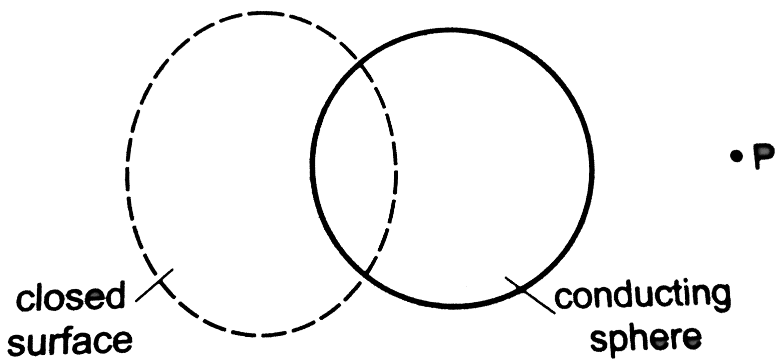
68. Figure shown a closed surface which intersects a conducting sphere. If a positive charge is placed at the point P, the flux of the electric field through the closed surface



A. Will remain zero

B. Will become positive

C. Will becomes negative

D. Data insufficient

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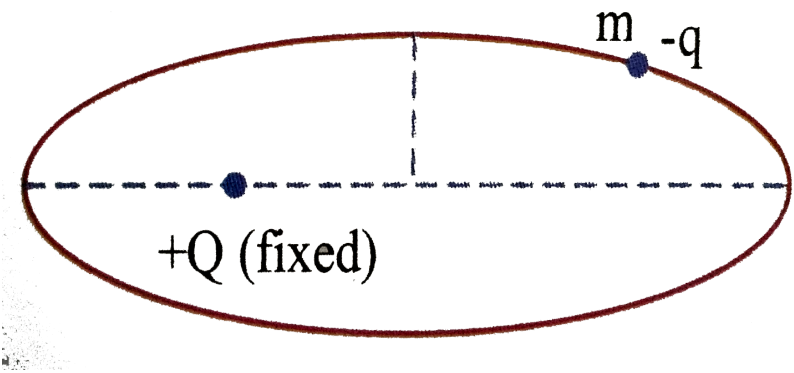
69. A positive point charge $+Q$ is fixed in space .A negative point charge $-q$ of mass m revolves around a fixed charge in elliptical orbits .The fixed charge $+Q$is at one focus of the ellipse.The only force acting on negative charge is the electrostatic force due to positive charge is the electrostatic force due to positive charge.Then which of the following statement is true



A. Linear momentum of negative point charge is conserved

B. Angular momentum of negative point charge about fixed positive charge is conserved

C. Total kinetic energyofnegative point charge is conserved

D. Electrostatic potential energy of system of both point charges is conserved

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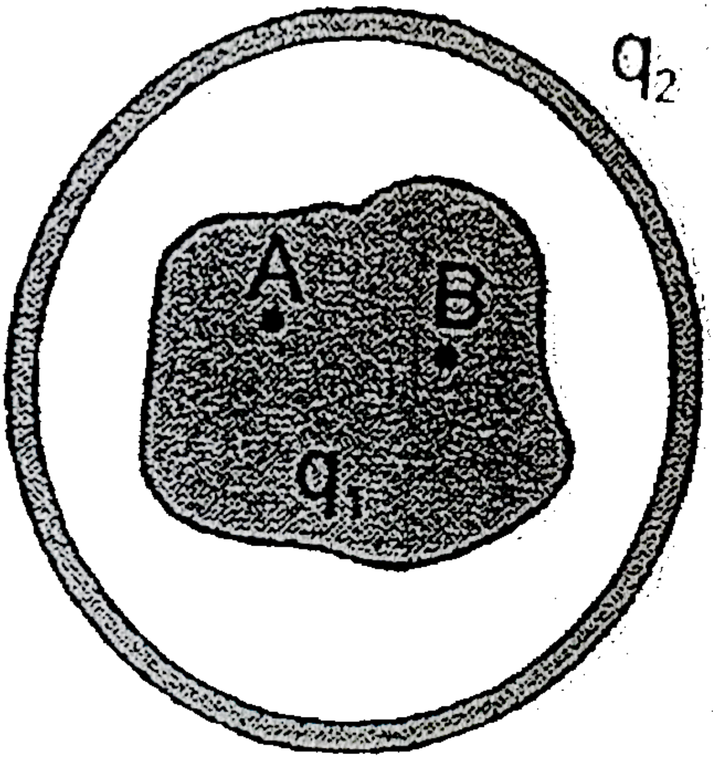
70. An irregular shaped non conductor has some charge distribution. The potential difference between the two points A and B in it is V. If it is now enveloped in an spherical non conducting shell having uniform charge distribution in it, the new potential difference between the points (neglect any induction due to presence of charge)



A. Is greater than V

B. Is less than V

C. Is equal to V

D. Depends on the relative position of inner nonconductor vis-a-vis outer nonconducting shell

Answer: C

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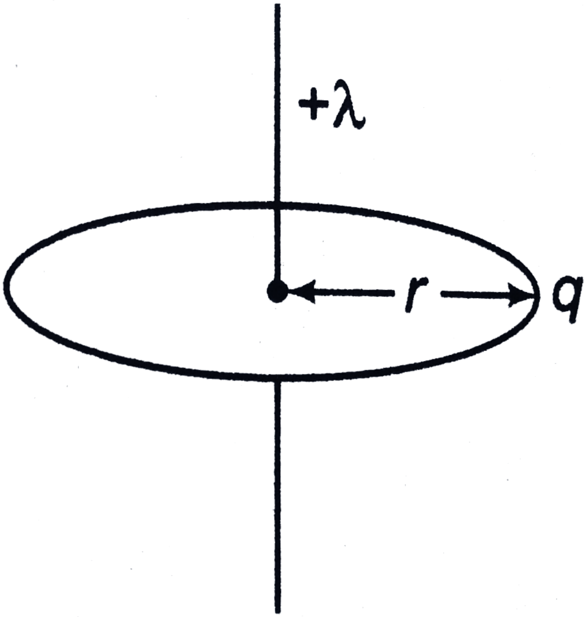
Numerical MCQs Single options Correct

1. A particle of charge $-q$ and mass m moves in a circle of radius r around an infinitely long line charge of linear charge density $+\lambda$. Then, time period will be



where ,

$k = \frac{1}{4}\pi\varepsilon_0)$

A. $T = 2\pi r\sqrt{\frac{m}{2K\lambda q}}$

B. $T^2 = \frac{4\pi^2 m}{2K\lambda q}r^3$

C. $T = \frac{1}{2\pi r}\sqrt{\frac{2K\lambda q}{m}}$

D. $T = \frac{1}{2\pi r}\sqrt{\frac{m}{2K\lambda q}}$

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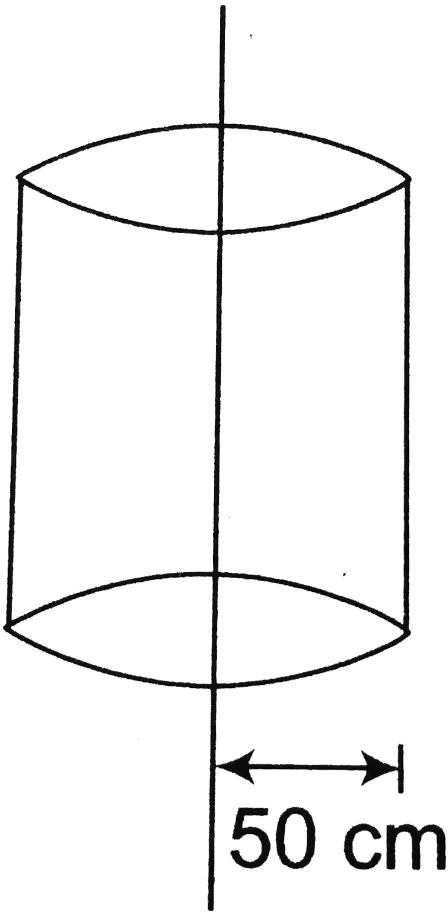
2. Electric charge is uniformly distributed along a along straight wire of radius $1mm$. The charge per centimeter length of the wire is Q coulomb. Another cyclindrical surface of radius $50cm$ and length $1m$ symmetrically enclose the wire ask shown in figure. The total electric flux passing through the cyclindrical surface is



A. $\frac{Q}{\varepsilon_0}$

B. $\frac{100Q}{\varepsilon_0}$

C. $\frac{10Q}{(\pi\varepsilon_0)}$

D. $\frac{100Q}{(\pi\varepsilon_0)}$

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3. A copper(density of Cu=p_c) ball of diameter dis innnersed in oil of density p_0 . What is the charge on the ball if, in a homogeneous elecltric field E directed vertically upward, it is suspended in the oil ? $\left(k = \pi d^3 \frac{p_c g}{E}\right)$:

A. $\frac{1}{6}k\left(1 - \frac{p_0}{p_c}\right)$

B. $\frac{1}{3}k\left(1 - \frac{p_0}{p_c}\right)$

C. $\frac{1}{2}k\left(1 - \frac{p_0}{p_c}\right)$

D. $k\left(1-\frac{p_0}{p_c}\right)$

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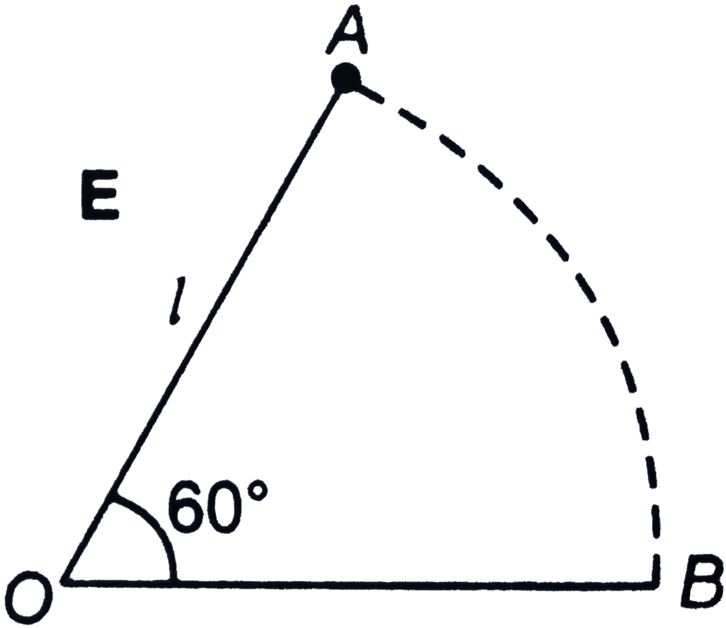
4. A particle of mass m and charge q is fastened to one end of a string of length. The other end of the string is fixed to the point O. The whole sytem liles on as frictionless horizontal plane. Initially, the mass is at rest at A. A uniform electric field in the direction shown in then switfched on. Then



A. The speed of the particle when it reaches B is $\sqrt{\frac{2qEl}{m}}$

B. The speed of the particle when it reaches B is $\sqrt{\frac{qEl}{m}}$

C. The tension in the string when the particle reaches at B is qE.

D. The tension in the string when the particle reaches at B is zero

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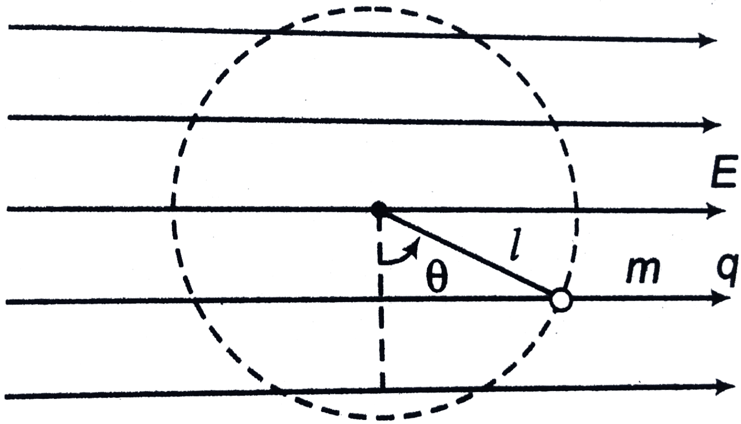
5. A small ball of masss m and charge +q tied with a string of length l, rotating in a veticle circle under gravity and a uniform horizontal electric field E as shown. The tension in the string will be minimum for



A. $\theta = \tan^{-1}\left(\frac{qE}{mg}\right)$

B. $\theta = \pi$

C. $\theta = 0^\circ$

D. $\theta = \pi + \tan^{-1}\left(\frac{qE}{mg}\right)$

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6. If unifrom electric filed $\overrightarrow{E} = E_0\hat{i} + 2E_0\hat{j}$, where E_0 is a constant, exists in a region of space and at $(0, 0)$ the electric potential V is zero, then the potential at $(x_0, 0)$ will be.

A. Zero

B. $-E_0x_0$

C. $-2E_0x_0$

D. $-\sqrt{5}E_0x_0$

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7. Two metal pieces having a potential difference of $800V$ are $0.02m$ apart horizontally. A particle of mass $1.96 \times 10^{-15}kg$ is suspended in

equilibrium between the plates. If the e is the elementary charge, then charge on the particle is

A. e

B. 3e

C. 6e

D. 8e

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8. A sphere of radius 2R has a uniform charge density p. The difference in the electric potential at r = R and r = 0 from the centre is:

A. $\dfrac{-pR^2}{\varepsilon_0}$

B. $\dfrac{-2pR^2}{\varepsilon_0}$

C. $\dfrac{pR^2}{3\varepsilon_0}$

D. $\dfrac{-pR^2}{6\varepsilon_0}$

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9. A sphere of radius R carries charge density p proportional to the square of the distance from the centre such that $p = Cr^2$, where C is a positive constant. At a distance R/2 from the centre, the magnitude of the electric field is :

A. $\dfrac{CR^2}{20\varepsilon_0}$

B. $\dfrac{CR^2}{10\varepsilon_0}$

C. $\dfrac{CR^2}{5\varepsilon_0}$

D. None of these

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10. The work done in bringing a 20 coulomb charge from point A to point B for disatnce $0.2m$ is $2J$. The potential difference between the two points will be (in volt)

A. 0.2 V

B. 8 V

C. 0.1 V

D. 0.4 V

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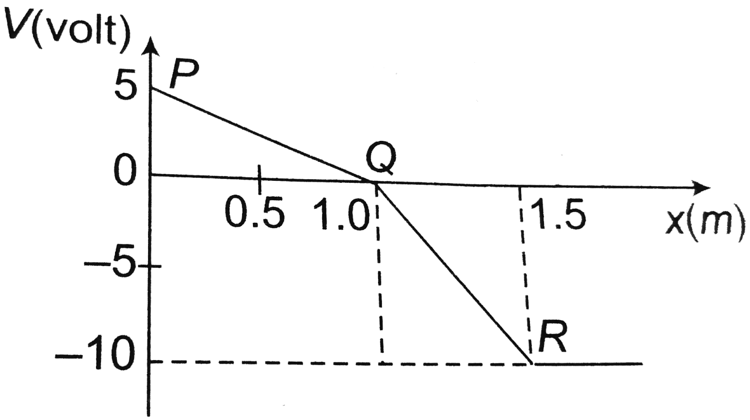
11. In an electric field region, the electric potential varies along the x-axis as shown in the graph. The x components of the electirc field in the regions for the intervals PQ and QR as market in the garph, in

N/C, are respectively:



A. $5.0N/C$ along negative x-direction and 20.0N / C along positive x-direction

B. $5.0N/C$ along positive x-direction and 20.0N / C along negative x-direction

C. $5.0N/C$ along negative x-direction and 20.0N / C along negative x-direction

D. $5.0N/C$ along positive x-direction and 20.0N / C along positive x-direction

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12. Two spheres A and B of radii 17 cm each and having charges of 1 and 2 coulombs respectively are separated by a distance of SO cm. The electric field at a point on the line joining the centres of two spheres is approximately zero at some distance from the sphere A. The electric potential at this point is:

A. $6.56 \times 10^{10} V$

B. $8.12 \times 10^{7} V$

C. $2.03 \times 10^{9} V$

D. $1.2 \times 10^{11} V$

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13. Electric potential at any point in a region is given as

$V = 5x + 3y + \sqrt{15}z$

In this region the magnitude of the electric field is:

A. $3\sqrt{2}$

B. $4\sqrt{2}$

C. $5\sqrt{2}$

D. 7

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14. A charge $+Q$ is uniformly distributed in a spherical volume of radius R. A particle of charge $+q$ and mass m projected with velocity v_0 the surface of the sherical volume to its centre inside a smooth tunnel dug across the sphere. The minimum value of v_0 such tht it just reaches the centre (assume that thee is no resistance on the particle except electrostatic force) of he sphericle volume is

A. $\sqrt{\frac{Qq}{2\pi\varepsilon_o mR}}$

B. $\sqrt{\frac{Qq}{\pi\varepsilon_o mR}}$

C. $\sqrt{\frac{2Qq}{\pi\varepsilon_o mR}}$

D. $\sqrt{\frac{Qq}{4\pi\varepsilon_o mR}}$

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15. A charge $+q$ is fixed at each of the points $x = x_0$, $x = 3x_0$, $x = 5x_0$,............$x = \infty$ on the x axis, and a charge $-q$ is fixed at each of the points $x = 2x_0$, $x = 4x_0$, $x = 6x_0$, ...$x = \infty$. Here x_0 is a positive constant. Take the electric potential at a point due to a charge Q at a distance r from it to be $Q/(4\pi\varepsilon_0 r)$.Then, the potential at the origin due to the above system of

A. 0

B. $\dfrac{q}{8\pi\varepsilon_0 x_0 \text{in} 2}$

C. ∞

D. $\dfrac{q \text{in} 2}{4\pi\varepsilon_0 x_0}$

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16. The displacement of a chrage Q in the electric field $E = e_1\hat{i} + e_2\hat{j} + e_3\hat{k}$ is $\overrightarrow{r} = a\hat{i} + b\hat{j}$. The work done is

A. $Q(ae_1 + be_2)$

B. $Q\sqrt{(ae_1)^2 + (be_2)^2}$

C. $Q(e_1 + e_2)\sqrt{a^2 + b^2}$

D. $Q(e_1^2 + e_2^2)(a + b)$

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17. A non-conducting ring ofradius 0.5 m carries a total charge of 1.11×10^{-10} C distributed non-uniformly on its circumference producing an electric field $\overrightarrow{E}$ everywhere in space. The value of the line integral $\int_{l=\infty}^{l=0} -\overrightarrow{E}.d\overrightarrow{l}$ (l= 0 being centre of the ring) is

A. $+2V$

B. $-1V$

C. $-2V$

D. zero

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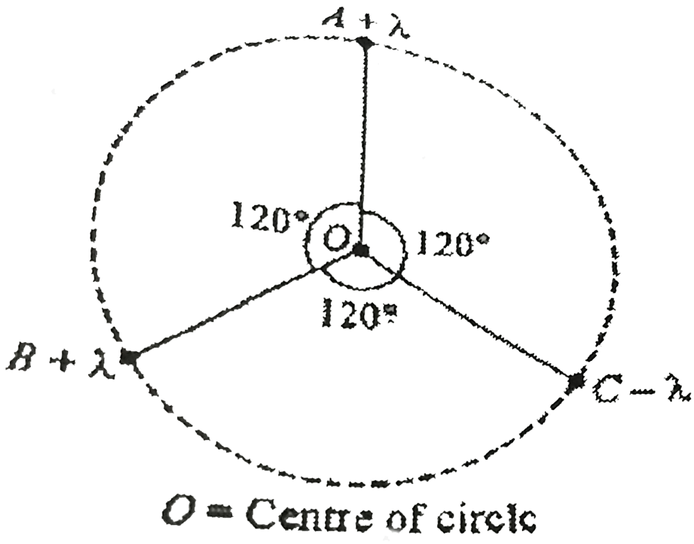
18. Three semi-infinite rods uniformly charged out of which one is negatively charged and other two are positively charged are kept perpendicular to plane of paper outward such that the finite ends of the rods are located at points A, B and C on a circle of radius R as shown in figure. The net electric field at centre of circle O is :



