American University of Beirut

Department of Electrical and Computer Engineering

EECE 310 – Electronics
Quiz 1 – November 4, 2011
Closed Book – No Programmable Calculators

90 minutes

There are 20 problems. All problems are equally graded.

Penalty is 5 to 1
(1 to 4 wrong answers do not result in a penalty; 5 to 9 wrong answers cancel one correct answer; 10 to 14 wrong answers cancel two correct answers; and so on)

Name: ________________________________ **ID number:** ________________

Unless otherwise specified, assume that:

$V_T = 25$ mV $n = 1$ $n_i = 1.5\times10^{10}$ cm^{-3} $q = 1.6\times10^{-19}$ C

$$J_p = -qD_p \frac{dp}{dx} \qquad J_n = qD_n \frac{dn}{dx}$$

$$J_d = \left(qp\mu_p + qn\mu_n\right)E$$

$$I = J \times A$$

1. An amplifier operating from ±15 V power supplies provides a 5 V rms sine-wave signal to a 1 kΩ load and draws negligible current from the signal source. The amplifier draws a current of 3 mA from each of its two power supplies. Find the power dissipated (lost) in the amplifier (in mW).

a) 9 b) 26 c) 41 d) 65 e) 54

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2. An amplifier has a linear transfer characteristic passing through (0, 0) and with output saturation at 10 V and –10 V. The amplifier gain is 100 V/V. The input voltage consists of a sine-wave component superimposed over a 30 mV DC component. What is the amplitude (in V) of the largest undistorted sine-wave that can appear at the output?

a) 5 b) 8 c) 7 d) 6 e) 9

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3. An amplifier has the transfer characteristic $v_O = e^{3(v_I - 1)}$ for $v_I \geq 1$ V and $v_O \leq 20$ V. Both voltages are expressed in V. If the output voltage at the operating point is 10 V, find the voltage gain (in dB).

a) 29.5 b) 31.1 c) 32.5 d) 25.1 e) 27.6

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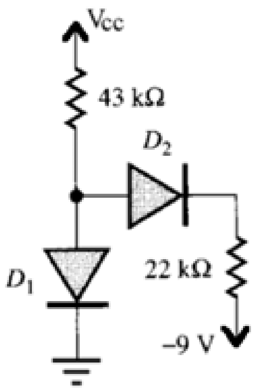
4. The diodes in the circuit shown below are ideal. Find the forward current in diode D_2 (in mA) if Vcc = 6 V.

a) 0.26 b) 0.29 c) 0.32 d) 0.35 e) 0.23



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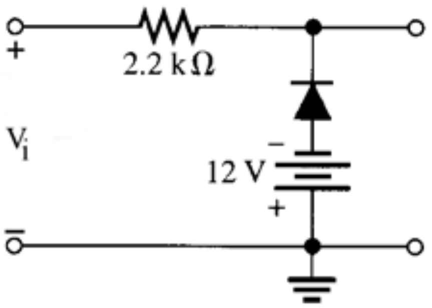
In the circuit shown below, the sine-wave input V_i has a *peak-to-peak* value of 48 V. The diode is modeled by a fixed 0.8 V drop when conducting, and by an open circuit when OFF. Refer to this circuit for questions 5 and 6.



5. Find the peak inverse voltage (PIV) of the diode (in V).

a) 30 b) 32 c) 34 d) 36 e) 38

6. Find the peak value of the diode current (in mA).

a) 6.0 b) 2.4 c) 3.3 d) 4.2 e) 5.1

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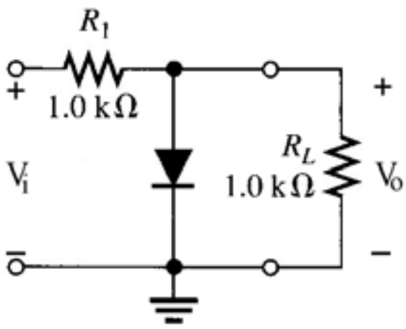
7. The diode in the circuit shown below is modeled by a fixed 0.8 V drop when conducting, and by an open circuit when OFF. The square-wave input voltage V_i is –6 V for 50% of the time, and +6 V for 50% of the time. Find the average (DC) value of the output voltage V_o (in V).

