University of Portland
School of Engineering

EE 261-Electrical Circuits-3 cr. hrs.
Spring 2015

Midterm Exam # 2

(Friday, April 10, 2015)
(Closed Book Exam, Two Formula Sheets Allowed)
(Total Time: 55 minutes)

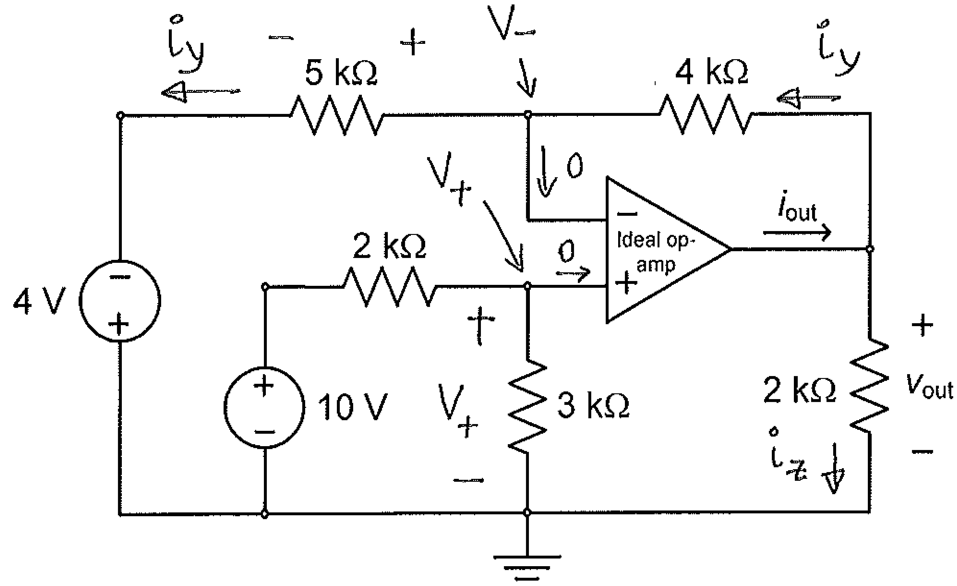
Name: SOLUTIONS ☺

Signature: Solutions ☺

"An honest mind possesses a kingdom."
Lucius Annaeus Seneca (4B.C.–65A.D.)

"Honest people are the true winners of the universe."
Anonymous

1. (15 mins., 30 Points) For the op-amp circuit shown, find the values of the output voltage v_o and the current i_o. Show your work and box your answers with the appropriate units.



$$V_+ \overset{VDP}{=} \frac{3k\Omega}{2k\Omega+3k\Omega}(10V) = 6V = V_-$$

$$i_y = \frac{6-(-4)}{5k\Omega} = 2mA$$

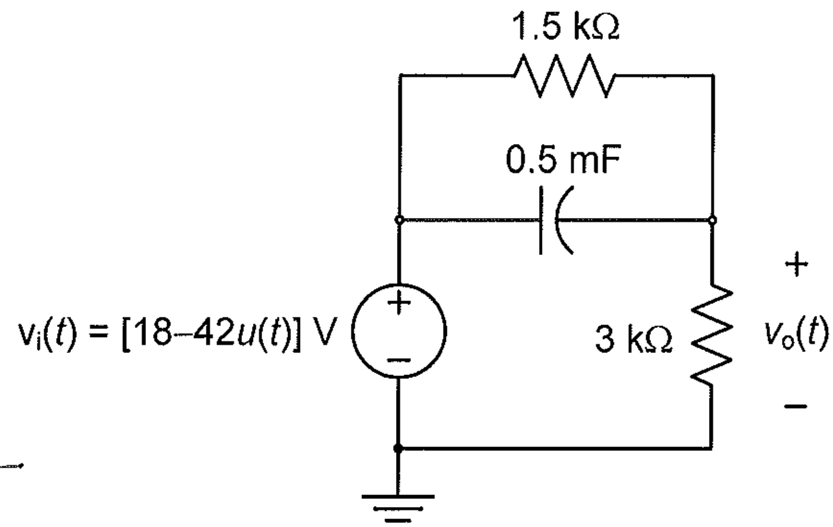
$$V_{out} = (4k\Omega)i_y + V_+ = 8 + 6 = \boxed{14\,V}$$

$$i_z = \frac{V_{out}}{2k\Omega} = \frac{14V}{2k\Omega} = 7mA \rightarrow i_{out} \overset{KCL}{=} i_y + i_z = (2+7)\,mA = \boxed{9\,mA}$$

