Test 2

EE315 Spring 2017—Dr. B

NAME Solution Key

DO ALL YOUR WORK ON THIS EXAM. USE THE BACK SIDES of EXAM PAPER IF NECESSARY BUT POINT ME WHERE YOU DID THAT.

- ***Your Equation sheet must be turned in with the Exam.***
- ***NO Cell PHONE Calculators allowed. Other calculators ok.***
- ***Closed books/closed lecture notes.***
- ***<u>Each Problem worth 18 points.</u>***

A good engineer is someone who is good with math without having the personality of an accountant.

EE315 SPRING TERM 2017

TEST 2- 22 MARCH 2017

NAME SOLUTION KEY

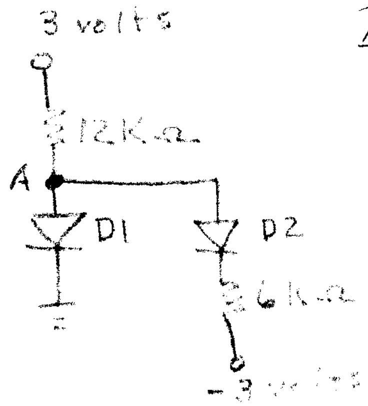
CIRCLE TRUE OR FALSE (1 point each)

1. (T/F) Thermal voltage for a semiconductor diode depends on temperature (in Kelvin degrees), Boltzmann's Constant, and charge on the electron. $V_T = \frac{kT}{q}$
2. (T/F) An intrinsic semiconductor does not have any doping to change the conductivity of the material.
3. (T/F) A semiconductor diode has only two states; either forward biased or electrically biased. Meaningless. "Reversed biased"
4. (T/F) At room temperature, thermal voltage for silicon is about 26 volts. just compute V_T @ 300°K
5. (T/F) A depletion region in a semiconductor diode is a region free of charge carriers. That's why it's called depletion region.
6. (T/F) A semiconductor diode is formed by a p-n junction. diodes = pn junction, pn junction = diode
7. (T/F) A Zener diode must be forward biased to perform and operate as a Zener diode. Reversed
8. (T/F) A "hole" is the empty space where an electron was but the space still has an effective mass and electrical charge. Talked this in class many times.
9. (T/F) A forward biased semiconductor diode is, ideally, an open circuit. short ckt
10. (T/F) A "p region" in a semiconductor diode is a region where an excess of positive charges are available for conduction. That's why it's called p region!

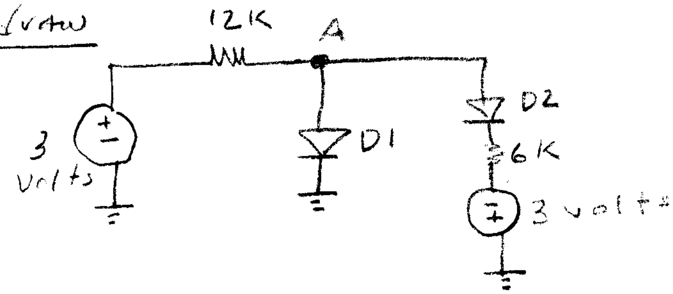
Some people MAY have gotten an exam saying 26 millivolts. TRUE then!! Messed up inserting this page in some exams.

2. A newly hired EE recently graduated from Loachapoka University School of Engineering tells you that both diodes in circuit below are forward biased. Is the EE correct? YES or NO?

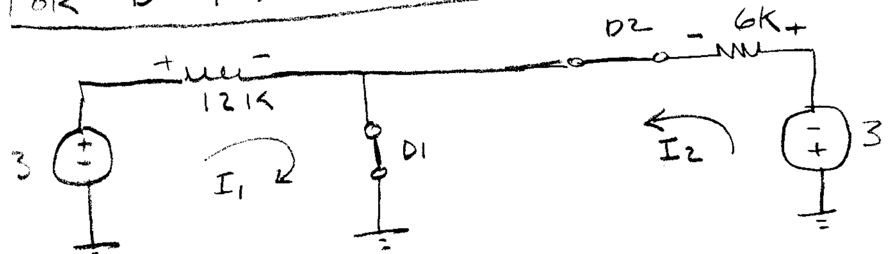
Show your work!! NO CREDIT FOR GUESSING



Redraw



FOR D1 & D2 both Forward Biased:



$3 - 12K\,I_1 = 0$

$I_1 = 3/12K = .25\text{ mA}$

$-3 - 6K\,I_2 = 0$

$-6K\,I_2 = 3$

$I_2 = \dfrac{3}{-6K} = -.5\text{ mA}$

This says I_2 is in Clockwise direction not CCW. I_2 will therefore Reverse bias D2.

The EE graduate is incorrect!

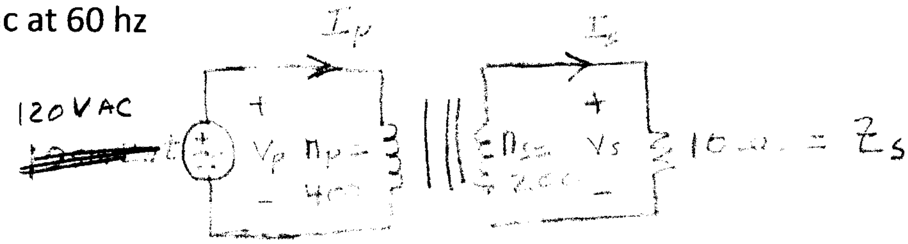
3. A step down transformer has the following data:

Vp = 120 volts ac at 60 hz

Np = 400

Ns = 200

Zs = 10 ohm



FIND Vs, Is, and Ip

Recall $\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{I_s}{I_p}$

Then:

$$\frac{400}{200} = \frac{120}{V_s} \Rightarrow V_s = \frac{120(200)}{400} = \boxed{60 \text{ volts} = V_s}$$

Then $I_s = \frac{60\text{ V}}{10\,\Omega} = \boxed{6 \text{ Amps} = I_s}$

Then $\frac{N_p}{N_s} = \frac{I_s}{I_p} \Rightarrow I_p = \frac{N_s I_s}{N_p} = \frac{200(6)}{400} = \boxed{3 \text{ Amps} = I_p}$

4. A diode operating in forward bias has a voltage drop of 0.7 volts at 1.0 milliamp. The diode is then operated at 0.5 milliamp. What is the new value of diode voltage? Assume: V_T = 25 millivolts.

