ID # ______________________

NAME ______________________

EE-255 EXAM 1 September 11, 2001

Instructor (circle one) Talavage Gray

This exam consists of 16 multiple choice questions and one workout problem. Record all answers to the multiple choice questions on this page. You must turn in the entire exam. There will be no partial credit for the multiple choice questions, but there will be partial credit for the workout problems. You MUST show your work on the workout problems.

Circle the one best answer for each question. Five points per question.

Do not open and begin until you are instructed to do so!

1) a b c d e

2) a b c d e

3) a b c d e

4) a b c d e

5) a b c d e

6) a b c d e

7) a b c d e

8) a b c d e

9) a b c d e

10) a b c d e

11) a b c d e

12) a b c d e

13) a b c d e

14) a b c d e

15) a b c d e

16) a b c d e

1) In semiconductor physics, the term “holes” refers to

a) negatively charged carriers of current
b) protons
c) positrons
d) charge neutral carriers of current
e) positively charged carriers of current

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2) A semiconductor that has been doped with donor impurity atoms is called

a) a gifted semiconductor
b) an intrinsic semiconductor
c) a rich semiconductor
d) a p-type semiconductor
e) an n-type semiconductor

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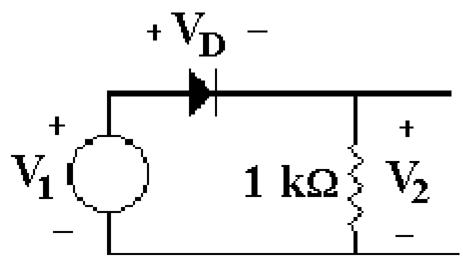
3) In the diagram below, the diode may be modeled as an ideal diode. If $V_1 = 5$ V, Compute the diode current, I_D.



a) 0 mA
b) 1 mA
c) 4 mA
d) 4.4 mA
e) 5 mA

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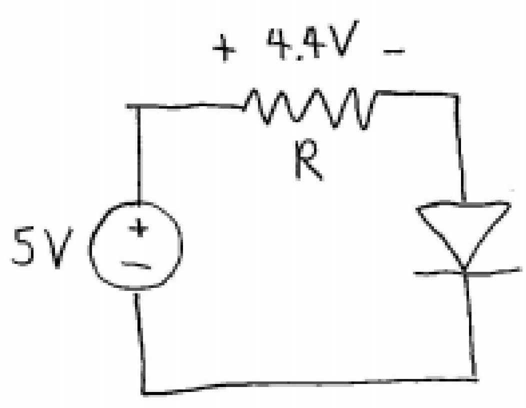
4) Use the diode equation with $I_S = 10^{-10}$ mA, $V_T = 26$ mV and n = 1, to find the diode current, I_D, in the circuit below.



a) 9.4 V
b) 1.1 A
c) 0.0011 mA
d) -1.1 A
e) 1.1 mA

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5) A forward biased diode is found to have a current of I_D = 1 mA. If this diode is known to have n = 1.5 and $I_S = 10^{-10}$ A, solve for the voltage across the diode, V_D.

a) 0.63 V
b) 0.54 V
c) 0.42 V
d) 0.36 V
e) 0.21 V

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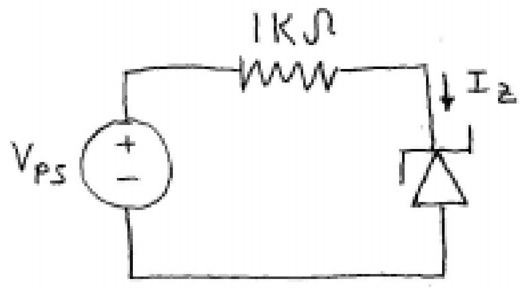
6) A particular diode is found to have an ideality factor of n = 2 and a reverse saturation current of $I_S = 10^{-6}$ A. If V_T = 26 mV, solve for the current when V_D = 0.1 V.

a) 4.58 µA
b) 5.84 µA
c) 6.84 µA
d) 45.8 µA
e) 46.8 µA

Use the figure below as you answer Questions 7–9. The Zener diode can be modeled with V_Z = 10 V & r_Z = 0 Ω when the diode is reverse biased and with V_γ = 0.6 V & r_O= 0 Ω when it is forward biased. You are to determine I_Z given different values for V_{PS}.



7) If V_{PS} = 15 V, I_Z = ?

a) 0 mA
b) -4.4 mA
c) -5 mA
d) 4.4 mA
e) 5 mA

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8) If V_{PS} = 10V, I_Z = ?

a) 0 mA
b) -4.4 mA
c) -5 mA
d) 4.4 mA
e) 5 mA

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9) If V_{PS} = -5 V, I_Z = ?

