e.g. [redacted] An Illuminating Surprise.

A 60-W and a 100-W light bulbs are connected in series.

which one is brighter? The 60-W one!

why? The specifications of 60-W and 100-W.

assumes a voltage of 120V.

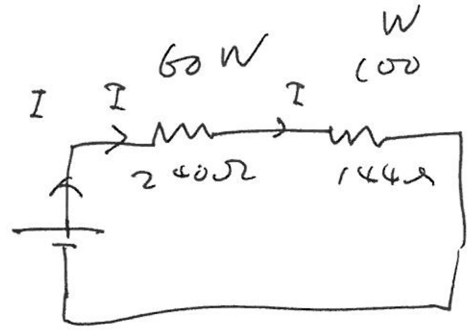
when the light bulbs are made. R is fixed, NOT the power!

The power depends on voltage : $P = \frac{V^2}{R}$.

$\underbrace{\text{power}}_{\text{brightness}}$

In series, $V \neq 120V$. P is NOT 60 W. or 100 W any more.

$\boxed{\cancel{R_{60} = \frac{120^2}{60}} =}$



$$R_{60} = \frac{120^2}{60} = 240\,\Omega$$

$$R_{100} = \frac{120^2}{100} = 144\,\Omega.$$

In series.. $R_{Total} = 240 + 144 = 384\,\Omega$.

current. $I = \frac{V}{R} = \frac{120}{384} = 0.3125\,A$.

$$V_{60} = R_{60} \cdot I = 240 \times 0.3125 = 75\,V$$

$$V_{100} = R_{100}\, I = 144 \times 0.3125 = 45\,V.$$

Actually power :

$$P_{60} = \frac{V_{60}^2}{R_{60}} = \frac{75^2}{240} = 23.4 \text{ W}$$

$$P_{100} = \frac{V_{100}^2}{R_{100}} = \frac{45^2}{144} = 14.1 \text{ W}.$$

$$\therefore \quad P_{60} > P_{100}$$

$\uparrow$

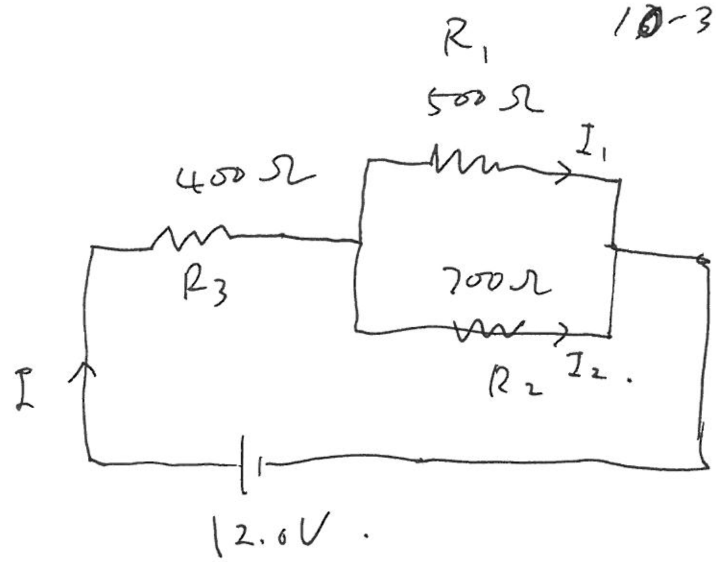
brighter.

OR: $P_{60} = R_{60} I^2 = 240 \times 0.3125^2 = 23.4 \text{ W}$

$P_{100} = R_{100} I^2 = 144 \times 0.3125^2 = 14.1 \text{ W}.$

e.g [redacted].

Find $I = ?$



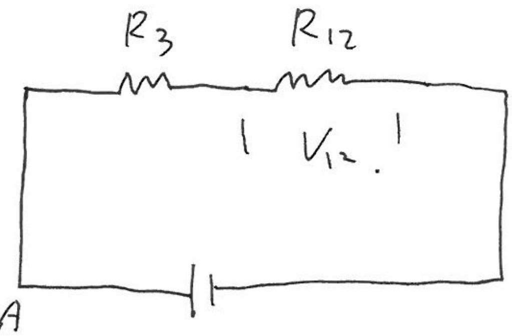
$R_{12} = R_1 // R_2$

$$\frac{1}{R_{12}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_2+R_1}{R_1 R_2}$$

$$R_{12} = \frac{R_1 R_2}{R_1 + R_2} = 290\ \Omega$$

⇕ equivalent.

$$R_{Total} = R_1 + R_{12}$$
$$= 400 + 290$$
$$= 690\ \Omega.$$



$$I = \frac{V_{Total}}{R_{Total}} = \frac{12}{690} = 0.0174 A$$
$$= 17\ mA.$$

e.g. 26-5 Find $I_1 = ?$

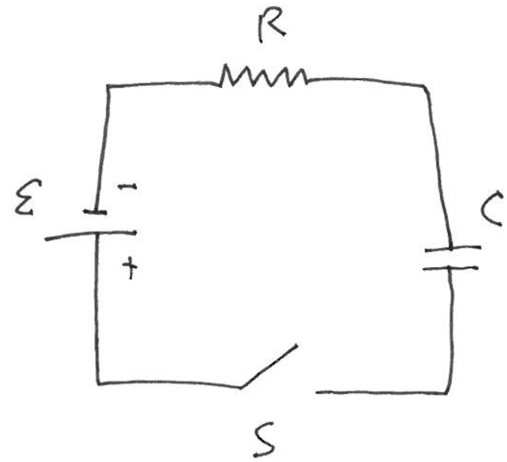
$$I_1 = \frac{V_1}{R_1} = \frac{V_{12}}{R_1}.$$

$$V_{12} = I \cdot R_{12} = 0.0174\ A \times 290\ \Omega = 5.0\ V$$

$$I_1 = \frac{5.0\ V}{500\ \Omega} = 10\ mA.$$

$$I_2 = \frac{5.0\ V}{700\ \Omega} = 7\ mA.$$

e.g. RC-circuit.



