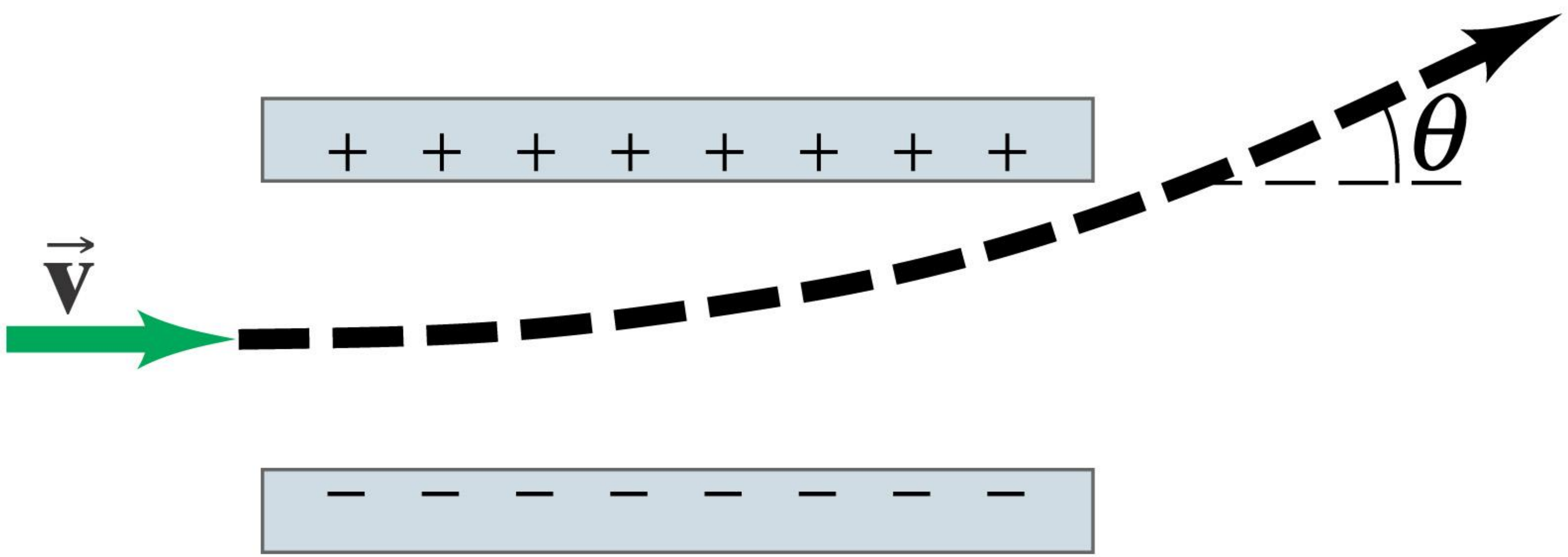
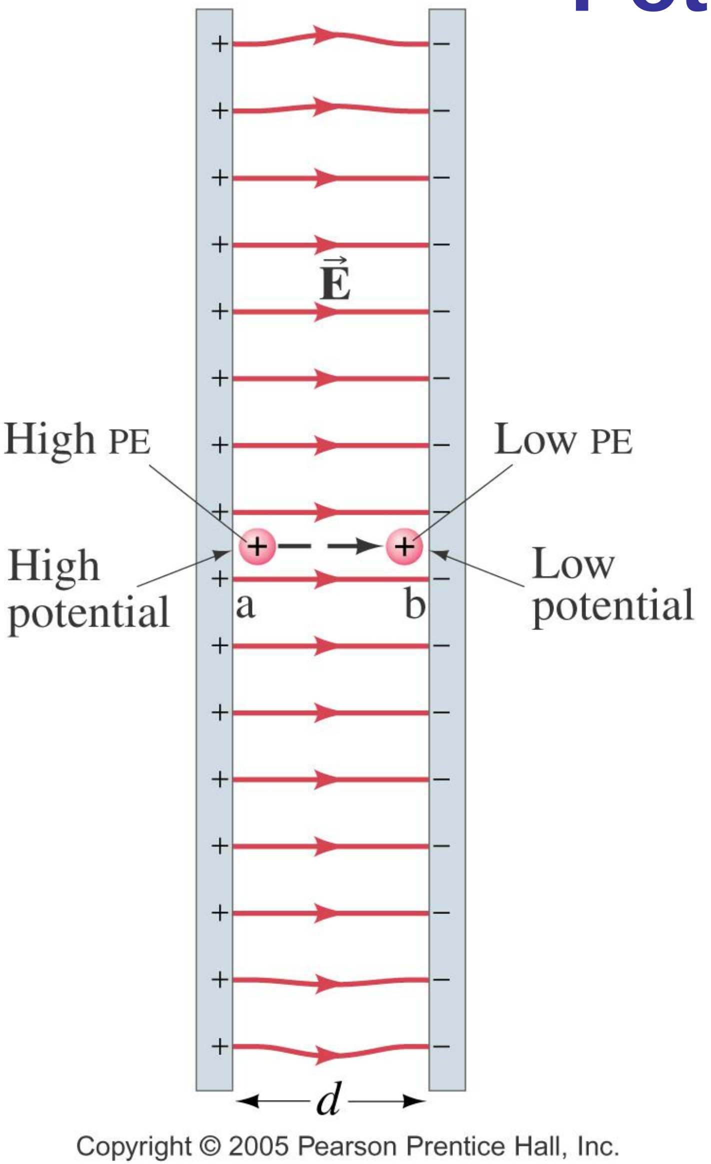
Chapter 17

