1 ~~2~~ ~~3~~ ~~4~~ ~~5a~~ 5b ~~6~~
? ?

Print Your Name Nolan Anderson

University of Alabama, Huntsville
Department of Electrical and Computer Engineering

EE 315
Examination I
Professor Jennifer English
Fall 2014

This exam is closed book and closed notes. One 3"X5" piece of paper with handwritten notes on both sides is permitted. Calculators are also permitted to perform mathematical operations and matrix operations, but no other programmable feature is to be used. The exam consists of 6 problems. The point values for each question/problem are given. The problems are not necessarily equally difficult, so you are encouraged to **read the entire examination before starting** and begin with the problem you find the easiest. The examination is worth a total of 100 points. Partial credit will be given for each problem; however, work must be **legible** and **logical** to receive credit. Remember to give applicable units with each answer and place a box around your final answer for each problem.

Please do all your work on this examination paper. If more room is required or you wish to do scratch work, please use the extra paper provided. Remember, partial credit cannot be given if you do your work on a piece of paper you don't hand in!

Please place your name on the top of each examination page.

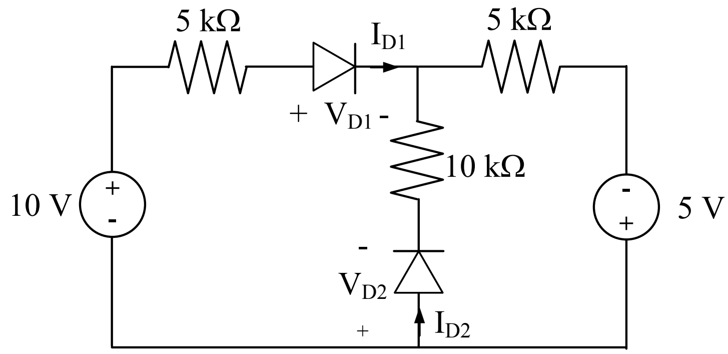
In the interest of academic honesty, please read the following statement and write your signature below.

On my honor, I have neither given help to anyone on this examination, nor received help from anyone on this examination.

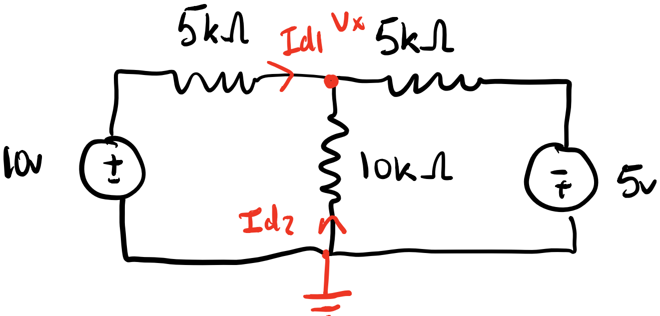
Signed NA

Print Your Name____

1. [20 points] Consider the following circuit that contains ideal diodes. Find the currents, I_{D1} and I_{D2} and the voltages, V_{D1} and V_{D2}.



Assume both diodes are on



$I_{d1}, I_{d2} > 0$

$$\frac{V_x - 10}{5k} + \frac{V_x - 0}{10k} + \frac{V_x + 5}{5k} = 0$$

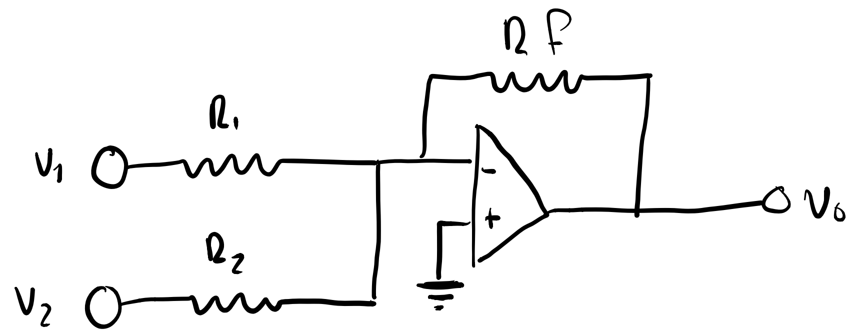
$$I_{d1} = \frac{10 - V_x}{5k} \qquad I_{d2} = \frac{-V_x}{10k}$$

