PHYSICS

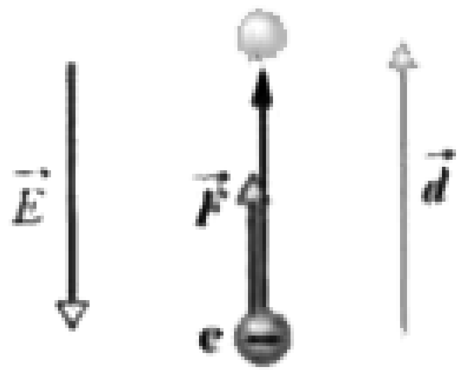
BOOKS - RESNICK AND HALLIDAY PHYSICS (HINGLISH)

ELECTRIC POTENTIAL

Sample Problem 24 01 Work And Potential Energy In An Electric Field

1. Electrons are continually being knocked out of air molecules in the atmosphere by cosmic-ray particles coming in from space. Once released, each electron

experiences an electric force $\vec{F}$ due to the electric field $\vec{E}$ that is produced in the atmosphere by charged particles already on Earth. Near Earth's surface the electric field has the magnitude $E = 150 N/C$ and is directed downward. What is the change ΔU in the electric potential energy of a released electron when the electric force causes it to move vertically upward through a distance $d = 520$ m (Fig. 24-4)? Through what potential change does the electron move?



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Sample Problem 24 02 Distance Velocity Closest Separation For Charged Particle Projected From ∞ Towards Fixed Particle

1. A ball of mass of 1 kg and charge $50 \mu C$ is directly projected from infinity toward another fixed ball of charge $1/6 \mu C$ (as shown in Fig. 24-5). The initial velocity of projection is 10 m/s. Find the distance and its velocity at the closest separation. Assume that the initial line of motion is at a distance of 1 m from the second fixed charge.

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Sample Problem 24 03 Locating Equipotential Surfaces

1. An infinite nonconducting sheet has a surface charge density of $\sigma = 0.10 \mu C / m^2$ on one side. How far apart are equipotential surfaces whose potentials differ by 50 V?

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Sample Problem 24 04 Finding The Potential Change From The Electric Field

1. (a) Figure 24-10a shows two points i and fin a uniform electric field $\vec{E}$. The points lie on the same electric field line (not shown) and are separated by a distanced. Find the potential difference $V_f - V_i$ by moving a positive test charge q_0 from i to f along the path shown, which is parallel to the field direction.

(b) Now find the potential difference $V_f - V_i$ by moving the positive test charge q_0 from i to f along the path icf shown in Fig. 24-10b.

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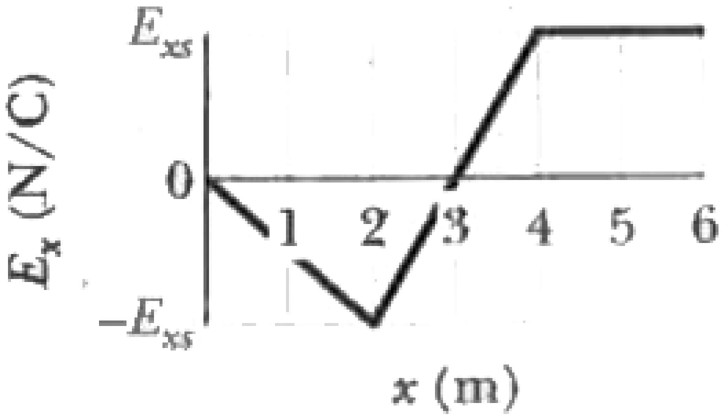
Sample Problem 24 05 Finding Electric Potential

1. A graph of the x component of the electric field as a function of x in a region of space is shown in Fig. 24-11. The scale of the vertical axis is set by $E_{xs} = 20.0$ N//C. The y and z components of the electric field are zero in this region. If the electric potential at the origin is 10 V, then:



(a) What is the electric potential at x = 2.0 m?

(b) What is the greatest positive value of the electric potential for points on the x axis for which $0 \leq x \leq 6.0$ m?

(c) For what value of x is the electric potential zero?

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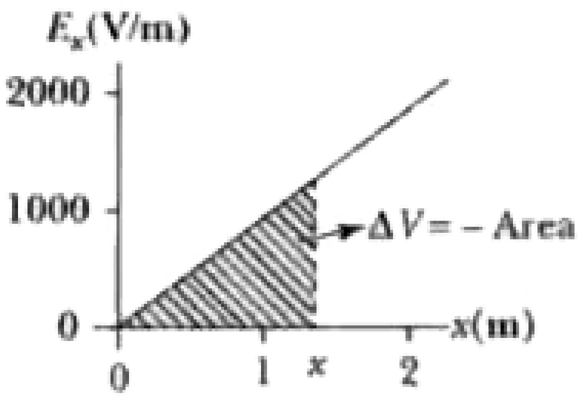
Sample Problem 24 06 Finding The Potential

1. Figure 24-12 is a graph of Ex, the x component of the electric field, versus position along the x axis. Find and graph V(x). Assume V = O, V at x = 0 m.



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Sample Problem 24 07 Net Potential Of Several Charged Particles

1. What is the electric potential at point P, located at the center of the square of charged particles shown in Fig. 24-16a? The distanced is 1.3 m, and the charges are

$$q_1 = +12nC, \qquad q_3 = +31nC,$$

$$q_2 = -24nC, \qquad q_4 = +17nC.$$

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Sample Problem 24 08 Potential Is Not A Vector Orientation Is Irrelevant

1. (a) In Fig. 24-17 a, 12 electrons (of charge $-e$) are equally spaced and fixed around a circle of radius R. Relative to $V = 0$ at infinity, what are the electric potential and electric field at the center C of the circle due to these electrons?

(b) The electrons are moved along the circle until they are nonuniformly spaced over a 120° arc (Fig. 24-17b). At C, find the electric potential and describe the electric field.

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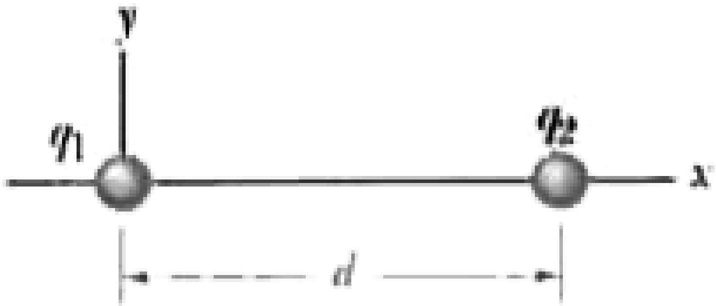
Sample Problem 24 09 Net Potential Due To Two Charged Particles

1. Two particles, of charges q_1 and q_2, are separated by distance d in Fig. 24-18 with V = 0 at infinity.

(a) If the particles with charges $q_1 = +5e$ and

$q_2 = -15e$ are fixed in place with a separation of $d = 24.0$ cm, what are the finite (i) positive and (ii) negative values of x at which the net electric potential on the x axis is zero?



(b) If the net electric field due to the particles is zero at x = d/4, then locate (in terms of d) any point on the x axis (other than at infinity) at which the electric potential due to the two particles is zero?

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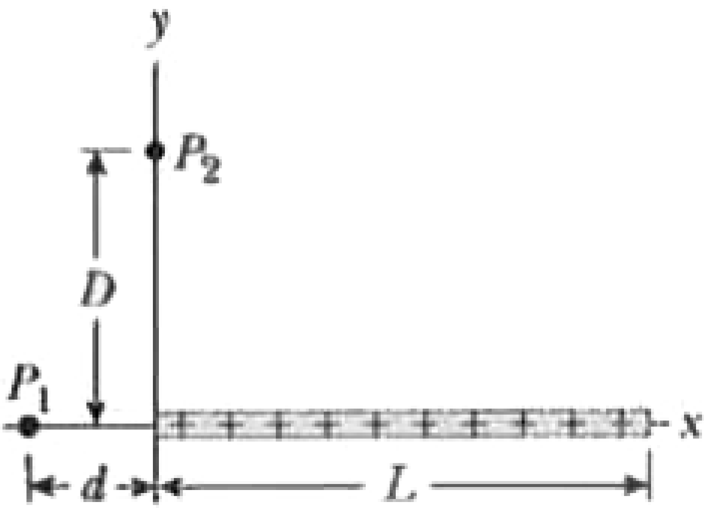
Sample Problem 24 10 Potential Due To Line Of Charge

1. Figure 24-20 shows a thin plastic rod of length L = 12.0 cm and uniform positive charge $Q = 56.1$ fC lying on the x axis. With $V = 0$ at infinity, find the electric potential at point P_1 on the axis, at distance $d = 2.50$ cm of the rod.



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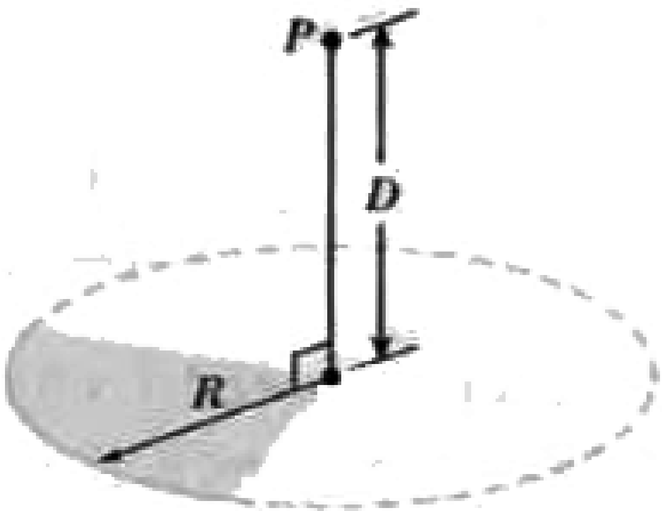
Sample Problem 24 11 Finding Potential Of Charged Disk

1. A plastic disk of radius R = 64.0 cm is charged on one side with a uniform surface charge density $\sigma = 7.73 fC/m^2$, and then three quadrants of the disk are removed. The remaining quadrant is shown in Fig. 24-22. With V = 0 at infinity, what is the potential due to the remaining quadrant at point P, which is on the central axis of the original disk at distance D = 25.9 cm from the original center?



