EECS 215 Winter 2005 Midterm 2

Name: ____

Lecture Section (circle one): McAfee Terry

Rules:

1. One (1) 8.5x11" note sheet allowed. No other information aids allowed.
2. A formulae sheet is provided on the back of this exam and can be removed if desired. No other pages should be removed.
3. DO NOT UNSTAPLE THE PAGES OF THIS EXAM.
4. TURN IN ALL PAGES EXCEPT THE FORMULAE SHEET..
5. Calculators Needed and Allowed
6. Work to be done in Exam booklet.
7. **DO NOT WRITE ON THE BACK OF PAGES.**
8. **Exam given under CoE Honor Code**
9. Show your work and *briefly* explain major steps to maximize partial credit. (ex: i3=i1+i2 ,node A, KCL). **NO CREDIT WILL BE GIVEN IF NO WORK IS SHOWN.**
10. *WRITE YOUR FINAL ANSWERS IN THE AREAS PROVIDED*

This Exam Contains
4 problems over 15 pages (including workspace& formulae page).

Sign the College of Engineering Honor Code Below (NO credit will be given for the exam without a signed pledge):

I have neither given nor received aid on this examination.

***Signed:*____**

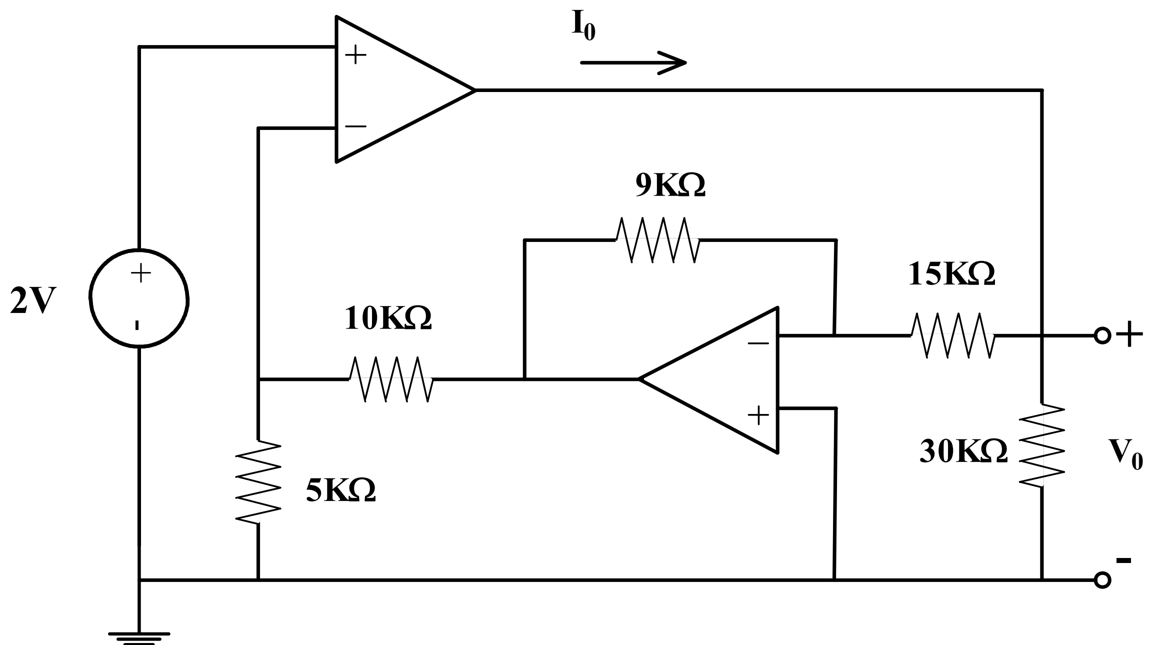
Do not write on this page below this line – Instructional Staff Use Only!

