EE 355 Analog Electronics
Test 1

Name Solutions
February 22, 2016

RULES

This is a closed book, closed notes test. You are, however, allowed one one piece of paper (front side only) for notes and definitions, but no sample problems. You must staple your equations sheet to the back of your test when you hand your test in.

You are permitted to use a calculator.

You have 50 minutes to complete the test. Please read through the entire test before starting, and read through the directions carefully. To receive partial credit, you must show your work.

There is to be absolutely no cheating. Cheating will not be tolerated.

I you have any questions, please raise your hand, and I will come to you to answer them. Do not hesitate to ask questions.

$n_i=10^{10}cm^{-3}$, $\mu_n=1360cm^2/Vs$, $\mu_p=460cm^2/Vs$, $\tau_n=\tau_p=100\mu s$, $E_g=1.12eV$,
$K_s=11.8$, $\varepsilon_0=8.854x10^{-12}F/m$,
$k=1.38x10^{-23}J/K$, $T=300K$, $q=1.602x10^{-19}C$

Opamp Parameters Vsat=±15V

Diode Parameters $V_{ON}=0.7$, $V_Z=5.6V$, $n=1$, $I_0=0.1pA$

Problem	Value	Score
1	10	
2	10	
3	20	
4	15	
5	20	
6	20	
7	5	
Total	100	

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PROBLEM 1 (10 Points)

Fill in the blank with the most appropriate response.

An ideal voltage-controlled voltage source has infinite input impedance and zero output impedance.

Diffusion is a type of thermal motion of charged particles due to a concentration gradient.

Silicon has 4 valence band electrons (i.e. outer shell electrons).

A/An Acceptor is a type of dopant that is used to create p-type material in silicon.

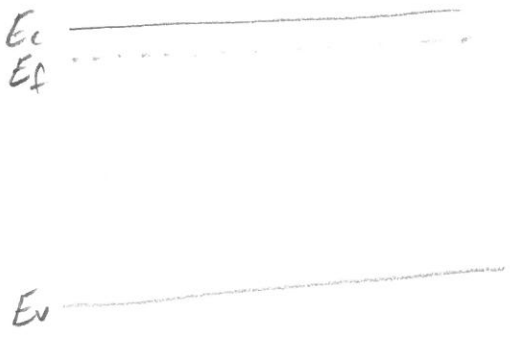
PROBLEM 2 (10 Points)

Draw the following.

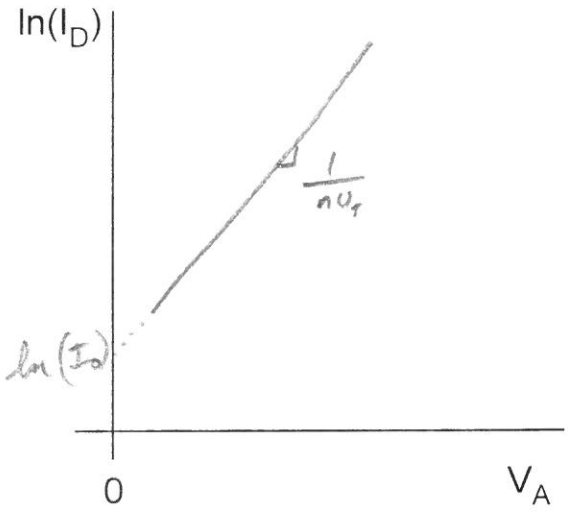
A. General band diagram of n-type material (make sure that you label all bands).

B. The forward bias current in a p-n junction on the axes that have been provided. Be sure to label any slopes, intercepts, or significant items.

Band Diagram (n-type)



Diode Current (Forward Bias)



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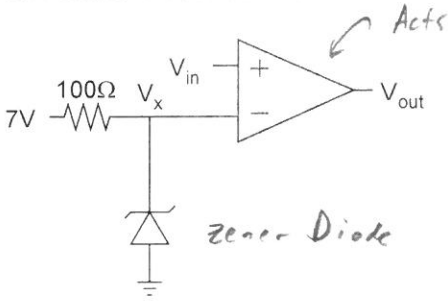
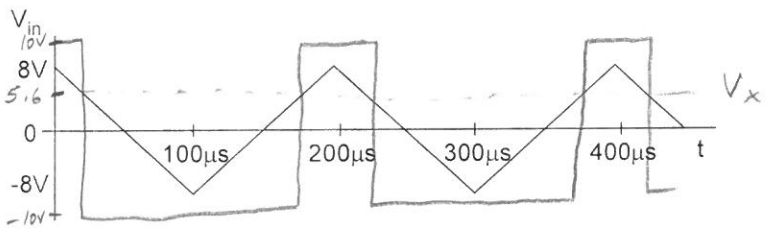
PROBLEM 3 (20 Points)

For the following circuit, the input signal is displayed below. Determine the time-domain values of Vx and Vout. Provide sketches of these signals.





