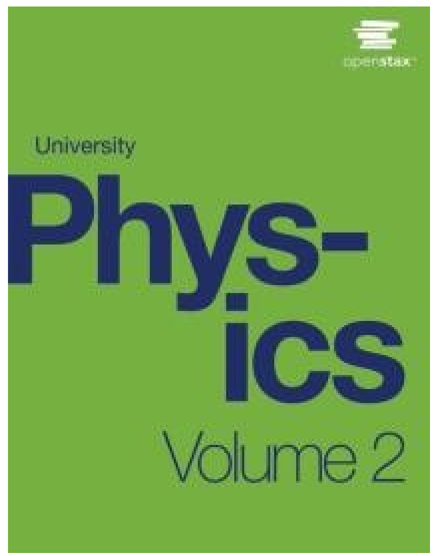
UNIVERSITY PHYSICS

Chapter 7 ELECTRIC POTENTIAL

PowerPoint Image Slideshow



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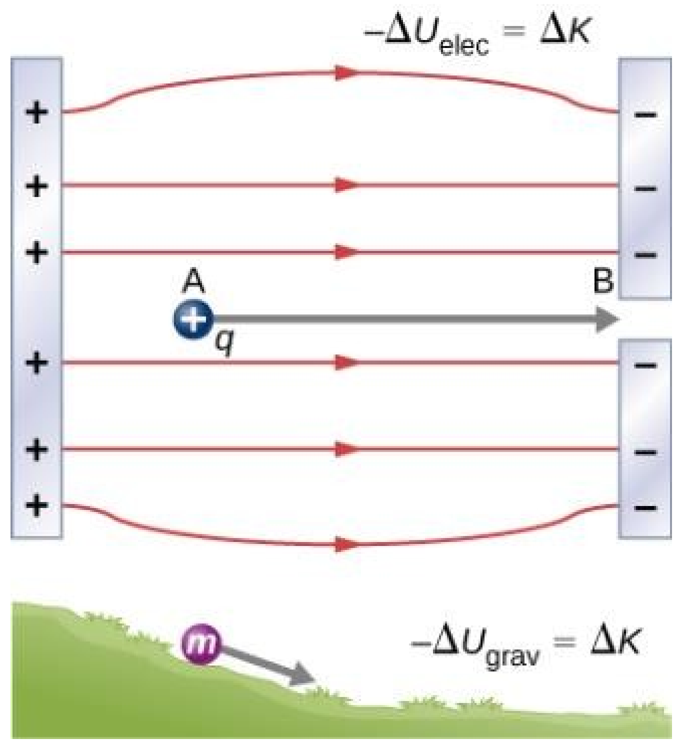
Energy

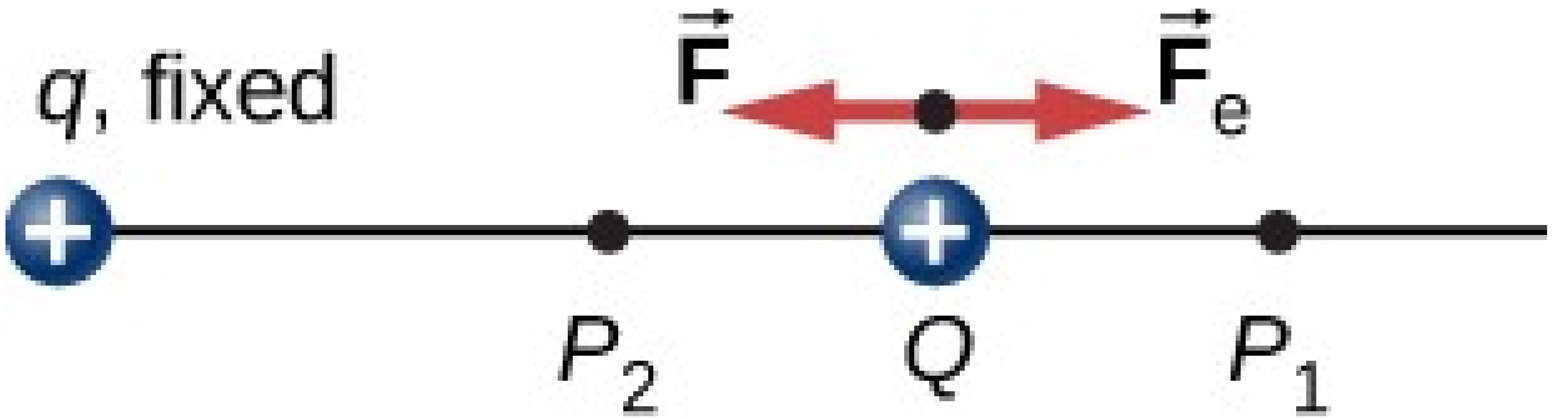
$$E = k\frac{q_1 q_2}{r}$$

FIGURE 7.2



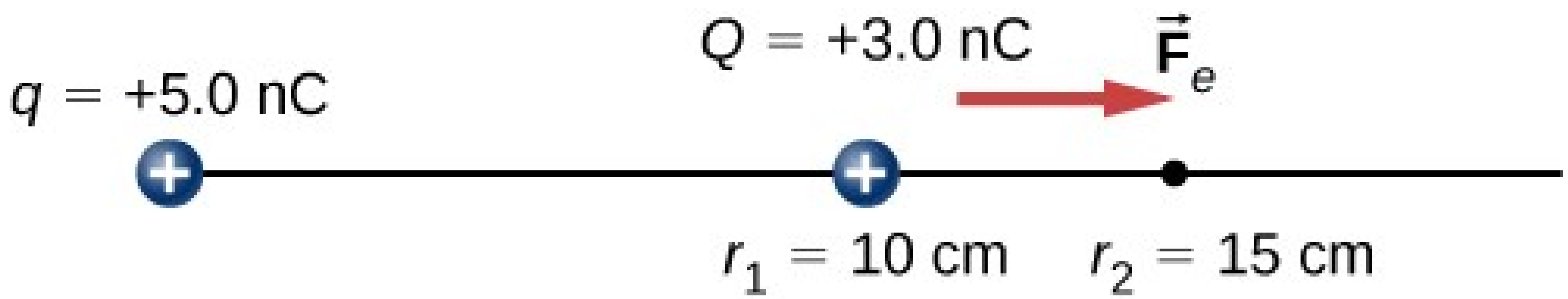
A charge accelerated by an electric field is analogous to a mass going down a hill. In both cases, potential energy decreases as kinetic energy increases, $-\Delta U = \Delta K$. Work is done by a force, but since this force is conservative, we can write $W = -\Delta U$.

FIGURE 7.3



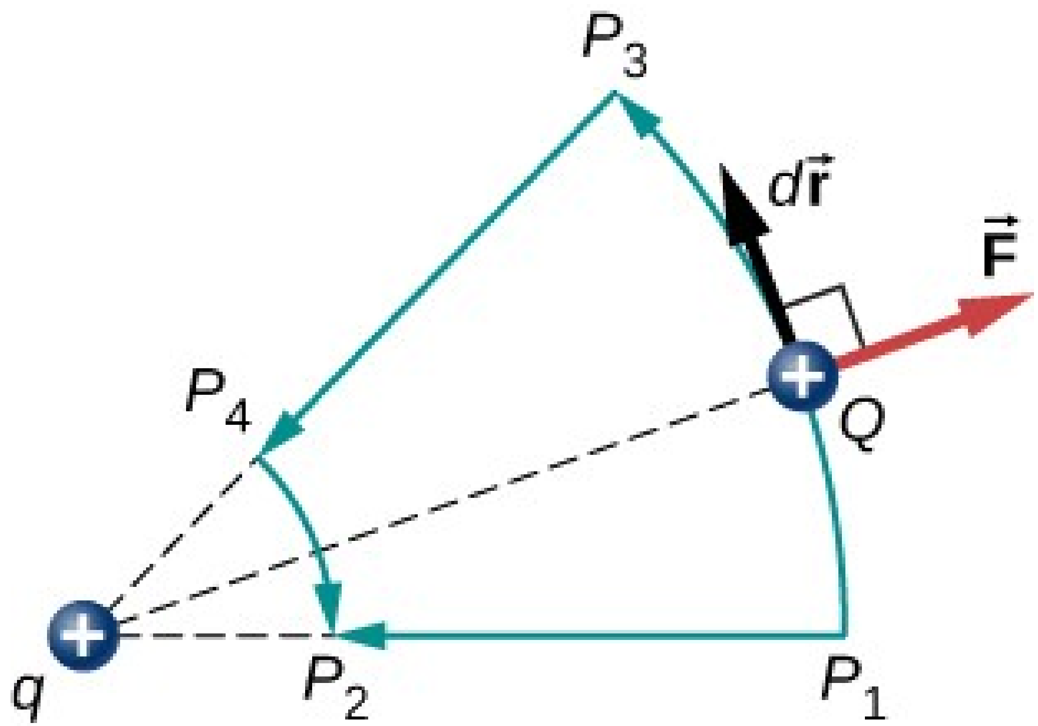
Displacement of “test” charge *Q* in the presence of fixed “source” charge *q*.

