University of California
College of Engineering
Department of Electrical Engineering
and Computer Sciences

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TuTh 2-3:30

Thursday, September 28, 6:30-8:00pm

EECS 105: FALL 06 — MIDTERM 1

NAME	Last First

SID	

Problem 1 (8):

Problem 2 (12):

Problem 3 (10):

Total (30)	

PROBLEM 1: Circuit Analysis (8 pts)

In the lab of EE105, you are given a special device "X", shown in the Figure 1a to analyze large and small signal behavior. Your measurements reveal that the device has the I-V relationship of Figure 1b, which can be expressed as $I = -(V\text{-a})^2 + \text{a}^2$ with a = 1 (for $0 \le V \le 2$).

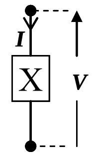


figure 1a

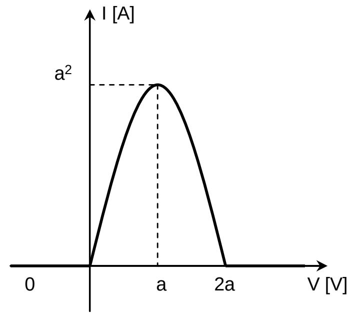
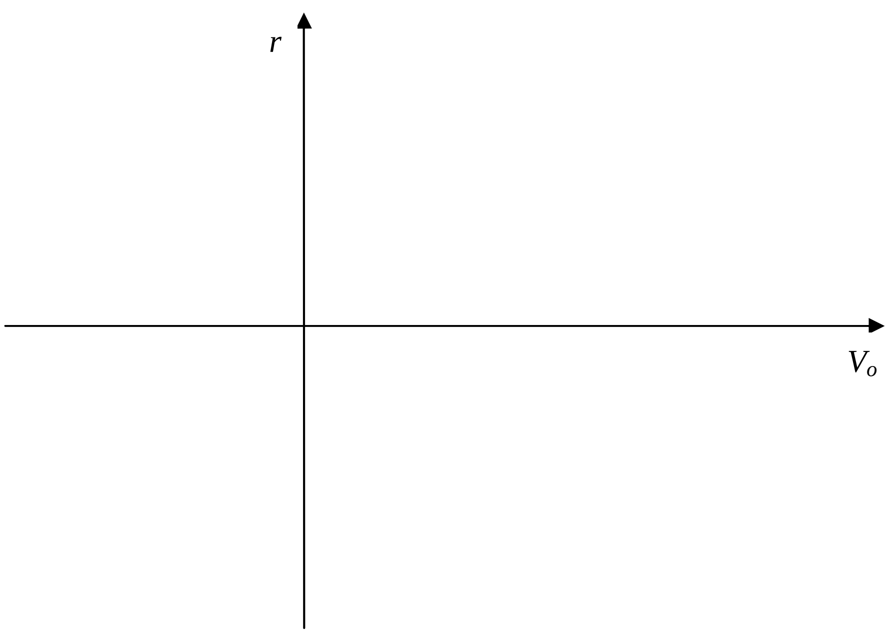


figure 1b

a. Determine the current I_o for $V = V_o$=0.5V. (**1 pt)**

I_o =

b. Draw the small signal resistance r vs V_o. Note that I = 0[A] outside the region 0[V] ≤ V_o ≤ 2a[V]. **(2 pt)**



c. Now you slightly change the voltage from the bias point established in (a), increasing it with $\Delta v = +0.1$V. **Using the results from (b)**, determine the current change Δi. **(2pt)**

Δi =

d. We now hook up X between the reference voltage $VDD = 2$[V], and an input current source $I_{in} = I_o + 0.1 \sin(2\pi 1000t)$ as shown in Figure 2 (with I_o as computed in **a**). Draw V_{out} as a function of time. **(3 pt)**

