University of Portland
School of Engineering

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

Midterm Exam # 2

(Friday, November 13, 2015)

Happy Sequential Calendar Date
11/13/15!

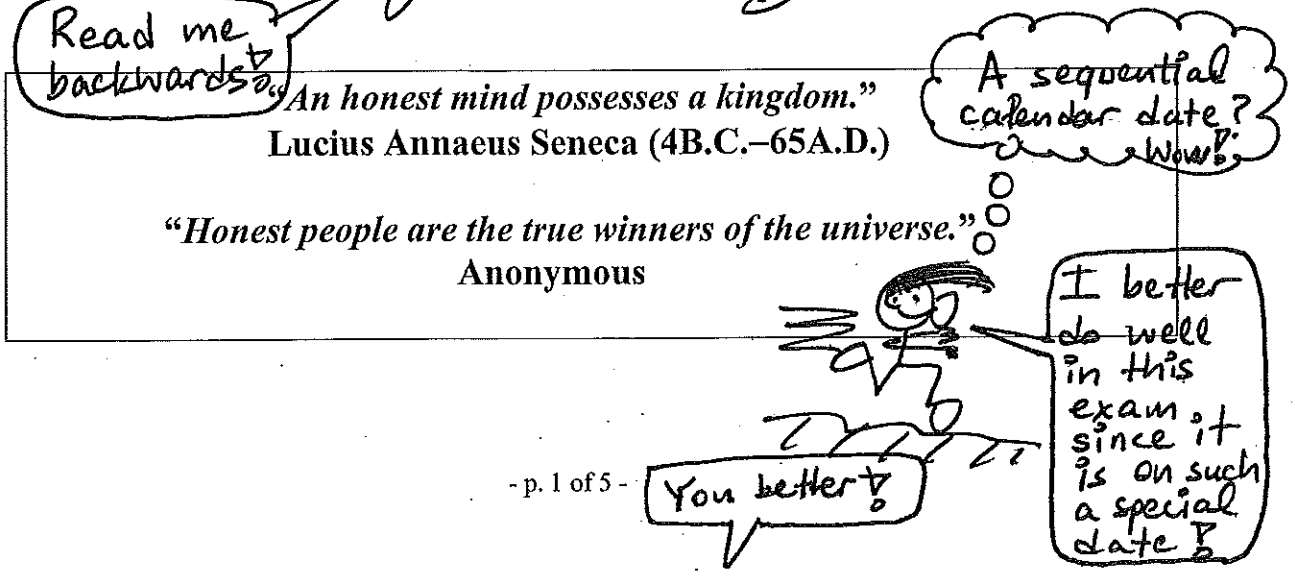
(Closed Book Exam, Two Formula Sheets Allowed)
(Total Time: 55 minutes)

