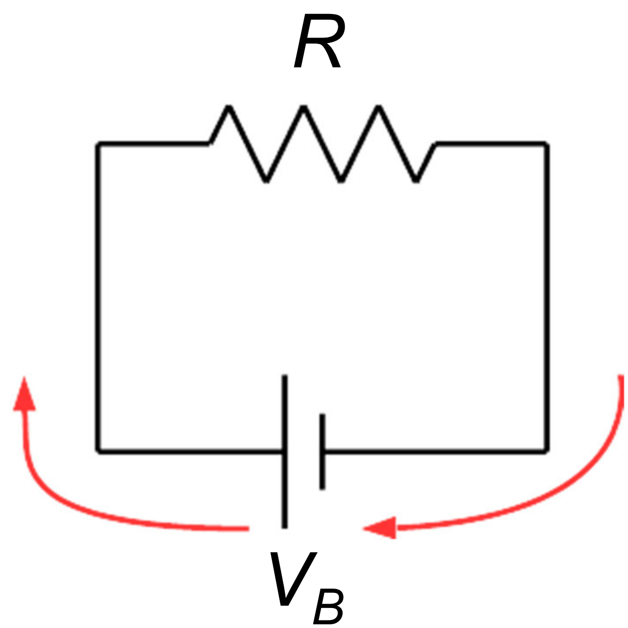
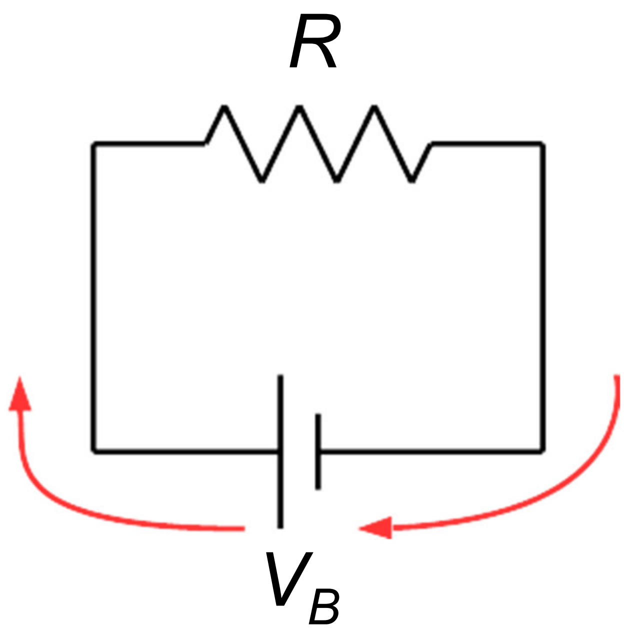
Simple Circuits



Simple Circuits



Charges leaving the battery have more energy than charges entering battery. Consider $V = \frac{U}{q}$

$$V_{\text{Leaving}} = V_{\text{Entering}} + V_B$$

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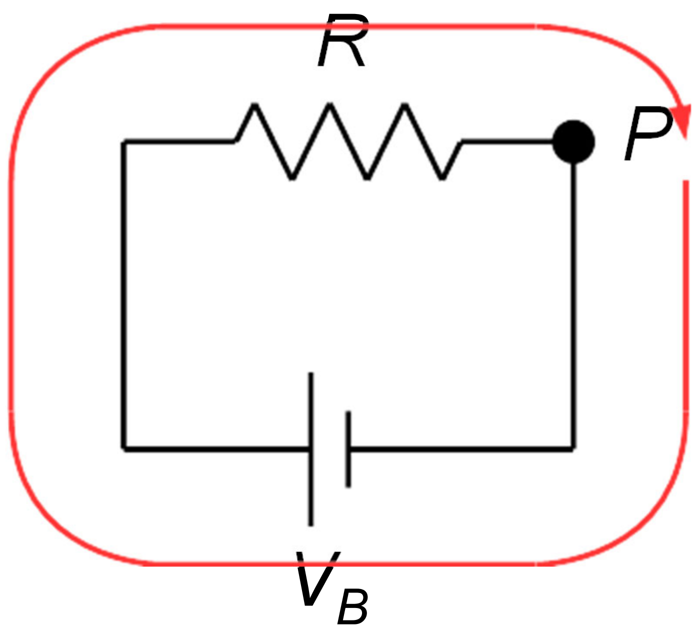