a) 0 mA
b) -4.4 mA
c) -5 mA
d) 4.4 mA
e) 5 mA

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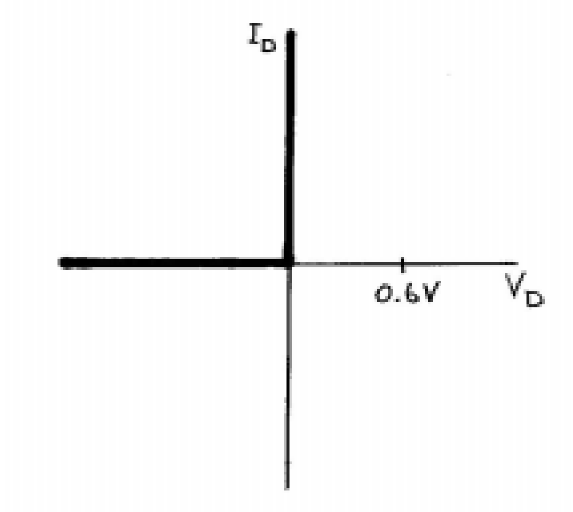
10) A particular diode is modeled with a piecewise linear model having the current-voltage characteristic below. Determine the parameters for this model.



a) $V\gamma = 0$ V; $r_f = 0\ \Omega$
b) $V\gamma = 0.6$ V; $r_f = 0\ \Omega$
c) $V\gamma = -0.6$ V; $r_f = 0\ \Omega$
d) $V\gamma = 0$ V; $r_f = \infty\ \Omega$
e) $V\gamma = 0$ V; $r_f = 1\ \Omega$

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11) A silicon diode is observed to exhibit $I_D = 1$ mA at $V_D = 700$ mV and $I_D = 3.6$ mA at $V_D = 750$ mV, all at T = 300 K. What is the value of n?

a) 1.5
b) 1.0
c) 1.9
d) 2.0
e) 1.7

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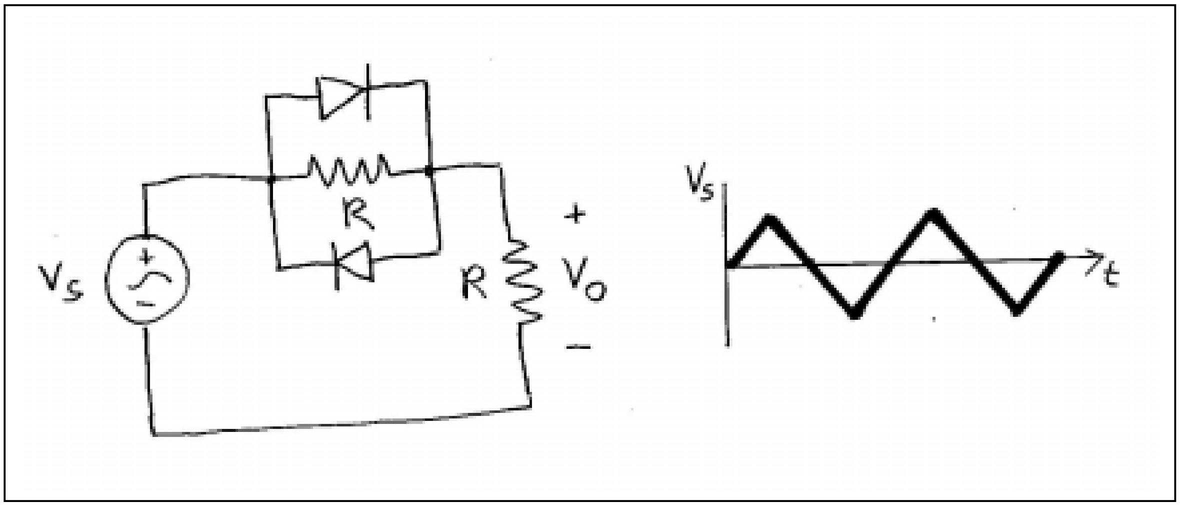
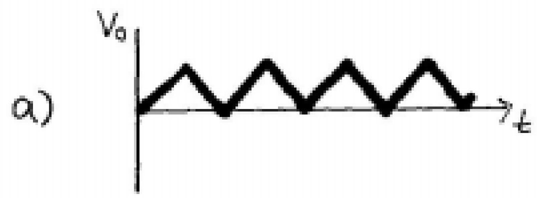
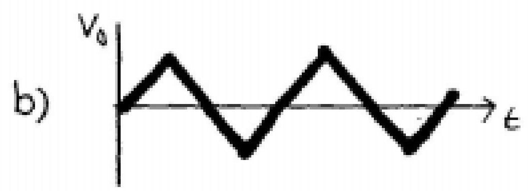
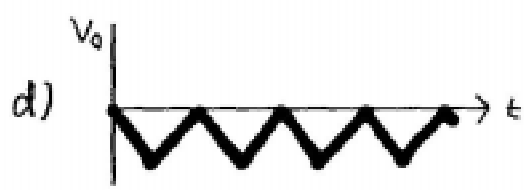
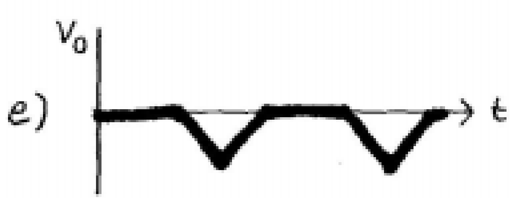
12) Given the circuit and signal voltage below, what is V_o?



