Announcements

1. Problem sessions Tuesday 6-7 in Olin 107
2. Program on summer research opportunities in the sciences – tonight (1/29/03) at 7 PM in Olin 101

   (Including programs such as the WFU Research Fellowships available at WFU as well as programs elsewhere.)
3. Capacitor demo with a big bang– starring Machele Cable
4. Topic for today (beginning of Chapter 27)

   Electric current

   Resistivity & conductivity

Capacitor demo

C = 7900 μf

V = 100 Volts

Q = CV = 0.79 Coulombs (!)

$$U = \frac{Q^2}{2C} = 39.5J$$

Electrical current

Up to now, we have been mostly concerned with stationary charges. Now we will focus our attention on moving charges – specifically charges moving in a conductor.

Static properties of a conducting material:

- Mobile charges within conductor move in response to forces applied to them
  - Charges tend to migrate to surfaces of conductors
  - $E=0$ and V=constant within interior of conductor

Dynamical properties of a conducting material:

- Mobile charges within conductor move in response to forces applied to them
  - Charges can flow within conductor
  - $E\neq0$ and $V\neq$constant within interior of conductor

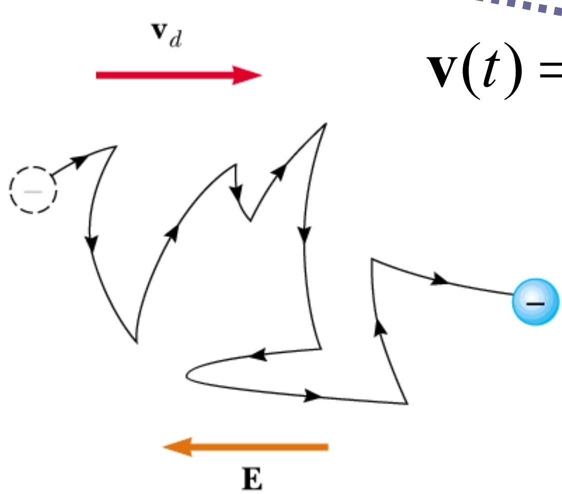
Quantitative measure of electrical current

$$I = \frac{dQ}{dt}$$ Units of I = Coulombs/s ≡ Ampere

Microscopic picture of electrical current:

$$\mathbf{v}(t) = \mathbf{v}_i - \frac{q\mathbf{E}}{m}t$$

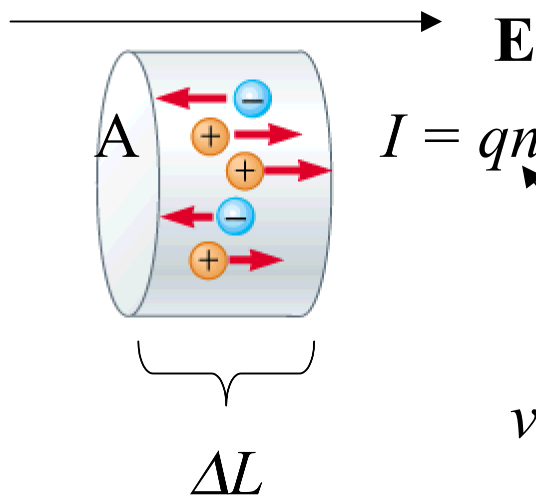
After accelerating for some time, the electron will collide and change direction



$$\Rightarrow \quad v_d = \frac{qE}{m}\tau$$

time between collisions

Expression for the current in terms of the drift velocity v_d



$$I = qnAv_d$$

number of electrons per unit volume

$$v_d = \frac{qE}{m}\tau$$

In terms of the potential: $\Delta V = \Delta L\ E$ ➔ $v_d = \frac{q\Delta V}{m\Delta L}\tau$

$$I = \underbrace{\left(\frac{q^2 n\tau A}{m\Delta L}\right)}_{\equiv\ 1/R \text{ (constant for each material)}}\Delta V$$

Ohm's law (actually an approximation, not really a "law")

$\Delta V = I\,R$ units: R = volts/amp ≡ ohm (Ω)