FIGURE 7.4



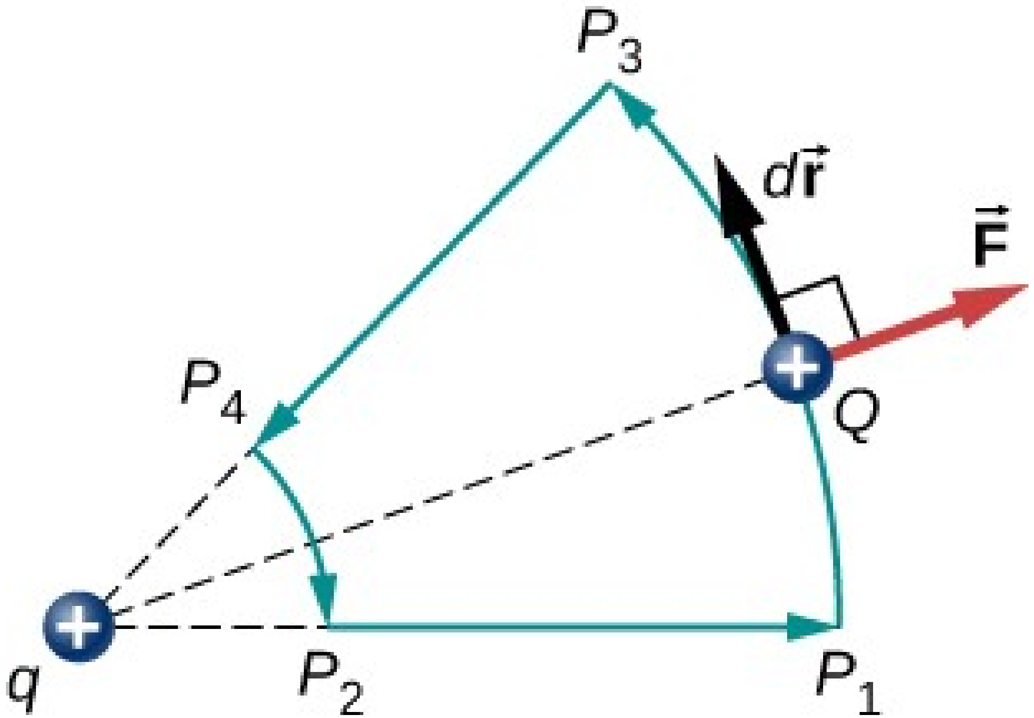
The charge *Q* is repelled by *q*, thus having work done on it and gaining kinetic energy.

FIGURE 7.5



Two paths for displacement P_1 to P_2. The work on segments P_1P_3 and P_4P_2 are zero due to the electrical force being perpendicular to the displacement along these paths. Therefore, work on paths P_1P_2 and $P_1P_3P_4P_2$ are equal.

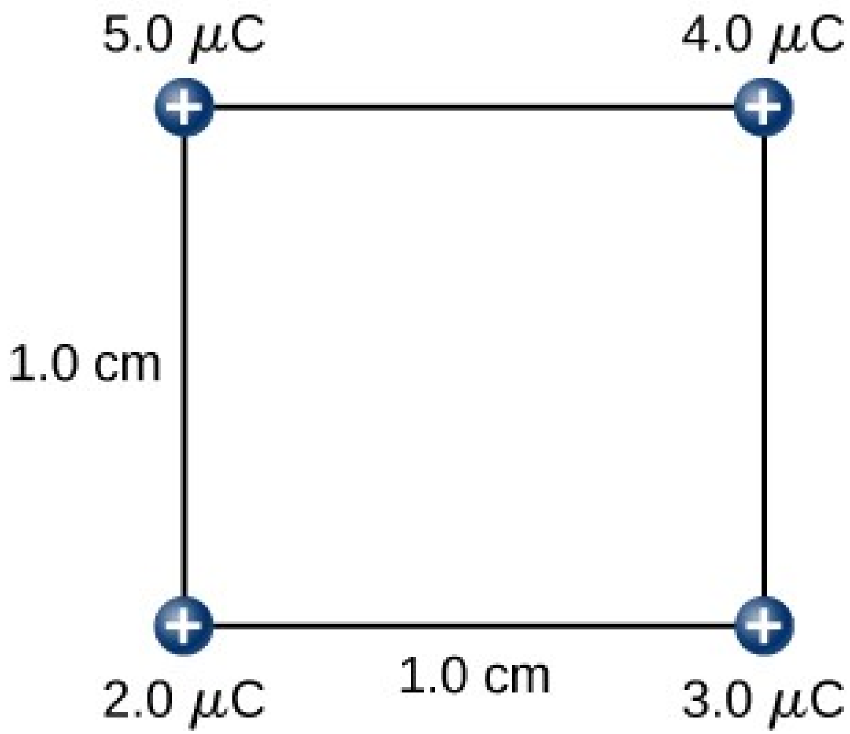
FIGURE 7.6



A closed path in an electric field. The net work around this path is zero.

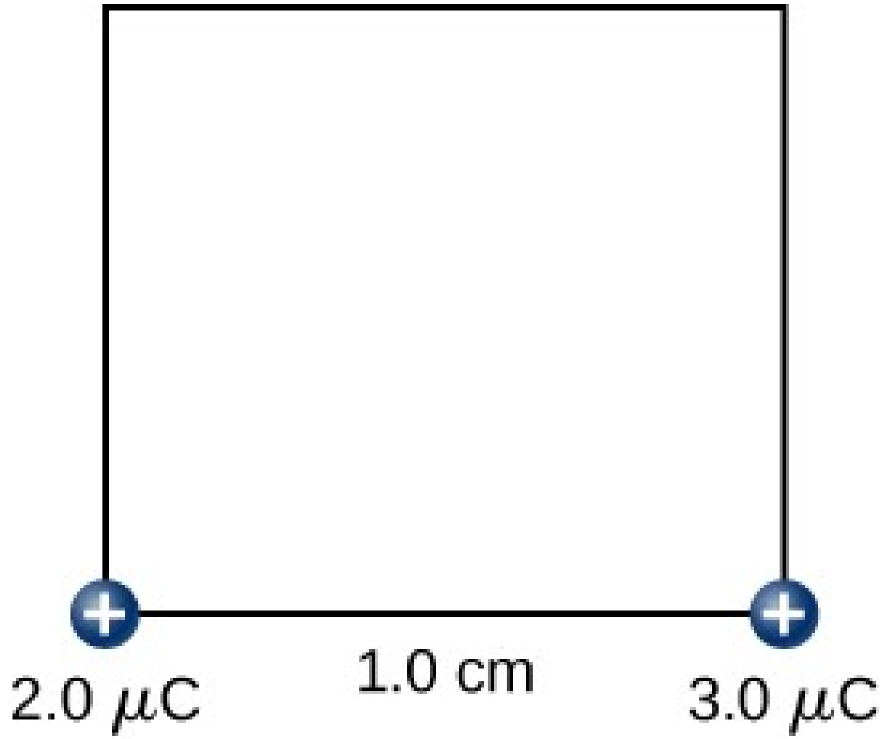
Energy: an example

FIGURE 7.8



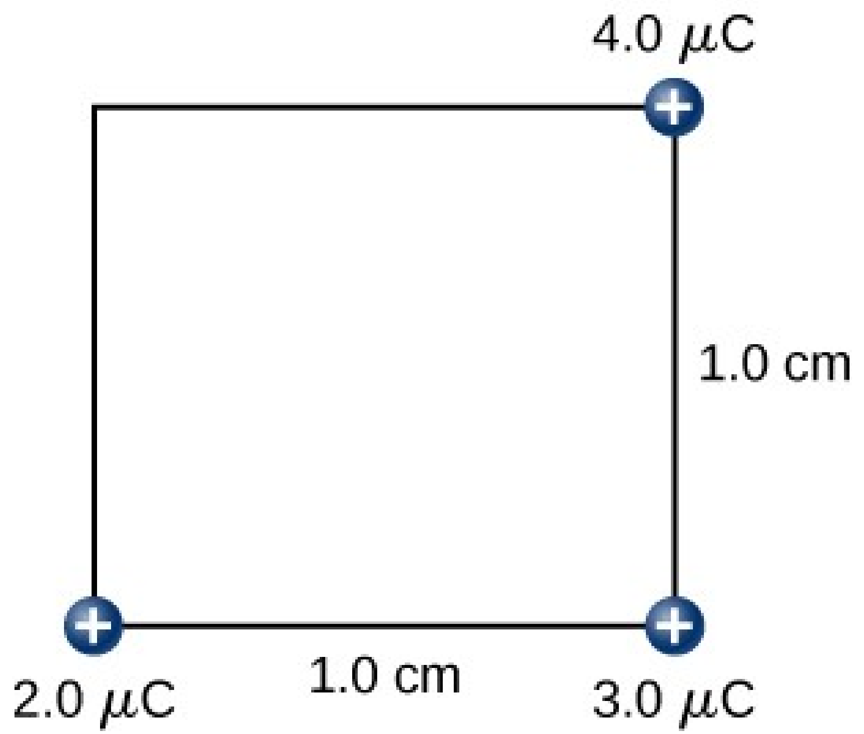
How much work is needed to assemble this charge configuration?