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Sample Problem 24 12 Potential Due To Infinite Sheet Of Charge

1. Find the potential due to an infinite sheet of charge at a distance x from it. Assume that the potential is zero at a distance a from it.

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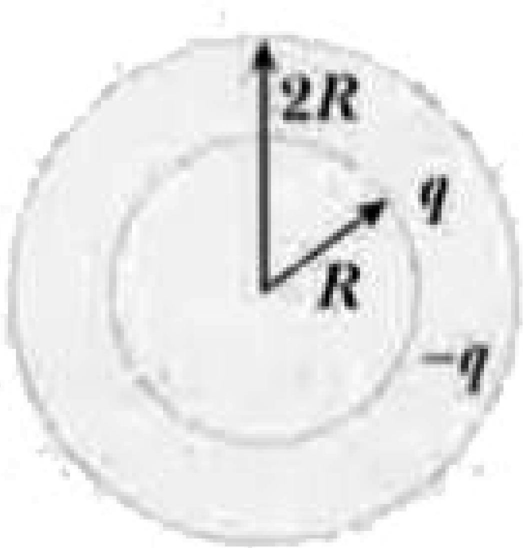
Sample Problem 24 13 Potential At The Surface Of The Outer Shell

1. Consider two concentric shells shown in Fig. 24-27, one of charge q and radius R and another outer shell of charge $-q$ and radius 2R. Find the potential at the surface of the outer shell and at the center.



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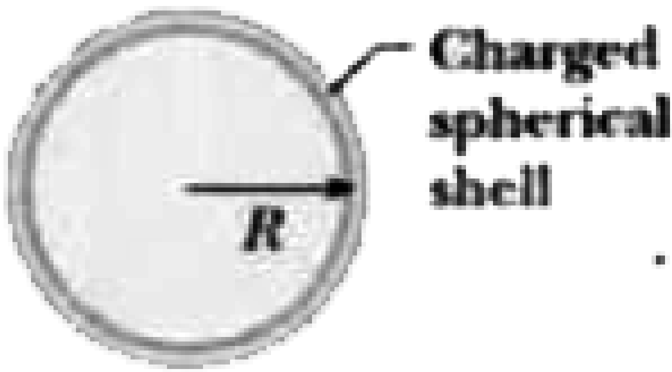
Sample Problem 24 14 Field And Potential Inside A Charged Spherical Shell

1. In Fig. 24-28, a thin conducting spherical shell of radius

$R = 2.00$ cm has a uniformly spread surface charge of

$q = -5.00 \times 10^{-15} C$. What are the electric potential and magnitude of the electric field on (a) the surface and at (b) $r = 2.00R$ and (c) $r = 0.500R$?



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Sample Problem 24 15 Point Charge Projected From A Large Distance Towards Center Of Fixed Charged Ring

1. Assume that a point charge q is projected from a large distance toward the center of a fixed charged ring along its axis. What should be its initial velocity so that the charge may reach the other side of infinity?

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Sample Problem 24 16 Finding The Field From The Potential

1. The electric potential at any point on the central axis of a uniformly charged disk is given by Eq. 24-37,

$$V = \frac{\sigma}{2\varepsilon_0}\left(\sqrt{z^2 + R^2} - z\right).$$

Starting with this expression, derive an expression for the electric field at any point on the axis of the disk.

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Sample Problem 24 17 Acceleration Of Charge Of Given Potential

1. The potential at a point (x, y) is expressed as $V = 4x + 3y$. A charge $1\mu C$ and mass 1 mg is released from $(1, 1)$ from rest. (a) Find the acceleration of the charge.

(b) Find the time when it crosses x axis.

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Sample Problem 24 18 Electric Field Due To A Dipole At A Point On Dipole Axis

1. Starting from Eq. 24-54 derive the expression for the electric field due to a dipole at a point on the dipole axis.

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Sample Problem 24 19 Resultant Potential And Electric Field Of Dipoles

1. A dipole of dipole moment p is placed at origin along x axis. Another dipole of dipole moment also p is kept at (0, 1, 0) along y axis. Find the resultant potential and electric field at (1, 0, 0).

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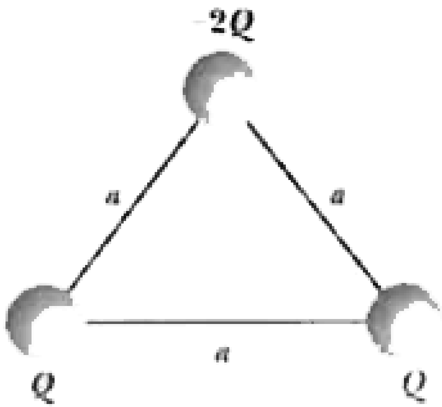
Sample Problem 24 20 Dipole Moment Of Combination Of Three Charges

1. Three charges $Q, Q,$ and $-2Q$ are located on the vertices of an equilateral triangle of side a. Find the dipole moment of the combination (Fig. 24-38).



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Sample Problem 24 21 Potential Energy Of A System Of Three Charged Particles

1. Three charged particles held in fixed positions by forces that are not shown. What is the electric potential energy U of this system of charges? Assume that d = 12 cm and that

$q_1 = +q, q_2 = 4q, \text{ and } q_3 = +2q,$

in which $q = 150$ n C.

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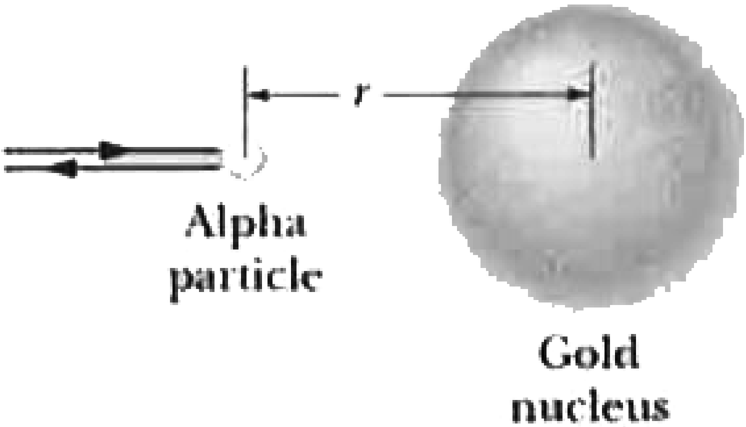
Sample Problem 24 22 Conservation Of Mechanical Energy With Electric Potential Energy

1. An alpha particle (two protons, two neutrons) moves into a stationary gold atom (79 protons, 118 neutrons), passing through the electron region that surrounds the gold nucleus like a shell and headed directly toward the nucleus (Fig. 24-42 . The alpha particle slows until it momentarily stops when its center is at radial distance $r = 9.23$ fm from the nuclear center. Then it moves back along its incoming path. (Because the gold nucleus is much more massive than the alpha particle, we can assume the gold nucleus does not move.) What was the kinetic energy K_i of the alpha particle when it was initially far away (hence external to the gold atom)?. Assume that the only force acting between the alpha particle and the gold nucleus is the (electrostatic)

Coulomb force and treat each as a single charged particle.



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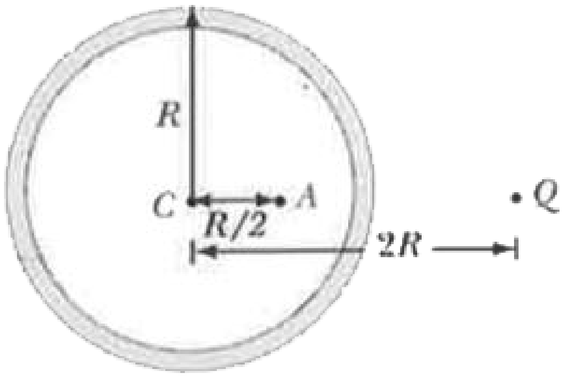
Sample Problem 24 23 Finding Potential On Spherical Conducting Shell Due To Point Charge Kept Outside The Shell

1. Find the potential at point A due to (a) charge Q, (b) charge on the outer surface of the conducting shell, and (c) total potential at A (Fig. 24-45).



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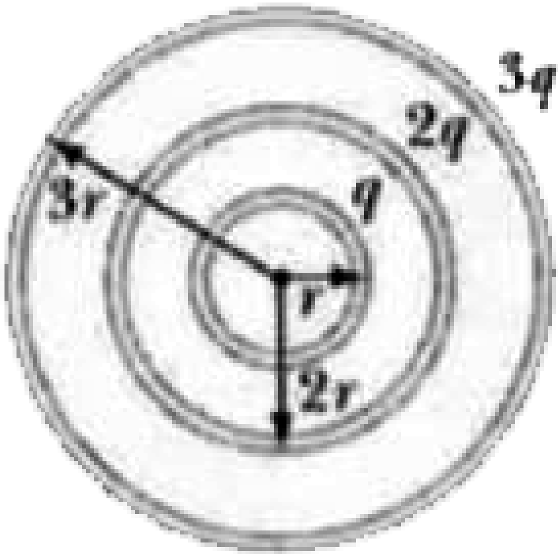
Sample Problem 24 24 Potential Due To Charges On Three Concentric Shells

1. Find the (a) potential of the shells in the situation shown in Fig. 24-50 and (b) the charge distribution on each of the shells after the inner shell and the outermost shells are connected by a conducting wire.