A. $\dfrac{2K\lambda}{R}$, along OC

B. $\dfrac{K\lambda}{R}$, perpendicular to plane of paper and inward direction

C. $\dfrac{\sqrt{5}K\lambda}{R}$ at an angle $\tan^{-1}.\ \dfrac{1}{2}$ with OC

D. $\dfrac{\sqrt{2}K\lambda}{R}$ at an angle 45° with OC

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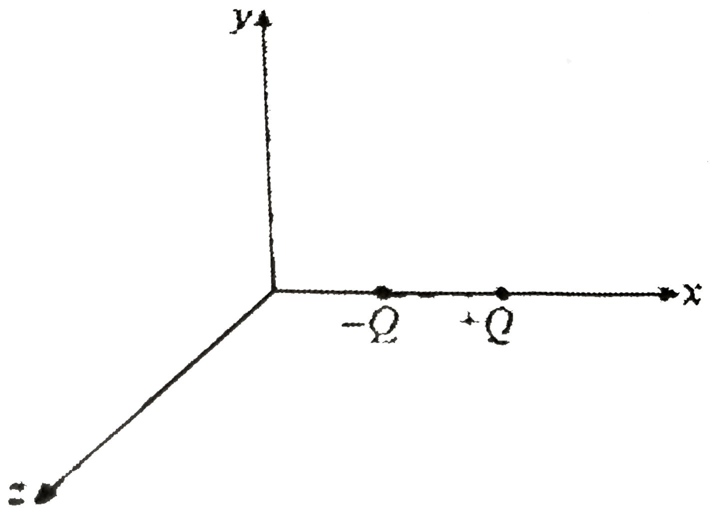
19. Two small balls of mass Meach carrying charges $+Q$ and $-Q$, connected by a massless rigid non-conducting rod of length L lie along x-axis as shown. A uniform electric field$\overrightarrow{E} = 3\hat{k} + 3\hat{j}$ has been switched on. The angular velocity vectorof the dipole when dipole nioment aligns with the electric field is :



A. $\sqrt{\frac{3\sqrt{2Q}}{2ML}}\left(-\hat{j}+\hat{k}\right)$

B. $\sqrt{\frac{6\sqrt{2Q}}{ML}}\left(-\hat{j}+\hat{k}\right)$

C. $\sqrt{\frac{3\sqrt{2Q}}{ML}}\left(-\hat{j}-\hat{k}\right)$

D. $\sqrt{\frac{3\sqrt{2Q}}{ML}}\left(-\hat{j}+\hat{k}\right)$

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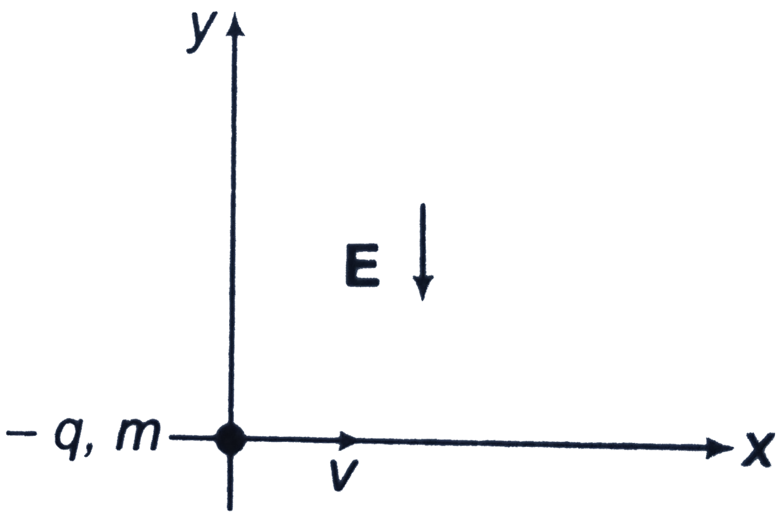
20. A particle of mass m and charge $-q$ is projected from the origin with a horizontal speed v into an electric field of intensity E directed downward. Choose the wrong statement. Neglect gravity



A. The kinetic energy after a displacement y is qEy

B. The horizontal and vertical components of acceleration are

$a_x = qE/m, a_y = 0$

C. The equation of trajectory is $y^2 = \frac{1}{2}\left(\frac{qEx^2}{mv^2}\right)$

D. The horizontal and vertical displacements x and y after a time t

are $x = vt^2$ and $y = \frac{1}{2}a_y t^2$

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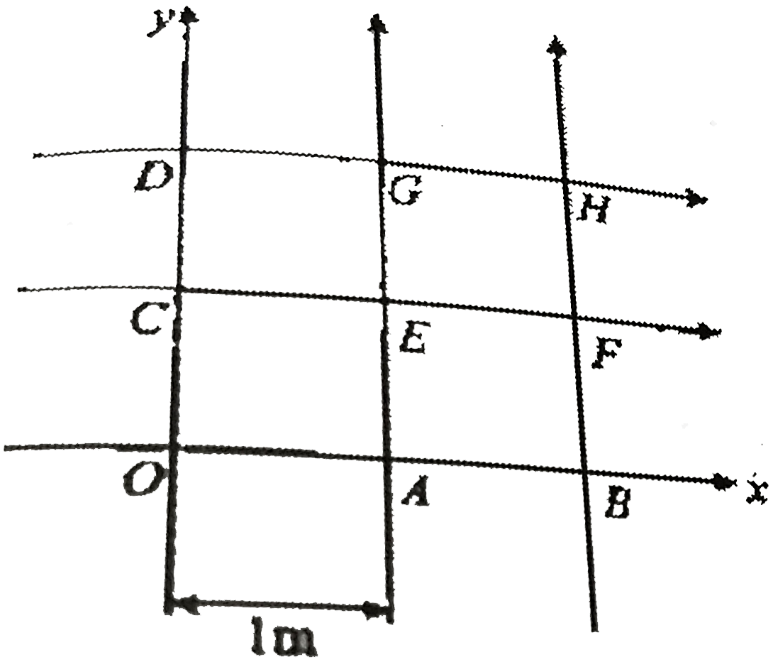
21. The grid (each square of $1m \times 1m$), represents a region in space containing a uniform electric field. If potentials at point O,A,B,C,D,E,F,G,H are respectively 0,-1,-2, 1,2,0,-1, 1 and 0 volts. Find the electric field intensity :



A. $\left(\hat{i}+\hat{j}\right)V/m$

B. $\left(\hat{i}-\hat{j}\right)V/m$

C. $\left(-\hat{i}+\hat{j}\right)V/m$

D. $\left(-\hat{i}-\hat{j}\right)V/m$

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22. At a certain distance from a point charge, the field intensity is $500V/m$ and the potentil is $-3000V$. The distance to the charge and the magnitude of the charge respectively are

A. $6m$ and 6muC

B. $4m$ and 2muC

C. $6m$ and 4muC`

D. $6m$ and 2muC`

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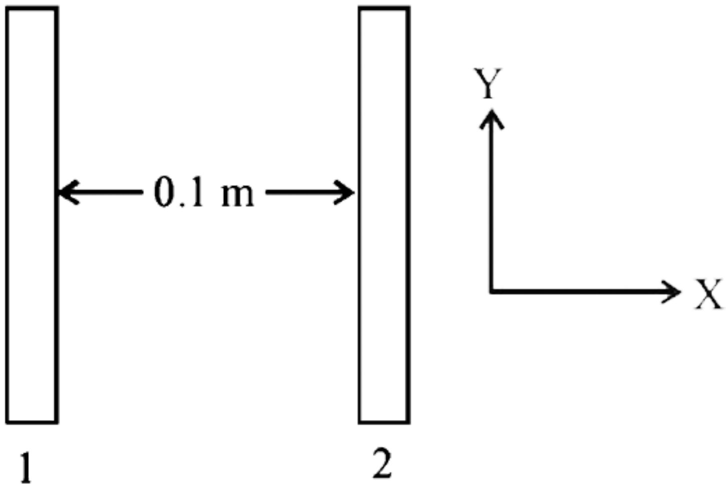
23. Two insulting plates are both uniformly charged in such a way that the potential difference between them is $V_2 - V_1 = 20V$. (i.e., plate 2 is at a higher potential). The plates are separated by $d = 0.1m$ and can be treated as infinity large. An electron is released from rest on the inner surface of plate 1. What is its speed when it hits plate 2? ($e = 1.6 \times 10^{-19} C, m_e = 9.11 \times 10^{-31} kg$)



A. $7.02 \times 10^{12} m/s$

B. $1.87 \times 10^{6} m/s$

C. $32 \times 10^{-19} m/s$

D. $2.65 \times 10^{6} m/s$

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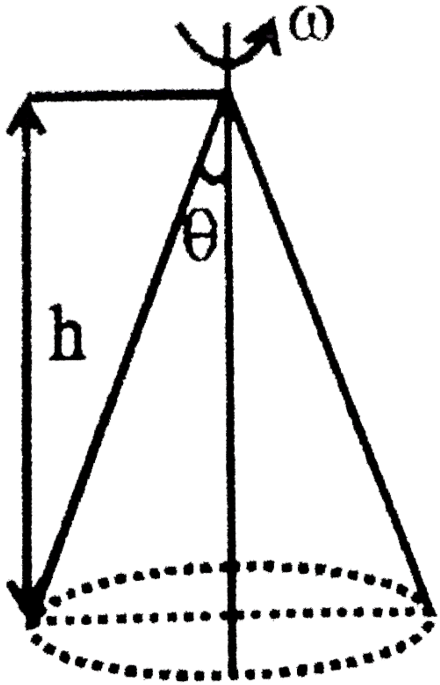
24. Q charge is uniformaly distributed over the same surface of a right circular cone of semi -vertical angle theta and height h The cone is uniformly rotated about its axis at angular velocity omega Calculated associated magnetic dipole moment



A. $\dfrac{3Qh^2\omega\cot^2\theta}{20}$

B. $\dfrac{Qh^2\omega\cot^2\theta}{20}$

C. $\dfrac{Qh^2\omega\tan^2\theta}{20}$

D. $\dfrac{3Qh^2\omega\tan^2\theta}{20}$

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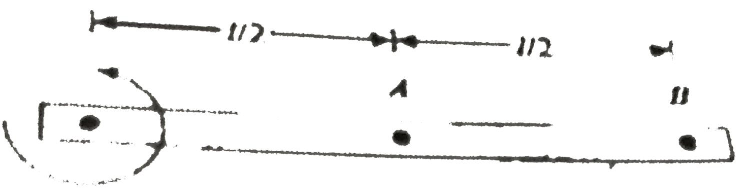
25. A conducting rod of length l rotates about its one end with angolar velocity ro. Potential difference between A and B points ofrod as shown in figore $-1.404isVAB$ Find VAB Taken as mass of electron and e is the charge of electron :



A. $\dfrac{m\omega^2l^2}{e}$

B. $\dfrac{3m\omega^2l^2}{4e}$

C. $\dfrac{3m\omega^2l^2}{8e}$

D. zero

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26. A tiny spherical oil drop carrying a net charge q is balanced in still air with a vertical uniform electric field of strength $\frac{81\pi}{7} \times 10^5 Vm^{-1}$. When the field is switched off, the drop is observed to fall with terminal velocity $2 \times 10^{-3} ms^{-1}$. Given $g = 9.8 ms^{-2}$, viscoisty of the air $= 1.8 \times 10^{-5} Nsm^{-2}$ and the denisty of oil $= 900 kgm^{-3}$, the magnitude of q is

A. $1.6 \times 10^{-1} C$

B. $3.2 \times 10^{-19} C$

C. $4.8 \times 10^{-19} C$

D. $7.8 \times 10^{-19} C$

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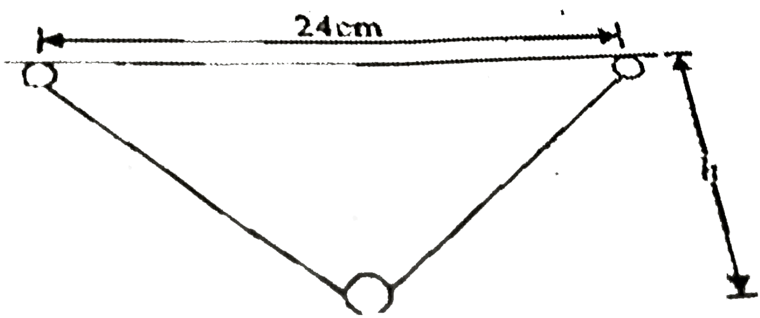
27. The two ends of a rubber string of negligible mass and having unstretched length 24cm are fixed at the same height as shown. A small object is attached to the string in its midpoint due to which the depression h of the object in equilibrium is 5cm. Then the small object is charged and a vertical electric field E_1 is switched on in the region. The ·equilibrium depression of the object increases to 9cm, now the electric field is changed to E_2 and the depression of object in equilibrium increases to 16cm. What is the ratio of electric field in the second case to that of in the first case ?



A. 4.25

B. 4.2

C. 4.3

D. 4.35

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28. Let there be a spherically symmetric charge distribution with charge density varying as $\rho(r) = \rho\left(\frac{5}{4} - \frac{r}{R}\right)$ upto $r = R$, and $\rho(r) = 0$ for $r > R$, where r is the distance from the origin. The electric field at a distance r(rltR) from the origin is given by

A. $\frac{\rho_0 r}{4\varepsilon_0}\left(\frac{5}{3} - \frac{r}{R}\right)$

B. $\frac{4\pi\rho_0 r}{4\varepsilon_0}\left(\frac{5}{3} - \frac{r}{R}\right)$

C. $\frac{4\pi\rho_0 r}{4\varepsilon_0}\left(\frac{5}{3} - \frac{r}{R}\right)$

D. $\frac{\rho_0 r}{3\varepsilon_0}\left(\frac{5}{4} - \frac{r}{R}\right)$

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29. The ratio of the electric force between two electrons to the gravitational force between them is of the order of

A. $10^8 : 1$

B. $10^{28} : 1$

C. $10^{31} : 1$

D. $10^{42} : 1$

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30. Two points charges q_1 and q_2 are placed at a distance of 50 m from each each other in air, and interact with a certain force. The same charges are now put in oil whose relative permittivity is 5. If the interacting force between them is still the same, their separation now is

A. 16.6m

B. 22.3m

C. 28.4m

D. 25.0m

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31. An electric field is uniform, and in the positive x-direction for positive x, and uniform with the same magnitude , but in the negative x-direction for negative x. It is given that

$\overrightarrow{E} = 200\hat{i} N/C f \text{ or } x > 0 \text{ and } \overrightarrow{E} = -200\hat{i} N/C$ for x gt 0. A right circular cylinder of length 20 cm and raidus 5cm has its center at the origin and its axis along the x-axis so that one face is at $x = +10cm$ and the other is at $x = -10cm$.

(a) What is the net outward flux through the side of the cylinder ? (b) What is the net outward flux through the cyclinder ? (c) what is net charge inside the cylinder ?

A. zero

B. $1.86 \times 10^{-5}C$

C. $1.77 \times 10^{-11}C$

D. $35.4 \times 10^{-8}C$

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32. A solid conducting sphere ofradius 5.0 cm has a charge of 0.25nC distributed uniformly on its surface. If point A is located at the centre of the sphere and a point Bis 15cm from the center, what is the magnitude of the electric potential difference between these two points ?

A. 23V

B. 30V

C. 15V

D. 45V

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33. An electric dipole is placed perpendicular to an infinite line of charge at same distance as shown in figure. Identify the correct statement.

A. The dipole is attracted towards the line charge

B. The dipole is repelled away from the line charge

C. The dipole does not experience a force

D. The dipole experiences a force as well as a torque

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34. S is a solid neutral conducting sphere. A point charge q of 1 × 10–6 C is placed at point A. C is the centre of sphere and AB is a tangent. BC = 3m and AB = 4m.

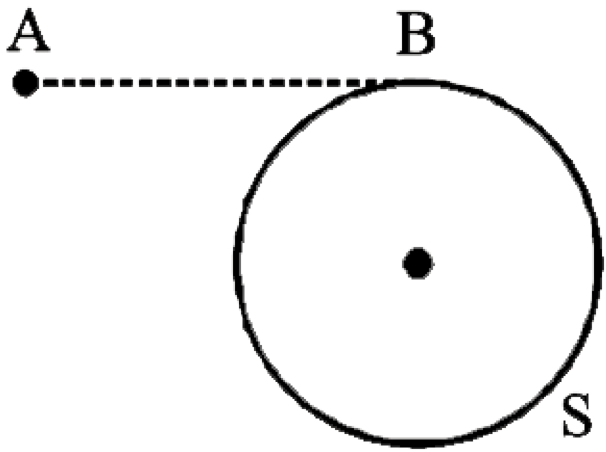
(1) The electric potential of the conductor is 1.8 kV

(2) The electric potential of the conductor is 2.25 kV

(3) The electric potential at B due to induced charges on the sphere is – 0.45 kV

(4) The electric potential at B due to induced charges on the sphere

is 0.45 kV



A. The electric potential at B due to induced charge on the sphere

is $1.2kV$

B. The electric potential at B due to induced charge on the

sphereis $-1.2kV$

C. The electric potential at B due to induced charge on the sphere

is $-0.45kV$

D. The electric potential at B due to induced charge on the sphere

is $0.45kV$

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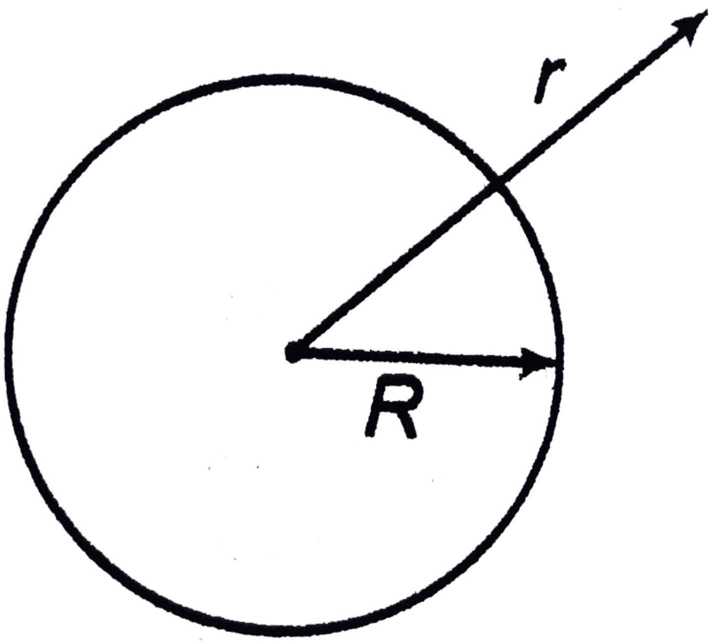
35. If the potential at the centre of a uniformly charged hollow sphere of radus R is V, then electric field at a distance r from the centre of sphere will be $(r > R)$.



A. $\frac{VR}{r^2}$

B. $\frac{V_r}{R^2}$

C. $\frac{VR}{r}$

D. $\frac{VR}{R^2 + r^2}$

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36. An isolated conduction sphere sphere whose radius $R = 1$ m has a charge $q = \frac{1}{9} nC$. The energy density at the surfasce of the sphere is

A. $\frac{e_0}{2} J/m^3$

B. $e_0 J/m^3$

C. $2e_0 J/m^3$

D. $\frac{e_0}{3} J/m^3$

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37. A charged rod have continuous charge distribution having density $\lambda = 2xC/m$. If rod is of length l then find ratio $\frac{q_1}{q_2}$. where q_1 is charge on half ofrod & q_2 is charge on 2^{nd} half of rod"

A. $\frac{1}{2}$

B. $\frac{1}{4}$

C. $\frac{1}{3}$

D. $\frac{3}{1}$

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38. Three concentric spherical metallic shells A, B and C of radii a, b and c (a lt b ltc) have surface charge densities σ, $-\sigma$ and σ respectively.

`(i) Find the potential of the three shells A, B and C.

