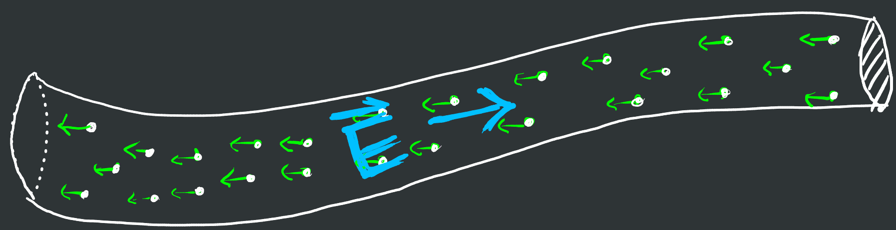
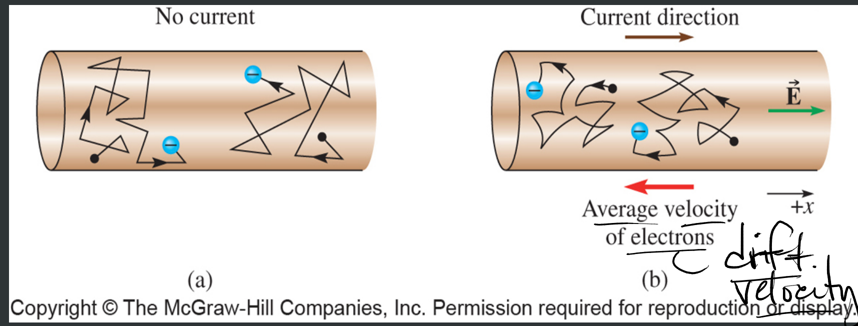
Chapter 18 - Circuits – resistance

After this you can
- discuss the new quantity of current → flow of charge
- differentiate the direction of current in real devices

$$I = \frac{\text{number of charges}}{\text{time interval}}$$

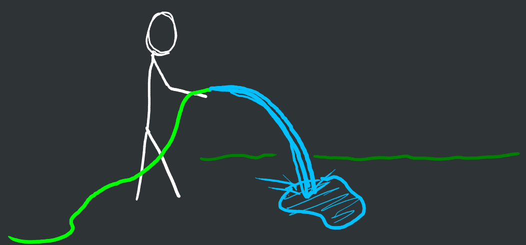
$$\left[\frac{C}{s}\right] = [\text{Ampere}] = [\text{Amps}] = [A]$$

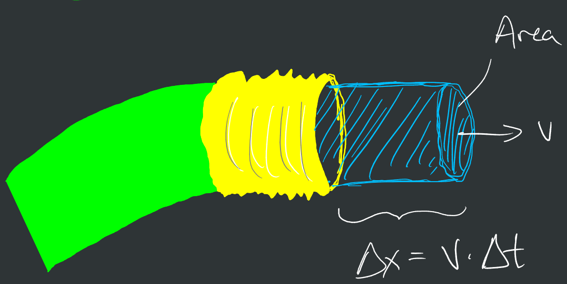




Conditions for current flow:
1. charges present in a region
2. charge are free to move
3. electric field is present

} metal conducting wire
→ only electrons move





Volumetric flow rate:

$$\frac{\Delta V}{\Delta t} = A \cdot v$$

Mass flow rate:

