UNIVERSITY OF CALIFORNIA, BERKELEY
Department of Electrical Engineering and Computer Sciences

EE 100
Intro. To Electronics Engineering

Summer 2004
Bharath Muthuswamy

FINAL EXAM
August 2004
Time Allotted: 3 hours

NAME: Solutions ______________________, ______________________
(print) Last First

STUDENT ID#:________________

I WILL NOT CHEAT ON THIS EXAM. Signature:________________________

Note(s):

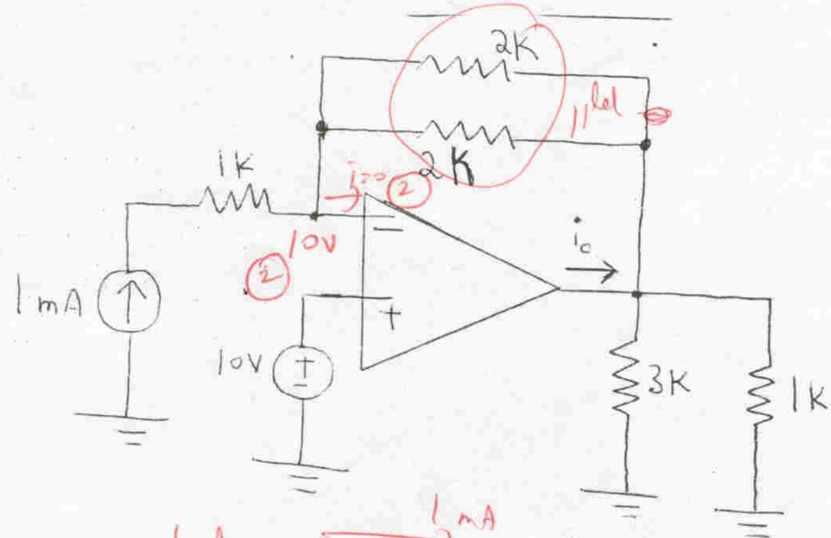
1. **You will receive [3 pts] for filling out the information above.**
2. **This is a CLOSED BOOK exam. However, you may use two 8.5 x 11" of notes (both sides) and a calculator.**
3. **SHOW YOUR WORK on this exam. MAKE YOUR METHODS CLEAR TO THE GRADER so you can receive partial credit.**
4. **WRITE ANSWERS CLEARLY IN THE SPACES (lines or boxes) PROVIDED.**
5. **Remember to specify units on answers whenever appropriate.**

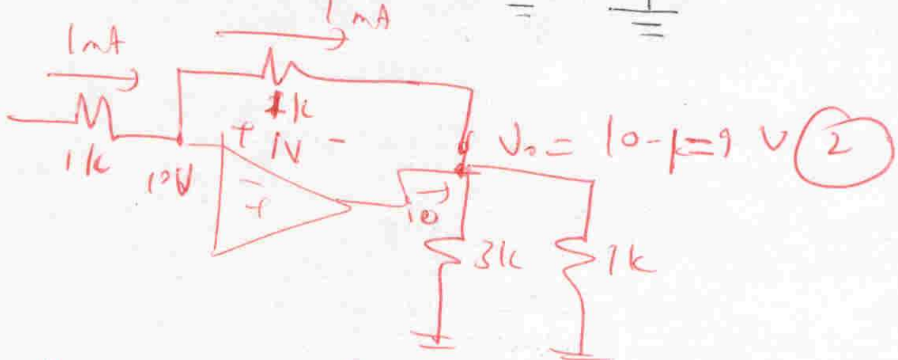
SCORE: This page: _______ / 3

1:______/ 7 → Ashwin
2:______/ 20] Bart
3:______/ 20]
4:______/ 10 → Jim
5:______/ 25] Justin
6:______/ 15]

TOTAL:______/ 100

1. (7 points) In the circuit below, assume the op-amp is ideal (ignore the effects of rail voltages). Find i_o.