(ii) If the shells A and C are at the same potential, obtain the relation between the radii a, b and c.

A. $a+b+c=0$

B. $a+b=b$

C. $a+b=c$

D. $a=b+c$

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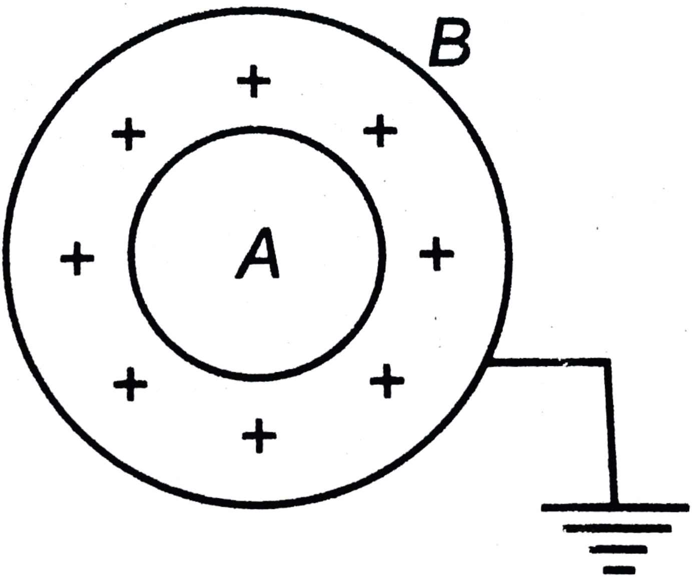
39. A and B are two concentric spherical shells. If A is given a charge $+q$ while B is earthed as shown in figure then



A. The charge density of A and Bare same

B. The field inside and outside A is zero

C. The field between A and B is not zero

D. All of these

Answer: D

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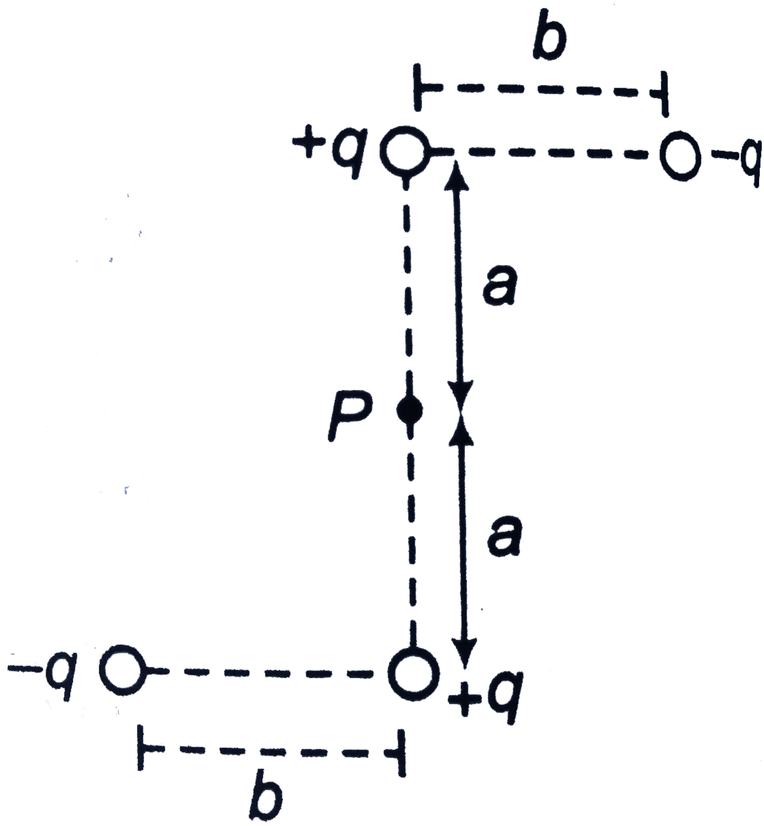
40. The electrostatic potential due to the charge configuration at point P as shown in figure for bltlta is



A. $\frac{2q}{4\pi\varepsilon_0 a}$

B. $\frac{2qb^2}{4\pi\varepsilon_0 a^3}$

C. $\frac{qb^2}{4\pi\varepsilon_0 a^3}$

D. zero

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41. Two thin wire rings each having radius R are placed at distance d apart with their axes coinciding. The charges on the two are $+Q$ and $-Q$. The potential difference between the centre so the two rings is

A. zero

B. $\frac{Q}{4\pi\varepsilon_0}\left[\frac{1}{4}-\frac{1}{\sqrt{R^2+d^2}}\right]$

C. $\frac{Q}{4\pi\varepsilon_0 d^2}$

D. $\frac{Q}{2\pi\varepsilon_0}\left[\frac{1}{R}-\frac{1}{\sqrt{R^2+d^2}}\right]$

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42. In a certain region of space, electric field is along the z-direction throughout. The magnitude of electric field is , however, not constant but increases uniformly along the positive z-direction. At the rate of $10^5 NC^{-1}m^{-1}$. What are the force and torque experienced by system having a total dipole moment equal to 10^{-7}Cm in the negative z-direction?

A. 0.01N

B. 0.02N

C. 0.04N

D. zero

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43. There are two uncharged identicasl metallic spheres 1 and 2 of radius r separated by a distance $d(d > > r)$. A charged metalllic sphere of same radius having charge q is touched with one of the sphere. After some time it is moved away fom the system. Now, the uncharged sphere is earthed. Charge on earthed sphere is

A. $+\frac{q}{2}$

B. $-\frac{q}{2}$

C. $-\frac{qr}{2d}$

D. $-\frac{qd}{2r}$

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44. Two small identical metal balls of radius rare at a distance a $(a < < r)$ from each other and are charged, one with a potential V_1 and the other with a potential V_2. The charges on the balls are:

A. $q_1 = V_1 a, q_2 = V_2 a$

B. $q_1 = V_1 r, q_2 = V_2 r$

C. $q_1 = \left(\frac{V_1 + V_2}{2}\right)a, q_2 = \left(\frac{V_1 + V_2}{2}\right)r$

D. $q_1 = -\frac{r}{a}(rV_2 - aV_1), q_2 = -\frac{r}{a}(rV_1 - aV_2)$

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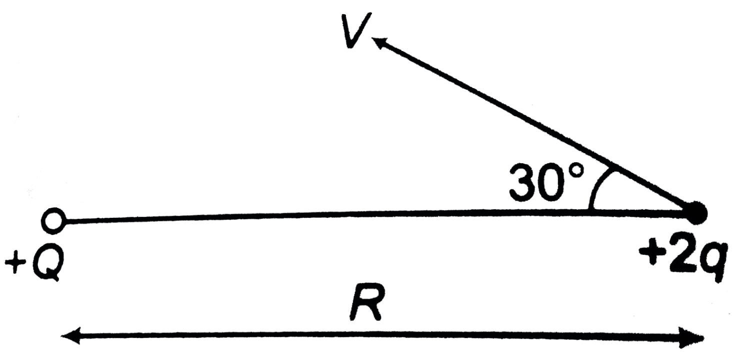
45. In the diagram shown the charge $+Q$ is fixed. Another charge $+2q$ and mass M is projected from a distance R from the fixed charge. Minimum separtion between the two charge if the velocity becomes $\frac{1}{\sqrt{3}}$ time of the projected velocity, at this moment is (Assume gravity to be absent)



A. $\frac{\sqrt{3}}{2}R$

B. $\frac{1}{\sqrt{3}}R$

C. $\frac{1}{2}R$

D. None of these

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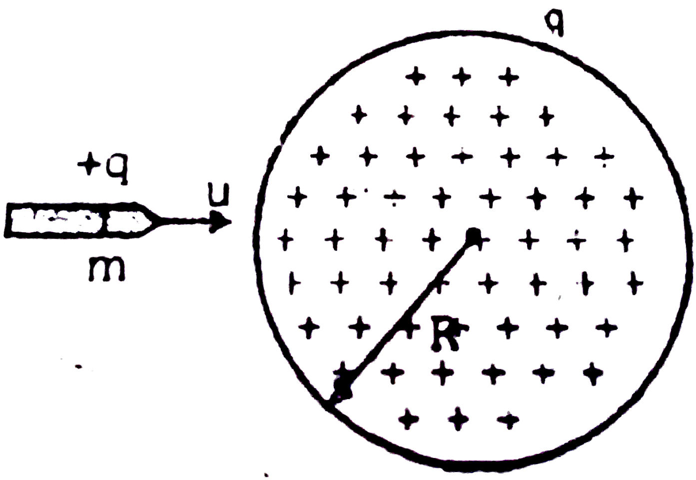
46. A bullet of mass m and charge q is fired towards a solid uniformly charge sphere of radius R and total charge +q. If it strikes the surface of sphere with speed u, find the minimum value of u so that it can penetrate through the sphere. (Neglect all resistance force or friction acting on bullet except electrostatic forces)



A. $\dfrac{Q}{\sqrt{2\pi \in_0 mR}}$

B. $\dfrac{Q}{\sqrt{6\pi \in_0 mR}}$

C. $\dfrac{Q}{\sqrt{4\pi \in_0 mR}}$

D. $\dfrac{3Q}{\sqrt{4\pi \in_0 mR}}$

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47. A charged particle of mass m and charge q is released from rest in an electric field of constant magnitude E. The kinetic energy of the particle after time t is

A. $\frac{2E^2t^2}{mq}$

B. $\frac{q^2m}{2t^2}$

C. $\frac{E^2q^2t^2}{2m}$

D. $\frac{Eqm}{2t}$

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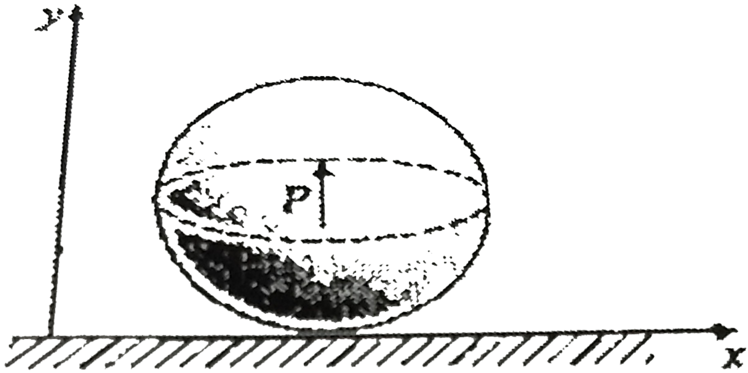
48. Consider the shown uniform solid insulating sphere of mass m with a short and light electric dipole moment $p\hat{j}$ embedded at its centre placed at rest on a horizontal surface. An electric field $E\hat{i}$ is suddenly switched on in the region such that the sphere starts ro/ling without sliding. Speed of the sphere when the dipole becomes horizontal for the first time is given as:



A. $\sqrt{\frac{5pR}{m}}$

B. $\sqrt{\frac{10pE}{7m}}$

C. $\sqrt{\frac{5pE}{2m}}$

D. zero

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49. A ring of diameter d is rotated in a uniform electric field until the position of maximum electric flux is found. The flux is found to be ϕ.

What is the electric field strength?

A. $\frac{4\phi}{\pi d^2}$

B. $\frac{2\phi}{\pi d^2}$

C. $\frac{\phi}{\pi d^2}$

D. $\frac{\pi \phi d^2}{4}$

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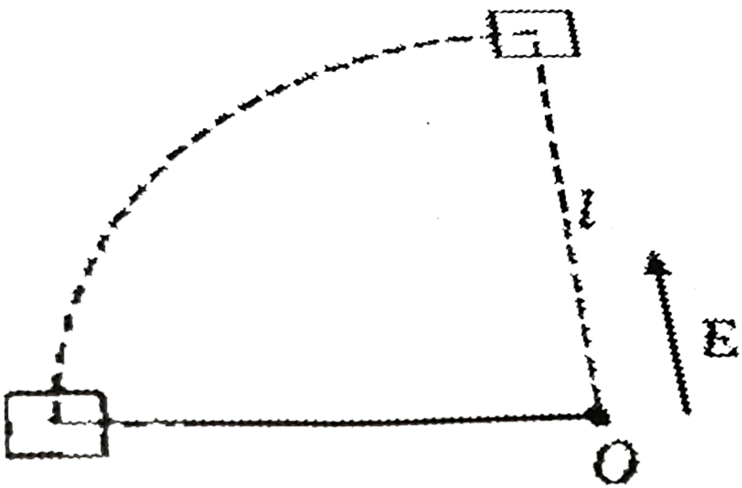
50. A block of mass m and charge q is connected to a point 0 with help ofan inextensible string. The system in on a horizontal table. An electric field is switched on in direction perpendicular to string. What will be tension in string when it become parallel to electric field?



A. $\frac{qE}{2}$

B. $3qE$

C. $\frac{qE}{l}$

D. $\frac{3qE}{5}$

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51. The electric potential V at any point (x, y, z), all in meters in space is given by $V = 4x^2$ volt. The electric field at the point $(1, 0, 2)$ in volt//meter is

A. 8 V /m along negative x-axis

B. 8 Vim along positive x-axis

C. 16V/malongnegativex-axis

D. 16 V /m along positive z-axis

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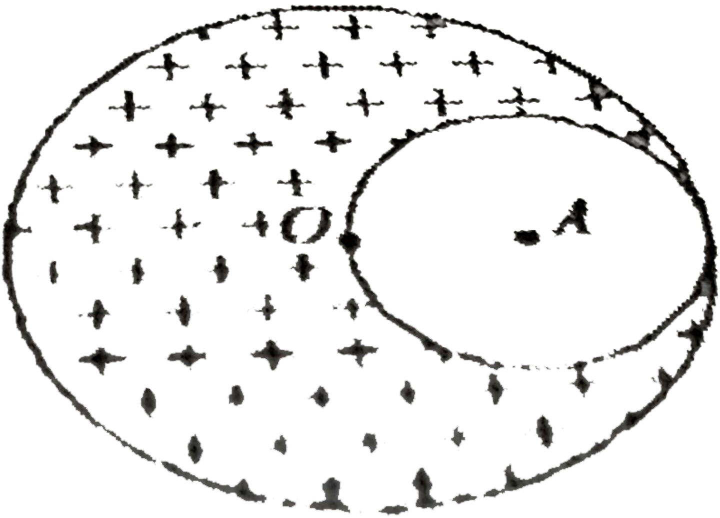
52. A solid sphere having uniform charge density ρ and radius R is shown in figure. A spherical cavity ofradius $\frac{R}{2}$ is made in it. What is the potential at point O?



A. $\frac{11R^2\rho}{24\varepsilon_0}$

B. $\frac{5}{12}\frac{R^2\rho}{\varepsilon_0}$

C. $\frac{7\rho R^2}{12\varepsilon_0}$

D. $\frac{3}{2}\frac{R^2\rho}{\varepsilon_0}$

Answer: B

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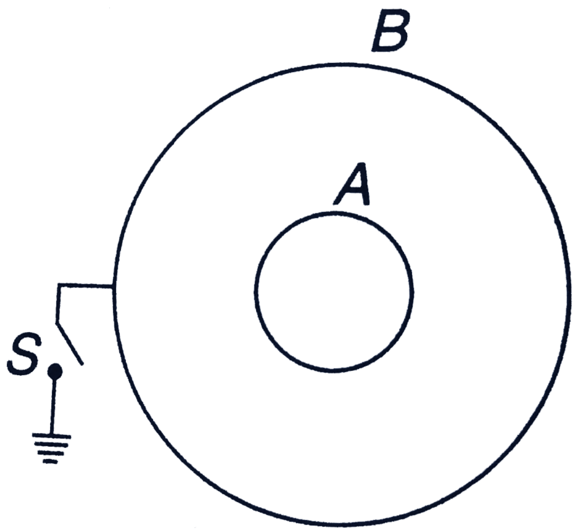
53. Initially the spheres A and B are at potentials V_A and V_B. Find the potential of A when sphere B is earthed.



A. 0

B. V_A

C. $V_A - V_B$

D. V_B^A

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54. 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. $+\frac{Q}{2}$

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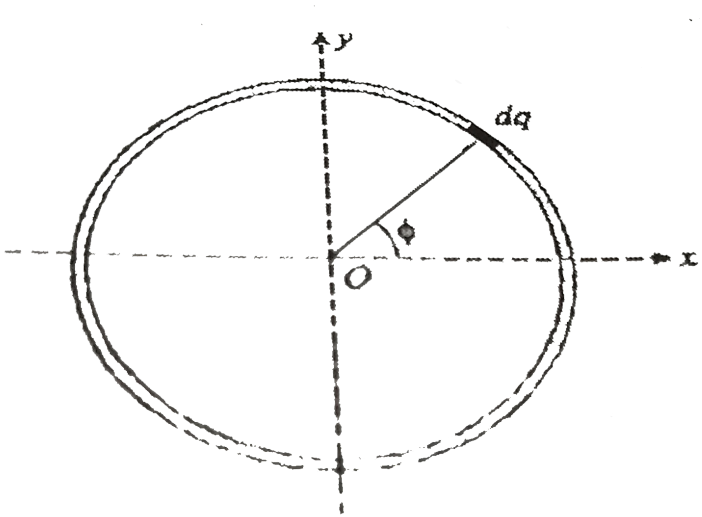
55. A thin non-conducting ring or radius a has a linear charge density $\lambda = \lambda_0 \sin \phi$. A uniform electric field $E_0 \hat{i} + E_0 \hat{j}$ exist in the region .

.Net torque acting on ring is given as :



A. $E_0\sqrt{2}\pi a^2\lambda_0$

B. $E_0\pi a^2\lambda_0$

C. $2E_0\pi a^2\lambda_0$

D. Zero

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56. The locus of the points (in the xy-plane) where the electric field due to a dipole (dipole axis is along x-axis and its equatorial is along y-axis) is perpendicular to its axis, is

A. Straight line perpendicular to the axis

B. Circle

C. Parabola

D. Straight line having inclination $\theta = \tan^{-1}\sqrt{2}$ with the axis.

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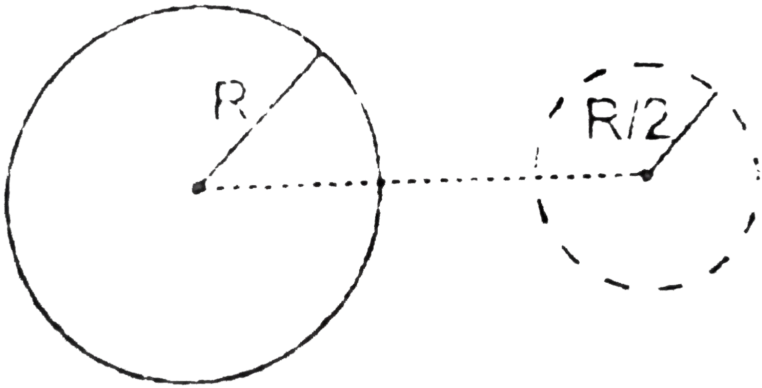
57. A ring of radius R having a linear charge density λ moves towards a solid imaginary sphere of radius $\frac{R}{2}$, so that the centre of ring passes through the centre of sphere. The axis of the ring is perpendicular to the line joining the centres of the ring and the sphere. The maximum flux through the sphere in this process is



A. $\frac{\lambda R}{\varepsilon_0}$

B. $\frac{\lambda R}{2\varepsilon_0}$

C. $\frac{\lambda \pi R}{4\varepsilon_0}$

D. $\frac{\lambda \pi R}{3\varepsilon_0}$

Answer: D

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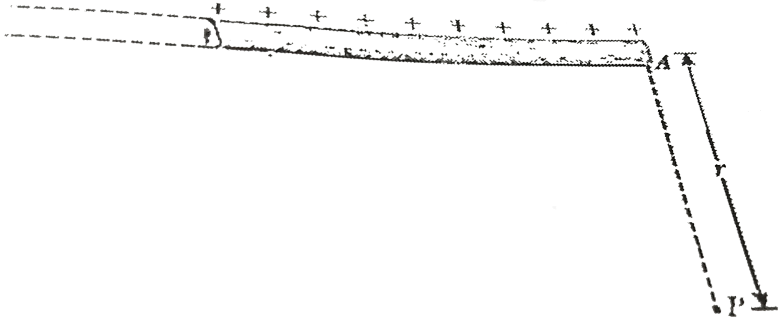
58. A semi-infinite insulating rod has linear charge density λ. The electric field atthe pointPshown in figure-1.418 is:



A. $\dfrac{2\lambda^2}{(4\pi\varepsilon_0 r)^2}$ at 45° with AB

B. $\dfrac{\sqrt{2}\lambda^2}{4\pi\varepsilon_0 r^2}$ at 45° with AB

C. $\dfrac{\sqrt{2}\lambda}{4\pi\varepsilon_0 r}$ at 45° with AB

D. $\dfrac{\sqrt{2}\lambda}{4\pi\varepsilon_0 r}$ at 135° with AB

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59. Two spherical conductors B and C having equal radii and cayying equal charges on them repel each other with a force F when kept apart at some distance. A third spherical conductor having same radius as that B but uncharged is brought in contact with B, then brought in contact with C and finally removed away from both. The new force of repulsion between B and C is

A. $F/4$

B. $3F/4$

C. $F/8$

D. $3F/8$

Answer: D

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60. Two insulated charged spheres of radii $20cm$ and $25cm$ respectively and having an equal charge Q are connected by a copper wire, they are separated

A. Both the spheres will have the same charge

B. Charge on the 20 cm sphere will be greater than that on the 25 cm sphere

C. Charge on the 25 cm sphere will be greater than that on the 20cmsphere

D. Charge on each of the spheres will be 2Q

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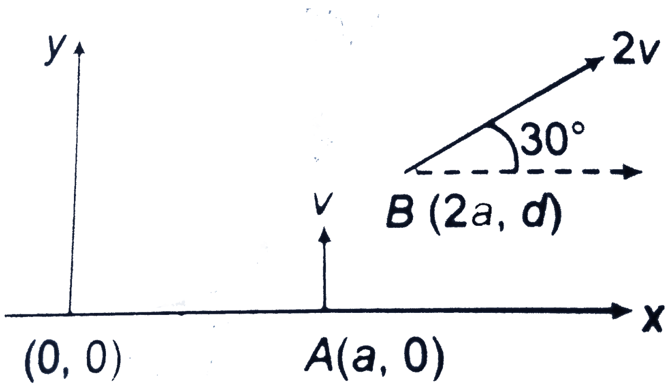
61. A uniform electric field of strength E exists in region. A electron enters a point A with velocity v as shown. It moves through the electric field and reaches at point B. Velocity particle at B is $2v$ at 30° with x-axis .

