American University of Beirut
Department of Electrical and Computer Engineering
EECE 310 – Electronics I
Fall 2004 – 2005
Quiz 1 – November 5, 2004
Closed Book – 90 minutes

P1	**/16**
P2	**/12**
P3	**/12**
P4	**/12**
P5	**/6**
P6	**/12**
P7	**/10**
P8	**/10**
P9	**/10**
Grade	**/100**

NAME:_____ ID Number: _____

I have neither given nor received aid on this exam

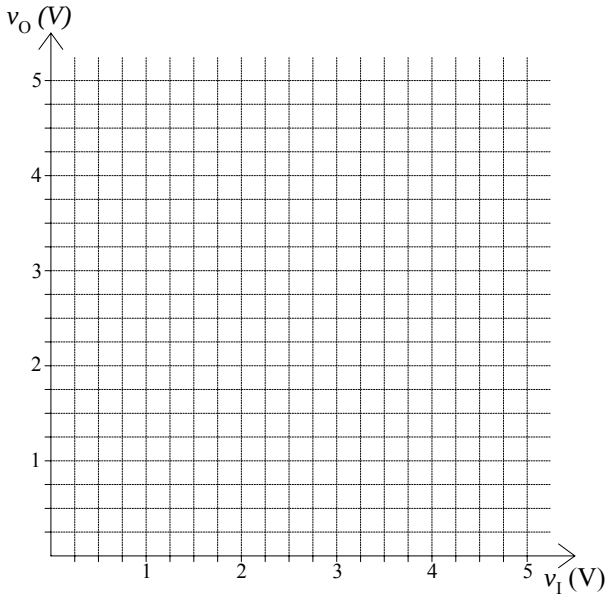
SIGNATURE

ASSUME V_T = 25 mV, UNLESS OTHERWISE SPECIFIED

Problem 1 [16 points]
An amplifier is characterized by the following relationships between its output voltage and its input voltage:

$v_O = 1$ V	for $v_I < 2$ V
v_O (in V) $= 3\, v_I - 5$	for $2\text{ V} \le v_I \le 3$ V
$v_O = 4$ V	for $v_I > 3$ V

a) Plot the amplifier transfer characteristics (v_O versus v_I) for $0\text{ V} \le v_I \le 5$ V. [3 points]

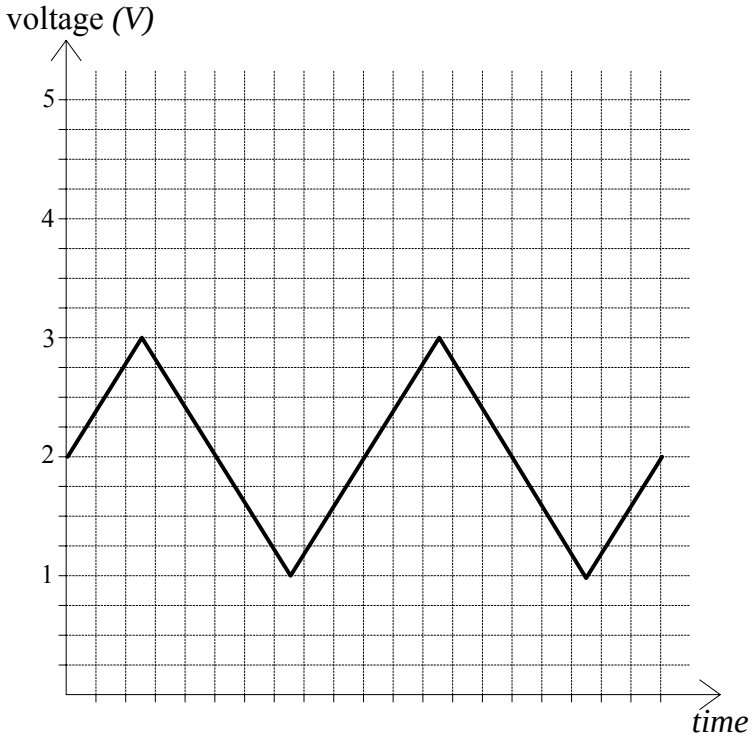


b) In the amplification region, what is the gain of the amplifier (in V/V)? What is the gain of the amplifier in dB? [3 points]

c) What is the maximum peak-to-peak undistorted variation in the output voltage? What is the corresponding peak-to-peak variation in the input voltage? [3 points]

d) Where should the bias point (V_I, V_O) of this amplifier be in order to get the maximum undistorted output? [3 points]

e) For the input waveform shown below, plot and label, on the same graph, the output waveform. [4 points]