FIGURE 7.9



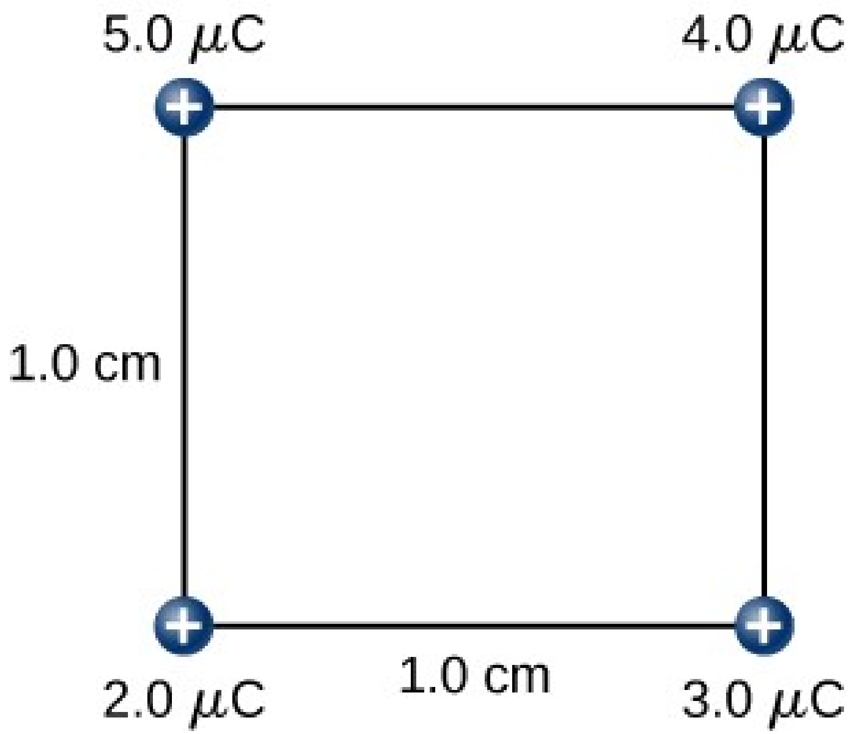
Step 2. Work W_2 to bring the $+3.0$–C charge from infinity.

FIGURE 7.10



Step 3. Work W_3 to bring the $+4.0$–C charge from infinity.

FIGURE 7.11

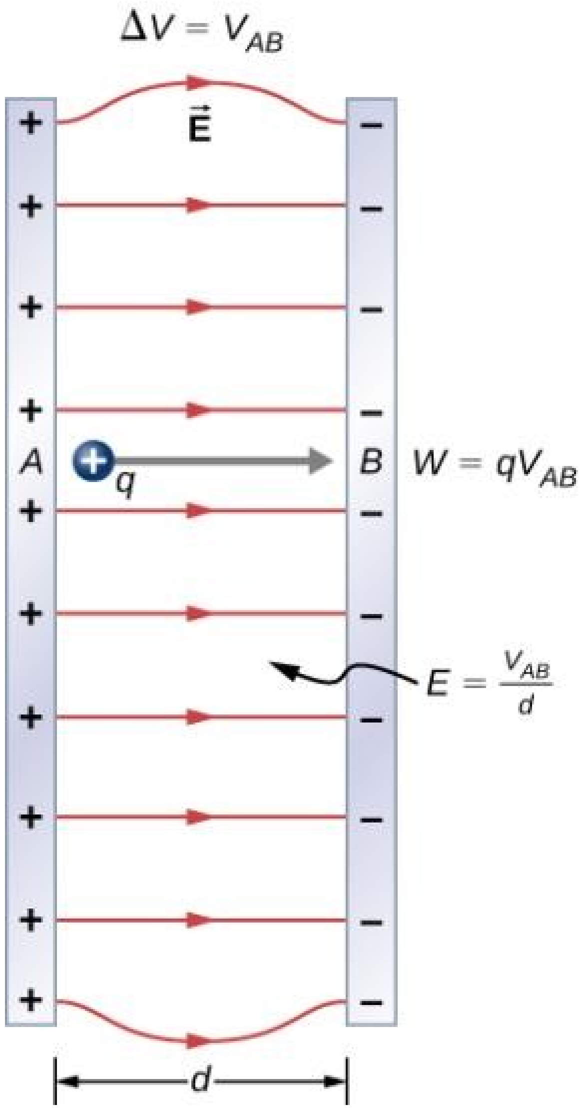


Step 4. Work W_4 to bring the $+5.0$–C charge from infinity.

Electric potential

$$E = k\frac{q}{r}$$

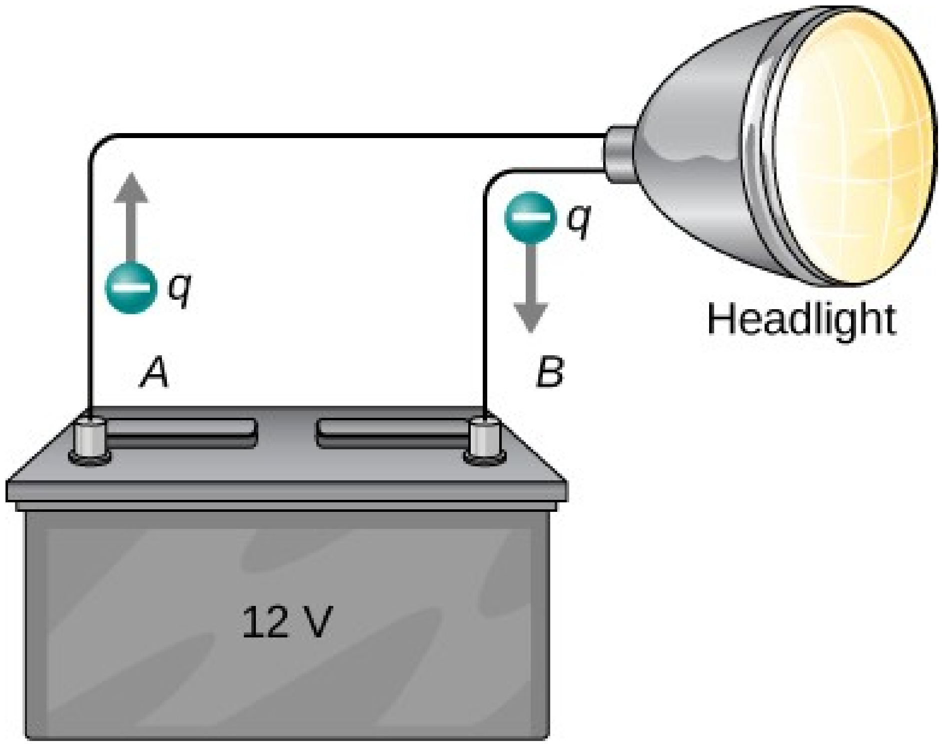
FIGURE 7.14



The relationship between V and E for parallel conducting plates is $E = V/d$. (Note that $\Delta V = V_{AB}$ in magnitude. For a charge that is moved from plate *A* at higher potential to plate *B* at lower potential, a minus sign needs to be included as follows: $-\Delta V = V_A - V_B = V_{AB}$.)

$$\vec{E} = \vec{\nabla} V$$

FIGURE 7.12



A battery moves negative charge from its negative terminal through a headlight to its positive terminal. Appropriate combinations of chemicals in the battery separate charges so that the negative terminal has an excess of negative charge, which is repelled by it and attracted to the excess positive charge on the other terminal. In terms of potential, the positive terminal is at a higher voltage than the negative terminal. Inside the battery, both positive and negative charges move.

FIGURE 7.18

The voltage of this demonstration Van de Graaff generator is measured between the charged sphere and ground. Earth's potential is taken to be zero as a reference. The potential of the charged conducting sphere is the same as that of an equal point charge at its center.

