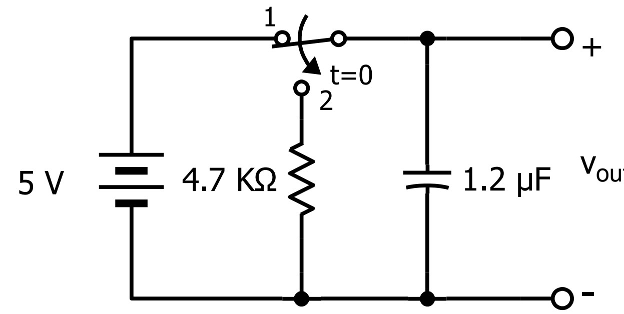
EE3 Fall 2020
Practice Problems 3

1. In this problem, there is no battery after the switch changes positions. We will be finding the <u>natural response</u> of the RC circuit (no forcing function). As I stated in lecture, this is not a course in the solution of differential equations. But I want you to understand key features of solving one. Assume the switch has been in position 1 for a LONG TIME. After it switches to position 2, we will find the expression for $v_{out}(t)$. $v_{out}(0-)=5$ V.



To find the trajectory followed by v_{out}, use the KCL Method:

$$i_R + i_C = 0$$

$$\frac{v_{out}}{R} + C\frac{dv_{out}}{dt} = 0$$

$$\frac{dv_{out}}{dt} + \frac{1}{RC}v_{out} = 0$$

Multiply by dt and divide by v_{out}: $\frac{dv_{out}}{v_{out}} + \frac{1}{RC}dt = 0$

Integrate from $time = 0^+$ to $time = t$: $\int_{v_{out}(0^+)}^{v_{out}(t)} \frac{dv_{out}}{v_{out}} = \int_0^t \frac{-1}{RC}dt$

$$\ln(v_{out}(t)) - \ln(v_{out}(0^+)) = \ln\left(\frac{v_{out}(t)}{v_{out}(0^+)}\right) = -\frac{t}{RC}$$

$$v_{out}(t) = v_{out}(0^+)e^{-\frac{t}{RC}}$$

This is where we must know how a capacitor behaves: if $v_{out}(0^-) = 5$, then what does $v_{out}(0^+)$ equal? Also, what is the trajectory $v_{out}(t)$?

$v_{out}(0^+) = 5$
because capacitors hate to see changes in voltage, and will not allow instantaneous changes in voltage.

So $v_{out}(t) = 5e^{-\frac{t}{RC}} = 5e^{-177t}$

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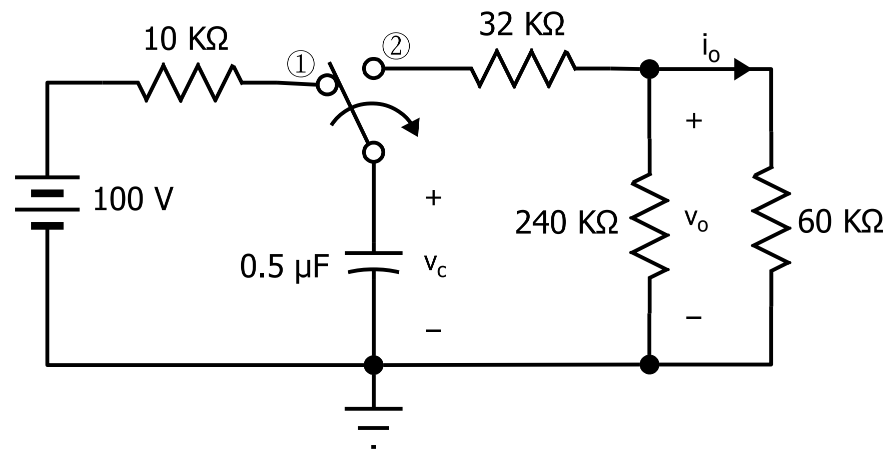
2. The switch has been in position ① for a long time. At t=0, the switch move instantaneously to position ②. Find:
   a. $v_c(0+)$
   b. $v_o(0+)$
   c. $i_o(0+)$
   d. [optional] $v_c(t)$



a. $v_c(0^+) = v_c(0^-) = 100\text{ V}$

b. $v_o(0+) = 100\left[\dfrac{240e3\|60e3}{32e3+240e3\|60e3}\right] = 60\text{ V}$