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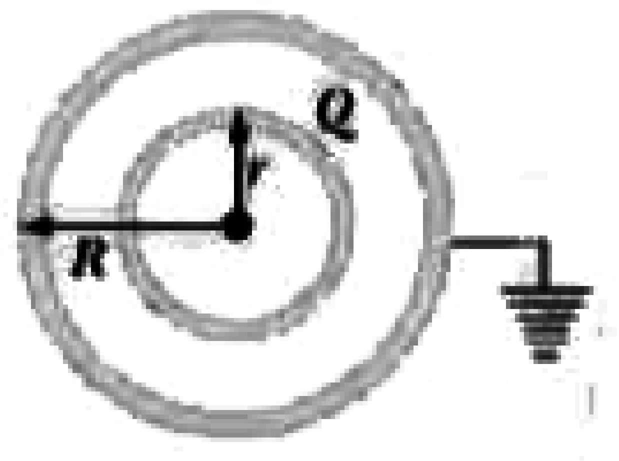
Sample Problem 24 25 Charge And Potential On A Conductor That Is Earthed

1. Assume that two spherical concentric conducting shells of radius r and R are kept as shown in Fig. 24-53. The inner shell is given a charge Q and the outer shell is earthed. Find the charge supplied by the Earth and the potential of the inner shell.



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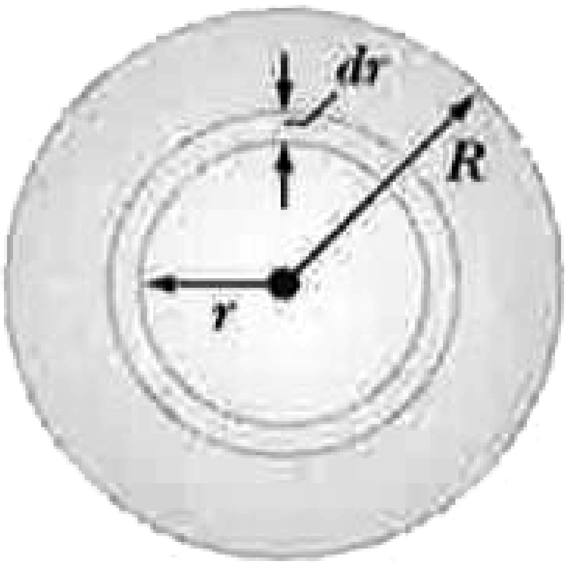
Sample Problem 24 26 Self Energy Of A Uniformly Charged Sphere

1. Find the self-energy of a uniformly charged sphere of radius R as shown in Fig. 24-57. Assume that the charge density is ρ.



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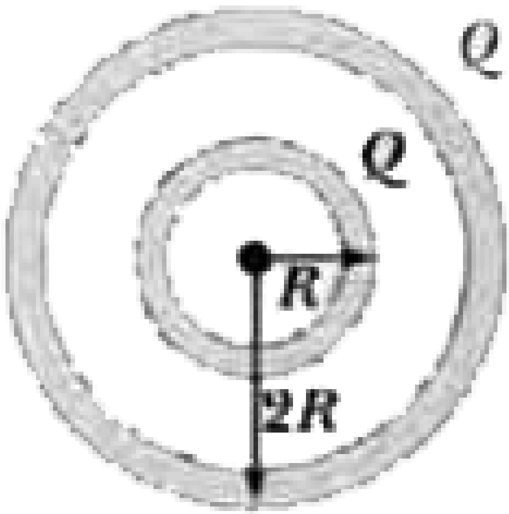
Sample Problem 24 27 Electrostatic Energy Of Two Charged Conducting Shells With And Without Earthing

1. (a) Find the total electrostatic energy of the configuration shown in Fig. 24-58



Here, we find that there are three shells of charges. In the innermost shell, charges on the inner surface of the outer shell form one shell and charges on the outer shell also form a shell. Each of these shells will have a self-energy and an interaction energy with the other two. Since there are three shells, there will be three pairs of interaction energy as seen in Fig. 24-59. So, in total, there will be six terms in the electrostatic potential energy expression.

(b) If the inner shell is earthed, find the new charges on each surface and the total electrostatic energy of the configuration.

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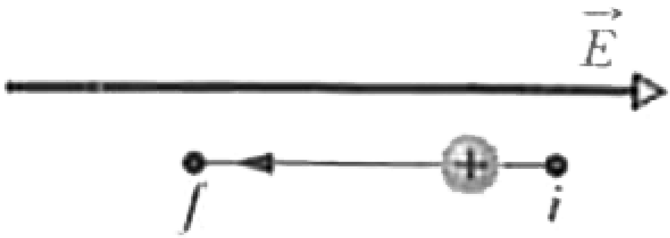
Checkpoint

1. In the figure, we move a proton from point i to point f in a uniform electric field. Is positive or negative work done by (a) the electric field and (b) our force? (c) Does the electric potential energy increase or decrease? (d) Does the proton move to a point of higher or lower electric potential?



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2. In the figure of Checkpoint 1, we move the proton from point i to point fin a uniform electric field directed as shown. (a) Does our force do positive or negative work?

(b) Does the proton move to a point of higher or lower potential?

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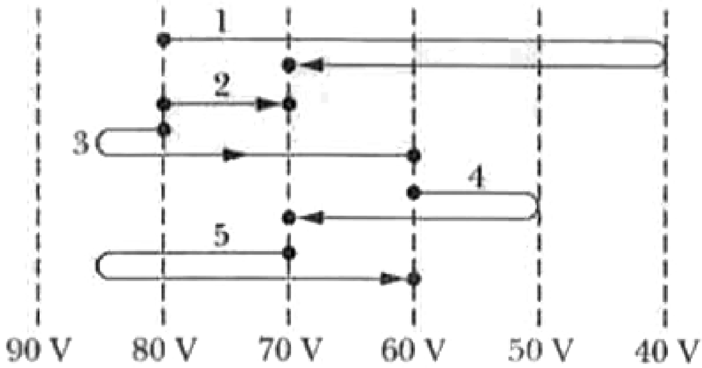
3. The figure here shows a family of parallel equipotential surfaces (in cross section) and five paths along which we shall move an electron from one surface to another. (a) What is the direction of the electric field associated with the surfaces? (b) For each path, is the work we do positive, negative, or zero? (c) Rank the paths according to the work we do, greatest first.



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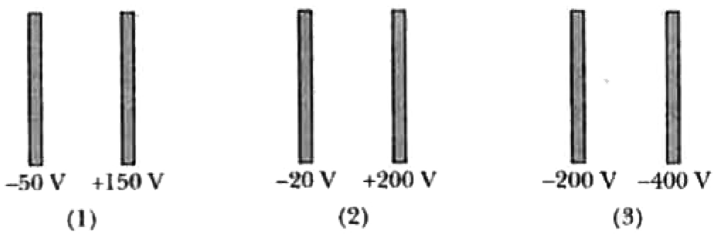
4. The figure shows three pairs of parallel plates with the same separation, and the electric potential of each plate. The electric field between the plates is uniform and perpendicular to the plates. (a) Rank the pairs according to the magnitude of the electric field between the plates, greatest first. (b) For which pair is the electric field pointing rightward? (c) If an electron is released midway between the third pair of plates, does it remain there, move rightward at constant speed, move leftward at constant speed, accelerate rightward, or accelerate leftward?



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5. Is the electrostatic field pattern shown in the figure possible? (Hint: Assume a rectangular loop in the field and find the work done by the electric field on a test charge in moving along that loop. Did you arrive at a contradiction?)

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6. Suppose that three points are set at equal (large) distances r from the center of the dipole in Fig. 24-33: Point a is on the dipole axis above the positive charge, point b is on the axis below the negative charge, and point c is on a perpendicular bisector through the line connecting the two charges. Rank the points according to the electric potential of the dipole there, greatest (most positive) first.

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Problems

1. A charged, conducting sphere of radius 5.5 cm sets up a potential of 75 V at a radial distance of 2.2 m (with V = 0 set at infinity). (a) What is the potential on the sphere's surface? (b) What is the surface charge density ?

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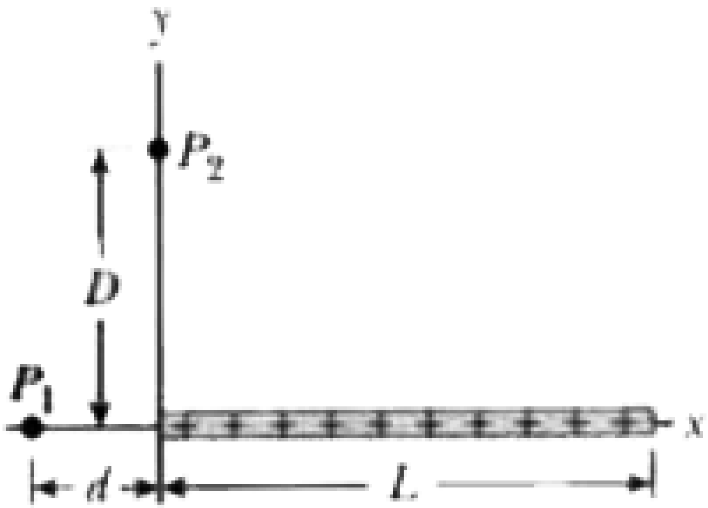
2. Figure 24-61 shows a thin plastic rod of length L = 13.5 cm and uniform charge 43.6 fC. (a) In terms of distance d, find an expression for the electric potential at point P_1. (b) Next, substitute variable x for d and find an expression for the magnitude of the component E_x of the electric field at P_1. (c) What is the direction of E_x relative to the positive direction of the x axis? (d) What is the value of E_x at P_1 for x = d = 6.60 cm? (e) From the symmetry in Fig. 24-61, determine E_y at P_1.



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3. The thin plastic rod of length L = 12.0 cm in Fig. 24-61 has a nonuniform linear charge density $\lambda = cx$, where $c = 49.9 pC / m^2$. With V = 0 at infinity, find the electric potential at point P_2 on the y axis at y = D = 3.56 cm. (b) Find the electric field component E_y at P_2. (c) Why cannot the field component E_x at P_2 be found using the result of (a) ?