Electric Potential



17.1 Electrostatic Potential Energy and Potential Difference



The electrostatic force is conservative – potential energy can be defined

Change in electric potential energy is negative of work done by electric force:

$$\mathrm{PE_b} - \mathrm{PE_a} = -qEd \qquad \textbf{(17-1)}$$

17.1 Electrostatic Potential Energy and Potential Difference

Electric potential is defined as potential energy per unit charge:

$$V_{\mathrm{a}} = \frac{\mathrm{PE}_{\mathrm{a}}}{q} \qquad (17\text{-}2a)$$

Unit of electric potential: the volt (V).

1 V = I J/C.

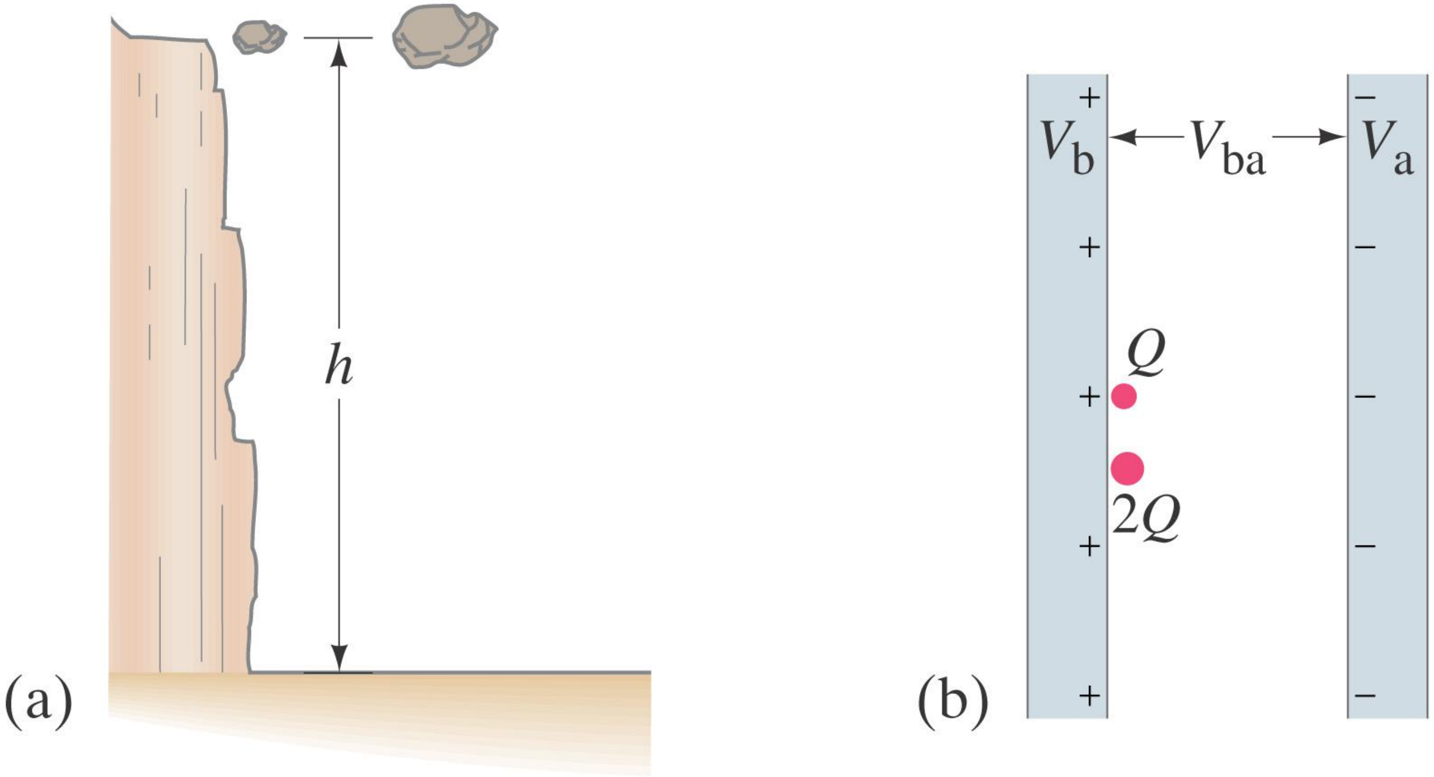
17.1 Electrostatic Potential Energy and Potential Difference