$$\frac{\Delta m}{\Delta t} = \rho_m \cdot A \cdot v$$

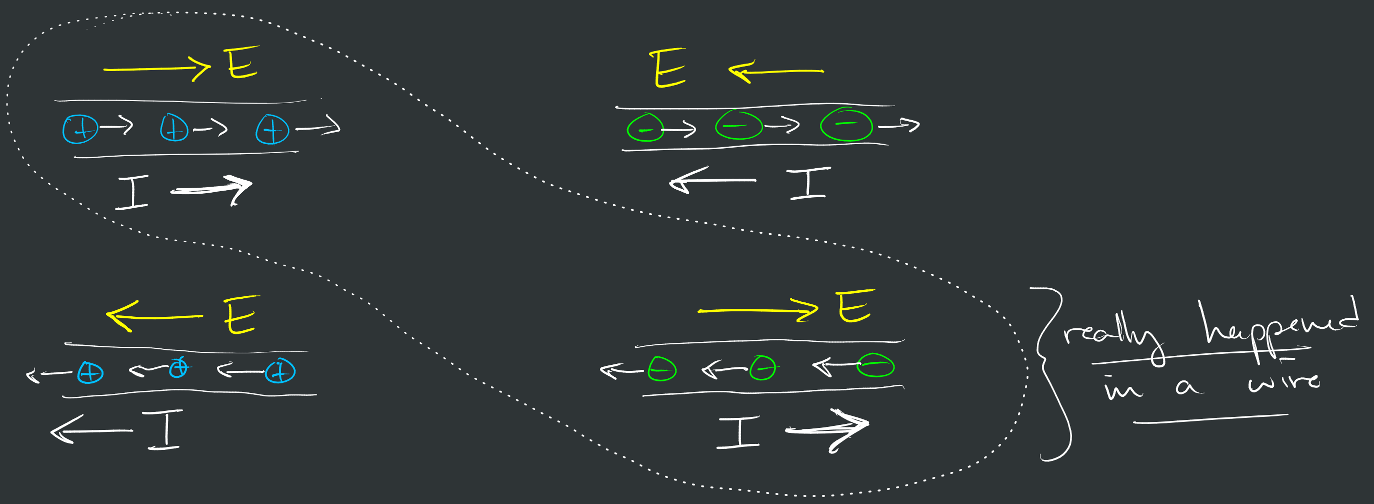
kg/m³

Charge flow rate:

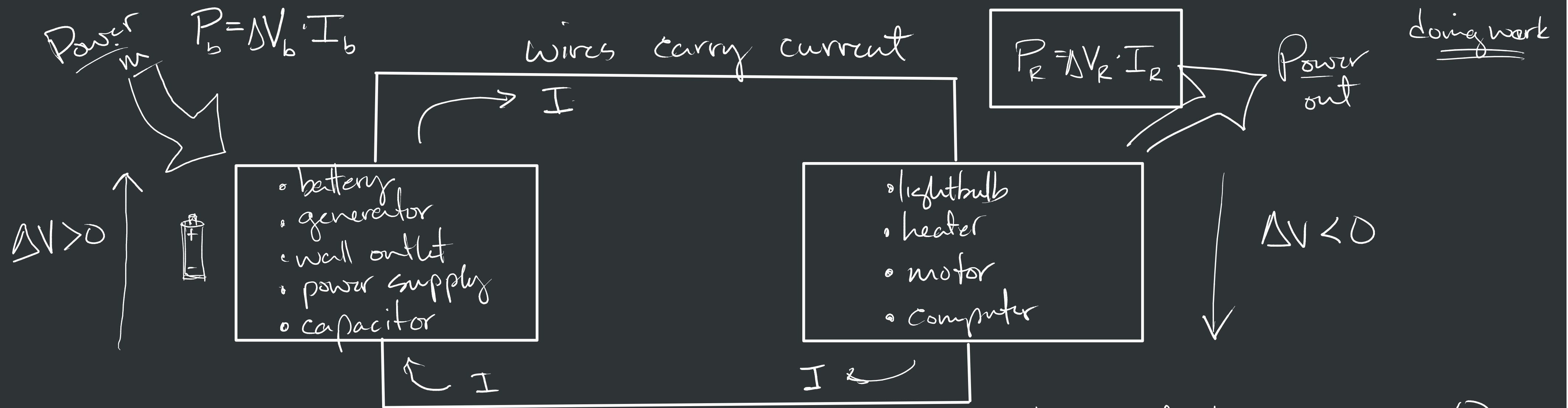
$$I = \frac{\Delta q}{\Delta t} = \rho_c \cdot A \cdot v$$

charge density C/m³

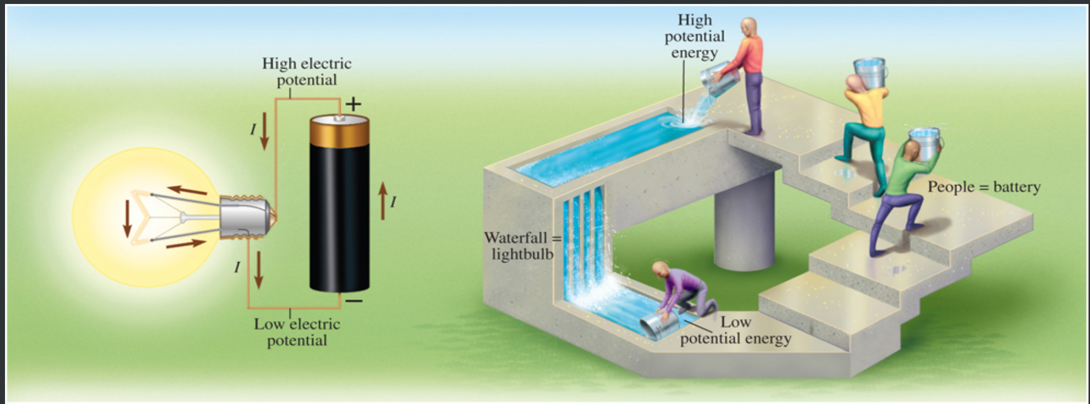
$$\boxed{I = e \cdot n \cdot A \cdot v}$$



