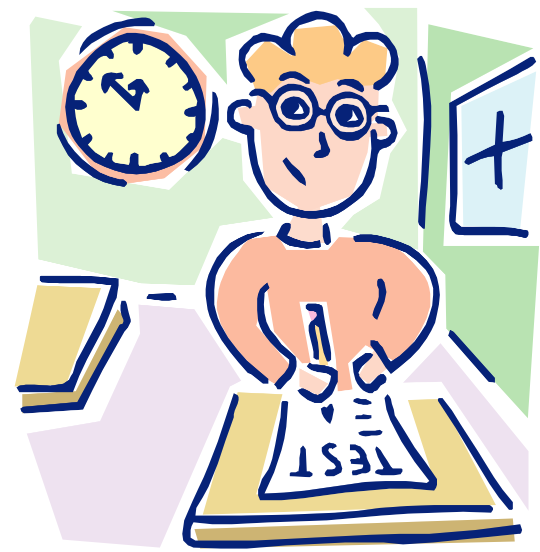
September 18th/19th

Chapter 27

Current and Resistance

Midterm-1 (see website)

- Wednesday Sept. 24th at 6pm
  - 4:10 pm – BCC N130 (Business College)
  - 6:00 pm – NR 158 (Natural Resources)
- Allowed one sheet of notes (both sides) and calculator
- Need photo ID
- Send me an email if you have a class conflict – make-up exam at 8 am Thursday in 3234 BPS
- Use the help-room to prepare
- Review in class on Tuesday

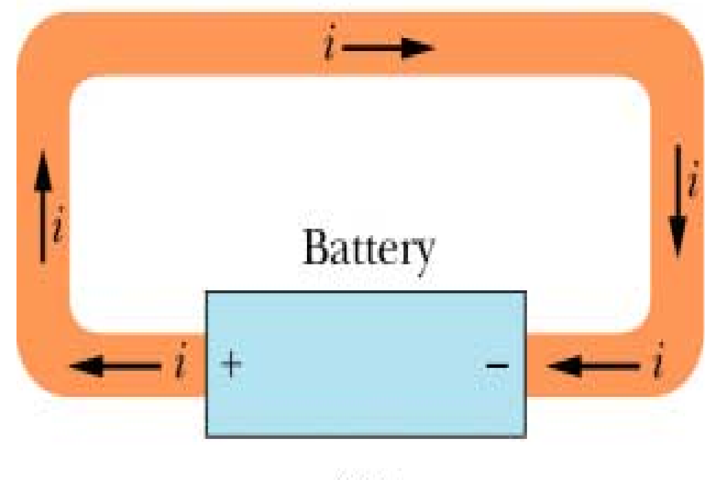


Current (Fig. 27-1)

- What happens when charges move?
- Isolated conductor –
  - Random motion of conduction electrons in both directions so no net transport of charges
  - Same potential everywhere, no *E* field inside or on surface so no electric *F* on electrons
- No current in isolated conductor

Current (Fig. 27-1)

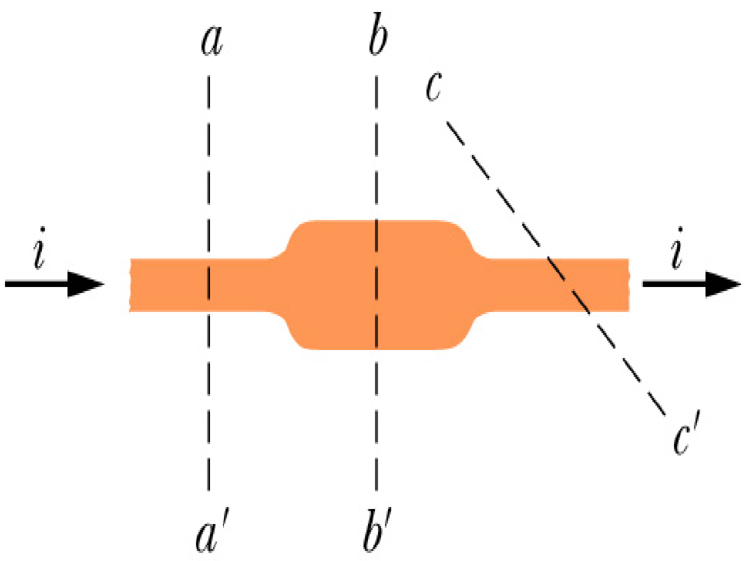
- What happens when charges move?
- Adding a battery –
  - Bias flow of conduction electrons in one direction have net transport of charge
  - Not a single potential, have *E* field inside which exerts *F* on electrons
- Current in a conductor when attached to a battery