Only changes in potential can be measured, allowing free assignment of *V* = 0.

$$V_{\mathrm{ba}} = V_{\mathrm{b}} - V_{\mathrm{a}} = \frac{\mathrm{PE}_{\mathrm{b}} - \mathrm{PE}_{\mathrm{a}}}{q} = -\frac{W_{\mathrm{ba}}}{q} \qquad (17\text{-}2b)$$

17.1 Electrostatic Potential Energy and Potential Difference

Analogy between gravitational and electrical potential energy:



17.2 Relation between Electric Potential and Electric Field

Work is charge multiplied by potential:

$$W = -q(V_{\mathrm{b}} - V_{\mathrm{a}}) = -qV_{\mathrm{ba}}$$

Work is also force multiplied by distance:

$$W = Fd = qEd$$

17.2 Relation between Electric Potential and Electric Field

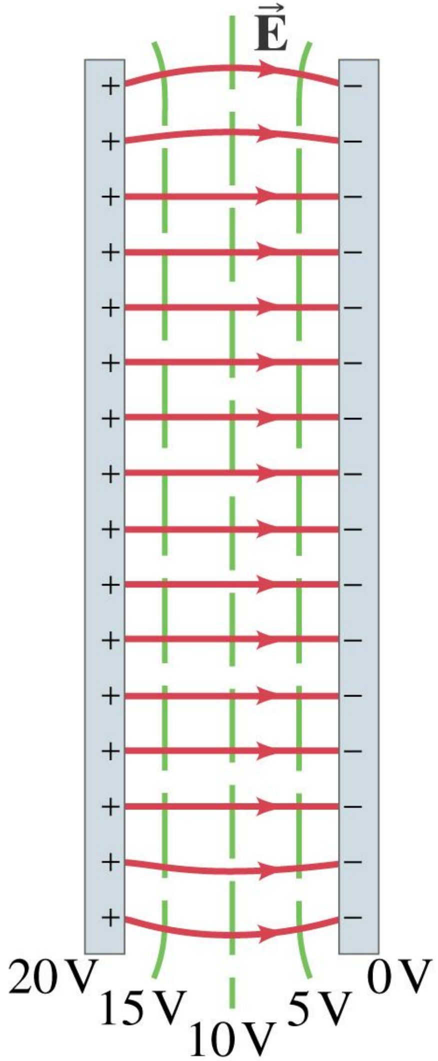
Solving for the field,

$$E = -\frac{V_{\mathrm{ba}}}{d} \qquad \textbf{(17-4b)}$$

If the field is not uniform, it can be calculated at multiple points:

$$E_x = -\Delta V / \Delta x$$

17.3 Equipotential Lines

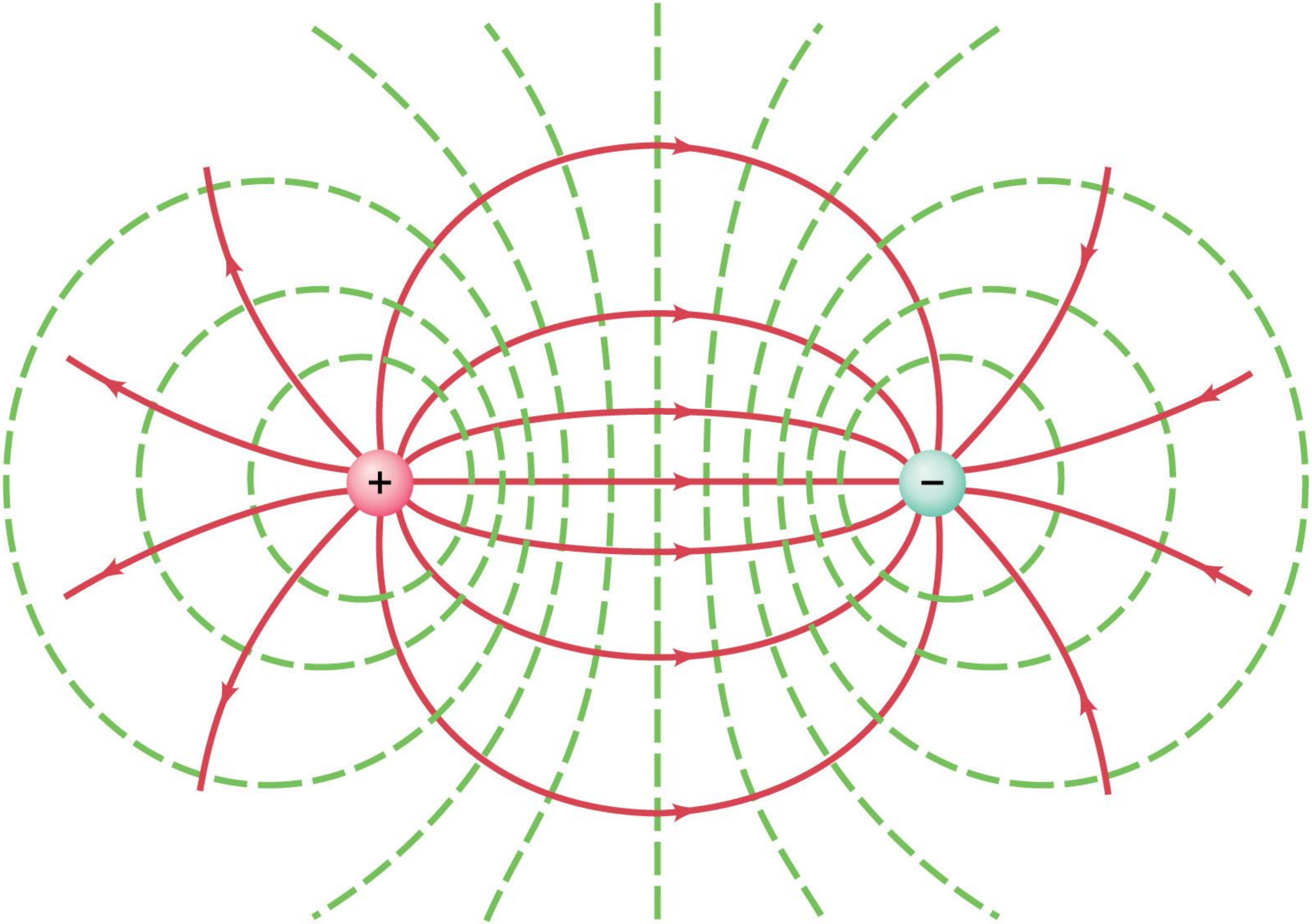


An equipotential is a line or surface over which the potential is constant.

Electric field lines are perpendicular to equipotentials.

The surface of a conductor is an equipotential.

17.3 Equipotential Lines



17.4 The Electron Volt, a Unit of Energy

One electron volt (eV) is the energy gained by an electron moving through a potential difference of one volt.