First Find I_S:

$$I_D = I_S \left(e^{V_D/V_T} - 1\right)$$

$$.001 = I_S \left(e^{.7/.025} - 1\right) = I_S e^{28}$$

$$I_S = \frac{.001}{e^{28}} = 6.9 \times 10^{-16}$$

Then $I_D = \underset{6.9\times 10^{-16}}{I_S} \left(e^{V_D/.025} - 1\right)$

So $5 \times 10^{-4} = 6.9 \times 10^{-16} \left(e^{V_D/.025}\right)$

OR $e^{V_D/.025} = 7.246 \times 10^{11}$ Take ln both sides...

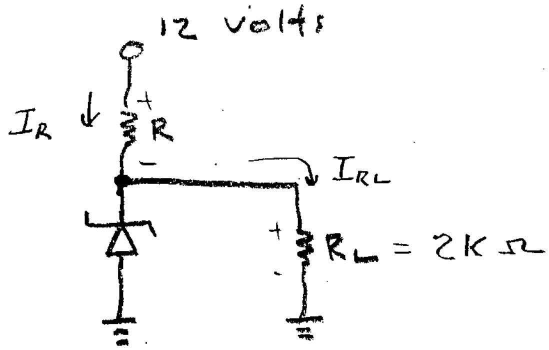
$$\frac{V_D}{.025} = 27.3089$$

$$\boxed{V_D = .68 \text{ volts}}$$

5. A Zener shunt regulator is shown below. Datasheet for the Zener shows:

V_z = 6.0 volts at I_z = 5 milliamp and r_z = 10 ohm.

(a) Find Zzo for the Zener diode
(b) Find the current through RL at that Zener voltage
(c) Find the current through R
(d) Find value for R



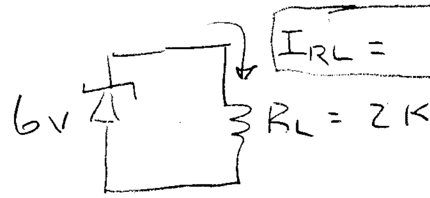
(a) $V_Z = V_{ZO} + r_Z I_Z$ BASIC EQUATION

$V_{ZO} = V_Z - r_Z I_Z$

$= 6 - (10)(.005)$

$\boxed{V_{ZO} = 5.95 \text{ volts}}$ This is the knee of the operating curve.

(b)



$\boxed{I_{RL} = \frac{6}{2K} = 3\text{ mA}}$

(c) $I_R = I_Z + I_{RL} = 5\text{ mA} + 3\text{ mA} = \boxed{8\text{ mA} = I_R}$

(d) $I_{RL} R_L + I_R R - 12 = 0$

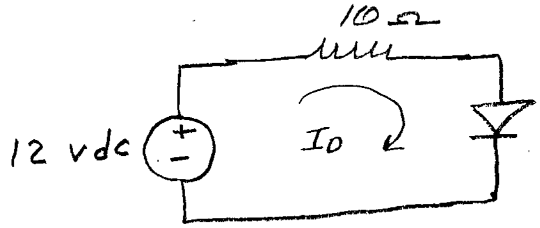
$(.003)(2K) + (.008)(R) - 12 = 0$

$6 + .008R = 12$

$.008R = 6$

$\boxed{R = 750\,\Omega}$

6. Using the Constant Voltage Drop Model for a Semiconductor Diode in the circuit below:



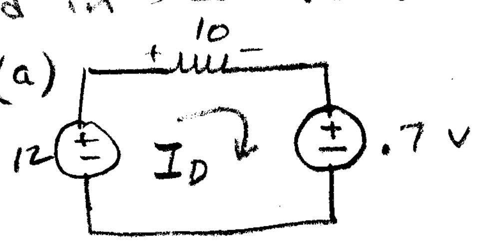
(a) Compute I_D

(b) If the 12 vdc SOURCE is Replaced by a 12 V peak sinusoid waveform, sketch I_D resulting waveform.

Recall Section 4.3.5, page 183

The constant voltage drop model in forward bias can be replaced by a voltage source of .7 volts and in reverse bias by an open circuit.

So (a)

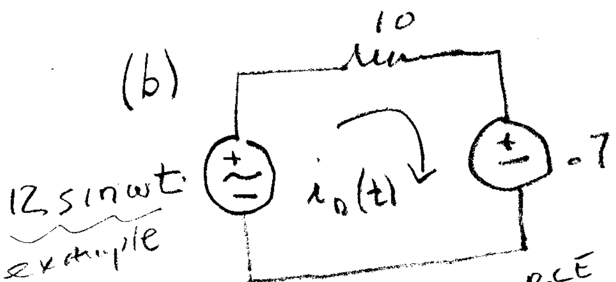


$12 - 10 I_D - .7 = 0$

$11.3 = 10 I_D$

$$\boxed{I_D = \frac{11.3}{10} = 1.13 \text{ Amp}}$$

(b)



on positive part of source

$i_D(t) = \frac{12 - .7}{10} = 1.13 \text{ Amp}$

Diode only conducts on positive half cycle of sinusoid.