Current (Fig. 27-2)

$$i = \frac{dq}{dt}$$

- Amount of current, *i* equals amount of *q* that passes in time *t* through an area ⊥ to the flow
- If *i* doesn't vary with time (called steady state) *q* is conserved, *i* is the same for all planes which pass through conductor
  - Orientation doesn't matter

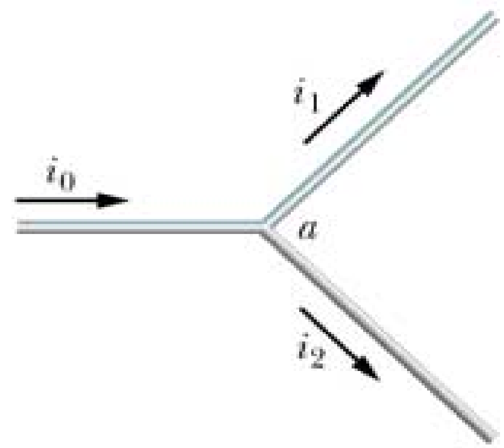


Current (Fig. 27-3)

- SI unit for current is ampere

$$1A = 1C/s$$

- Current is a scalar



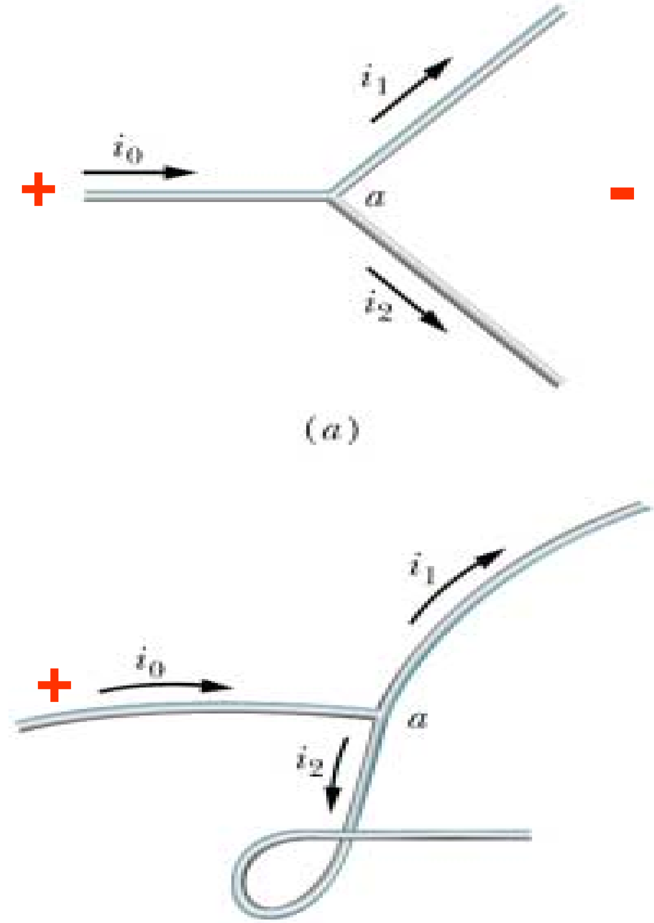
- Use arrows to indicate charge flow along conductor

- q is conserved so

$$i_0 = i_1 + i_2$$

Current (Fig. 27-3)

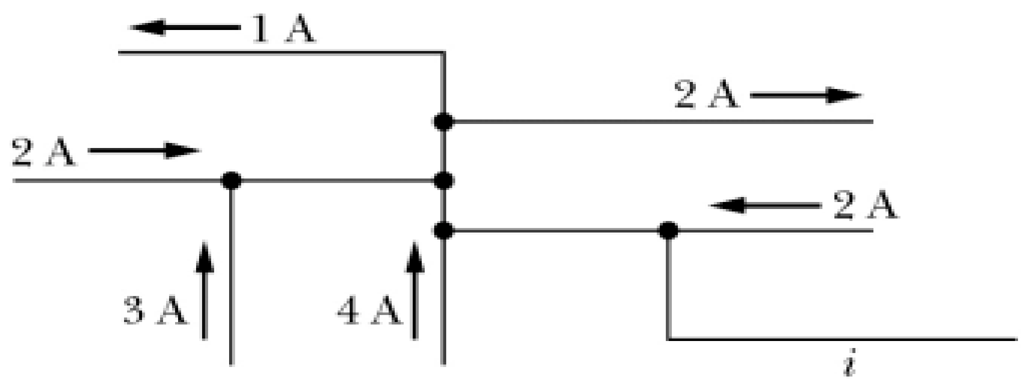
- Convention: a current arrow is drawn in direction of + charge flow
  - Defined direction of current is opposite to direction of physical current (electrons are the moving charges)
- Current arrows are not vectors
- Bending or reorienting wires does not change



$$i_0 = i_1 + i_2$$

Current (Checkpoint #1)