Then



A. Electric field $\overrightarrow{E} = -\frac{3mv^2}{2ea}\hat{i}$

B. Rate of doing work done by electric field at B is $\frac{3mv^2}{2ea}$

C. Both (A) and (B) are correct

D. Both (A) and (B) are wrong

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62. The potential at a point x (measured in μ m) due to some charges situated on the x-axis is given by

$V(x) = 20/(x^2 - 4)volt$

A. $5/3V/\mu m$ and in the-vex direction

B. $5/3V/\mu m$ and in the+ve direction

C. $10/9V/\mu m$ and in the-ve direction

D. $10/9V/\mu m$ and in the +ve direction

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63. Four charges $+q, -1, +q$ and $-q$ are placed in order on the four consecutive corners of a square of side a. The work done in interchanging the positions of any two neighbouring charges of the opposite sign is

A. $\frac{q^2}{4\pi\varepsilon_0 a}(-4+\sqrt{2})$

B. $\frac{q^2}{4\pi\varepsilon_0 a}(4+2\sqrt{2})$

C. $\frac{q^2}{4\pi\varepsilon_0 a}$

D. $\frac{q^2}{4\pi\varepsilon_0 a}(4+\sqrt{2})$

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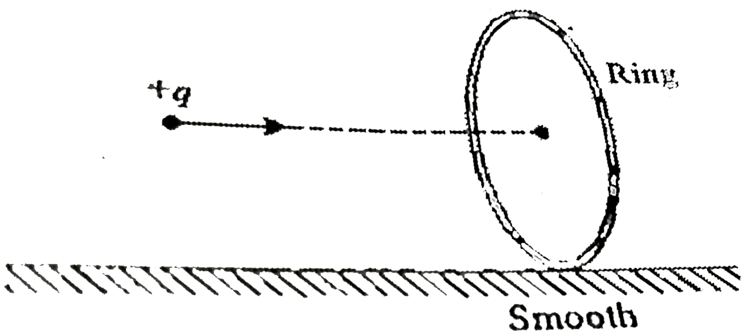
64. A particle of mass m and charge $+q$ approaches from a very large distance towards a uniformly charged ring ofradius Rand charge, mass same as that of particle, with initial velocity v_0 along the axis of the ring as shown in the figure-1.420. What is the closest distance of approach between the ring and the particle? Assume the space to be gravity free and frictionless :



A. $\sqrt{\frac{q^4}{\pi^2\varepsilon_0^2 m^2 v_0^4} - R^2}$

B. $\sqrt{\frac{3q^4}{2\pi^2\varepsilon_0^2 m^2 v_0^4} + R^2}$

C. $\sqrt{\frac{m^2 v_0^4}{2\pi^2 q^4 \varepsilon_0^2} - R^2}$

D. $\sqrt{\frac{q^4}{4\pi^2\varepsilon_0^2 m^2 v_0^4} - R^2}$

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Advance MCQs

1. A ring with a uniform charge Q and radius R, is placed in the yz plane with its centre at the origin

A. The field at the origin is zero

B. The field at the origin is $\frac{1}{4\pi\varepsilon_0}\frac{Q}{R}$

C. The field at the point $(x, 0, 0)$ is $\frac{1}{4\pi\varepsilon_0}\frac{Q}{R}$

D. The field at the point $(x, 0, 0)$ is $\frac{1}{4\pi\varepsilon_0}\frac{Q}{R^2 + x^2}$

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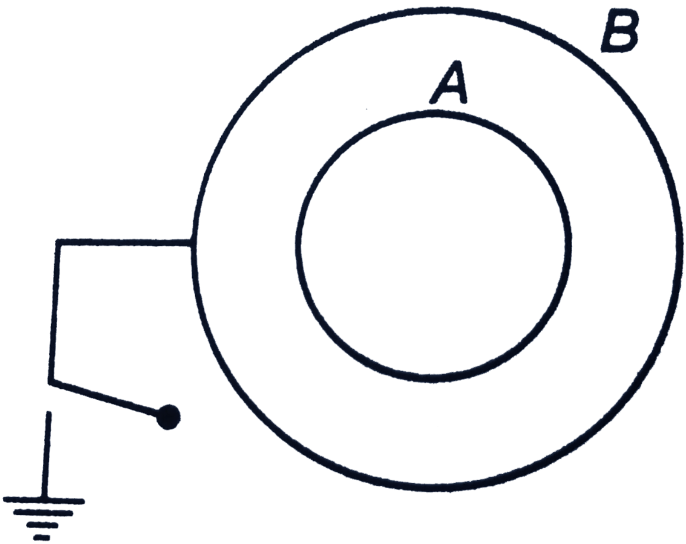
2. Two concentric shells have radii R and $2R$ charges q_A and q_B and potentials $2V$ and $\left(\frac{3}{2}\right)V$ respectively. Now, shell B is earthed and let charges on them become q_A' and q_B'. Then,



A. $q_A / q_B = 1/2$

B. $q_A' / q_B' = 1$

C. Potential of A after earthing becomes (3/2) V

D. None of these

Answer: A

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

A. If the. electric field due to a point charge varies as r^{25} instead of r^{-2}, then the Gauss law will still be valid

B. The Gauss law can be used io calculate the field distribution around and 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 unit positive charge from p'ointA at potential V_A to point B at potential V_B is $(VB - V)$

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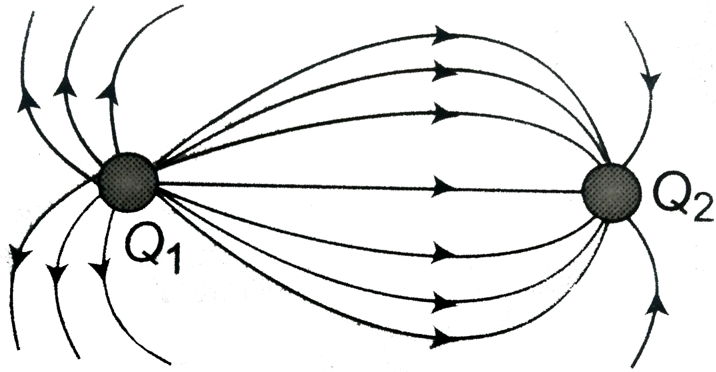
4. A few electric field lines for a system of two charges Q_1 and Q_2 fixed at two different points on the x-axis are shown in the figure. These lines suggest that

(i) $|Q_1| > |Q_2|$

(ii) $|Q_1| < |Q_2|$

(iii) At a finite distance to the left of Q_1 the electric field is zero

(iv) At a finite distance to the right of Q_2 the electric field is zero



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

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5. 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 are connected by a thin metal wire. Then

A. Inside shell A at every point electric field is zero:

B. After connections $Q_A > Q_B$

C. After connections $\frac{\sigma_A}{\sigma_B} = \frac{R_B}{R_A}$

D. After connections electric field strength on surface of A is less than that on the surface of B.

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6. A particle of mass 2 kg chrge 1 mC is projected vertially with velocity k$10ms^{-1}$. There is as uniform horizontal electric field of $10^4 N/C$, then

A. The horizontal range of the particle is 10m

B. The time offlight of the particle is 2s

C. The maximum height reached is 5m

D. The horizontal range of the particle is 5m

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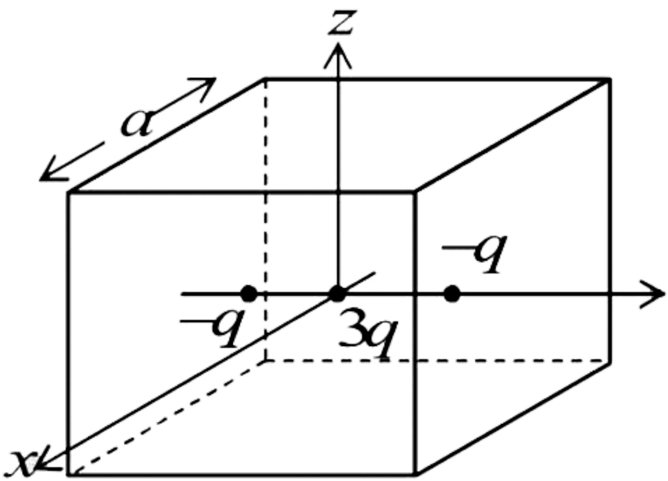
7. A cubical region of side a has its centre at the origin. It encloses three fixed point charges, $-q$ at $(0, \ -a/4, 0)$, $+3q$ at $(0, 0, 0)$ and $-q$ at $(0, \ +a/4, 0)$. Choose the correct options(s)



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 $x = +a/2$

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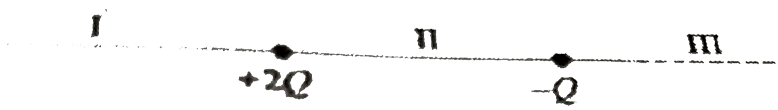
8. The figure- shows, two point charges $q_1 = +2Q$ and $q_2 = -Q$. The charges divide the line joining them in three parts I, II and III as shown in figure-1.424 then which_ofthe following statements is/are correct



A. Region III has a local maxima of electric field

B. Region I has a local minima of electric field

C. Equilibrium position for a test charge lies in region II

D. The equilibrium for constrained motion along the line joining the charges is stable for a negative charge

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9. At distance of 5 cm and 10 cm outwards from the surface of a uniformly charged solid sphere, the potentials are $100V$ and $75V$ respectively. Then:

A. Potential at its surface is 150V

B. The charge on the sphere is $\frac{50}{3} \times 10^{-10} C$

C. The electric field on the surface is $1500 V / m$

D. The electric potential at its centre is 250 V

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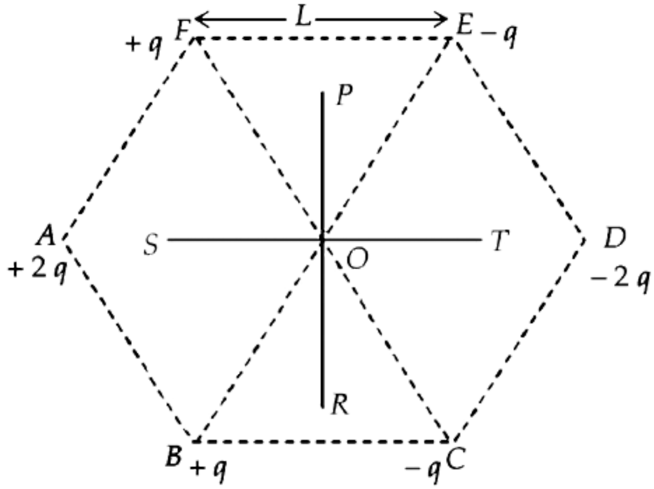
10. Six point charges are kept at the vertices of a regular hexagon of side L and centre O, as shown in the figure. Given that $K = \frac{1}{4\pi\varepsilon_0} \frac{q}{L^2}$, which of the following statements is incorrect?



A. The electric field at O is 6C 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

Answer: D

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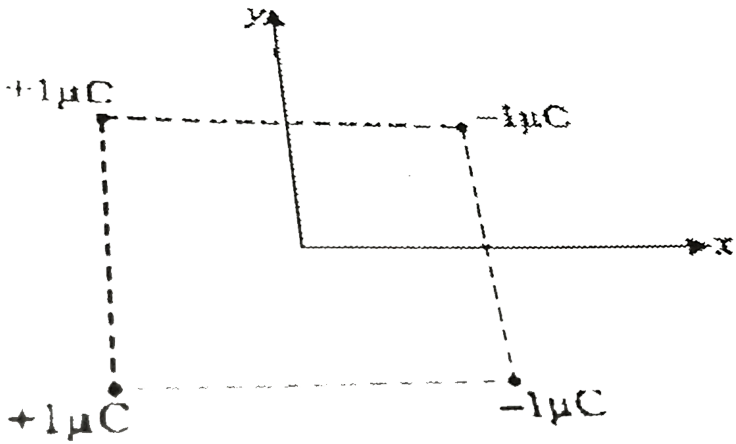
11. Point charges are located on the comer of a square as shown below. Find the component of electric field at any point on the z-axis which is the axis of symmetry of the square :



A. $E_z = 0$

B. $E_x = 0$

C. $E_y = 0$

D. None of these

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12. Charges Q_1 and Q_2 lie inside and outside, respectively, of a closed surface S. Let E be the field at any point on S and ϕ be the flux of E over S.

A. If Q_1 changes, both E and ϕ will change

B. If Q_2 changes, E will change but ϕ will not change

C. If $Q_1 = 0$ and $Q_2 \neq 0$ then $E \neq 0$ but $\phi = 0$

D. If $Q_1 \neq 0$ and $Q_2 = 0$ then $E = 0$ but $\phi \neq 0$

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13. In an uniform electric field, when we move from origin to x = Im, the potential changes by 10V. Which of the following can be a possible magnitude of the electric field ?

A. $10V/m$

B. $15V/m$

C. $5V/m$

D. $20V/m$

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14. An electric dipole is placed at the centre of a sphere. Mark the correct options:

A. The flux of the electric field through the sphere is zero

B. The electric field is zero at every point of the sphere

C. The electric field is not zero at any where on the sphere

D. The electric field is zero on a circle on the.sphere

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15. Two point charges Q each are placed at $(0, y)$ and $(0, -y)$ A point charge q of the same polarity can move along the x-axis. Then

A. The forceonq is maximuma at $x = \pm y / \sqrt{2}$

B. The charge q is in equilibrium at the origin

C. The charge q pe~forrns an oscillatory motion about the origin

D. For any position of q other then origin the force is directed away from origin

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16. Mark the correct options about electric field and Gauss's law in a region of space :

A. Gauss's law is valid only foruniform charge distributions

B. ·Gauss's law is valid only for charges placed iu vacuum

C. The elec.tric field calculated by Gauss's law is the field due to all the charges

D. The flux of the electric field through a closed surface due to all the charges is equal to the flux due to the charges enclosed by the surface

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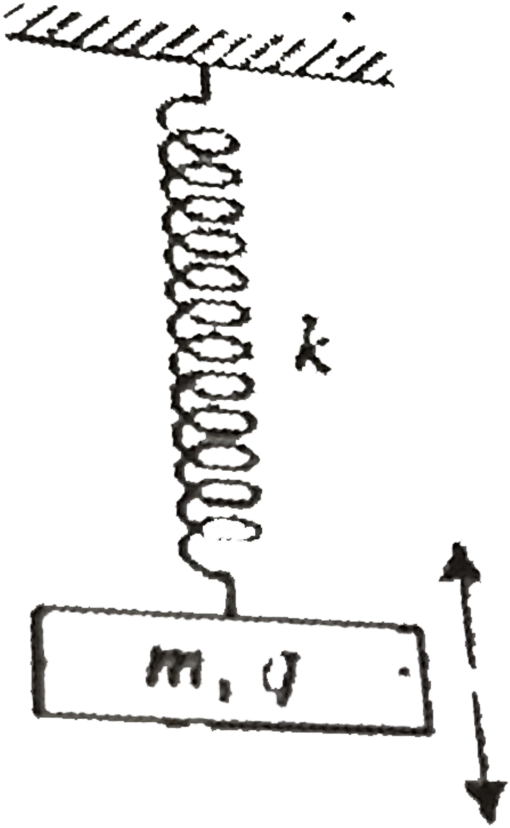
17. The following figure-I .427 shows a block of mass m suspended from a fixed point by means ofa vertical spring. The block is oscillating simple harmonically and carries a charge q. There also exists a uniform electric field in the space. Consider four different cases. The electric field is zero, in case-I, $E = mg/q$ downward in case-2, $E = mg/q$ upward in case-3 and $E = 2mg/q$ downward in case-4. The speed at mean position of block is same in all cases.

Select which of the following statements is/ are correct :



A. Time periods ofoscillation are equal in case-I and case-3

B. Amplitudes of displacement are same in case-2 and case-3

C. The maximum elongation (increment in length from natural length) is maximum in case-4

D. Time periods of oscillation are equal in case-2 and case-4

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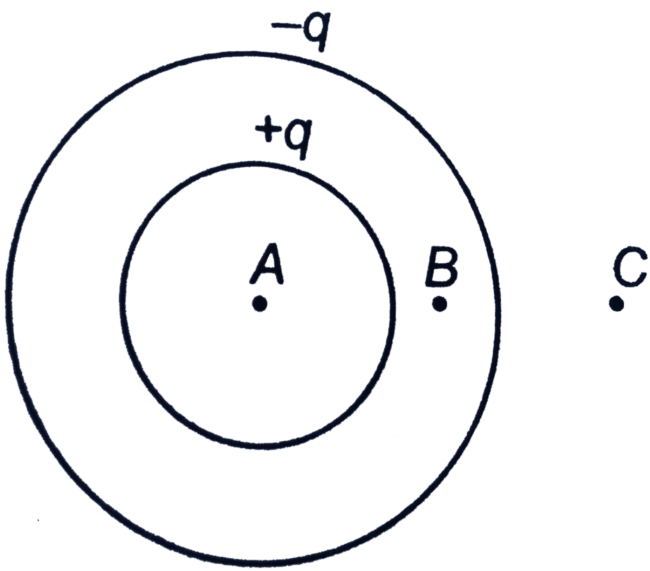
18. Two concentric spherical shells have charges $+q$ and $-q$ as shown in figure. Choose the incorrect option.



