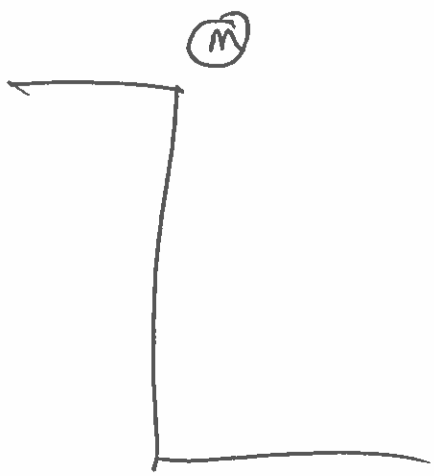
Ohm's Law

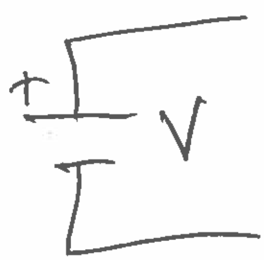
$$i = \left(\frac{1}{R}\right) V \qquad V = iR \qquad R = \frac{V}{i}$$

3 Primary variables of electrical circuits

- i – current — is through an element
- V – voltage — is across an element
- R – Resistance. – is of an element



Power source



Voltmeter Ammeter

Measures voltage across

Measures current through

Resistor

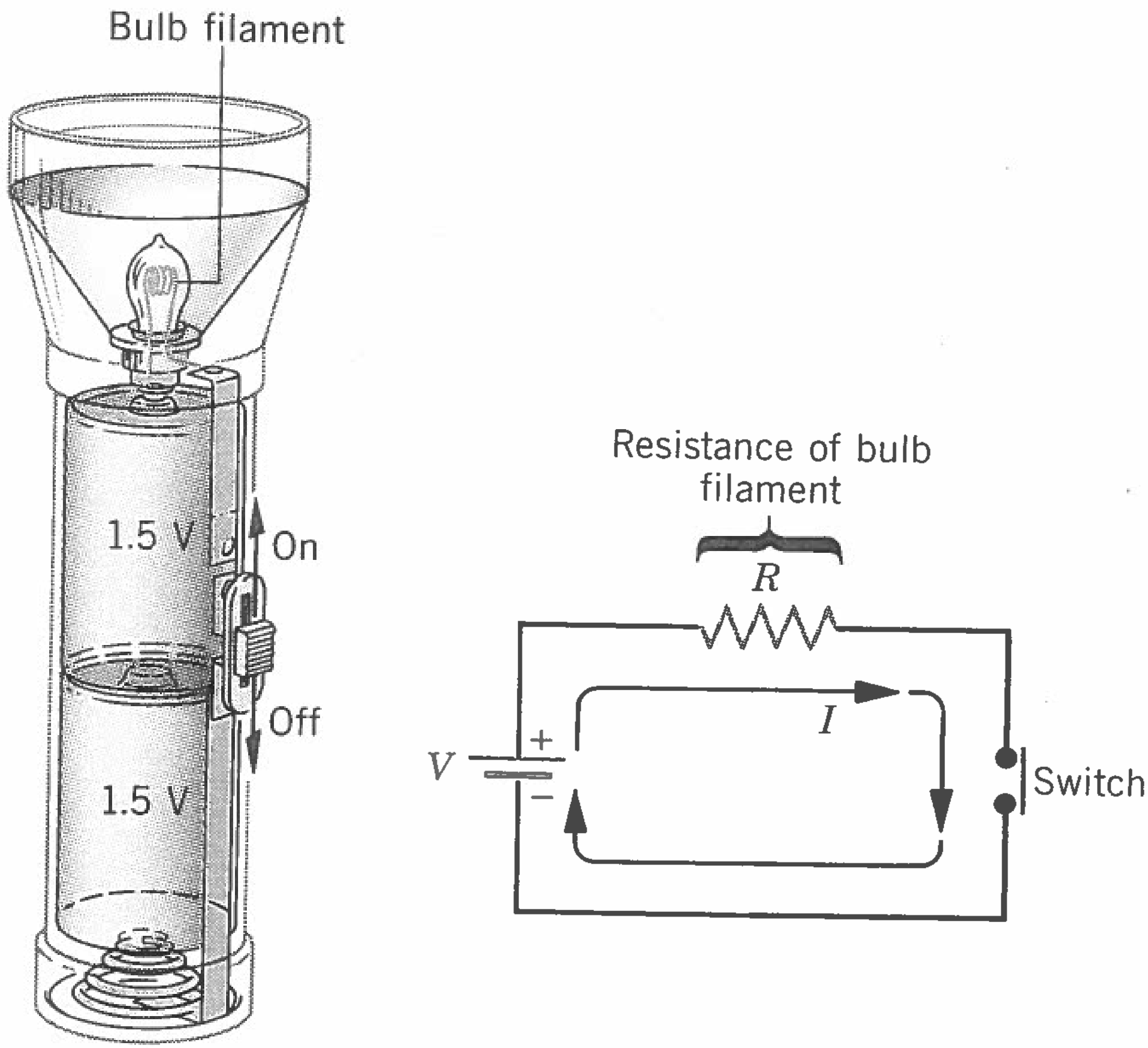


FIGURE 20.6 138