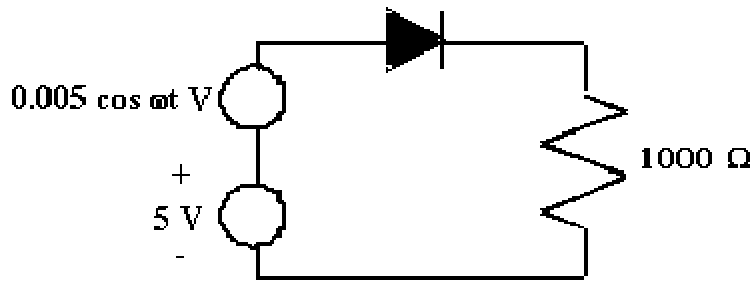








13) The diode in the circuit below may be modeled for dc analysis by piecewise-linear values $V_O = 0.6$ V and $R_O = 10\ \Omega$, and is found to have n = 1.2. Find the AC small signal conductance, g_d = ?



a) 200 mmhos
b) 190 mmhos
c) 170 mmhos
d) 160 mmhos
e) 140 mmhos

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14) For the circuit in **Problem 13**, what is the AC voltage across the diode, v_d?

a) 35.5 cos ωt μV
b) 29.6 cos ωt μV
c) 24.8 cos ωt μV
d) 26.2 cos ωt μV
e) 31.2 cos ωt μV

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15) A silicon diode with V_{bi} = 0.5 V and N = 0.5 is observed to have a junction capacitance of C_j = 2 pF when V_D = -1.5 V. What is the value of C_j when V_D = -4.0 V?

a) 1.33 pF
b) 2.25 pF
c) 3.00 pF
d) 0.89 pF
e) 2.00 pF

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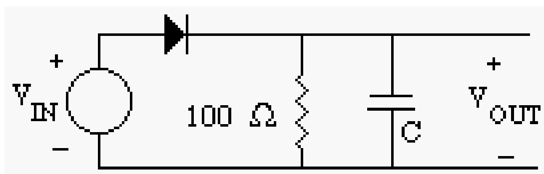
16) The diode in the rectifier circuit below is ideal. $V_{IN}(t) = 100 \sin(1000 \pi t)$. C should be as small as possible. If the ripple voltage at V_{OUT} is to be about 5 volts, a suitable choice for C is about:



a) 4 μF
b) 40 μF
c) 400 μF
d) 4000 μF
e) 2 F

SHOW ALL WORK FOR PROBLEM 17 ON THESE TWO SHEETS

17) In this problem you will examine the conditions necessary for a piecewise linear model of a diode to be accurate.

a) **(6 pts)** A particular diode is observed to exhibit the following two (I_D, V_D) pairs:

$$(I_{D1}, V_{D1}) = (4.80\ \mu A, 0.4\ V)$$
$$(I_{D2}, V_{D2}) = (225\ \mu A, 0.5\ V)$$

Compute the piecewise-linear components, R_O and V_O.

b) **(4 pts)** For your computed values of V_O and R_O, compute the diode voltage, V_D, that will result in a diode current of $I_D = 1$ mA.

c) **(2 pts)** A second pair of measurements with this diode

$$(I_{D1}, V_{D1}) = (10.5\ mA, 0.6\ V)$$
$$(I_{D2}, V_{D2}) = (493\ mA, 0.7\ V)$$

yield a second model having

$$V_O = 0.598\ V$$
$$R_O = 0.207\ \Omega$$

Using this model, compute the diode voltage, V_D, that will result in $I_D = 1$ mA.

d) **(4 pts)** Given that this particular diode as $n = 1.0$ and $I_S = 1$ pA, compute the ACTUAL value of V_D that results in $I_D = 1$ mA.

e) **(4 pts)** In a couple of sentences, compare the results of **parts b–d** and comment upon why the two linear models differ from the exact answer (Hint: consider how the piecewise-linear model approximates the diode equation)

EE-255 Formula Sheet: Exam 1

Data:

$At\ 25^{\circ}C(R.T.)\quad V_T = kT/q = 0.026\ V \qquad k = 1.3806\times10^{-23}\ J/K$

$q = 1.6022\times10^{-19}\ C \qquad 0^{\circ}C = 273.16K$

Formulas:

$e^x = 1 + x + x^2/2 + \cdots$

Diodes:

$I_D = I_0\left(e^{V_D/nV_T} - 1\right) \qquad V_D = V_0 + I_D R_0 \qquad C_j = \dfrac{C_{j0}}{\left(1 - V_D/V_{bi}\right)^N} \qquad nV_T = \dfrac{V_{D2} - V_{D1}}{\ln\left(I_{D2}/I_{D1}\right)}$

$r_d = \left.\dfrac{d\upsilon_D}{di_D}\right|_Q = \dfrac{nV_T}{I_D + I_0} \qquad v_D = V_D + v_d$

$V_r = \dfrac{V_M}{2fRC}$ (full wave)

Other Equations:

$R = R \times (L/W)$

$N_1/N_2 = V_1/V_2$