$V_z = 5.6V$

$7V > 5.6V$

So $V_x \approx 5.6V$

(regulated to V_z)

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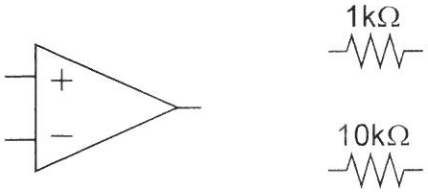
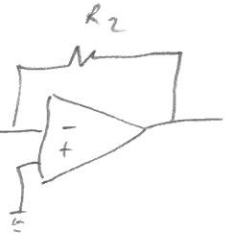
PROBLEM 4 (15 Points)

With the following three circuit components, design an amplifier with the highest possible |gain| that you can achieve using only these devices. The gain can be inverting or non-inverting. Both draw the circuit schematic and provide the value of the gain.



With these 3 circuit elements, the two major possible circuits

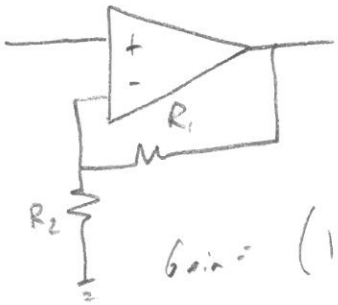
Inverting Amp



$$\text{Gain} = -\frac{R_2}{R_1}$$

Could provide $|\text{Gain}| = 10$

Noninverting Amp

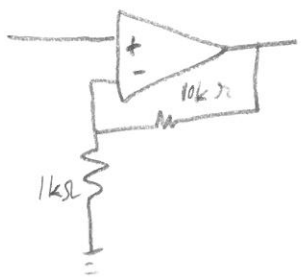


$$\text{Gain} = \left(1 + \frac{R_1}{R_2}\right)$$

Can provide

$$\text{Gain} = 1 + \frac{10k}{1k} = 11$$

Noninverting Amp



Gain = 11

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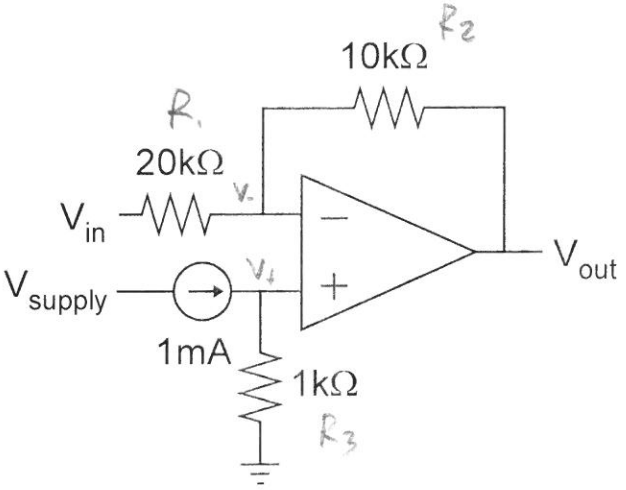
PROBLEM 5 (20 Points)

For the following circuit, determine the output voltage if V_{in}=1V. (The value of V_{supply} is coming from a higher voltage supply, and its value is not important).