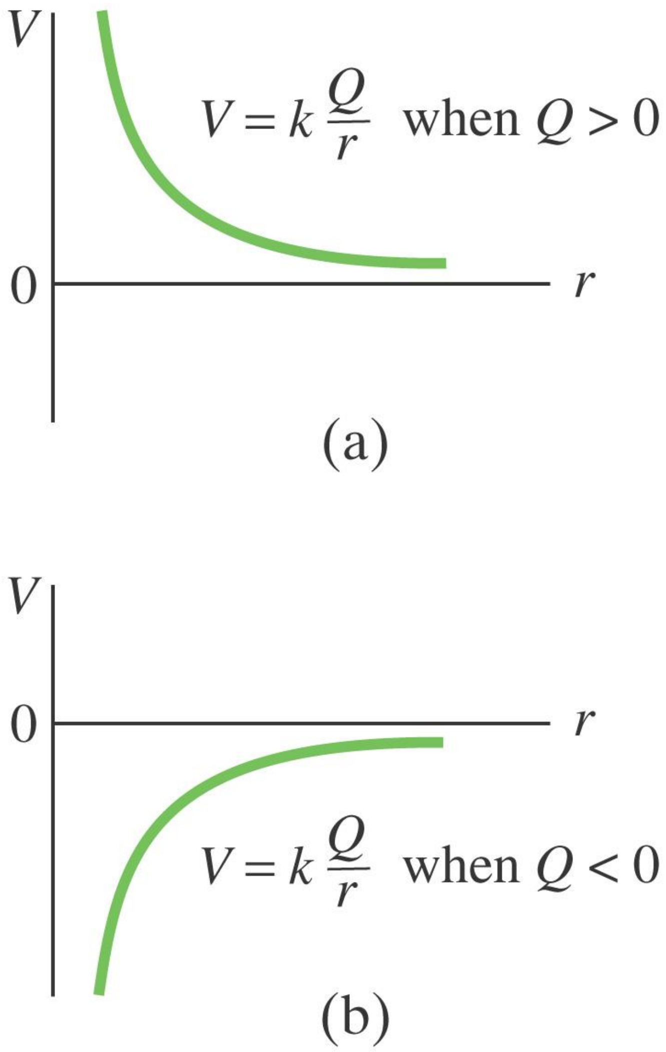
$$1\ \text{eV} = 1.6 \times 10^{-19}\ \text{J}$$

17.5 Electric Potential Due to Point Charges

The electric potential due to a point charge can be derived using calculus.

$$V = k\frac{Q}{r} = \frac{1}{4\pi\epsilon_0}\frac{Q}{r} \qquad \textbf{(17-5)}$$

17.5 Electric Potential Due to Point Charges



These plots show the potential due to (a) positive and (b) negative charge.

17.5 Electric Potential Due to Point Charges

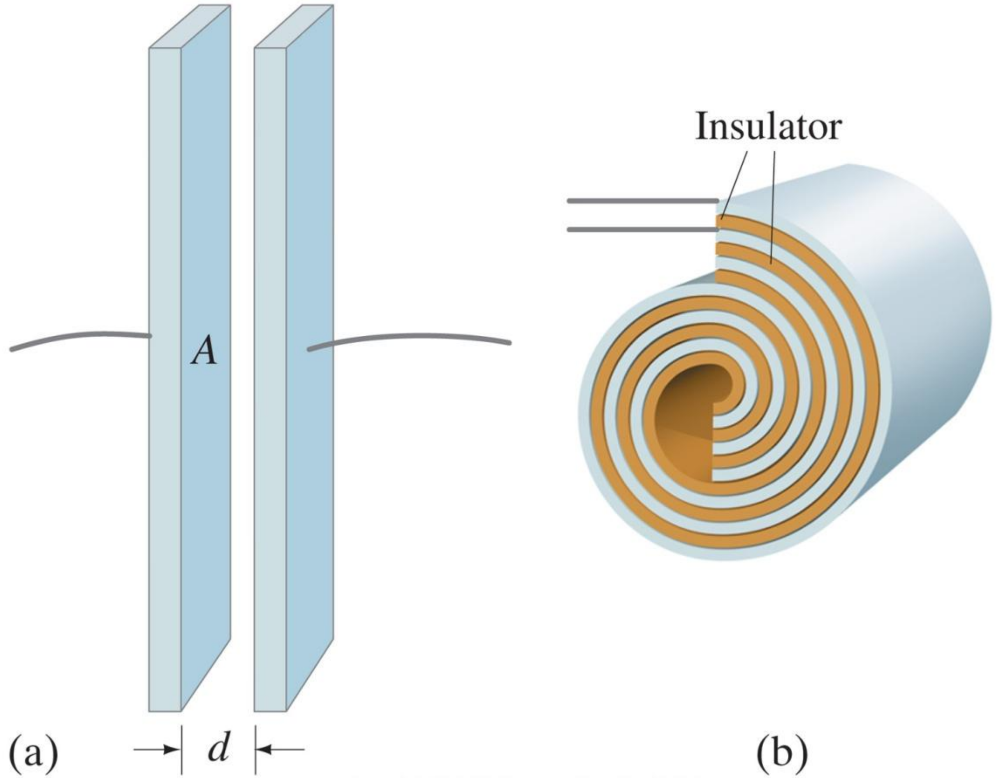
Using potentials instead of fields can make solving problems much easier – potential is a scalar quantity, whereas the field is a vector.