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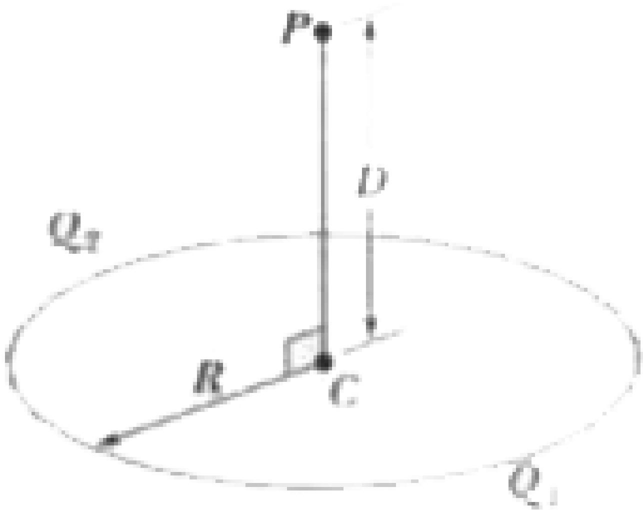
4. A plastic rod has been bent into a circle of radius R = 8.20 cm. It has a charge $Q_1 = 7.07$ cm. pC uniformly distributed along one quarter of its circumference and a charge $Q_2 = -6Q_1$ uniformly distributed along the rest of the circumference (Fig. 24-62). With V = 0 at infinity, what is the electric potential at (a) the center C of the circle and (b) point P, on the central axis of the circle at distance D = 2.05 cm from the center?



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5. A thin, spherical, conducting shell of radius R is mounted on an isolating support and charged to a potential of-170 V. An electron is then fired directly toward the center of the shell, from point P at distance r from the center of the shell $(r > \ > R)$. What initial speed v_0 is needed for the electron to just reach the shell before reversing direction?

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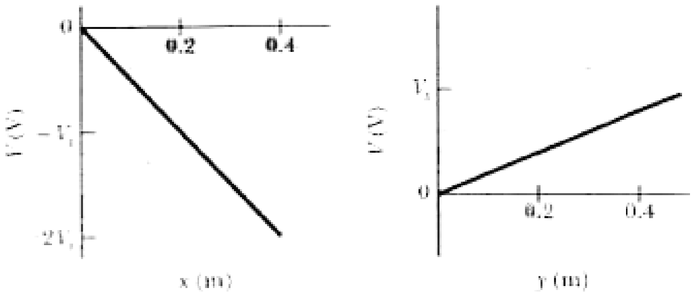
6. An electron is placed in an xy plane where the electric potential depends on x and y as shown, for the coordinate axes, in Fig. 24-63 (the potential does not depend on z). The scale of the vertical axis is set by $V_x = 1000V$. In unit vector notation, what is the electric force on the electron?



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7. The electric potential Vin the space between two flat parallel plates 1 and 2 is given (in volts) by $V = 1500x^2$, where x (in meters) is the perpendicular distance from plate 1. At x = 1.8 cm, (a) what is the magnitude of the electric field and (b) is the field directed toward or away from plate 1?

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8. A particle of charge q is fixed at point P, and a second particle of mass m and the same charge q is initially held a distance r_1 from P. The second particle is then released. Determine its momentum magnitude when it is a distance r_2 from P. Let $q = 3.1\mu C.\ m = 20mg, r_1 = 0.90mm,$ and $r_2 = 1.5mm.$

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9. If a lightning discharge lasts 1.4 ms and carries a current of 5.0×10^4 A through a potential difference of $2.4 \times 10^9 V$. what is the change in the energy of the charge that is transferred by the discharge?

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10. What is the magnitude of the electric field at the point $\left(-1.00\hat{i}-2.00\hat{j}+4.00\hat{k}\right)m$ if the electric potential in the region is given by $V=2.00xyz^2$, where V is in volts and coordinates x, y, and z are in meters?

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11. Two electrons are fixed 4.0 cm apart. Another electron is shot from infinity and stops midway between the two. What is its initial speed?

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12. (a) What is the electric potential energy of two electrons separated by 3.00 nm? (b) If the separation increases, does the potential energy increase or decrease ?

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13. In the rectangle of Fig. 24-64, the sides have lengths 5.0 cm and 15 cm, $q = -5.0\mu C$, and $q_2 = +2.0\mu C$. With $V = 0$ at infinity, what is the electric potential at (a) corner A and (b) comer B? (c) How much work is required to move a charge $q_3 = -2.0\mu C$ from B to A along a diagonal of the rectangle? (d) Does this work increase or decrease the electric potential energy of the three-charge system? Is more, less, or the same work required if q_3 is moved along a path that is (e) inside the rectangle but not on a diagonal and (f) outside the rectangle?

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14. If a proton moves through a potential difference of 4.5 kV,what is the magnitude of the change in the proton's potential energy expressed in the unit electron-volt ?

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15. Identical $50\mu C$ charges are fixed on an x axis at $x = + \pm 2.0$ m. A particle of charge $q = 15\mu C$ is then released from rest at a point on the positive part of they axis. Due to the symmetry of the situation, the particle moves along the y axis and has kinetic energy 1.2 J as it passes through the point$x = 0, y = 4.0m$. (a) What is the kinetic energy of the particle as it passes through the origin? (b) At what negative value of y will the particle momentarily stop?

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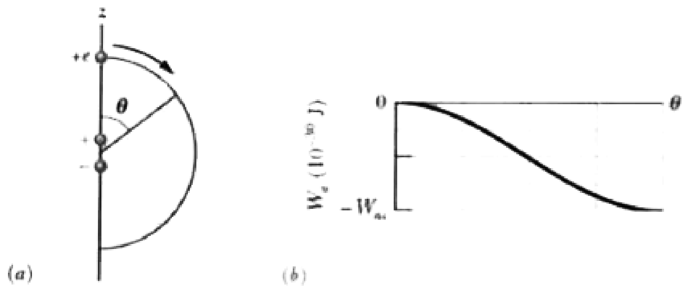
16. In Fig. $24-65a$, a particle of elementary charge $+e$ is initially at coordinate $-z=20$ nm on the dipole axis (here a z axis) through an electric dipole, on the positive side of the dipole. (The origin of z is at the center of the dipole.) The particle is then moved along a circular path around the dipole center until it is at coordinate $z=\ -20$ nm, on the negative side of the dipole axis. Figure 24-37b gives the work W. done by the force moving the particle versus the angle θ that locates the particle relative to the positive direction of the z axis. The scale of the vertical axis is set by $W_{\text{as}}=2.0\times10^{-30}$ J. What is the magnitude of the dipole moment?



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17. A particle of charge $+7.5\mu C$ is released from rest at the point $x = 60cm$ on an x axis. The particle begins to move due to the presence of a charge Q that remains fixed at the origin. What is the kinetic energy of the particle at the instant it has moved 50 cm if (a) $Q = 20\mu C$ and $(b) Q = -2\mu C$?

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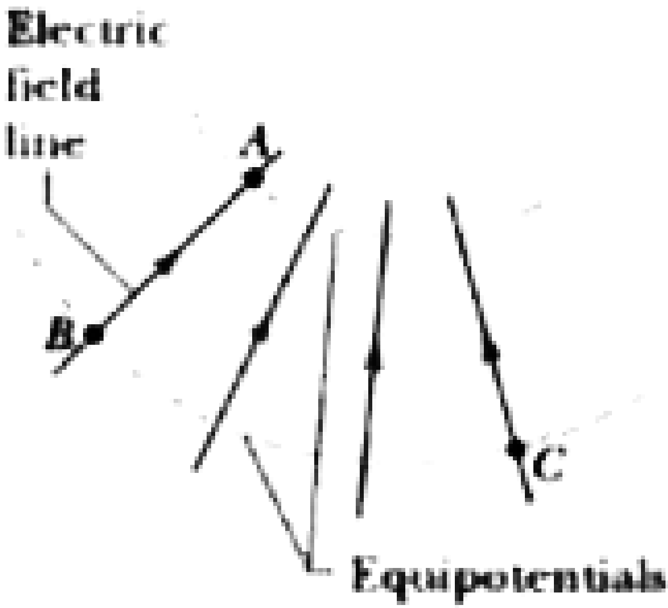
18. When an electron moves from A to B along an electric field line in Fig. 24-66, the electric field does $4.78 \times 10^{-19} J$ of work on it. What are the electric potential differences (a) $V_B - V_A$ (b) $V_C - V_A$ and (c) $V_C - V_B$?



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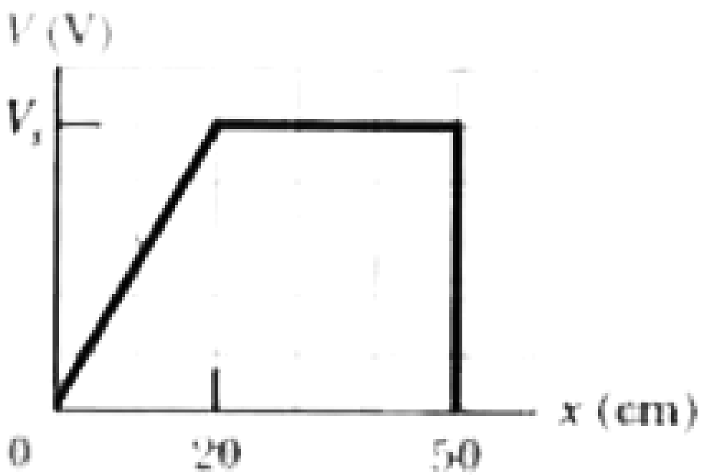
19. A positron (charge $+e$, mass equal to the electron mass) is moving at 1.5×10^7 m/s in the positive direction of an x axis when, at $x = 0$, it encounters an electric field directed along the x axis. The electric potential V associated in Fig. 24-67. The scale of the verticle axis is set by $V_s = 500.0$ V



(a) Does the positron emerge from the field at x = 0 (which means its motion is reversed) or at x = 0.50 m (which means its motion is not reversed)? (b) What is its speed when it emerges?