Negative Feedback
$\rightarrow V_+ = V_-$

$V_+ = (1mA)(1k\Omega) = 1V$

KCL @ V_-

$$\frac{V_{in} - V_-}{R_1} + \frac{V_{out} - V_-}{R_2} = 0$$

$$V_{out} = -\frac{R_2}{R_1} V_{in} + \left(1 + \frac{R_2}{R_1}\right) V_-$$

$$V_{out} = \frac{-10k\Omega}{20k\Omega}(1V) + (1.5)(1V)$$

$$V_{out} = -0.5V + 1.5V = \boxed{1V}$$

Simpler Solution

$V_+ = 1V$

Both V_{in} and V_- = 1V

$I_{R1} = 0$

$\therefore V_{out} = V_- = 1V$

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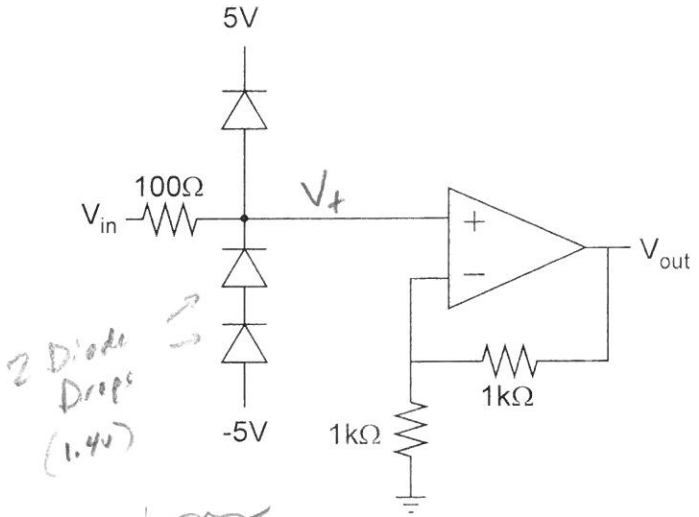
PROBLEM 6 (20 Points)

Sketch the V_{out} vs. V_{in} transfer function of the following circuit. (V_{out} on the y-axis and V_{in} on the x-axis.) Let V_{in} be limited to $-10V \leq Vin \leq 10V$.

Extra Credit (5 Points) – Sketch Vout in response to $Vin=(8V)\sin(2\pi t)$.

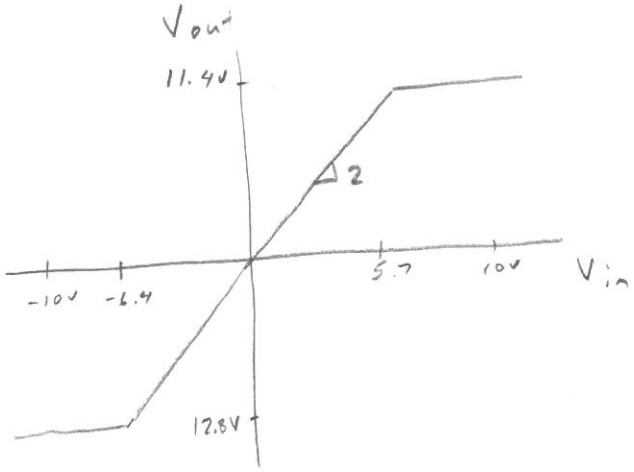


2 Diode Drops (1.4V)

Limiter

Noninverting Amp

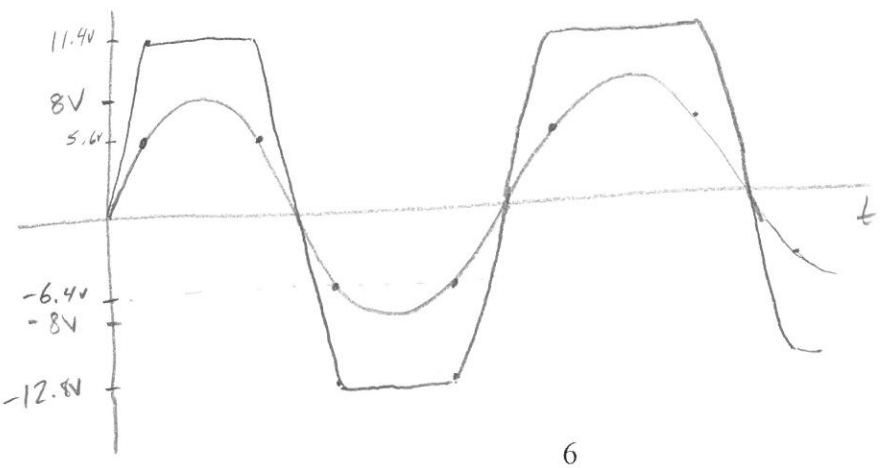
Gain: $1 + \frac{1k\Omega}{1k\Omega} = 2$



$-5V - 1.4V \leq V_+ \leq 5.7V$

$-6.4V \leq V_+ \leq 5.7V$

∴ The input of the noninverting amp is restricted to between -6.4V and 5.7V



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PROBLEM 7 (5 Points)

In class, we discussed two reverse-bias breakdown mechanisms in diodes. Choose one of these two breakdown mechanism and describe what physically happens. (Figures may help.)

See discussion from class