After this you can
- discuss the construction of a circuit
- use Ohm's law to determine the resistence of a circuit
- discuss power input and output in circuits



Conservation of Energy $\longrightarrow$ potential increases + potential decreases $= 0$



Ohm's Law

$I \propto \Delta V$

$\frac{\Delta V}{I} = \text{Resistance}$

$\boxed{\Delta V = I \cdot R}$

Idealized resistor

$R = 100\,\Omega$

$\left[\frac{V}{A}\right] = [\text{Ohms}]$

$= [\Omega]$

Resistance in a wire:

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

resistivity

Table 18.1 Resistivities and Temperature Coefficients at 20°C

	ρ (Ω·m)	α (°C^{-1})		ρ (Ω·m)	α (°C^{-1})
Conductors			**Semiconductors (pure)**		
Silver	1.59×10^{-8}	3.8×10^{-3}	Carbon	3.5×10^{-5}	-0.5×10^{-3}
Copper	1.67×10^{-8}	4.05×10^{-3}	Germanium	0.6	-50×10^{-3}
Gold	2.35×10^{-8}	3.4×10^{-3}	Silicon	2300	-70×10^{-3}
Aluminum	2.65×10^{-8}	3.9×10^{-3}			
Tungsten	5.40×10^{-8}	4.50×10^{-3}			
Iron	9.71×10^{-8}	5.0×10^{-3}	**Insulators**		
Lead	21×10^{-8}	3.9×10^{-3}	Glass	$10^{10} - 10^{14}$	
Platinum	10.6×10^{-8}	3.64×10^{-3}	Lucite	$> 10^{13}$	
Manganin	44×10^{-8}	0.002×10^{-3}	Quartz (fused)	$> 10^{16}$	
Constantan	49×10^{-8}	0.002×10^{-3}	Rubber (hard)	$10^{13} - 10^{16}$	
Mercury	96×10^{-8}	0.89×10^{-3}	Teflon	$> 10^{13}$	
Nichrome	108×10^{-8}	0.4×10^{-3}	Wood	$10^{8} - 10^{11}$	

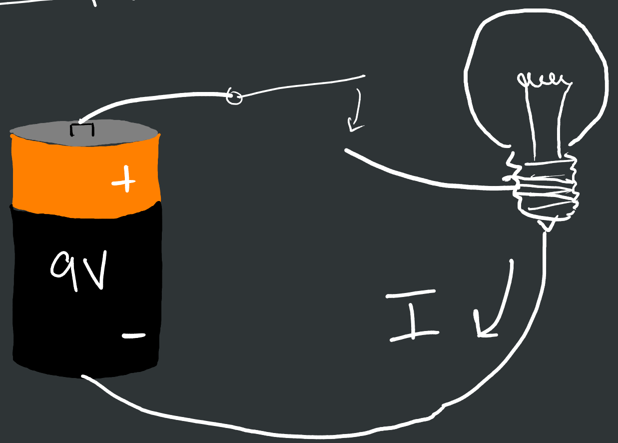
After this you can

- discuss the difference between resistors connected in series and resistors connected in parallel
- use the conservation of energy to set up an equation to solve for an unknown quantity in a circuit

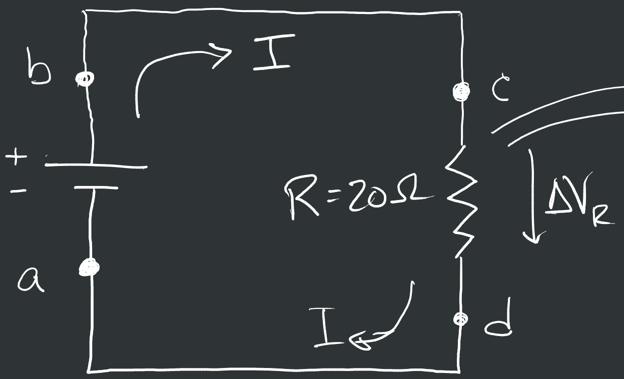
"emf"