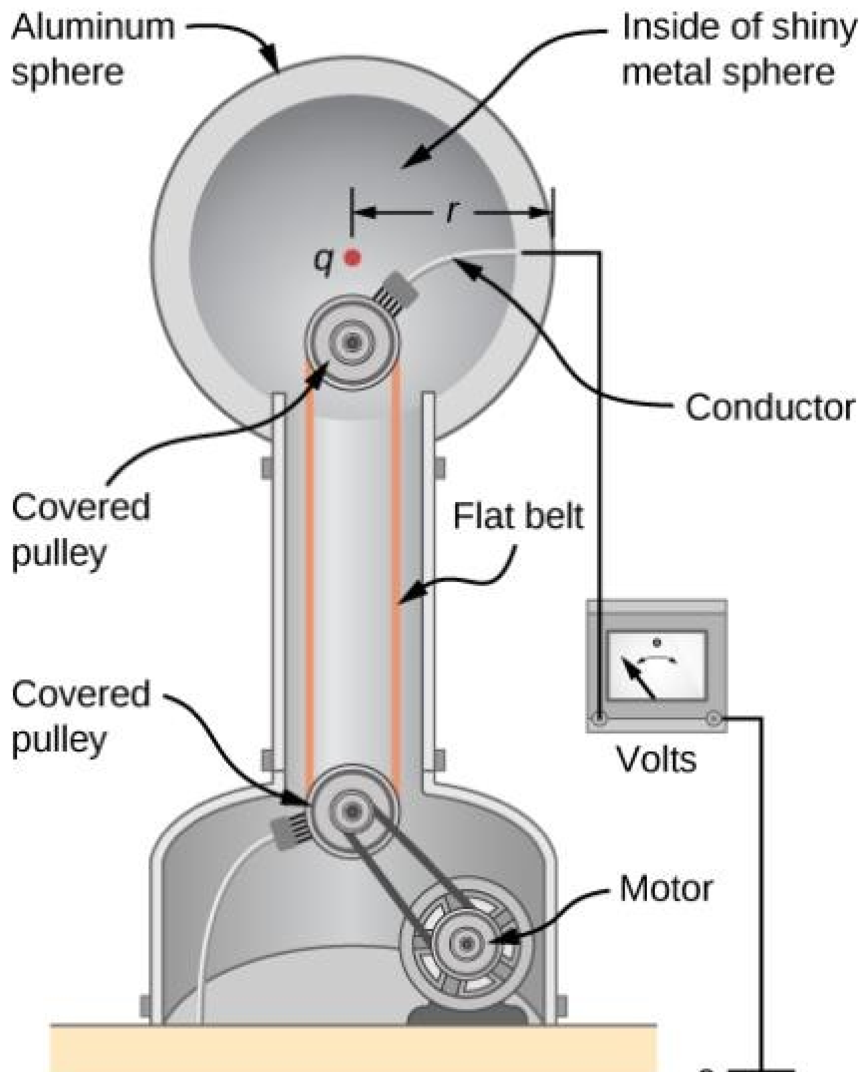
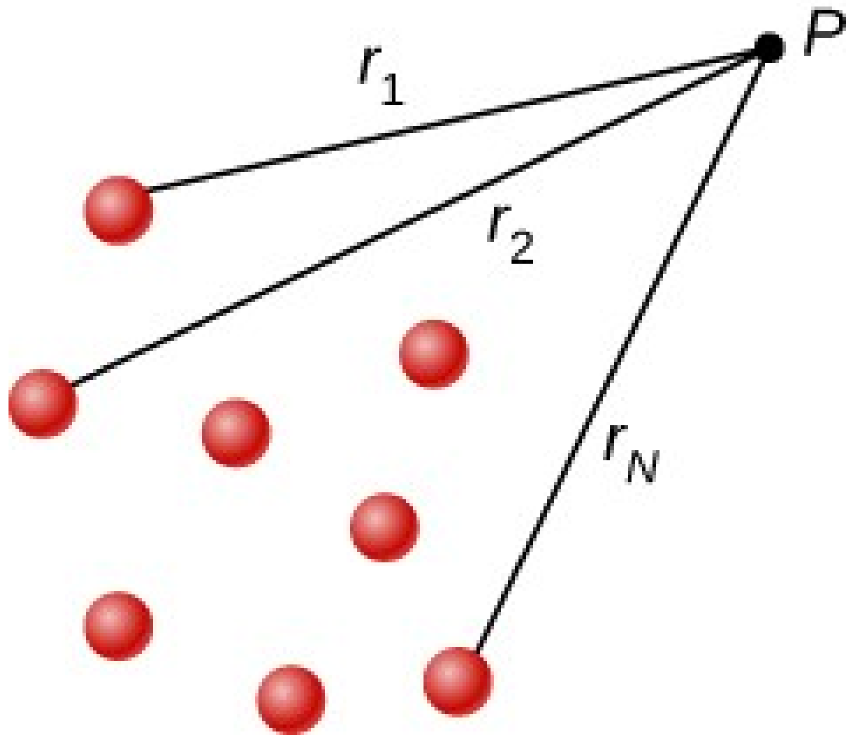


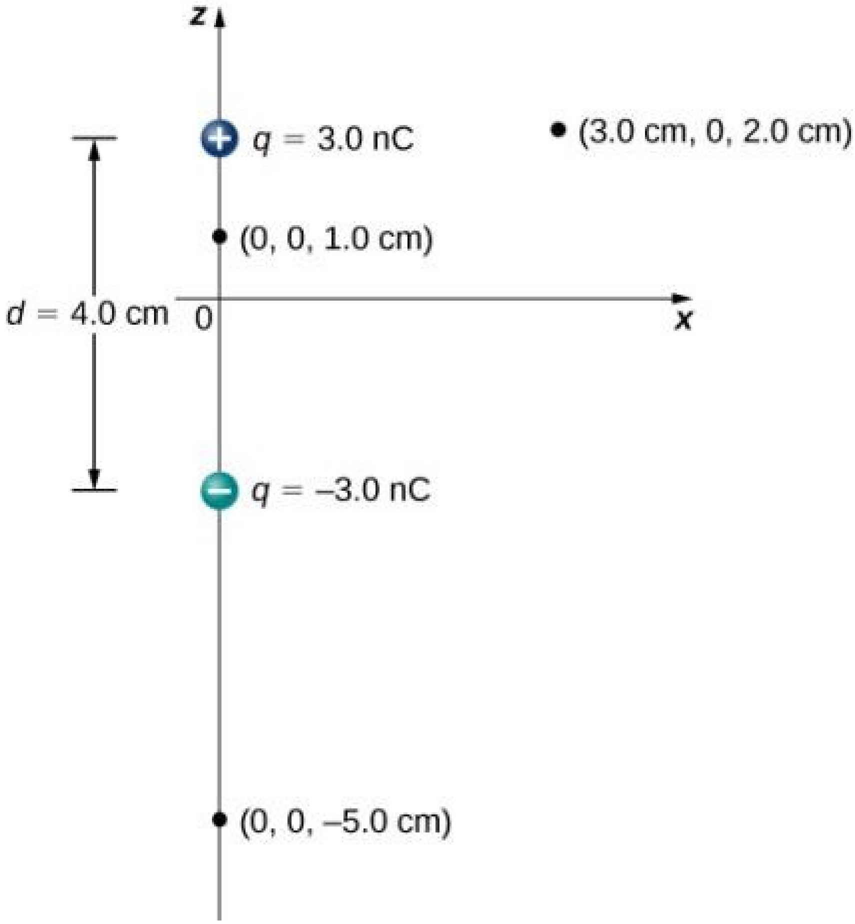
FIGURE 7.19



Notation for direct distances from charges to a space point *P*.

