Current conservation, power and fundamental circuits

Review:

$$\mathbf{I = \sigma A\, V/d = V / R}$$

where A is a cross section area of a wire, d is length.

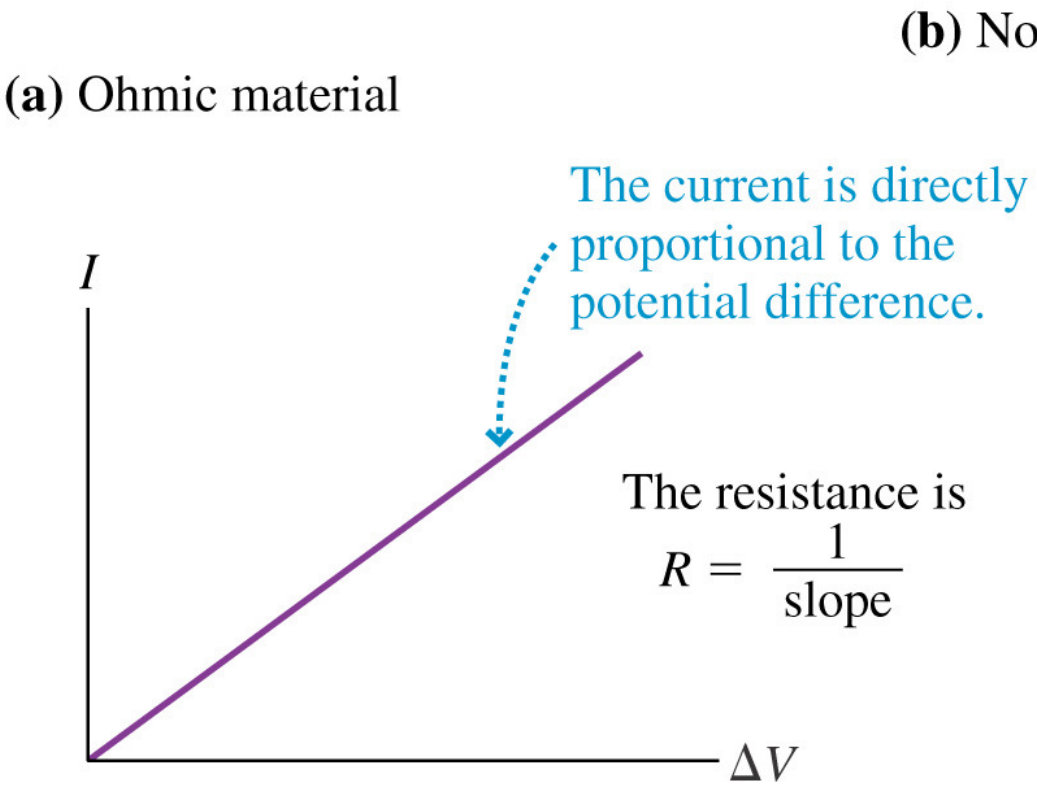
V is the voltage across the wire. We call the quantity characterizing the material conductivity σ.