17.6 Potential Due to Electric Dipole; Dipole Moment

The potential due to an electric dipole is just the sum of the potentials due to each charge, and can be calculated exactly.

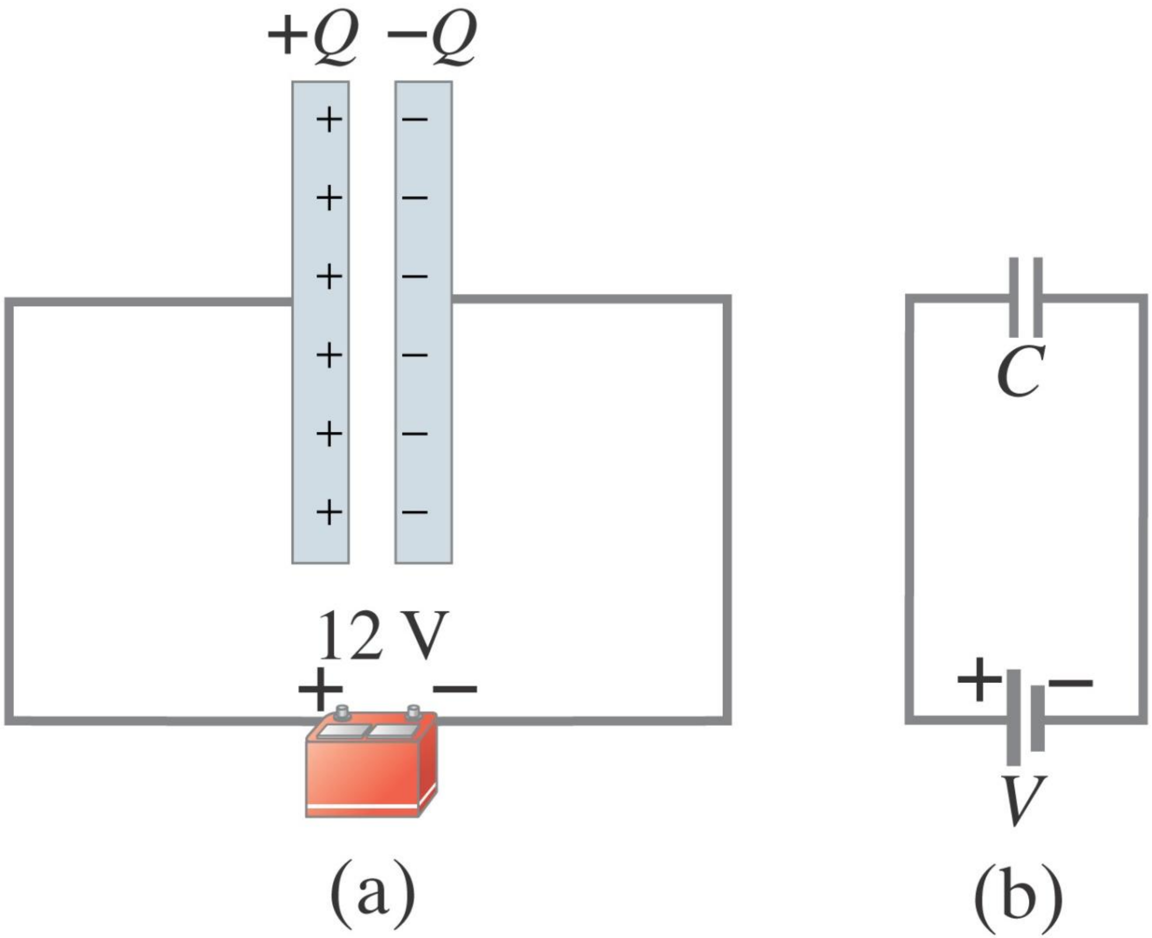
17.7 Capacitance

A capacitor consists of two conductors that are close but not touching. A capacitor has the ability to store electric charge.



17.7 Capacitance

Parallel-plate capacitor connected to battery. (b) is a circuit diagram.



17.7 Capacitance

When a capacitor is connected to a battery, the charge on its plates is proportional to the voltage:

$$Q = CV \tag{17-7}$$

The quantity *C* is called the capacitance.

Unit of capacitance: the farad (F)

1 F = 1 C/V

17.7 Capacitance

The capacitance does not depend on the voltage; it is a function of the geometry and materials of the capacitor.

For a parallel-plate capacitor:

$$C = \epsilon_0 \frac{A}{d} \qquad (17\text{-}8)$$

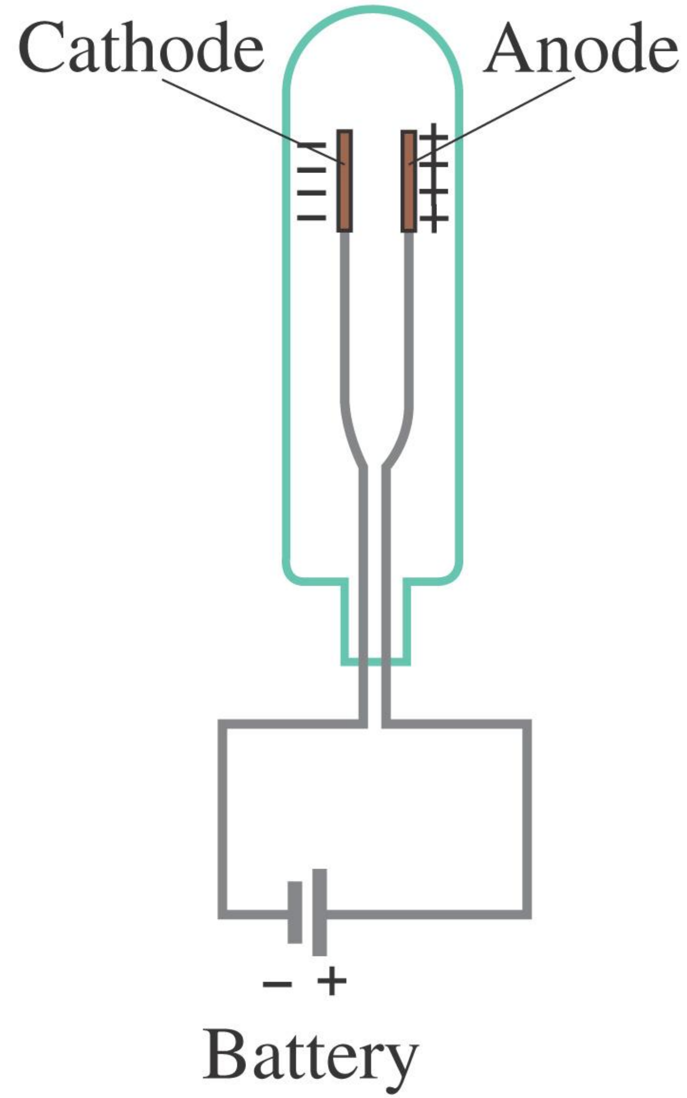
17.9 Storage of Electric Energy

A charged capacitor stores electric energy; the energy stored is equal to the work done to charge the capacitor.