A. At A electric field is zero, but electric potential is non-zero

B. At B electric field and electric poteniial both are non-zero

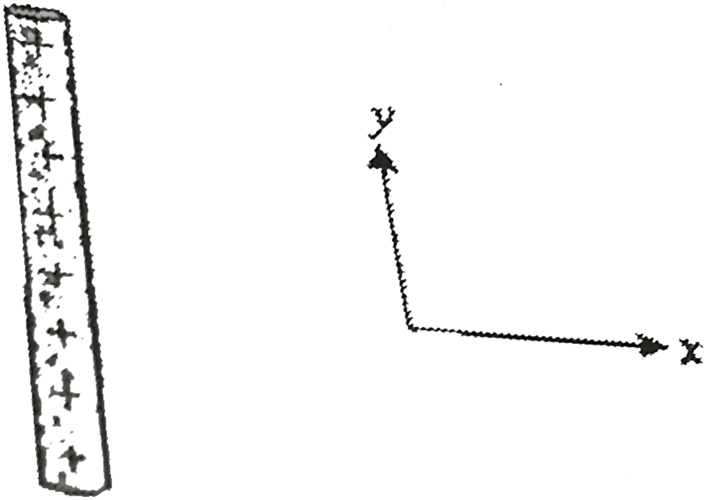
C. At C electric field is zero but electric potential is non-zero

D. At C electric field and electric potential both are zero

Answer: C

19. An insulating rod of uniform linear charge density A and uniform linear mass density μ lies on a smooth table whose surface is xy-

plane. A uniform electric field E is switched on in the space:



A. If electric field is along x-axis, the speed of the rod when it has travelled a distance d is $\sqrt{\frac{2\lambda Ed}{\mu}}$

B. If electric field Eis at an angle $\theta(<90^{\circ})$ with x-axis along the table surfa~e then the speed of the rod when it has travelled a distance d is $\sqrt{\frac{2\lambda Ed\cos\theta}{\mu}}$

C. A non zero torque acts on the rod due to the field about centre of mass in case electric field is into the plane of paper.

D. A non zero torque acts on the rod due to the field about centre of mass in case electric field is along the surface of table.

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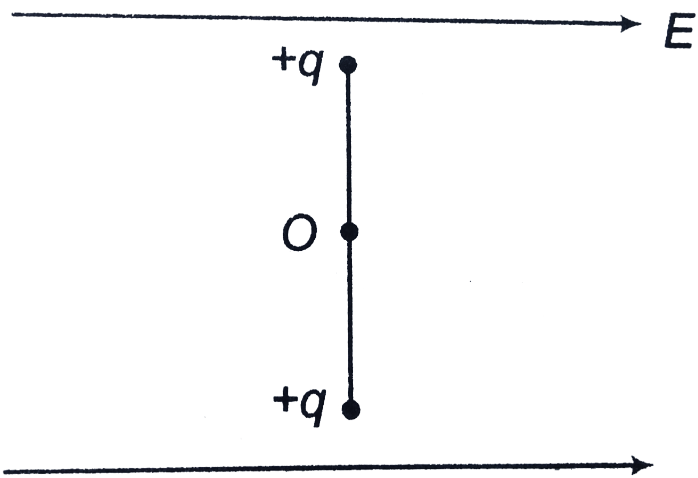
20. A rod is hinged (free to rotate) ast its centre O as shown in figue. Two point charge $+q$ and $+q$ are kept at its two ends. Rod is placed in uniform electric field E as shown. Space is gravity free. Choose the correct options.



A. Net force from the hinge on the rod is zero

B. Net force from the hinge on the rod is left wards

C. Equilibrium of rod is neutral

D. Equilibrium of rod is stable

Answer: C

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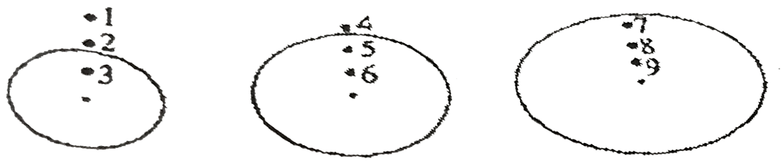
21. Figure- shows three spherical shells is separate situations, with each shell having the same uniformly distributed positive charge. Points I, 4 and 7 are at the same radial distances from the centre of the their respective shells so are points 2, 5 and 8 and so are points 3, 6 and 9. With the electric i:otential taken equal to zero at an in finite distance, which of the following statements is/are correct:



A. Point 3 has highest potential

B. Point l, 4 and 7 are at same potential

C. Point 8 has lowest potential

D. Point 5 and 8 are at same potential

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22. Which of the following quantites do not depend on the choice of zero potential or zero potential energy?

A. Potential at a point

B. Potential difference between two points

C. Potential energy of two-charge system

D. Change in potential energy of a two-charge system

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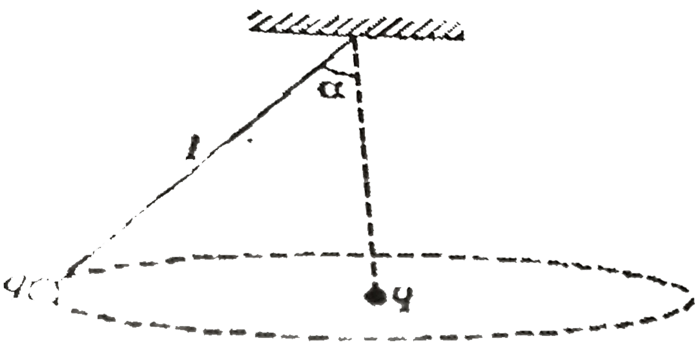
23. A charge q is revolving aroW1d another charge q as shown in a conical pendulum. The motion is in a horizontal plane. Which of the following statements is/are correct about this situation :



A. Tension in the string is greater than the weight of the ball

B. The tension in the string is greater than the electrostatic-repulsive force

C. If the charge is removed, the speed of the ball has to be increased to maintain the angle

D. If the charge is removed, the speed of ball has to be decreased to maintain the angle

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24. An electric dipole is placed in an electric field generated by a point charge

A. The net force on the dipole never be zero.

B. The net force on the dipole may be zero.

C. The torque on the dipole due to the field must be zero.

D. The torque on the dipole due to the field may be zero.

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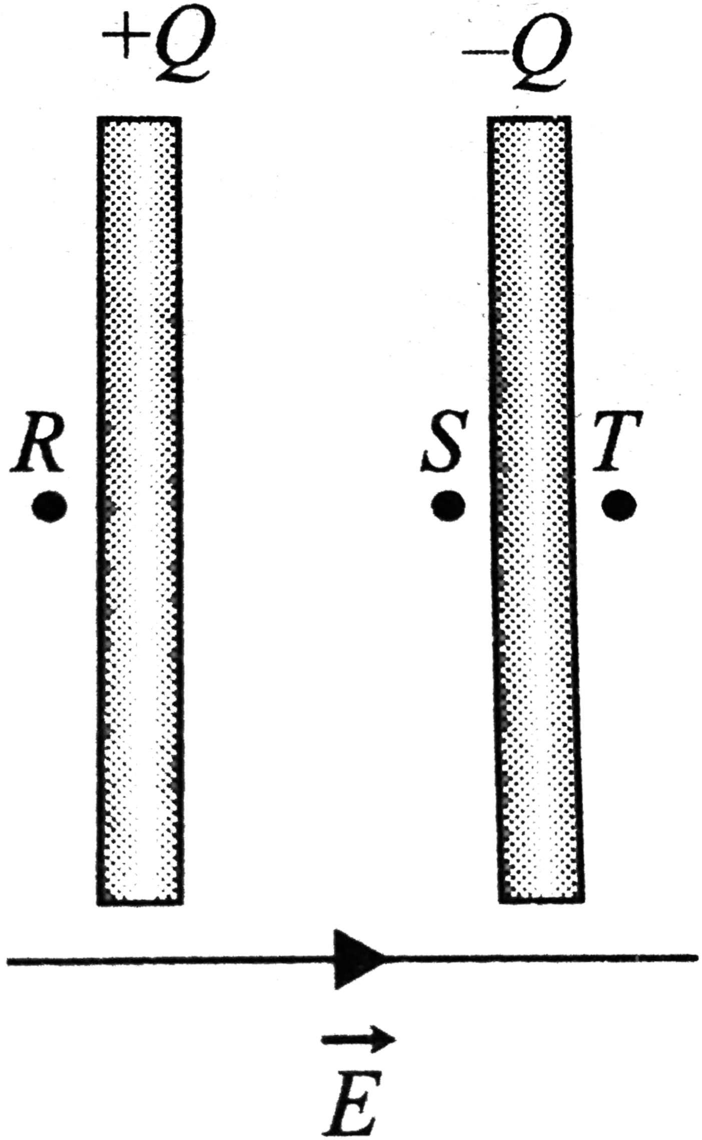
25. Two large thin conducting plates with a small gap in between are placed in a uniform electric field E (perpendicular to the plates.)The area of each plate is A, and charges $+Q \text{ and } -Q$ are given to these plates as shown in figure. If R,S, and T are three points in space, then the



A. field at point R is E

B. field at point Sis E

C. field at point Tis $\left(E + \frac{Q}{\varepsilon_o}A\right)$

D. fieid at point S is $\left(E + \frac{Q}{A\varepsilon_o}\right)$

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26. The electric potential decreases Wliforrnly from 100V to 50V as one moves on the y-axis from y = -Im toy= + l m. The electric field at the origin :

A. Must be equal to $25V/m$

B. May be equal to $25V/m$

C. May be less than $25V/m$

D. May be greater than $25V/m$

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27. A large insulating thick sheet of thickness 2d is charged with a Wliforrn volume charge density p. A particle of mass m, carrying a charge q having a sign opposite to that of the sheet, is released from the surface of the sheet. The sheet does not offer any mechanical resistance to the motion of the particle. Find the oscillation frequency v of the particle inside the sheet

A. $v = \frac{1}{2\pi}\sqrt{\frac{qp}{m\varepsilon o}}$

B. $v = \frac{1}{2\pi}\sqrt{\frac{2qp}{m\varepsilon o}}$

C. $v = \frac{1}{4\pi}\sqrt{\frac{2qp}{m\varepsilon o}}$

D. $v = \frac{1}{2\pi}\sqrt{\frac{2qp}{m\varepsilon o}}$

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28. If the flux of the electric field through a closed surface is zero,

A. The electric field must be zero everywhere on the surface.

B. The electric field may be zero everywhere on the surface.

C. The charge inside the surface mustbe zero.

D. The charge in the vicinity of the surface must be zero.

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29. Three non-conducting infinite planar sheets are parallel to the y-z plane. Each sheet has an unifomi surface charge density. The first sheet, with a negative surface charge density σ, passes through the x-axis at x = Im. The second sheet has an unknown surface charge density and passes through the x- axis at x = 2m. The third sheet has a negative surface charge density-3cr and passes through the x-axis atx = 4m. The net electric field due to the sheets is zero at x = 1.5m. Which of the following is/are correct :

A. The surface charge density on the second sheet is $+2\sigma$

B. The electric field at x=-2 m is $\frac{\sigma}{\varepsilon}\hat{i}$

C. The electric field atx = 3m is $\frac{\sigma}{\varepsilon}\hat{i}$

D. The electric fieldatx =6m is $\frac{-\sigma}{\varepsilon}\hat{i}$

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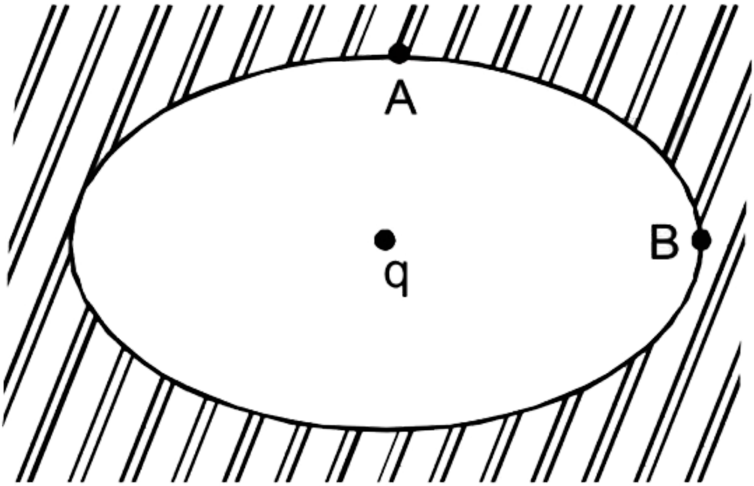
30. An ellipsoidal cavity is carved within a perfect conductor. A positive charge q is placed at the centre of the cavity. The points A and B are on the cavity surface as shown in the figure. Then



A. Electric field near A in the cavity= Electric field near Bin the cavity

B. Total electric field flux through the surface of the cavity is q/ε_o

C. Potential at A= Potential atB

D. Both (b) and (c)

Answer: D

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31. A positive charge q is fixed at the origin. An electric dipole withe dipole moment `vecP is placed „iong th ex-axis faraway from the origin with vecP pointing along thepositivex-axis and it is set free to move. The kinetic energy .when it reaches a distance x from the origin is Kand the magnitude of the force experienced by charge q at this moment is F. Then :

A. K varies as $1/x$

B. F varies as l/x^2

C. K varies as $1/x^2$

D. F varies as l/x^3

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32. A positively charged thin metal ring of radius R is fixed in the xy plane with its centre at the origin 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 $z_o$satisfying $0 < z_o < \infty$

B. Simple harmonic for all values of satisfying $0 < z_o < R$

C. Approximately simply harmonic provided $z_o < \; < R$

D. Such that P crosses O and continues to move along the negative z-axis towards $z = \; - \infty$

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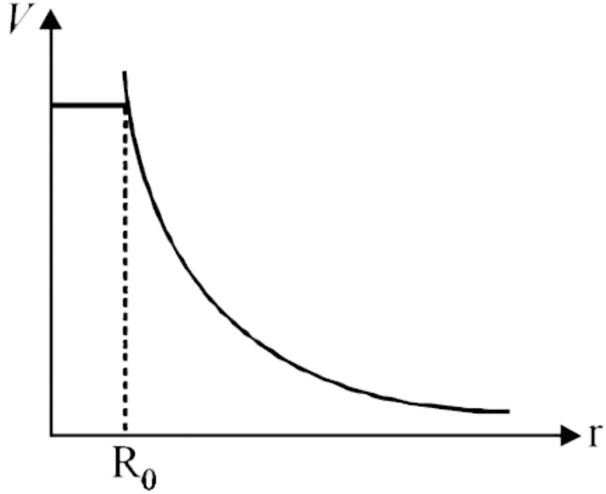
33. A spherical symmetric charge system is centered at origin. Given, Electric potential

$$V = \frac{Q}{4\pi\varepsilon_0 R_0}(r \leq R_0), V = \frac{Q}{4\pi\varepsilon_0 r}(r > R_0)$$



Choose the incorrect statement.

A. Electric field due to the charge system is discontinuous at

$r = r_o$

B. The net charge enclosed-in a sphere ofradi us $r = 2r_o$ is Q

C. No charge exists at any point in a spherical region of radius

$r < r_o$

D. Electrostatic energy inside the sphere of radius $r = r_o$ is zero

Answer: C

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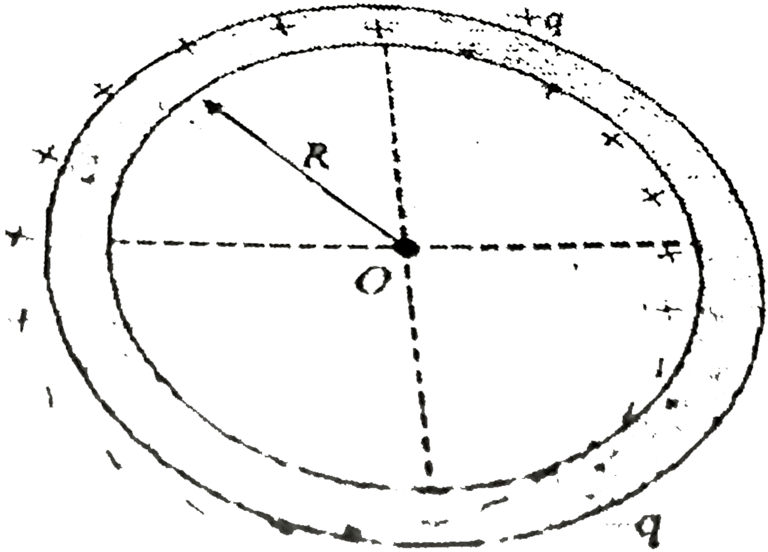
34. A non conducting ring of radius R is charged as shown in figure :



Figure

A. The electric field is zero at the centre of the ring

B. The electric potential is zero at centre of the ring

C. The electric poteotial atthe centre is, $V = \dfrac{2q}{4\pi\varepsilon_o R}$

D. The elcotric field at the centre is, $E = \dfrac{q}{\pi_2 \varepsilon_o R^2}$

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35. 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 statement(s).

A. The angular momentum of the charge $-q$ is constant

B. The linear momentum of the charge $-q$ is constant

C. Tlie angular velocity of the charge$-q$ is constant

D. The linear speed of the charge $-q$ is constant

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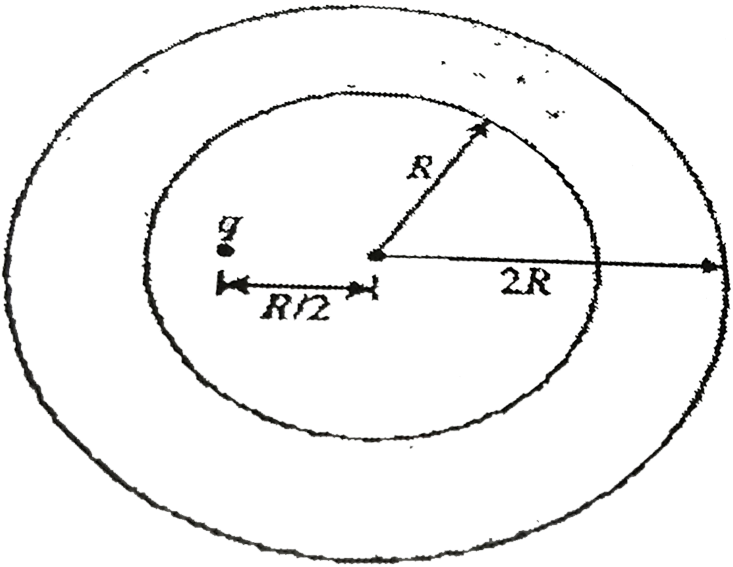
36. Figure shows a cross-section ofa spherical metal shell of inner radius R and out radius ZR. A point charge q is ·located at a distanceR/2 from the centre of the shell. If the shell is electrically neutral, then which of the following statements is/are correct :



A. The electric field at some point inside shell is zero

B. The electric field at all the point inside shell is non-zero

C. The electric field at the outer surface of the shell is $E\frac{1}{4\pi\varepsilon}$

$\frac{q}{(3R/2)^2}$

D. The electrical field at the outer surface is E $= \frac{1}{4\pi\varepsilon_o}$

$= \frac{q}{(2R)^2}$

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37. Two non-conducting solid spheres of radii R and 2R, having uniform volume charge densities ρ_1 and ρ_2 respectively, touch each other. The net electric field at a distance 2R from the centre of the smaller sphere, along the line joining the centres of the spheres, is zero. The ratio $\frac{\rho_1}{\rho_2}$ can be

A. -4

B. $-\frac{32}{25}$

C. $+\frac{32}{25}$

D. 4

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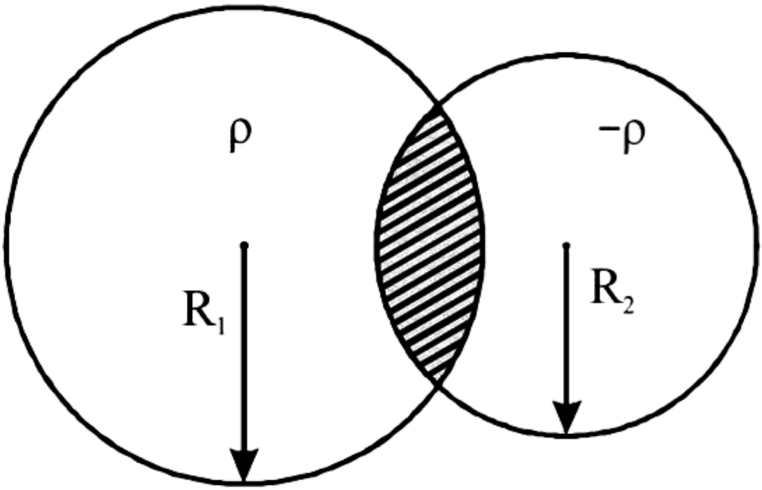
38. Two non-conducting spheres of radii R_1 and R_2 and carrying uniform volume charge densities $+\rho$ and $-\rho$, respectively, are placed such that they partially overlap, as shown in the figure. At all points in the overlapping region



A. The electric field is zero

B. The electric poteotialis constant

C. The electric field is constant in magnitude

D. The electric field has same direction

Answer: D

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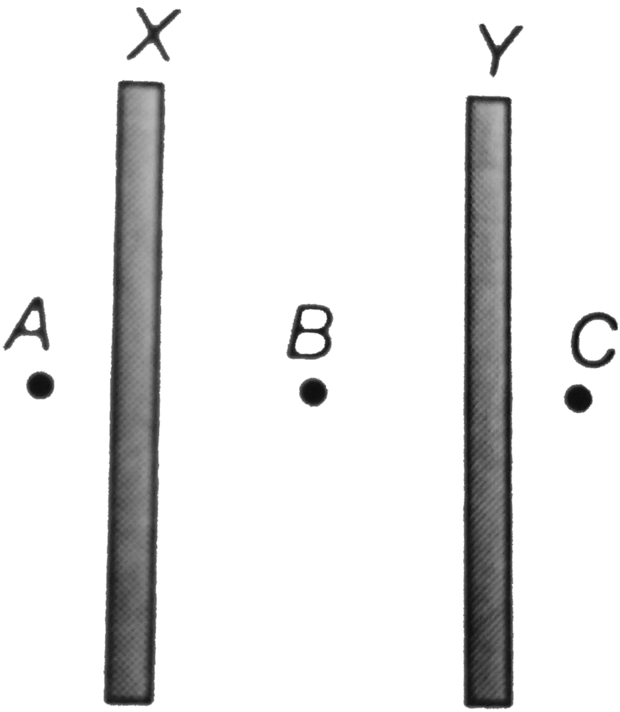
39. X and Y are large, parallel conducting plates close to each other. Each face has an area A. X is given a charge Q. Y is without any charge. Points A, B and C are as shown in the figure.