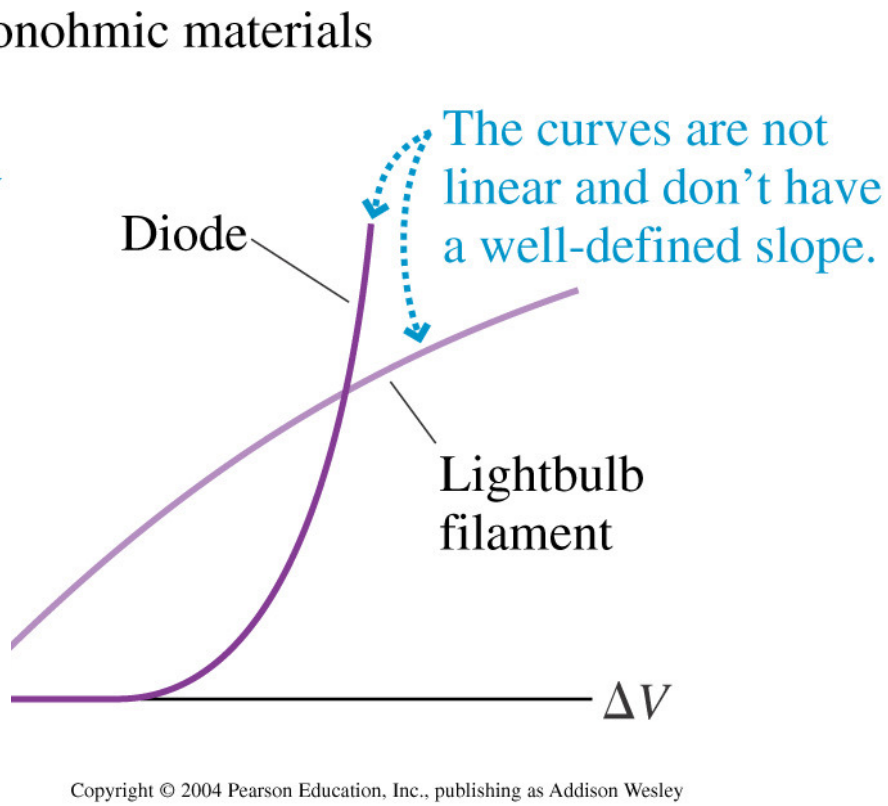
Inverse of σ is called resistivity **ρ**, $\rho = 1/\sigma$