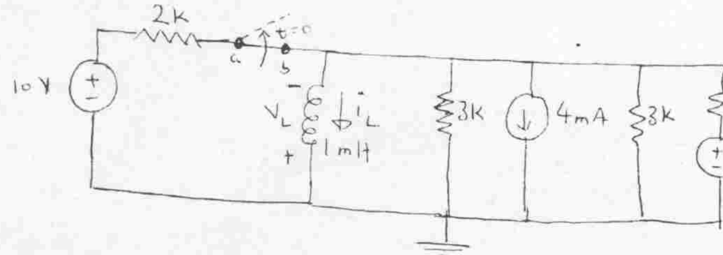
$i_o + 1\,mA = \frac{V_o}{3k} + \frac{V_o}{1k}$ (1)   ($V_o = 9V$)

$\Rightarrow i_o = 12 - 1 \Rightarrow i_o = 11\,mA$

Total: (2) + (2) + (2) + (1) = (7)

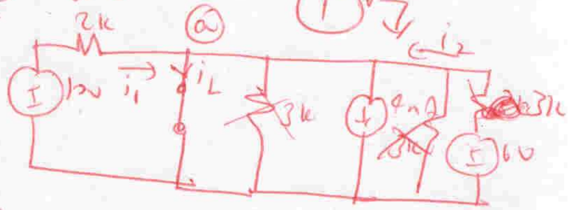
i_o = 11 mA

2. (20 points) In the circuit below, the switch has been closed for a long time before opening at t = 0.



Find: (a) $i_L(t = 0^-)$ (5 points)
(b) $i_L(t = 0^+)$ (5 points)
(c) $v_L(t = 0^+)$ (5 points)
(d) τ (5 points)

(a) $t = 0^-$ — 1 point



$i_1 = \frac{10\text{ V}}{2\text{k}} = 5\text{ mA}$

$i_2 = \frac{6\text{ V}}{3\text{k}} = 2\text{ mA}$ — 2 points

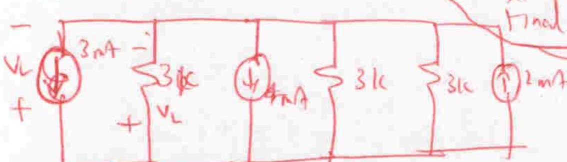
Resistors shorted out ⇒ 1 point

Final answer: KCL @ node a: $i_1 + i_2 = i_L + 4$ ⇒ $i_L = 3$ mA — 1 point

(b) $i_L(t=0^+) = i_L(t=0^-)$ — 5 point

⇒ $i_L(t=0^+) = 3$ mA

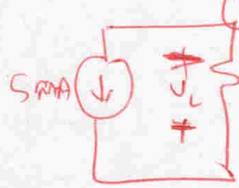
(C) $t = 0^+$



2 points

$\therefore v_L = (5\text{ mA})(1\text{ k})$

$v_L(t=0^+) = 5$ V — 1 point



2 points

$i_L(t = 0^-)$ = 3 mA

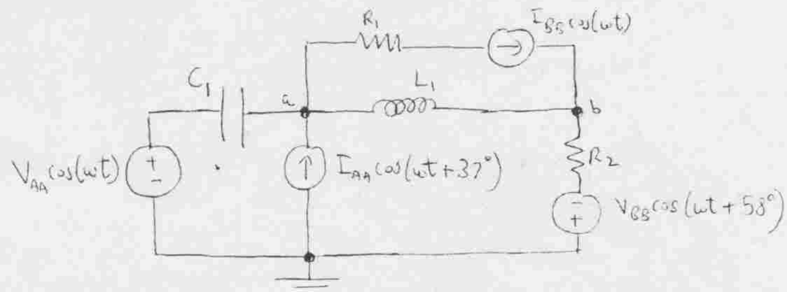
$i_L(t = 0^+)$ = 3 mA

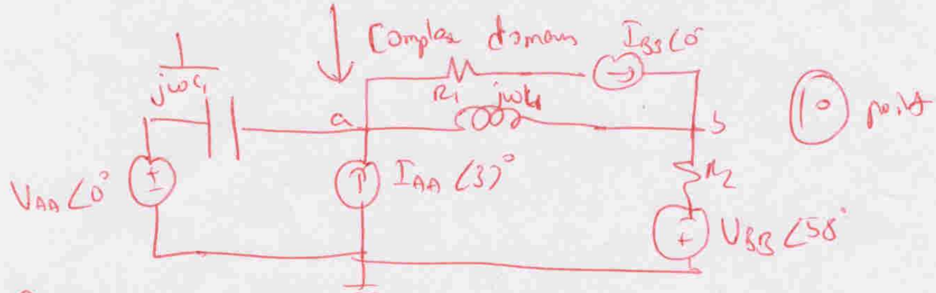
$v_L(t = 0^+)$ = 5 V

τ = 1 us

(d) $\tau = \frac{L}{R} = \frac{1\text{ mH}}{1\text{ K}} \Rightarrow 1$ us — 2 points, 2 points, 1 point

