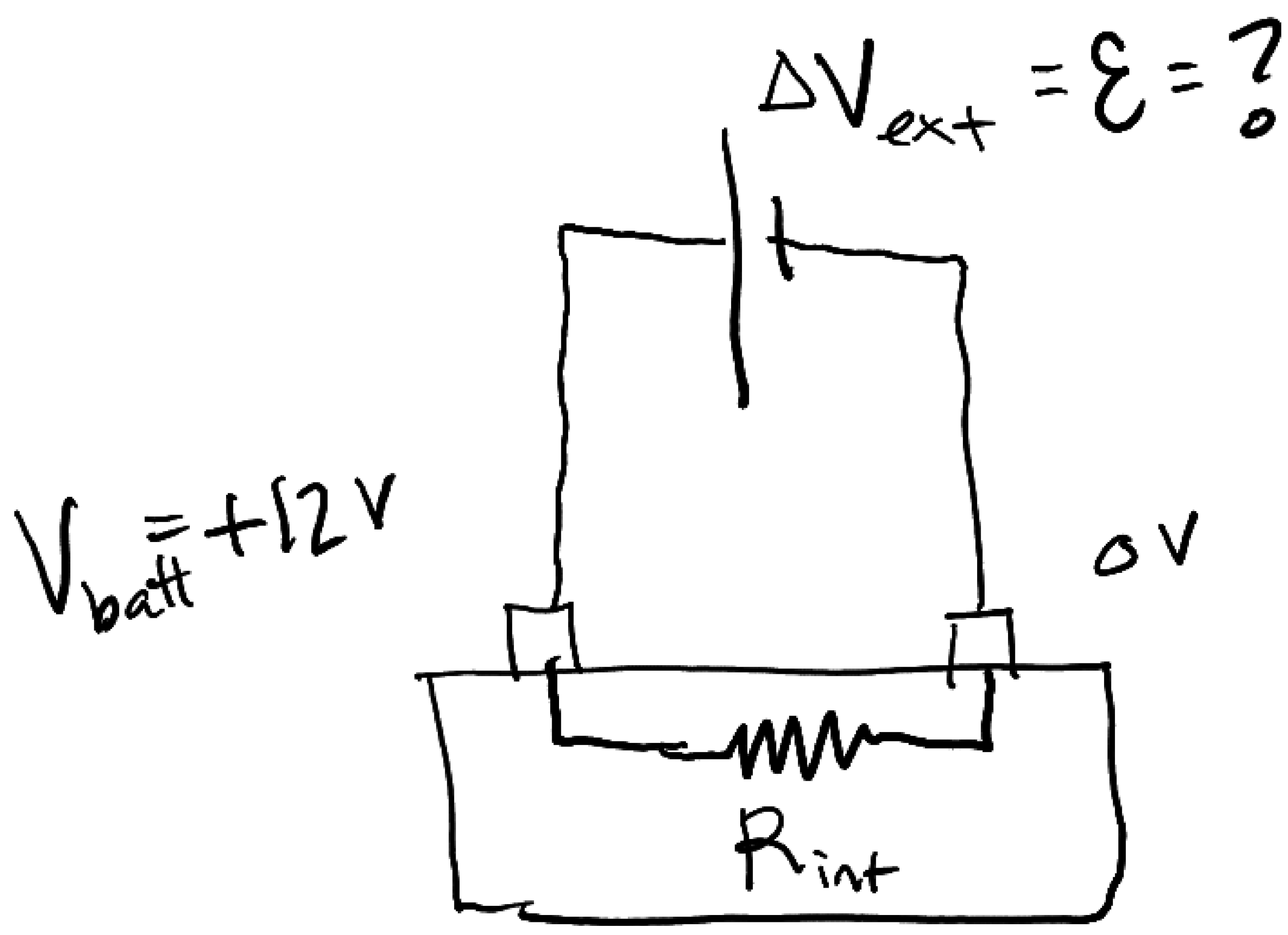
Problem 7.1:

1) $\mathcal{E} = 12V$ $\quad R_{int} = 0.050\,\Omega$

$I = 60A$



$$\Delta V_{int} = I R_{int}$$
$$= 3$$

$$\Delta V_{ext} = V_{batt} + \Delta V_{int}$$
$$= 12 + 3 = \boxed{15V}$$

2)

"Rate" means derivative

$$P = \frac{dE}{dt} = I\Delta V = I^2 R = V^2/R$$

$$P_{heat} = P_{int} = I^2 R_{int} = \boxed{180W}$$

$$P_{supplied} = IV = (60)(15) = 900W$$

3)

$$P_{chemicals} = IV_{batt} = (60)(12) = \boxed{720W}$$

problem 7.2:

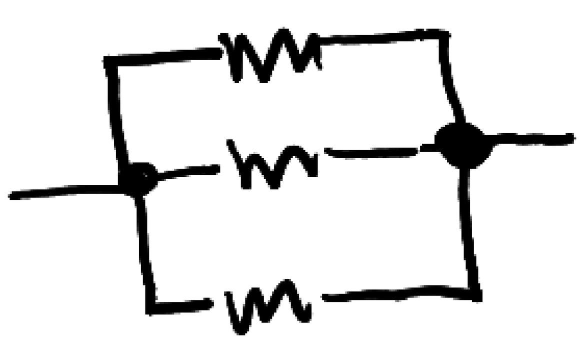
36, 50, 700

parallel

Resistors:

series $R_{eq} = R_1 + R_2 + \cdots$

parallel $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$



Largest: $R_{eq} = R_1 + R_2 + R_3 \Rightarrow \boxed{R_{eq} = 786\,\Omega}$

smallest: $\frac{1}{R_{eq}} = \frac{1}{36} + \frac{1}{50} + \frac{1}{700} \Rightarrow \boxed{R_{eq} = 20.3\,\Omega}$

problem 7.3:

Power $P = I\Delta V$

SI unit:
$[\text{Watt}] = [W] = [J/s]$

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

$$I = P/V$$

$$I_{toaster} = \frac{1800}{120} = 15 \text{ Amps}$$

$$I_{speaker} = \frac{1400}{120} = 11.67 \text{ Amps}$$

$$I_{Lamp} = \frac{75}{120} = 0.625 \text{ Amps}$$

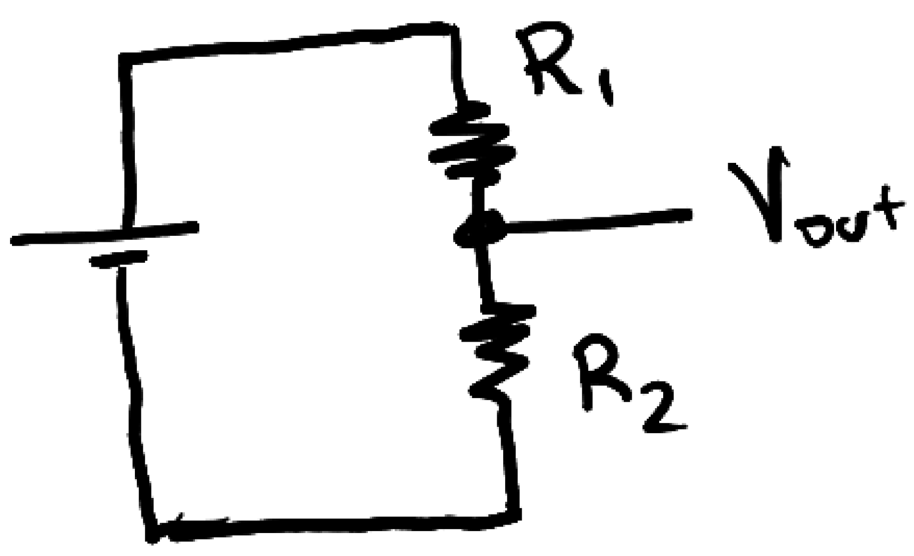
Circuit breaker: Ammeter which trips if $I > I_{max}$

$$I_{total} = 15 + 11.67 + 0.625 \boxed{= 27.3 \text{ Amps}}$$

breaker will "pop"