$$R = \frac{m\Delta L}{q^2 n\tau A} \equiv \rho\frac{\Delta L}{A}$$

Typically resistances for $A = 8 \times 10^{-7} m^2$; $\Delta L = 1m$

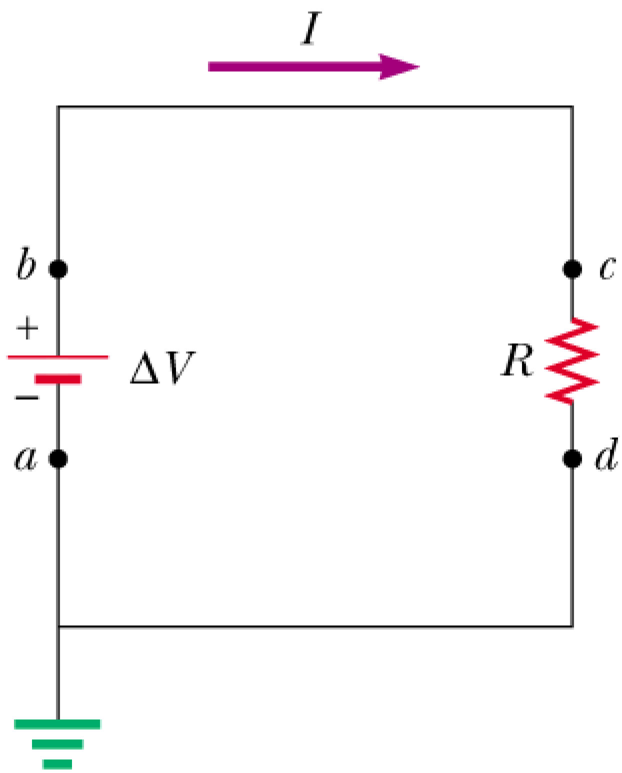
Material	Resistance (Ω)
Copper	1.4×10^{-14}
Carbon	2.8×10^{-11}
Silicon	5.1×10^{-4}
Glass	800 – 8000000

For “superconductors” $R \rightarrow 0$ at temperatures below T_c

The current is confined to the surface of the superconductor and acts to shield interior from all external fields. Used to create strong magnetic fields, for example in MRI machines.

New (as of 1986) “high temperature” superconductors – $T_c \approx 150$ K

Example of a resistor in a circuit:



$$\Delta V = I\,R$$

If ΔV = 10 V, R = 20 Ω,

I = 0.5 A

Peer instruction question

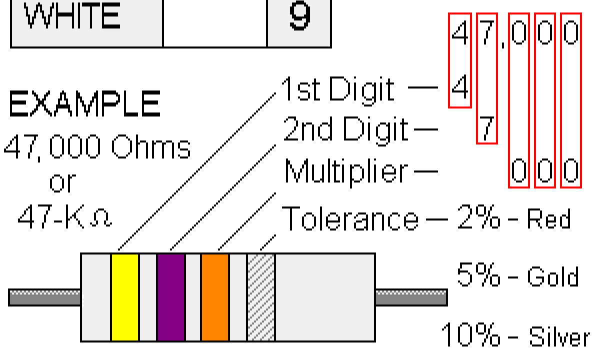
In the previous example, we assumed that the 10 V output of the battery is concentrated across the 20 Ω resistor. Are we justified in neglecting the resistance in the wire connecting this circuit? How much error is introduced by this assumption?

