Physics 4B
Chapter 24: Electric Potential

"There is nothing either good or bad, but thinking makes it so." **–** William Shakespeare

"It's not what happens to you that determines how far you will go in life; it is how you handle what happens to you." – Zig Ziglar

Reading: pages 628 – 646

Outline:

⇒ electric potential energy of a system of point charges
⇒ electric potential and potential difference
  definition
  electron volt
  potential due to point charges
  potential from an electric dipole (read on your own)
⇒ equipotential surfaces (PowerPoint and Lab)
⇒ calculating the potential from the electric field
⇒ potential due to continuous charge distributions
⇒ calculating the electric field from the potential
⇒ potential of a charge isolated conductor

Problem Solving Techniques

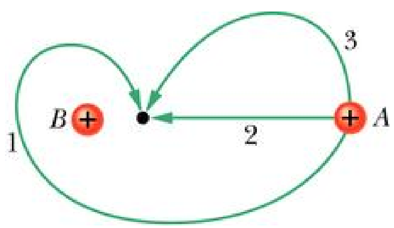
To solve the problems of this chapter, you should know how to calculate the electric potential of point charges and continuous distributions of charge. Use $V = q/4\pi\varepsilon_0 r$ for single point charge and use the sum of the potentials due to individual charges for a collection of point charges. Use $V = (1/4\pi\varepsilon_0)\int (1/r)\,dq$ for a continuous distribution of charge. Replace dq with λds for a line of charge or with σdA for a surface of charge. You should know how to compute the work done by the electric field ($W = -q\Delta V$) and the work ($-W$) done by an external agent when a charge q is moved from one place to another.

You should know how to calculate the potential energy of a collection of charges: $U = q_1 q_2 / 4\pi\varepsilon_0 r$ for two charges. You should also know that the potential energy of a collection of charges is the sum of the potential energies of all the pairs of charges in the collection. You should know how to compute the change in the potential energy when a charge moves. You should know how to interpret changes in potential energy in terms of the work done by the electric field or external agent. You should also know how to use the principle of conservation of energy to compute changes in the kinetic energy of a moving charge.

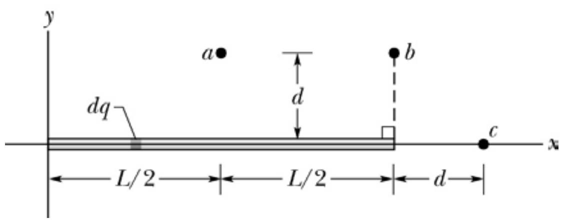
Some problems ask you to sketch equipotential surfaces. It is usually fairly easy to draw electric field lines and then sketch surfaces that are perpendicular to the lines.

Questions and Example Problems from Chapter 24

Question 1
The figure below shows three paths along which we can move positively charged sphere A closer to positively charged sphere B, which is fixed in place. (a) Would sphere A be moved to a higher or lower electric potential? Is the work done (b) by our force and (c) by the electric field (due to the second sphere) positive, negative, or zero? (d) Rank the paths according to the work our force does, greatest first.



Question 2
The figure below shows a thin, uniformly charged rod and three points at the same distance d from the rod. Without calculation, rank the magnitude of the electric potential the rod produces at these three points, greatest first.



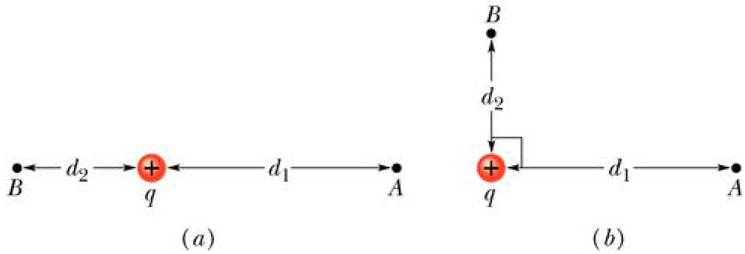
Problem 1
A particle of charge q is fixed at point P, and a second particle of mass m and the same charge q is initially held a distance r_1 from P. The second particle is then released. Determine its speed when it is a distance r_2 from P. Let q = 3.1 μC, m = 20 mg, r_1 = 0.90 mm, and r_2 = 2.5 mm.