Print Your Name____

2. [15 points] Design a weighted summer using an ideal op-amp to realize the following output:

$$v_O = -2v_1 - 6v_2$$

Design Notes: The input voltages range from -5V to +5V. For this input range, the current through any resistor is limited to 100 μA. You must draw the circuit you design.



$$\frac{RF}{R_1} = 2$$

$$\frac{RF}{R_2} = 6$$

$$V_0 = -\frac{RF}{R_1} V_1 - \frac{RF}{R_2} V_2$$

For +5v... $V_0 = -(2)(5) - (6)(5)$

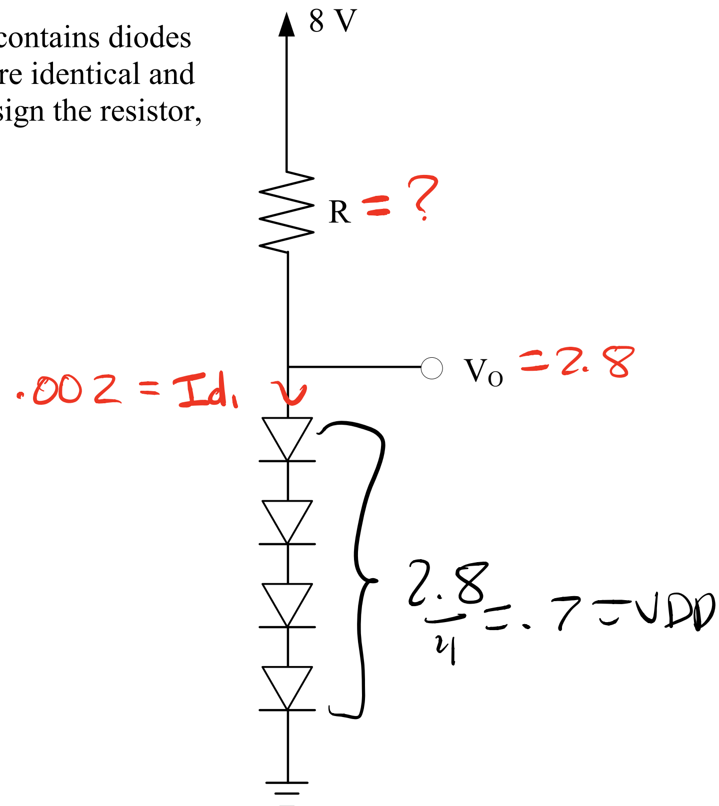
$V_0 = -40v$

$$RF = \frac{V_0}{100E-6} = \frac{40}{100E-6} = 400k\Omega$$

$$\boxed{\begin{aligned} R_1 &= \frac{RF}{2} = \frac{400}{2} = 200k\Omega \\ R_2 &= \frac{RF}{6} = \frac{400}{6} = 66.67k\Omega \end{aligned}}$$

Print Your Name____

3. [15 points] Consider the following circuit which contains diodes operating in the forward bias region. The diodes are identical and have a current of 2mA for a voltage of 0.75V. Design the resistor, R, so that the output voltage is 2.8 V.



