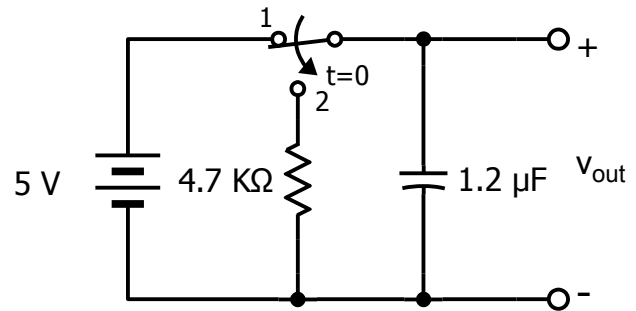


EE3 Fall 2020

Practice Problems 3

1. In this problem, there is no battery after the switch changes positions. We will be finding the natural response 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.

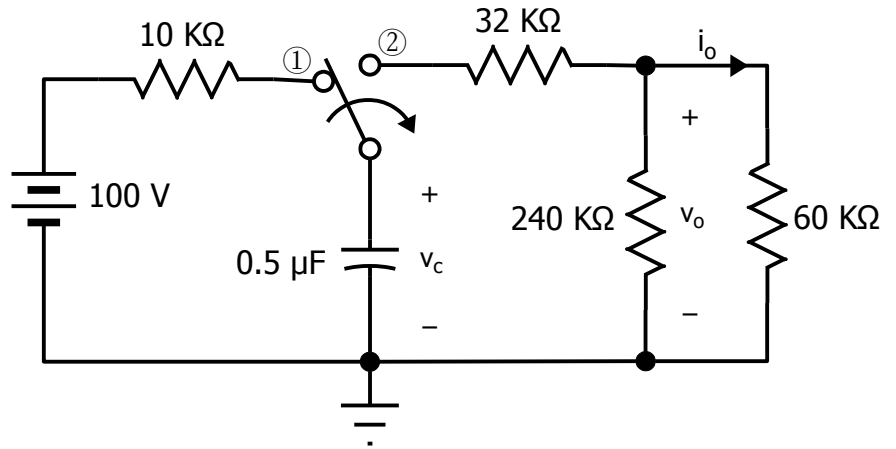
$$\text{So } v_{out}(t) = 5 e^{-\frac{t}{RC}} = 5 e^{-177t}$$

EE3 Fall 2020 Practice Problems 3

2. The switch has been in position ① for a long time. At $t=0$, the switch move instantaneously to position ②.

Find:

- $v_c(0^+)$
- $v_o(0^+)$
- $i_o(0^+)$
- [optional] $v_c(t)$



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

$$b. v_o(0^+) = 100 \left[\frac{240\text{e}3 \parallel 60\text{e}3}{32\text{e}3 + 240\text{e}3 \parallel 60\text{e}3} \right] = 60 \text{ V}$$

$$c. i_o(0^+) = \frac{60 \text{ V}}{240\text{e}3 \parallel 60\text{e}3 \Omega} = 1 \text{ A}$$

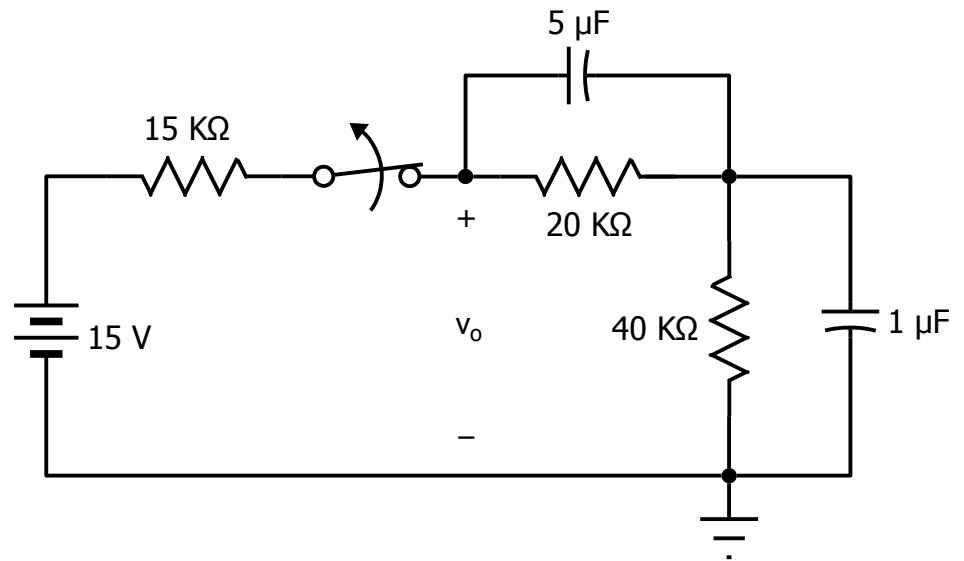
$$d. 32\text{e}3 + 240\text{e}3 \parallel 60\text{e}3 = 80\text{e}3$$

$$RC = (80\text{e}3) \cdot (0.5\text{e}-6) = 0.04 \text{ s}$$

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

EE3 Fall 2020 Practice Problems 3

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



$$\text{a. } v_o(0^+) = 15 \left[\frac{20e3 + 40e3}{15e3 + 20e3 + 40e3} \right] = 12 \text{ V}$$

$$\text{b. } \tau_5 = (5e-6) \cdot (20e3) = 0.1 \text{ s}; \quad \tau_4 = (1e-6) \cdot (40e3) = 0.04 \text{ s}$$

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

$$v_4(t) = 12 \left(\frac{40e3}{20e3 + 40e3} \right) e^{-25t} = 8e^{-25t}$$

$$v_o(t) = v_5(t) + v_4(t) = 4e^{-10t} + 8e^{-25t}$$

EE3 Fall 2020

Practice Problems 3

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

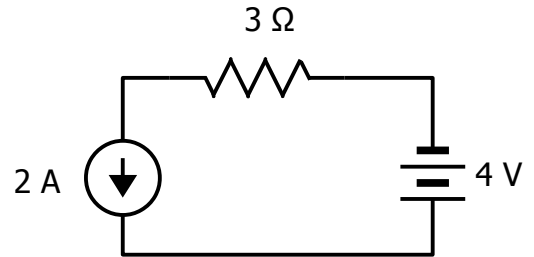
Yes

No



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

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

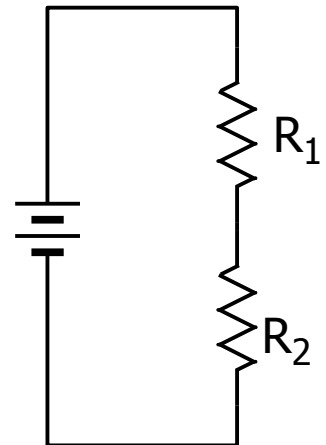


6. In this circuit, $R_1 > R_2$. Which resistor dissipates the most power?

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