a) –1.1 b) –1.6 c) –2.1 d) –2.6 e) –3.1



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8. A diode conducts 0.1 mA at 0.8 V and its voltage changes by 0.060 V for every decade change in current. Find its reverse saturation current I_S (in A).

a) 4.64×10^{-18} b) 3.73×10^{-16} c) 1.75×10^{-14} d) 1.29×10^{-13} e) 5.34×10^{-12}

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9. The average (DC) value of the output voltage of a full-wave bridge rectifier is 14 V. If the diodes are ideal and the load is purely resistive, find the RMS value of the sinusoidal supply voltage (in V rms) at the transformer secondary.

a) 15.5 b) 13.3 c) 14.4 d) 11.1 e) 12.2

10. A half-wave peak rectifier is fed with a sinusoidal voltage source $v_I = V_p \times \sin(2\pi ft)$ V. The diode is ideal, the capacitance C = 100 μF, and the load resistance R = 10 kΩ. If the output ripple voltage should not exceed $0.01 \times V_p$, find the minimum supply frequency f (in Hz).

a) 20   b) 100   c) 50   d) 33.3   e) 25

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11. The load resistor in a full-wave bridge rectifier with capacitor filter is 100 Ω. The source is sinusoidal, with 8 V rms, and 50 Hz frequency. Find the ripple voltage (in V) if the capacitance value is 2 mF. Assume that each diode drops 0.65 V when conducting.

a) 0.36   b) 0.50   c) 0.64   d) 0.78   e) 0.92

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12. The total voltage across a diode is $v_D = 0.7 + 0.005 \times \sin(\omega t)$ V when the total diode current is $i_D = I_D + 0.05 \times \sin(\omega t)$ mA. The diode has n = 1.8 and negligible reverse saturation current. Find the DC value of the diode current (I_D) in mA.

a) 0.35   b) 0.40   c) 0.45   d) 0.50   e) 0.3

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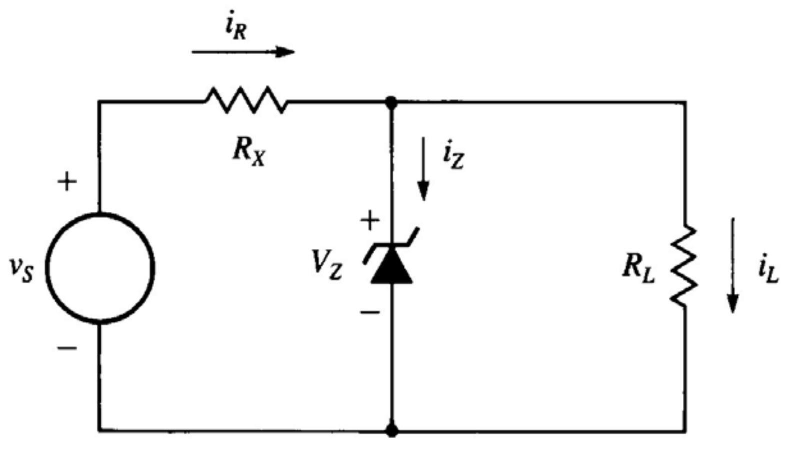
The circuit shown below must be designed to provide a stabilized voltage for load currents i_L less than or equal to 9 mA when v_S = 11 V. The Zener diode has a nominal Zener voltage of 6.2 V at a test current I_{ZT} = 20 mA, a resistance r_Z = 10 Ω, and should conduct a current of at least 1 mA to ensure operation in the breakdown region. Refer to this circuit for questions 13 and 14.