$$\frac{I_{D2}}{I_{D1}} = \exp\left(\frac{V_{DD}-V_D}{V_T}\right)$$

$$\frac{I_{D2}}{.002} = \exp\left(\frac{.7-.75}{.025}\right)$$

$$I_{D2} = .002(.135)$$

$$I_{D2} = .00027A$$

$$R = \frac{8-2.8}{.00027A} = 19.21\ k\Omega$$

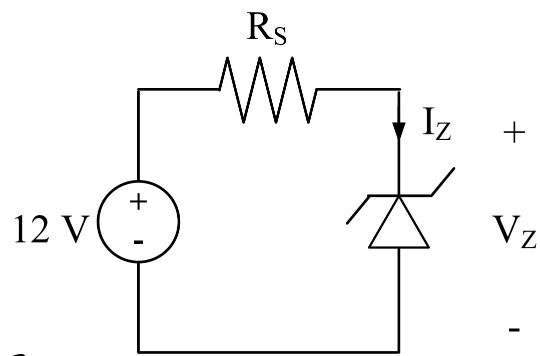
$$V_{D2} = 0.7$$

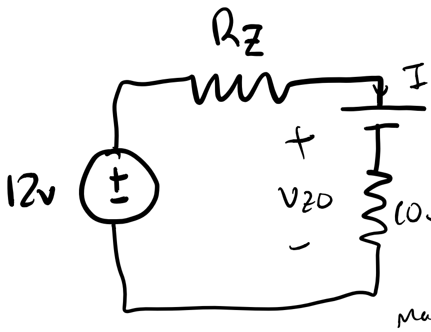
$$V_{D1} = 0.75$$

$$I_{D2} = I_{D1}\exp\left(\frac{V_{D2}-V_{D1}}{V_T}\right)$$

Print Your Name____

4. [15 points] Consider the following circuit that contains a Zener diode. It is known that when the Zener voltage is 4.7 V, the Zener current is 15mA. The incremental Zener resistance is 10 Ω. Find the value of V_{ZO} and design the resistor, R_S for a Zener current of 20 mA.





$I_Z = 15mA$ (initial)

$$V_{ZO} = \overset{4.7}{V_Z} - \overset{15mA}{I_Z}\,\overset{10\Omega}{R_Z}$$

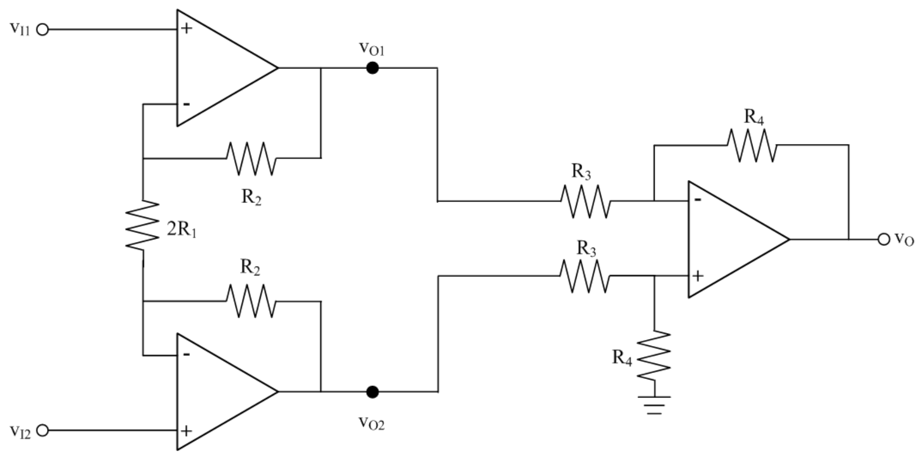
modified $V_{ZO} = 4.55v$

$$V_Z = \overset{4.55}{V_{ZO}} + \overset{.020}{I_Z}\,\overset{10}{R_Z} = 4.55 + (0.02)(10) = 4.75v$$

$$R = \frac{12 - 4.75}{0.020} = 362.5\Omega$$

Print Your Name____

5. [20 points] Consider the instrumentation amplifier.



   a. [10 points] Design the differential gain to be adjustable between 10 and 1000 V/V. Use a 100 kΩ potentiometer to adjust the gain.

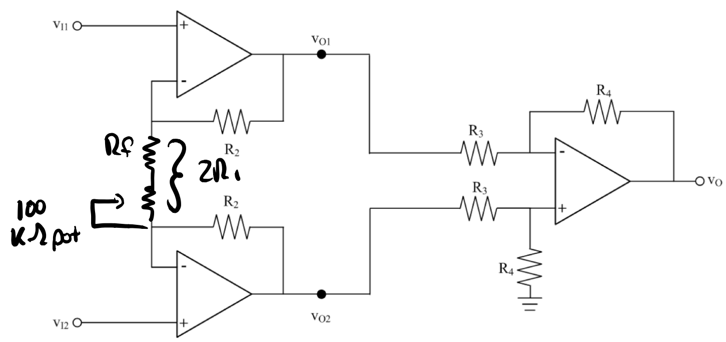
Design Note: You must use the full swing of the potentiometer (0 to 100 kΩ). The resistors must less than 200kΩ. Stage 2 gain should be 5 V/V.

