U.C Berkeley

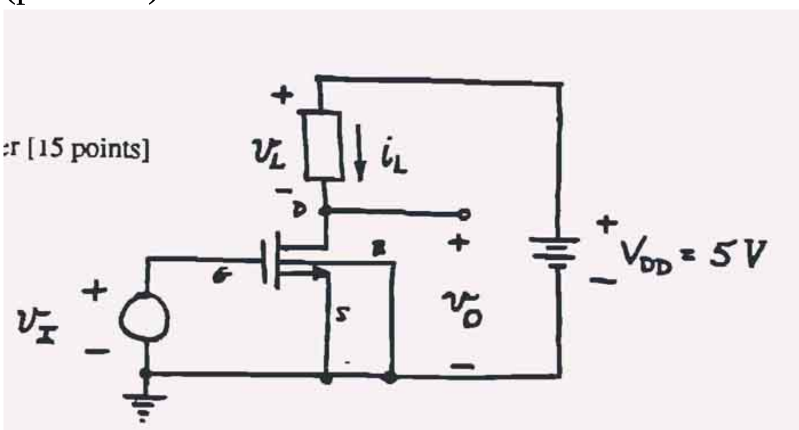
EECS 140 Midterm 1: October 8, 1990 Fall 1990
Professor R.T. Howe

Ground Rules:

Closed Book and Notes
Do all work on exam pages
You have 50 minutes; use your time wisely

QUESTION 1.
MOS Inverter [15 points]

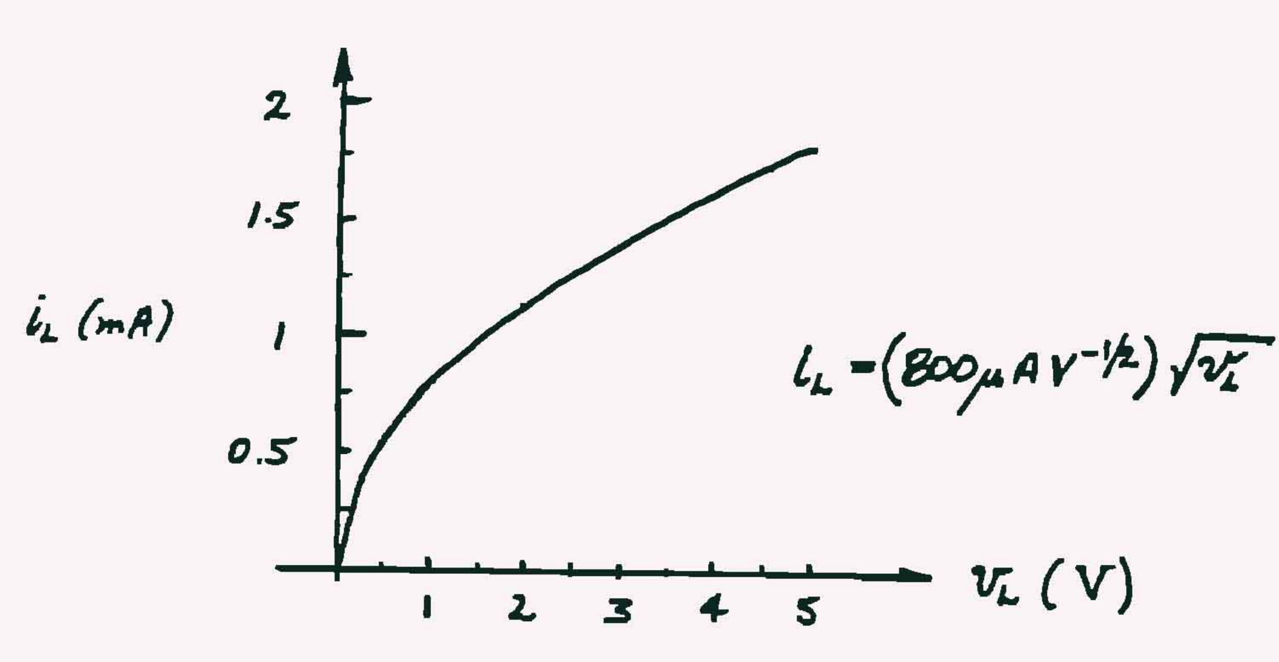
(picture 1)