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20. Suppose N electrons can be placed in either of two configurations. In configuration 1, they are all placed on the circumference of a narrow ring of radius R and are uniformly distributed so that the distance between adjacent electrons is the same everywhere. In configuration 2, N - 1 electrons are uniformly distributed on the ring and one electron is placed in the center of the ring. (a) What is the smallest value of N for which the second configuration is less energetic than the first? (b) For that value of N, consider any one circumference electron-call it e_0. How many other circumference electrons are closer to e_0 than the central electron is ?

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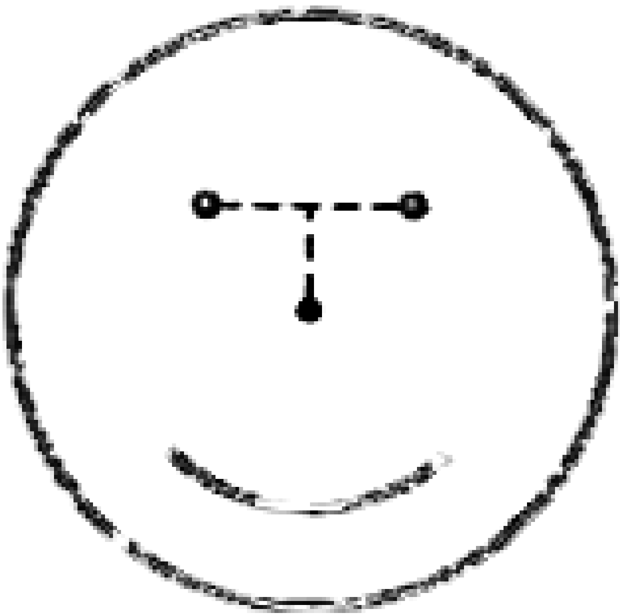
21. The smiling face of Fig. 24-68 consists of three items:

(1) a thin rod of charge $-3.0\mu C$ that forms a full circle of radius 6.0 cm,

(2) a second thin rod of charge $1, 0\mu C$ that forms a circular arc of radius 4.0 cm, subtending an angle of 90° about the center of the full circle,

(3) an electric dipole with a dipole moment that is perpendicular to a radial line and has a magnitude of 1.28×10^{-21} C. m.

What is the net electric potential at the center?



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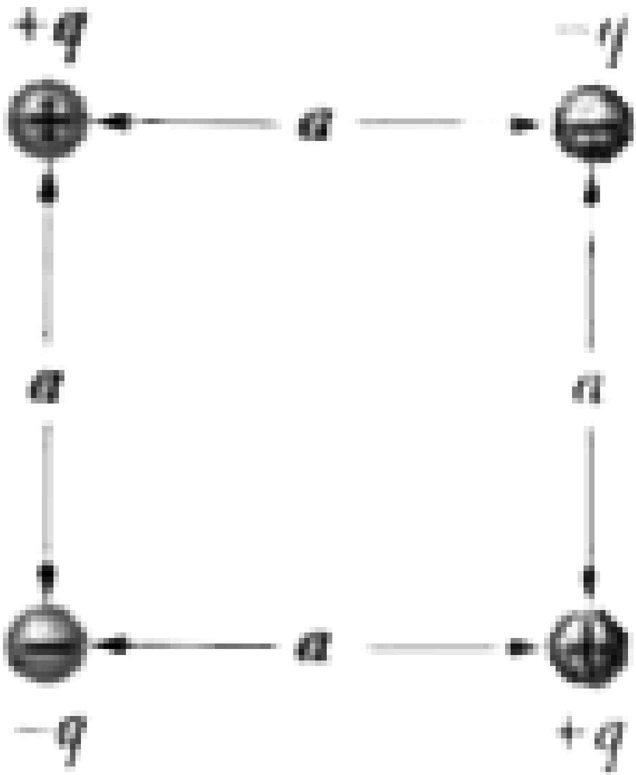
22. The particles shown in Fig. 24-69 each have charge magnitude q = 5.00 pC and were initially infinitely far apart. To form the square with edge length $a = 64.0$ cm, (a) how much work must be done by an external agent,

(b) how work must be done by the electric forces, and (c) what is the potential energy of the system?



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23. Two uniformly charged, infinite, nonconducting planes are parallel to a yz plane and positioned at $x = -50cm$ and $x = +50$ cm. The charge densities on the planes are $-50nC/m^2$ and $+25nC/m^2$, respectively. What is the magnitude of the potential difference between the origin and the point on the x axis at $x = +100cm$?

(Hint: Use Gauss' law.)

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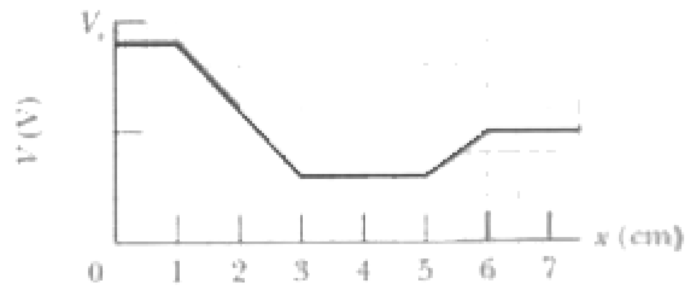
24. Proton in a well. Figure 24-70 shows electric potential V along an x axis. The scale of the vertical axis is set by V_s = 10.0 V. A proton is to be released at x = 3.5 cm with initial kinetic energy 5.00 eV. (a) If it is initially moving in the negative direction of the axis, does it reach a turning point (if so, what is the x coordinate of that point) or does it escape from the plotted region (if so, what is its speed at x = 0)? (b) If it is initially moving in the positive direction of the axis, does it reach a turning point (if so, what is the x coordinate of that point) or does it escape from the plotted region (if so, what is its speed at x = 6.0 cm)? What are the (c) magnitude F and (d) direction (positive or negative direction of the x axis) of the electric force on the proton if the proton moves just to the left of x = 3.0 cm? What are (e) F and (f) the direction if the proton moves just to the right of x = 5.0 cm?



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25. A charge of 70 A-h (ampere-hours) moves through a potential difference of 25 V. What are (a) the charge in coulombs and (b) the magnitude of the change in the potential energy of the charge?

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26. An infinite nonconducting sheet with a uniform surface charge density sets up parallel equipotential surfaces. Any pair of surfaces differing by 25.0 V are separated by 8.80 mm. (a) What is the magnitude of the surface charge density? (b) If an electron is released near the sheet, does it tend to move from higher to lower potential or vice versa ?

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27. A hollow metal sphere has a potential of +300 V with respect to ground (defined to be at V = 0) and a charge of $5.0 \times 10^{-9} C$. Find the electric potential at the center of the sphere.

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28. Two metal spheres, each of radius 3.0 cm, have a center-to center separation of2.0 m. Sphere 1 has charge $+1.0 \times 10^{-8} C$, sphere 2 has charge $-8.0 \times 10^{-8} C$. Assume that the separation is large enough for us to say that the charge on each sphere is uniformly distributed (the spheres do not affect each other). With $V = 0$ at infinity, calculate (a) the potential at the point halfway between the centers and the potential on the surface of (b) sphere 1 and (c) sphere 2.

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29. A charge of-9.0 nC is uniformly distributed around a thin plastic ring lying in a yz plane with the ring center at the origin. A -3.0 pC particle is located on the x axis at $x = 3.0$m. For a ring radius of 1.5 m, how much work must an external force do on the particle to move it to the origin?

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30. The ammonia molecule NH_3 has a permanent electric dipole moment equal to 1.47 D, where 1 D = 1 debye unit $= 3.34 \times 10^{-30} C. m.$ Calculate the electric potential due to an ammonia molecule at a point 103 nm away along the axis of the dipole. (Set V = 0 at infinity.)

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31. The electric field between two large, parallel, metal plates is approximately uniform, especially away from the edges where there can be some fringing. Suppose the plate separation is 8.00 cm. If the electric force on an electron placed in the uniform field has a magnitude of $7.90 \times 10^{-16} N$, (a) what is the potential difference between the plates and (b) is the force directed toward the plate with the higher potential or the lower potential?

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32. A nonconducting sphere has radius R = 2.31 cm and uniformly distributed charge q = +3.50 fC. Take the electric potential at the sphere's center to be $V_0 = 0$. What is V at radial distance (a) r = 1.45 cm and (b) r = R. (c) If, instead, $V_0 = 0$ at infinity, what is V at $r = R$?

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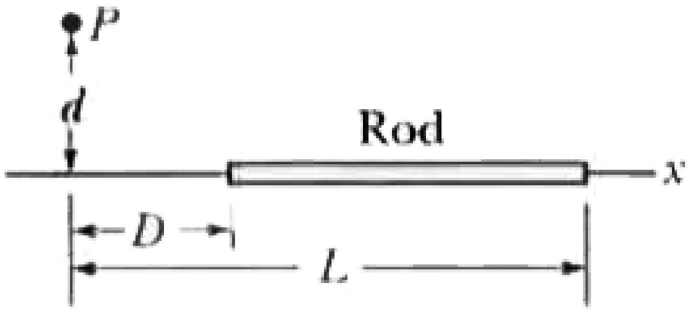
33. Figure 24-72 shows a thin rod with a uniform charge density of $1.00 \mu C / m$. Evaluate the electric potential at point P if $d = D = L / 4.00$. Assume that the potential is zero at infinity.



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34. What is the excess charge on a conducting sphere of radius r = 0.35 m if the potential of the sphere is 1500 V and V = 0 at infinity ?

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35. Two large parallel metal plates are 1.5 cm apart and have charges of equal magnitudes but opposite signs on their facing surfaces. Take the potential of the negative plate to be zero. If the potential halfway between the plates is then $+10.0V$, what is the electric field in the region between the plates?