Name: SOLUTIONS

Signature: Gnoitulos

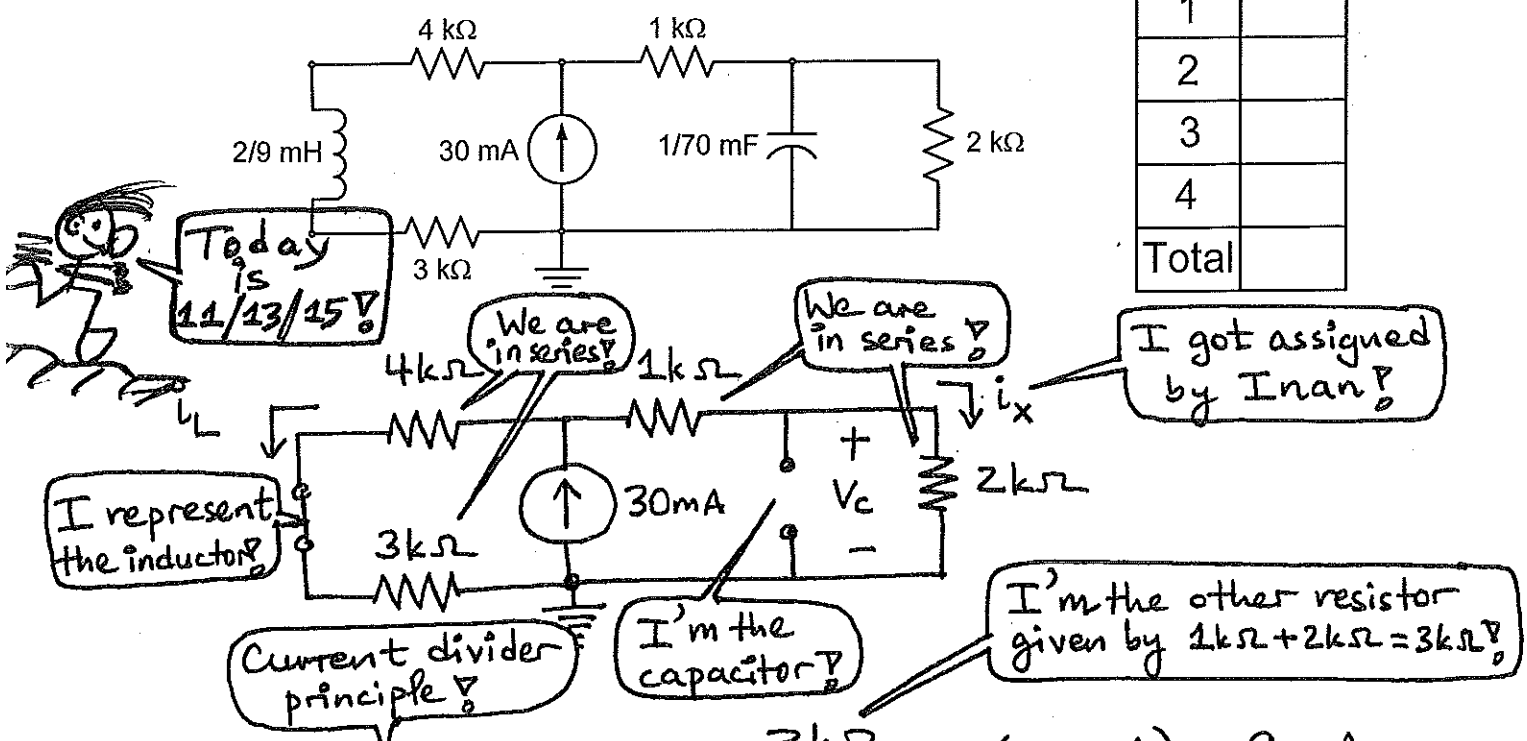
"An honest mind possesses a kingdom."
Lucius Annaeus Seneca (4B.C.–65A.D.)

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



1. (25 points) The electric circuit shown below is at DC steady state. Find the energies stored in the capacitor and the inductor. Provide units for your answers. Box your answers.

1	
2	
3	
4	
Total	



Using CDP: $i_L = \dfrac{3\text{k}\Omega}{7\text{k}\Omega+3\text{k}\Omega}(30\text{mA}) = 9\text{ mA}$

Kirchhoff's current law! KCL: $i_x = 30\text{mA} - i_L = 21\text{ mA}$

Energies stored in the capacitor and inductor can be calculated as

I represent capacitor energy! $W_c = \frac{1}{2}CV_c^2 = \frac{1}{2}\left(\frac{1}{70}\times 10^{-3}\right)\underbrace{[(2\text{k}\Omega)\,i_x]}_{42\text{ V}}^2$

$= 0.0126\text{ J} = \boxed{12.6\text{ mJ}}$

Since 13/15/17 is not a date!

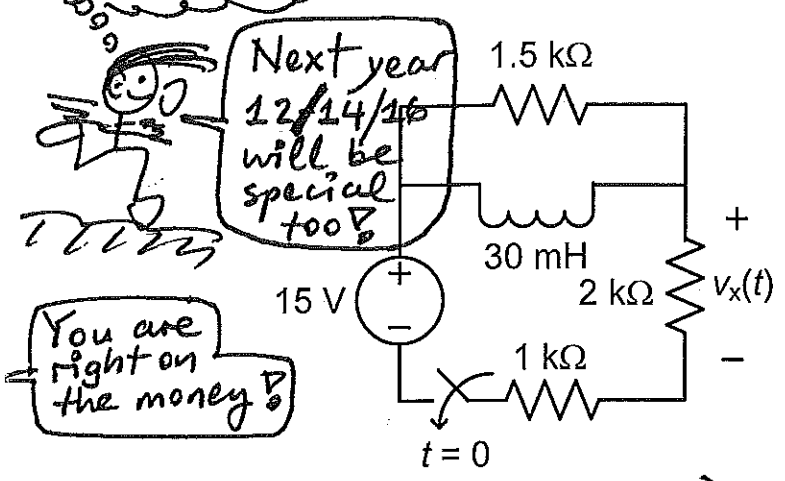
I'm the inductor energy! $W_L = \frac{1}{2}Li_L^2 = \frac{1}{2}\left(\frac{2}{9}\times 10^{-3}\right)(9\times 10^{-3})^2 = 0$

$= 9\times 10^{-9}\text{ J} = \boxed{9\text{ nJ}}$

Last odd-numbered sequence calendar date of this century!