You must draw the part of the circuit where you use the potentiometer.

$$A_d = \left(1 + \frac{2R_2}{2R_1}\right)\left(\frac{R_4}{R_3}\right)$$

Let $R_4 = 50\,\Omega$

$R_3 = 10\,\Omega$



For $2R_1 = 100E3 + RF$

$$10 = \left(1 + \frac{2R_2}{RF + 100E3}\right)(5)$$

$$1 = \frac{2R_2}{RF + 100E3}$$

$$RF + 100E3 = 2R_2$$

$$100E3 = 198RF$$

For $2R_1 = RF$

$$1000 = \left(1 + \frac{2R_2}{RF}\right)(5)$$

$$199 = \frac{2R_2}{RF}$$

$$R_2 = 99.5RF$$

$$R_2 = 99.5(.505)$$

$$\boxed{RF = .505\,k\Omega \qquad R_2 = 502.25\,k\Omega}$$

Print Your Name____

5. [continued]

$R_4 = R_2$ $R_3 = R_1$ $\frac{R_4}{R_3} = 5$

$\frac{R_4}{R_3}$ $\frac{50}{10} = 5$ ACM

$R_2 = R_4 (1 \pm .05)$

$R_2 = R_4 = 47.5$ $\frac{52.5}{10}$ $\frac{R_2}{10} =$

52.5

b. [10 points] Show that for perfectly matched resistors, the common-mode gain of the second stage is zero. What is the worst case common mode gain if the R_4 resistors can vary by ±5%.

$R_4 = R_2 = 50$ $\frac{R_4}{R_3} = 5$

$R_3 = R_1 = 10$

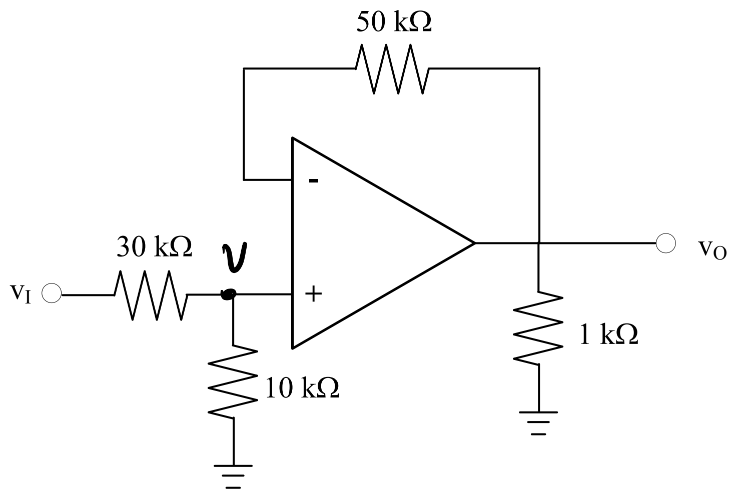
$$ACM = -\frac{R_2}{R_1} + \left(1 + \frac{R_2}{R_1}\right)\left(\frac{R_4}{R_3 + R_4}\right) = 0$$

$$ACM = -5 + (1 + 5)\left(\frac{50}{60}\right) = 0$$

$R_2 = R_4(1 \pm .05)$ $-\frac{47.5}{10} + \left(1 + \frac{47.5}{10}\right)\left(\frac{47.5}{57.5}\right)$

Print Your Name________________________________ $R_2 = 0$

6. [15 points] Consider the following circuit. The 1kΩ load resistor must absorb 4mW. Find the output voltage and the input voltage required.



$$4mW = \frac{V_o^2}{1k\Omega} \Rightarrow V_o = \sqrt{4}$$

$V_o = 2v$

$$\frac{V - Vin}{30} + \frac{V}{10} = 0 \Rightarrow \frac{V - Vin}{3} + V = 0$$

$$\frac{V}{3} - \frac{Vin}{3} + V = 0 \qquad \frac{4V}{3} = \frac{Vin}{3} \Rightarrow 4V = Vin$$

$$Vin = 4 \cdot 2 = 8v$$