[ ] Prob 1 [ ] Prob 3

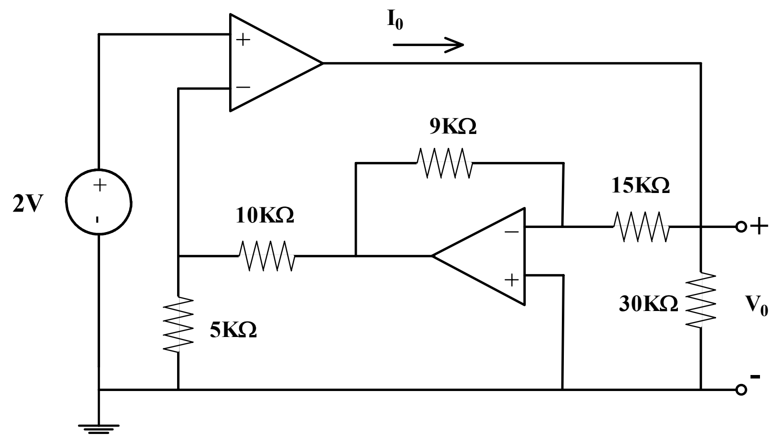
[ ] Prob 2 [ ] Prob 4

<u>Problem 1: Op-Amps (15 points total)</u>

For the circuit shown below, find V_0 and I_0. You may assume ideal opamps under negative feedback conditions.

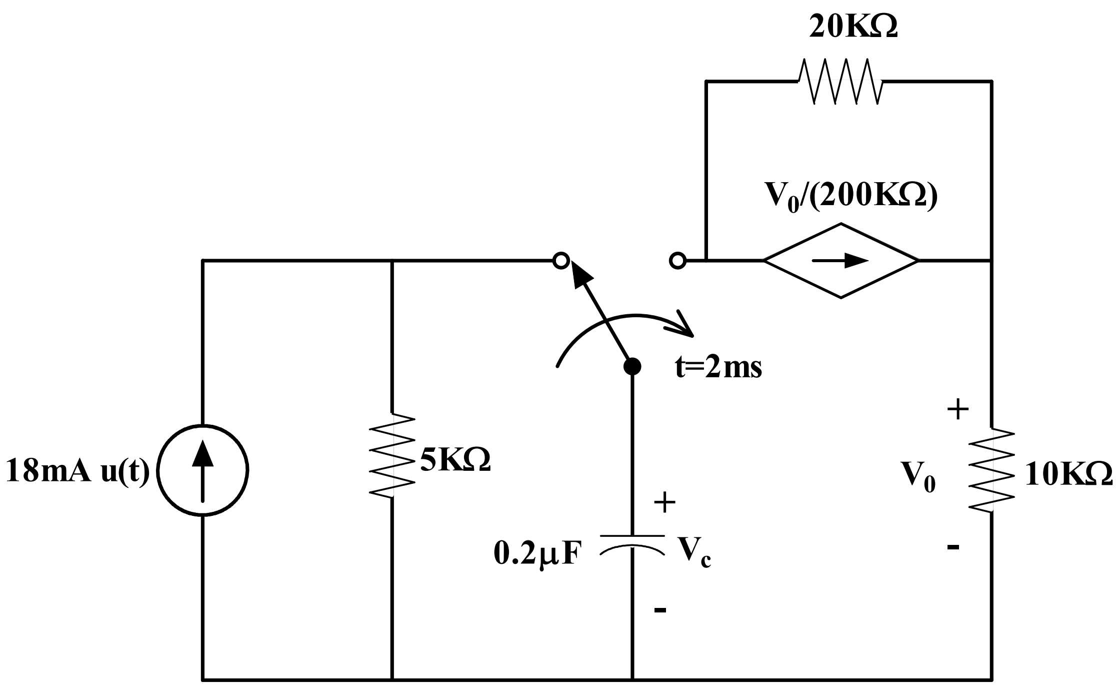


additional workspace for problem 1



Problem 2: First Order Circuits (25 points)

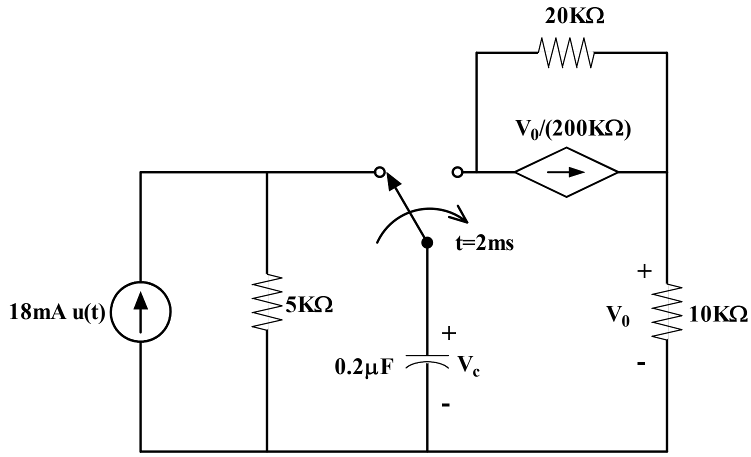
For the circuit shown below, find $v_c(t)$ for $t \geq 0$. *Note that the independent current source is (18mA)u(t) and the switch is toggled at t=2ms.*



a) Find Vc(t) for t=0 to 2ms.