3. (20 points) In the circuit below, use the **NODE VOLTAGE** method to write 2 equations **(IN THE COMPLEX DOMAIN)** sufficient to solve for $\mathbf{V_a}$ and $\mathbf{V_b}$ (the phasor voltages at nodes a and b respectively). Your equations will obviously be in terms of the impedances and the independent AC source values. To receive credit, you must write your answer in the box below. **DO NOT SOLVE OR SIMPLIFY THE EQUATIONS!**





(10) points

@ a:

$$\frac{V_{AA}\angle 0^\circ - \bar{V}_a}{\frac{1}{j\omega C_1}} + I_{AA}\angle 37^\circ = I_{BB}\angle 0^\circ + \frac{\bar{V}_a - \bar{V}_b}{j\omega L_1}$$ (5) point

Write your equations here:

$$\left(V_{AA}\angle 0^\circ - \bar{V}_a\right) \Big/ \frac{1}{j\omega C_1} + I_{AA}\angle 37^\circ = I_{BB}\angle 0^\circ + \frac{\bar{V}_a - \bar{V}_b}{j\omega L_1}$$

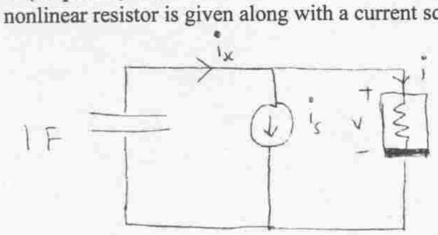
$$I_{BB}\angle 0^\circ + \frac{\bar{V}_a - \bar{V}_b}{j\omega L_1} = \frac{\bar{V}_b + V_{BB}\angle 58^\circ}{R_2}$$

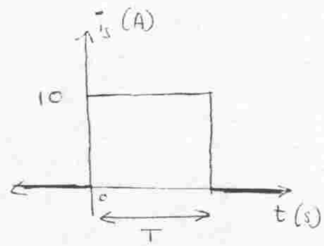
ok to miss 2 match!

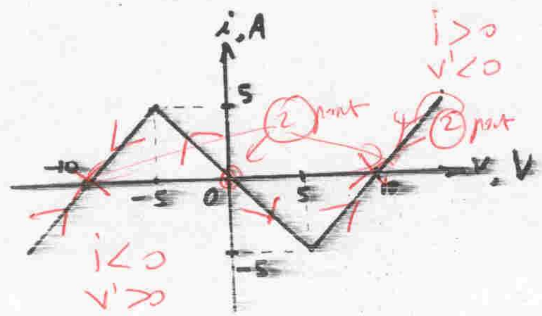
@ b:

$$I_{BB}\angle 0^\circ + \frac{\bar{V}_a - \bar{V}_b}{j\omega L_1} = \frac{\bar{V}_b + V_{BB}\angle 58^\circ}{R_2}$$ (5) points

4. (10 points) The circuit below is to be used as a flip-flop. The i-v characteristic of the nonlinear resistor is given along with a current square pulse as input.



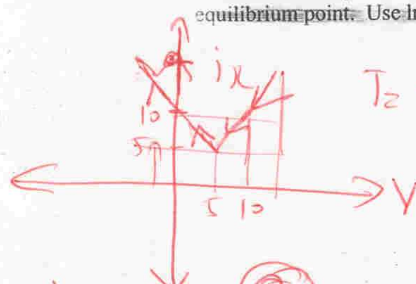




① point $i = -C\frac{dv}{dt}$

(a) Determine the equilibrium points, classify them as stable or unstable and determine the dynamic route. (5 points) (assume $i_s = 0$) ← correction!

(b) If the amplitude of the current pulse is 10 A as shown above, calculate the minimum T required to move from the right equilibrium point to the left equilibrium point. Use ln(2) = 0.69. (5 points)



$T = t_1 + t_2 = 2\ln(2) = 1.38s$ ② points

$i_x = i_s + i$ ③ point

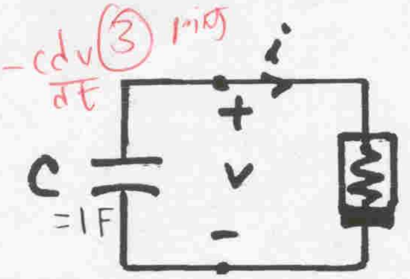
Stable equilibrium point(s): (10, 0) ; (−10, 0)

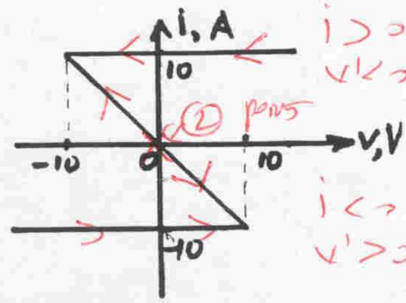
Unstable equilibrium point(s): (0, 0)

T= 1.38s

5. (25 points) Consider the oscillator circuit and the i-v characteristic of the nonlinear resistor shown below. C = 1F.

