American University of Beirut

Department of Electrical and Computer Engineering

EECE 310 – Electronics
Midterm – July 16, 2010
Closed Book – No Programmable Calculators

90 minutes

Profs. Chehab and Kayssi

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**

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

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

$$I = J \times A$$

$$V_0 = V_T \ln\left(\frac{N_A N_D}{n_i^2}\right)$$

1. The voltage gain of an amplifier is 100 V/V. Its power gain is 45 dB. Find the current gain in dB.
a) 50 b) 40 c) 25 d) 45 e) 20

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2. A voltage amplifier is powered by a single 16 V DC supply. The amplifier is loaded by a 50 Ohm resistor and produces a peak-to-peak sinusoidal output voltage of 8 V across the load. Find the average DC supply current (in mA) if the efficiency of the amplifier is 20%.
a) 200 b) 100 c) 250 d) 150 e) 50

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3. A circuit consists of a 5 V DC source, a 12 kΩ resistor, and a forward-biased diode. The diode has $I_S = 10^{-15}$ A and $n = 1.5$. Starting with an initial guess for the diode current equal to the current that flows if the diode were ideal, find the value of the diode current (in mA) after completing two iterations.
a) 0.386 b) 0.218 c) 0.471 d) 0.334 e) 0.417

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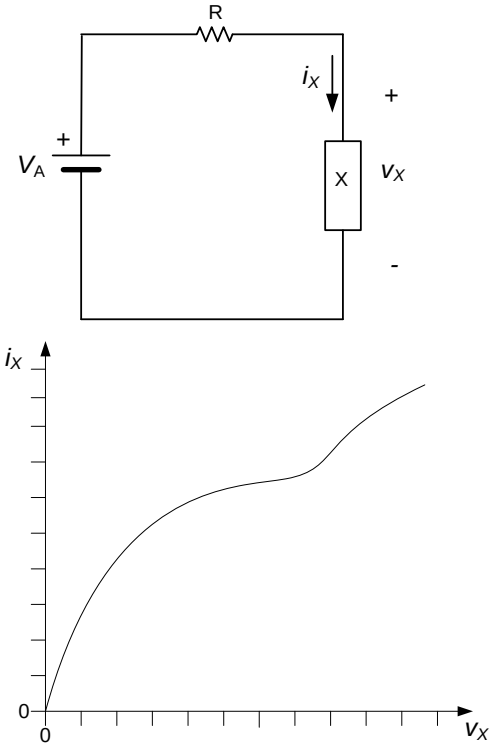
4. The current-voltage characteristics of device X are shown on the i_x–v_x plot in the figure below. The x-axis division is 0.25 V, and the y-axis division is 200 μA. Using the load line graphical method, estimate the voltage v_x (in V) when $V_A = 2$ V and $R = 1$ kΩ.
a) 0.64 b) 0.83 c) 1.37 d) 0.45 e) 1.12



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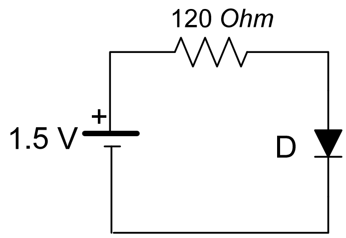
5. The diode in the circuit shown below is modeled by V_{D0} = 0.6 V and r_D = 30 Ohms, when conducting, and by an open circuit when OFF. Determine the power dissipation in diode (in mW).



a) 6.00 b) 7.50 c) 4.68 d) 2.40 e) 3.38

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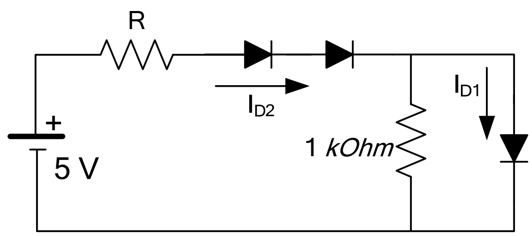
6. Assume that the diodes are ideal in the circuit shown below. Find the value of R (in kΩ) needed to obtain I_{D2} = 1 mA.

a) 10 b) 4 c) 1 d) 5 e) 2



7. In the circuit of the previous problem, assume now that the diodes are modeled by a fixed 0.65 V drop when conducting, and an open circuit when OFF. Find the value of R (in kΩ) needed to obtain I_{D2} = 2 I_{D1}.

a) 1.46 b) 2.35 c) 1.29 d) 2.08 e) 6.71

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8. Find the drift current density (in mA/cm^2) that results due to the application of a 900 V/cm electric field to a volume of intrinsic semiconductor. The mobility of free electrons in the semiconductor is 1150 cm^2/V.s, and it is three times larger than the mobility of holes.

a) 3.3 b) 2.5 c) 0.83 d) 9.9 e) 4.9

9. The free electron density in a doped semiconductor is 500 cm^{-3} at room temperature. What is the type of impurity atoms?

a) Acceptors b) Donors c) Silicon d) Not enough information to decide

10. The density of impurity atoms on the two sides of a PN junction is $10^X \times n_i$. The potential barrier is 0.921 V. Find X.