The sum of voltage changes around a loop is 0.

$$\Delta V = V_P - V_P = 0$$

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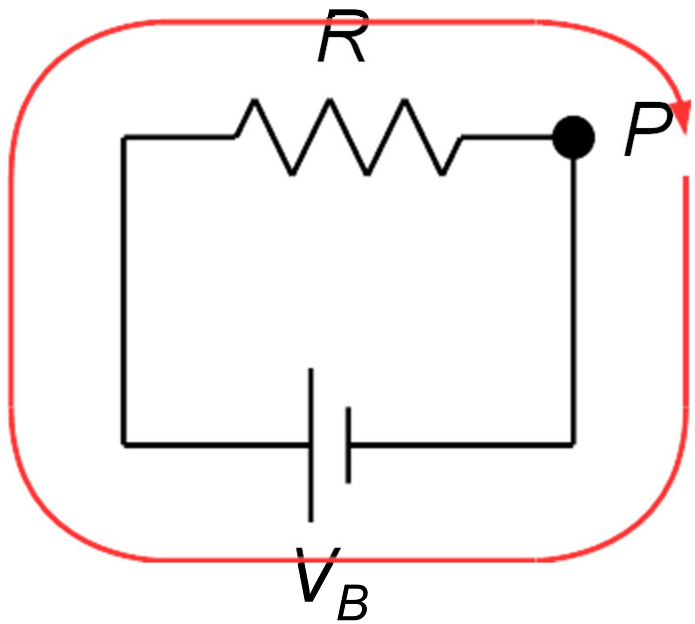

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$$\Delta V = V_P - V_P = 0$$

Kirchhoff's Loop Rule, $\sum_i \Delta V_i = 0$

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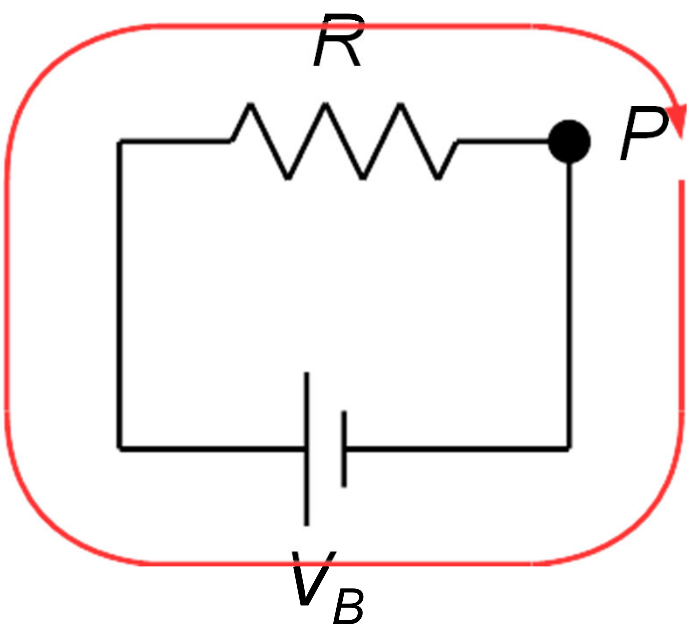