A. The field at B is $\dfrac{Q}{2\varepsilon_o A}$

B. The field at B is $\frac{Q}{\varepsilon_o A}$

C. The field at A, Band Care of the same magnitude

D. The fields at A and Care of the same magnitude, but in opposite directions

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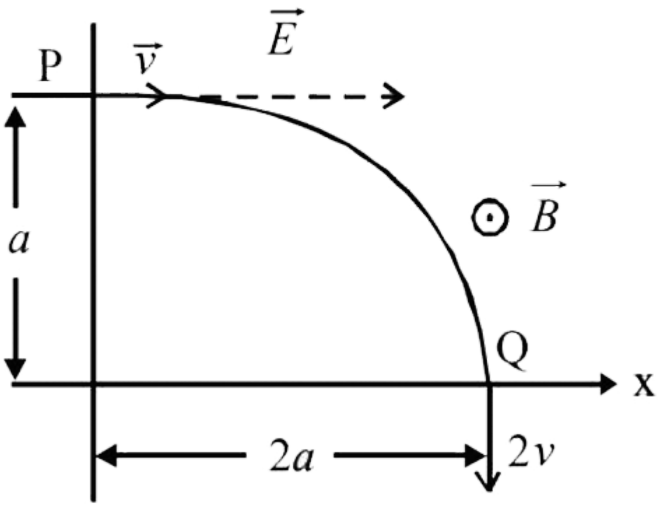
40. A particle of charge $+q$ and mass m moving under the influence of a uniform electric field $E\hat{i}$ and uniform magnetic field $B\hat{k}$ follows a trajectory from $P \to Q$ as shown in fig. The velocities at P and Q

are $v\hat{i}$ and $-2v\hat{j}$. which of the following statement(s) is/are correct ?



A. $E = \frac{3}{4}\left(\frac{mv^2}{qa}\right)$

B. Ratc of work done by the electric field at P is $\frac{3}{4}\left(\frac{mv^3}{a}\right)$

C. Rate of work done by the electric field at Pis zero

D. Rate of work done by both the fields at Q is zero

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Unsolved Numberical Problems

1. A small sphere is charged uniformly and placed at point A (u, v) so that at point B (8, 7) electric field strength is $\overrightarrow{E} = \left(54\hat{i} + 72\hat{j}\right)$ N/C and potential is+ 900V. Calculate:

(a) Magnitude of charge,

(b) Co-ordinates of point A, and

(c) If di-electric strength ofair is $3 \times I0^{6}$ V/m, minimum possible radius of the sphere.

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2. The electric intensity Eat a point on the axis ofa ring of radius a at a distance x from its centre is given by

$$\frac{1}{4\pi\varepsilon_0}\frac{qx}{\left(a^2 + x^2\right)^{3/2}}$$

where q is charge on ring.

An electron is constrained to move along the axis of this ring. Show that the electron can perform oscillations whose frequency is given by

$\omega = \left(\frac{eq}{4\pi\varepsilon_0 ma^3}\right)^{1/3}$

Where e is the charge on electron:

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3. Two long wires each oflength I are placed on a smooth horizontal table. Wires have equal but opposite charges. Magnitude oflinear charge density on each wire is λ. Calculate the work required to increase the separation between the wires from a to 2a:

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4. Four charges $+50 \times I0^{-9}C, -12 \times I0^{-19}C, +36 \times I0^{-9}C$ and $+90x10^{-9}C$ are placed respectively at the corners of a rectangula: ABCD,AB being equal to 5cm and BC being 12cm. Find:

(a) the force on the charge at A, and

(b) the field strength at the point of intersection of the two diagonals

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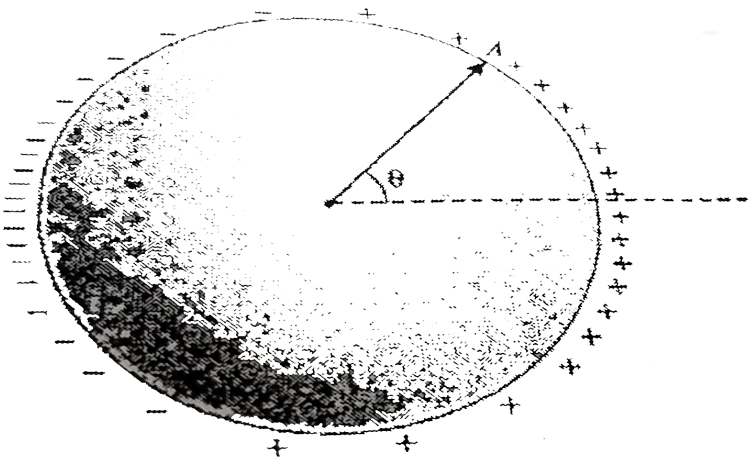
5. A solid conducting sphere of radius R is placed in a uniform electric field E as showo in figure. Due to electric field non uniform surface charges are induced on the surface of the sphere. Consider a point A on the surface of sphere at a polar angle θ from the direction of electric field as shown in figure. Find the surface density of induced charges at point A in terms of electric field and polar angle θ : It brgt



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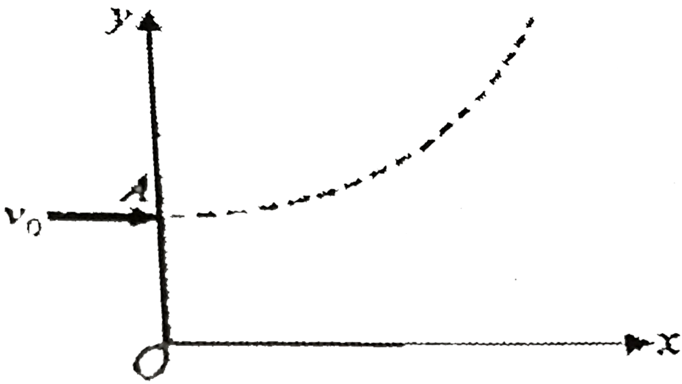
6. Suppose in an insulating medium, having di-electric constant k= 1, volume density of positive charge varies with y-coordinate according to law $\rho = ay$. A particle of mass m having positive charge q is placed in the medium at point A $(0, y_0)$J and projected with velocity $\vec{v} = v_0\hat{i}$ as shown in figure. Neglecting gravity and frictional resistance of the medium and assuming electric field strength to be zero at y = 0, calculate slope of trajectory of the particle as a function of y :



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7. Two short dipoles $p\hat{k}$ and $\frac{P}{2}\hat{k}$ are located at $(0, 0, 0)$ & $(1m, 0, 2m)$ respectivley. The resultant electric field due to the two dipoles at the point $(1m, 0, 0)$ is

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8. Two long straight parallel wires carry charges λ_1 and λ_2 per unit length. The distance between them is d. Calculate the magnitude of force externed on the length of one due to charge on the other.

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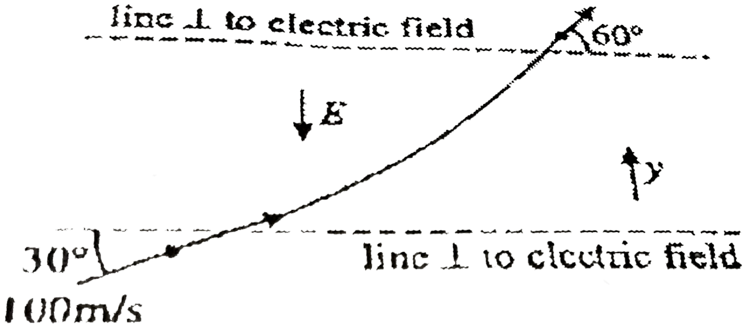
9. Find the magnitude of uniform electric field E of which the direction is shown in figure if an electron entering with velocity l00m/s making 30° comes out making 60° , after a time numerically equal to m/e ofelectron where m is mass ofelectron and e is

electronic charge :



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10. Two short electric dipoles having dipole moment p_1 and p_2 are placed co-axially and uni-directionally, at a distance r apart. Calculate nature and magnitude of force between them :

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11. Three identically charged, small spheres each of mass m are suspended from a common point by insulated light strings each of length l. The spheres are always on vertices of an equilateral triangle of length of the sides $x(< < l)$. Calculate the rate dq/ dt with which charge on each sphere increases if length of the sides of the equilateral triangle increases slowly according to law $\frac{dx}{dt} = \frac{a}{\sqrt{x}}$

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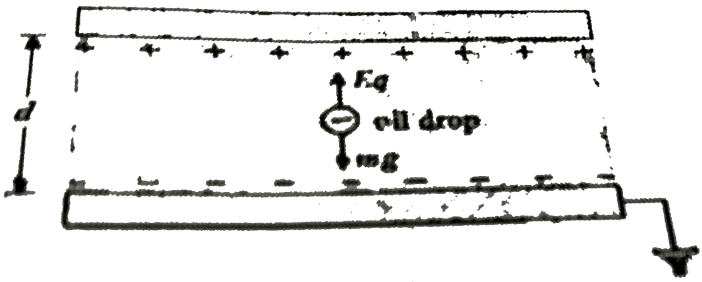
12. Two horizontal parallel conducting plates are kept at a separation $d = 1.5 \times 10^{-2} m$ apart one above the other in air as shown in figure. The upper plate is maintained at a positive potential of $1.5kV$ while the other plate is earthed which maintains it at zero potential. Calculate the number of electrons which must be attached to a small oil drop of mass $m = 4.9 \times 10^{-15} kg$ between the plates to maintain it at rest. Consider density of air is negligible in comparison with that ofoil. If the potential of above plate is suddenly changed to $-l.5kV$, what will be the initial acceleration of the charged drop? Also calculate the terminal velocity of the drop if its radius is $r = 5.0 \times 10^{-6} m$ and the coefficient of viscosity of air is

$\eta = 1.8x10 - \quad - 5N - s / m^2 \left[3, 2g, 5.7 \times 10^{-5} m / s^2\right]$



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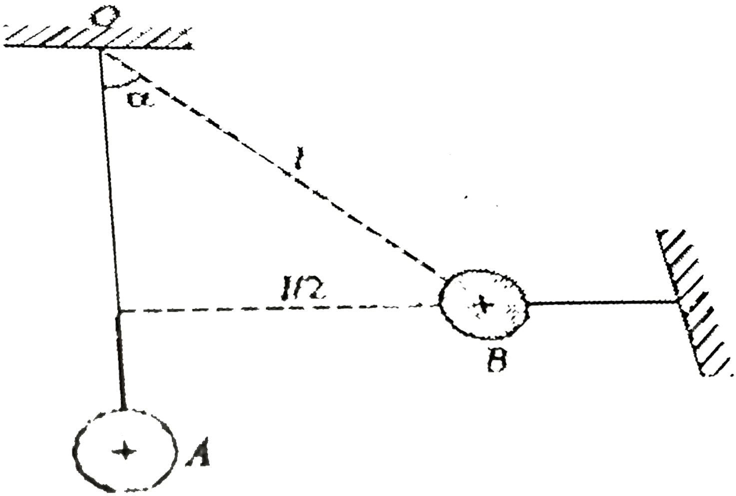
13. A small cork ball A of mass m is suspended by a thread of length l. Another ball B is fixed at a distance l from point of suspension and distance l/2 from thread when is vertical, as shown in figure-1.444. Balls A and B have charges (+ q) each. Ball A is held by an external force such that the thread remains vertical.



When ball A is released from rest, thread deflects through a . maximum angle of $\beta = 30^{\circ}$, calculate m in terms of other parameters

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14. A particle of mass m having negative charge q moves along an ellipse around a fixed positive charge Q so that its maximum and minimum distances from fixed charge are equal to r_1 and r_2 respectively. Calculate angular momentum L of this particle:

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15. Two concentric spheres of radii R and $2R$ are charged. The inner sphere has a charge if $1\mu C$ and the outer sphere has a charge of $2\mu C$ of the same sigh. The potential is $9000V$ at a distance $3R$ from the common centre. The value of R is

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16. A charged particle of radius $5 \times 10^{-7} m$ is located in a horizontal electric field of intensity $6.28 \times 10^{5} Vm^{-1}$. The surrounding medium has the coefficient of viscosity $\eta = 1.6 \times 10^{5} Nsm^{-2}$. The particle starts moving under the effect of electric field and finally attains a uniform horizontal speed of $0.02ms^{-1}$. Find the number of electrons on it. Assume gravity free space.

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17. Two small balls having the same mass and charge and located on the same vertical at heights h_1 and h_2 are thrown in the same direction along the horizontal at the same velocity v. The first ball touches the ground at a horizontal distance R from the initial vertical position. At what height h_2 will the second ball be at this instant? Neglect any frictional resistance of air and the effect of any induced charge on the ground.

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18. What is the percentage change in distance if the force of attraction between two point charges increases to 4 times keeping magnitude of charges constant ?

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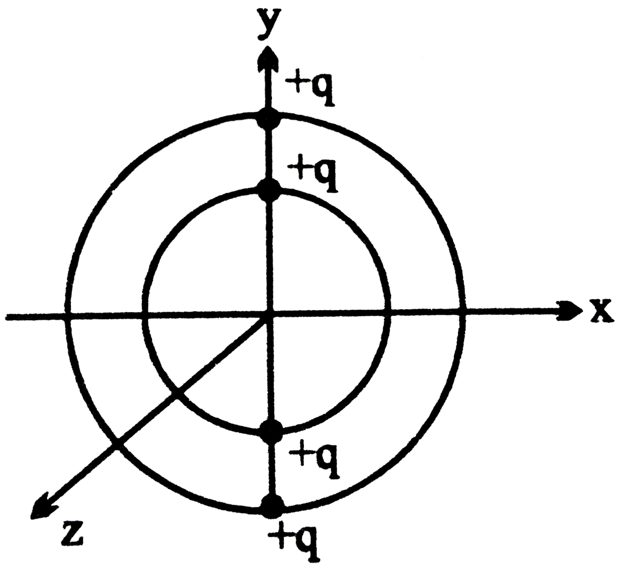
19. two concentric rings of radii r and $2r$are placed with centre at origin. Tow charges $+q$ each are fixed at the diametrically opposite points of the rings as shown in figure . Smaller ring is now rotated by an angle 90° about Z-axis then it is again rotated by 90° about Y-axis . Find the work done by electrostatic forces in each step . If finally larger ring is rotated by 90° about X-axis , find the total work required to perform all three steps .



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20. Find the electric field strength vector at the centre of a ball of raiduius R with volume charge density $\rho \Rightarrow ar$, where a is a constant vector, and r is a radius vector drawn from the ball's centre.

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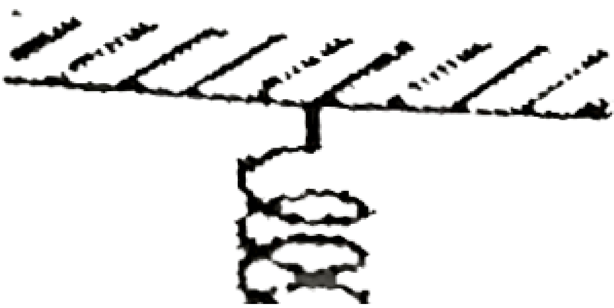
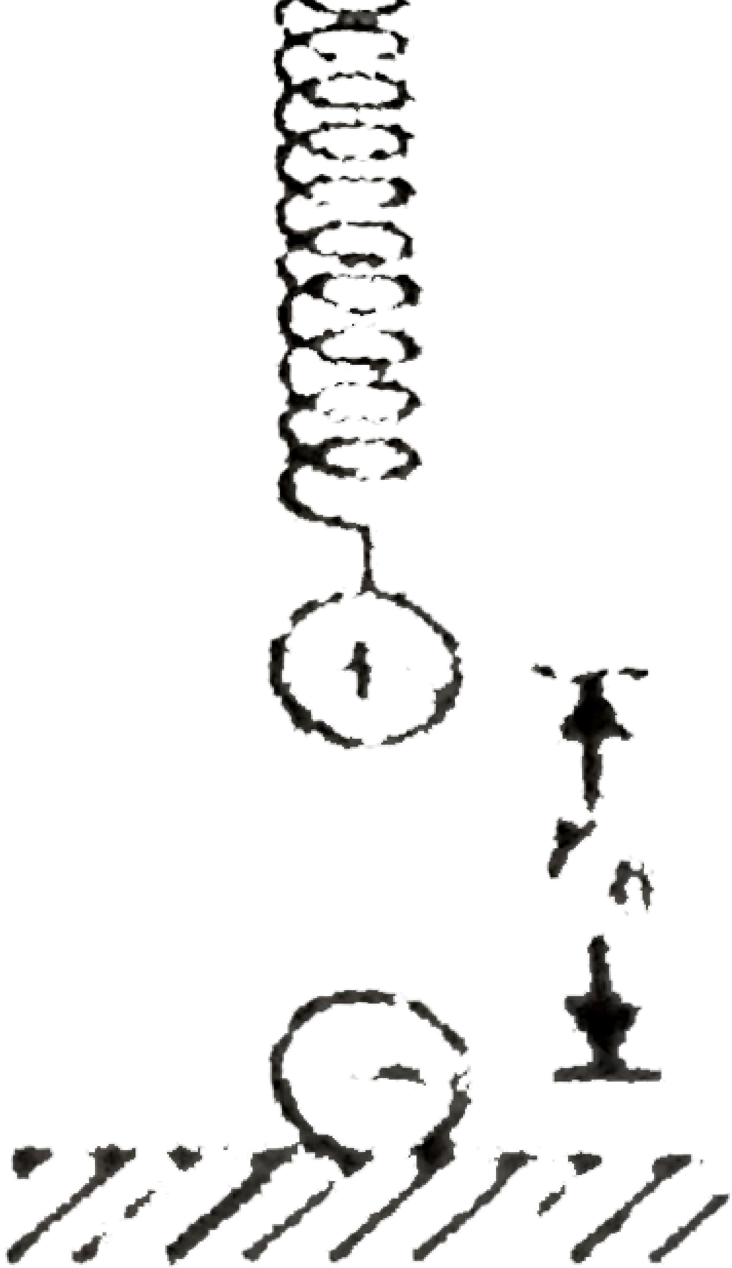
21. A positively charged sphere of mass m = 5kg is attached by a spring of force constant $K = 10^4$ N/m. The sphere is tied with a thread so that spring is in its natural length. Another identical, negatively charged sphere is fixed with floor, vertically below the positively charged sphere as shown in fignre. If initial separation between sphere is r_0 = 50cm and magnitnde ofcharge on each sphere is $q = 100\mu C$, calculate maximum elongation of spring when the thread is burnt. Take $g = 10m/s^2$:





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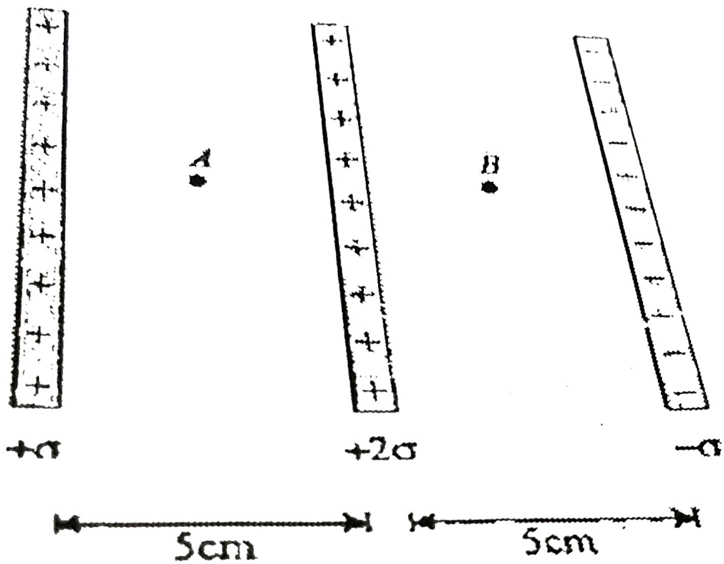
22. The figure shows thrednfinite non-conducting plates of charge perpendicular to the plane of the paper with charge per unit area $+\sigma, +2\sigma$ and $-\sigma$. Find the ratio of the net electric field atthat point A to that at point B. The points A and Bare located midway between the plates :



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23. A ball of radius R is uniformly charged with the volume density ρ. Find the flux if the electric field strength vector across the balls section formed by the plane located at a distance $r_0 < R$ from the centre of the ball.