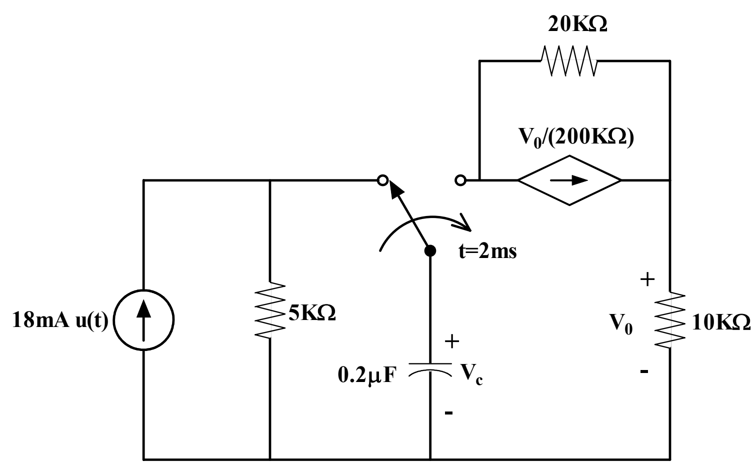
$V_c(t)$=____ **0□t□2ms**

Additional workspace for 2(a)

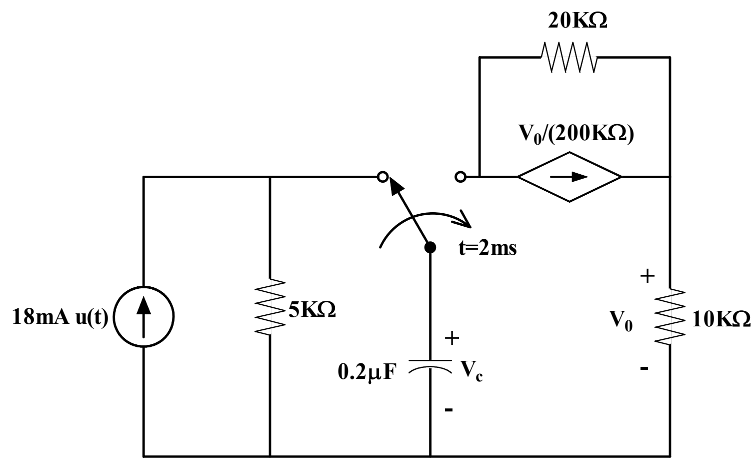


b) Find Vc(t) for t>2ms

Vc(t)=____ **t≥2ms**

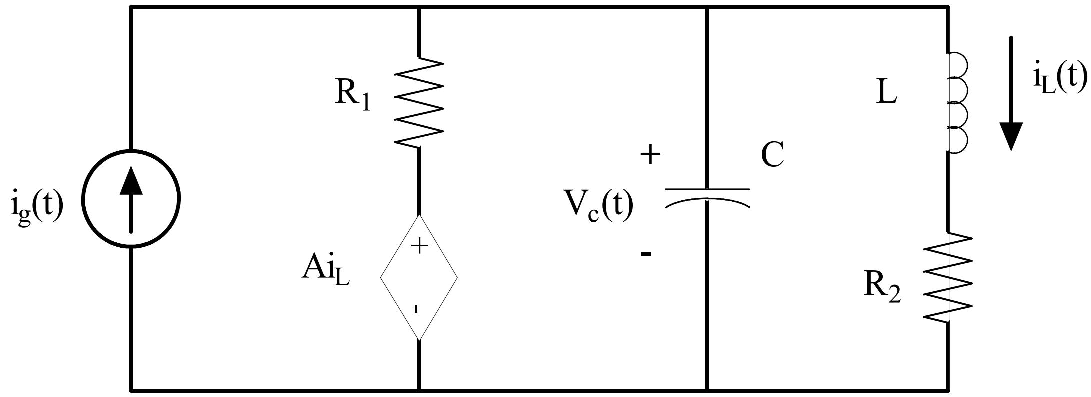


additional workspace for 2(b)



