

Mid-Term Exam (3 hours)

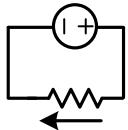
1. [Linearity & Electrical elements] [12pts]

- (a) Suppose the input and the output of a resistor are defined as voltage across the device and temperature of the device, respectively. Is this system linear? Assume that the temperature is proportional to power dissipated in the resistor. [2pts]

- (b) Suppose the input and output of the below circuits are the phase of the voltage and current, respectively.

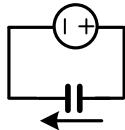
(i.e., input =  $\phi_i(t)$ , output =  $\phi_o(t)$ ) Is this system linear? Assume  $R=1\Omega$ ,  $C=1F$ . [4pts]

$$V = \sin(\phi_i(t))$$



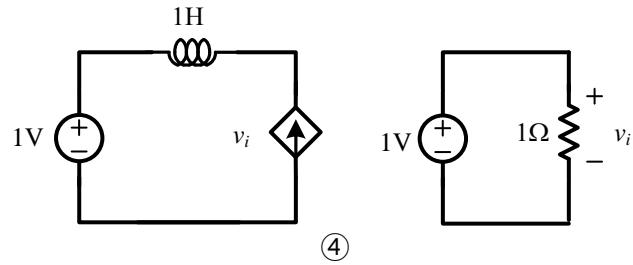
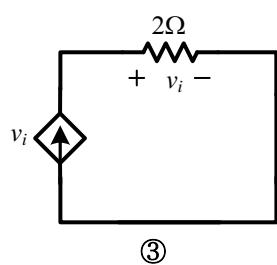
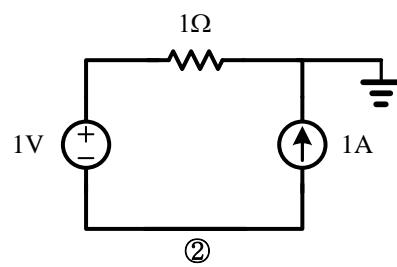
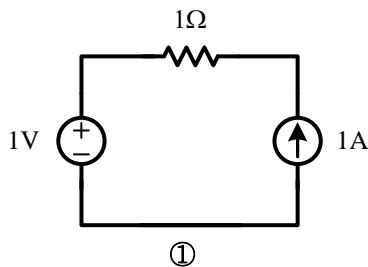
Linear? (Yes, No)

$$V = \sin(\phi_i(t))$$

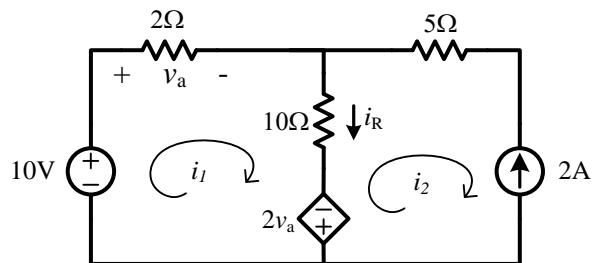


Linear? (Yes, No)

- (c) Please choose the circuits that are physically possible ( $0 < v_i < \infty$ ). [6pts]



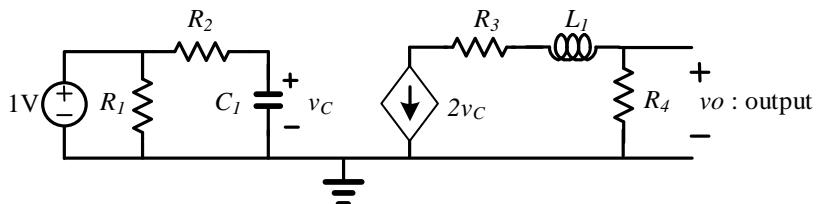
Answer: ( )

**2. Analyze the circuit shown below. [9pts]**

(a) Write down two equations necessary to analyze this circuit. [6pts]

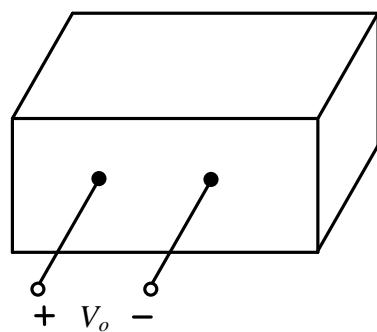
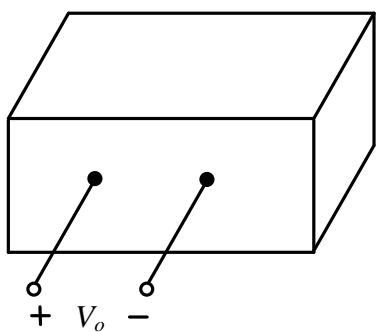
(b) Find  $i_R$  and the mesh currents  $i_1$  and  $i_2$ . [3pts]