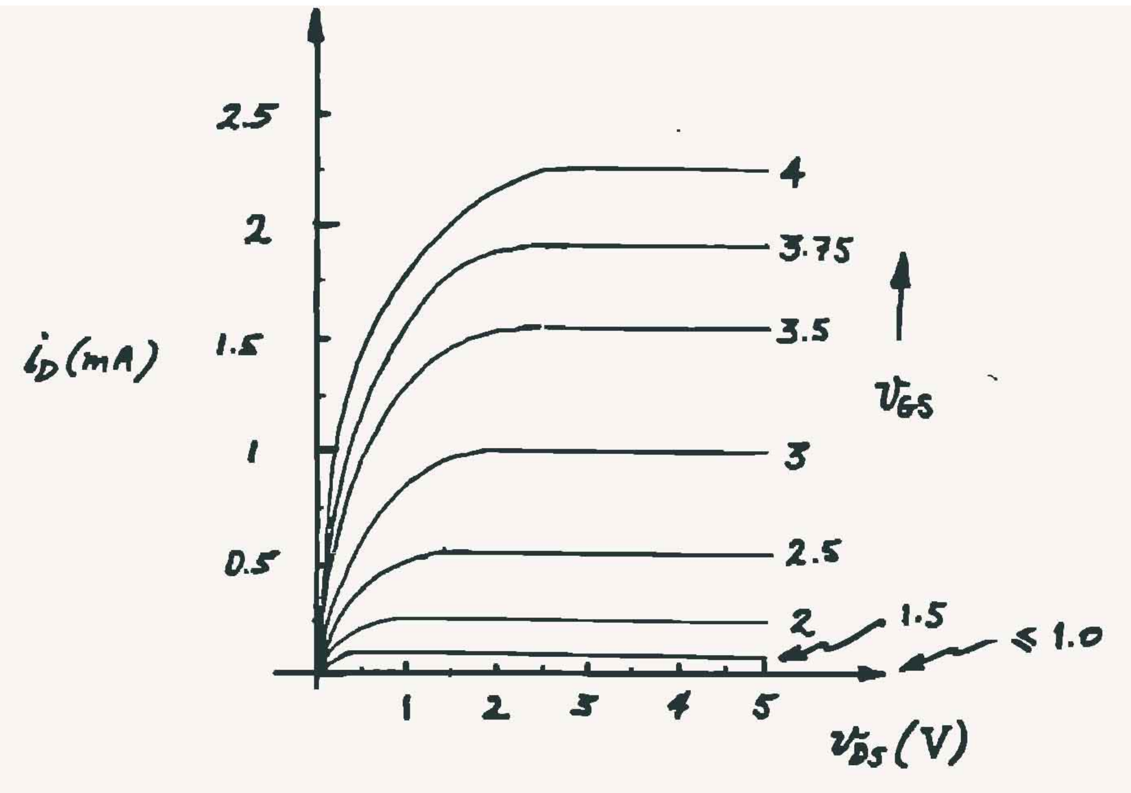
Non-linear i_L versus v_l characteristics of load device.

$i_L = k_L$* squareroot (v_L) where k_L = 800 micro * A * V $^{-1/2}$

(picture 2)



Output characteristics of the MOSFET. The constant mu sub n * C_{ox} (W / L) = 500 micro * A * V $^{-1/2}$