Problem 7.4

Important problem: Voltage Divider



$$R_{eq} = R_1 + R_2$$

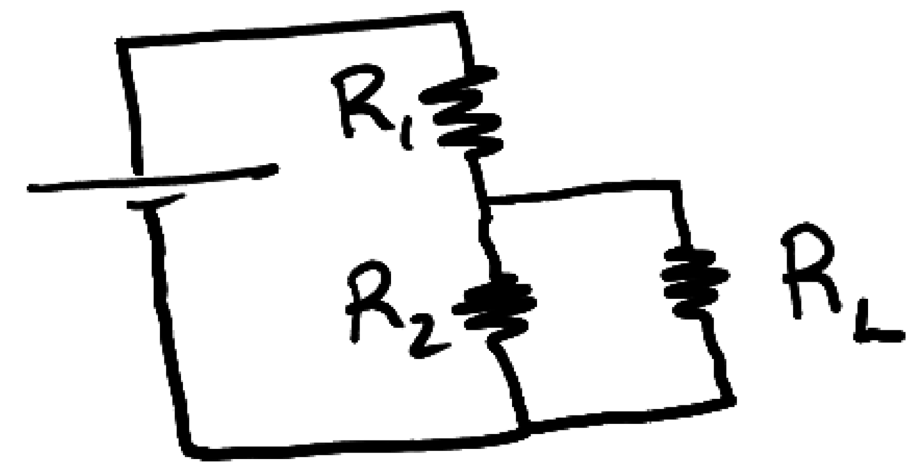
$$V_{in} = I(R_1 + R_2)$$

$$V_{out} = V_{in} - IR_1$$

$$= V_{in} - \frac{V_{in}R_1}{R_1+R_2}$$

$$= \left(\frac{R_1+R_2-R_1}{R_1+R_2}\right)V_{in}$$

$$\boxed{V_{out} = \left(\frac{R_2}{R_1+R_2}\right)V_{in}}$$



$$R_{eq} = R_1 + \frac{R_2R_L}{R_2+R_L}$$

$$= \frac{R_1(R_2+R_L)}{R_2+R_L} + \frac{R_2R_L}{R_2+R_L}$$

$$= \frac{R_1R_2 + R_1R_L + R_2R_L}{R_2+R_L}$$

$$V_{in} = IR_{eq}$$

$$V_{out} = V_{in} - IR_1 = V_{in} - \frac{V_{in}}{R_{eq}}R_1$$

$$= V_{in}\left(1 - \frac{R_1}{R_{eq}}\right)$$

$$= V_{in}\left(1 - \frac{R_1(R_2+R_L)}{R_1R_2+R_1R_L+R_2R_L}\right)$$

$$\boxed{V_{out} = V_{in}\left(\frac{R_2R_L}{R_1R_2+R_1R_L+R_2R_L}\right)}$$

practice fractions: common denominator

problem 7.5 :