- What is the magnitude and direction of the current, *i*, in the lower right-hand wire?
- *q* is conserved



$$i_{in} = i_{out}$$

$$i_{in} = 11A \qquad i_{out} = 3A + i$$

$$i = 8A$$

To the right

Current and Resistance

- Total current through a surface can be defined in terms of the Current density, *J* – flow of charge through a cross section

$$i = \int \vec{J} \bullet d\vec{A}$$

- If *J* is uniform and parallel to *dA*

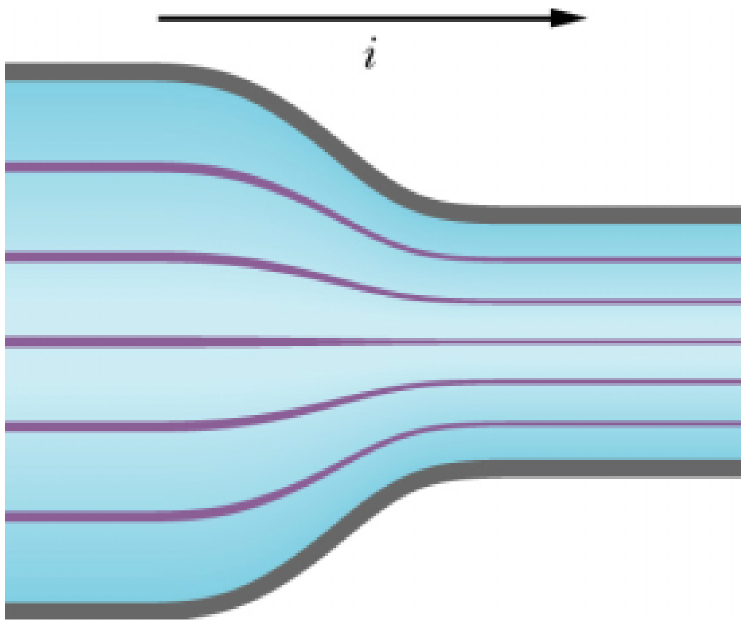
$$i = \int J dA = JA$$

$$J = \frac{i}{A}$$

- SI unit for *J* is A/m^2

Current and Resistance (Fig. 27-4)

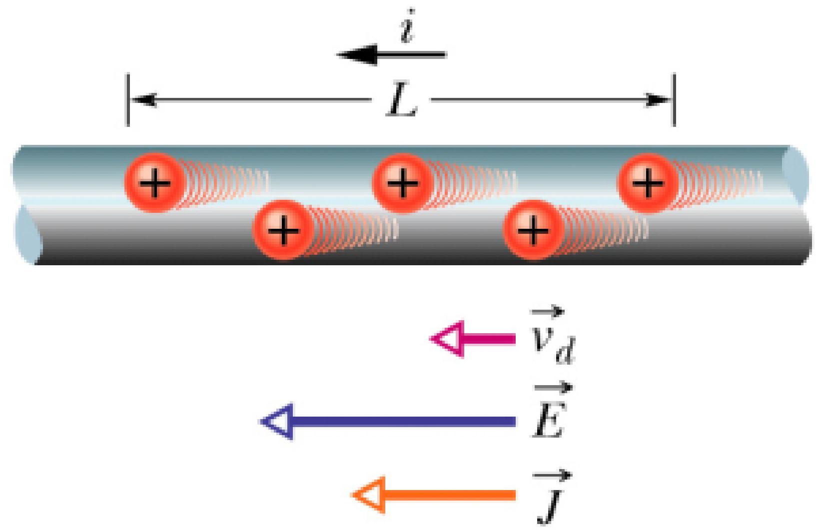
- Represent J by streamlines
- q is conserved so amount of i cannot change
- J becomes greater in narrower conductor
- Streamlines closer together mean greater J