13. What is the maximum value of R_X (in Ω) for which the Zener diode remains in the breakdown region?

a) 499   b) 599   c) 399   d) 199   e) 299

14. Assume that R_X = 190 Ω. At no-load (R_L is disconnected), find the change in the Zener voltage (in V) if the supply voltage v_S changes by 3 V.

a) 0.15 b) 0.20 c) 0.25 d) 0.05 e) 0.10

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15. A circuit consists of a 5 V DC source, a 1 kΩ resistor, and a forward-biased diode. The diode has $I_S = 10^{-12}$ A. Starting with an initial guess for the diode current of 5 mA, the value of the diode current after completing one iteration is found to be 4.1067 mA. Find the value of n for this diode.

a) 1.8 b) 1.2 c) 1.4 d) 1.6 e) 1.0

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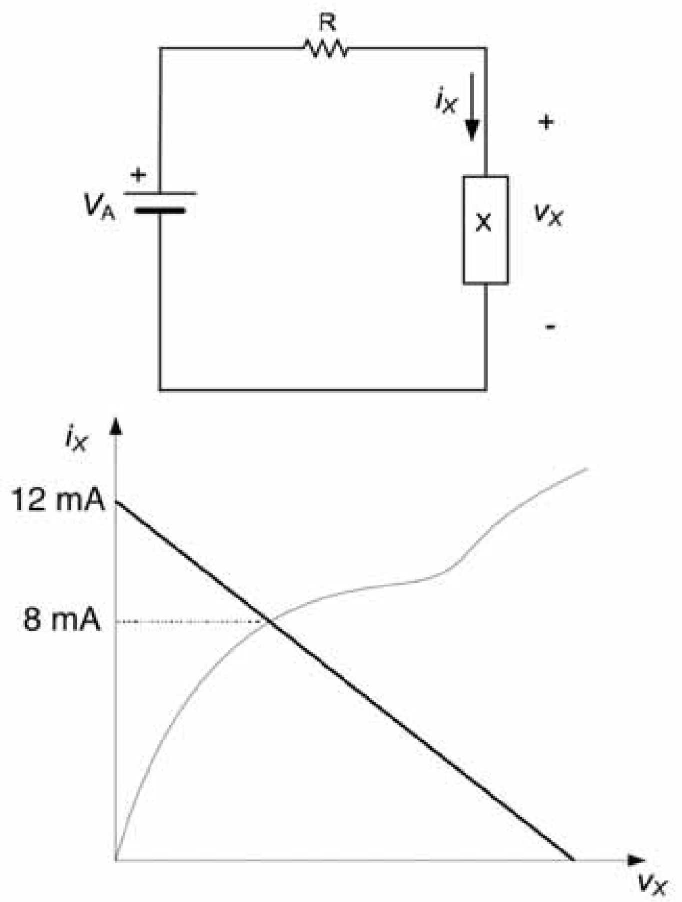
16. Find the power dissipated in device X (in mW) when R is 1 kΩ. The load line is shown on the plot below.

a) 70.4 b) 38.4 c) 48.0 d) 57.6 e) 32.0



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17. A piece of semiconductor material is doped with donor atoms with a density N_D = 1.1×10^{17} cm^{-3}. Estimate the resulting hole density (in cm^{-3}).

a) 1607 b) 1500 c) 2045 d) 1875 e) 1731

18. Estimate the conductivity (in S/cm) in the previous problem. The electron mobility is 1800 cm^2/V.s and is three times that of holes.

a) 31.7 b) 34.6 c) 37.4 d) 40.3 e) 43.2

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19. The diffusion current density for electrons in a piece of semiconductor is J_1 at x = 0.1 cm but becomes $0.85\times J_1$ at x = 0.3 cm. The electron density function is given by $n(x) = a + 3x + bx^3$, where x is in cm, and n is in cm^{-3}. Find the value of b (in cm^{-6}.)

a) –1.84 b) –6.43 c) –5.33 d) –4.19 e) –3.03

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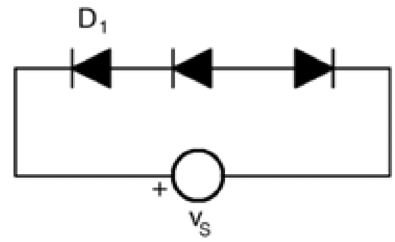
20. In the circuit shown below, the three diodes are identical and have $I_S = 10^{-12}$ A, and n = 2. Find the PIV for diode D_1 when $v_S = 8.5 + 10 \sin(\omega t)$ V.



a) 9.783 b) 10.083 c) 7.983 d) 8.483 e) 9.233

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