$R = \boldsymbol{\rho}\, \mathbf{d/A}$

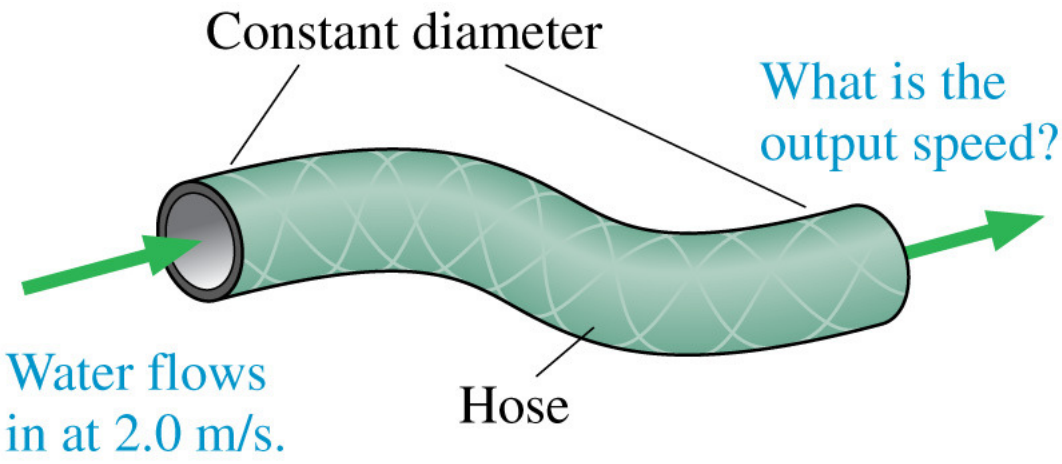
Resistance

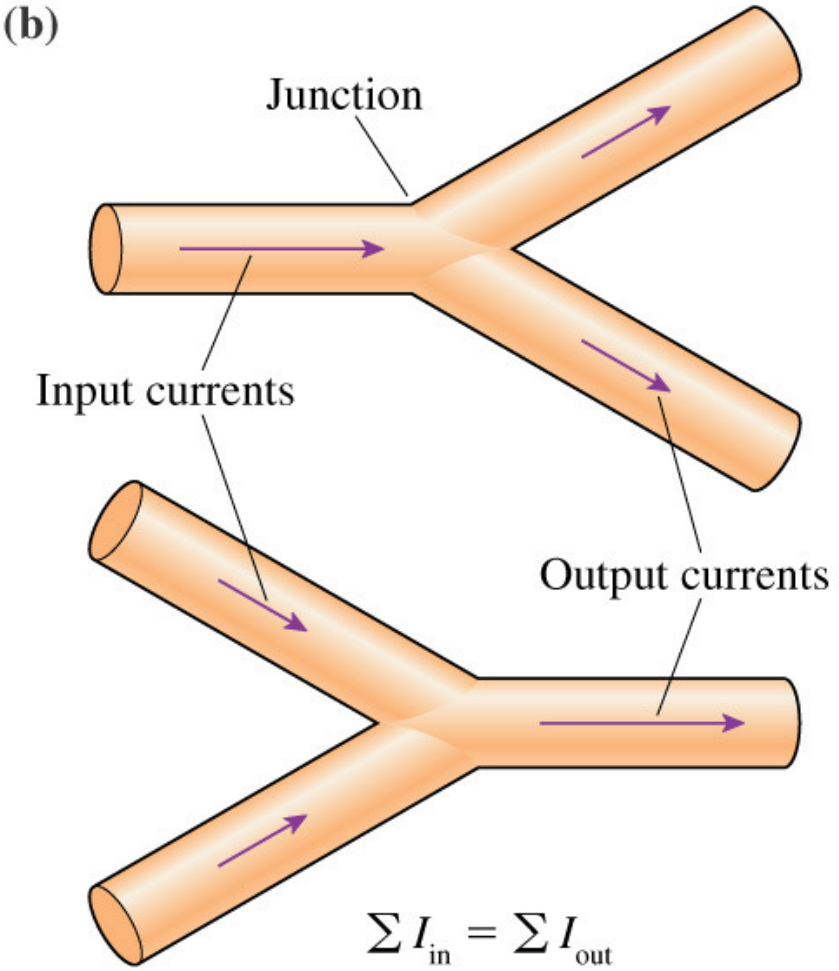
- Valid for “ohmic” devices mainly metallic conductors at constant temperature.