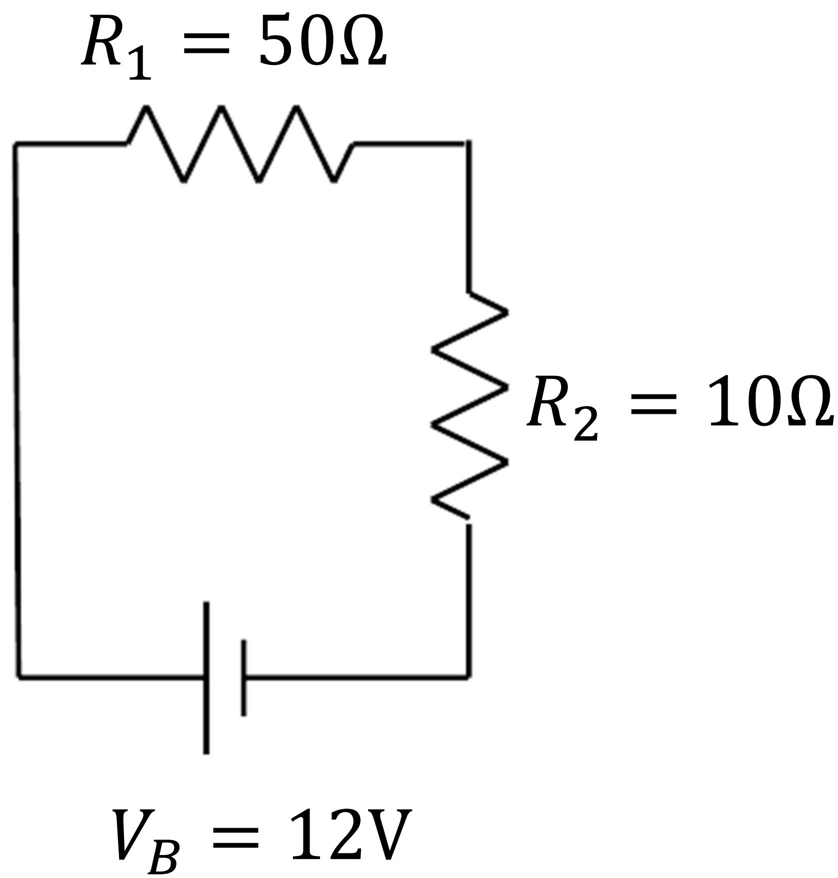
$$V_B + V_R = 0$$

V_R is negative.

From previous lecture, $|V_R| = IR$.

$$V_R = -IR$$

Example: Determine the current in the given circuit.



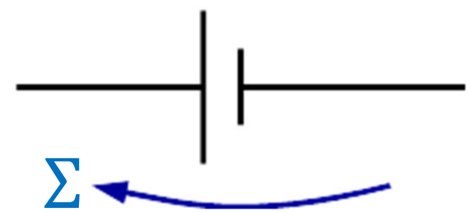
Strategy

Select and label a direction for current.

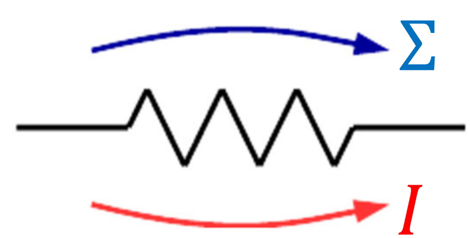
Select a direction for summation.

Add ΔV's.