$$\boxed{P = IV}$$

1) All series $\quad R_{eq} = R_1 + R_2 + R_3 = \boxed{9\,\Omega}$

2) $V = IR \quad I = \frac{V}{R} = \frac{18}{9} = \boxed{2\,A}$

3) $V_1 = IR_1 = 8V$

$V_2 = IR_2 = 2V$

$V_3 = IR_3 = 8V$

4) $P_1 = 16W$

$P_2 = 4W$

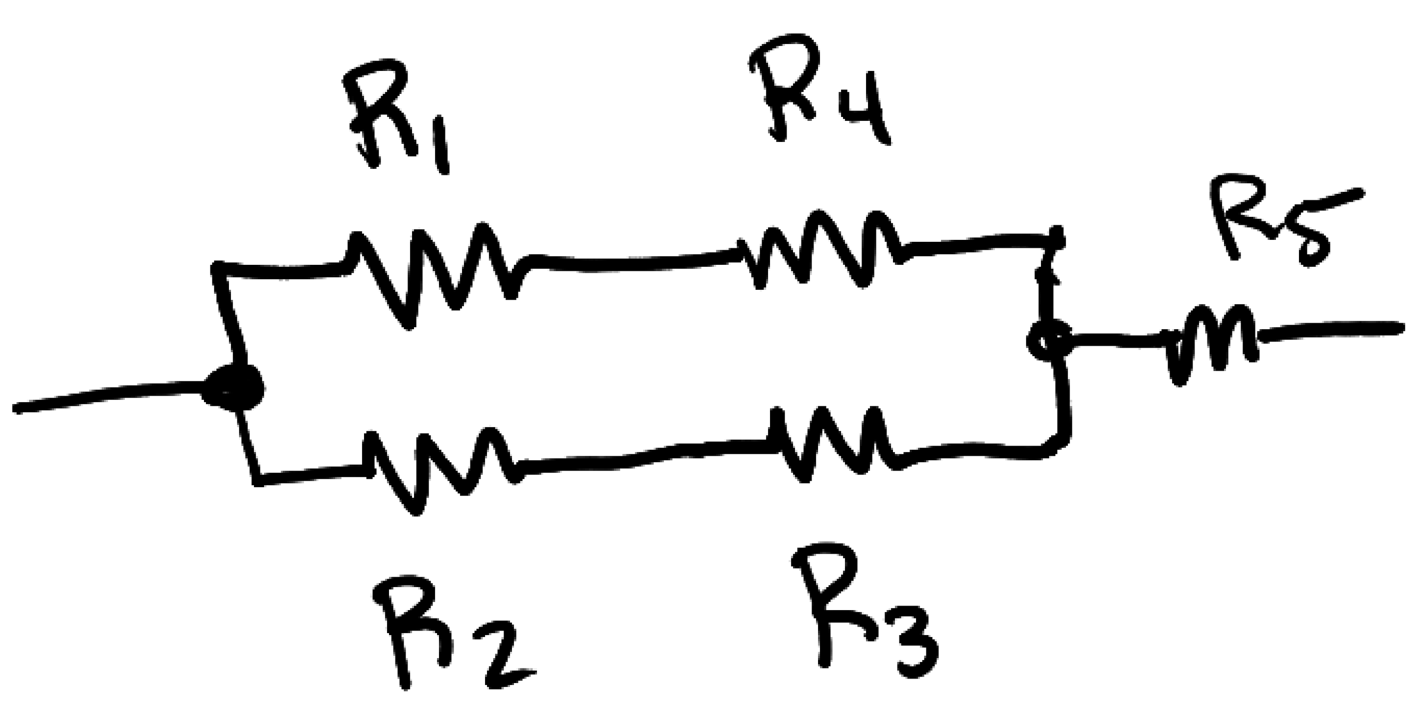
$P_3 = 16W$

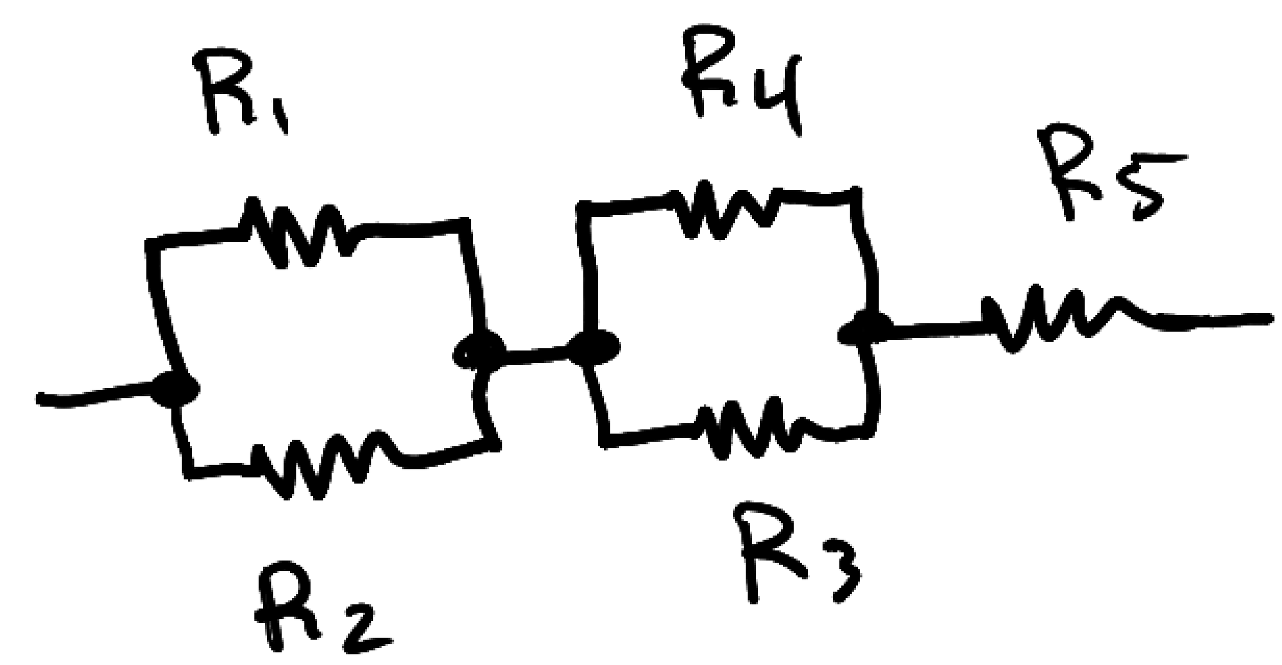
5) $P_{batt} = \sum P = 16 + 4 + 16 = 36W$

$= IV = (2A)(18V) = \underline{36W}$

problem 7.6 :

