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

EE 100
Intro. To Electronics Engineering

Spring 2005
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Final Exam
May 13th 2005
Time Allotted: 3 hours

NAME: SOLUTIONS / GRADING SCHEME
(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. **MAKE SURE THE EXAM HAS 10 NUMBERED PAGES.**
3. **This is a CLOSED BOOK exam. However, you may use THREE 8.5 x 11" of notes (both sides) and a calculator.**
4. **SHOW YOUR WORK on this exam. MAKE YOUR METHODS CLEAR TO THE GRADER so you can receive partial credit.**
5. **WRITE ANSWERS CLEARLY IN THE SPACES (lines or boxes) PROVIDED.**
6. **Remember to specify units on answers whenever appropriate.**
7. **PLEASE NOTE: THE NUMERICAL ANSWER TO THE PROBLEMS MAY NOT BE WHOLE NUMBERS (i.e..THEY COULD BE NEGATIVE or DECIMAL).**

SCORE: This page: 3 / 3

1: ____ / 22

2: ____ / 25

3: ____ / 25

4: ____ / 25

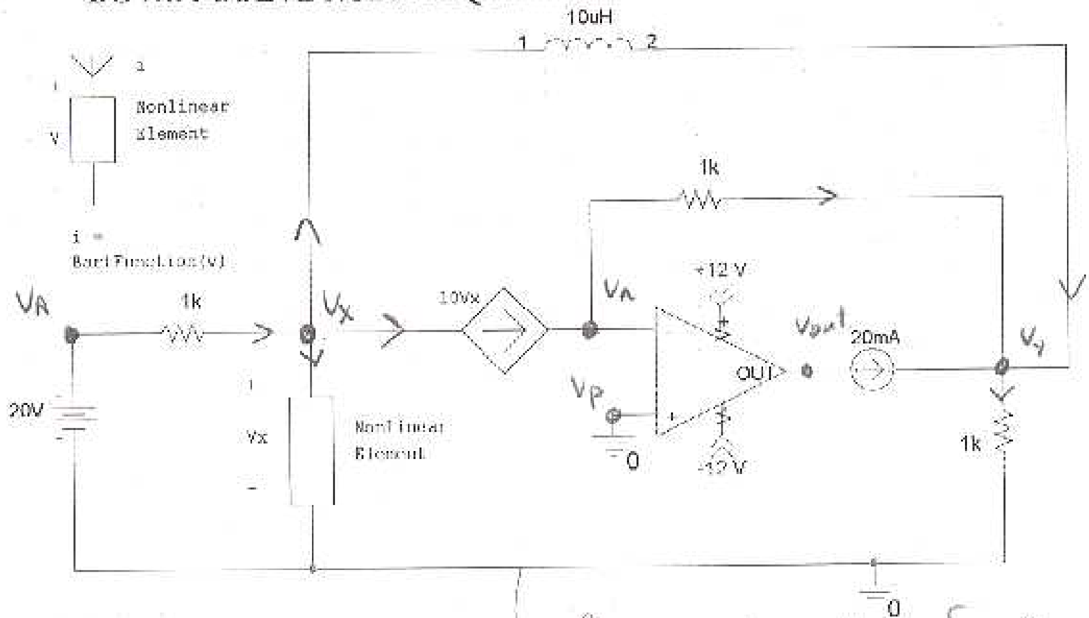
TOTAL: ____ / 100

Problem 1 (22 points)

In the circuit below:

NOTE: DO NOT ASSUME Vp = Vn for the op-amp.

a. Mark the known node voltage(s) with **CORRECT** voltage values.
b. Label the unknown node voltages.
c. Write sufficient nodal equations to solve for the unknown node voltages in (b). **DO NOT SOLVE NODAL EQUATIONS.**



nodes: VxVn,Vp,Vy,Vout

Missing a voltage for a or b → -1
Sign Error in an equation → -3 per equation
Missing an equation → -5
Equation just wrong (period) → -4
Integrated for i_L (assume v=const) → -2
$V_{out} = \pm 12$ → -2

(a) Known node voltages: $V_A = 20V,\ V_p = 0V$ +2

(b) Unknown node voltages: V_x, V_y, V_n, V_{out} +4

(c) Write final nodal equations in the box. Make sure equations are SUFFICIENT.