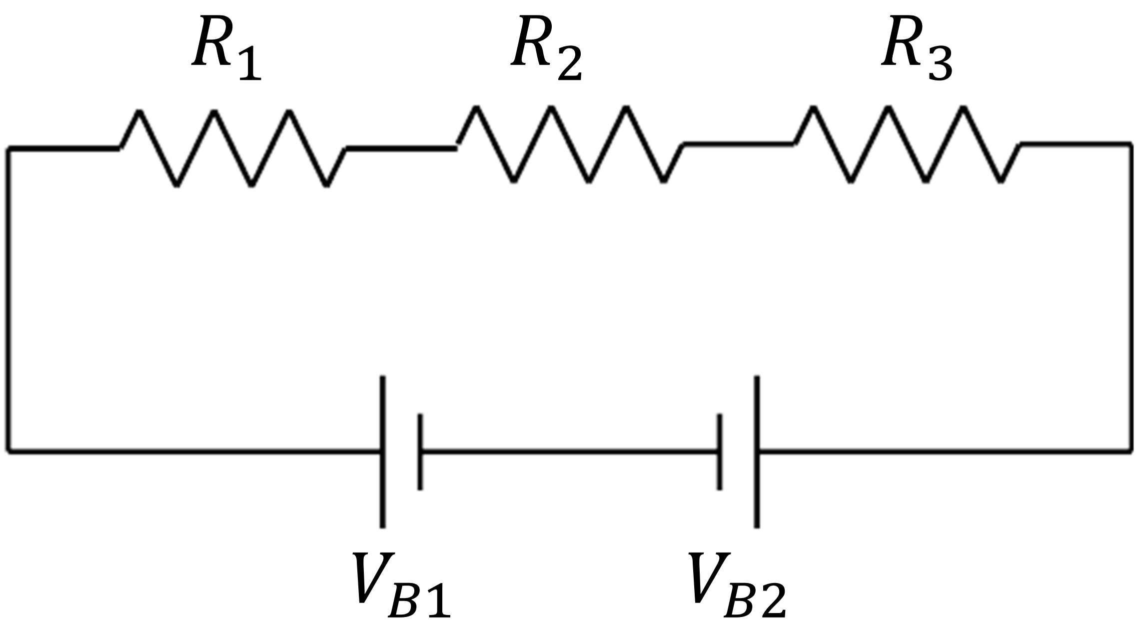
- V_B is positive going from – to +



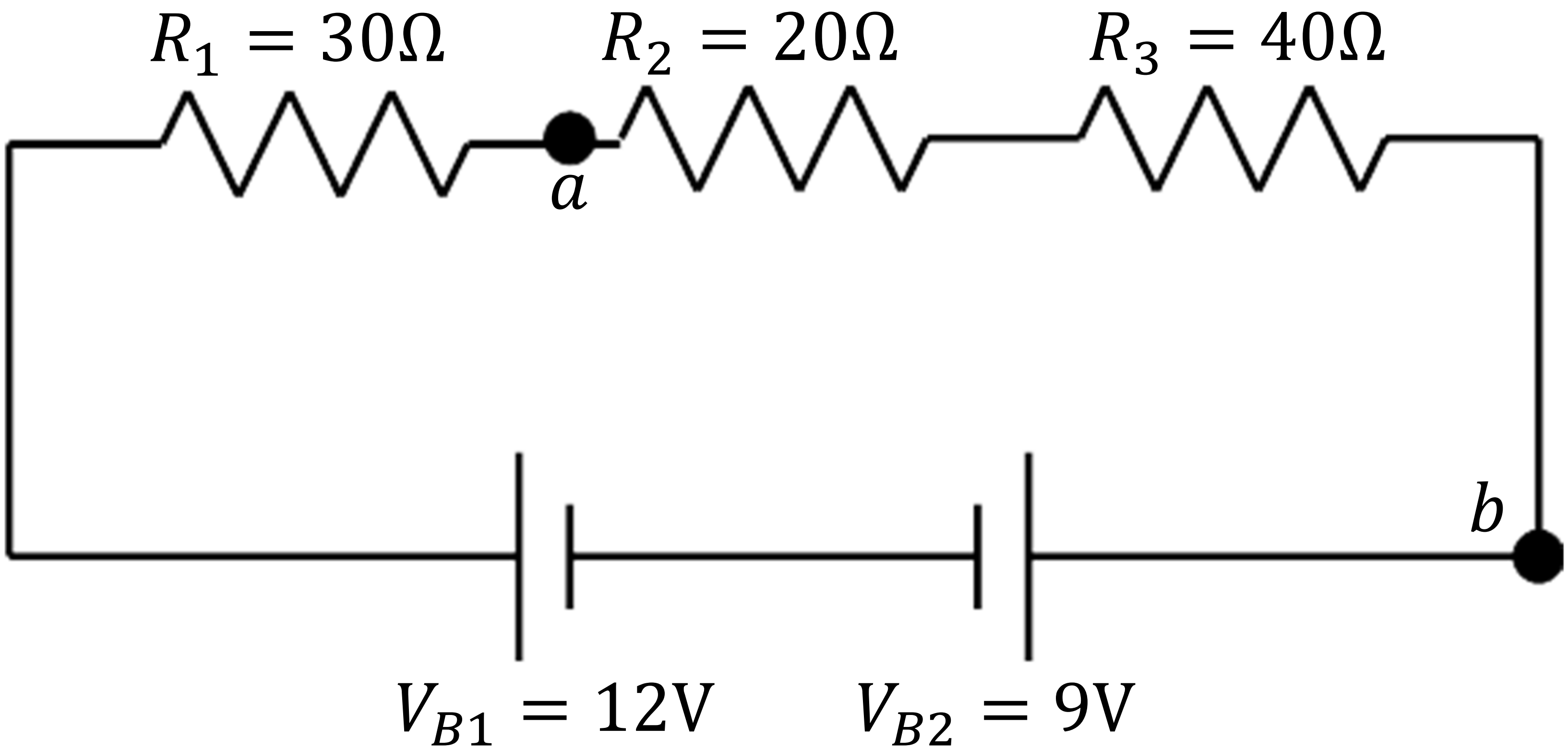
- V_R is negative going with current



Example: Determine the current in the given circuit.



Example: For the given circuit, determine I, V_{ab} and V_{ba}.



$V_{\text{ab}} = \Delta V_{\text{ab}} = V_{\text{b}} - V_{\text{a}}$

Real Batteries

- Have internal resistance