$\mathcal{E}$

Example



$+9V = \Delta V_b$



$$P_b = \Delta V_b \cdot I_b$$
$$= 9V \cdot 0.45\ A$$
$$P_b = 4.05\ \text{Watts}$$

$$P_R = \Delta V_R \cdot I_R$$
$$= 9V \cdot 0.45A$$
$$P_R = 4.05\ \text{Watts}$$

→ loop around the circuit

$$+\Delta V_b - \Delta V_R = 0$$

$$\Delta V_b = \Delta V_R$$

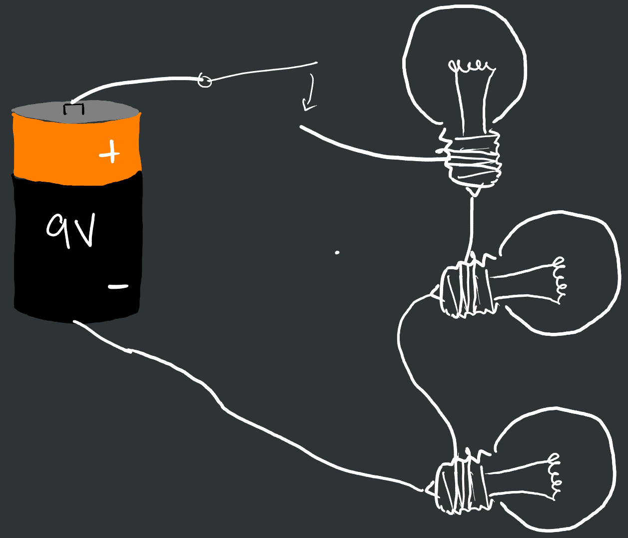
Ohm's Law

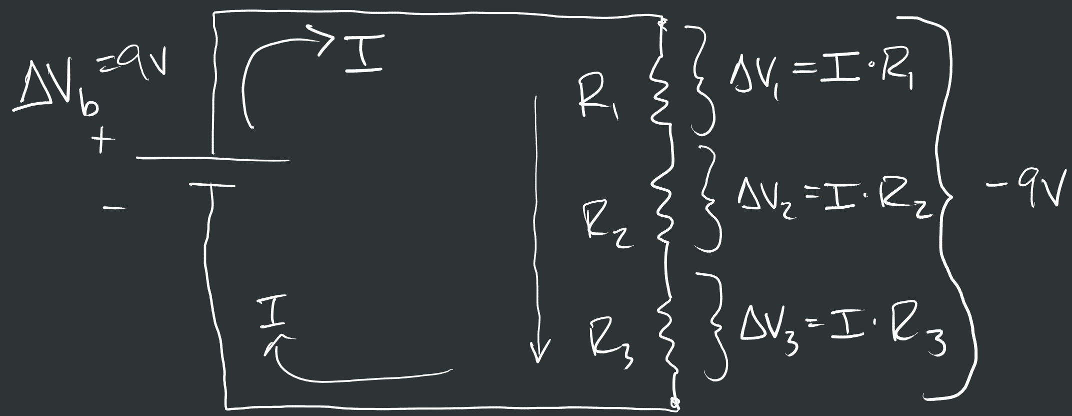
$$\Delta V_R = I \cdot R$$

$$\Delta V_b = I \cdot R$$

$$\frac{\Delta V_b}{R} = I \longrightarrow \frac{9V}{20\Omega} = I = 0.45\ A$$

Resistors in series
- resistors connected end to end
- one pathway out of the battery
- current is the same through each resistor