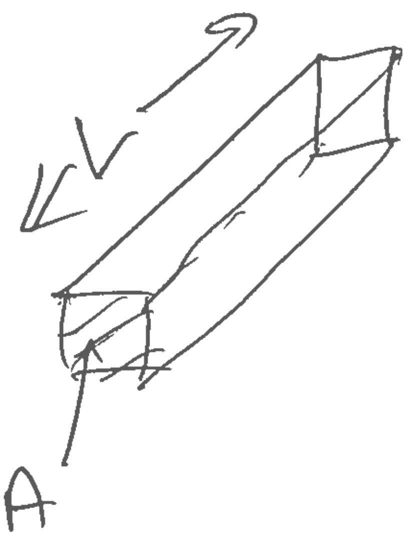
Flashlight Bulb has 0.40 A

$$V = 1.5V + 1.5V = 3.0V$$

$$R = ?$$

$$R = \frac{V}{I} = \frac{3.0V}{0.4A} = 7.5\Omega$$

Resistance is the opposition to the flow of current in a circuit.



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

ρ – resistivity ($\Omega \cdot m$)

It is a material dependent quantity

L – Length of the component

A – Cross-sectional Area

$$\rho_{maple} = 3 \times 10^{10}\ \Omega m$$

$L = 1\ m$

$A = 0.25\ m^2$ (.50m on a side)