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

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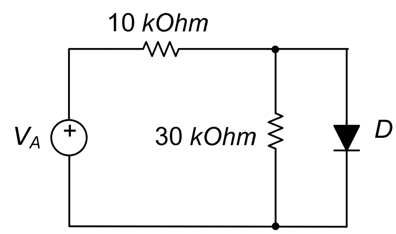
11. Find the power dissipation (in μW) in the 10 kΩ resistor in the circuit shown below when V_A is 1.2 V DC. The diode is modeled by a fixed 0.7 V drop when conducting, and an open circuit when OFF.

a) 9 b) 25 c) 16 d) 36 e) 4



12. Repeat the previous problem when V_A is –1.2 V DC.

a) 4 b) 25 c) 16 d) 36 e) 9

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13. A GaAs forward-biased junction diode is conducting a current of 12 mA at a diode voltage of 1.1 V. Find the diode current (in mA) when the diode voltage is 1 V.

a) 24 b) 1.2 c) 5.6 d) 7.8 e) 0.22

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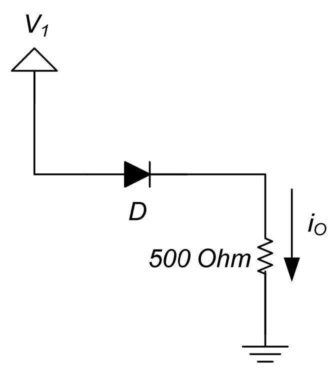
In the circuit shown below, the voltage V_1 has a DC value of 5 V on which a sinusoidal signal equal to 0.1 sin(ωt) V is superimposed. Assume that the DC characteristics of the diode are modeled by a fixed voltage drop of 0.6 V when conducting, and an open circuit when OFF.



14. Find the incremental small-signal resistance r_d for the diode (in Ohms).

a) 14.9 b) 8.32 c) 2.84 d) 18.5 e) 1.52

15. Calculate i_O(t) in mA.

a) 4.4–0.199×sin(ωt) b) 8.8–0.199×sin(ωt) c) 8.8+0.199×sin(ωt)

d) 4.4+0.1×sin(ωt) e) 4.4–0.1×sin(ωt)

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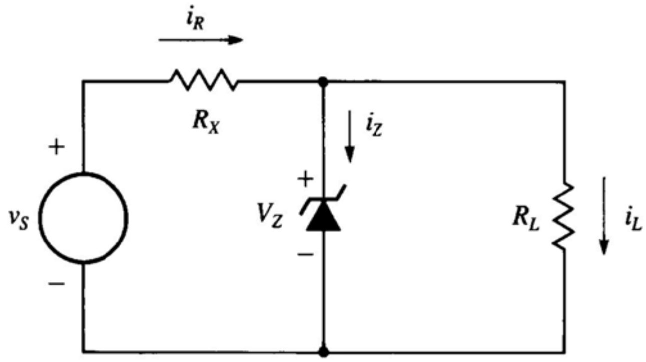
The Zener diode shown below has V_Z = 10 V at I_Z = 25 mA, with r_Z = 5 Ω and I_{ZK} = 5 mA. The source v_S is 20 V, but varies by +/ –25%, i.e. between 15 V and 25 V. The load draws a current that varies from 0 to 20 mA.



16. Find the largest value of R_X (in Ω) that ensures Zener region operation for the diode under all conditions.
a) 81 b) 152 c) 267 d) 204 e) 533

17. For the value of R_X calculated in the previous problem, what is the maximum variation in the Zener voltage V_Z (in V)?
a) 0.34 b) 0.27 c) 0.56 d) 0.11 e) 0.01

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18. A full-wave rectifier circuit with a 3 kΩ load operates from a 311 V (peak) 50 Hz sinusoidal wave supply through step-down transformer having two secondary windings and a center tap. The transformer turns ratio for each secondary is 15-to-1. The rectifier uses two diodes each of which is modeled by a 0.75 V drop for any forward current. What is the average (DC) current in the load resistor (in mA)?
a) 9.21 b) 8.31 c) 4.91 d) 4.15 e) 2.51

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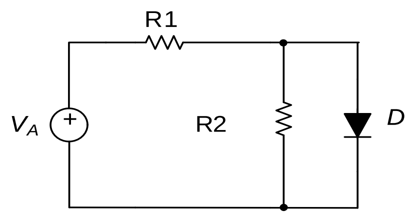
The diode in the circuit shown below drops a constant 0.7 V when conducting. The diode *should* remain conducting when V_A varies between 5 V and 10 V. Moreover, the diode current should not drop below 2 mA, and the power dissipation of the diode should not exceed 10 mW. *[Note: multiple solutions are possible]*



19. Find the value of R_1 (in Ω).
a) 521 b) 407 c) 372 d) 233 e) 311

20. Find the value of R_2 (in Ω).
a) 33.6 b) 18.9 c) 81.7 d) 24.4 e) 67.2