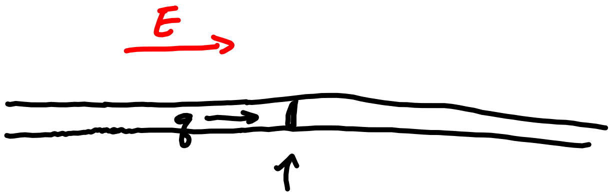
Electric Charge → Electric field → Electric flux → Electric potential → Electric flow → Electric circuit

infinite conductor



electric current $I = \frac{\Delta q}{\Delta t} = \frac{\text{amount of charge}}{\text{unit time}}$

Const $I \Rightarrow$ const velocity flow

for a const $E \Rightarrow F = qE$

$ma = qE$

Const $E \rightarrow$ const acceleration

$\Rightarrow a = \frac{qE}{m}$

$v = at = \frac{qE}{m} t$

However, with $E \rightarrow$

$\rightarrow v_d$

for $t = \tau$ ← average time between collision

$v = v_d = \frac{qE}{m} \tau$ drift velocity

under $\vec{E}$ + collision ⇒ const velocity flow

⇒ I

potential V ⟶ current flow

for Given V, cause a current I of

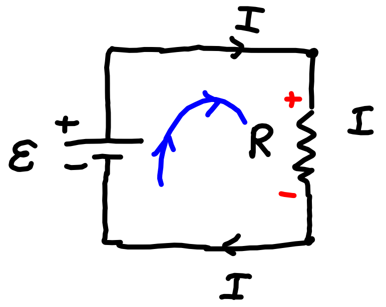
current → $I = \frac{V}{R}$ ← pot diff or voltage; R ← resistance of the material

$\left[a = \frac{F}{m} \right]$

Ohm's Law.

Current flows in direct proportion to the applied voltage & inversely proportional to the resistance.

Current flow is maintained by a "potential pump"



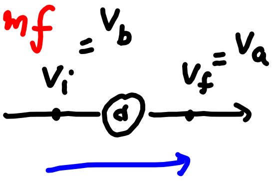
$$\Delta V_{\varepsilon} + \Delta V_R = 0$$

$$\varepsilon - V = 0, \quad V = IR$$

$$\varepsilon = IR \Rightarrow I = \frac{\varepsilon}{R}$$

1) + sign where the current enters the device
− sign where it exists

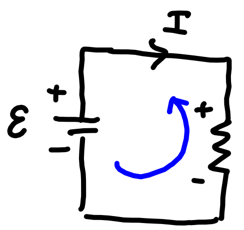
"
battery = Emf



pot diff
voltage diff

2) Kirchhoff Rule:
The sum of all pot. diff. across all devices must be zero.

choose a direction of calculation: $\Delta V = V_{after} - V_{before}$



$$\Delta \varepsilon + \Delta R = 0$$

$$-\varepsilon + IR = 0$$

$$I = \frac{\varepsilon}{R} \, !$$

Power dissipation in a resistor

pot.

$$P = \frac{\Delta W}{\Delta t} = \frac{\text{work done}}{\text{unit time}} = \frac{\Delta U}{\Delta t} = \frac{qV}{\Delta t} = IV$$

$$P = IV$$

Since

$V = IR$

$\rightarrow I = \frac{V}{R}$

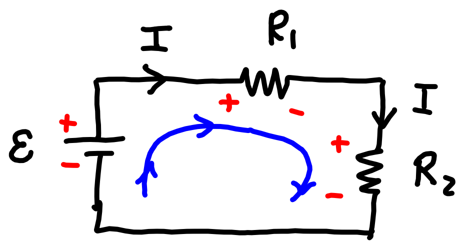
either current

$$= I^2 R$$

$$= \frac{V^2}{R}$$

or the voltage

Apply Kirchhoff's rule



$$\Delta V_{\varepsilon} + \Delta V_{R_1} + \Delta V_{R_2} = 0$$

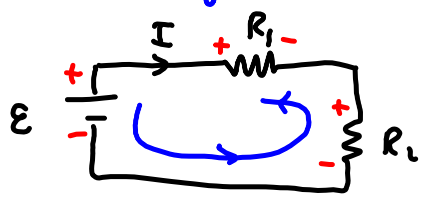
$$\varepsilon - IR_1 - IR_1 = 0$$

$$\varepsilon = I(R_1 + R_2)$$

Resistors in series:

$$R_{eq} = R_1 + R_2 + R_3 \quad \therefore \quad I = \frac{\varepsilon}{R_1 + R_2} \doteq R_{eq}$$