$$R = \frac{\rho L}{A} = \frac{(3 \times 10^{10}\ \Omega m)(1m)}{0.25m}$$

$$\boxed{R = 12 \times 10^{10}\ \Omega}$$

ρ is Temperature dependent

$$\rho = \rho_0 (1 + \alpha(T - T_0))$$

ρ_0 resistivity at a reference Temperature $\sim 20°C$

α is the Temperature coefficient

T_0 is reference Temp $\sim 20°C$

If $\alpha < 0$ Then resistance decreases with rising Temperature

Usually $\alpha > 0$. $\alpha < 0 \Rightarrow$ Semi-conductors

$$\rho = \rho_0 (1 + \alpha(T - T_0)) \qquad R = \frac{\rho L}{A}$$

$$R = R_0(1 + \alpha(T - T_0))$$

Wire made of Iron $R = 100\,\Omega$ @ $20°C$

$\alpha_{Fe} = 0.0050/°C$ $R = ?$ @ $420°C$

$$R_{420°C} = R_{20°}(1 + \alpha(T - T_{20}))$$

$$= (100\,\Omega)(1 + (0.0050/°C)(420° - 20°C))$$

$$\boxed{R_{420} = 300\,\Omega}$$

$$\text{Power} = \frac{\text{work}}{\text{time}} = \frac{Q\Delta V}{t}$$

$$\text{Power} = \left(\frac{Q}{t}\right)\Delta V = i\,\Delta V = iV$$

$$P = iV$$

Use ohms Law

$$P = iV = i(iR) = i^2R$$

$$P = iV = \left(\frac{V}{R}\right)V = \frac{V^2}{R}$$

$$\boxed{P = iV = i^2R = \frac{V^2}{R}}$$

60 Watt Light bulb $\Rightarrow$ electrical outlet $\sim 120V$

$R = ?$

$$P = \frac{V^2}{R} \Rightarrow R = \frac{V^2}{P} = \frac{(120V)^2}{60W}$$

$$\boxed{R = 240\,\Omega}$$

BACK TO flashlight

$i = 0.40A \quad V = 3.0V$

$P = iV = (.40\,A)(3.0V) = 1.20\,W$

How much energy do Batteries Provide for 5 minutes of use?

Energy = (Power)(time)

$\text{Energy} = (1.20\,W)(5\,min)\left(\frac{60\,s}{min}\right)$

Energy = 360J

kW hr — kilowatt hr

$(1000\,\frac{J}{s})(3600\,s) = 3.6$ Million Joules

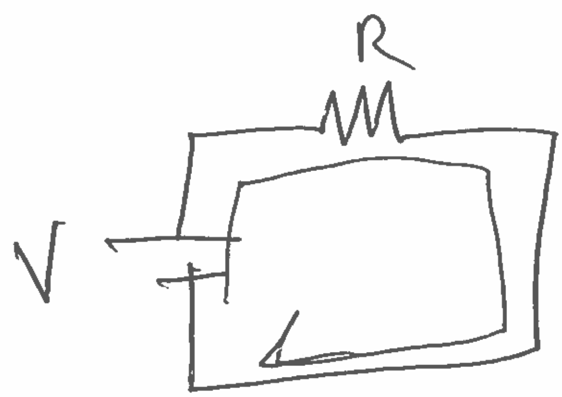
on Batteries A hr — Amp hours ⇒ charge

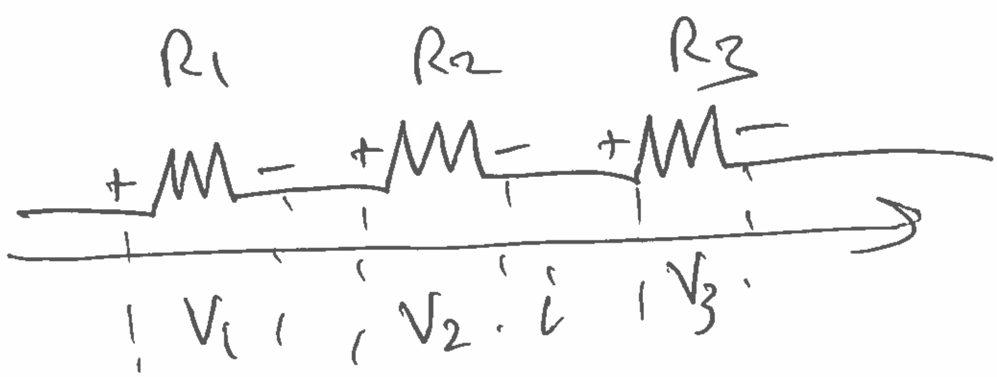
How many Amps for 1hr

48 Ahr ⇒ 48 A for 1hr
24A for 2hr

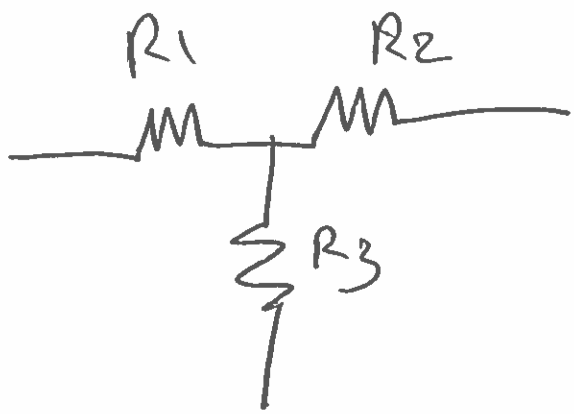
Series circuits

Two electrical elements are wired in series if the current has no option other than to go from one ~~item~~ element directly into the next element