Problem 3: Second Order Circuits (35 points)

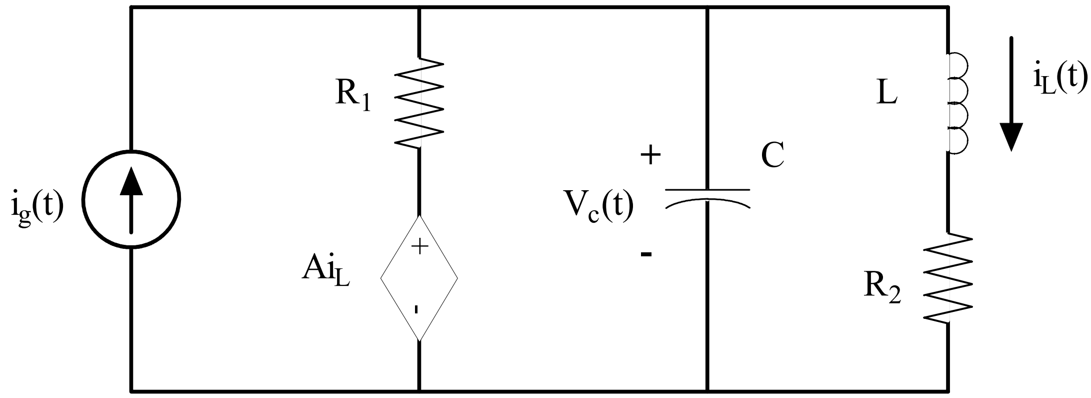
Problem has parts (a) & (b). These two parts can be done independently of each other.



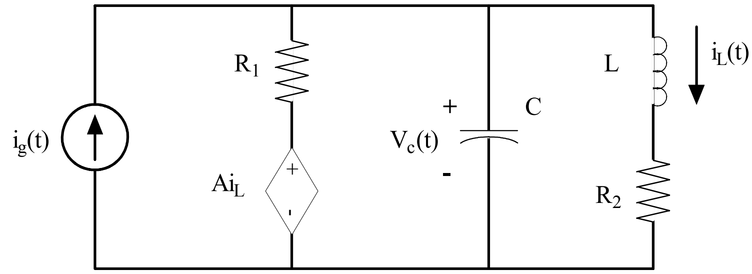
a) For the circuit picture above, find the differential equation that relates $i_L(t)$ to $i_g(t)$. Write the equation in one of the standard forms - $\frac{d^2 i_L}{dt^2} + A\frac{di_L}{dt} + Bi_L = function(i_g)$ or $D\frac{d^2 i_L}{dt^2} + F\frac{di_L}{dt} + i_L = function(i_g)$. V_c must be the only unknown (assuming $i_g(t)$ is known). You may use KVL/KCL/time domain methods or s-domain, but you must clearly show your work to receive full or partial credit. **Warning**: *Attempts to mix time-domain and s-domain approaches are likely to result in zero credit.*

Differential Equation:

Workspace for 3(a)



Workspace for 3(a)



b) Assume that the source had the following behavior: $i_g(t) = i_a + i_b u(t)$, where i_a & i_b are constants. Find $i_L(t)$ & $V_L(t)$ for $t=0^-,0^+$, and t□∞.

$i_L(0^-)$=______________________________

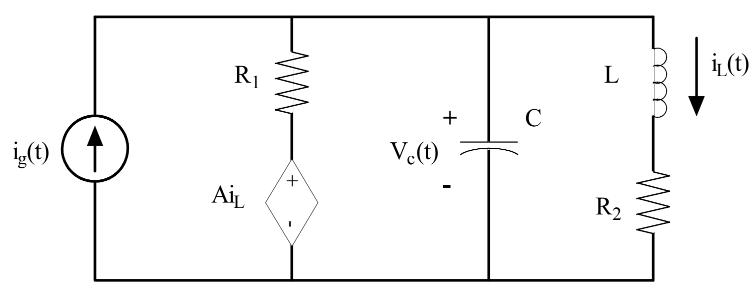
$V_L(0^-)$=______________________________