(A) < 1% (B) 1% (C) 10% (D) >10%

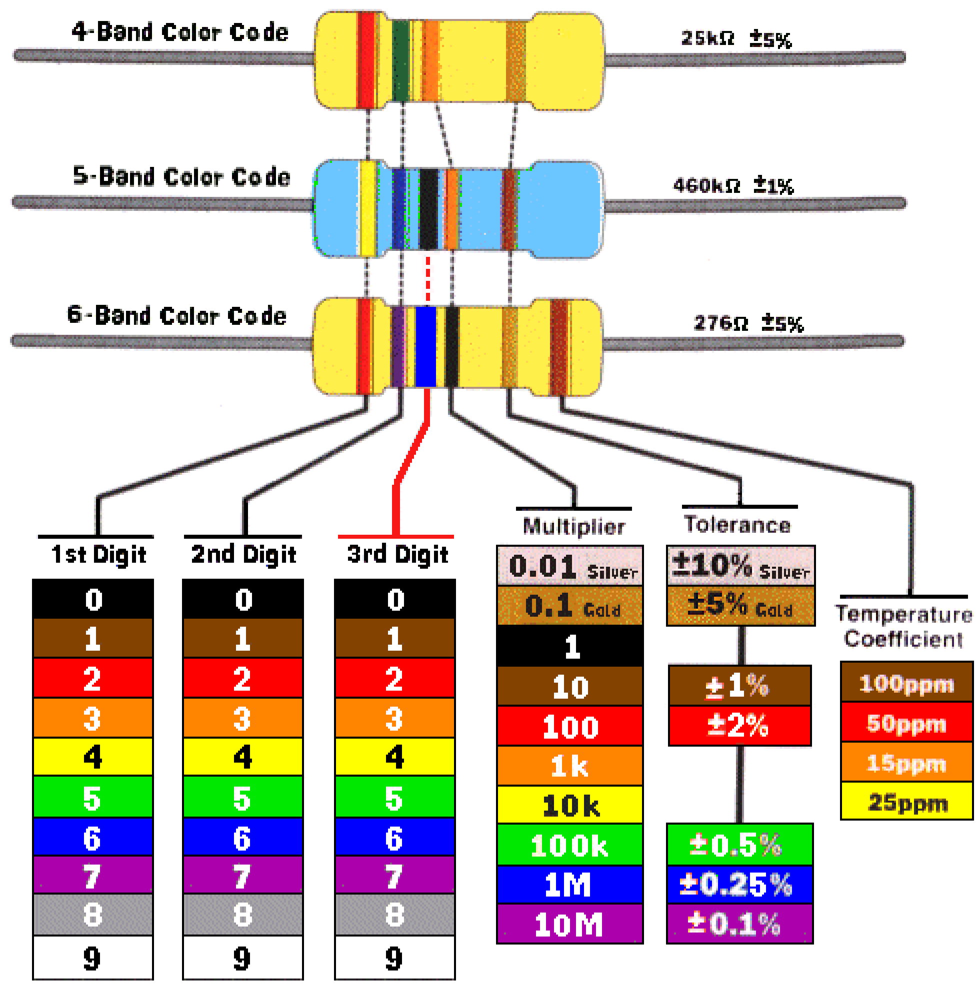
Resistor Color Code

		Multiplier
BLACK	0	________
BROWN	1	_______0
RED	2	______00
ORANGE	3	_____000
YELLOW	4	__0, 000
GREEN	5	_00, 000
BLUE	6	000, 000
VIOLET	7	
GRAY	8	
WHITE	9	

EXAMPLE
47, 000 Ohms
or
47-KΩ



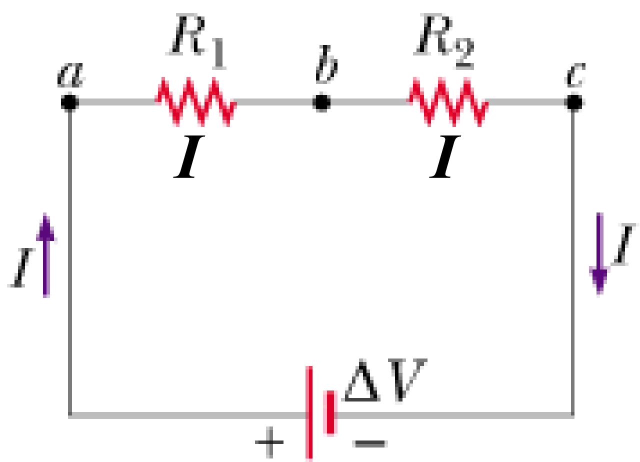
4 Band Color Code



Be Careful when reading 5 and 6 Band Resistors

Note: the 3rd Digit is not used when reading the 4 band resistor

Connecting resistors in series:



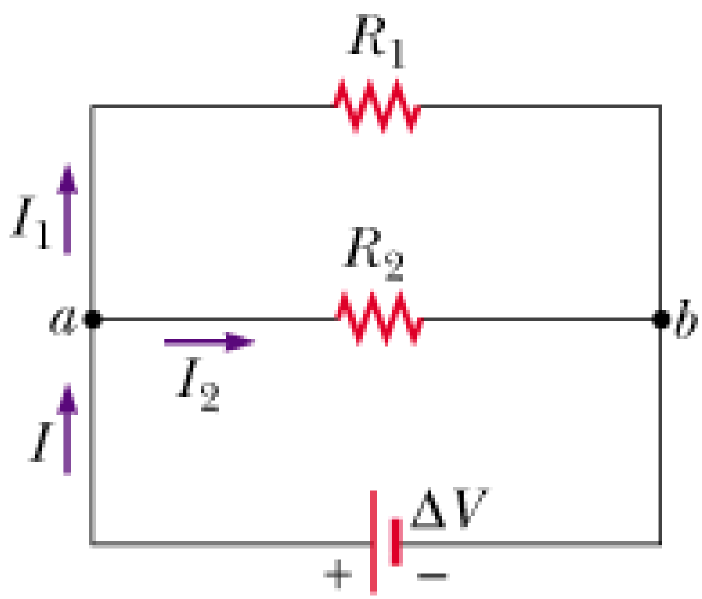
The same current I passes through both resistors R_1 and R_2.

$$\Delta V = I\,R_1 + I\,R_2$$
$$= I\,(R_1 + R_2)$$

➔For resistors connected in series:

$$R_{eq} = \sum_i R_i$$

Resistors connect in parallel



The same voltage ΔV passes through each resistor:

$\Delta V = I_1 R_1 = I_2 R_2$

➔For resistors connected in parallel:

$$\frac{1}{R_{eq}} = \sum_i \frac{1}{R_i}$$