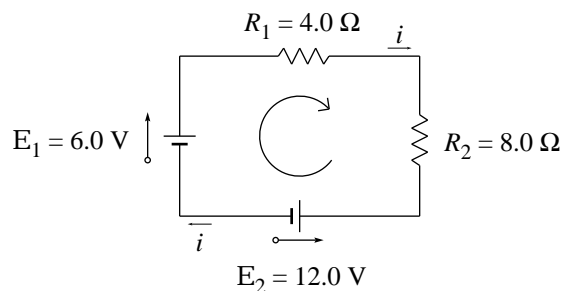


## A circuit with two batteries



(a.) The sum of voltage changes around the loop (starting at the lower left corner and going clockwise) is

$$\begin{aligned} +6.0 \text{ V} - i(4.0 \Omega) - i(8.0 \Omega) - 12.0 \text{ V} &= 0 \\ -6.0 \text{ V} - i(12.0 \Omega) &= 0 \\ i &= -0.50 \text{ A} \end{aligned}$$

The negative sign means that the current flows in the opposite of the direction shown in the sketch, i.e. it flows counterclockwise.

(b.) The power dissipated in each resistor is:

$$\begin{aligned} \text{In } R_1 = 4.0 \Omega: \quad i^2 R_1 &= (-0.50 \text{ A})^2 (4.0 \Omega) = 1.0 \text{ watt.} \\ \text{In } R_2 = 8.0 \Omega: \quad i^2 R_2 &= (-0.50 \text{ A})^2 (8.0 \Omega) = 2.0 \text{ watt.} \end{aligned}$$

(c.) The power transfer at each battery is: (Use the sign conventions established in the figure above. For example, at battery  $\mathcal{E}_2$  the voltage change is  $\Delta V = -12 \text{ V}$ , because we're talking about the change when moving in the direction of the big circular arrow.)

$$\text{At } \mathcal{E}_2 = 12.0 \text{ V:} \quad i\Delta V = (-0.50 \text{ A})(-12.0 \text{ V}) = +6.0 \text{ watt.}$$

(The positive sign means that power is supplied by the battery: the battery is “discharging”.)

$$\text{At } \mathcal{E}_1 = 6.0 \text{ V:} \quad i\Delta V = (-0.50 \text{ A})(+6.0 \text{ V}) = -3.0 \text{ watt.}$$

(The negative sign means that power is absorbed by the battery: the battery is being “charged”.)

[[The terms “charging” and “discharging” are poor ones. A battery does not supply charge like a capacitor, instead it pumps out of one wire the charge supplied through the other wire. Better terms would be “energizing” and “deenergizing”. But these are the terms we're stuck with.]]

**In summary**, the battery  $\mathcal{E}_2$  supplies 6.0 watts to the circuit. Of that power, 3.0 watts goes into “charging up” battery  $\mathcal{E}_1$ , 2.0 watts goes into heat at resistor  $R_2$ , and 1.0 watt goes into heat at resistor  $R_1$ .

*Grading:* Sketch or something else to start off, 1 point.

Part (a), 1 point.

Part (b), 1 point each.

Part (c), 1 point for each number, 1 point for each sign.

If every numerical result has attached units, add 1 point.

If every numerical result has two sig.figs., add 1 point.