• V_x: $\frac{20 - V_x}{1k} = \text{Bartfunction}(V_x) + 10V_x + i_L$

$V_x - V_y = L\frac{d\,i_L}{dt}$

or $\frac{20 - V_x}{1k} = \text{Bartfunction}(V_x) + 10V_x + \frac{1}{L}\int_0^t (V_x - V_y)\,dt$

• V_y: $\frac{V_n - V_y}{1k} + 20mA + i_L = \frac{V_y}{1k}$ or $\frac{V_n - V_y}{1k} + 20mA + \frac{1}{L}\int_0^t (V_x - V_y)\,dt = \frac{V_y}{1k}$

• V_n: $10V_x = \frac{V_n - V_y}{1k}$

• V_{out}: $V_{out} = A(V_p - V_n) = A(0 - V_n) = -AV_n$

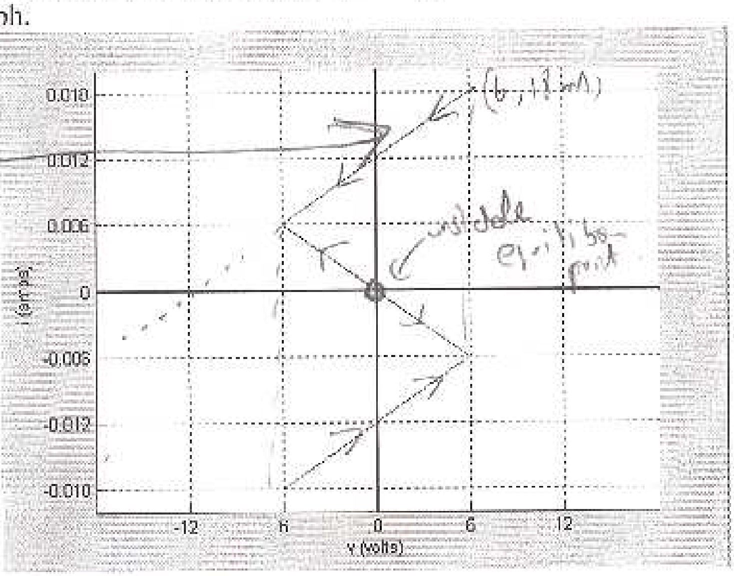
Problem 2 (25 points)

In the circuit below, assume (v(0),i(0)) is (6 V, 18 mA). Assume C2 is initially discharged. DO NOT IGNORE THE EFFECTS OF THE RAIL VOLTAGES FOR THE OP-AMPS. You may use ln(1/3) = -1.1

(a) On the driving point characteristic for the nonlinear op-amp, label the equilibrium point(s), stability of the equilibrium point(s) and dynamic route. (5)

(b) Sketch $v_1(t)$ (output voltage of first op-amp) for $t \geq 0$ and for one time period. Clearly mark the periods, maximum voltage value and minimum voltage value on the graph. (10)

(c) Sketch $v_2(t)$ (output voltage of second op-amp) for $t \geq 0$ and for one time period. Clearly mark the periods, maximum voltage value and minimum voltage value on the graph. (10)



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

$i > 0,\ v' < 0$

$i < 0,\ v' > 0$

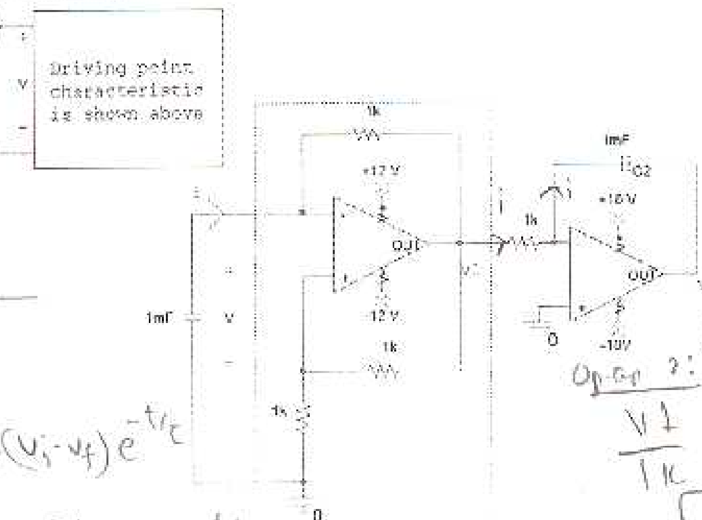
$i = \frac{V - V1}{1K}$

at (6, 18 mA)