Problem 2
Two electrons are fixed 2.0 cm apart. Another electron is shot from infinity and stops midway between the two. What is its initial speed?

Problem 3
The electric potential difference between the ground and a cloud in a particular thunderstorm is 1.2×10^9 V. What is the magnitude of the change in the electric potential energy (in multiples of the electron-volt) of an electron that moves between the ground and the cloud?

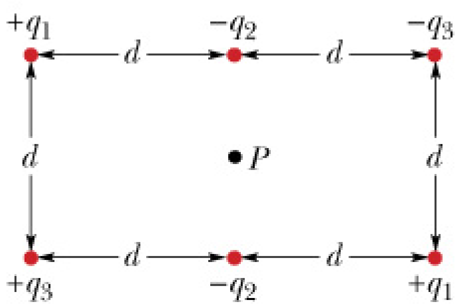
Problem 4

Consider a point charge q = 1.0 μC, 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. a below, what is the electric potential difference $V_A - V_B$? (b) What is that electric potential difference if points A and B are located as in Fig. b?



Problem 5

In the figure below, point P is at the center of the rectangle. With V = 0 at infinity, q_1 = 5.00 fC, q_2 = 2.00 fC, q_3 = 3.00 fC, and d = 2.54 cm, what is the net electric potential at P due to the six charged particles?

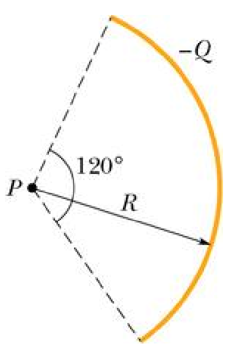


Problem 6

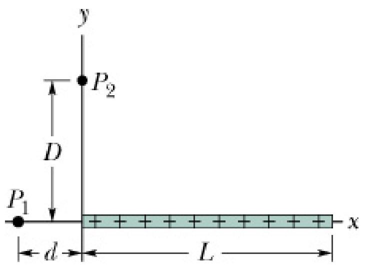
A long wire has a uniform linear charge density λ. What is the potential difference V_{ab} between two points a and b located radial distances r_a and $r_b = 2r_a$ from the wire?

Problem 7

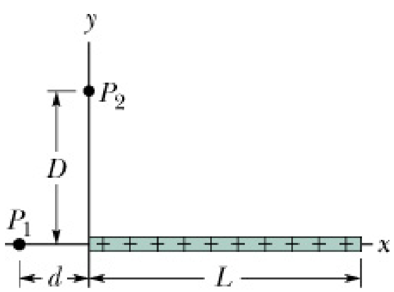
The figure below, a plastic rod having a uniformly distributed charge Q = -25.6 pC has been bent into a circular arc of radius R = 3.71 cm and central angle 120°. With V = 0 at infinity, what is the electric potential at P, the center of curvature of the rod?



Problem 8
The figure below shows a thin plastic rod of length L = 12.0 cm and uniform positive charge Q = 56.1 pC lying on an x axis. With V = 0 at infinity, find the electric potential at point P_1 on the axis, at distance d = 2.50 cm from one end of the rod.



Problem 9
The thin plastic rod of length L = 10.0 cm in the figure below has a nonuniform linear charge density λ = cx, where c = 49.9 pC/m. (a) With V = 0 at infinity, find the electric potential at point P_2 on the y axis, a distance 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)?



Problem 10

The electric potential V in 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 $x = 1.3$ cm, (a) what is the magnitude of the electric field and (b) is the field directed toward or away from plate 1?

Problem 11

What is the magnitude of the electric field at the point $(3.00\hat{i} - 2.00\hat{j} + 4.00\hat{k})m$ if the electric potential is given by $V = 2.00xyz^2$, where V is in volts and x, y, and z are in meters?