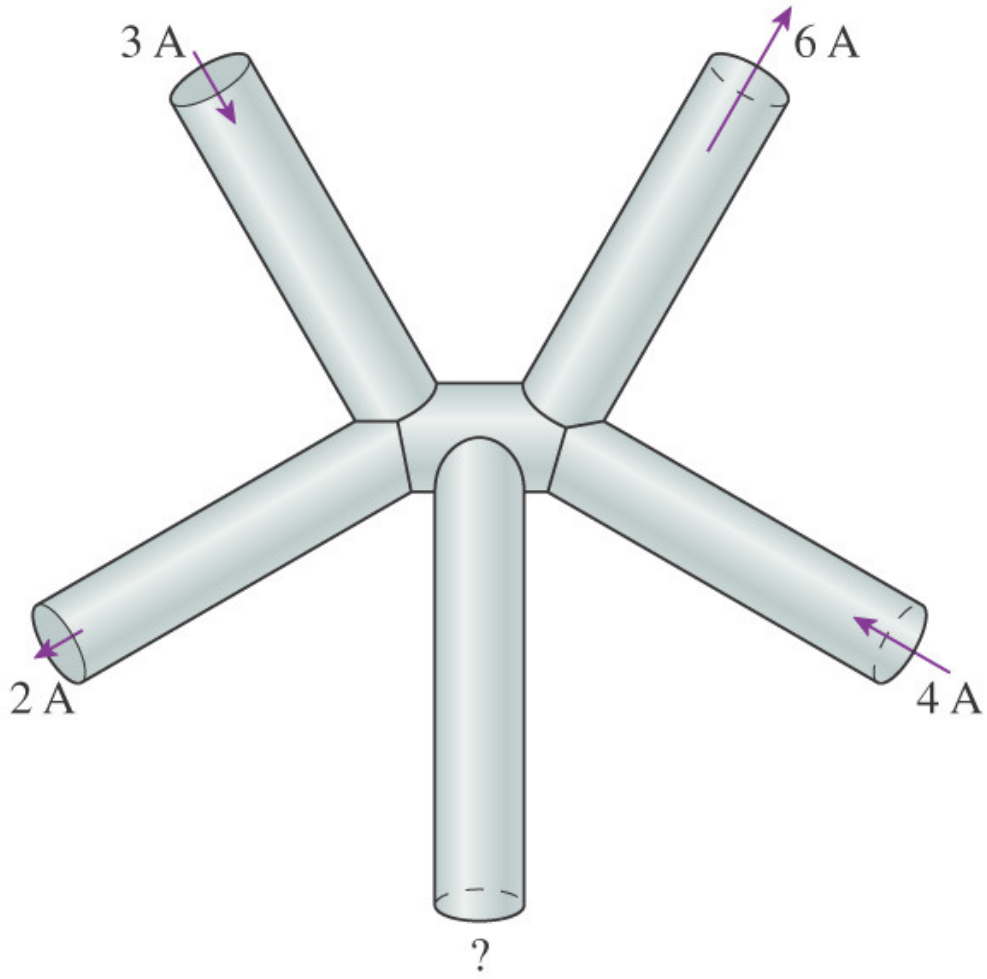


Conservation of current

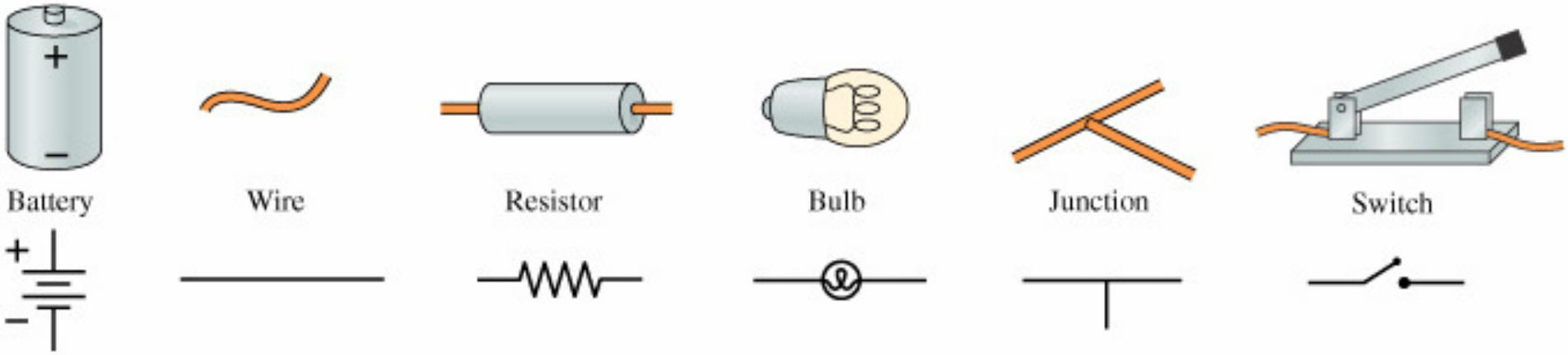




Q3. What is the magnitude of the current flowing through the conductor at the bottom?



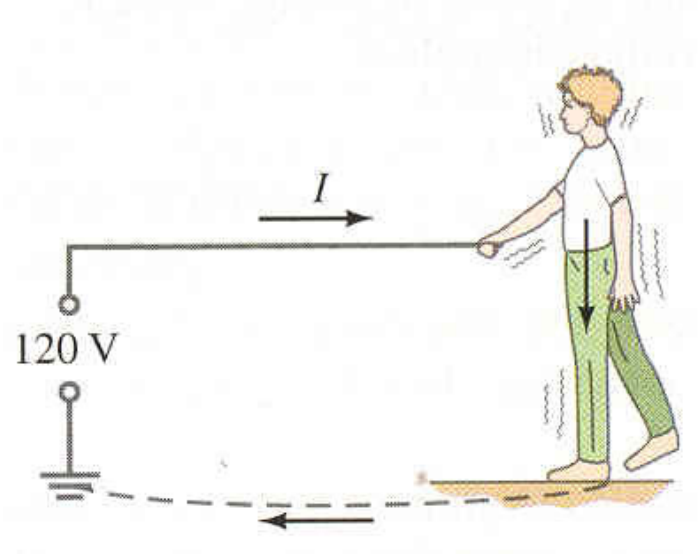
Circuit elements



Elements with negligible resistance---Wires.

We assume that there is no potential difference across a wire.