$18\text{ mA} = \frac{6}{1K} - \frac{V1}{1K}$

$18 = 6 - V1$

$V1 = -12\text{ V}$



Op-amp 2:

$\frac{V1}{1K} = C\frac{d}{dt}(0 - V2)$

$V2 = -\int V1$

$v(t) = v_f + (v_i - v_f)e^{-t/\tau}$

$\Rightarrow v(t) = -12 + (6+12)e^{-t/1\,sec}$

$\Rightarrow v(t) = -12 + 18e^{-t/1\,sec}$; $v(t_1) = -6$

$\Rightarrow -\frac{t_1}{1\,sec} = \ln\left(\frac{1}{3}\right) \Rightarrow t_1 = 1.1\text{ sec}$

Algebraic Integration (N.1 ...)

$$V2_{①} = \int_0^{1.1} 12\,dt + V_{initial}$$

$V_{initial}$ → V (C2 initially discharged)

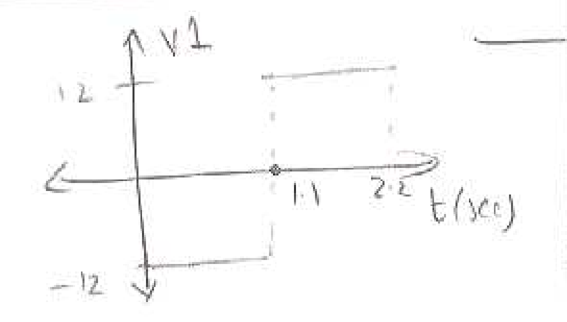
$= 12 \cdot 1.1 = 13.2\ V$ (< 18 V ⇒ op-amp (2) does not ...)

$$V2_{②} = -\int_{1.1}^{2.2} (12)\,dt + 13.2\ V$$

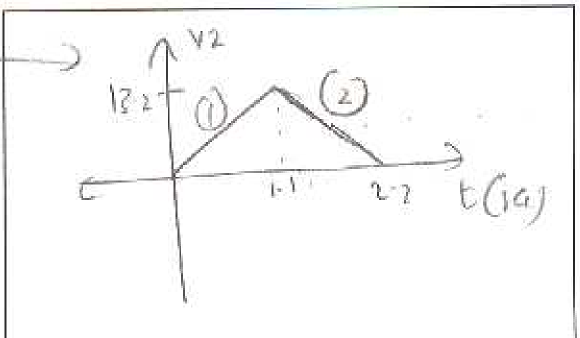
← don't forget $V_{initial}$ from region ①

$= -12(1.1) + 13.2\ V = 0\ V$

visually integrate →



(b) Sketch $v_1(t)$



(c) Sketch $v_2(t)$

work → -15 to -25 (2) $V_p = V_n = 0$ → -15 points

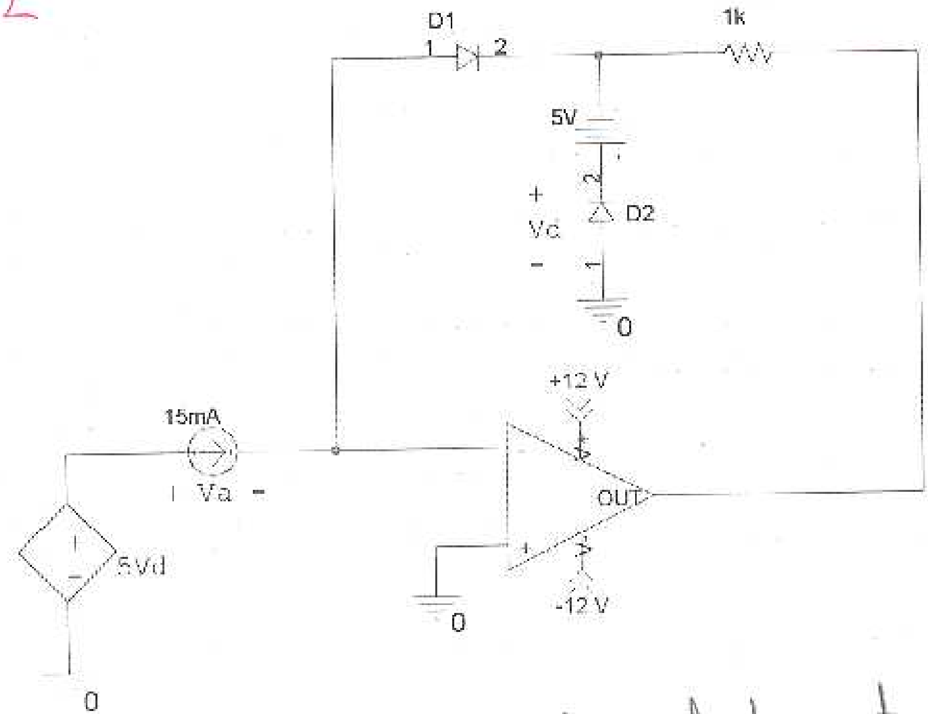
w/ KCL → -15 (3) op-amp is not railing / wrong rail → -15