$i_L(0^+)$=______________________________

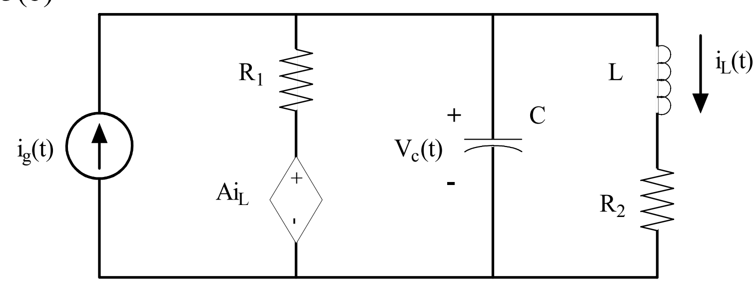
$V_L(0^+)$=______________________________

$i_L(\infty)$ =______________________________

$V_L(\infty)$=______________________________



additional workspace for 3(b)



<u>Problem 4: Second Order Circuits (25 points)</u>

Using the same circuit as problem 3, assume we have the following component values:

$$R_1 = 1K\Omega \quad R_2 = 5\Omega \quad A = 996\Omega \quad L = 1mH \quad C = 1\mu F$$

with these values, the differential equation becomes:

$$\left(\frac{1}{9}x10^{-6}s\right)\frac{d^2i_L}{dt^2} + \left(\frac{2}{3}x10^{-4}s\right)\frac{di_L}{dt} + i_L = i_g$$

or equivalently:

$$\frac{d^2i_L}{dt^2} + \left(6x10^3 s^{-1}\right)\frac{di_L}{dt} + \left(9x10^6 s^{-1}\right)i_L = i_g$$

where s here is the unit seconds

a) Find the natural (source-free/homogeneous) solution for this case and name the damping type.

Damping type (circle only one)

Underdamped **Critically Damped** **Overdamped**

$i_{L,n}$(t)=____

b) Assuming $i_g\left(t\right)=\left[9u\left(t\right)+81\right]mA$, find the complete solution (with no unknowns) for $i_L(t)$.

i_L (t)=____

Formulae

General Second Order Equation:

$$\frac{\partial^2 y}{\partial t^2} + 2\alpha \frac{\partial y}{\partial t} + \omega_0^2 y = f(t) \quad or \quad \omega_0^{-2} \frac{\partial^2 y}{\partial t^2} + 2\alpha\, \omega_0^{-2} \frac{\partial y}{\partial t} + y = p(t)$$

Natural (Source Free, Homogeneous) Part:

$$\frac{\partial^2 y}{\partial t^2} + 2\alpha \frac{\partial y}{\partial t} + \omega_0^2 y = 0 \;\; or \;\; \omega_0^{-2} \frac{\partial^2 y}{\partial t^2} + 2\alpha\, \omega_0^{-2} \frac{\partial y}{\partial t} + y = 0$$

Trial Solution to natural equation:

$$y = Ae^{st}$$

Result:

$$s^2 + 2\alpha s + \omega_0^2 = 0 \quad or \;\; \omega_0^{-2} s^2 + 2\alpha\, \omega_0^{-2} s + 1 = 0 \;\; \text{Characteristic Equation}$$

$$s_{1,2} = -\alpha \pm \left[\alpha^2 - \omega_0^2\right]^{1/2} \;\; \text{Time Constants}$$

Three Possibilities for natural solutions:

$\alpha > \omega_0$ <u>*Overdamped Response*</u>

$s_{1,2}$ *are real numbers (negative)*

$$y_n(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}$$

$\alpha < \omega_0$ <u>*Underdamped Response*</u>

$s_{1,2}$ *are complex numbers*

$$y_n(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}$$

$$s_{1,2} = -\alpha \pm \left[\alpha^2 - \omega_0^2\right]^{1/2} = -\alpha \pm j\omega_d$$

$$\omega_d = \left[\omega_0^2 - \alpha^2\right]^{1/2} \;\; \text{damped frequency of oscillation}$$

$$y_n(t) = \left[B_1 \cos(\omega_d t) + B_2 \sin(\omega_d t)\right] e^{-\alpha t}$$

$\alpha = \omega_0$ <u>*Critically Damped Response*</u>

$s_1 = s_2 = -\alpha$ *a negative real number*

$$y_n(t) = A_1 e^{-\alpha t} + A_2 t e^{-\alpha t} = (A_1 + A_2 t) e^{-\alpha t}$$