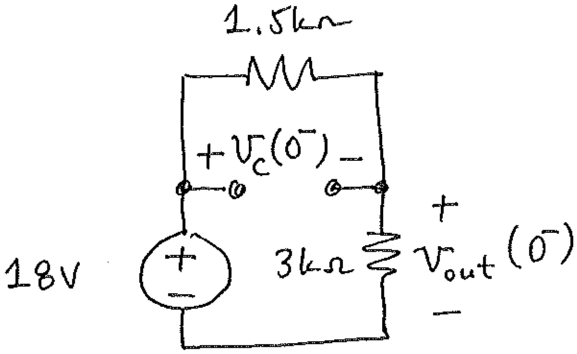
Inan's table!

Problem # 1	
Problem # 2	
Problem # 3	
Total Score	

2. (15 mins., 30 points) For the circuit shown, find the complete mathematical expression for the voltage $v_o(t)$. Provide your steps and box your answer with the appropriate unit.



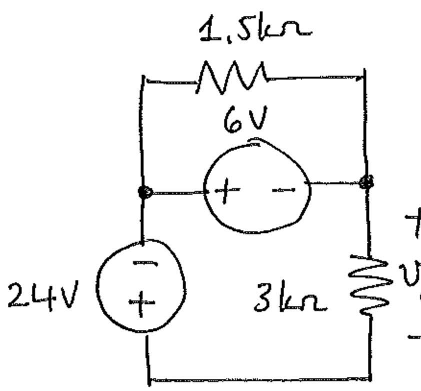
At $t = 0^-$ (ss):



$$v_c(0^-) = \frac{1.5k\Omega}{4.5k\Omega}(18V) = 6V$$

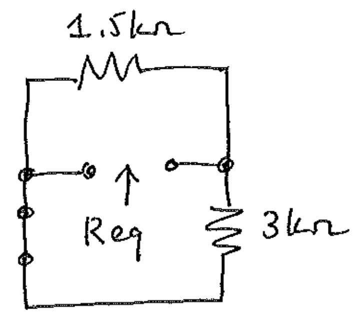
$$v_{out}(0^-) = 18 - 6 = 12V$$

At $t = 0^+$ (not ss):



$$v_{out}(0^+) = -6 - 24 = -30V$$

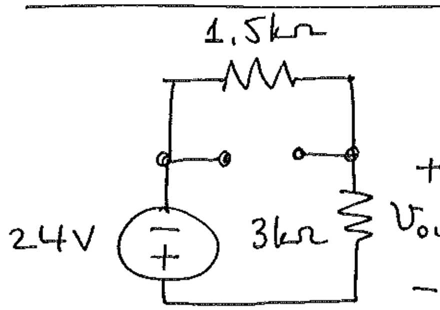
To find $\tau = R_{eq}C$:



$$R_{eq} = 1.5k\Omega // 3k\Omega = 1k\Omega$$

$$\tau = R_{eq}C = (1k\Omega)(0.5mF) = 0.5s$$

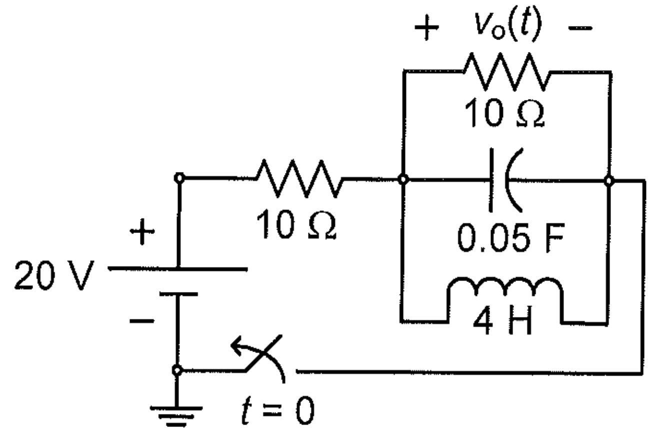
At $t \to \infty$ (ss):



