Problems
Chapter 4

1. A charged cloud and the ground have a potential difference of 1.5×10^9V. If an electron moves from the cloud to the ground, what is the magnitude of the change of electrical potential energy for the electron? Give your answer in Joules as well as electron volts (eV).

   Note: 1 eV $= 1.602 \times 10^{-19}$ Joules.

2. An infinite (large) flat sheet has a uniform surface charge density $\sigma = 0.50\mu\text{C/m}^2$. Two equipotential surfaces near this sheet have a potential difference of 75V. Find the distance between the two equipotentials.

3. Two large oppositely charged conducting plates are placed parallel to each other to produce a uniform electric field of magnitude 2.00×10^4N/C. The distance between the plates is 1.00cm.

   (a) Find the potential difference between the plates.

   (b) If an electron is released from rest at the negative plate, find its speed when it reaches the positive plate.

4. For some spherically symmetric charge distribution, it is known that the electric field is radially outwards and its magnitude at a distance r from the center is given by

$$E = E_0 e^{-r/r_0},$$

   where E_0 and r_0 are constants. Find the potential at a distance r from the center using infinity as the reference.

5. A charge q uniformly spread over the volume of a sphere of radius R is known to produce a radially directed electric field. Inside the sphere, at a distance r from the center, the electric field magnitude is known to be

$$E = \frac{qr}{4\pi\epsilon_0 R^3}; \quad (r < R).$$

   Outside the sphere, at a distance r from the center, the electric field magnitude is known to be

$$E = \frac{q}{4\pi\epsilon_0 r^2}; \quad (r > R).$$

   (a) Taking $V = 0$ at the center of the sphere, find the potential at a point inside the sphere.

   (b) Taking $V = 0$ at the center of the sphere, find the potential at a point outside the sphere.

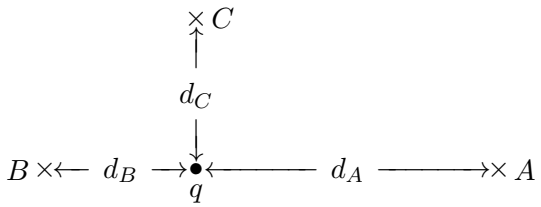
   (c) Taking $V = 0$ at infinity, find the potential at a point inside the sphere.

   (d) Taking $V = 0$ at infinity, find the potential at a point outside the sphere.

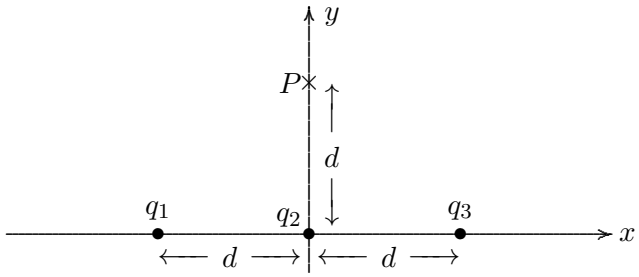
6. The figure below shows a point charge $q = 5.0\mu$C. The three positions A, B and C are as marked in the figure. The distances of these positions from the point charge are $d_A = 4.0$m, and $d_B = d_C = 2.0$m.

(a) Find the potential difference $V_B - V_A$ between the points A and B.

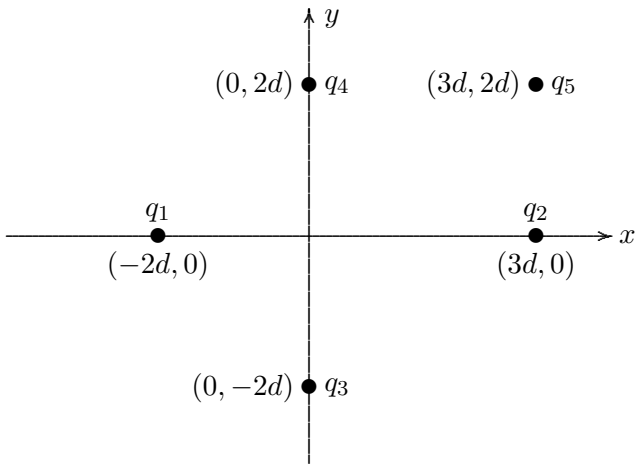
(b) Find the potential difference $V_C - V_A$ between the points A and C.



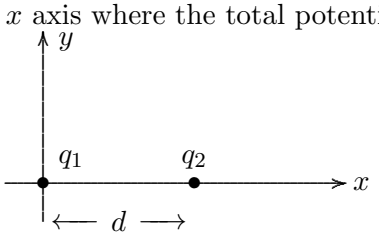
7. The figure below shows three charges ($q_1 = q$, $q_2 = -2q$ and $q_3 = q$) placed along the x axis of a coordinate system. They are separated by a distance d. Find the potential due to these charges at the point marked P on the y axis where $y = d$.



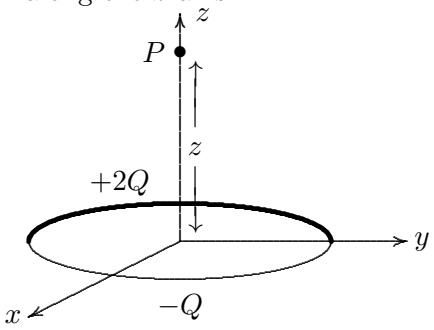
8. The figure below shows five point charges ($q_1 = q$, $q_2 = -2q$, $q_3 = -q$, $q_4 = 3q$ and $q_5 = -3q$) placed in a coordinate system. The respective coordinates for these charges are: $(-2d, 0)$, $(3d, 0)$, $(0, -2d)$, $(0, 2d)$ and $(3d, 2d)$ where d is a constant. Find the total potential due to these charges at the origin.



9. The figure below shows a charge q_1 placed at the origin of a coordinate system. Another charge q_2 is placed on the positive x axis a distance d from the origin. If $q_1 = q$ and $q_2 = -2q$, find the points along the x axis where the total potential is zero.



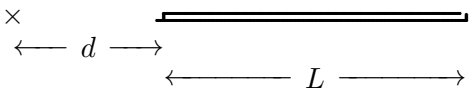
10. A thin charged ring of radius R is placed in the xy plane with its center at the origin (see figure below). Half the ring (negative x) has a charge of $+2Q$ spread uniformly on it and the other half has a charge of $-Q$ spread uniformly on it. Find the potential at the point P a distance z from the origin along the z axis.



11. The figure below shows a thin straight charged rod of length L. The charge density on this rod is nonuniform and given by the following.

$$\lambda = c(L - x),$$

where c is a constant and x is the distance from the left end of the rod. Find the potential at a point to the left of the left end of the rod a distance d from it.



12. In problem 10 the potential along the z axis as a function of z was found for the given charge distribution.

    (a) Using that expression for the potential, find the z component of the electric field along the z axis.

    (b) Can you find the x component of the electric field along the z axis from the same formula? If yes, find it. If not, explain why.

13. For some charge distribution the potential is given by

$$V = 5x^2 - 20e^{-y} + 4x^3\sqrt{z}.$$

Find the corresponding electric field components E_x, E_y and E_z.