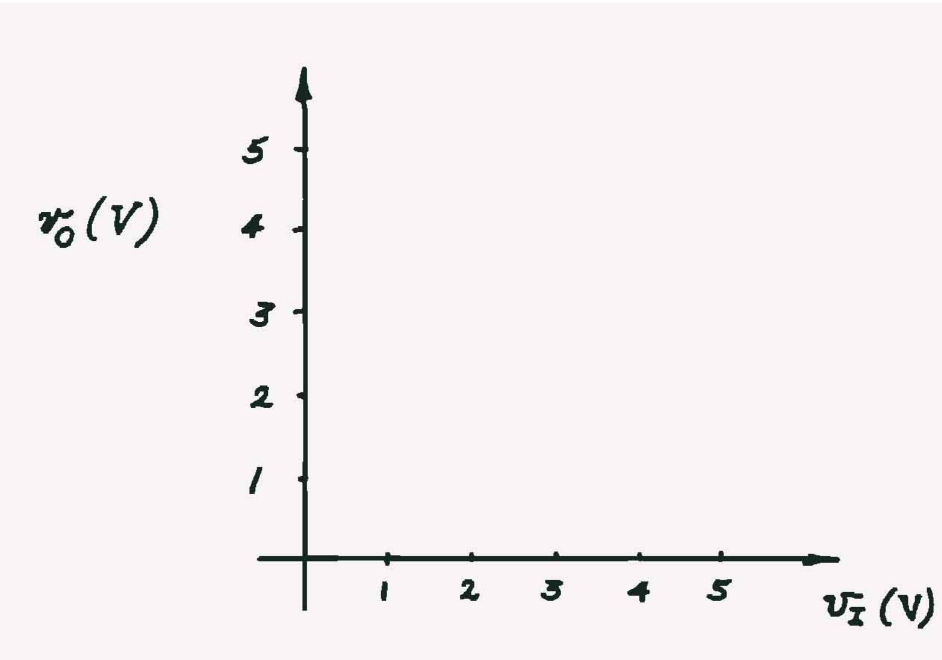


a.) [5 points] Find an equation relating v_o to v_I which is valid when the MOSFET is in the triode region.

b.) [5 points] Find an equation relating v_o to v_I which is valid when the MOSFET is saturated.

c.) [5 points] Using the graphical load line technique, plot the transfer curve v_o versus v_I on the graph below, using the given current-voltage characteristics of the MOSFET. Label on your plot the points on the transfer curve which mark the boundaries between the cutoff, saturation, and triode regions of operation.

picture 4

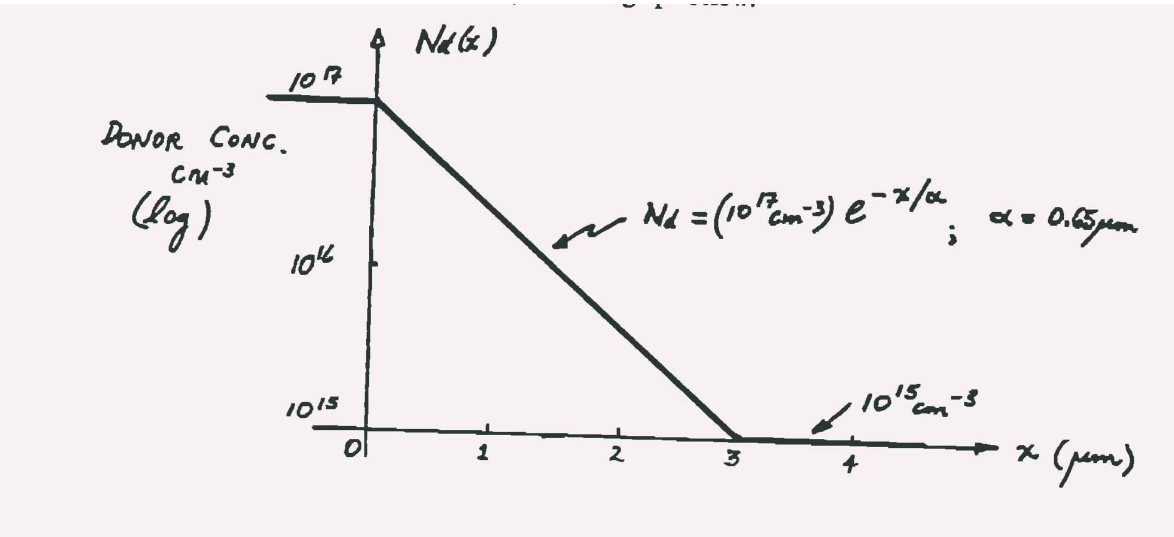


QUESTION 2 [17 points]