## 3. [Thevenin &amp; Norton] [8pts]

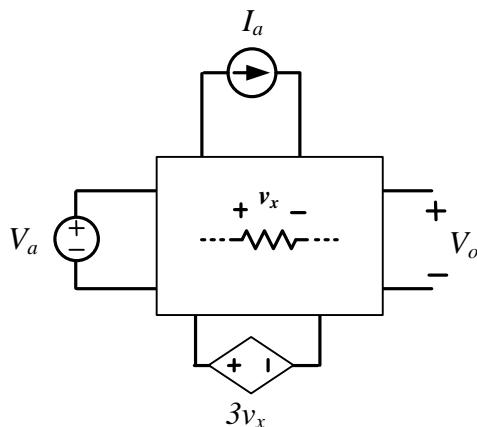


- (a) Find the Thevenin equivalent of the above circuit seen from the output at DC. [5pts]

- (b) Suppose there are two boxes with two electrical outputs. One has a Thevenin equivalent circuit of the above circuit, and the other has the Norton equivalent. Please describe how you can distinguish Norton and Thevenin between these two boxes. [3pts]



4. Please consider the circuit shown below. The rectangular box consists of resistors, capacitors and inductors only. Note that a dependent source is affected by one of the resistor in the box. [9pts]



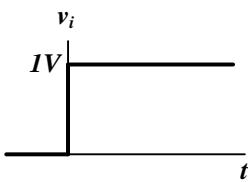
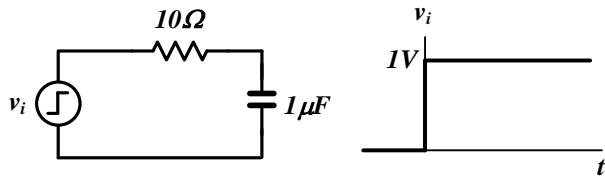
- (a) Suppose that  $V_o = 0.5V$  when  $(V_a, I_a) = (2V, 3A)$  and  $V_o = 1V$  when  $(V_a, I_a) = (3V, 4A)$ , respectively. What is the value of  $V_o$  when  $(V_a, I_a) = (1V, 2A)$ ? If it is not solvable, explain why. [5pts]

- (b) Suppose the dependent source is changed to  $3v_x^2$ . Repeat (a). If it is not solvable, explain why. [4pts]

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5. Please consider the circuit shown below. Assume that the circuit reaches steady-state when calculating energy. [12pts]

For (a) ~ (c), consider the circuit shown below. Assume that the initial charge in the capacitor is zero.

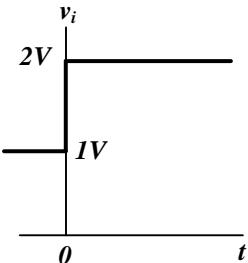
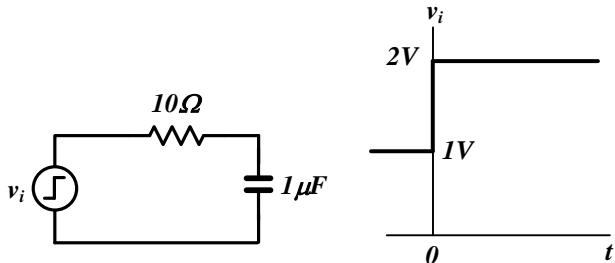


- (a) What is the energy stored in the capacitor? [2pts]

- (b) What is the energy drawn from the source? [2pts]

- (c) What is the energy absorbed (dissipated) in the resistor? [2pts]

For (d) ~ (e), consider the circuit shown below. Assume that the initial voltage across the capacitor is 1V.