$$v_{out}(t\to\infty) = -\frac{3k\Omega}{4.5k\Omega}(24) = -16V$$

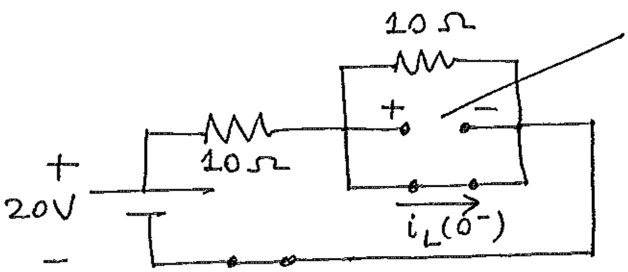
$$\therefore v_{out}(t) = \begin{cases} 12V, & t < 0 \\ -30e^{-2t} - 16(1 - e^{-2t})V, & t > 0 \end{cases}$$

3. (15 mins., Total: 40 points) For the circuit shown, the switch opens at $t = 0$, after being closed for a long time. Find the complete mathematical expression for the voltage $v_o(t)$ for $t \geq 0$.



(a) (10 points) Determine the initial conditions.

At $t = 0^-$ (ss):

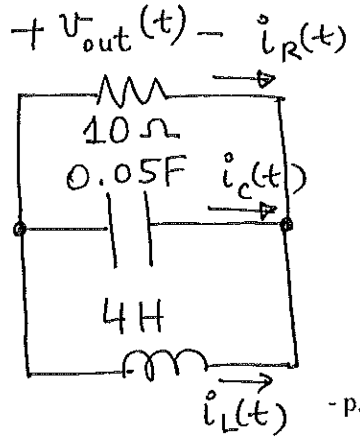


$v_C(0^-) = 0 = v_o(0^-)$

$i_L(0^-) = \frac{20\,V}{10\Omega} = 2A$

(b) (10 points) Determine the characteristic roots and the type of the transient response.

For $t > 0$:



Parallel RLC circuit:

$$s^2 + \frac{1}{RC} s + \frac{1}{LC} = 0$$

$$s^2 + 2s + 5 = 0$$

$$s_1, s_2 = \frac{-2 \pm \sqrt{4 - 20}}{2}$$

$$= \boxed{-1 \pm j2}$$

$\therefore$ Underdamped response!

(c) (20 points) Find the complete mathematical expression for the output voltage $v_o(t)$ for $t \geq 0$.

$$v_o(t) = A_1 e^{-t}\cos(2t) + A_2 e^{-t}\sin(2t) + A_3 , \quad t \geq 0.$$

First initial condition $\rightarrow v_o(0^+) = A_1 + A_3 = v_o(0^-) = 0$

Final condition $\rightarrow v_o(t \rightarrow \infty) = A_3 = 0 \rightarrow A_1 = 0$

$$v_o(t) = A_2 e^{-t}\sin(2t)$$

$$\text{KCL} \rightarrow i_L(t) = -i_R(t) - i_C(t) = -\frac{v_{out}(t)}{R} - C\frac{dv_{out}(t)}{dt}$$

$$= -\frac{A_2 e^{-t}\sin(2t)}{10} - (0.05)\left[-A_2 e^{-t}\sin(2t) + 2A_2 e^{-t}\cos(2t)\right]$$

Second initial condition $\rightarrow i_L(0^+) = -0.1 A_2 = 2 \rightarrow A_2 = -20$

$$\therefore v_o(t) = -20 e^{-t}\sin(2t) \text{ V}, \text{ for } t \geq 0$$