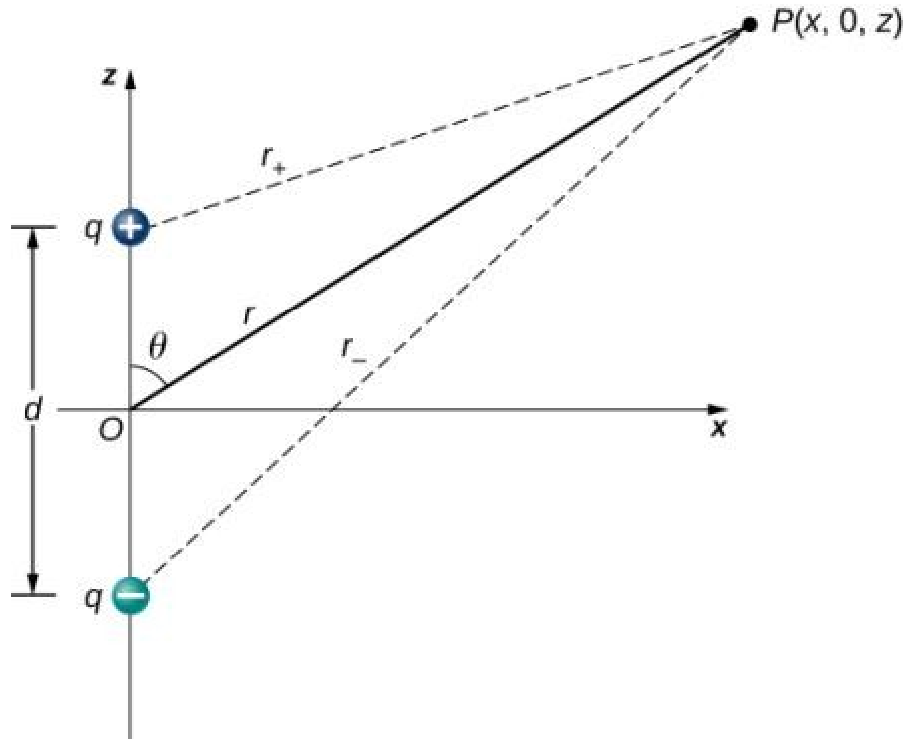
Dipoles

FIGURE 7.20



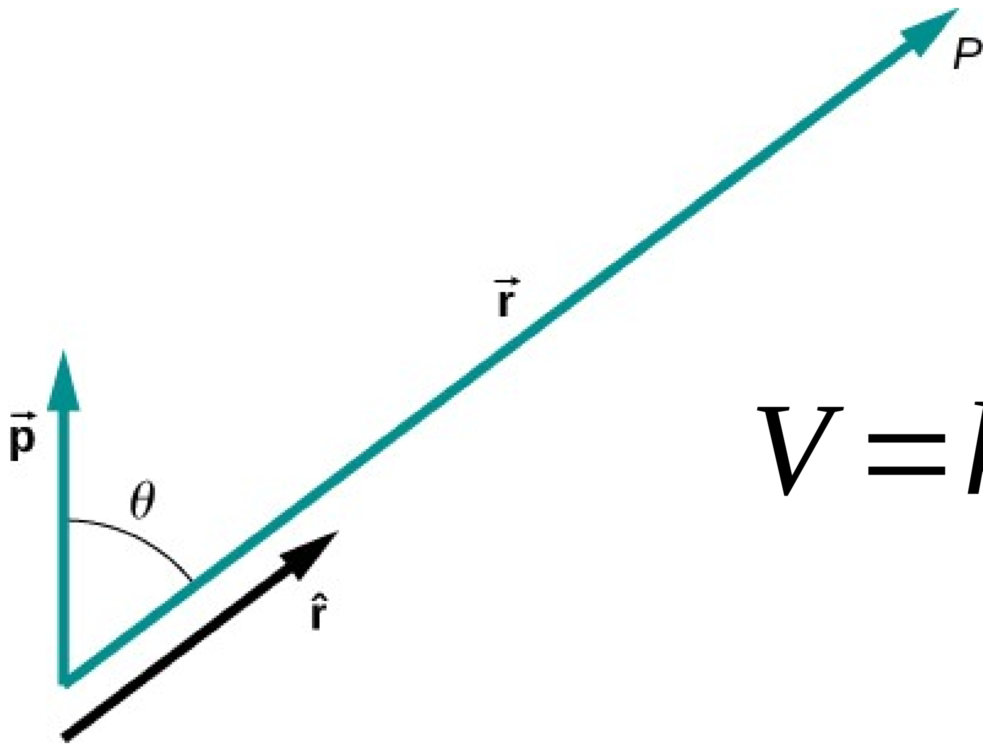
A general diagram of an electric dipole, and the notation for the distances from the individual charges to a point *P* in space.

FIGURE 7.21



A general diagram of an electric dipole, and the notation for the distances from the individual charges to a point *P* in space.

FIGURE 7.22

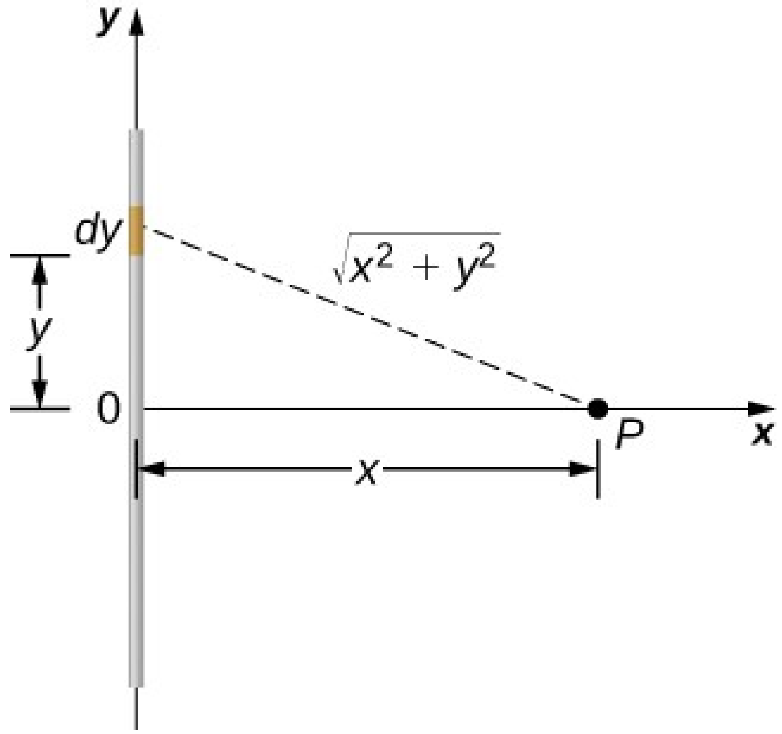


$$V = k\frac{\vec{p}\cdot\hat{r}}{r^2}$$

The geometry for the application of the potential of a dipole.

Electric potential: sample problems

FIGURE 7.23



We want to calculate the electric potential due to a line of charge.

FIGURE 7.24

We want to calculate the electric potential due to a ring of charge.

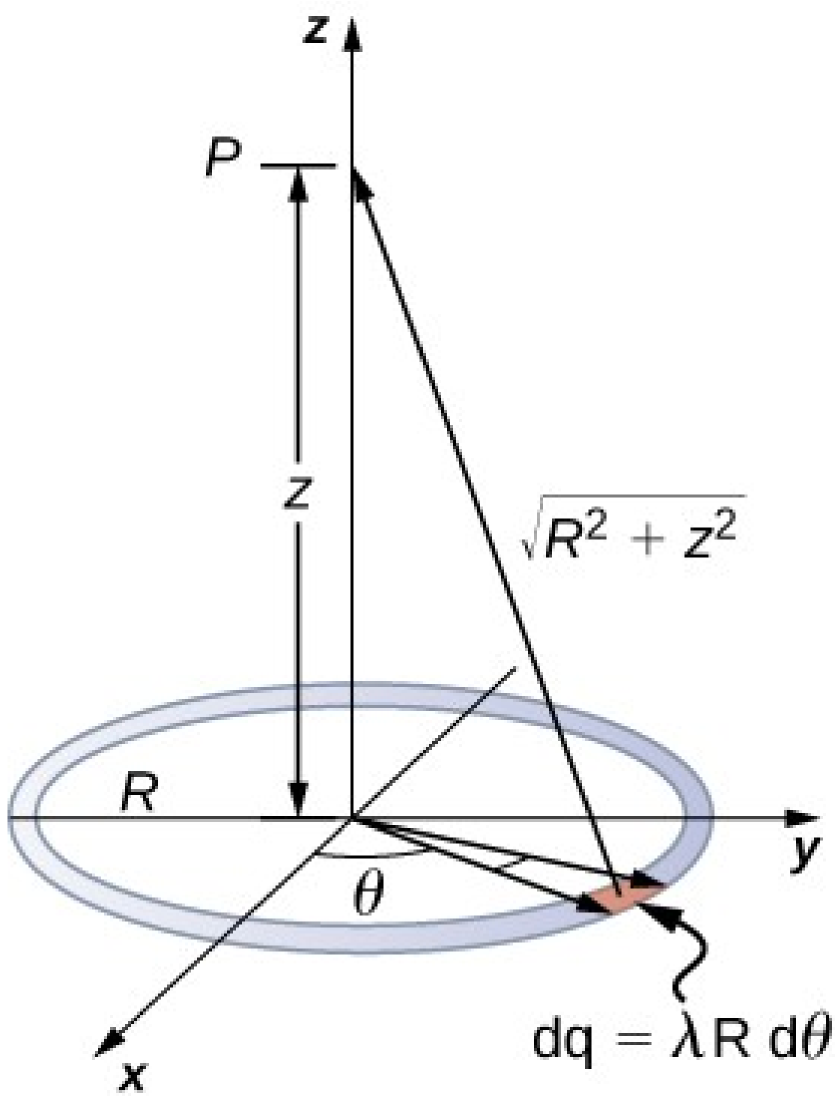
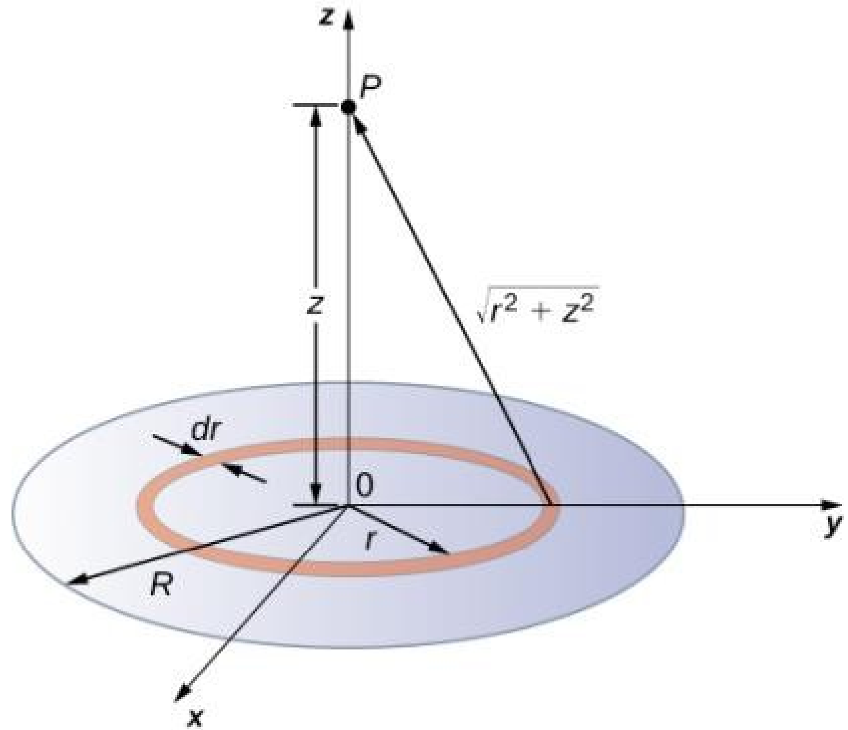