I agree!

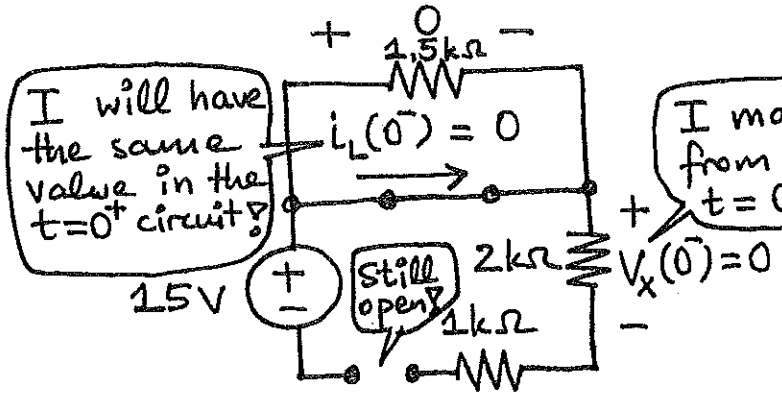
2. (25 Points) For the electric circuit shown, find the voltage $v_x(t)$ across the 2 kΩ resistor for $t > 0$. Assume the switch to be open for a long time before it closes at $t = 0$.



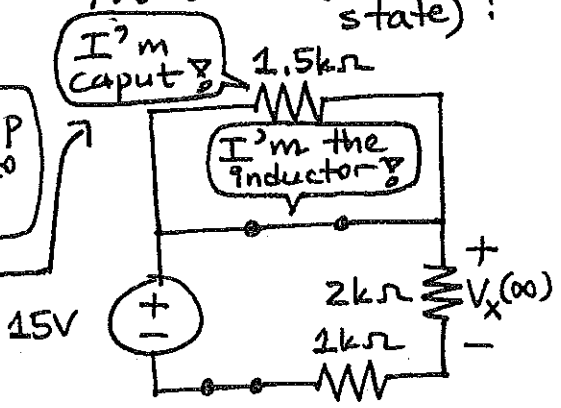
Since 1st-order, switching, DC circuit, $V_x(t)$ has the general form:

$$V_x(t) = V_x(0^+)e^{-t/\tau} + V_x(\infty)(1-e^{-t/\tau}), \text{ for } t>0.$$

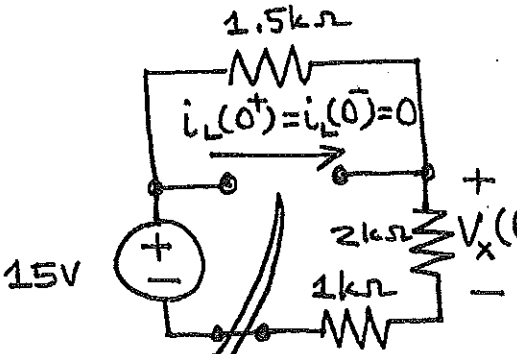
At $t=0^-$ (steady state):



At $t\to\infty$ (steady state):



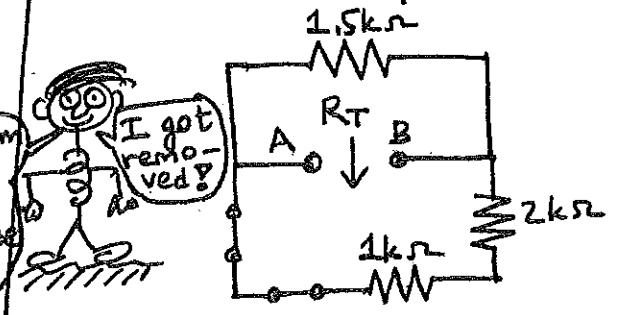
At $t= 0^+$ (not steady state):