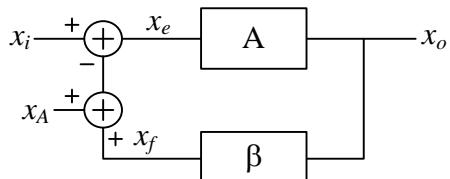
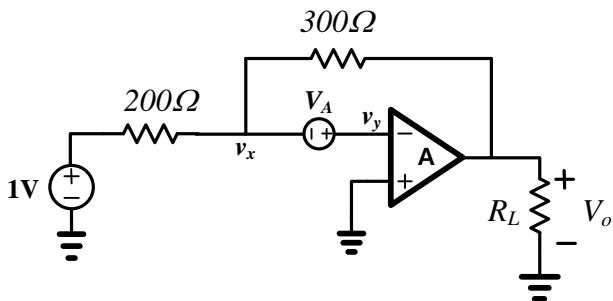
- (d) What is the energy stored in the capacitor? [2pts]

- (e) What is the energy drawn from the source? [2pts]

- (f) What is the energy absorbed (dissipated) in the resistor? [2pts]

## 6. [Opamp and Feedback] [13pts]

(a) Consider the block diagram below. [3pts]

i. Express  $x_e$  in terms of  $x_i$ ,  $x_A$ ,  $A$  and  $\beta$ . [2pts]ii. What happens to  $x_e$  as  $A$  goes to infinity? [1pt]For (b) ~ (e), consider the circuit shown below. Assume that the opamp is ideal. (i.e.  $A = \infty$ )(b) Suppose  $V_A=0$  and  $R_L = 100\Omega$ . What is  $V_o$ ? [3pts](c) Suppose  $V_A \neq 0$  and  $R_L = 100\Omega$ . [5pts]

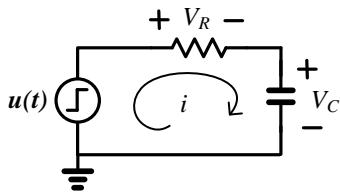
i. Which of the following is true? [2pts]

- ①  $v_x=0$  ②  $v_y=0$  ③ none of the above.

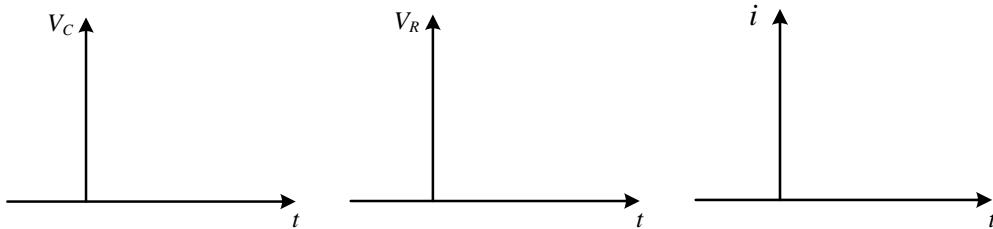
ii. Express  $V_o$  in terms of  $V_A$ . [3pts](d) What is the value of  $R_L$  that results in maximum power transfer? Assume  $V_A = 0$ . [2pts]

- ①  $200\Omega$  ②  $300\Omega$  ③  $120\Omega$  ④  $500\Omega$  ⑤ There is no specific value that results in maximum power transfer.

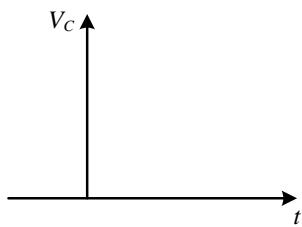
## 7. [RC Circuit] [16pts]



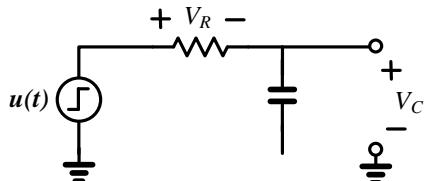
- (a) Draw the voltage  $V_C$ ,  $V_R$  and the current  $i$  when step input is applied for the above circuit. Assume that the initial charge in the capacitor is zero. Draw the answer both when  $t > 0$  and  $t < 0$ . [6pts]



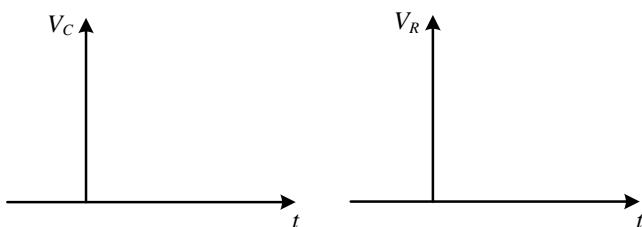
- (b) Suppose the initial charge is 0.5V. Draw  $V_C$ . [2pts]



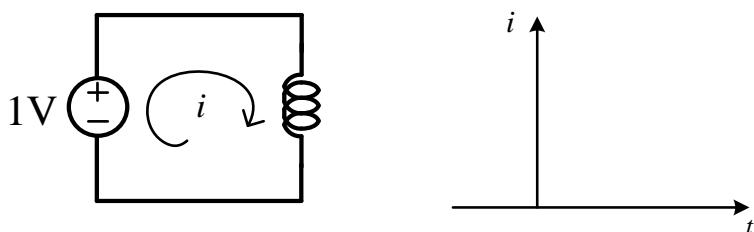
Suppose the circuit is cut and the ground is removed from the capacitor, as shown below.



