Chapter 18

Electric Currents

Current

- = motion of charge

a steady flow of charge →a steady force on mobile charges

$$I = \frac{\Delta Q}{\Delta t}$$

current = amount of charge moving through given cross section per unit time

[I] = ampere, 1 A = 1 C / s

Current in a Complete Circuit

- current is the same at all cross sections, it does not emerge from the positive battery terminal and disappear in the negative terminal
- speed to establish current >> electron drift speed

conventional current flow:
from + to – (opposite to electron motion)

Resistance and Resistivity

Electric field is proportional to the potential difference between the ends of a conductor, and current is caused by electric field

$$R = \frac{V}{I}$$

Ohm's law: For many materials, current is proportional to potential difference (voltage)

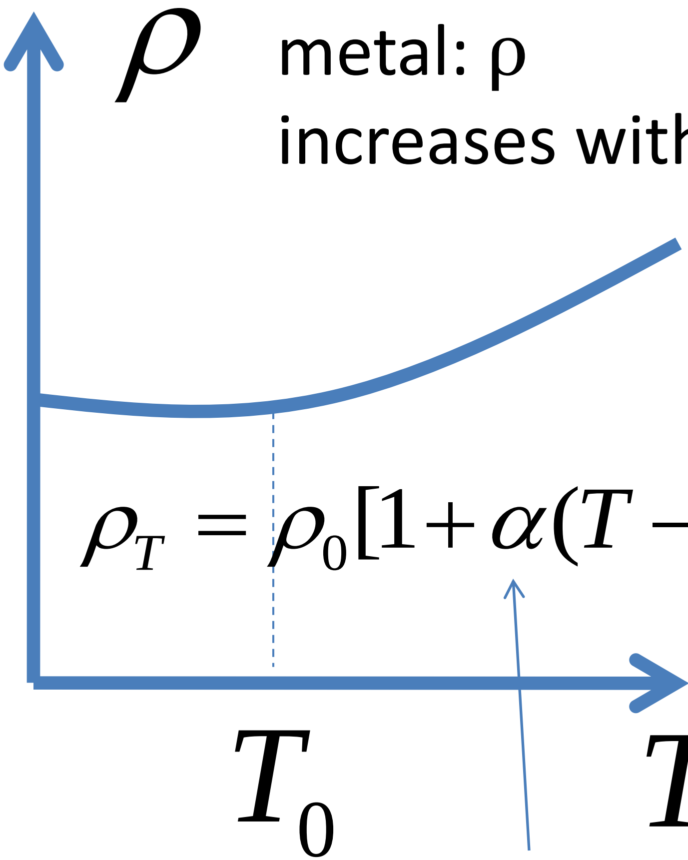
Resistance: the proportionality factor

Resistivity ρ: geometry independent

$$R = \rho \frac{L}{A}$$

Resistance is for an object, resistivity for material

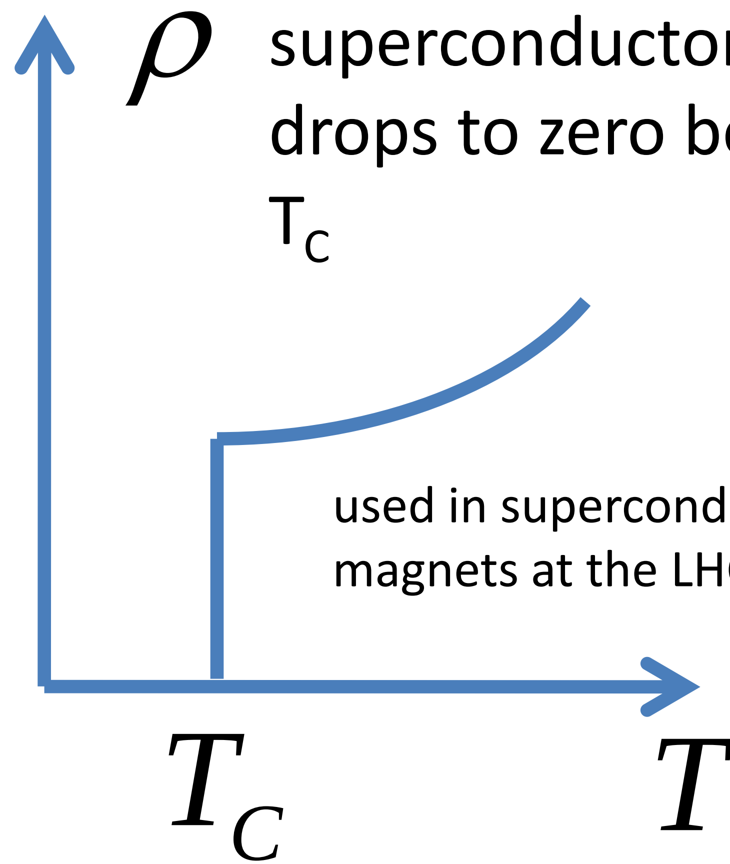
Temperature Dependence of R



metal: ρ increases with T

$$\rho_T = \rho_0[1 + \alpha(T - T_0)]$$

temperature coefficient of resistivity



superconductor: ρ drops to zero below T_C

used in superconducting magnets at the LHC

Energy and Power in Circuits

- as charge passes through a circuit, the electric field does work on the charge

$$\Delta W = V\Delta Q$$ ← definition of potential difference

$$\Delta Q = I\Delta t$$ ← definition of current

$$VI = \frac{\Delta W}{\Delta t} = P$$

power = work/unit time

from Ohm's law:

$$P = I^2 R = \frac{V^2}{R}$$

Alternating Current

- Direct current: charges move steadily in one direction
- Alternating current: the direction changes over time

$$V = V_0 \sin \omega t$$

$$I = \frac{V}{R} = \frac{V_0}{R} \sin \omega t = I_0 \sin \omega t$$

Alternating Current Power

- Power is always positive, can talk about average power

$$P = I^2 R = I_0^2 \sin^2 \omega t$$

$$\overline{P} = \frac{1}{2} I_0^2 R = \frac{1}{2} \frac{V_0^2}{R}$$

$$I_{\mathrm{rms}} = I_0 / \sqrt{2}$$

$$V_{\mathrm{rms}} = V_0 / \sqrt{2}$$

$$\overline{P} = I_{\mathrm{rms}} V_{\mathrm{rms}}$$