Electrical Hazards



Electrical Hazards

Feel: 1mA
pain: few mA
deadly: over 70mA

Electrical Power

- $P = VQ/t = VI$
- Unit: Watt (W) = VA
- kW, MW, GW

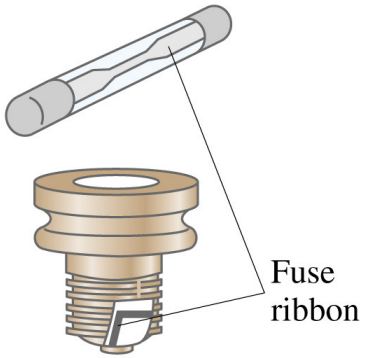
Electrical power on the ohmic device

- $P = VI$
- $V = RI$ (Ohm's Law)
- $P = V^2/R = I^2R$

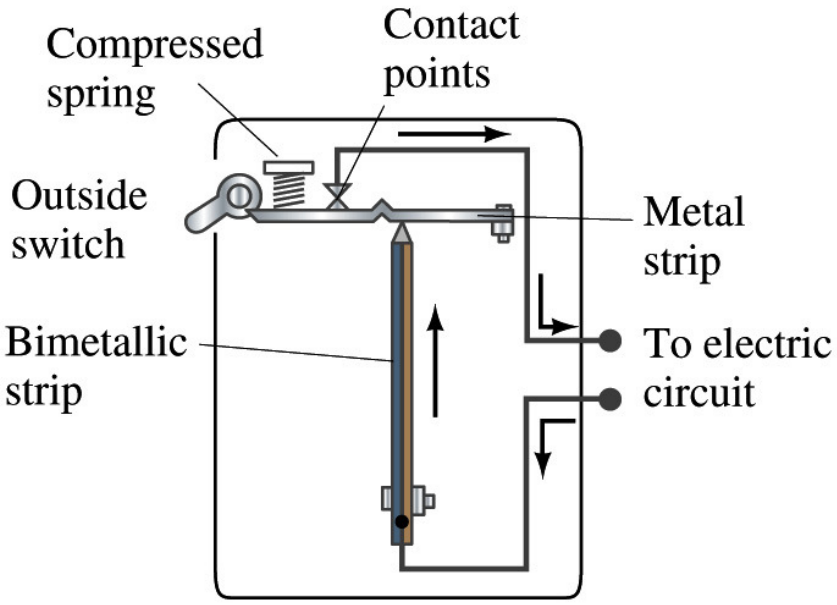
Q2. The 60 W bulb is working at 120V. What is the current flowing through the bulb?

Q3. The 60 W bulb is working at 120V. What is the resistance of the bulb (in ohms)?

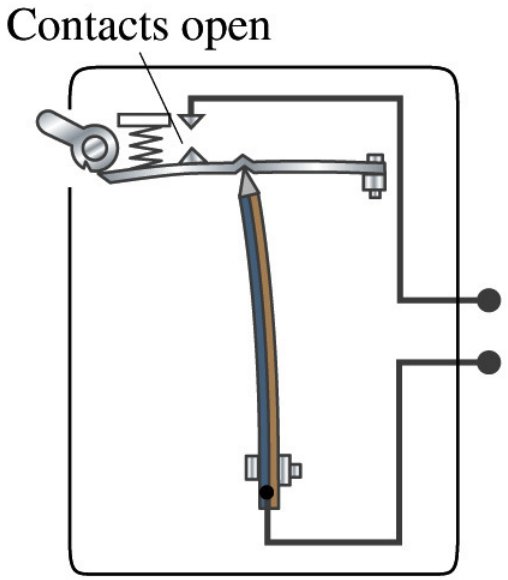
Fuses and switch



(a) Fuses



(b) Circuit breaker
(closed)



(c) Circuit breaker
(open)