- Voltage depends on current

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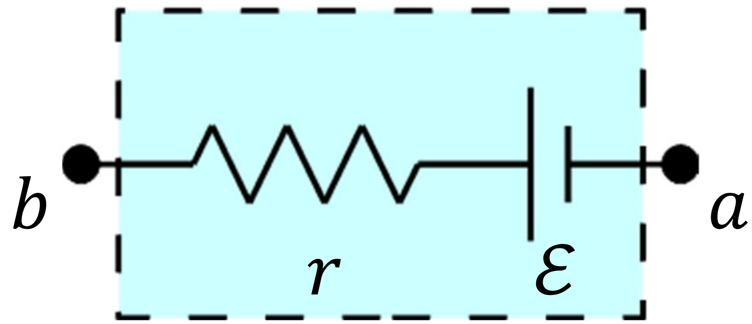
- Have internal resistance
- Voltage depends on current

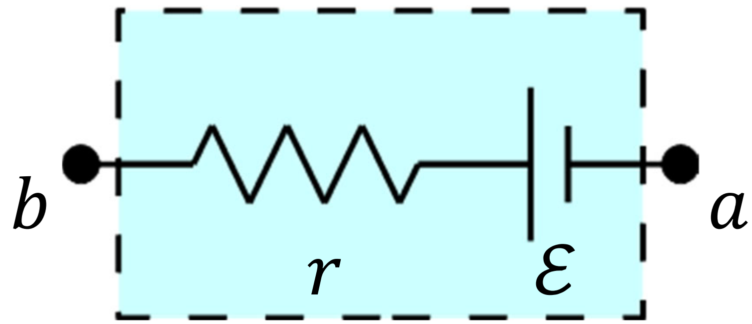
Model of a real battery:



$\mathcal{E}$ is the ideal V of the battery.
r is the internal resistance of the battery.
V_{ab} is the real V of the battery.

