University of New Mexico

Department of Electrical and Computer Engineering

ECE 321 – Electronics I (Fall 2009) Exam 1

Name: _____ Date: Sept. 25, 2009

Note: Only calculator, pencils, and pens are allowed.

1. (10 points) True or false:

(a) In a PMOS, the potential of Drain is higher than the potential of Source. ( )

(b) The width of depletion region in a PN junction increases, by increasing the applied reverse bias voltage. ( )

(c) The minority carriers in a semiconductor doped with acceptor atoms are electrons. ( )

(d) The change of drain current in saturation region due to V_{DS} change (i.e. factor of $(1+\lambda V_{DS})$) is called "body effect". ( )

(e) The threshold voltage of an NMOS is normally negative. ( )

2. (10 points) Draw the logic gate implementation for the Boolean function $F=\overline{A(B+C)}$.

3. (20 points) Determine the width of the depletion region and the junction capacitance of a PN^+ junction when it is connected to a 1V reverse bias potential. The doping concentration of P and N+ are $N_A=10^{15}$ cm^{-3} and $N_D=10^{19}$ cm^{-3}, respectively, and the junction area is 0.25μmx0.25μm. The relative permittivity of silicon is 11.9, V_{th}=25.9 mV at 300ºK, $n_i=1.45x10^{10}$ cm^{-3} at 300ºK, and $\varepsilon_0=8.854x10^{-14}$ F/cm.

Hint: You may use the following equations:

$$V_{bi} = V_{th} Ln\left(\frac{N_A \cdot N_D}{n_i^2}\right) \qquad W = \sqrt{\frac{2\varepsilon_{si}}{q}\frac{N_A + N_D}{N_A \cdot N_D}\left(V_{bi} - V_D\right)}$$

4. (20 points) The following figure is cross sectional view of an MOS device.

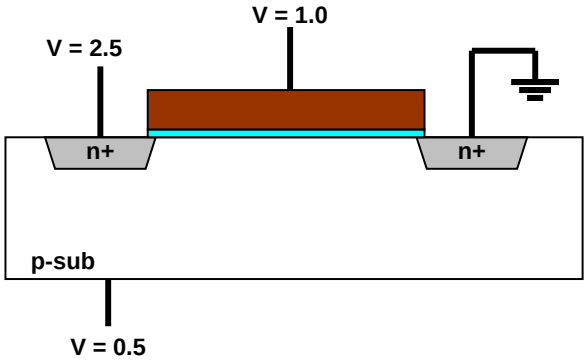
(a) What type is this device (NMOS or PMOS)?

(b) Considering the potential of each terminal in this figure, determine Source, Drain, Gate, and Substrate terminals and label them on the diagram.

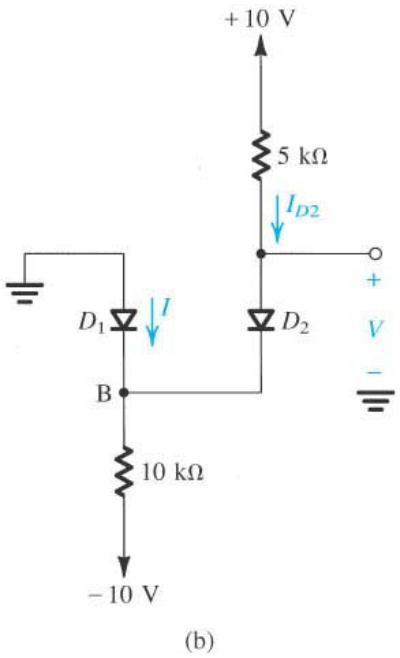
(c) Assuming that $|V_T| = 0.5$ v. Find the region of operation of the device. Ignore body effect.

(d) Determine drain current if $|K'| = 100\ \mu A/v^2$, $(W/L) = 10$, and $|\lambda| = 0.1\ v^{-1}$.

(f) Draw ***depletion region*** and the ***channel*** on the diagram. What is the potential ***across the channel*** in this device?



5. (20 points) Calculate the currents I and I_{D2}, and the voltage V in this diode circuit. Assume that the forward bias diode voltage is 0.7 V. Specify the whether D_1 and D_2 are in forward bias or reverse bias.



(b)

6. (20 points) The following circuit is called “current mirror”. Assume that the physical parameters of M_2 is the same as M_1, except that M_2 is N times larger than M_1 (i.e. $(W/L)_2=N*(W/L)_1$)

(a) Determine the region of operation for M_1.

(b) Based on your answer to part (a), find V_x as a function of K'_n, I_{Ref}, V_T, $(W/L)_1$.

(c) Assume that R_L is chosen such that M_2 is in saturation region. Find I_L as a function of V_x, then use your V_x equation form part (b) to simplify the result.

(d) Determine the range of R_L that guarantees saturation region for M_2.