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24. Small identical balls with equal charges are fixed at vertices of regular 2009 -gon with side a. At a certain instant, one of the balls is released & a sufficiently long time interval later, the ball adjacent to the first released ball is freed. The kinetic energies of the relased balls are found to differ by K at a sufficiently long distance from the polygon. Determine the charge q of each part.

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25. An infinitely long cylindrical surface density $\sigma = \sigma_0 \cos \varphi$. Where φ is the polar angle of the cylindrical coordinate system whose z axis coincides with the axis of the given surface. Find the magnitude and direction of the electric field strength vector on the z axis.

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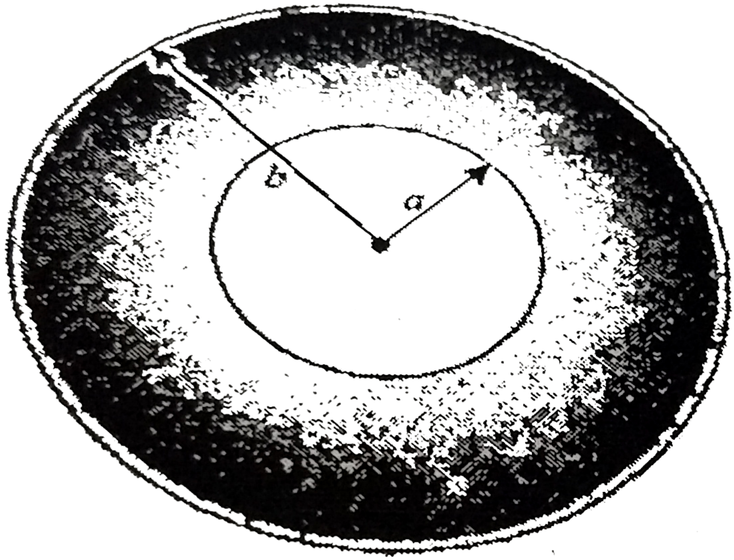
26. A non-conducting hollow sphere having inner and outer radii a and b respectively is made ofa material having di-electric constant K and has uniformly distributed charge over its entire solid volume. Volume density of charge is ρ . Calculate potential at a distance r from its centre when :



(a) $r > b$,

(b) $r < a$,

(c) $a < r < b$

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27. Two thin parallel threads carry a uniform charge with linear densities λ and $-\lambda$. The distance between the threads is equal to l. Find the potential of the electric field and the magnitude of its strength vector at the distance $r > > l$ at the angle θ to the vector

1 (fig).

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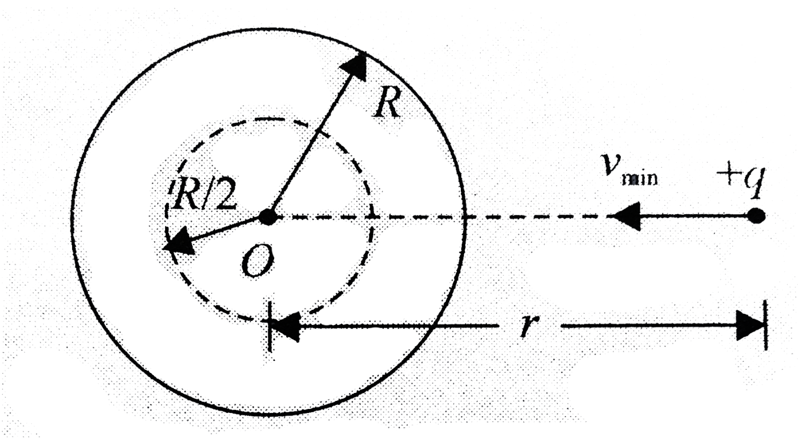
28. A positive charge Q is uniformly distributed throughout the volume of a dielectric sphere of radius R. A point mass having charge +q and mass m is fired toward the center of the sphere with velocity v from a point at distance $r(r > R)$ from the center of the sphere. Find the minimum velocity v so that it can penetrate $(R/2)$ distance of the sphere. Neglect any resistance other than electric interaction. Charge on the small mass remains constant throughout the motion.



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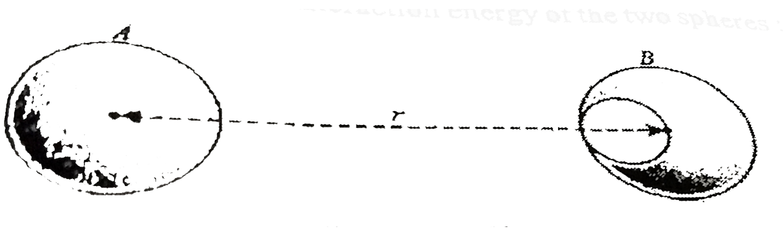
29. Distance between centres of two spheres A andB, each of radius R is r as shown in figure-1.450. SphereB has a spherical cavity of radius $R/2$ such that distance of centre of cavity is (r-R/2) from the centre of sphere A and $R/2$ from the centre of sphere B. Di-electric constant of material of each sphere is K = I and material of each sphere has a uniform charge density· p per unit volume. Calculate interaction energy of the two spheres :



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30. A clock face has charges $-q, -2q, , \dots . -12q$ fixed at the position of the corresponding numerals on the dial. The clock hands do not disturb the net field due to point charges. At what time does the hour hand point in the direction of the electric field at the centre of the dial.

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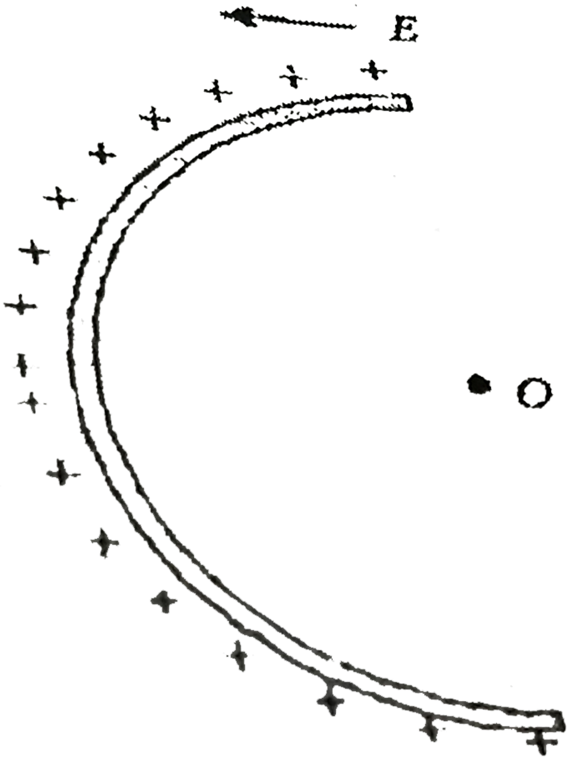
31. A semi-circular ring of mass m and radius R with linear charge ilensity λ, hinged at its centre. is placed in a uniform electric field as shown in the figure -1.451. Ifthe ring is slightly rotated about O and released find the time period (in sec) of oscillation. Take $m = 8kg, \lambda = 2C/m$ and $E = 2N/c$. Assume that coil is rotated in its own plane



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32. A charge $+10^{-9}C$ is located at the origin in free space $\&$ another charge Q at $(2, 0, 0)$. If the X-component of the electric field at (3,1,1) is zero , calculate the value of Q, Is the Y-component zero at (3,1,1) ?

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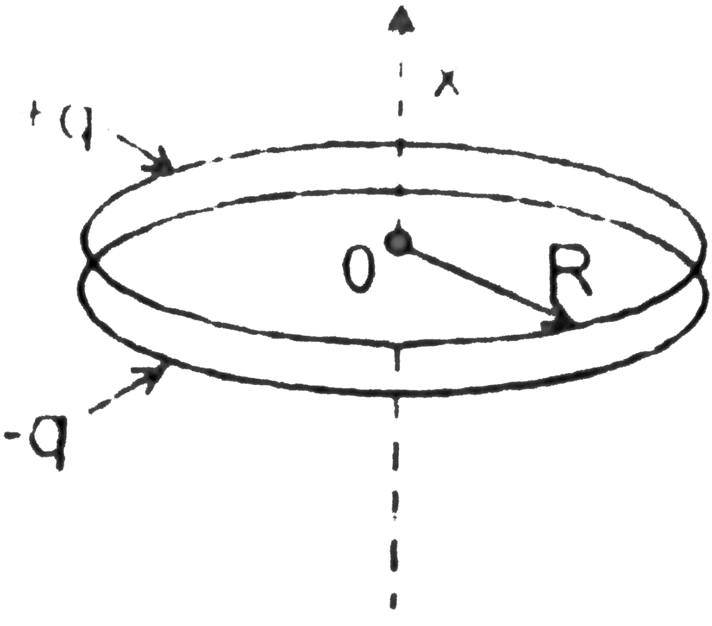
33. Two coaxial rings, each of radius R, made of thin wire are separated by a small distance $l(l < < R)$ and carry the charges q and $-q$. Find the electric field potential and strength at the axis of the system as a function of the x coordinate (see figure). Investigate these functions at $|x| > > R$



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34. On a thin rod oflength $l = 1m$, lying along the x-axis with one end at the origin x = 0, there is uniformly distributed charge per unit length $\lambda = Kx$, where K =constant $= 10^{-9} cm^{-2}$ Find the work done in displacing a charge $q = 1000 \mu C$ from a point $(0, \sqrt{0.44m} \text{to} (0, Im))$.

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35. Find the interaction force between two water molecules separated by a distance $l = 10mm$ if their electric moments are oriented along the same straight line. The moment of each molecule equals $p = 0.62.10^{-29} C. m.$

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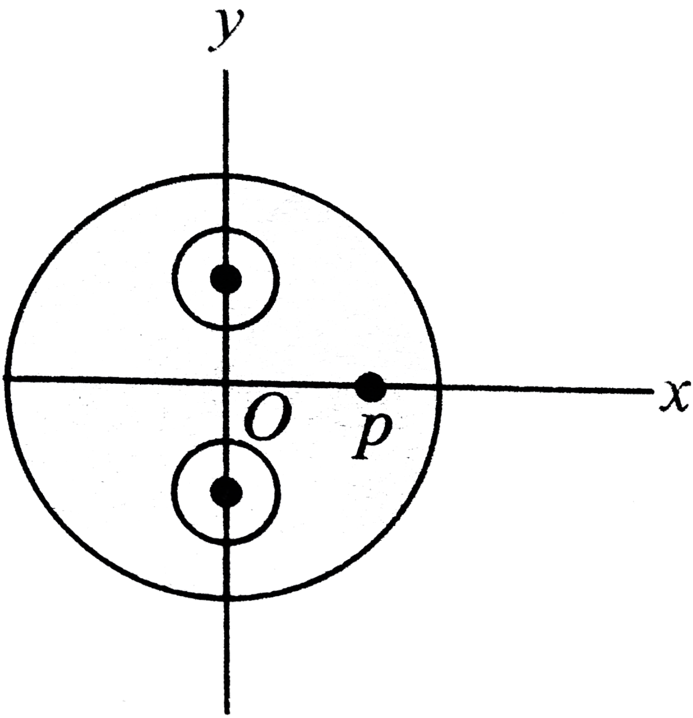
36. A nonconducting sphere of radius $R = 5cm$ has its center at the origin O of the coordinate system as shown in (Fig. 3.112). It has two spherical cavities of radius $r = 1cm$, whose centers are at $0, 3cm$ and $0, -3cm$, respectively, and solid material of the sphere has uniform positive charge density $\rho = 1/\pi\mu Cm^{-3}$. Calculate the electric potential at point $P(4cm, 0)$.



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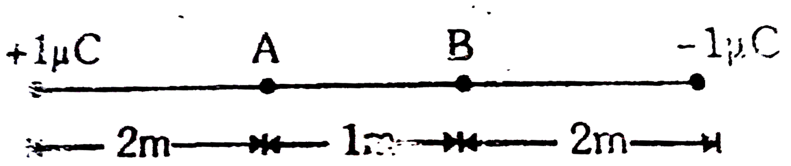
37. Positive and negative charges of $1\mu C$ each are placed at two points as shown in the figure. Find the potential difference between A and B



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38. Three particles, each of mass m and carrying a charge q each, are suspended from a common point by insulating mass-less strings each of length L. If the particles are in equilibrium and are located at the corners of an equilateral triangle of side a, calculate the charge q on each particle. Assume $L > \; > a$.

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39. A uniformly distributed space charge fills up the space between two large parallel plates separated by a distance d. The potential difference between the plates is equal to zero ? What will then be the field strength near the other plate ?

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40. Consider three identical metal spheres A, B and C. Sphere A carries charge $+6q$, sphere B carries charge $-3q$ and sphere C carries no charge . Spheres A and B are touched together and then separated. Sphere C is then touched to sphere A and separated from it . Finally the sphere C is touched to sphere B and separated from it . Find the final charge on the sphere C.

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41. A copper atom consists of copper nucleus surrounded by 29 electrons. The atomic weight of copper is $63.5 mole^{-1}$. Let us now take two pieces of copper each weighing $10g$. Let us trandfer one elcetron from one piece to another for every 100 atoms in that piece. What will be the Coulomb force between the two pieces after the trandfer of electrons, if they are $1cm$ apart? Avogadro number $= 6 \times 10^{23} mole^{-1}$, charge on an electron $= -1.6 \times 10^{-19} C$.

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42. A solid non-conducting hemisphere ofradius R has' a uniformly distributed positive charge of density p per unit volume. A negatively charged particle having charge q is transferred from centre of its base to infinity. Calculate workperformed.in the processc Di-electric constant of material of hemisphere is unity:

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43. Show that, for a given dipole, V & E cannot have the same magnitude at distance less than 2m from the dipole. Suppose that the distance is $\sqrt{5}m$, determine the directions along which V & E are equal in magnitude.

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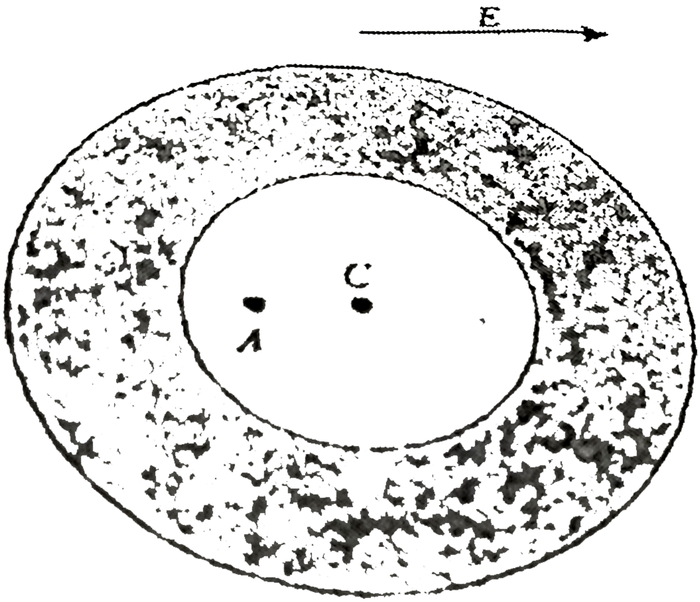
44. In a conducting hollow sphere of inner and outer radii 5cm and 10cm respectively, a point charge 1 μC is placed at point A, thaUs 3cm from the centre C of the hollow sphere. An external uniform electric field of magnitude 20 N/C is also applied. Net electric force on the this. charge is 15N, away from the away from the centre of the sphere as shown in figure-1.455. Find magnitude of force exerted by the charge placed at point A on the sphere:



centre of the

sphere as shown in figure. Find magnitude

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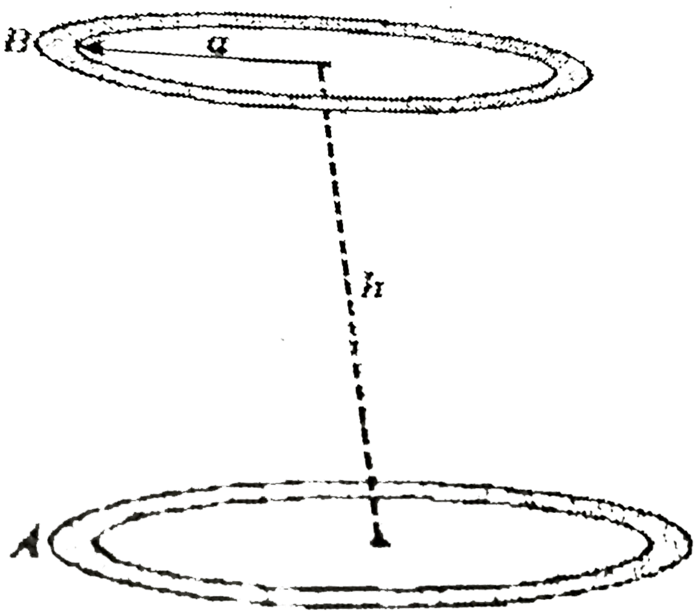
45. Two circular rings A and B, each of radius a = 30cm, are placed coaxiallywith their axes vertical as shown in figure-1.456. Distance between centres of these rings is $h = 40cm$. Lower ring A has a positive charge of 10μC, while upper ringB has a negative charge of $20\mu C$. A particle of mass $m = 100$ gm carrying a positive charge of $q = 10\mu$ C is released from rest at the centre of the ring ltbergt (a)

Calculate initial acceleration of the particle.