VDP: $V_x(0^+) = \frac{2k\Omega}{4.5k\Omega}(15V) = \frac{20}{3}V$

VDP: $V_x(\infty) = \frac{2k\Omega}{3k\Omega}(15V) = 10V$

To find $\tau = \frac{L}{R_T}$

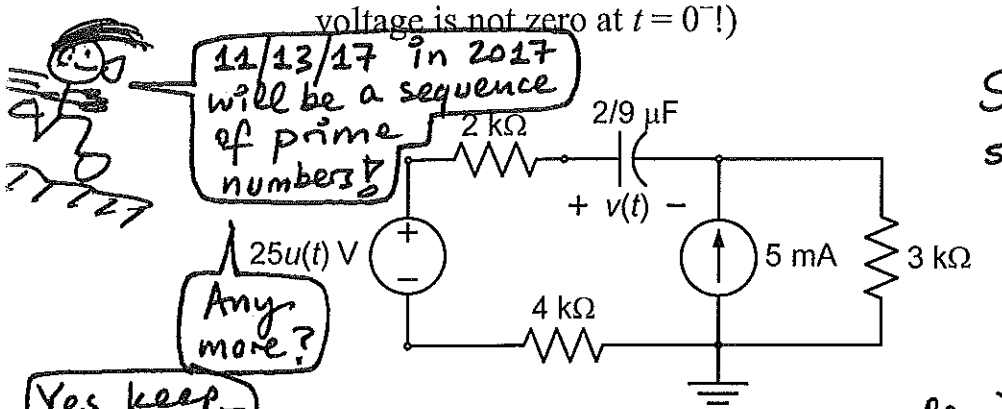


$R_{T_{A-B}} = 3k\Omega \,//\, 1.5k\Omega = 1k\Omega$

$\tau = \frac{30mH}{1k\Omega} = 30\mu s$

$$\therefore V_x(t) = \frac{20}{3}e^{-t/30\mu s} + 10(1-e^{-t/30\mu s})\ V, \text{ for } t>0$$

3. (25 Points) For the electric circuit shown, find the voltage waveform $v(t)$ across the capacitor for $t \geq 0$. (Hint: Note that the capacitor voltage is not zero at $t = 0^-$!)



11/13/17 in 2017 will be a sequence of prime numbers!

Any more?

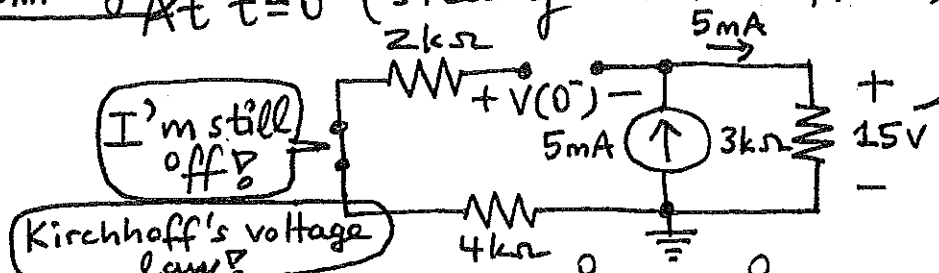
Yes, keep thinking!

Good job!

Since 1st-order, switching, DC circuit:

$v(t) = v(0^+)\, e^{-t/\tau} + v(\infty)(1 - e^{-t/\tau})$, for $t \geq 0$

At $t = 0^-$ (steady state applies):



I got my value from Ohm's law!

I'm still off!

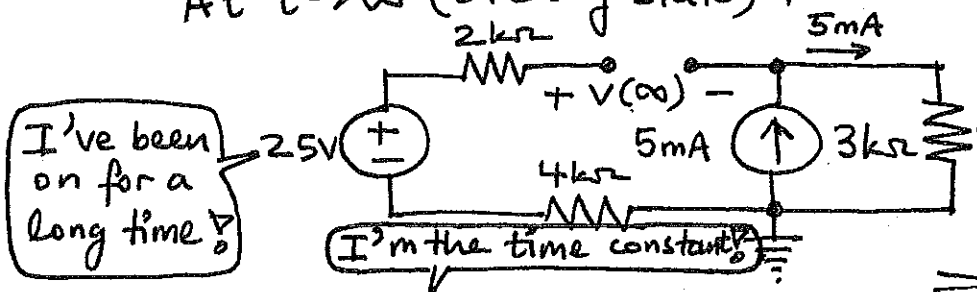
Kirchhoff's voltage law!