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36. The electric field in a region of space has the components $E_y = E_z = 0$ and $E_x = (4.00N/C)x^2$. Point A is on the y axis at y = 3.00 m, and point B is on the x axis at x = 4.00 m. What is the potential difference $V_B - V_A$?

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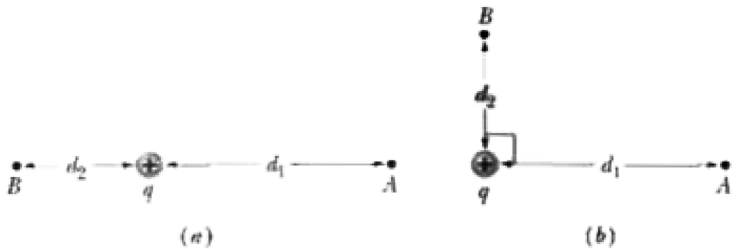
37. Consider a particle with charge $q = 3.0 nC$, point A at distance $d_1 = 2.0$ m from q, and point B at distance $d_2 = 1.0$m. (a) If A and B are diametrically opposite each other, as in Fig. 24-74a, what is the electric potential difference $V_A - V_B$? (b) What is that electric potential difference if A and Bare located as in Fig. 24-74b?



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38. The electric potential at points in an xy plane is given by $V = (2.00V/m^2)x^2 - (3.00V/m^2)y^2$. What are (a) the magnitude and (b) angle (relative to $+x$) of the electric field at the point (4.00 m, 2.00 m)?

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39. A ball of mass 1 kg and charge $1\mu C$ is directly projected from infinity toward another stationary ball of mass 2 kg and same charge as the first. The initial velocity of projection is 10 mis. Find the distance of closest separation and their velocities at the closest separation (Fig. 24-76).

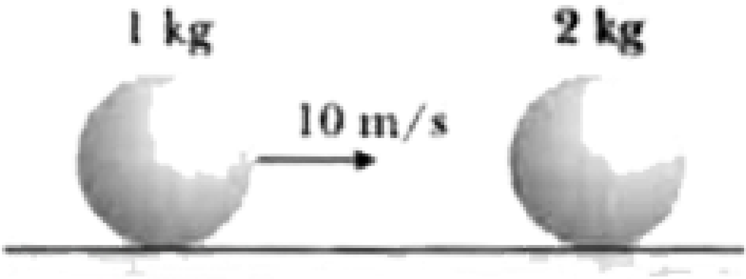

Figure 24-76 Problem 43.

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40. Sphere 1 with radius R_1 has positive charge q. Sphere 2 with radius 2.00 R_1 is far from sphere 1 and initially uncharged. After the separated spheres are connected with a wire thin enough to retain only negligible charge, (a) is potential V_1 of sphere 1 greater than, less than, or equal to potential V_2 of sphere 2? What fraction of q ends up on (b) sphere 1 and (c) sphere 2? (d) What is the ratio σ_1/σ_2 of the surface charge densities of the spheres ?

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41. Two metal spheres, each of radius 3.0 cm, have a center to center separation of 2.0 m. Sphere 1 has charge 1.0×10^{-8} C, sphere 2 has charge $-3.0 \times 10^{-8} C$. Assume ,that the separation is large enough for us to assume that the charge on each sphere is uniformly distributed (the spheres do not affect each other) . With V = 0 at infinity, calculate (a) the potential at the point halfway between the centers and the potential on the surface of (b) sphere 1 and (c) sphere 2.

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42. Thousand small mercury drops each of the radius r and charge q coalesce together to form one spherical drop. What is the ratio of the potential of the bigger drop to that of the smaller one?

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43. A point object with a charge $+Q$ is placed at the center of a conducting shell of inner radius R, outer radius 2R, and a charge of $-4Q$. A thin - walled conducting shell of radius 3 R and a charge of +4Q is concentric with the point object and the first shell.

Defining V = 0 at infinity, find all the distances from the center at which the electric potential is zero .

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44. On the middle one of three thin concentric spherical metal shells of radius R there is electric charge of magnitude Q. The inner spherical shell of radius R/2 and the outer spherical shell of radius 3R/2 are earthed. (a) What is the amount of the electric charge on the earthed spherical shells? (b) Plot the electric field strength versus the distance from the center.

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45. If a thin spherical shell of radius r and charge q is kept inside a thick spherical shell of inner radius 2r, outer radius 3r, and total charge 2q. (a) Find the charge distribution on each surface. (b) Find the self-energy of each charge distribution. (c) Find the total electrostatic energy stored in the system.

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46. Two isolated metallic solid spheres of radii R and 2R are charged such that both have the same charge Q. The spheres are located far away from each other and connected by a thin conducting wire. Find the heat dissipated in the wire.

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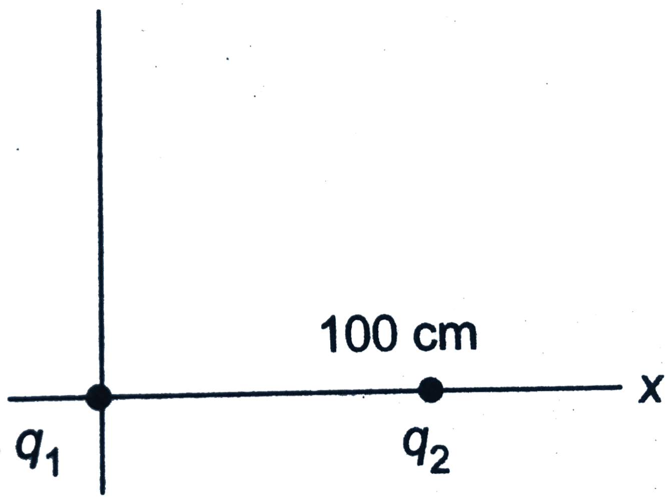
47. A point charge $q_1 = +2\mu C$ is placed at the origin of coordinates. A second charge, $q_2 = -3\mu C$, is placed on the x-axis at $x = 100cm$. At what point (or points) on the x-axis will the absolute potential be zero?



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Practice Questions Single Correct Choice Type

1. Which one of the following statements best explains why it is possible to define an electrostatic potential in a region of space that contains an electrostatic field?

A. Work must be done to bring two positive charges closer together

B. Like charges repel one another and unlike charges attract one another

C. A positive charge will gain kinetic energy as it approaches a negative charge

D. The work required to bring two charges together is independent of the path taken

Answer: D

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2. Two positive point charges are separated by a distance R. If the distance between the charges is reduced to R/2, what happens to the total electric potential energy of the system?

A. It is doubled

B. It is reduced to one-half of its original value

C. It remains the same

D. It is reduced to one-fourth of its original value

Answer: A

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3. Two point charges are located at two of the vertices of a right triangle. If a third charge $-2q$ is brought from infinity and placed at the third vertex, what will its electric potential energy be? Use the following values: $a = 0.15m, b = 0.45m, \text{ and } q = 2.0 \times 10^{-5}$ C.

A. $-17J$

B. $+8.5J$

C. $-12J$

D. $+14J$

Answer: A

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4. In total, 10 charges (5 of them are $+q$ each and other 5 are $-q$ each) are placed randomly on the circumference of a circle. The radius of the circle is R. The electric potential at the center of this circle due to these charges will be

A. 0

B. $10Kq/R$

C. $5Kq/R$

D. Cannot be calculated unless the positions of the charges on the circle are specified.

Answer: A

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5. The potential at a point distant x (mesured in μm) due to some charges situated on the x-axis is given by $V(x)=\frac{20}{x^2-4}$ V. The electric field at $x=4\mu m$ is given by

A. 5/3 volt/μ m and in the negative x direction

B. 5/3 volt/ μ m and in the positive x direction

C. 10/9 volt/ μ m and in the negative x direction

D. 10/9 volt/μ m and in the positive x direction

Answer: D

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6. A particle has a charge of $+1.5\mu C$ and moves from point A to point B, a distance of 0.20 m. The particle experiences a constant electric force, and its motion is along the line of action of the force. The difference between the particle's electric potential energy at A and B is $EPE_A - EPE_B = +9.0 \times 10^{-4}$ J. Find the magnitude and direction of the electric force that acts on the particle.

A. 3.0×10^{-3} N, from A toward B

B. 4.5×10^{-3} N, from A toward B

C. 3.0×10^{-3} N, from B toward A

D. 4.5×10^{-3} N, from B toward A

Answer: B

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7. Electric field_ on the axis of a small electric dipole at a distance r is $\overline{E_1}$ and_ at a distance of 2r on a line of perpendicular bisector is $\overline{E_2}$. Then

A. $\overline{E_2} = -\frac{\overline{E_1}}{8}$

B. $\overline{E_2} = \frac{\overline{E_1}}{16}$

C. $\overline{E_2} = -\frac{\overline{E_1}}{4}$

D. $\overline{E_2} = -\frac{\overline{E_1}}{10}$

Answer: B

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8. A charge is located at the center of sphere A (radius $R_A = 0.0010$ m), which is in the center of sphere B (radius $R_B = 0.0012$ m). Spheres A and B are both equipotential surfaces. What is the ratio V_A / V_B of the potentials of these surfaces?

A. 0.42

B. 1.2

C. 0.83

D. 1.4

Answer: B

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9. Point A is located 0.25 m away from a charge of $-2.1 \times 10^{-9} C$. Point B is located 0.50 m away from the charge. What is the electric potential difference `V_(B)-V_(A) between these two points ?

A. 19 V

B. 26 V

C. 38 V

D. 76 V

Answer: C

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10. 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:

A. $-6a\varepsilon_0 r$

B. $-24\pi a\varepsilon_0 r$

C. $-6a\varepsilon_0$

D. $-24\pi a\varepsilon_0 r$

Answer: C

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11. Identical point charges of $+1.7\mu C$ are fixed to diagonally opposite corners of a square. A third charge is then fixed at the center of the square, such that it causes the potentials at the empty corners to change signs without changing magnitudes. Find the sign and magnitude of the third charge.