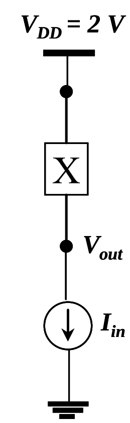
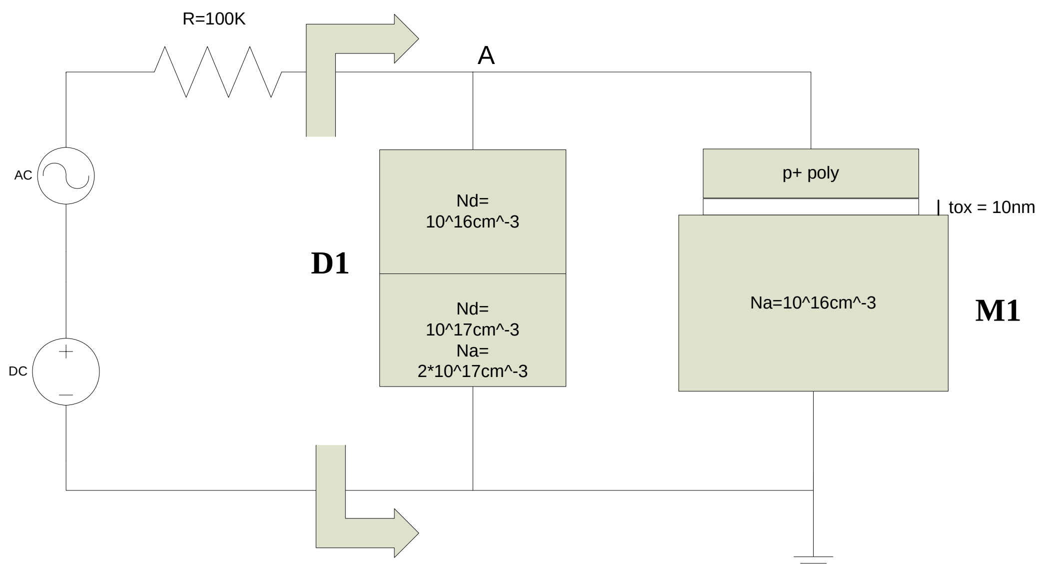


Figure 2

PROBLEM 2: Diode (12 pts)

Consider the circuit picture in the Figure below. For this problem, you may assume the following values: $\varepsilon_s = 1.035\ 10^{-12}$ F cm^{-1}; ε_{ox} = 3.45 10-13 F cm^{-1}. Contact potentials should be ignored throughout this question. Also, D1 and M1 are identical in area.



a. The pn-diode D1 has the following doping profile:

p-type material:

$Na = 2*10^{17}$ cm^{-3}

$Nd = 1*10^{17}$ cm^{-3}

n-type material:

$Nd=10^{16}$ cm^{-3}

Determine the depletion capacitance per unit area of D1 in thermal equilibrium. **(2 pts)**

***C_0* =**

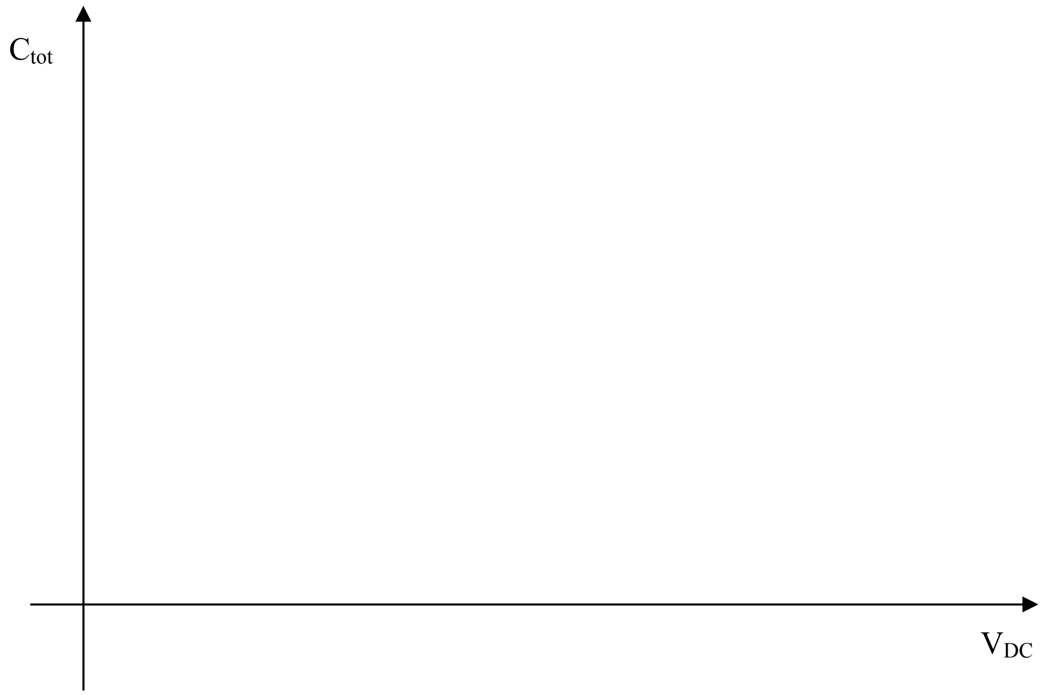
b. The second component M1 is a MOSCAP with the following characteristics: Gate = p+ material with ϕ_{p+} = -550 mV; tox = 10 nm; substrate is doped with Na = 10^{16} cm^{-3}; and $\mathbf{V_T}$ **= 1.05V**. Determine the flatband voltage V_{FB} of M1. **(2pts)**

