EECS105 Name________________________
Midterm 1
2/17/12 SID________________________

1	/20
2	/16
3	/24
4	/20
Total	/80

2 1. You have a silicon PN junction diode with $N_D=10^{19}$ cm^{-3} and $N_A=10^{16}$ cm^{-3}

a. What is the built-in potential of the junction, V_0?

0.9 V . -1 leave as formula w/ values

-1 leave as ln( ).26mV

-2 write formula

4 b. At room temperature, what are the n and p concentrations on each side of the unbiased junction?

$n_n = 10^{19}$	$n_p = 10^4$
$p_n = 10$	$p_p = 10^{16}$

4 c. If the temperature changes, and n_i increases by a factor of 100, what are the new carrier concentrations?

-1 both p_n, n_p off by 100

$n_n = 10^{19}$	$n_p = 10^8$
$p_n = 10^5$	$p_p = 10^{16}$

4 d. If you forward bias this diode, will the carriers in the depletion region be mostly n-type or p-type? Will the current be mostly due to drift or diffusion?

n-type, diffusion

2 e. In reverse bias, will the depletion region extend mostly into the n-type region, mostly into the p-type region, or will it be roughly equal sized in both regions?

p-type +1 if "more lightly doped side"

2 f. You have a reverse bias of 32V across the junction, and measure a capacitance of 2pF. What reverse bias should you apply to get 4pF? (accurate to 10%)

$C_j \sim \frac{1}{\sqrt{V_R}}$ $V_R = 8$

2 g. There is a huge charge carrier concentration gradient in an unbiased PN junction. Why don't the carriers diffuse to the other side?

OK {
built-in potential
E-field in depletion region
fixed charges from impurity ions

2. You have a box full of identical ideal diodes. You apply 0.6V to one, and observe a current of 10mA.

4 a. What is a rough guess at the current in a single diode if you apply -0.6V across it?

-1pA

-1 missing negative sign but right answer

-3 wrong answer

-1 not knowing 60mV/decade

4 b. You wire two diodes in parallel and apply 0.6V across them. Estimate the current.

20mA

-3 not finding the answer

-1 not knowing that two parallel diodes give twice current.

4 c. You wire 100 diodes in parallel and drive 10mA through them. Estimate the voltage across the pair.

0.48V

-2 not finding the answer

-2 not finding the current per each diode (I_D= 10mA/100)

4 d. You wire two diodes in series and apply 0.6V across the series combo. Estimate the current.

100nA

-2 not finding the current (answer)

-2 not finding the voltage V_{BE} = 0.3V

(24') → 4' for each 2' for expressions

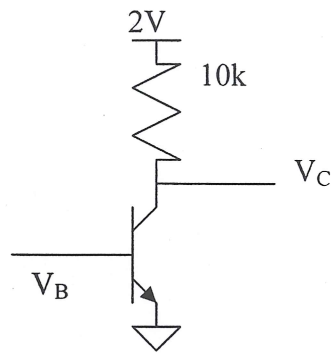
1' for correct plug-ins

1' for final results

3. For the circuit below, at room temperature find the input V^*_B necessary to make V^*_C=1V and find the operating point currents I^*_B, and I^*_C. Calculate the transconductance and output resistance, and calculate the DC gain, A_V. Assume $I_S=10^{-12}$ A, β=100, and V_A=100V. Answers should be accurate to 10%.

V^*_B = 0.48 V or 480 mV	I^*_C = 100 μA or 0.1 mA ~~1×10⁻⁴ A~~	I^*_B = 1 μA or 10^{-6} A
g_m = 1/250 S or 1/260 S (4 mS)	r_o = 1 MΩ or 10^6 Ω	A_V = −40 or −500/13

$V_C^* = 1^V$



$I_C = \frac{2^V - V_C^*}{R_C} = \frac{1^V}{10k} = 0.1\,mA$

$I_C = I_S \cdot \exp\left(\frac{V_{BE}}{26\,mV}\right)$

$I_C \to 1\times10^{-4}$, $I_S \to 10^{-12}$

$V_{BE} = 8 \cdot 60^{mV} = 0.48^V$

$I_B = \frac{I_C}{\beta} = 1\,\mu A$

$g_m = \left(\frac{k_BT/q}{I_C}\right)^{-1} = \left(\frac{26\,mV}{0.1\,mA}\right)^{-1} = (260\,\Omega)^{-1} = 1/250$

$r_o = \frac{V_A}{I_C} = \frac{100^V}{0.1\,mA} = 1\,M\Omega$

$r_\pi = \frac{\beta}{g_m} = \frac{10^2}{26^{mV}/0.1^{mA}} = \frac{10^3}{26}$

$A_0 = -g_m \cdot (r_o \,//\, R_C)$

$\doteq -g_m \cdot R_C$

$= -260^{\Omega^{-1}} \cdot 10^4$

$= -\frac{10^4}{260}$

4.