use trick $\quad R_{parallel} = \frac{R_1 R_2}{R_1 + R_2}$





$$R_{eq} = \frac{(R_1 + R_4)(R_2 + R_3)}{R_1 + R_4 + R_2 + R_3} + R_5$$

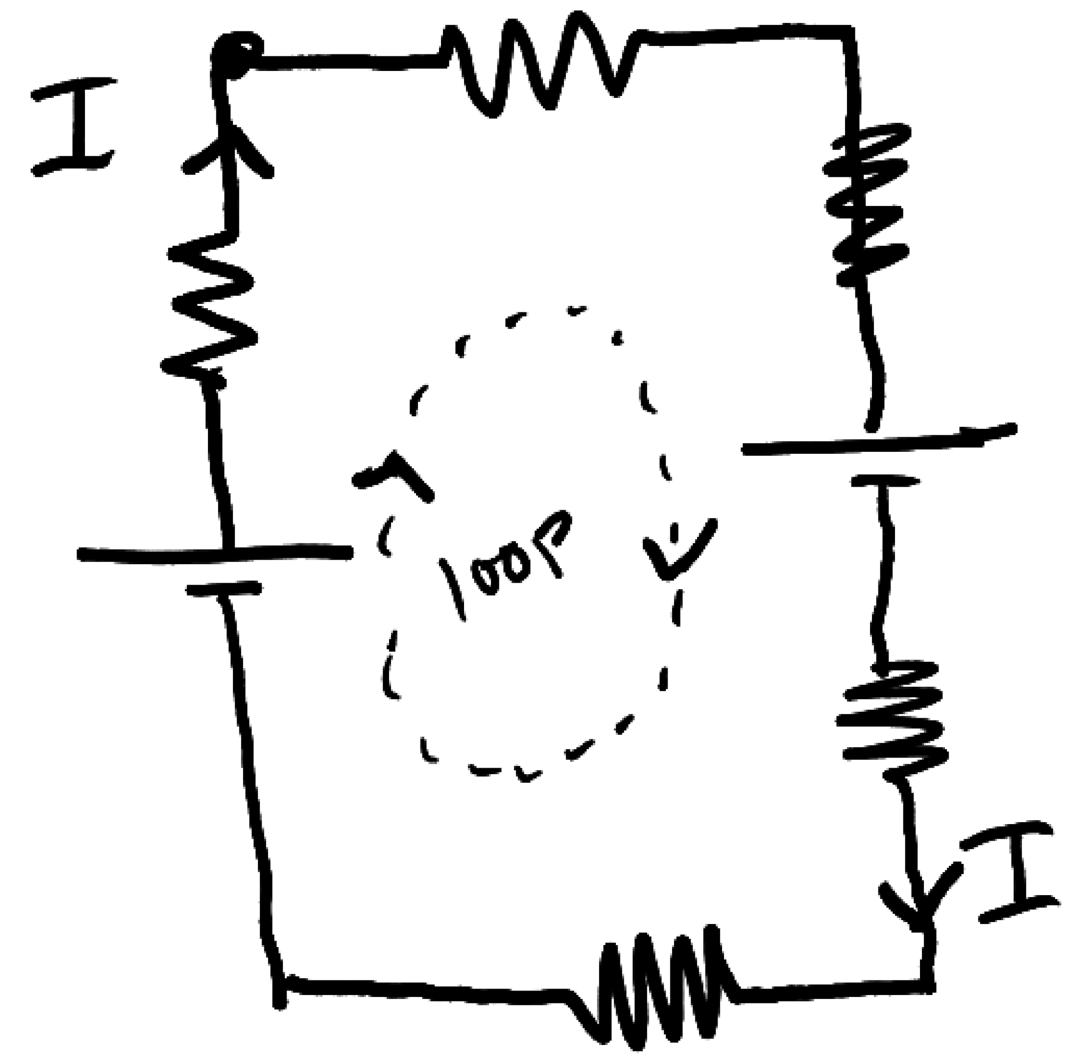
$$\boxed{= 12\,\Omega}$$

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2} + \frac{R_4 R_3}{R_4 + R_3} + R_5$$

$$\boxed{= 12\,\Omega}$$

problem 7.7:

use a loop!
$\Sigma \Delta V$ around loop is 0



all in kΩ

$$0 = -20I - 10I - 24 - 10I - 10I + 12 - 10I$$

$$0 = -60I - 12 \Rightarrow I = \frac{-12}{60E3}$$

reinsert kΩ

$$\boxed{I = -0.5\,mA}$$

$$P = IV = I^2 R \boxed{= 0.015 \quad W}$$

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problem 7.8:

* loops all start at top left corner and are clockwise

loop A: $-I_1R_1 - I_3R_3 - I_2R_2 + \underline{V_1} = 0$

loop B: $+I_2R_2 \quad - \underline{V_2} \quad - I_6 \underline{R_4} = 0$

loop C: $+I_3R_3 \quad - I_5R_5 \quad + \underline{V_2} = 0$

unknowns are underlined!

A: $-24 - 6 - 12 + V_1 = 0 \Rightarrow$

C: $+6 - 12 + V_2 = 0 \Rightarrow$

B: $12 - 6 - 1R_4 = 0 \Rightarrow$

$$\boxed{\begin{aligned} V_1 &= 42\text{ Volts} \\ V_2 &= 6\text{ Volts} \\ R_4 &= 6\,\Omega \end{aligned}}$$

problem 7.9

loop1: $-I_2 R_2 - I_1 R_1 + V_1 = 0$

loop2: $+I_3 R_3 - V_2 - I_4 R_4 + I_2 R_2 = 0$

loop3: $-I_5 R_5 + V_2 = 0$

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problem 7.10:

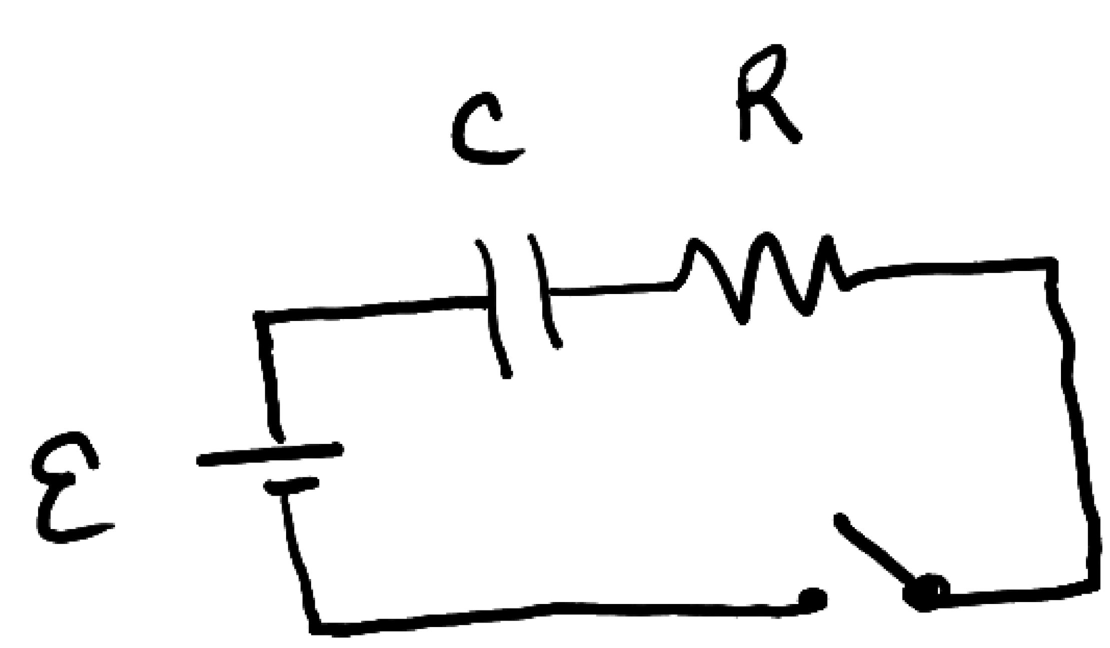
RC-Circuit: charging

$$q(t) = Q_{max}\left(1 - e^{-t/\tau}\right)$$

$$V_{cap}(t) = \mathcal{E}\left(1 - e^{-t/\tau}\right)$$

$$V_{resist}(t) = \mathcal{E}\left(e^{-t/\tau}\right)$$

$$I_{Resist} = I_{max}\left(e^{-t/\tau}\right)$$



1)

First construct the Capacitor

$$C = \frac{\varepsilon A}{d} = \frac{(3.7)(8.85E\text{-}12)(2)}{5E\text{-}5} = \boxed{1.31\,\mu F}$$

Find time constant: $\tau = RC = \boxed{1.31 \times 10^{-4}\text{ sec}}$

2) $$I_{max} = \frac{\mathcal{E}}{R} = \frac{6}{100} = \boxed{0.06A}$$

Called "inrush" current

3) time to get $I = \frac{1}{3} I_{max}$ ← use I_{Resist} from above

$$\frac{1}{3} = e^{-t/\tau} \Rightarrow \ln\left(\frac{1}{3}\right) = -\frac{t}{\tau} \Rightarrow t = -\tau \ln(3) = \boxed{1.44 \times 10^{-4}\,s}$$

problem 7.11:

$$\tau = RC = 10\,ms$$

$$R = \tau/C = 1250\,\Omega$$

$$V_{max} = 12KV = 12E3$$

$$V = 600V$$

Charging Cap:

$$V = V_{max}\left(1 - e^{-t/\tau}\right)$$

$$0.05 = 1 - e^{-t/\tau}$$

$$0.95 = e^{-t/\tau}$$

$$t = -\tau \ln(0.95)$$

$$\boxed{= 0.5\,ms}$$

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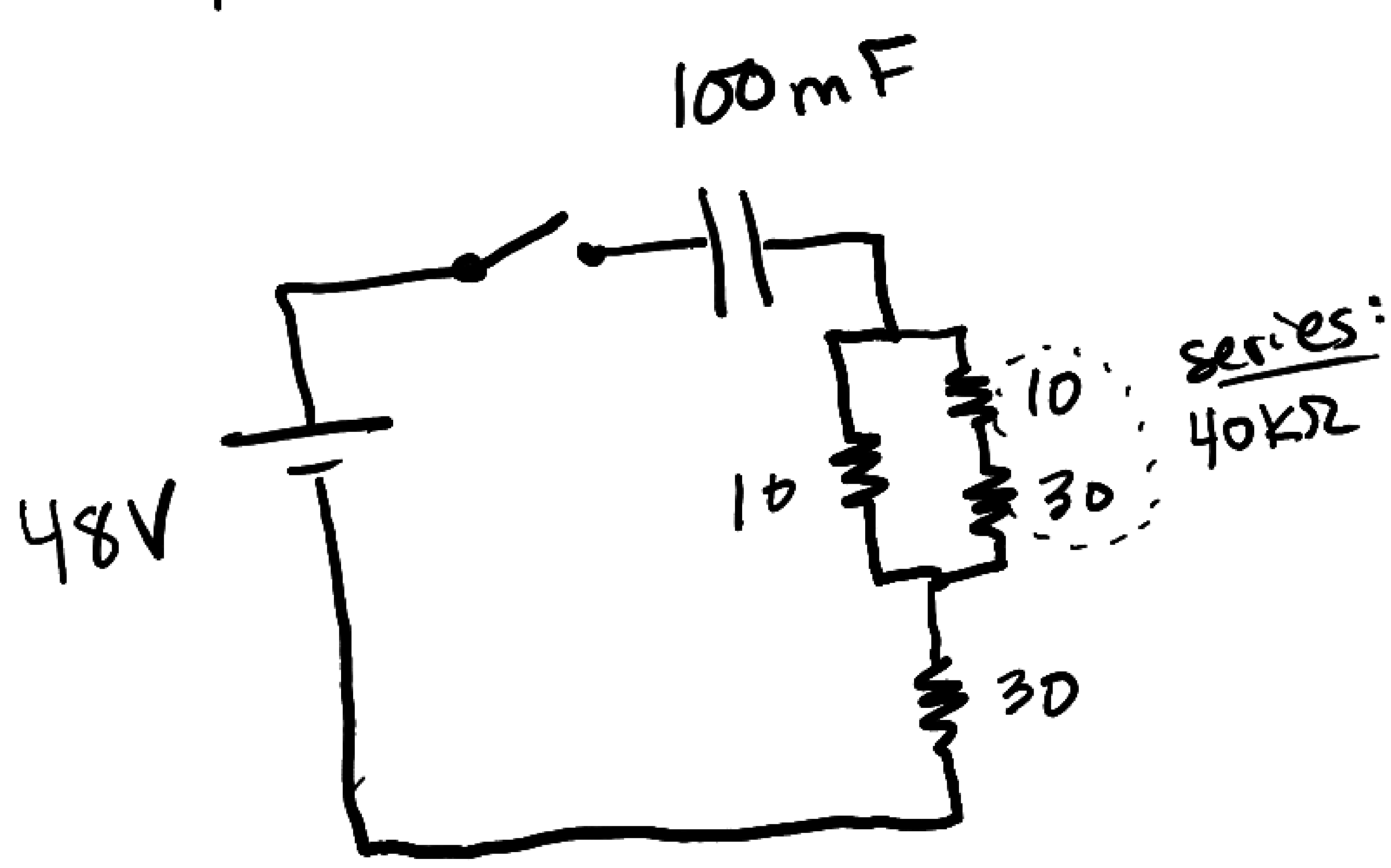
problem 7.12

First reduce the circuit



1)

$$R_{eq} = \frac{(10)(40)}{10+40} + 30 = 38\,\Omega$$

$$\tau = RC = \boxed{3.8\,sec}$$

2)

$$I_{max} = \frac{\mathcal{E}}{R} = \frac{48}{38}$$

$$\boxed{= 1.26A}$$

3)

$$\frac{1}{2} I_{max} = I_{max}\left(e^{-t/\tau}\right)$$

$$\ln\left(\tfrac{1}{2}\right) = -t/\tau$$

$$t = -\tau \ln(1/2) = \boxed{2.64s}$$