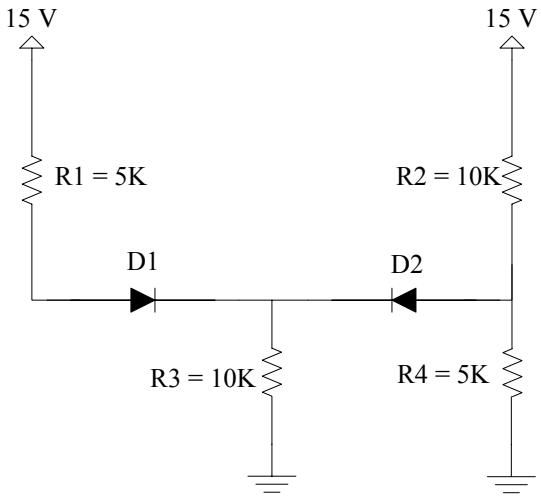


Problem 2 [12 points]
Measurements on a Si diode were taken at v_D = 0.35 V, 0.45 V, 0.55 V, and 0.65 V. The natural logarithm of the diode current in Amps, ln(i_D), is plotted on the y-axis versus v_D in Volts, on the x-axis. The resulting *straight-line* has a slope of 32, and a y-axis intercept of –30.

a) For this diode, find the values of n and I_S. [8 points]

b) What is the diode current when v_D = 0.7 V? [4 points]

Problem 3 [12 points]
The diodes in the circuit shown drop 0.7 V when conducting.
Calculate the current in D2 and the voltage across R3. Verify all your assumptions.

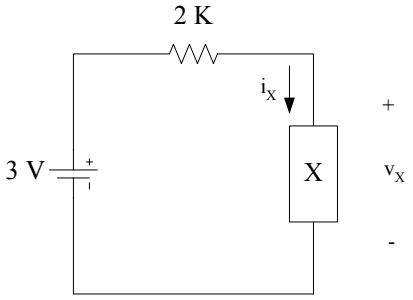


Problem 4 [12 points]

A certain device *X* is described by the following I-V characteristic:

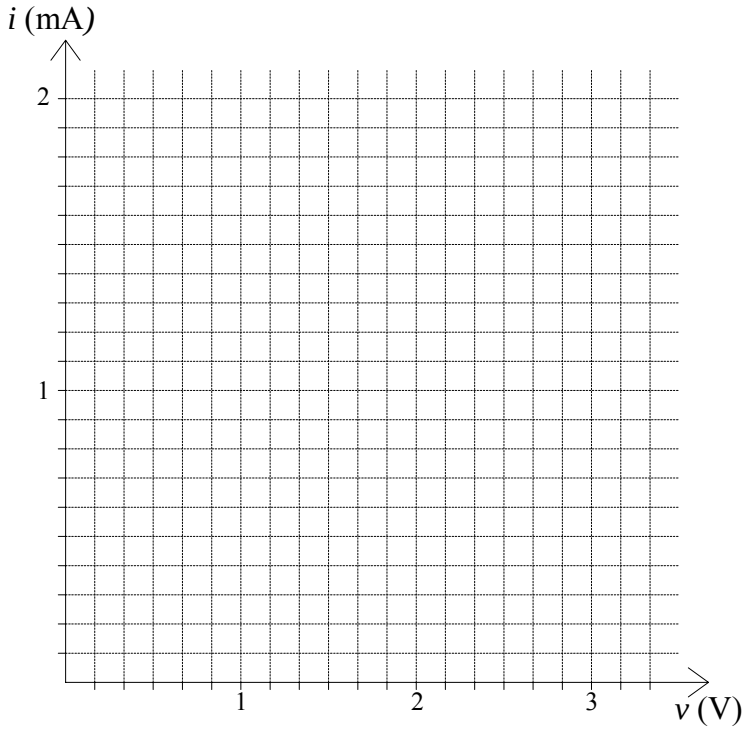
$$i_X = \frac{v_X}{4} + \sqrt{v_X} \qquad i_X \text{ is in mA and } v_X \text{ is in Volts}$$

This device is connected in series with a 2 KΩ resistor and a 3 V battery as shown below.



a) Using numerical iterations, and starting with $v_X = 0.8$ V, find the values of v_X and i_X for the device in this circuit. Show all steps in the calculation, and stop the iterations when consecutive values of v_X do not differ by more than 2 mV in absolute value. [6 points]

b) Plot the I-V characteristic for the device on the graph below at values of v_X = 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, and 1.1 V. Then, use the load line method to ***graphically*** determine i_X and v_X. [6 points]



Problem 5 [6 points]

A Si diode is biased at a DC current of 5 mA. What is the peak-to-peak *signal current* that can appear in the diode without exceeding the small-signal approximation limit?