$$\mathrm{PE} = \tfrac{1}{2}QV = \tfrac{1}{2}CV^2 = \tfrac{1}{2}\frac{Q^2}{C} \qquad \textbf{(17-10)}$$

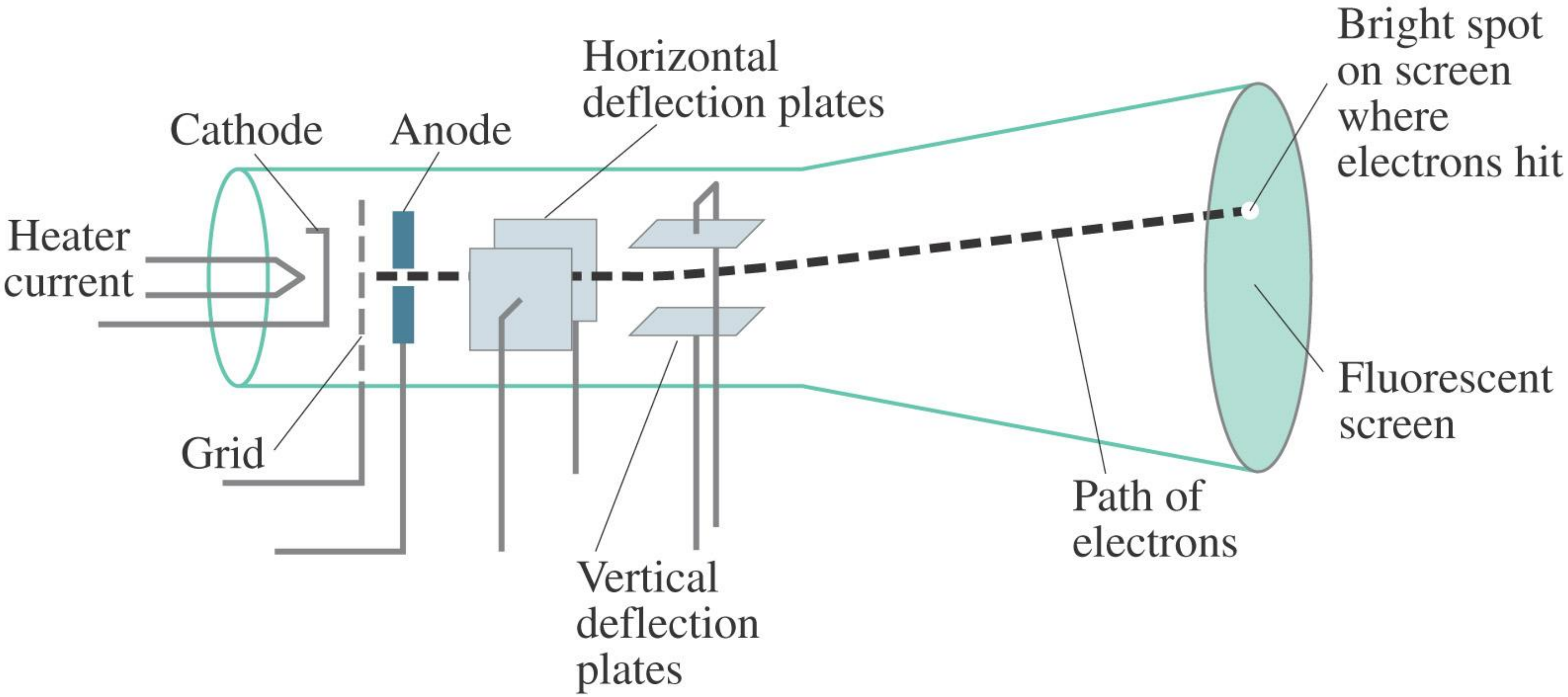
17.10 Cathode Ray Tube: TV and Computer Monitors, Oscilloscope

A cathode ray tube contains a wire cathode that, when heated, emits electrons. A voltage source causes the electrons to travel to the anode.



17.10 Cathode Ray Tube: TV and Computer Monitors, Oscilloscope

The electrons can be steered using electric or magnetic fields.



17.10 Cathode Ray Tube: TV and Computer Monitors, Oscilloscope

Televisions and computer monitors (except for LCD and plasma models) have a large cathode ray tube as their display. Variations in the field steer the electrons on their way to the screen.