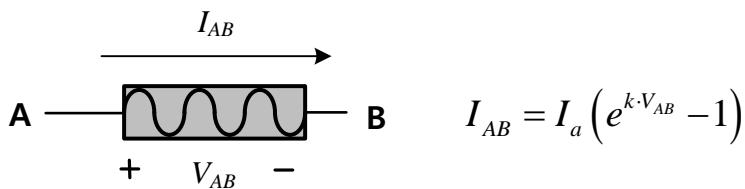
- (c) Repeat (a) for the circuit shown in right. [6pts]



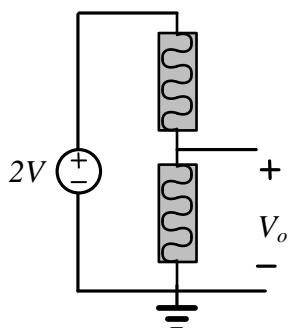
- (d) Draw the output current  $i$  in the below figure. Assume that initial current is zero. [2pts]



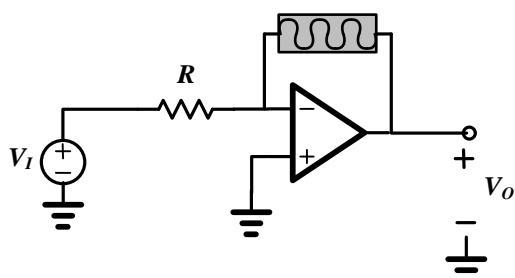
8. Consider the following 2-terminal device which has the following characteristics. [13pts]



- (a) What is the output voltage,  $V_o$ , of the below circuit? Assume  $I_a=10^{-6}$  (A) and  $k=0.5(V^{-1})$  [3pts]



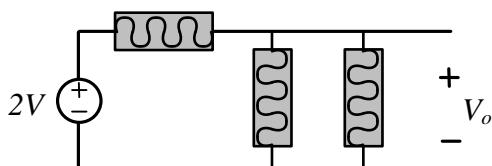
- (b) Analyze the circuit shown below. Assume that the opamp is ideal. [5pts]



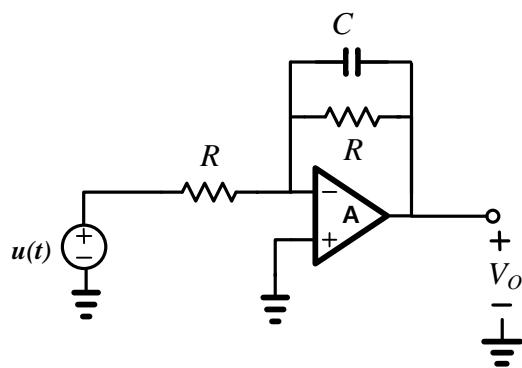
- i. Is the circuit in a positive feedback or negative feedback? If the circuit does not operate properly, please fix the circuit so that it is stable. [1pt]
- ii. Write down the equation for KCL. Express your answer in terms of  $V_o$ ,  $V_I$ , R, k and  $I_a$ . [2pts]
- iii. Express  $V_o$  in terms of  $V_I$ , R, k and  $I_a$ . [2pts]

- (c) What is the approximate output voltage,  $V_o$ ? In order to calculate the approximate  $V_o$ , please assume that

$$I_{AB} \cong I_a e^{k \cdot V_{AB}} . \text{ Assume } I_a=10^{-6} \text{ (A)} \text{ and } k=0.5(V^{-1}) \text{ [5pts]}$$



## 9. [RC Circuit] [8pts]



- (a) What is the time-constant of the above circuit? [3pts]
- (b) Draw a circuit that exhibits the same output voltage as the above circuit using a capacitor, a resistor, and a unit-step voltage source. [5pts]



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EE201 Circuit Theory  
KAIST, Fall 2013  
Prof. SeongHwan Cho

Oct 25, 2013

#1	#2	#3	#4	#5	#6	#7	#8	#9	Total
/12	/9	/8	/9	/12	/13	/16	/13	/8	/100