errors (4) wrong diode D2 voltage → -15 points

Problem 3 (25 points)

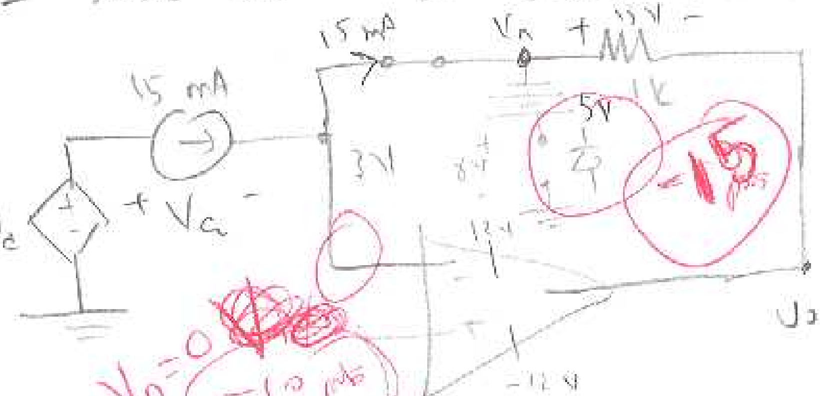
In the circuit below, find Va. **DO NOT IGNORE THE EFFECTS OF THE OP-AMP RAIL VOLTAGES.** Assume all diodes are ideal.

th → -2



Easiest to start with diodes: look at circuit, diod...

1 seems on & D2 seems off.



If $V_n = V_p = 0$, ⇒ $V_o = -15$

⇒ Obviously, op-amp rail

⇒ $V_o = -12$ V

∴ $V_n = -12\text{ V} + 15\text{ V} = ...$

[Check: $V_D = 8$ V ⇒ D2 ...

$V_p = V_n = 0$ -10 pts

$5V_d = 40$ V

Va = 37 V

9

Op amp is not railing/wrong rail -15

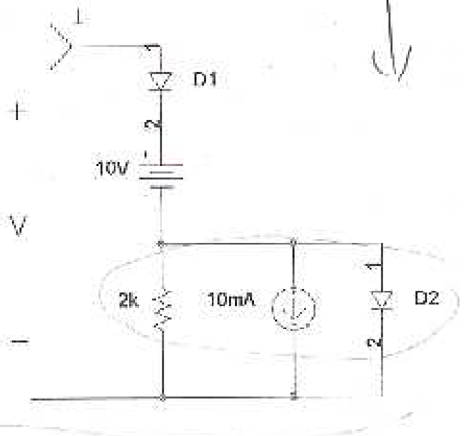
$V_a = 40 - 3 = 37$ V

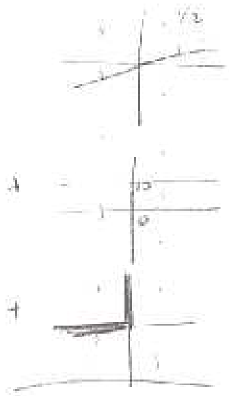
Wrong diode state, -15 pts

Hey Justin, do this problem :)

Problem 4 (25 points)

-10 wrong graphical addition





Using the grid shown below, plot the I-V graph of the circuit above. Assume all diodes are ideal.