Batteries in Series or Parallel

A) ![Diagram of batteries in series or parallel]

Current is the direction of positive charge flow. It will flow away from the positive battery terminals and thus **COUNTER-CLOCKWISE**

B) In a closed loop, \( \sum \Delta V_i = 0 \)

\[ \Rightarrow E - IR_2 - IR_1 + E - IR_1 = 0 \]

\[ I = \frac{2E}{2R_1 + R_2} \]

C) Circuit B is a little different

![Diagram of circuit B]
This circuit consists of two loops, one around the outside branch and one including the inside branch:

\[ \sum \Delta V_i = 0 \quad \text{(loop 1)} \]
\[ \Rightarrow -I_1 R_1 + \varepsilon - I_3 R_2 = 0 \quad 1) \]

\[ \sum \Delta V_i = 0 \quad \text{(loop 2)} \]
\[ \Rightarrow -I_2 R_1 + \varepsilon - I_3 R_2 = 0 \quad 2) \]

And we use the junction rule to write (at J)
\[ I_1 + I_2 = I_3 \quad 3) \]

So we just use algebra to solve for \( I_3 \)
let \( I_1 = I_3 - I_2 \) from 3)
put this into eqn 1)
\[ \varepsilon = I_3 R_1 - I_2 R_1 + I_3 R_2 \]
now add to eqn 2) \[ + \varepsilon = I_3 R_2 + I_2 R_1 \]
\[ 2 \varepsilon = 2 I_3 R_2 + I_3 R_1 \]
\[ I_3 = \frac{2\varepsilon}{2R_1 + R_2} \]

D) Power is \( P = I^2 R_2 \)

\[ I = \frac{2\varepsilon}{2R_1 + R_2} \quad \text{for circuit A} \]

\[ P = \left( \frac{2\varepsilon}{2R_1 + R_2} \right)^2 R_2 \quad \text{for } \varepsilon = 10V \]
\[ R_1 = 300 \Omega \]
\[ R_2 = 5000 \Omega \]

\[ P = \left( \frac{20V}{5600 \Omega} \right)^2 5000 \Omega = 0.064 \text{ W} \]

E) Want \( P_A = P_B \) or

\[ \left( \frac{2\varepsilon}{2R_1 + R_2} \right)^2 R_2 = \left( \frac{2\varepsilon}{2R_2 + R_1} \right)^2 R_2 \]

Rearranging and cancelling like terms...

\[ 2R_2 + R_1 = 2R_1 + R_2 \]

\[ \Rightarrow R_2 = R_1 \]

or \[ \frac{R_1}{R_2} = 1 \]
F) When is $P_A > P_B$?

When

$$\left(\frac{\frac{2E}{2R_2 + R_1}}{2R_2 + R_1}\right)^2 R_2 \geq \left(\frac{2E}{2R_1 + R_2}\right)^2 R_2$$

rearranging...

need

$$\left(\frac{2R_2 + R_1}{2R_1 + R_2}\right)^2 > 1$$

or

$$2R_2 + R_1 > 2R_1 + R_2$$

$$\Rightarrow R_2 > R_1$$

Ex 26.15

4) We know that $E = I_1(1R) + I_1(2R)$

We are told that $I_1(2R) = 12.2V$

so $I_1 = 6.1A$.

Thus $I_1(1R) = 6.1V$.

Total drop on that branch is then

$$E = 6.1V + 12.2V = 18.3V$$

8) $E = I_2(6\Omega) \Rightarrow I_2 = \frac{18.3V}{6\Omega} = 3.05A$
\[ \text{RC circuit.} \]

C, R and \( \varepsilon \) are all in series and at time \( t=0 \), a switch is closed that connects them.

A) At \( t=0 \) (just after circuit is completed)

\[ V_c = 0 \]

Since \( Q(t) = CE(1 - e^{-t/RC}) \)

and \( V_c = \frac{Q}{C} \) so \( V_c = \varepsilon (1 - e^{-t/RC}) \)

\[ V_c = \varepsilon (1 - e^0) = \varepsilon (1 - 1) = 0 \]

B) If \( V_c = 0 \) at \( t=0 \) then \( V_R = \varepsilon \) to satisfy Kirchoff's Loop Rule

\[ V_R = 115 \text{V} \]

C) At \( t=0 \) \( Q(t) = CE(1 - e^0) = 0 \)

\[ Q = 0 \]

D) \( V_R = \varepsilon = IR \) \( \Rightarrow \) \( I = \frac{E}{R} = \frac{115 \text{V}}{6.8 \times 10^3 \Omega} \)

\[ I = 1.69 \times 10^{-2} \text{A} \]

E) At \( t \gg RC \) \( V_c \approx \varepsilon (1 - e^{-t}) \approx \varepsilon \)

\[ V_c \approx 115 \text{V} \]
F) If \( V_c = E \) then \( V_R = 0 \) since \( E = V_R + V_c \).

G) \( q + t = \infty \) \( Q = CE = (3.50 \times 10^{-6} \text{ F}) (115 \text{ V}) \)
   \[ Q = 4.03 \times 10^{-4} \text{ C} \]

H) If \( V_R = 0 \) then \( I = 0 \) since \( I = \frac{V_R}{R} \).