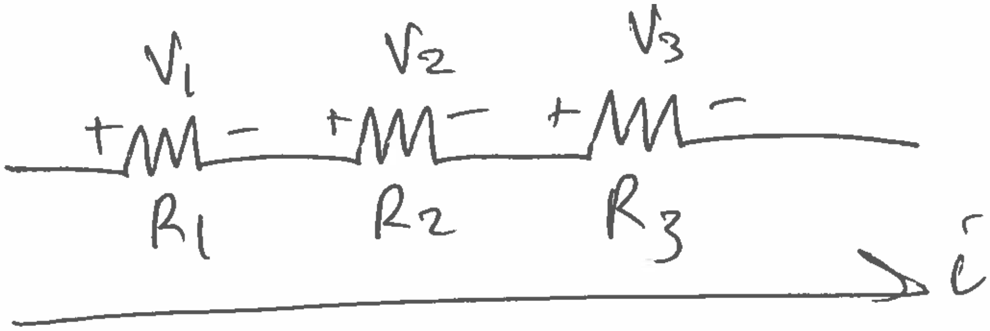




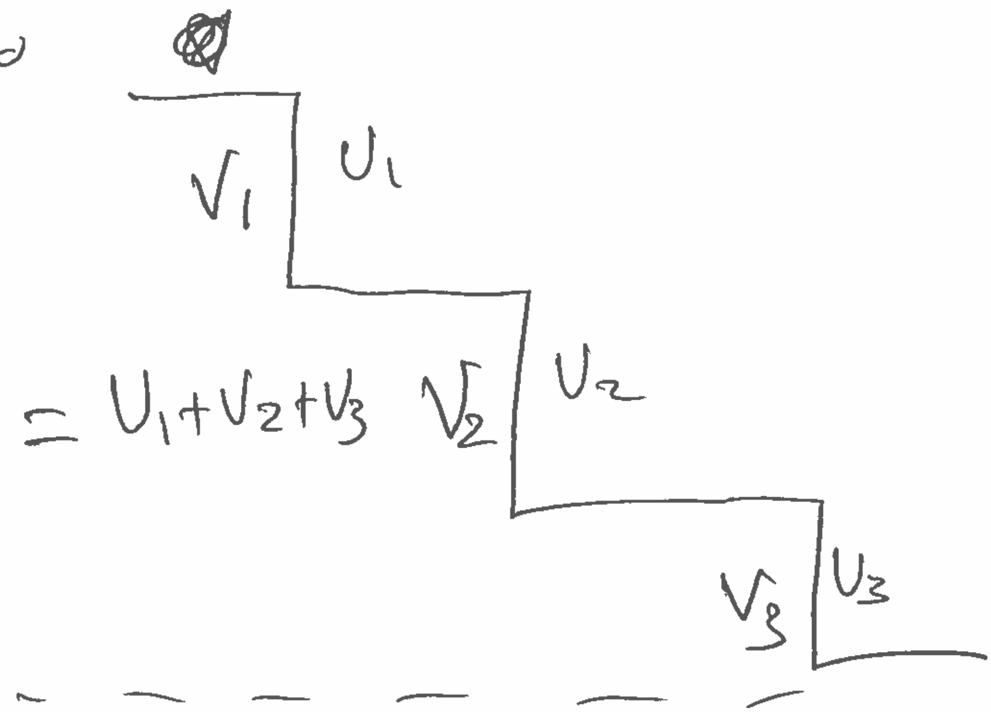
3 resistors in series



3 resistors not in series



equivalent To



$$U_{TOT} = U_1 + V_2 + V_3$$

$$V_{TOT} = V_1 + V_2 + V_3$$

$$i_{TOT} R_{TOT} = i_1 R_1 + i_2 R_2 + i_3 R_3$$

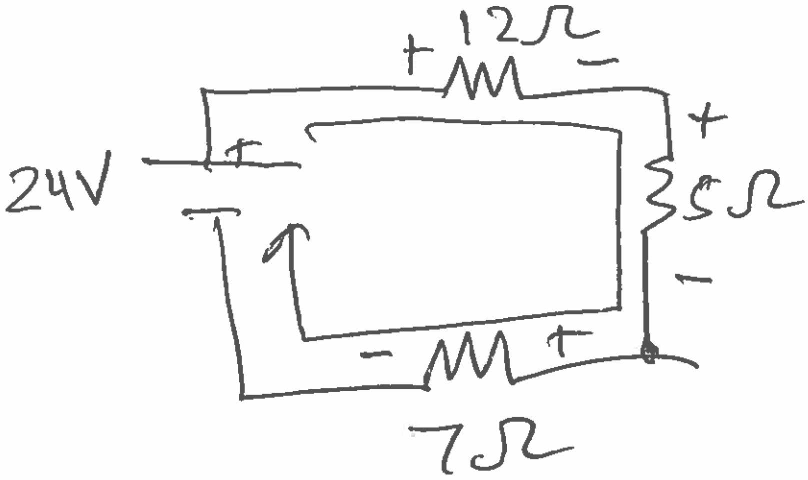
$$i_{TOT} = i_1 = i_2 = i_3 = i$$

$$i R_{TOT} = iR_1 + iR_2 + iR_3 \Rightarrow$$

$$R_{TOT} = R_1 + R_2 + R_3$$

Series