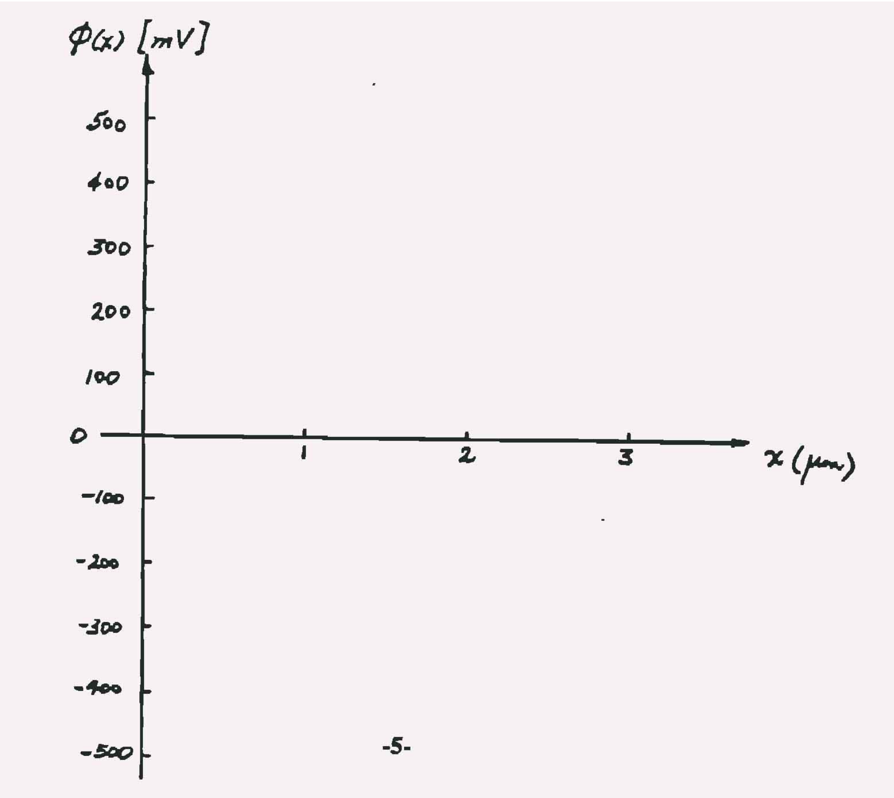
Potential in Thermal Equilibrium

a.) 6 points Consider an n-type sample with the donor concentration varying as shown in the *log-linear* plot below. In thermal equilibrium, plot the variation in potential phi (x) for $0 < x < 3$ micro metres on the plot below.