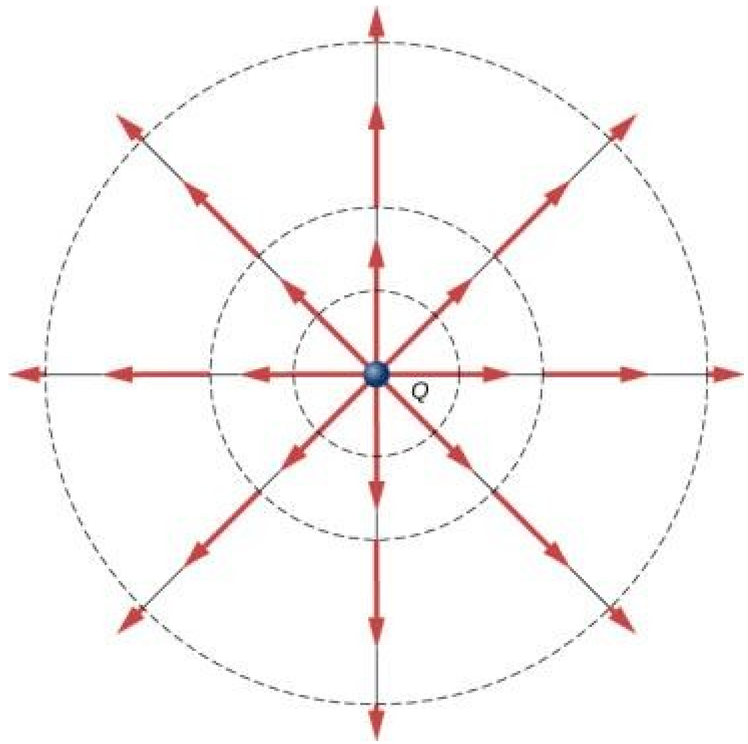
FIGURE 7.25



We want to calculate the electric potential due to a disk of charge.