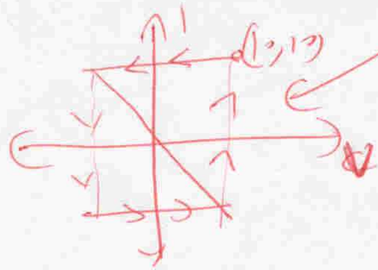
$i = -C\frac{dv}{dt}$ (3) points





(a) Find the equilibrium points, classify them as stable or unstable and determine the dynamic route. (10 points)

(b) Assuming v(0) = 10 V and i(0) = 10 A, find the period of oscillation. Plot i(t) and v(t) for two periods and indicate the maximum and minimum values of current and voltage in the graphs. (15 points)



oscillation (3) points

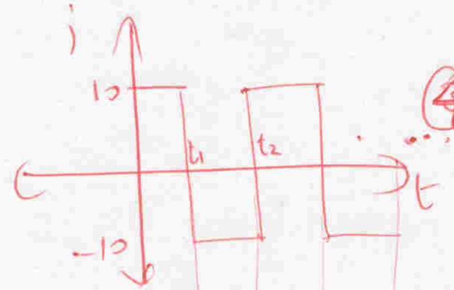
(4) points:

$i = -C\frac{dv}{dt}$

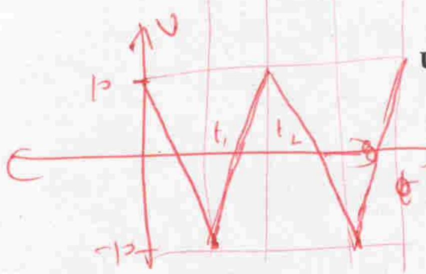
$\Rightarrow 10 = -1F \cdot \frac{[-10-(10)]}{t_1 - 0}$

$\Rightarrow t_1 = 2 \text{ sec} = t_2$

$\therefore T = 4 \text{ sec}$



(4) points



(4) points

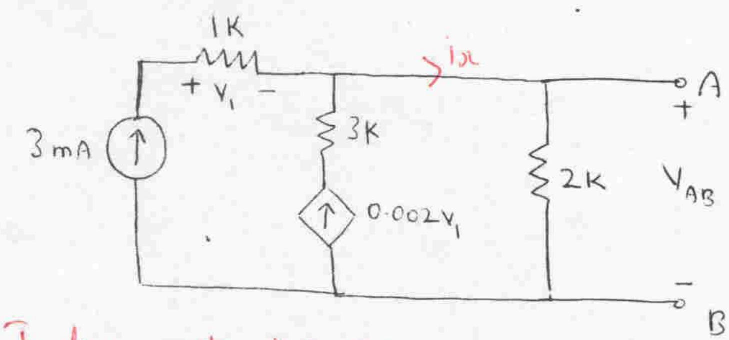
Stable equilibrium point(s): None

Unstable equilibrium point(s): (0,0)

Period of Oscillation = 4 sec

6. (15 points)

(a) Find the Thevenin equivalent of the following circuit at terminals AB (3 points):

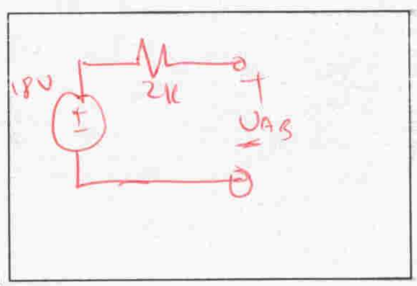


Justin: points distoo??