Same current



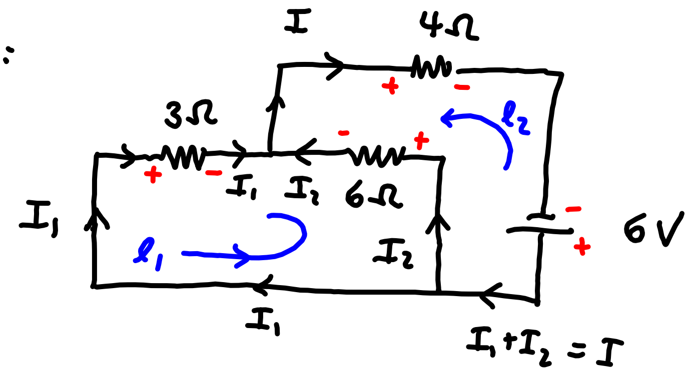
$$\Delta V_{\varepsilon} + \Delta V_{R_1} + \Delta V_{R_2} = 0$$

$$-\varepsilon + IR_2 + IR_1 = 0$$

$$I = \frac{\varepsilon}{R_1 + R_2}$$

Ex 3:

Find all currents flowing thru each device



ℓ_1 : $\Delta V_6 + \Delta V_3 = 0$

$-I_2 6 + I_1 3 = 0$

$3I_1 = 6I_2$

$\boxed{I_1 = 2I_2}$

$\boxed{I_2 = \frac{6}{18} = \frac{1}{3}}$

ℓ_2 : $-6 + 4(I_1 + I_2) + 6I_2 = 0$

$6I_2 + 4I_1 + 4I_2 = 6$

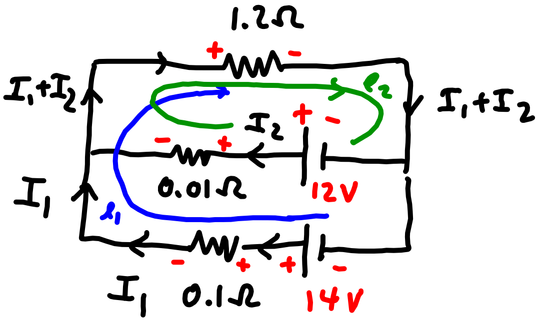
$10I_2 + 4I_1 = 6$

$10I_2 + 4(2I_2) = 6$

$18I_2 = 6$

Ex 4 : Two batteries

Find all current thru each resistors.



ℓ_1 : $14 - I_1\, 0.1 - (I_1+I_2)\, 1.2 = 0$

ℓ_2 : $12 - I_2\, 0.01 - (I_1+I_2)\, 1.2 = 0$

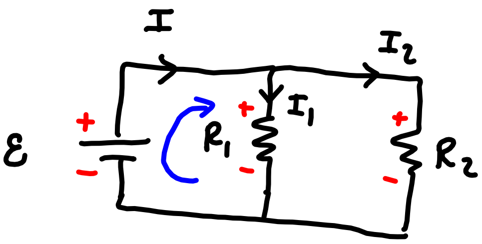
$$14 = 1.3\, I_1 + 1.2\, I_2$$
$$12 = 1.21\, I_2 + I_1\, 1.2$$

$$I_2 = \frac{12 - I_1\, 1.2}{1.21}$$

$$14 = 1.3\, I_1 + 1.2 \left(\frac{12 - I_1\, 1.2}{1.21} \right)$$
$$= 1.3\, I_1 + \frac{1.2 \cdot 12}{1.21} - I_1 \frac{(1.2)^2}{1.21}$$

$$\boxed{I_1 = 19.1\ A} \qquad \boxed{I_2 = -9.02\ A}$$

Ex.



$$I = I_1 + I_2$$

in parallel

having the same voltage

$$\Delta V_{\varepsilon} + \Delta V_{R_1} = 0$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\varepsilon - I_1 R_1 = 0 \qquad \varepsilon - I_2 R_2 = 0$$

$$\Rightarrow \quad I_1 = \frac{\varepsilon}{R_1} \qquad I_2 = \frac{\varepsilon}{R_2}$$

$$I = \frac{\varepsilon}{R_1} + \frac{\varepsilon}{R_2} = \varepsilon\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = \varepsilon \frac{1}{R_{eq}}$$