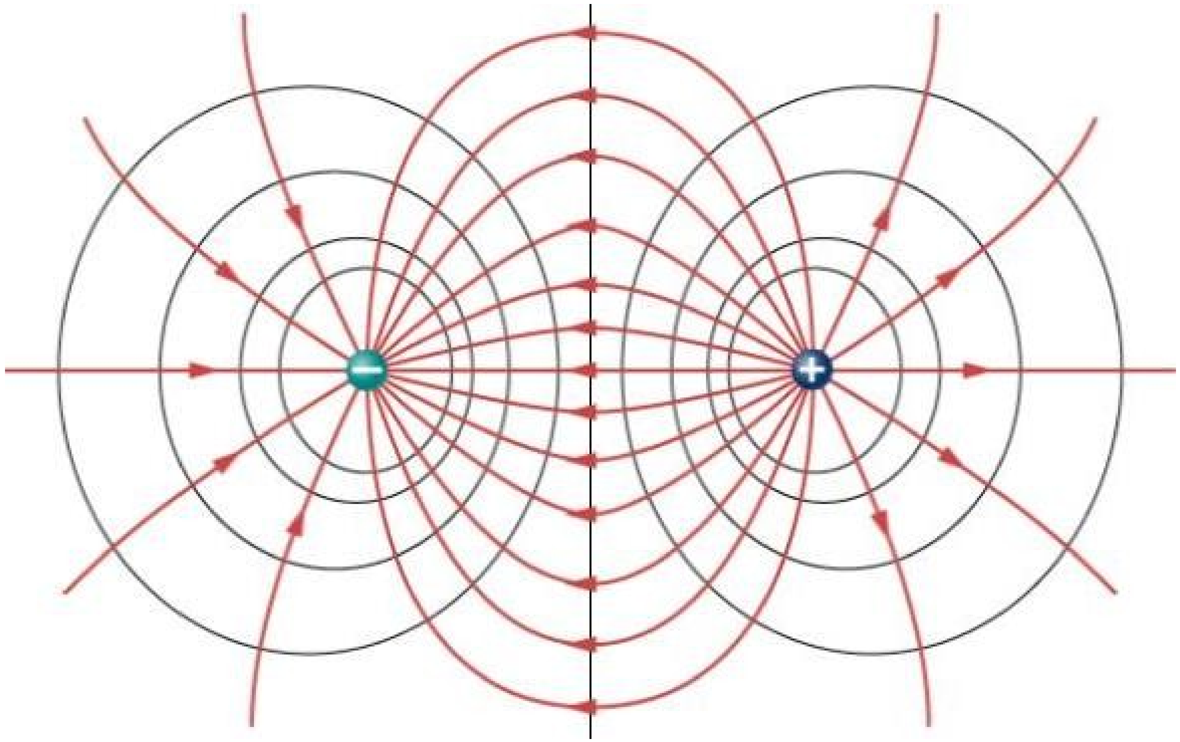
Field lines and equipotential surfaces

FIGURE 7.28



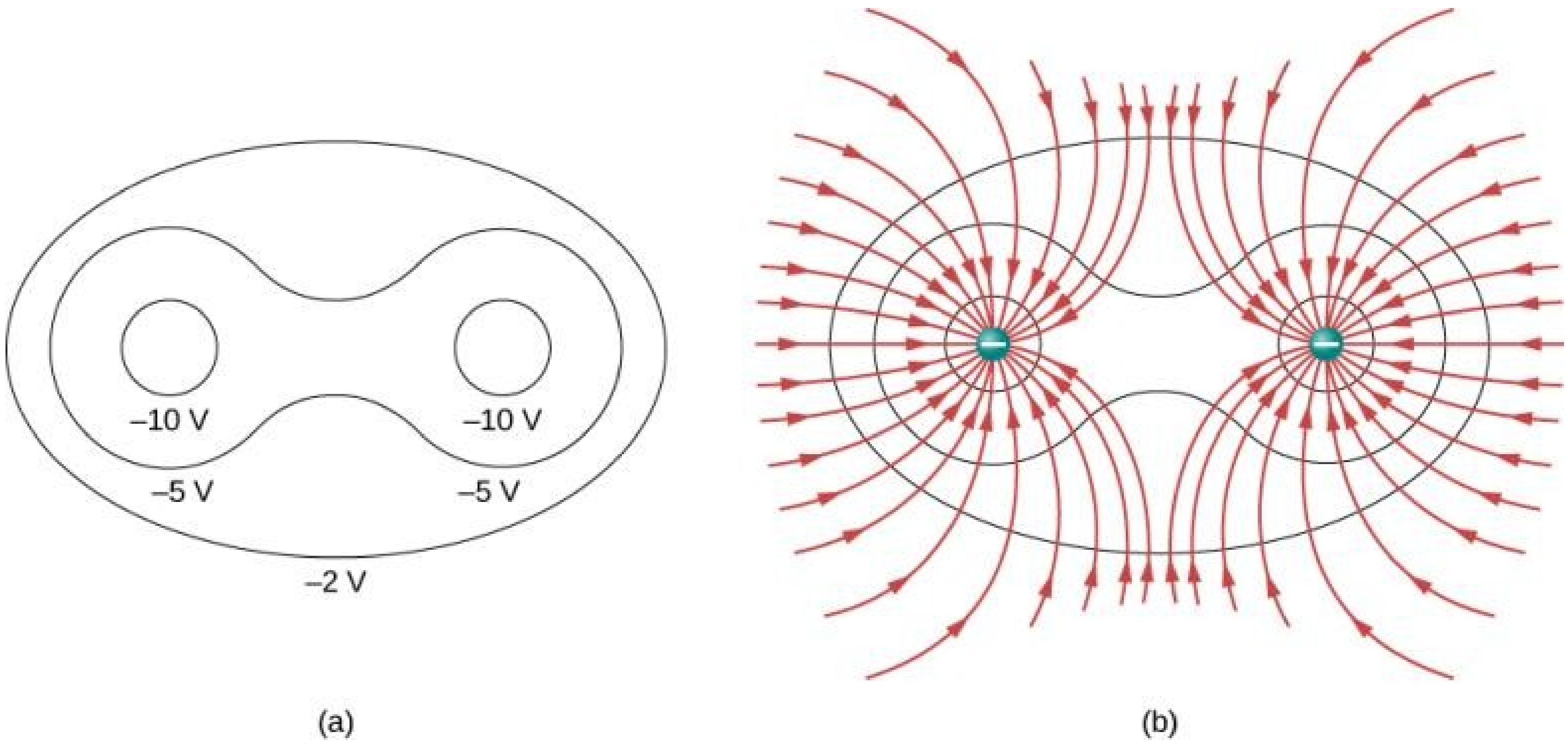
Electric field vectors inside and outside a uniformly charged sphere.

FIGURE 7.31



The electric field lines and equipotential lines for two equal but opposite charges. The equipotential lines can be drawn by making them perpendicular to the electric field lines, if those are known. Note that the potential is greatest (most positive) near the positive charge and least (most negative) near the negative charge. For a three-dimensional version, explore the first media link.

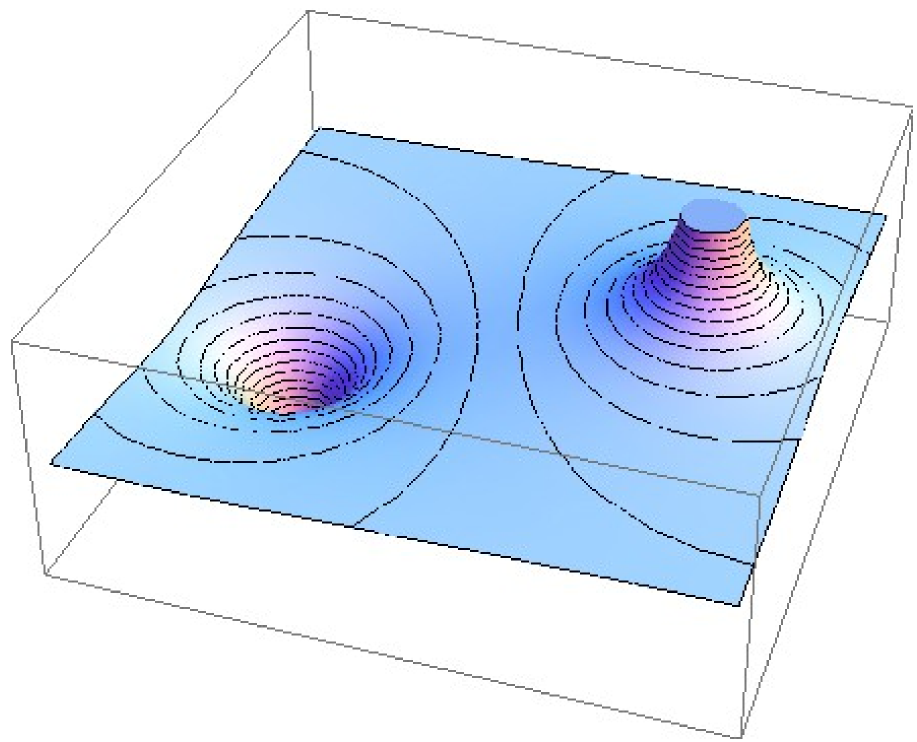
FIGURE 7.32



a) These equipotential lines might be measured with a voltmeter in a laboratory experiment.

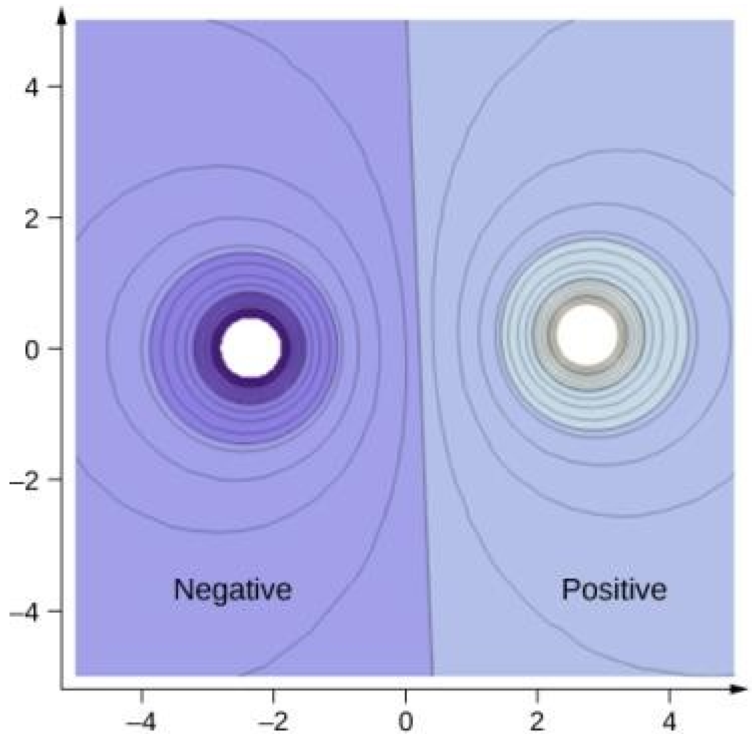
b) The corresponding electric field lines are found by drawing them perpendicular to the equipotentials. Note that these fields are consistent with two equal negative charges. For a three-dimensional version, play with the first media link.

FIGURE 7.33



Electric potential map of two opposite charges of equal magnitude on conducting spheres. The potential is negative near the negative charge and positive near the positive charge.