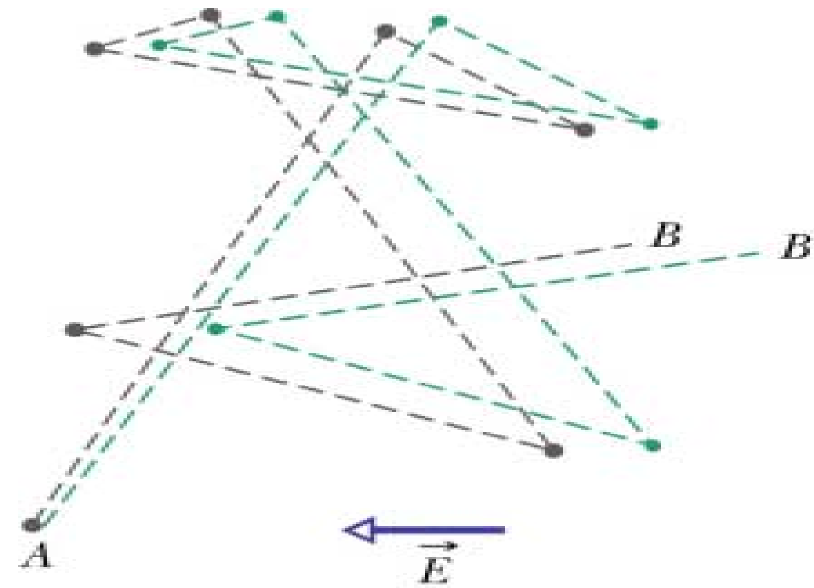


$$J = \frac{i}{A}$$

Current and Resistance (Fig. 27-5)

- No current in conductor - electrons move randomly with speeds ≈ 10^6 m/s (gray lines on bottom)
- If current is present electrons also move with a drift speed $-v_d$ (green lines)
- Drift speeds are tiny $|v_d| \approx 10^{-5}$ or 10^{-4} m/s



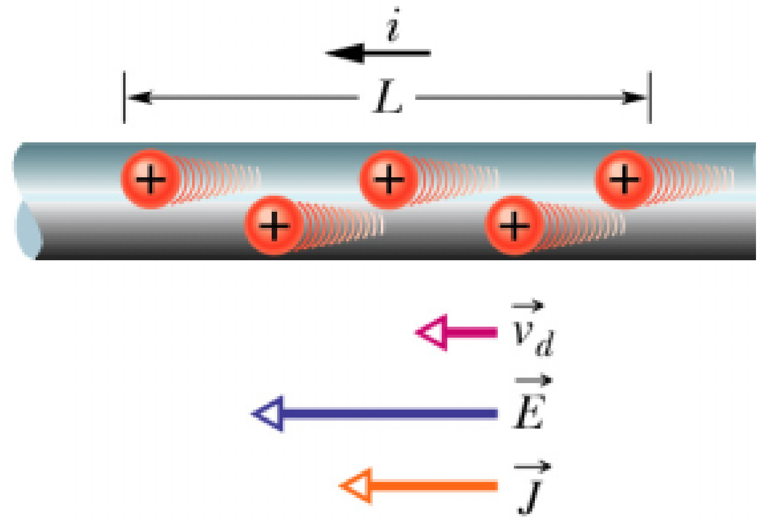


Current and Resistance

- Why do the lights come on quickly?

- *E* field provided by *V* moves at speed of light

- Relate the drift speed, v_d, to the charge density, J.



- Assume J uniform across cross-sectional area A

- Total charge in length L is

$$q = ne(AL)$$

- Where n = number of carriers per unit volume

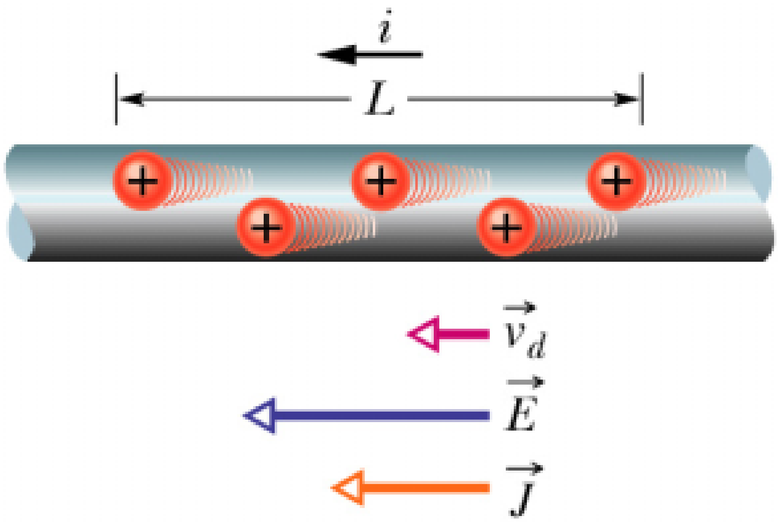
- Time to move a distance L is

$$t = \frac{L}{v_d}$$

Current and Resistance

- Current is given by

$$i = \frac{q}{t} = \frac{neAL}{L/v_d} = neAv_d$$



- Solving for drift speed

- $$v_d = \frac{i}{neA}$$ But $$J = \frac{i}{A}$$

- Thus $$\vec{v}_d = \frac{\vec{J}}{ne}$$ or $$\vec{J} = (ne)\,\vec{v}_d$$