KVL: $v(0^-) = \cancel{v_{2k\Omega}}^{\,0} + \cancel{v_{4k\Omega}}^{\,0} + v_{3k\Omega} = -15\text{V}$

$\rightarrow v(0^+) = v(0^-) = -15\text{ V}$

Note that I can't jump!

At $t \rightarrow \infty$ (steady state):

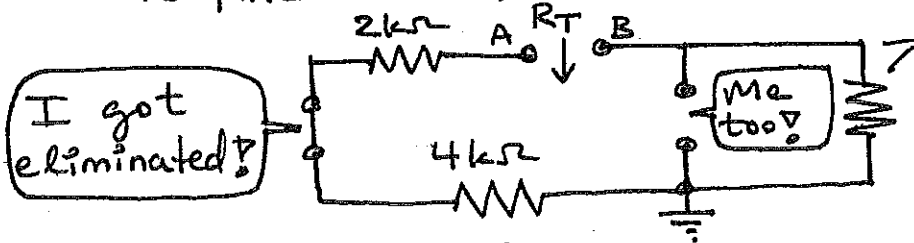


I've been on for a long time!

I'm the time constant!

KVL: $v(\infty) = 25 - 15 = 10\text{V}$

To find $\tau = R_T C$:



I got eliminated!

How about 4/3/21? 5/4/32? 6/5/43, 7/6/54, and so on?

1/2/34, 2/3/45, 3/4/56...?

Now you are talking!

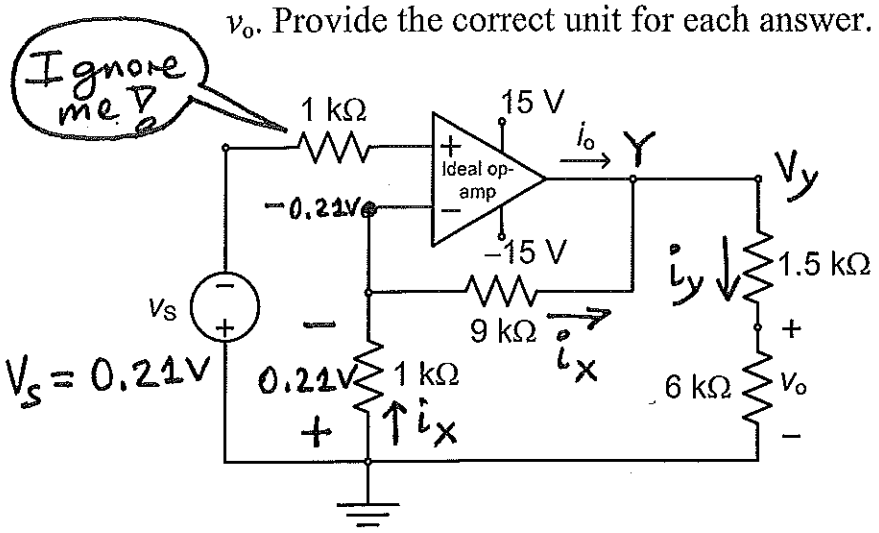
01/23/45! Wow!

$R_{T_{A-B}} = (2+4+3)\,k\Omega = 9\,k\Omega$

$\tau = (9k\Omega)\left(\frac{2}{9}\mu F\right) = 2\text{ ms}$

$\therefore v(t) = -15\, e^{-500t} + 10(1 - e^{-500t})$ V, for $t \geq 0$

4. (25 Points) For the op-amp circuit shown, given the source voltage to be $v_S = 0.21$ V, determine the values of the current i_o and the voltage v_o. Provide the correct unit for each answer. Please box your answers.



$$\text{Ohm} \rightarrow i_x = \frac{0.21\text{V}}{1\text{k}\Omega} = 0.21\text{mA}$$

$$\text{KVL} \rightarrow V_y = -(9\text{k}\Omega)\, i_x - 0.21 = -1.89 - 0.21 = -2.1\text{V}$$

$$\text{Ohm} \rightarrow i_y = \frac{V_y}{7.5\text{k}\Omega} = -0.28\text{mA}$$

$$\text{VDP} \rightarrow V_o = \frac{6\text{k}\Omega}{7.5\text{k}\Omega}(V_y) = \boxed{-1.68\text{V}}$$

$$\text{KCL at node Y} \rightarrow i_x + i_o = i_y \rightarrow i_o = i_y - i_x$$

$$= -0.28\text{mA} - 0.21\text{mA}$$

$$= \boxed{-0.49\text{mA}}$$