picture 5

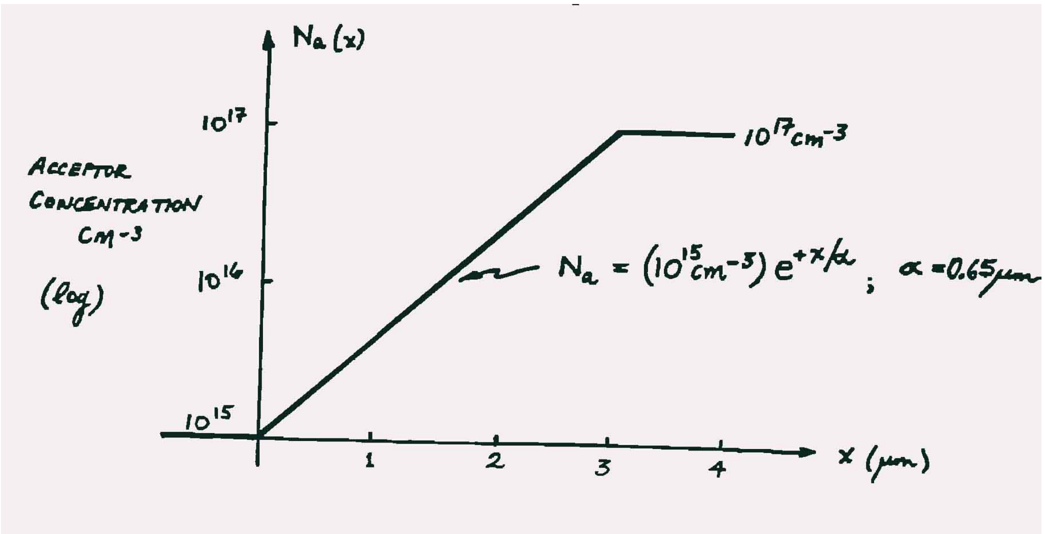


picture 6

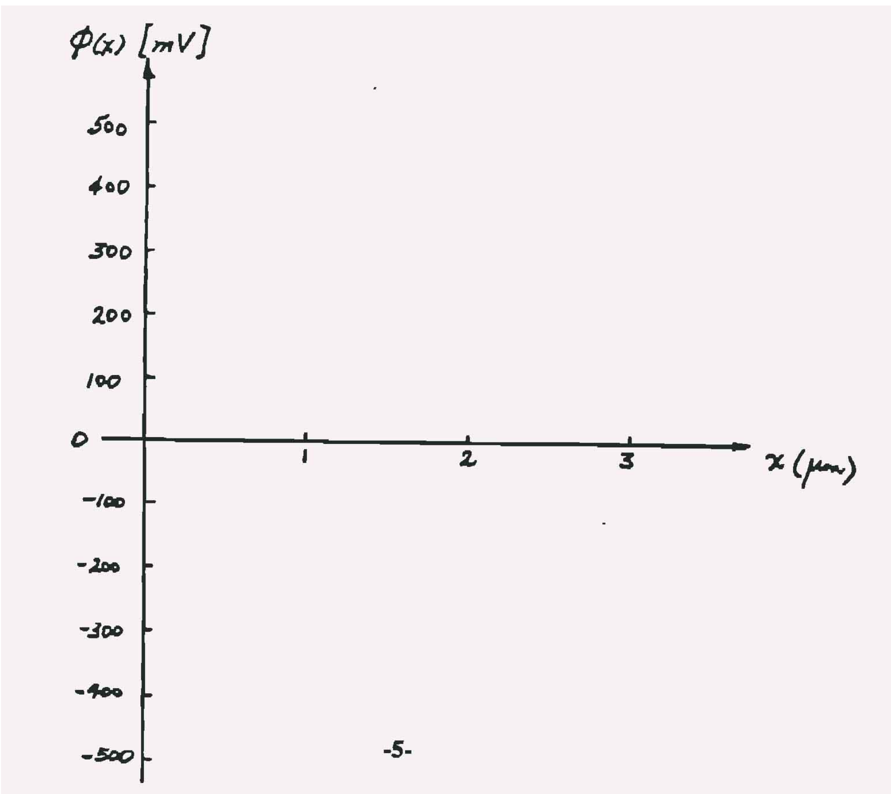


b.) [6 points]
Consider a p-type sample with the acceptor concentration varying as shown in the *log-linear* plot below. In thermal equilibrium, plot the variation in potential phi (x) for 0 < x < 3 micro metres on the plot below.