loop $\longrightarrow$ $+\Delta V_b - \Delta V_1 - \Delta V_2 - \Delta V_3 = 0$

$$\Delta V_b = \Delta V_1 + \Delta V_2 + \Delta V_3$$

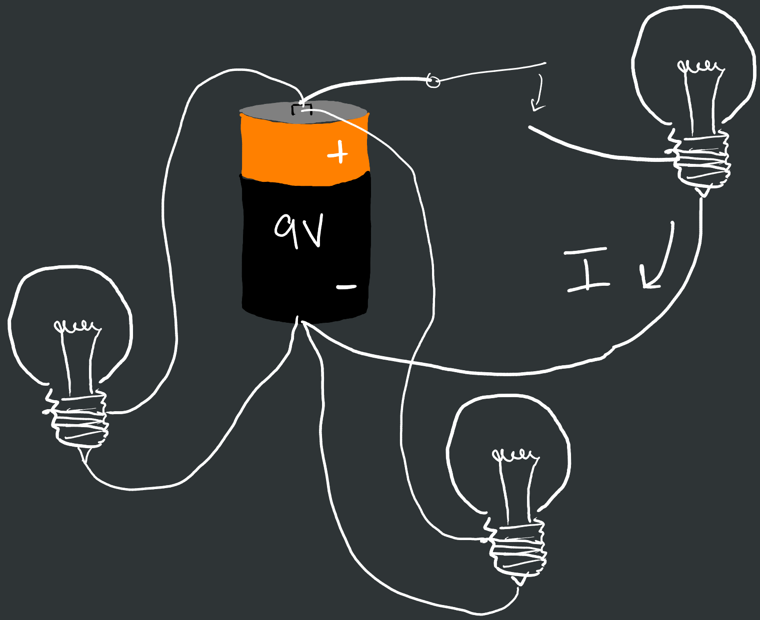
$$\Delta V_b = IR_1 + IR_2 + IR_3$$

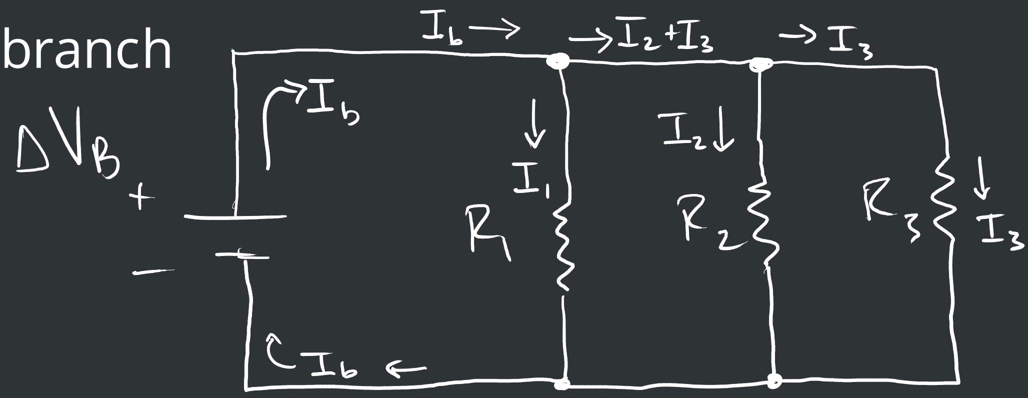
Equivalent Resistance of Resistors in Series

$$\Delta V_b = I\underbrace{(R_1 + R_2 + R_3)}_{R_E} \Rightarrow \frac{\Delta V_b}{R_E} = I$$

↳ $\underline{R_E} = R_1 + R_2 + R_3 + \ldots$

Resistors in parallel
- each resistor has its own connection
  to the power supply
- potential drop is the same across
  each resistor
- current through the battery is the sum
  of the currents through each branch





$$\Delta V_b - \Delta V_1 = 0 \qquad \Delta V_b - \Delta V_2 = 0 \qquad \Delta V_b - \Delta V_3 = 0$$

$$\Delta V_b = I_1 \cdot R_1 \qquad \Delta V_b = I_2 R_2 \qquad \Delta V_b = I_3 R_3$$

$$I_1 = \frac{\Delta V_b}{R_1}$$

$$I_b = I_1 + I_2 + I_3$$

$$I_b = \frac{\Delta V_b}{R_1} + \frac{\Delta V_b}{R_2} + \frac{\Delta V_b}{R_3}$$

$$\Delta V_b = I_b \cdot R_E$$

$$I_b = \frac{\Delta V_b \left(\cancel{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} \right)}{\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right) \left(\cancel{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} \right)}$$

$$\Delta V_b = I_b \cdot \underbrace{\boxed{\frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}}}_{R_E}$$

$$\rightarrow \boxed{R_E = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots}}$$

$$\boxed{\frac{1}{R_E} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots}$$

from the book