$\mathbf{V_{FB}}$ **=**

c. Determine the minimum and maximum small signal capacitance per unit area of M1. **(3 pts)**

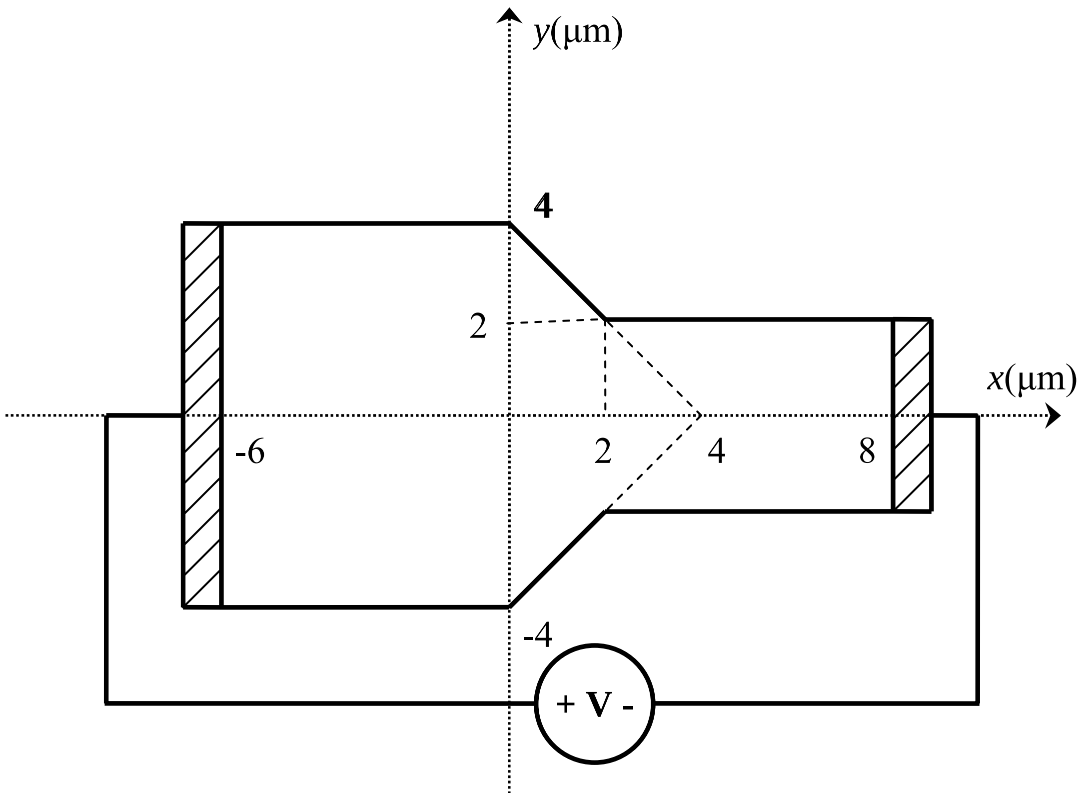
Cmin =
Cmax =

d. Plot the total small signal capacitance per unit area as seen between node A and the ground (as indicated by the arrows in the Figure) when sweeping the bias voltage V_{DC} between 0 and 5 V. Your plot should show the individual components and should include numerical values for the important breakpoints in the graphs. **(5 pts)**



PROBLEM 3: Semiconductor Physics (10 pts)

Given an ion-implanted silicon region with dimension as shown in figure below. The arsenic dose implanted per unit area equals $Q_d = 10^{13}\text{cm}^{-2}$, and the post-anneal thickness $t = 1\mu\text{m}$. You may ignore the contact potential effect and assume room temperature. Also use Figure 2.8 in the text book to derive mobilities.



(a) Compute the doping concentration N_d, and the carrier concentrations n_0 and p_0 under thermal equilibrium. (2 pts)

N_d =
n_0 =
p_0 =

(b) Viewing the silicon as three regions (-6 to 0, 0 to 2, and 2 to 8 μm), compute the resistance of each region as well as the total resistance of the strip. **(4 pts)**

R1 **=**
R2 **=**
R3 **=**
Rtot **=**

(c) If $V = 2$V, compute the electric field and sketch it. You may ignore the variation effect along the y-axis. (**4 pts)**