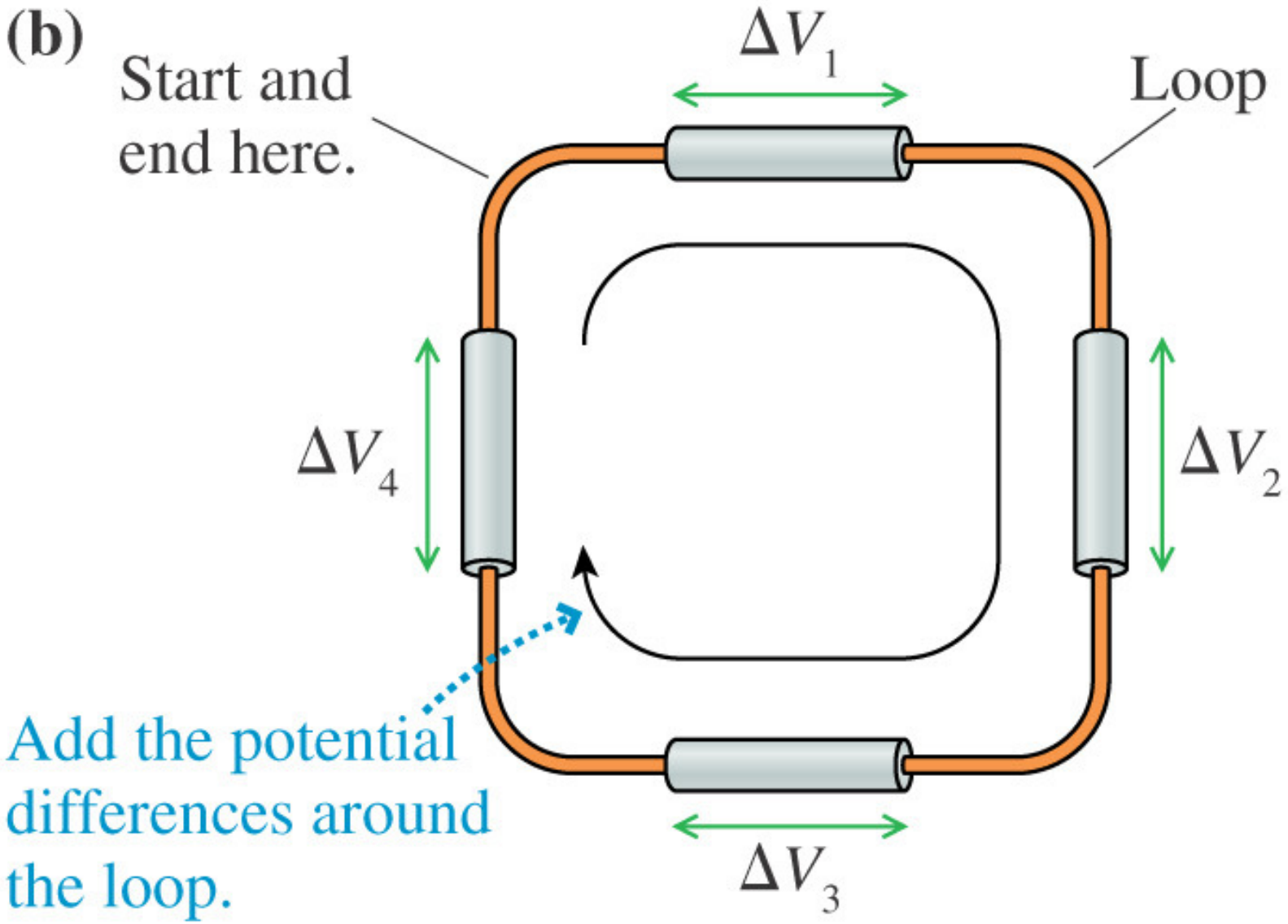
Q4. The voltage across the nail is 2V at 25A. What is the resistance of the nail (in Ohms)?

Q5. The voltage across the nail is 2V at 25A. What is the power dissipated in the nail?

Kirchhoff's rules

- At any junction point, the sum of all currents entering the junction must equal the sum of all currents leaving the junction.