picture 7



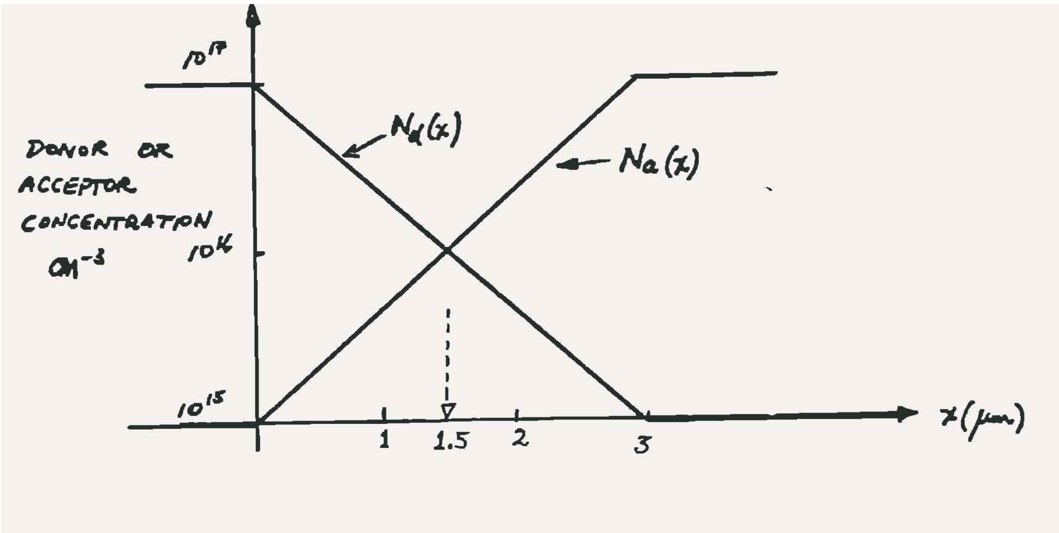
picture 6



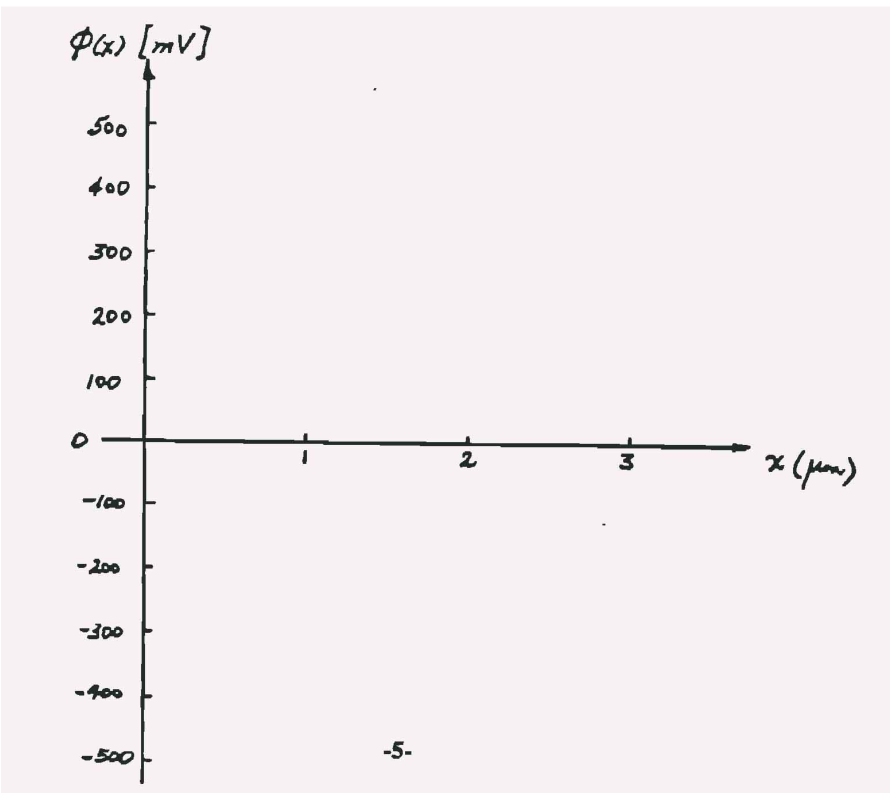
c.) [5 points]

Consider a sample which is doped with the superposition of the donor and acceptor concentrations from part a and part b, as shown in the *log-linear* plot below. In thermal equilibrium, *sketch* the variation potential phi (x) for 0 < x < 3 micro metres on the plot below. *Hint:* the width of the deletion region is 1 micro meter

picture 7



picture 5



QUESTION 3 [18 POINTS]
pn junction diode

Given : pn junction diode with cross sectional area of $10 * 10^{-6}$ cm ^{2}

p side doping:

$N_a = 2 * 10^{16}$ cm $^{-3}$

$N_d = 0$

n side doping:

$N_a = 1 * 10^{16}$ cm $^{-3}$

$N_d = 0$

minority carrier properties:

$D_n = 25$ cm ^{2}s^{-1}

Tau_n = 400 ns = .4 micro seconds

$D_p = 25$ cm ^{2}s^{-1}

Tau_n = 10 microseconds (translators note: Yes the exam redefines tau???)

