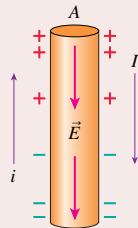


SUMMARY

The goal of Chapter 28 has been to learn how and why charge moves through a conductor as a current.

GENERAL PRINCIPLES

Current is a nonequilibrium motion of charges sustained by an electric field. Nonuniform surface charge density creates an electric field in a wire. The electric field pushes the electron current i in a direction opposite to \vec{E} . The conventional current I is in the direction in which positive charge *seems* to move.



Electron current

i = rate of electron flow

$$N_e = i\Delta t$$

Conventional current

I = rate of charge flow = ei

$$Q = I\Delta t$$

Current density

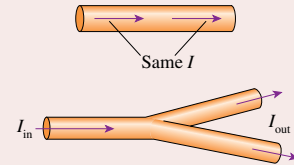
$$J = I/A$$

Conservation of Current

The current is the same at any two points in a wire.

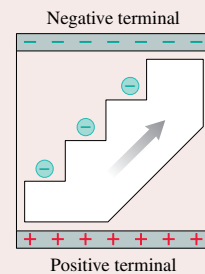
At a junction,

$$\sum I_{\text{in}} = \sum I_{\text{out}}$$



Batteries

The role of a battery is to maintain a charge separation and thus sustain a current. Chemical reactions power the “charge escalator” that moves electrons from the positive terminal to the negative terminal.



IMPORTANT CONCEPTS

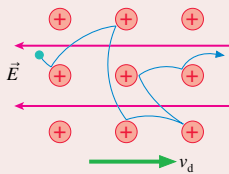
Sea of electrons

Conduction electrons move freely around the positive ions that form the atomic lattice.

Conduction

An electric field causes a slow drift at speed v_d to be superimposed on the rapid but random thermal motions of the electrons.

Collisions of electrons with the ions transfer energy to the atoms. This makes the wire warm and lightbulbs glow. More collisions mean a higher resistivity ρ and a lower conductivity σ .



The **drift speed** is $v_d = \frac{e\tau}{m}E$

where τ is the mean time between collisions. v_d is related to the electron current by

$$i = nAv_d$$

where n is the electron density.

An electric field E in a conductor causes a current density $J = nev_d = \sigma E$ where the **conductivity** is

$$\sigma = \frac{ne^2\tau}{m}$$

The **resistivity** is $\rho = 1/\sigma$.