A. $-4.8\mu C$

B. $-3.4\mu C$

C. $+5.9\mu C$

D. $+1.7\mu C$

Answer: A

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12. A positive charge $+q_1$ is located to the left of a negative charge $-q_2$. On a line passing through the two charges, there are two places where the total potential is zero. The first place is between the charges and is 4.00 cm to the left of the negative charge. The second place is 7.00 cm to the right of the negative charge. What is the distance between the charges?

A. $0.637m$

B. $0.773m$

C. 0.442

D. $0.187m$

Answer: D

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13. One particle has a mass of $3.0 \times 10^{-3} kg$ and a charge of $+8.00 \mu C$. A second particle has a mass of 6.0×10^{-3} kg and place and then released. The particles fly apart, and when the separation between them is 0.100 m, the speed of the 3.00×10^{-3} kg particle is 125 mis. Find the initial separation between the particles.

A. 6.63×10^{-2}m

B. 8.83×10^{-2}m

C. 2.06×10^{-2} m

D. 1.41×10^{-2} m

Answer: D

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14. Two particles each have a mass of 6.0×10^{-3} kg. One has a charge of $+5.0 \times 10^{-6}$ C. and the other has a charge of -5.0×10^{-6} C. They are initially held at rest at a distance of 0.80 m apart. Both are then released and accelerate toward each other. How fast is each particle moving when the separation between them is one-third its initial value?

A. 7.3 m/s

B. 3.9 m/s

C. 9.7 m/s

D. 5.4 m/s

Answer: C

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15. A large solid sphere with uniformly distributed positive charge has a smooth narrow tunnel along its direction. A small particle with negative charge, initially at rest far from the sphere, approaches it along the line of the tunnel, reaches its surface with a speed v, and passes through the tunnel. Its speed at the centre of the sphere will be

A. Zero

B. v

C. $\sqrt{2}v$

D. $\sqrt{1.5}v$

Answer: D

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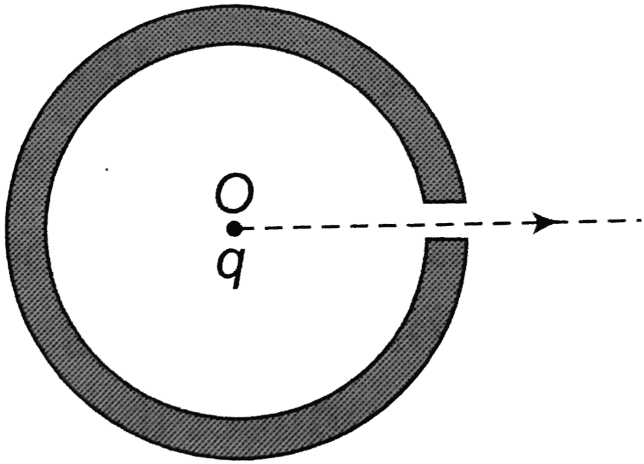
16. A point charge q is located at the centre O of a spherical uncharged coducting layer provided with small orifice. The inside and outside radii of the layer are equal to a and b respectively. The amount of work that has to be performed to slowly transfer the charge q from teh point O through the orifice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



A. $\frac{q^2}{8\pi\varepsilon_0}\left(\frac{1}{a}-\frac{1}{b}\right)$

B. $\frac{q^2}{4\varepsilon_0}\left(\frac{1}{b}-\frac{1}{a}\right)$

C. $\frac{q^2}{8\pi\varepsilon_0}\left(\frac{1}{b}-\frac{1}{a}\right)$

D. $\frac{q^2}{4\pi\varepsilon_0}\left(\frac{1}{a}-\frac{1}{b}\right)$

Answer: A

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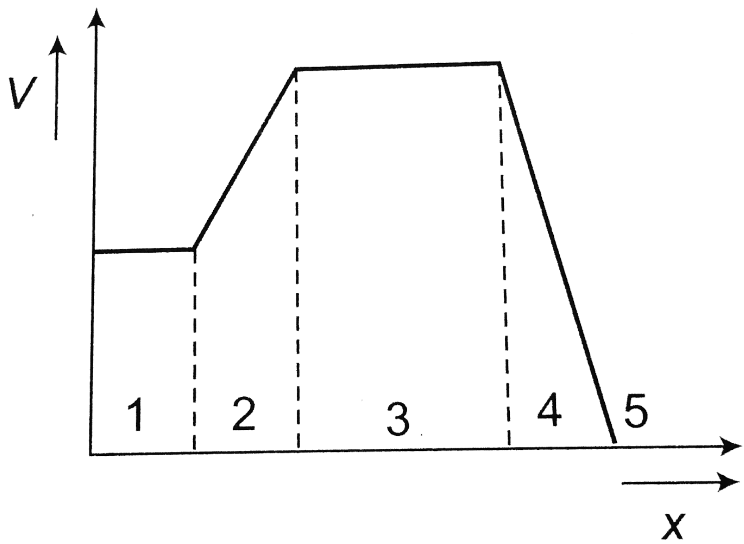
17. The figure gives the electric potential V as a function of distance through five regions on x-axis. Which of the following is true for the electric E in these regions ?



A. $E_1 > E_2 > E_3 > E_4 > E_5$

B. $E_1 = E_3 = E_5$ and $E_2 < E_4$

C. $E_2 = E_4 = E_5$ and $E_1 < E_3$

D. $E_1 < E_2 < E_3 < E_4 < E_5$

Answer: B

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18. A solid spherical conducting object has a nonzero charge on it. Which of the following statements is most appropriate?

A. Electric potential is zero throughout the volume but the electric field is nonzero constant

B. Electric field is zero throughout the volume but the electric potential is nonzero constant

C. Electric potential as well as field are zero throughout the volume

D. Electric potential as well as field are nonzero constant throughout the volume

Answer: B

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19. Two conducting concentric spherical shells are given positive charges. Choose the correct outcome.

A. Outer shell will be at higher potential

B. Inner shell will be at higher potential

C. Outer will always be at higher potential irrespective of the sign of charges given to two spheres

D. No prediction can be made using the given data

Answer: B

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20. Which of the following statements about solid conductors in electrostatics is (are) true?

(I) The electric fie)d inside the conductor is always zero

(II) The electric potential inside the conductor is always zero

(III) Any net charge is on the surface

A. I only

B. III only

C. II and III only

D. I and III only

Answer: D

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21. A very large sphere having charge Q uniformly distributed on the surface s compressed uniformly till its radius reduces to R. The work done by the electric force in this process is :

A. $\frac{Q^2}{8\pi\varepsilon_0 R}$

B. $\frac{Q^2}{8\pi\varepsilon_0 R}$

C. ∞

D. 0

Answer: B

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Practice Questions More Than One Correct Choice Type

1. When a negative charge moves in a direction opposite to the direction of an electric field,

A. The field does work on the charge

B. The charge does work on the field

C. The charge gains potential energy

D. The charge loses potential energy

Answer: A::D

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2. Which statement about a system of point charges that are fixed in space is necessarily true? Assuming electrostatic potential energy at infinity to be zero.

A. If the electrostatic potential energy of the system is negative, net positive work by an external agent is required to take the charges in the system back to infinity.

B. If the electrostatic potential energy of the system is zero, all charges in the configuration cannot have same sign.

C. If the electrostatic potential energy of the system is negative, net positive work by an external agent was required to assemble the system of charges.

D. If the electrostatic potential energy of the system is negative, then there is no electric force anywhere in space on any other charged particle not part of the system.

Answer: A::B

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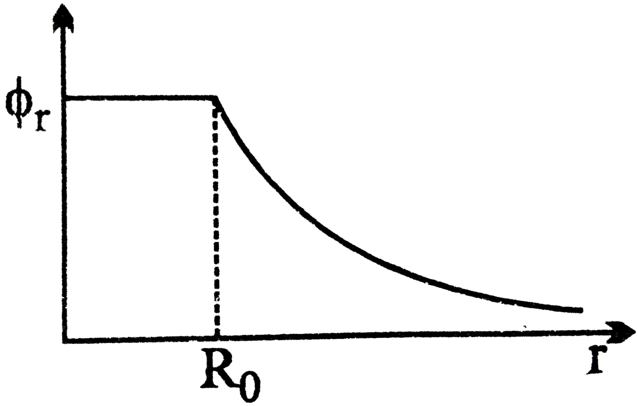
3. The electrostatic potential (ϕ_r) of a spherical symmetric system , kept at origin is shown in the adjacent figure, and given as

$$\phi_e = \frac{q}{4\pi\varepsilon_0 r}(r \geq R_o)$$

$$\phi_e = \frac{q}{4\pi\varepsilon_0 R_o}(r \leq R_0)$$



Which of the following option s in //are correct ?