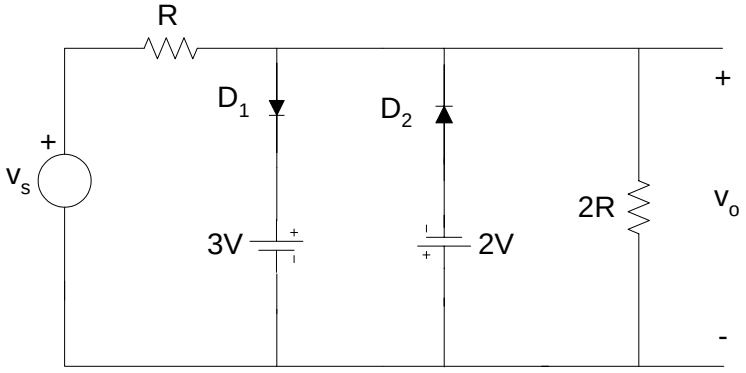
Problem 6 [12 points]
A full-wave rectifier with a center-tap transformer uses two diodes that are assumed ideal. The average value of the output voltage is 10 V, across a 100 Ω load resistor.

a) Find the maximum value of the sinusoidal voltage at the secondary of the transformer (from the center tap to one of the transformer terminals on the secondary.) [4 points]

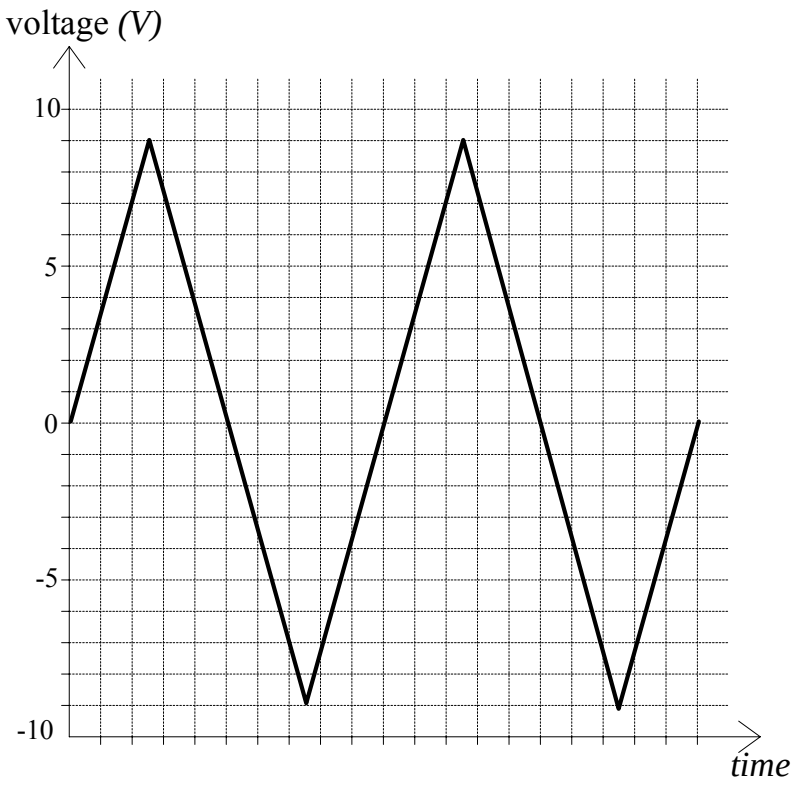
b) Find the average diode current. [4 points]

c) Find the diode PIV. [4 points]

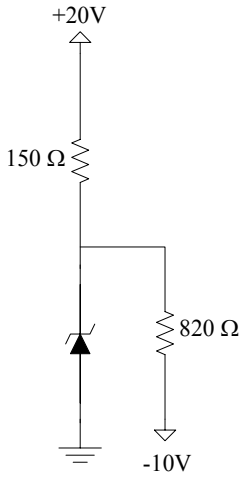
Problem 7 [10 points]



For the v_S waveform shown below, plot and label, on the same graph, the output waveform that is produced by the circuit shown above.



Problem 8 [10 points]
The Zener diode shown in the circuit below is rated at V_Z = 12 V for a test current of 25 mA. The value of the incremental Zener resistance r_Z is 10 Ω. The Zener knee current I_{ZK} is 5 mA. Find the Zener current and the Zener voltage in the circuit shown. Verify all assumptions.


+20V
150 Ω
820 Ω
-10V

Not included in the material of Quiz 1 for Fall 2006 - 2007

Problem 9 [10 points]

The density of donor atoms in a semiconductor is 5×10^{16} cm^{-3}. The mobility of electrons in the semiconductor is 1300 $cm^2/V.sec$ and that of holes is 500 $cm^2/V.sec$. The intrinsic density is $n_i = 1.5 \times 10^{10}$ cm^{-3}. The magnitude of electron charge is 1.6×10^{-19} C.

a) Is the semiconductor N-type or P-type? Why? [2 points]

b) Find the hole concentration. Does the hole concentration increase, decrease, or remain unchanged when temperature increases? [2 points]

c) Find the concentration of free electrons. Does the free electron concentration increase, decrease, or remain unchanged when temperature increases? [2 points]

d) Calculate the conductivity of the semiconductor. [2 points]

e) Find the drift current density due to holes if an electric field of 10^4 V/cm is applied. [2 points]