$$R_{\substack{series\\Total}} = \sum_{i=1}^{n} R_i = R_1 + R_2 + \cdots + R_n$$



$$R_{TOT} = 12\Omega + 5\Omega + 7\Omega$$

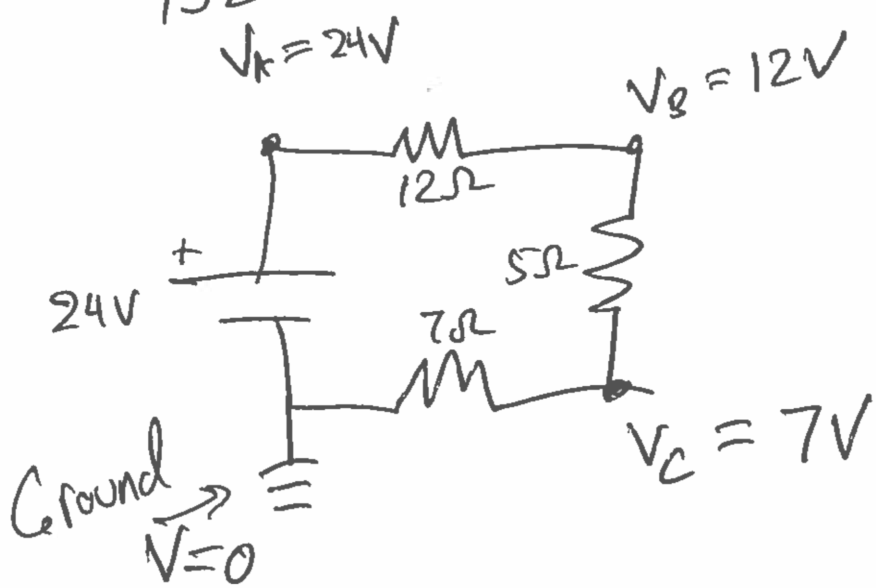
$$R_{TOT} = 24\Omega$$

$$i_{TOT} = \frac{V_{TOT}}{R_{TOT}} = \frac{24V}{24\Omega} = \boxed{1A}$$

$$V_{12\Omega} = iR_{12} = (1A)(12\Omega) = 12V$$

$$V_{5\Omega} = iR_5 = (1A)(5\Omega) = 5V$$

$$V_{7\Omega} = iR_7 = (1A)(7\Omega) = 7V$$



Series Circuits are Voltage dividers