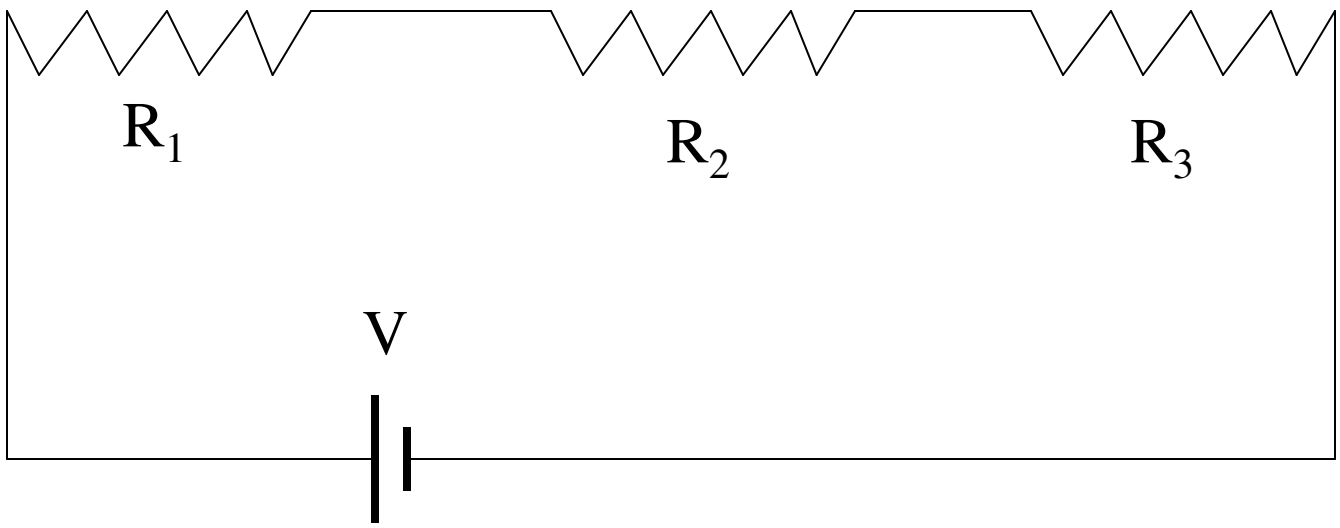
  (Conservation of charge)
- The Sum of the changes in potential around any closed path of the circuit must be zero



Loop law: $\Delta V_1 + \Delta V_2 + \Delta V_3 + \Delta V_4 = 0$

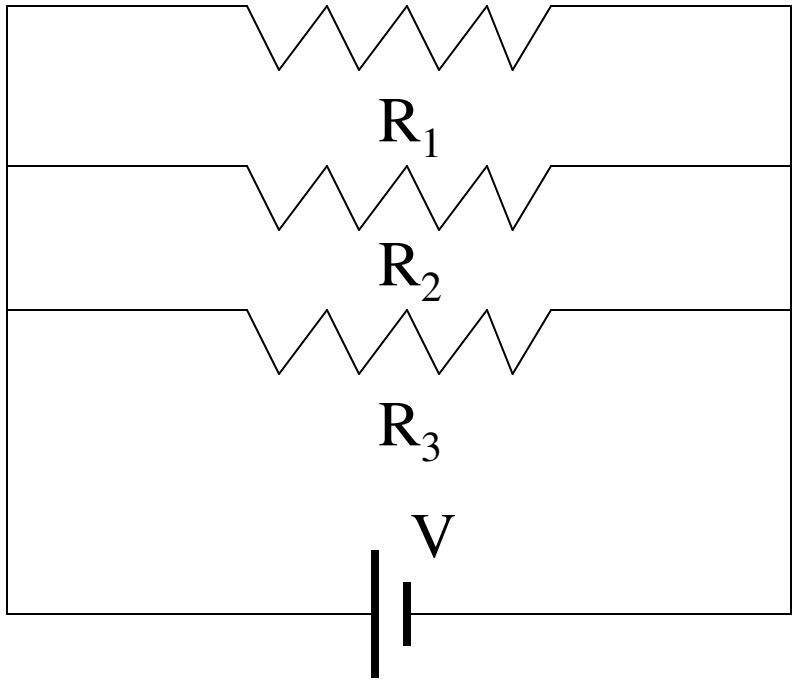
Combinations of resistors

- Resistors in series:
- $V = V_1+V_2+V_3 = IR_1+ IR_2+ IR_3$
- $R_{eq} = V/I = R_1+ R_2+ R_3$



Combinations of resistors

- Resistors in parallel
- $I = I_1+I_2+I_3 = V/ R_1 + V/ R_2+ V/R_3$
- $I = V/R_{eq}$
- $1/R_{eq} = 1/ R_1+ 1/ R_2+ 1/R_3$



Combinations of resistors

- Resistors in parallel
- $1/R_{eq} = 1/ R_1 + 1/ R_2 + 1/R_3$
- $R_{eq} = R_1 \cdot R_2 \cdot R_3 / (R_1 \cdot R_2 + R_2 \cdot R_3 + R_1 \cdot R_3)$
- Notice R_{eq} is smaller than all of them!