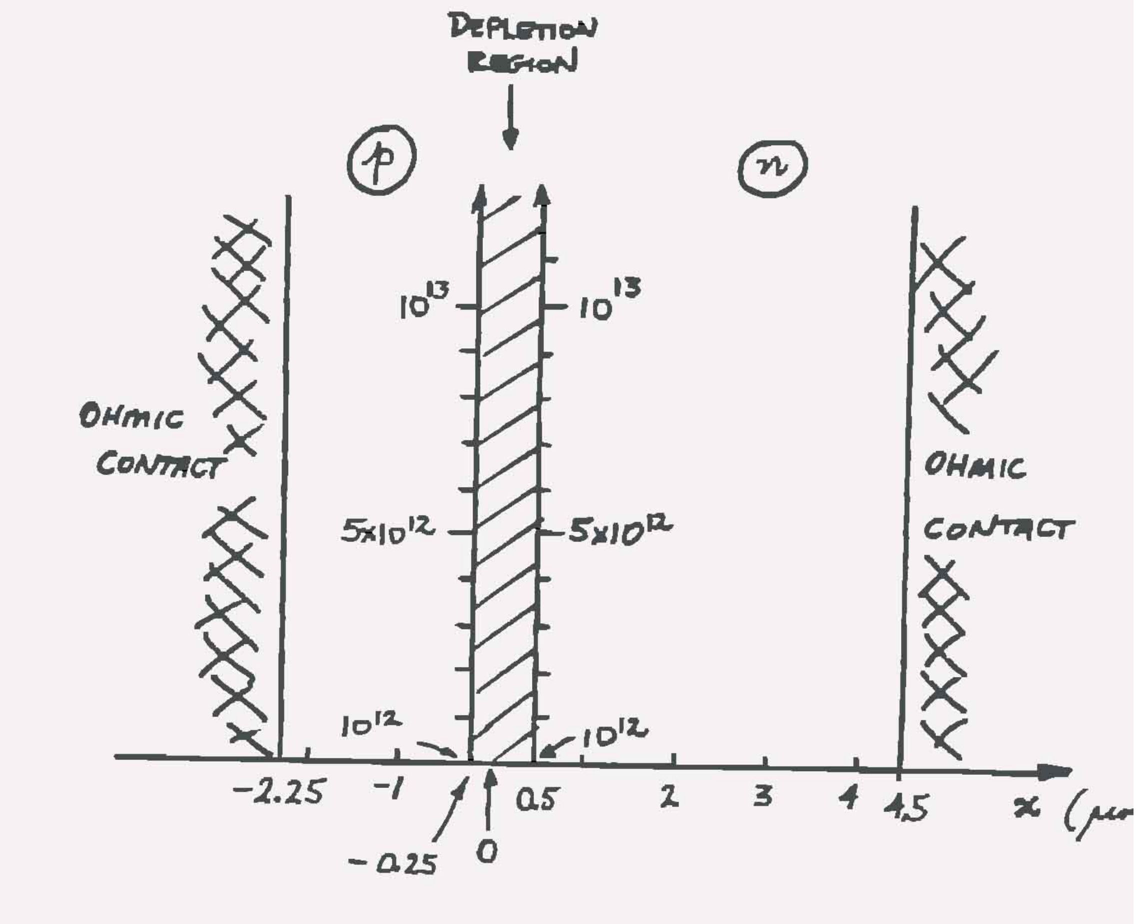
miscellaneous

kT/q = 26mV

$n_i = 1 * 10^{10}$ cm $^{-3}$

a.) [7 points] Plot the minority carrier concentrations on the *linear* graphs below for the case of forward bias
$V_D = 0.6$ V

picture 8



b.) [7 points] Find the numerical value of the saturation current I_S for this diode. Note: the saturation current is defined in the diode characteristic

$$\mathbf{I_D = I_S (e^{qVsubp / kT} - 1)}.$$

c.) [4 points]
Find the numerical value of the small signal registor r_d for a bias voltage V_D = 0.6 V. If you couldn't solve part (b), assume that $I_S = 10^{-15}$ A.