c. $i_o(0+) = \dfrac{60\text{ V}}{60e3\,\Omega} = 1\text{ mA}$

d. $32e3+240e3\|60e3 = 80e3$

$RC = (80e3)\cdot(0.5e\text{-}6) = 0.04\text{ s}$

$v_c(t) = 100\,e^{-\frac{t}{RC}} = 100\,e^{-25t}$

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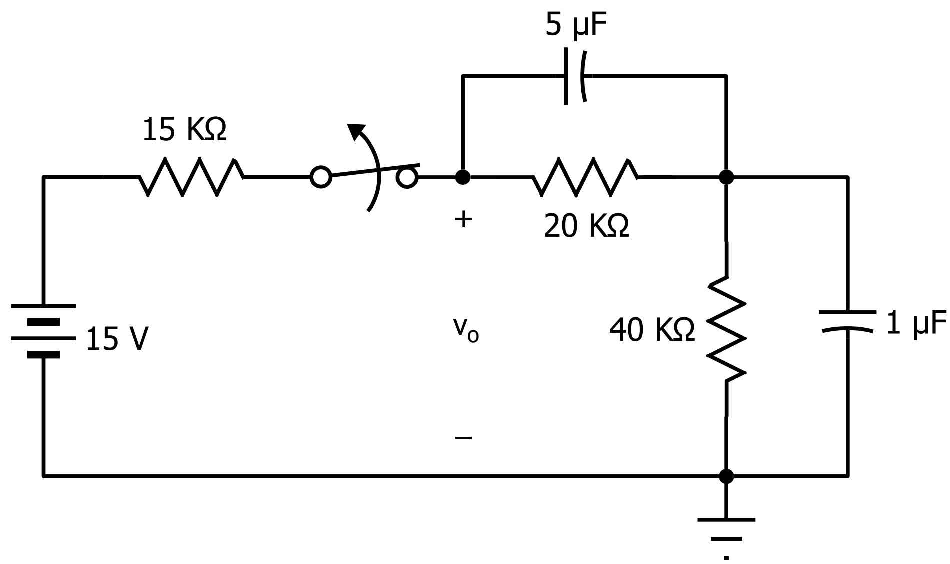
3. The switch has been closed for a long time. At t=0, the switch opens. Find:
   a. $v_o(0+)$
   b. The capacitors will discharge into their parallel resistors. What are ther two time constants?
   c. [OPTIONAL] Find $v_o(t)$.



a. $v_o(o^+) = 15\left[\dfrac{20e3+40e3}{15e3+20e3+40e3}\right] = 12\ \text{V}$

b. $\tau_5 = (5e\text{-}6)\cdot(20e3) = 0.1\ \text{s};\ \tau_5 = (1e\text{-}6)\cdot(40e3) = 0.04\ \text{s}$

c. $v_5(t) = 12\left(\dfrac{20e3}{20e3+40e3}\right)e^{-10t} = 4e^{-10t}$

$$v_1(t) = 12\left(\dfrac{40e3}{20e3+40e3}\right)e^{-25t} = 8e^{-25t}$$

$$v_o(t) = v_5(t)+v_1(t) = 4e^{-10t}+8e^{-25t}$$

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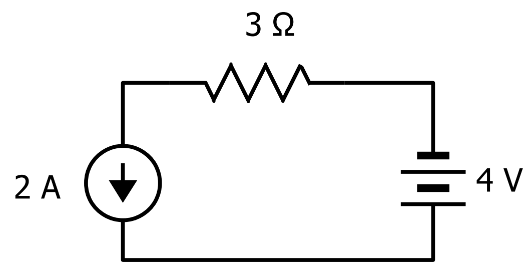
4. In the world of EE3, is this a legal circuit?

Yes

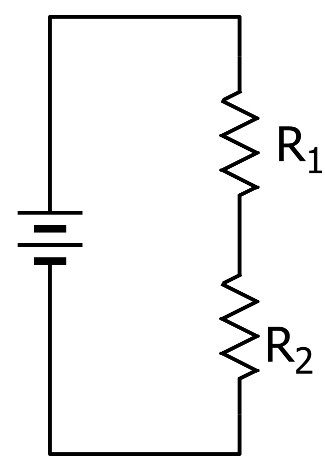
No

5. Is the 2 A current source providing or absorbing power?



Current is leaving the positive end, so it is providing power.

6. In this circuit, $R_1 > R_2$. Which resistor dissipates the most power?

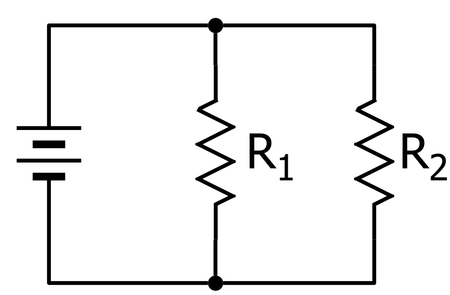


a. Neither; they dissipate the same power.

b. R_1 $I^2 R_1 > I_2 R_2$

c. R_2

7. In this circuit, $R_1 > R_2$. Which resistor dissipates the most power?



a. Neither; they dissipate the same power.

b. R_1

c. R_2 $\frac{V^2}{R_1} < \frac{V^2}{R_2}$