A)You have an NMOS transistor with $\mu_n C_{ox}$ (W/L)= 2mA/V^2 and λ=0.1/V, and V_{TH}=0.5V. Carefully plot the drain current vs. drain voltage of the NMOS device for V_{DS}=0 to 10V and V_{GS}= 1.5 volts.

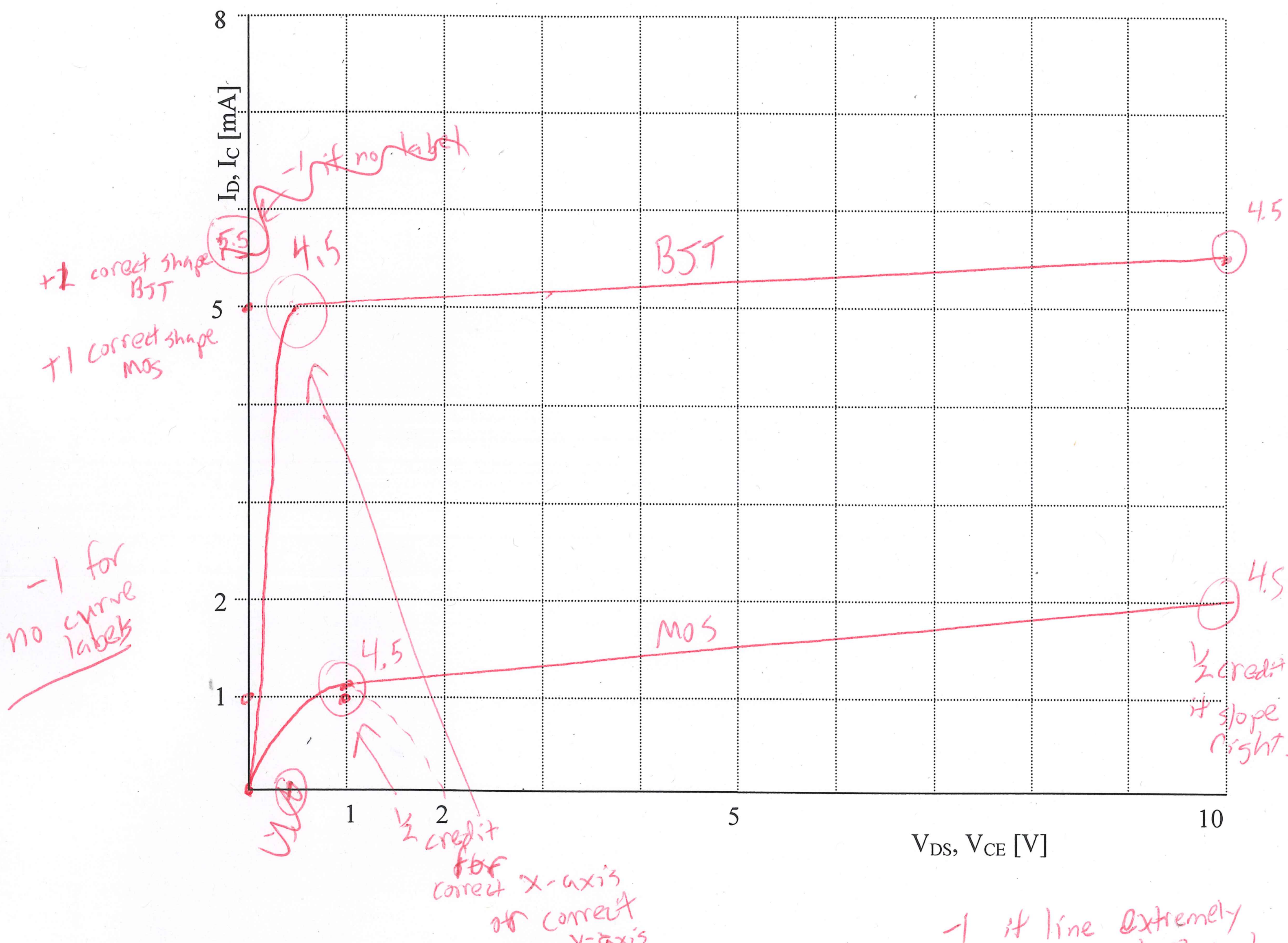
10:16

$I_D = \frac{2mA}{2V^2}(V_{GS}-0.5)^2 = 1mA$

B) on the same plot, plot the collector current of an NPN bipolar transistor at room temperature with V_A=100V , I_S=5x10^{-13} A, V_{BE}=0.6V, and $V_{CE,sat}$=0.5V, for V_{CE}=0 to 10V.

$I_C = 5\times10^{-3}$

I labeled the axes for you.



Note: everyone knows roughly what these curves look like. You get points for showing me that you know *exactly* what it looks like. Be neat!

10:19 done.