$C = 0.30\,\mu F$. $R = 20\,K\Omega$

$= 3\times10^{-7} F$. $= 2\times10^{4}\,\Omega$.

$\varepsilon = 12\,V$.

a). $\tau = ?$

$\tau = RC = 3\times10^{-7} \times 2\times10^{4} = 6\times10^{-3}\,s = 6\,ms$.

b). $Q_{max} = Q_{final} = CV = 3\times10^{-7}\times 12 = 3.6\times10^{-6}\,C$

$= 3.6\,\mu C$.

c). $t = ?$ $Q = 0.99\,Q_{final}$.

$$Q = \underbrace{C\varepsilon}_{Q_{final}}\left(1-e^{-t/\tau}\right) = Q_{final}\left(1-e^{-t/\tau}\right).$$

Now $Q = 0.99\,Q_{final}$: $0.99 = 1-e^{-t/\tau}$.

Solve for t: $0.01 = e^{-t/\tau}$.

$-\dfrac{t}{\tau} = \ln 0.01 = -4.605$.

$t = 4.605\,\tau = 27.6\,ms$.

d). $I = ?$ when $Q = \frac{1}{2} Q_{final}$.

solve for t: $\frac{1}{2} = 1 - e^{-t/\tau}$.

$-\frac{1}{2} = -e^{-t/\tau}$. $\quad 0.5 = e^{-t/\tau}$.

$\ln 0.5 = -t/\tau$.

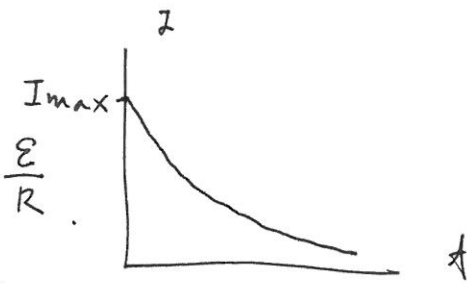
$t = 0.693\tau = 4.16$ ms.

$$I = \frac{\mathcal{E}}{R} e^{-t/\tau} = \frac{12V}{20k\Omega} e^{-t/\tau}.$$

$$= \frac{12}{2 \times 10^4} e^{-\frac{4.16 \times 10^{-3}}{6 \times 10^{-3}}}$$

$$= 3 \times 10^{-4} \text{ A} = 0.3 \text{ mA}. = 300 \mu A.$$

e). $I = \underbrace{I_0}_{I_{max}} e^{-t/\tau}$. $= \frac{\mathcal{E}}{R}$.



$$I_0 = \frac{12V}{20k\Omega} = 0.6 \text{ mA}$$

$= 600 \mu A$.

f). $Q = ?$ when $I = 0.2 I_0$. solve for t: $0.2 I_0 = I_0 e^{-t/\tau}$.

$0.2 = e^{-t/\tau}$.

$\ln 0.2 = -t/\tau$.

$t = (1.609)\tau =$

$= 9.657$ ms.

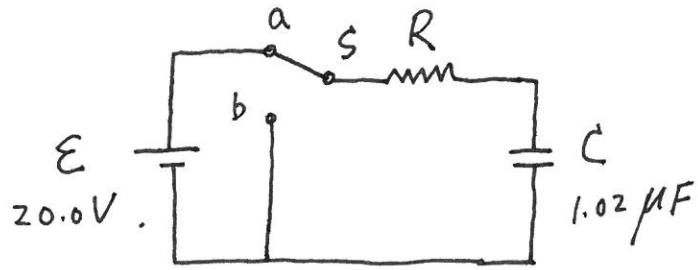
$$Q = C\mathcal{E}(1 - e^{-t/\tau})$$

$$= 3.6(1 - e^{-9.657/6}) \quad (\mu C).$$

$= 2.88 \mu C$.

e.g. Discharging RC circuit.

$Q_0 = C\mathcal{E}$, $\tau = RC$



Discharging:

$$Q = Q_0 e^{-t/RC}$$

$$V_c = V_0 e^{-t/RC}, \quad (V_0 = \mathcal{E})$$

$$I = I_0 e^{-t/RC}$$

Given, when $t = 4.0 \times 10^{-5}$ s, $I = 0.5 I_0$:

$$0.5 I_0 = I_0 e^{-t/RC}$$

$$0.5 = e^{-t/RC}$$

Solve for RC: $-t/RC = \ln 0.5 \doteq -0.693$

$$\tau = RC = \frac{t}{0.693} = \frac{4.0 \times 10^{-5}}{0.693} = 5.77 \times 10^{-5} \text{ s}$$

a). at $t = 0$,

$$Q = Q_0 = C\mathcal{E} = 1.02 \times 10^{-6} \times 20 = 2.04 \times 10^{-5} \text{ C}.$$

b). $\tau = RC$. $R = \frac{\tau}{C} = \frac{5.77 \times 10^{-5}}{1.02 \times 10^{-6}} = 56.6\ \Omega$.

c) $Q = Q_0 e^{-t/RC}$

$$= 2.04 \times 10^{-5}\, e^{-\frac{6.0 \times 10^{-5}}{5.77 \times 10^{-5}}} = 7.21 \times 10^{-6} \text{ C}$$

$$= 7.21\ \mu\text{C}.$$