A. For spherical region $(r \leq R_0)$, total electrostatic energy stored is zero.

B. Within $r = 2R_0$ total charge is q.

C. There will be no charge anywhere except at $r = R_0$.

D. Electric field is discontinuous at $r = R_0$.

Answer: A::B::C::D

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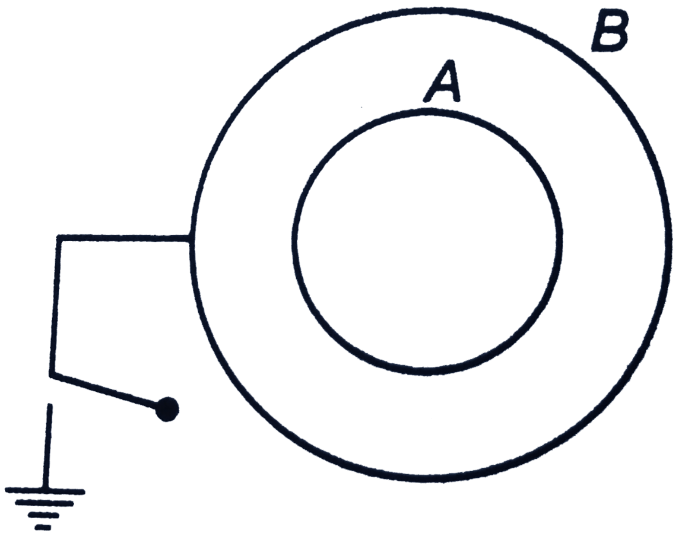
4. Two concentric shells have radii R and $2R$ charges q_A and q_B and potentials $2V$ and $\left(\frac{3}{2}\right)V$ respectively. Now, shell B is earthed and let charges on them become $q_A{'}$ and $q_B{'}$. Then,



A. $\frac{q_A}{q_B} = \frac{1}{2}$

B. $\frac{|q'_A|}{|q'_B|} = 1$

C. potential of A after earthing becomes $\left(\frac{3}{2}\right)$ V

D. potential difference between A and B after earthing becomes $\frac{v}{2}$

Answer: A::B

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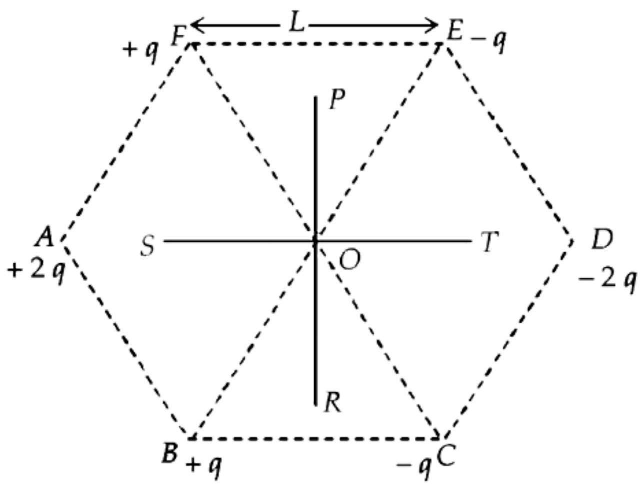
5. Six point charges are kept at the vertices of a regular hexagon of side L and centre O, as shown in the figure. Given that $K = \frac{1}{4\pi\varepsilon_0}\frac{q}{L^2}$, which of the following statements(s) is (are) correct?



A. The electric field at O is 6K along OD

B. The potential at O is zero

C. The potential at all points on the line PR is same

D. The potential at all points on the line ST is same

Answer: A::B::C

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6. A uniformly charged solid shpere fo radius R has potential V_0 (measured with respect to ∞) on its surface. For this sphere the equipotentail surfaces with potentials $\frac{3V_0}{2}, \frac{5V_0}{4}, \frac{3V_0}{4}$ and $\frac{V_0}{4}$ have radius R_1, R_2, R_3 and R_4 respecatively. Then

A. $R_1 \neq 0$ and $(R_2 - R_1) > (R_4 - R_3)$

B. $R_1 = 0$ and $R_2 < (R_4 - R_3)$

C. $2R < R_4$

D. $R_1 = 0$ and $R_2 > (R_4 - R_3)$

Answer: B::C

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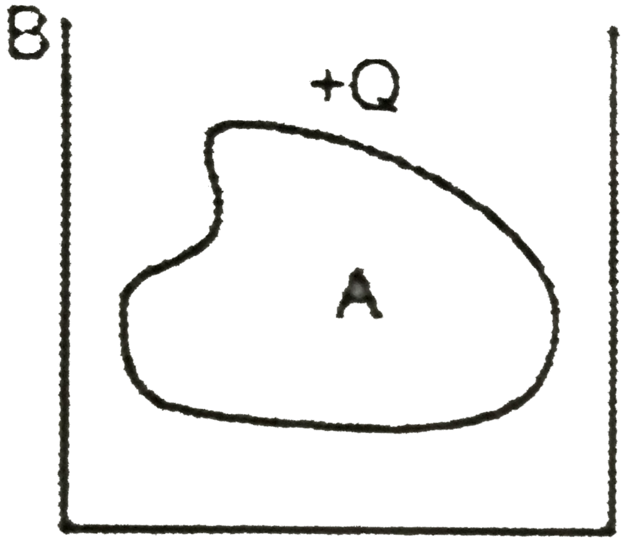
7.



A conductor A is given a charge of amount $+Q$ and then placed inside a deep metal can B, without touching it

A. The potential of A does not change when it is placed inside B

B. If B is earthed, +Q amount of charge flows from it into the Earth

C. If B is earthed, the potential of A is reduced

D. If B is earthed, the potential of A and B both becomes zero

Answer: B::C

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8. A sphere of radius R is charged uniformly with a volume charge density. It is disassembled and reassembled in two identical spheres kept far from each other.

A. Positive work is done by external agent

B. Potential energy of system decreases

C. Potential energy of system increases

D. Work is done by the system

Answer: B::D

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Practice Questions Linked Comprehension

1. Paragraph for Questions 53 and 54: An isolated system consists of two conducting spheres A and B. Sphere A has five times the radius of sphere B. Initially, the spheres are given equal amounts of positive charge and are isolated from each other. The two spheres are then connected by a conducting wire.

Note: The potential of a sphere of radius R that carries a charge Q is $V = kQ/R$, if the potential at infinity is zero.

Which one of the following statements is true after the spheres are connected by the wire?

A. The electric potential of A is 1/25 as large as that of B.

B. The electric potential of A equals that of B.

C. The electric potential of A is 25 times larger than that of B.

D. The electric potential of A is 1/5 as large as that of B.

Answer: B

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2. Paragraph for Questions 53 and 54: An isolated system consists of two conducting spheres A and B. Sphere A has five times the radius of sphere B. Initially, the spheres are given equal amounts of positive charge and are isolated from each other. The two spheres are then connected by a conducting wire.

Note: The potential of a sphere of radius R that carries a charge Q is $V = kQ/R$, if the potential at infinity is zero.

Determine the ratio of the charge on sphere A to that on sphere $B, q_A / q_B$, after the spheres are connected by the wire.

A. 1

B. $1 / 5$

C. 5

D. 25

Answer: C

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Practice Questions Matrix Match

1. Match the appropriate Column I with Column II.

Column I	Column II
(A) Same dimension of mass	(P) electric charge
(B) Negative dimension of mass	(Q) electric potential
(C) Zero dimension of mass	(R) electric capacity
(D) Dimension of length is $\pm$D	(S) energy density

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2. Directions for Questions 56 and 57: In each question, there is a table having 3 columns and 4 rows. Based on the table, there are 3 questions. Each question has 4 options (a), (b), (c) and (d), ONLY ONE of these four options is correct.

Two charges of opposite sign and equal magnitude Q = 2.0 C are held 2.0 m apart. And there is a point Pat 4.0

cm from +Q charge. In the given table there are four values each of electric field (Column I), potential difference each of electric field (Column I), potential difference

`{:("Column I","Column II", "Column III"),((I) E=1.27 xx 10^(9) V//m,(i) V=1.5 xx 10^(9) V,(J)

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The combination for maximum electric field is

A. (I) (ii) (M)

B. (III) (iv) (K)

C. (IV) (iii) (J)

D. (II) (i) (L)

Answer: A

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3. Directions for Questions 56 and 57: In each question, there is a table having 3 columns and 4 rows. Based on the table, there are 3 questions. Each question has 4 options (a), (b), (c) and (d), ONLY ONE of these four options is correct.

Two charges of opposite sign and equal magnitude Q = 2.0 C are held 2.0 m apart. And there is a point Pat 4.0 cm from +Q charge. In the given table there are four values each of electric field (Column I), potential difference each of electric field (Column I), potential difference

`{:("Column I","Column II", "Column III"),((I) E=1.27 xx 10^(9)

V//m,(i) V=1.5 xx 10^(9) V,(J)

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The combination for maximum electric potential is

A. (I) (ii) (M)

B. (III) (iv) (K)

C. (IV) (iii) (J)

D. (II) (i) (L)

Answer: A::B

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4. Directions for Questions 56 and 57: In each question, there is a table having 3 columns and 4 rows. Based on the table, there are 3 questions. Each question has 4 options (a), (b), (c) and (d), ONLY ONE of these four options is correct.

Two charges of opposite sign and equal magnitude Q = 2.0 C are held 2.0 m apart. And there is a point Pat 4.0 cm from +Q charge. In the given table there are four values each of electric field (Column I), potential difference each of electric field (Column I), potential difference

`{:("Column I","Column II", "Column III"),((I) E=1.27 xx 10^(9) V//m,(i) V=1.5 xx 10^(9) V,(J)

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(3) The combination for minimum electric potential is

A. (I) (iii) (M)

B. (II) (ii) (K)

C. (III) (i) (L)

D. (IV) (iv} (J)

Answer: C::D

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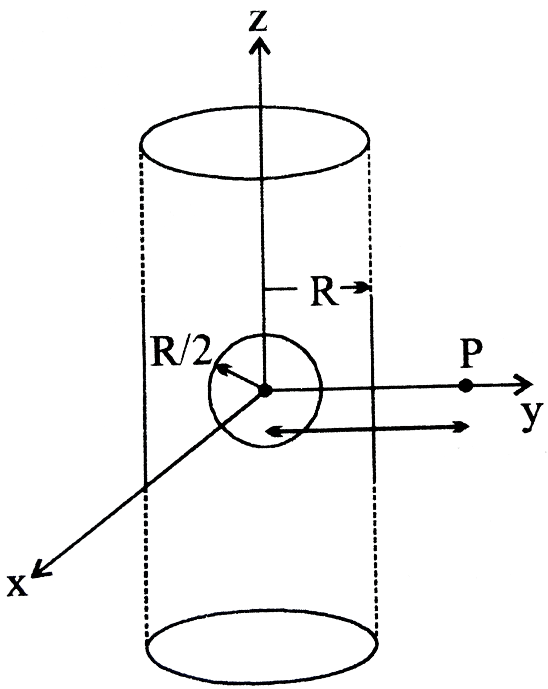
Practice Questions Integer Type

1. 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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