$$P = iV = \frac{dQ}{dt}\frac{dW}{dQ} = \frac{dW}{dt}$$

Energy (W)

$$i = 4t^2 - t$$

$$V = 3$$

$$P = iV = 3(4t^2 - t) = 12t^2 - 3t$$

How much energy used in t_a

$$W = \int P\,dt = \int_0^{t_a} 12t^2 - 3t\,dt$$

$$W = 4t^3 - \frac{3}{2}t^2 \Big|_0^{t_a}$$

$$W = 4t_a^3 - \frac{3}{2}t_a^2$$

How much charge flowed in t_a?

$$Q = \int_0^{t_a} i\,dt = \int_0^{t_a} 4t^2 - t\,dt$$

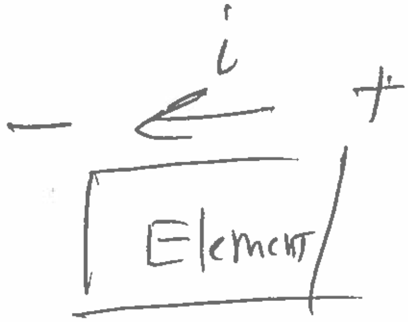
$$Q = \frac{4}{3}t^3 - \frac{1}{2}t^2 \Big|_0^{t_a}$$

$$Q = \frac{4}{3}t_a^3 - \frac{1}{2}t_a^2$$

What is V @ Q passed through?

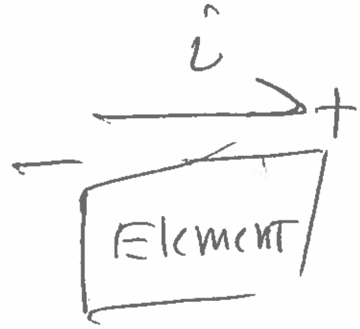
$$W = QV \Rightarrow V = \frac{W}{Q}$$

$$V = \frac{4t_a^3 - \frac{3}{2}t_a^2}{\frac{4}{3}t_a^3 - \frac{1}{2}t_a^2}$$ ⇐ Mess



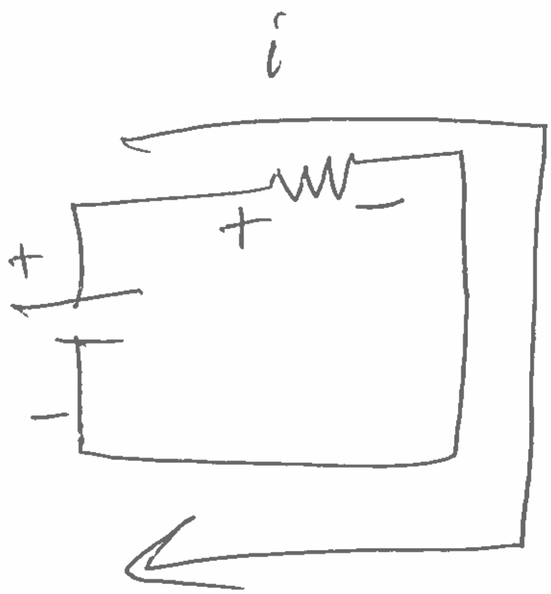
Absorbing power

$p < 0$



Power supplied

$p > 0$

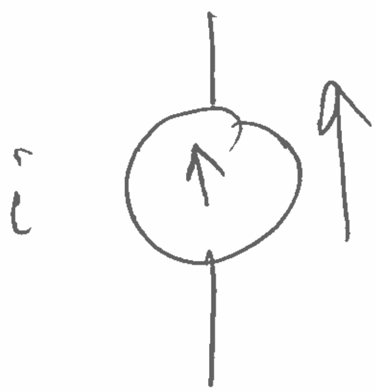


Voltage Power Sources

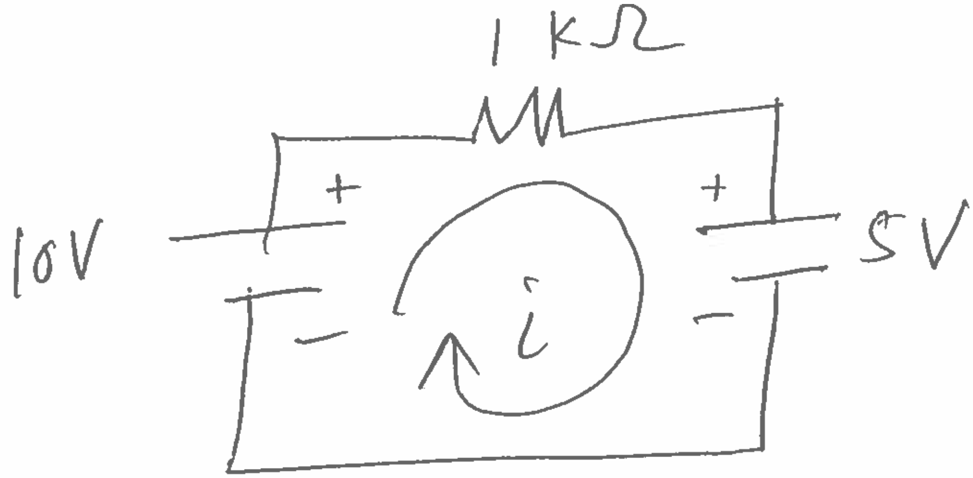
V is fixed
i is whatever external circuit needs.