(b) Calculate velocity of particle when it reaches at the centre ofupper ring B. $\left(g = 10ms^{-2}\right)$



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46. A hollow charged conductor has a tiny hole cut into its surface. Show that the electric field in the holes is $(\sigma / 2 \in_0 \ \hat{n}$, where $\hat{n}$ is the unit vector in the outward normal direction, and σ is the surface charge density near ther hole.

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47. Two point charges $q_1 = 20\mu C$ and $q_2 = 25\mu C$ are placed at (-1, 1, 1) m and (3, 1, -2)m, with respect to a coordinate system. Find the magnitude and unit vector along electrostatic force on q_2 ?

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48. A spherical balloon of radius R charged uniformly on its surface with surface density σ. Find work done against electric forces in expanding it upto radius 2R.

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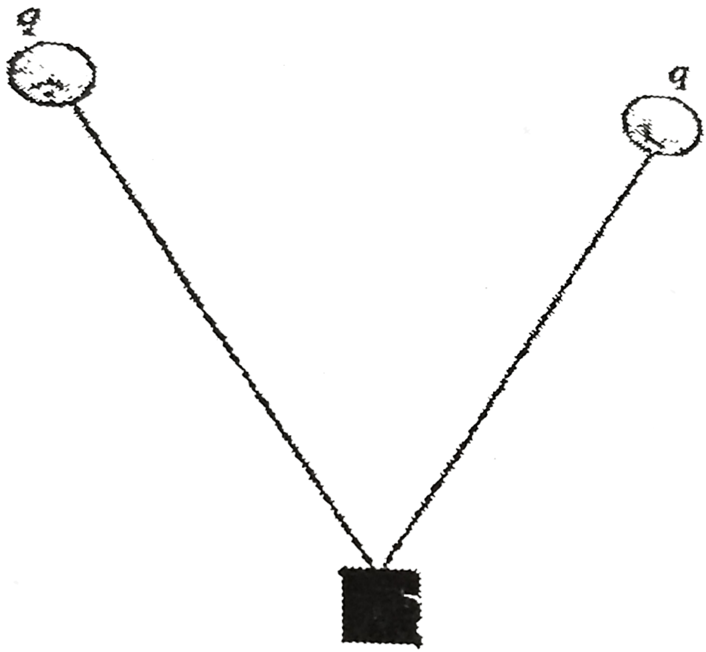
49. Two similar helium-filled spherical balloons tied to a 5g weight with strings and each carrying a charge q floats in equilibrium as shown in figure-1.457. Find (a) the magnitude of q, assuming that the charge on each balloon acts as ifit were concentrated at the centre and (b) the volume of each balloon. Neglect weight of the unfilled balloons and take density ofair $1.29kg/m^3$ and the density of helium in the balloons $0.2kg/m^3$:



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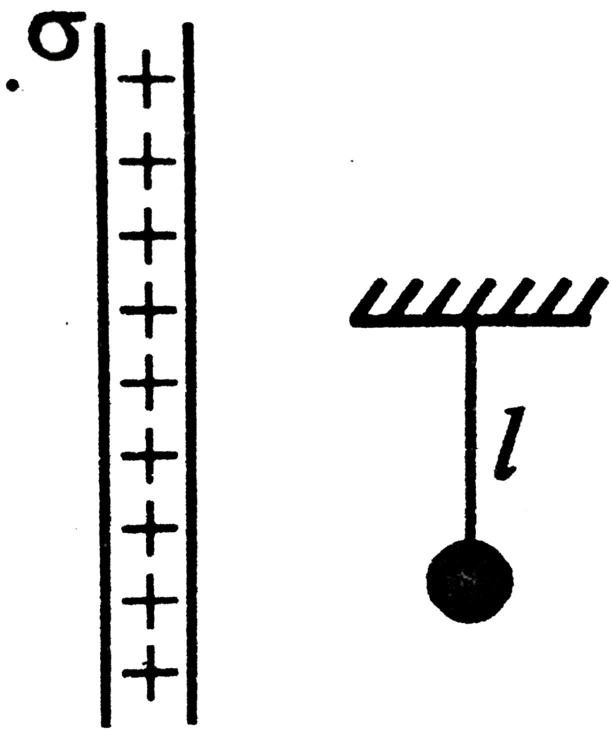
50. A simple pendulum of length l and bob mass m is hanging in front of a large nonconducting sheet having surface charge density σ. If suddenly a charge $+q$ is given to the bob $\&$ it is released from the position shown in figure. Find the maximum angle through which the string is deflected from vertical .



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51. The electric field in a region is given by $E = \alpha x \hat{i}$. Here α is a constant of proper dimensions. Find

a. the total flux passing throug a cube bounded by the surface $x = l, x = 2l, y = 0, y = l, z = 0, z = l.$

b. the charge contained inside in above cube.

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52. The electric field in a region is given by $\overrightarrow{E} = E_0 \frac{x}{\iota} \overrightarrow{i}$. Find the charge contained inside a cubical volume bounded by the curfaced $x = 0, x = \alpha, y = 0, y = \alpha, z = 0$ and $z = \alpha.$ Take $E_0 = 5 \times 10^3 NC^{-1}, l = 2cm$ and $\alpha = 1cm.$

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53. When an uncharged conducting ball of radius R is placed in an external uniform electric field, a surface charge densityh $\sigma = \sigma_0 \cos\theta$

is induced on the ball's surface charge (here σ_0 is a constant, θ is a polar angle). Find the magnitude of the resultant electric force acting on an induced charge of the same sign.

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54. Two identical balls of charge q_1 & q_2 initially have equal of the same magnitude and direction. After a ubiform electric field is applied for some time, the direction of the velocity of the first ball charges by 60° and the magnitude is reduced by half. The direction of the velocity of the second ball charges there by 90°. In what proportion will the velocity of the second ball changes?

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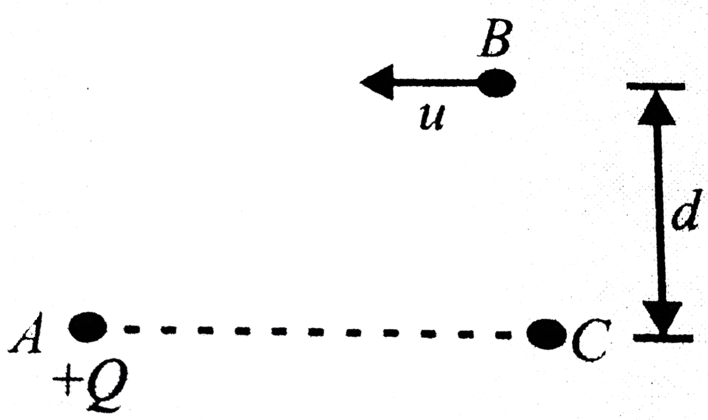
55. A positive charge $+Q$ is fixed at a poibt A. Another positively charged particle of mass m and charge +q is projected from a point B with velocity u as shown in (Fig. 3.103). Point B is at a large distance from A and at distance d from the line A C. The initial velocity is parallel to the line A C. The point C is at a very large distance from A. Find the minimum distance (in meter) of +q from +Q during the motion. Take $Qq = 4\pi\varepsilon_0 m u^2 d$ and $d\left(\sqrt{2}-1\right)m$.



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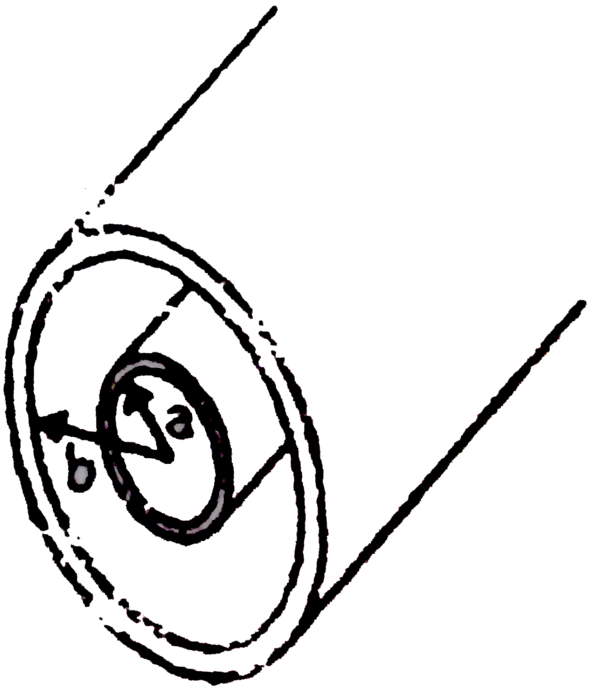
56. Figure shown a section through two long thin concentric cylinders of radii a & b with $a > b$. The cylinders have equal and opposite per unit length λ. Find the electric field at a distance r from the axis for (i) $r < a$ (ii) $a < r < b$ (iii) $r > b$



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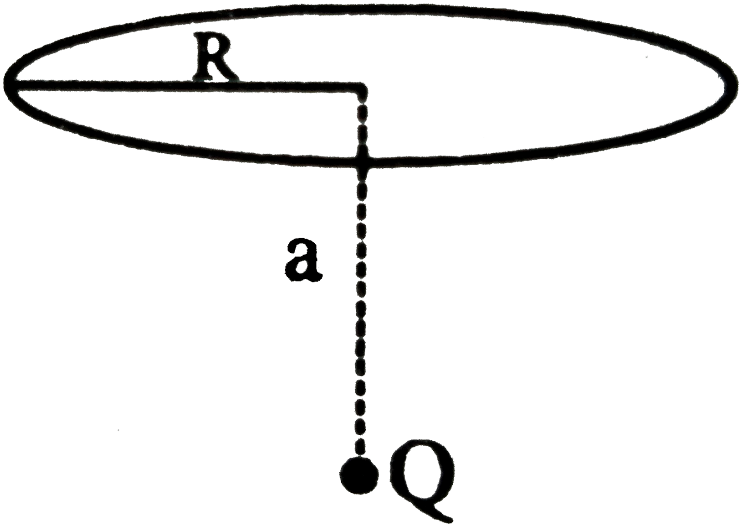
57. A point charge Q is located on the axis of disc of a radius R at a distance a from the plane of the disc . If one fourth $(1/4th)$ of the flux from the charge passes through the disc, then find the relation between a & R.



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58. A very long uniformly charged thread oriented along the axis of a a circle of radius R rests on its centre with one of the ends. The charge of the thread per unit length is equal to λ. Find the flux of the vector E across the circle area.

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59. Three point charges of 1C, 2C and 3C are placed at the . corners of an equilateral triangle of side 1m. Calculate the work required to move these charges to the corners of a smaller equilateral triangle of side 1.5m.

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60. Two small metallic balls of radii $R_1 \& R_2$ are kept in vacuum at a large distance compared to the radii. Find the ratio between the charges on the two balls at which electrostatic energy of the system is minimum. What is the potential difference between the two balls ? total charge of balls is constant.

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61. Two concentric spheres of radii R and $2R$ are charged. The inner sphere has a charge if $1 \mu C$ and the outer sphere has a charge of

$2\mu C$ of the same sigh. The potential is $9000V$ at a distance $3R$ from the common centre. The value of R is

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62. A charge Q is uniformly distributed over a rod of length l. Consider a hypothetical cube of edge l with the centre of the cube at one end of the rod. Find the minimum possible flux of the electric field through the entire surface of the cube.

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63. A particle having a charge of $q = 8.85 \mu C$ is placed on the axis of a circular ring of radius $R = 30cm$ at a point P at a distance of $a = 40cm$ from the centre of the ring.The electric flux passing through the ring is $x \times 10^5 N/C$ .Find the value of x?

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64. Electrically charged drops of mercury fall from an altitude h into a spherical metal vessel of radius R. There is a small opening in the upper part of the vessel. The mass of each drop is m, and the charge on the drop is Q. What will be the number n of the last drop that can still enter the sphere?

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65. A non-conducting sphere ofradius R has a positive charge which is distributed over its volume with density $\rho = \rho_0\left(1 - \frac{x}{R}\right)$ per unit volume, wherex is distance from the centre. If dielectric constant of material of the sphere is k= I, calculate energy stored in surrounding space and total self energy of the sphere:

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66. Two identical charges, $5\mu C$ each are fixed at a distance 8 cm and a charged particle of mass $9 \times 10^{-6} kg$ and charge $-10\mu C$ is placed at a distance 5 cm from each of them and is released. Find the speed of the particle when it is nearest to the two charges.

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67. A particle of mass m and charge $-q$ moves along a diameter of a uniformly charged sphere of radius R and carrying a total charge $+Q$. Find the frequency of S.H.M. of the particle if the amplitude does not exceed R .

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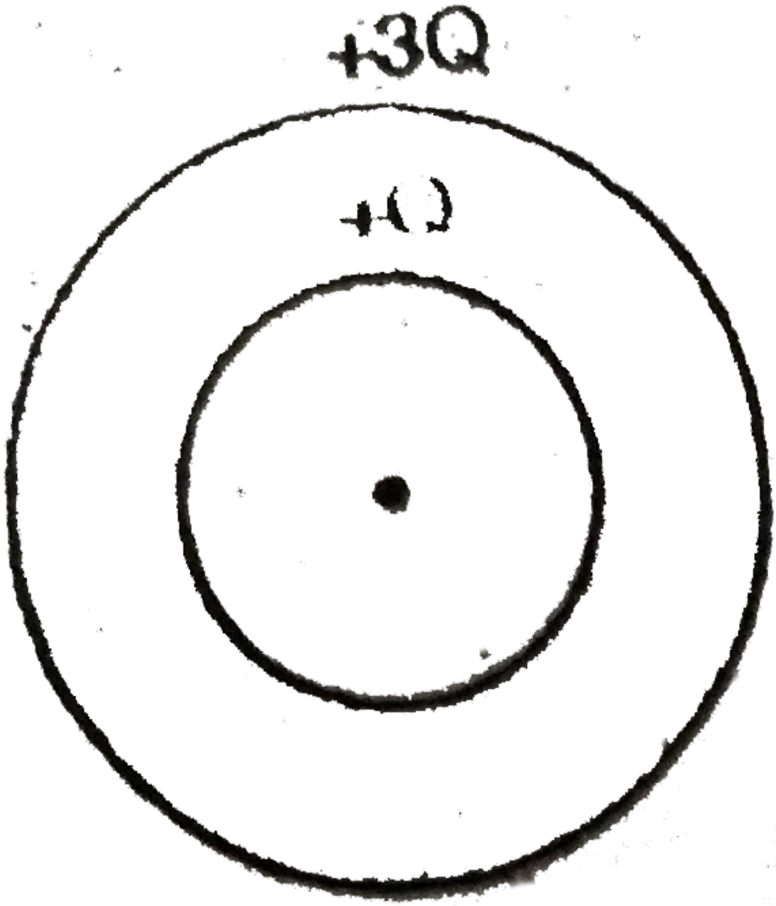
68. Two concentric conducting thin shells of radius R and 2 R carry charges +Q and +3Q respectively. The magnitude of electric field at a distance x outside and inside from the surface of outer sphere is same. Then the value of x is



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69. The electric field strength depends only on the x and y coordinates according to the law E = $\frac{a\left(x\hat{i}+y\hat{j}\right)}{x^2+y^2}$, where a is a

constant $\hat{i}$ and $\hat{j}$ are unit vectors of the x and y axes . Find the potential difference between x = 1 and x = 5 :

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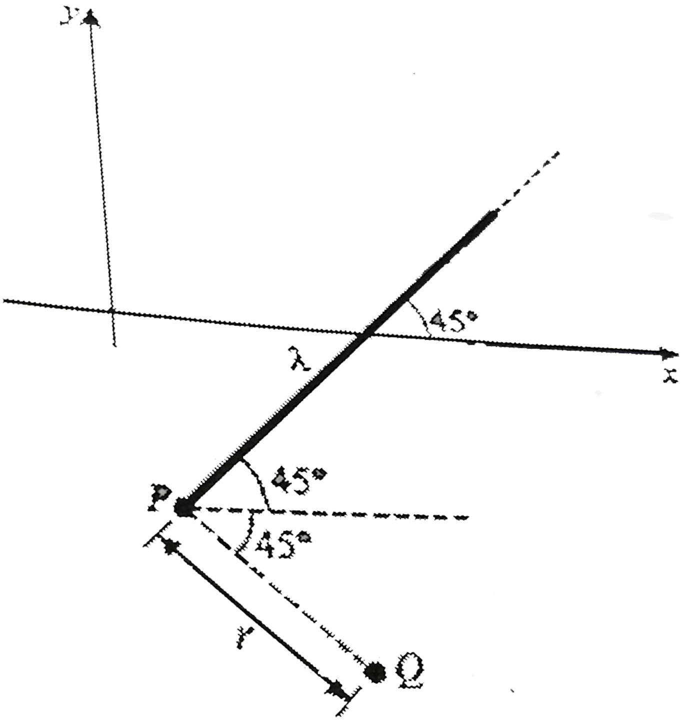
70. A very long charged wire (lying in the xy plane) which is having a linear charge density λ is having one of its end at a point P as shown in figure . What is electric field intensity at point Q :



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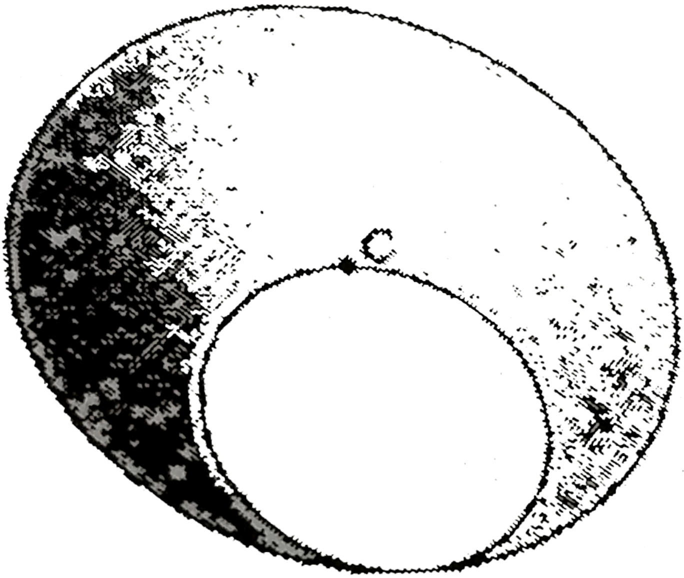
71. A solid sphere ofradius 'R' is uniformly charged with charge density ρin its volume. A spherical cavity of radius $\frac{R}{2}$ is made in the sphere as shown in the figure. It is given that $\frac{\rho R^2}{\epsilon_0} = 48V$. Find the electric potential at the centre C of the sphere:



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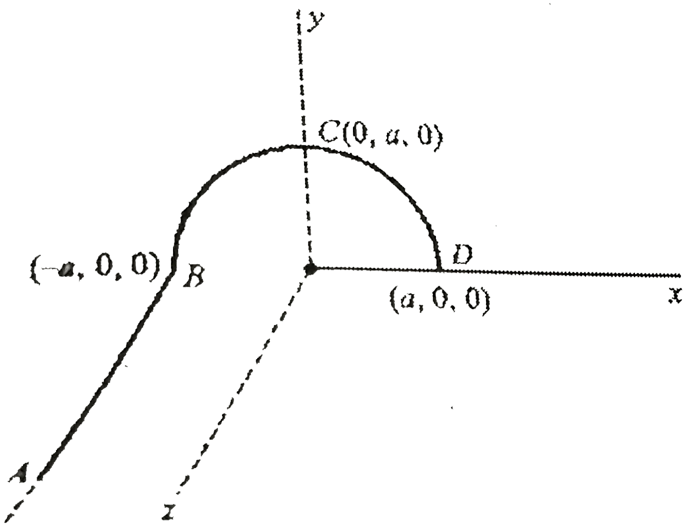
72. Find the electric field at the origin due to the line charge (ABCD) of linear charge density λ,



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73. A point charge $+q$ & mass $100gm$ experiences a force of $100N$ at a point of distance $20cm$ from a long infinite uniformly charged wire , If it is released find its speed when it is at a distance 40 cm from wire .

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