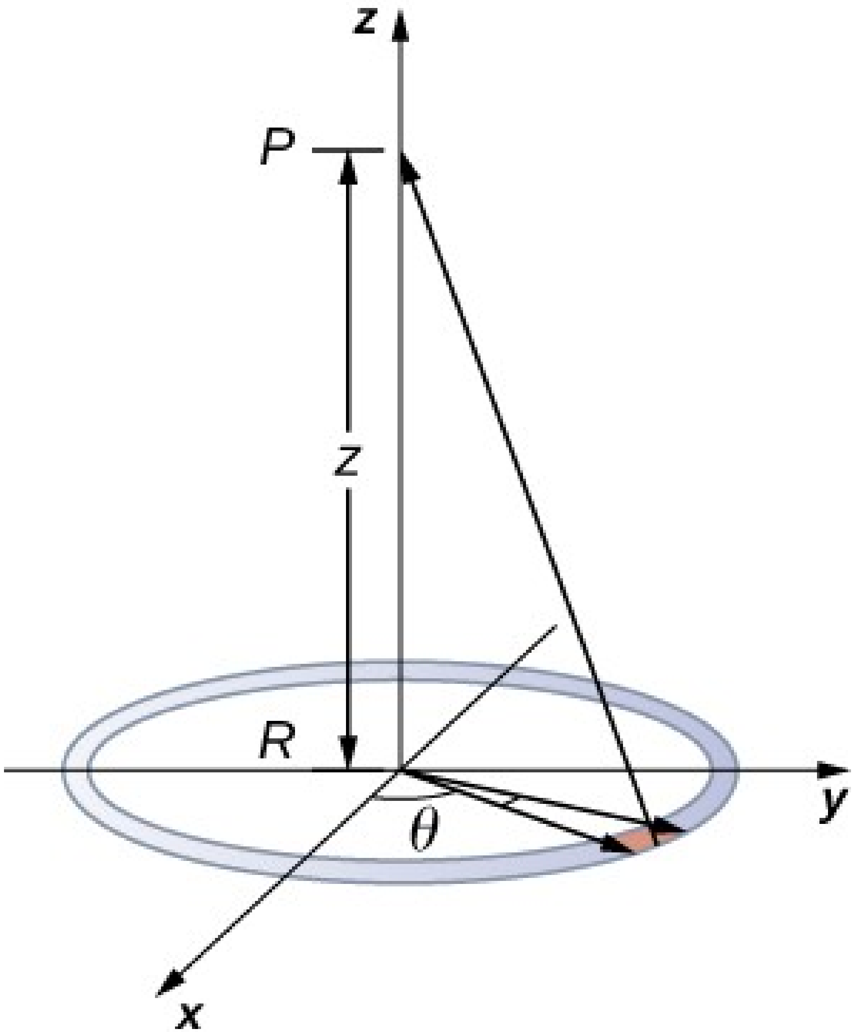
FIGURE 7.34



A cross-section of the electric potential map of two opposite charges of equal magnitude. The potential is negative near the negative charge and positive near the positive charge.

Examples

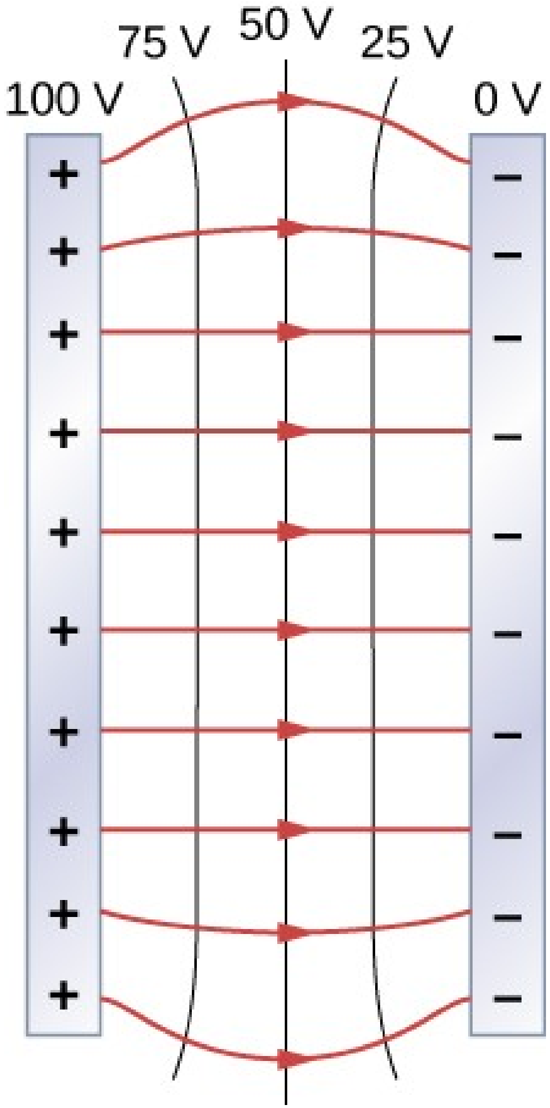
FIGURE 7.29



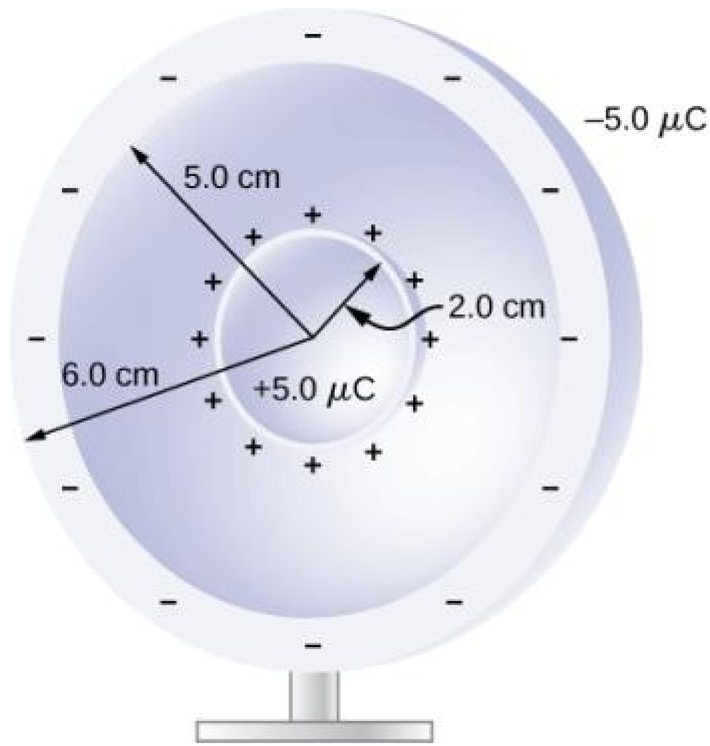
We want to calculate the electric field from the electric potential due to a ring charge.

FIGURE 7.35

The electric field and equipotential lines between two metal plates. Note that the electric field is perpendicular to the equipotentials and hence normal to the plates at their surface as well as in the center of the region between them.

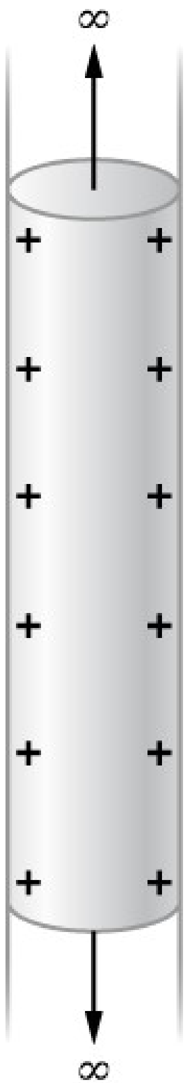


EXERCISE 60



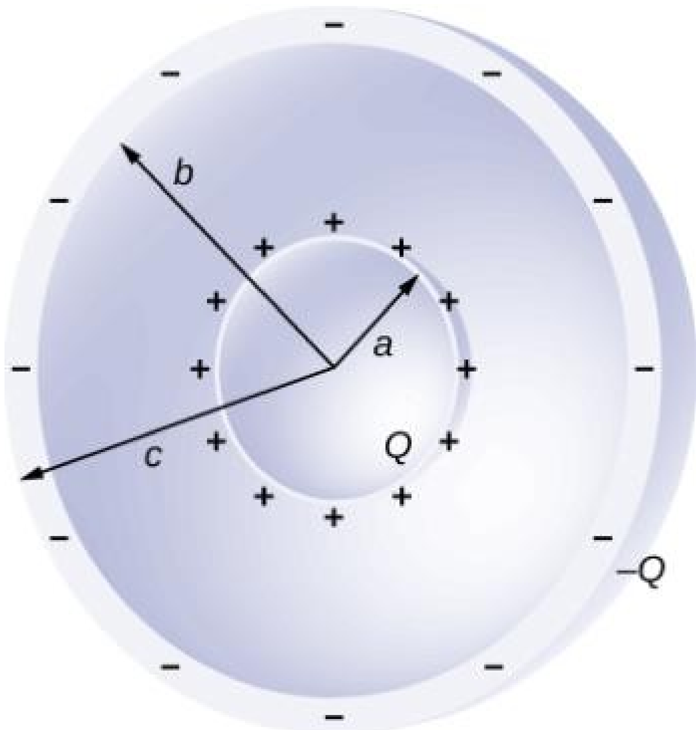
A metallic sphere of radius 2.0 cm is charged with charge, which spreads on the surface of the sphere uniformly. The metallic sphere stands on an insulated stand and is surrounded by a larger metallic spherical shell, of inner radius 5.0 cm and outer radius 6.0 cm. Now, a charge of is placed on the inside of the spherical shell, which spreads out uniformly on the inside surface of the shell. If potential is zero at infinity, what is the potential of (a) the spherical shell, (b) the sphere, (c) the space between the two, (d) inside the sphere, and (e) outside the shell?

EXERCISE 64



The surface charge density on a long straight metallic pipe is . What is the electric potential outside and inside the pipe? Assume the pipe has a diameter of 2a.

EXERCISE 65



Concentric conducting spherical shells carry charges Q and –Q, respectively. The inner shell has negligible thickness. What is the potential difference between the shells?