Voltage source

Current Power Sources



i is fixed
V is whatever is needed by external circuit.



$$i = 10V - i(1k\Omega) - 5V = 0$$

$$5V = i(1k\Omega)$$

$$i = \frac{5V}{1k\Omega} = 5\,mA$$

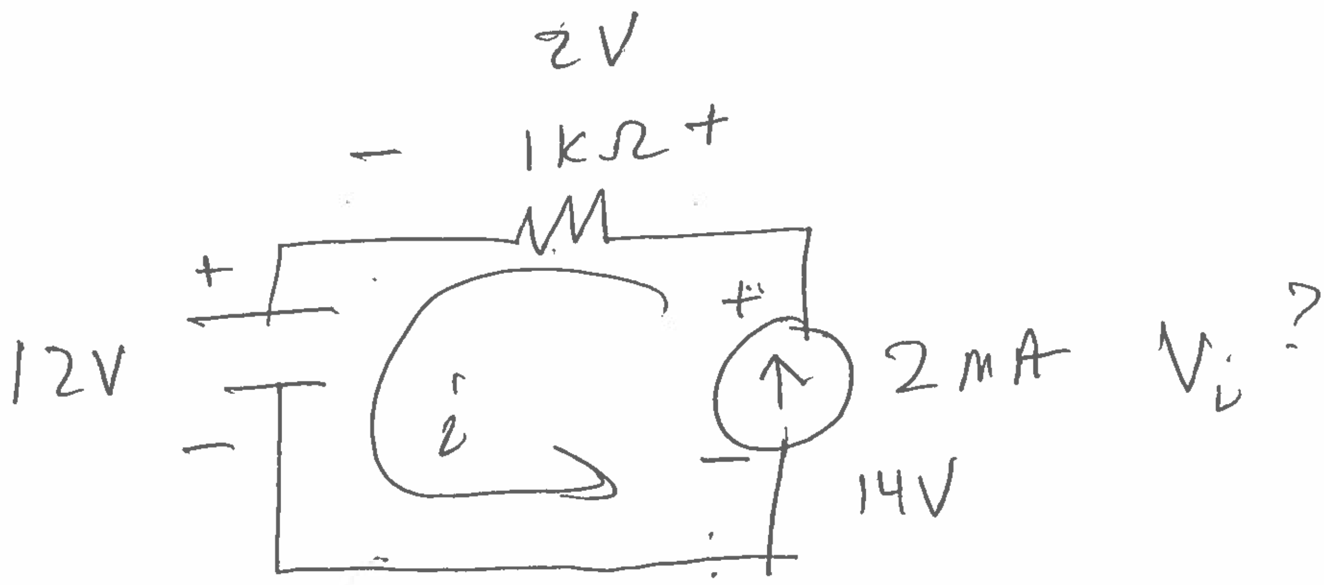
$$P_{10V} = 5mA(10V) = +50\,mW \text{ Supplied}$$

$$P_{1k\Omega} = (5mA)^2(1k\Omega) = -25\,mW$$

Absorbed

$$P_{5V} = 5mA(-5V) = -25\,mW$$

Absorbed



$$12V + 2V - V_i = 0$$

$$V_i = 14V$$

$$P_V = (-12V)(2mA) = -24\,mW$$

$$P_R = -(2mA)^2(1k\Omega) = -4\,mW$$

$$P_i = (2mA)(14V) = +28\,mW$$

$$0$$

Definition of a linear circuit

A linear circuit must satisfy Superposition and Homogeneity

Superposition

$i_1 \rightarrow V_1 \qquad i_2 \rightarrow V_2$

Superposition $\Rightarrow (i_1 + i_2) \longrightarrow (V_1 + V_2)$

$i_1 = \frac{V_1}{R} \qquad i_2 = \frac{V_2}{R}$

$? = \frac{(V_1 + V_2)}{R} = \frac{V_1}{R} + \frac{V_2}{R} = i_1 + i_2$

$i = \frac{V^2}{R} \qquad \frac{V_1^2}{R} = i_1$

$$\frac{V_2^2}{R} = i_2$$

$$\frac{(V_1+V_2)^2}{R} = \frac{V_1^2 + 2V_1V_2 + V_2^2}{R}$$

$$= i_1 + i_2 + \underbrace{i_{mixed}}_{\frac{2V_1V_2}{R}}$$

Homogeneity

$$i \to V$$

$$ki \to kV$$

k Parameter for transducers switches

$$i_1 = kV_1 \qquad i_2 = kV_2$$

$$i_1 + i_2 = k(V_1 + V_2)$$

$$i = ke^V \qquad k(e^{V_1} + e^{V_2})$$

$$\neq ke^{(V_1+V_2)}$$

Ohm's Law

$i = \frac{1}{R} V \qquad \vec{J} = \sigma \vec{E}$

$\vec{J} = \frac{i}{A} \qquad E = \frac{V}{d}$

$G = \frac{1}{R} \qquad R = \frac{\rho L}{A} \qquad \rho$ is resistivity

$G = \frac{\sigma A}{L} \qquad \sigma = \frac{1}{\rho}$

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