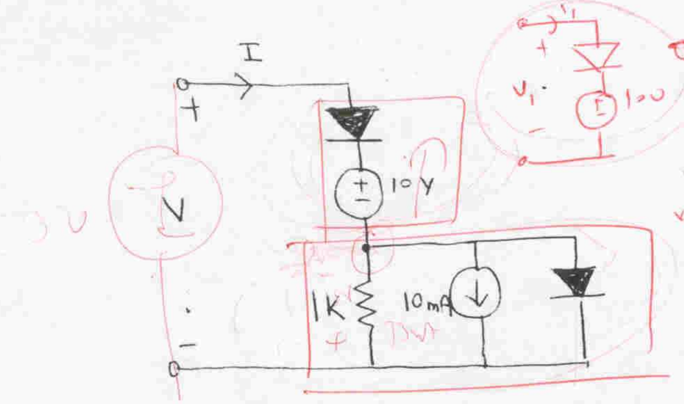
$$V_{oc} = i_{sc} \cdot 2K$$
$$= (0.002\, v_1 + 3mA)\, 2k$$
$$= [0.002 \cdot (3mA)(1K) + 3mA)\, 2K = 18\ V$$

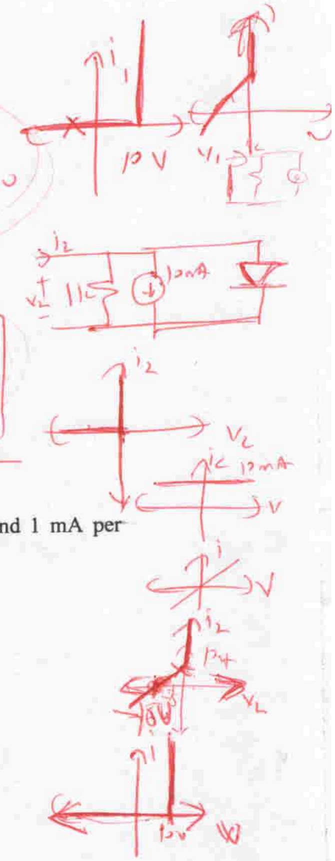
$$R_{Th} = \frac{V_{oc}}{I_{sc}} = \frac{V_{oc}}{i_{sc}} = \frac{18\ V}{9\ mA} = 2K$$

Draw Thevenin eq. in the box:

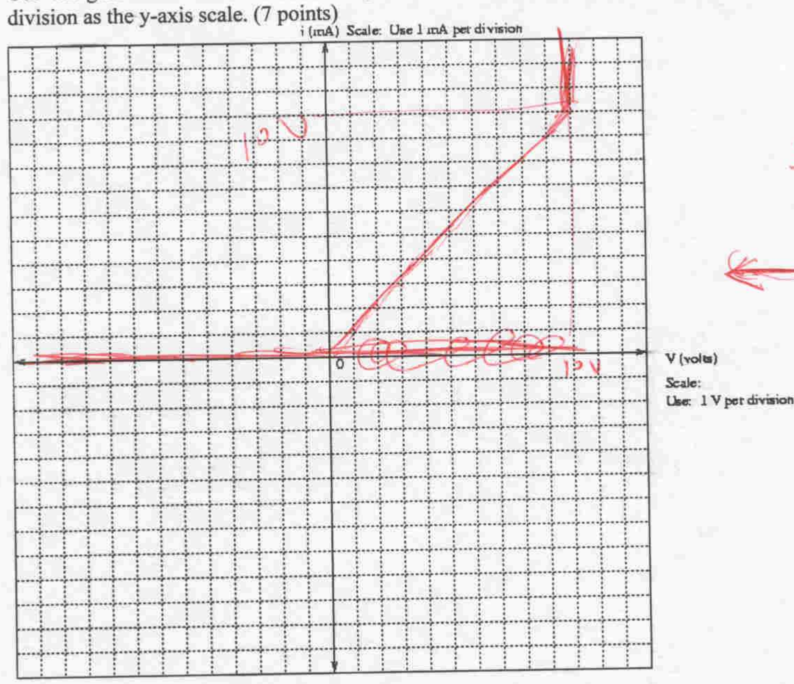


(b) Plot the i-v characteristic of the following non-linear circuit.

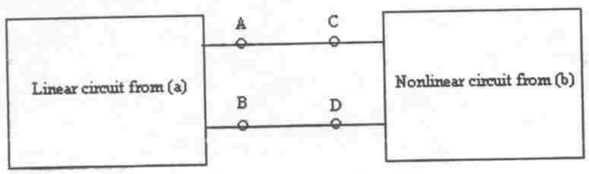




Use the grid shown below. Use 1 V per division as the x-axis scale and 1 mA per division as the y-axis scale. (7 points)



(c) Suppose we connect the circuits in (a) and (b) such that node A is connected to node C and node B is connected to node D, as shown below. Using the graph from (b) and load line data from (a) solve for the operating point of the circuit. (3 points)



Operating Point = (6V, 6mA)

(d) Is power being absorbed or delivered by the non-linear portion of the circuit at the operating point? How much power? (2 points)

Power = 36mW absorbed