Electromotive Force, $\mathcal{E}$ (emf)

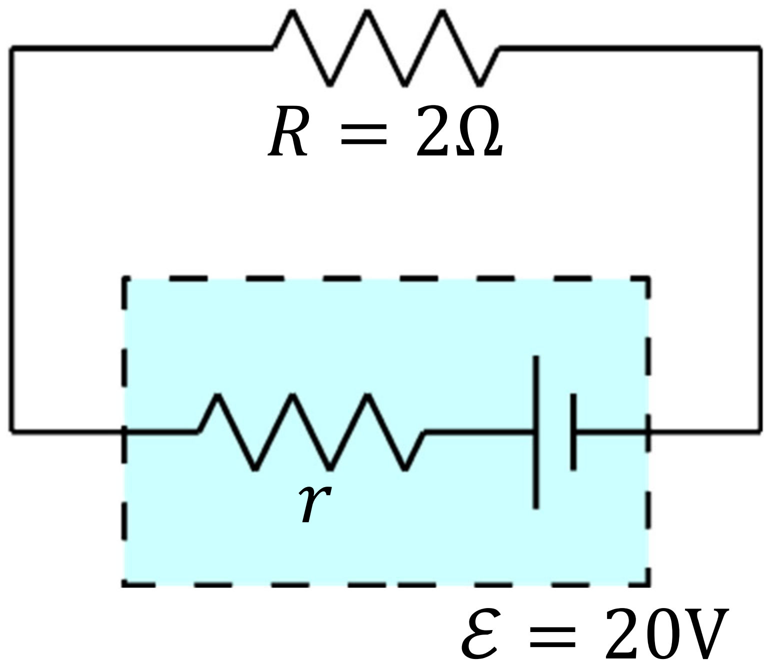
- Is not a force
- Cannot be directly measured



Can only measure terminal voltage, V_{ab}.

V_{ab} is a function of current. $V_{ab} = \mathcal{E} - Ir$

Example: The terminal voltage of a "20V" battery is found to be 16V when connected in a circuit with a 2Ω resistor. Determine the internal resistance of the battery.



Power

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

$$W = \Delta U = q\Delta V$$

$$P = \frac{dq\Delta V}{dt}$$

$$P = I\Delta V$$

$$P = IV = I^2R = \frac{V^2}{R}$$

Power

$$P = IV = I^2R = \frac{V^2}{R}$$

Rate of energy production in battery. $(V_B > 0)$

Rate of energy dissipation in resistor. $(V_R < 0)$

Example: An electric heater draws 15A on a 120V line.
(a) How much power does the heater use?

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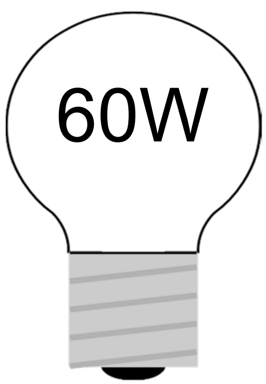
How much energy is a kilowatt hour?

Example: A 12V battery with 2Ω internal resistance is connected to a 4Ω resistor. (a) Determine the rate at which chemical energy is converted to electrical energy in the battery. (b) Determine the rate at which power is dissipated internally in the battery. (c) Determine the total power output of the battery.

Power Ratings

Light bulbs are rated by power

- Rated power and dissipated power may differ
- Rated power is for specific voltage
- Dissipated power depends on voltage
- Usually better to describe bulbs by resistance



P = 60W IF V = 120V (I = 0.5A)

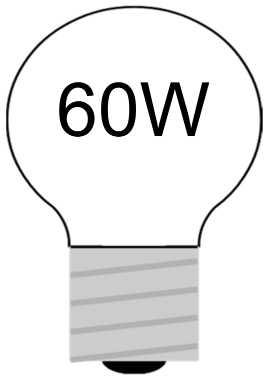
R = 240Ω

P = 202W IF V = 220V (I = 0.9A)

Power Ratings

Light bulbs are rated by power

- Higher power rating → lower resistance



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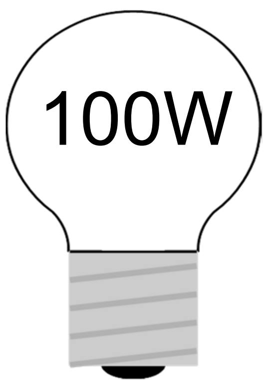

P = 100W IF V = 120V (I = 0.8A)

R = 144Ω