University of California at Berkeley
College of Engineering
Dept. of Electrical Engineering and Computer Sciences

EECS 40 Midterm II

Spring 2001 Prof. Roger T. Howe April 11, 2001

Name: ______________________ Student ID _____________

Last, First

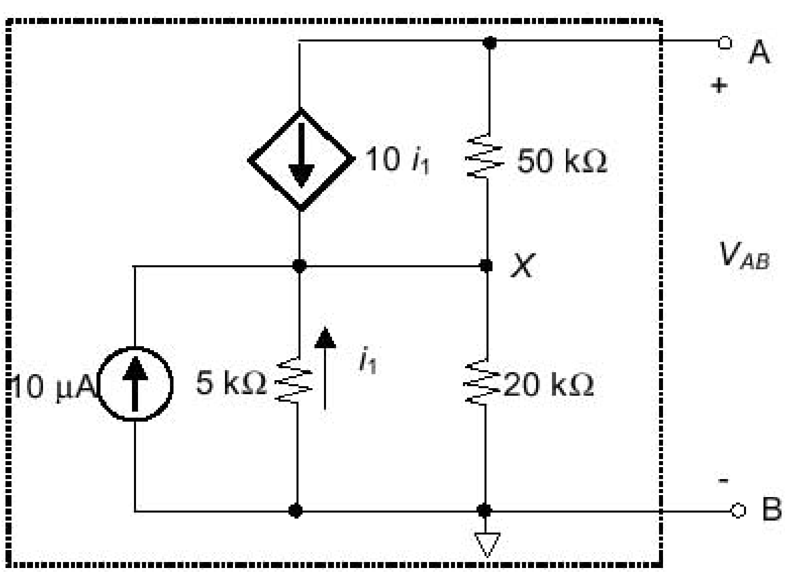
Guidelines

1. Closed book and notes; one 8.5” x 11” page (both sides) of your own notes is allowed.
2. You may use a calculator.
3. Do not unstaple the exam.
4. Show all your work and reasoning on the exam in order to receive full or partial credit.

Score

Problem	Points Possible	Score
1	18	
2	18	
3	14	
Total	50	

1. Equivalent circuits [18 points]



(a) [4 pts.] Using Kirchhoff's Current Law (KCL) at node X, find an equation relating the current i1 and the voltage Vab. *Write your answer in the box.*

Answer to 1 (a): [ ]

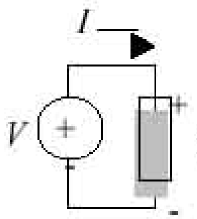
(b) [5 pts.] Find the numerical value of the Thevenin voltage across terminals A and B (A positive) for this circuit. Your answer to part (a) should be helpful; write your answer in the box provided.

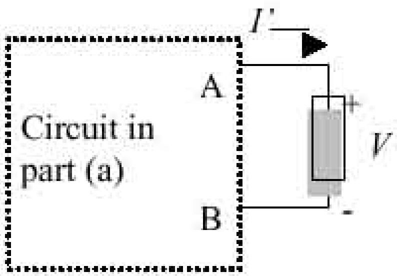
Answer to 1 (b): Vth = V

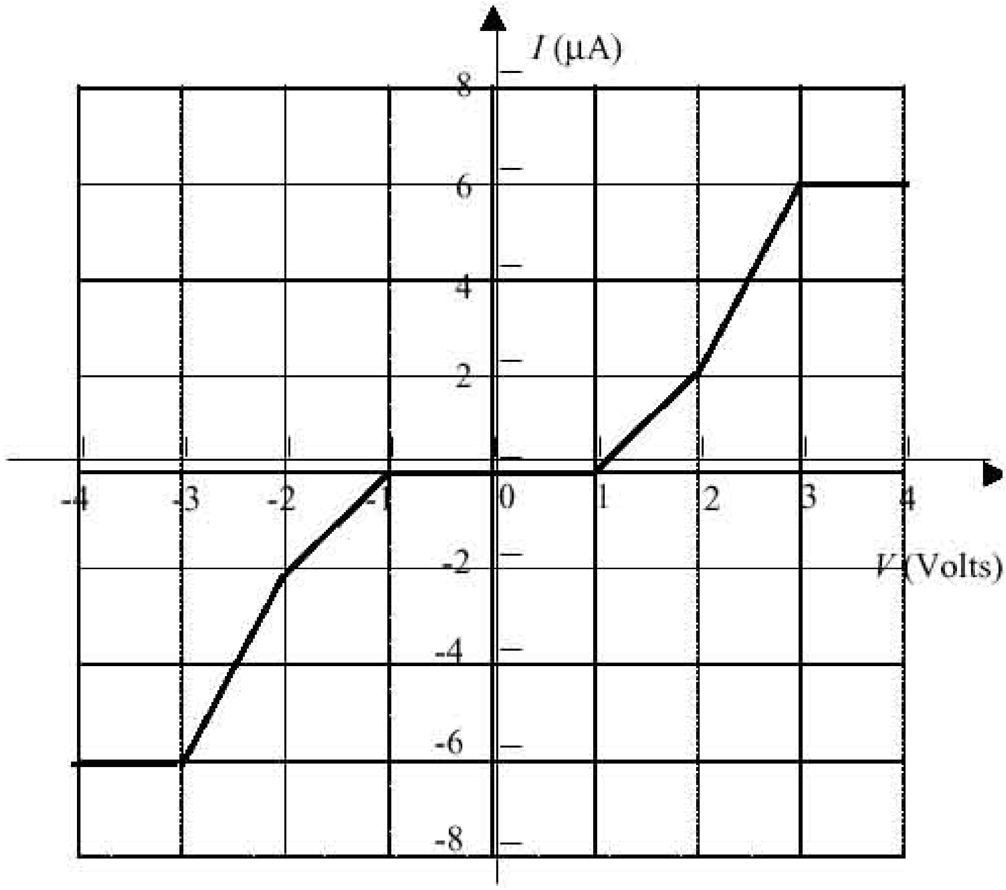
(c) [5 pts.] Find the numerical value of the Thevenin resistance RTH in kW across terminals A and B. Write your answer in the box provided.

Answer to 1 (c): Rth = kW

(d) [4 pts.] We next connect a new type of two-terminal circuit element across terminals A and B. The current-voltage characteristics of this element are plotted on the graph. Find the numerical value of the current I' and the voltage V' by using the graph below and write your answers in the box provided. If you couldn't solve parts (b) and (c) or your answers appear to be "out of bounds," you can use VTH = -2.5 V and RTH = 200 kW here.

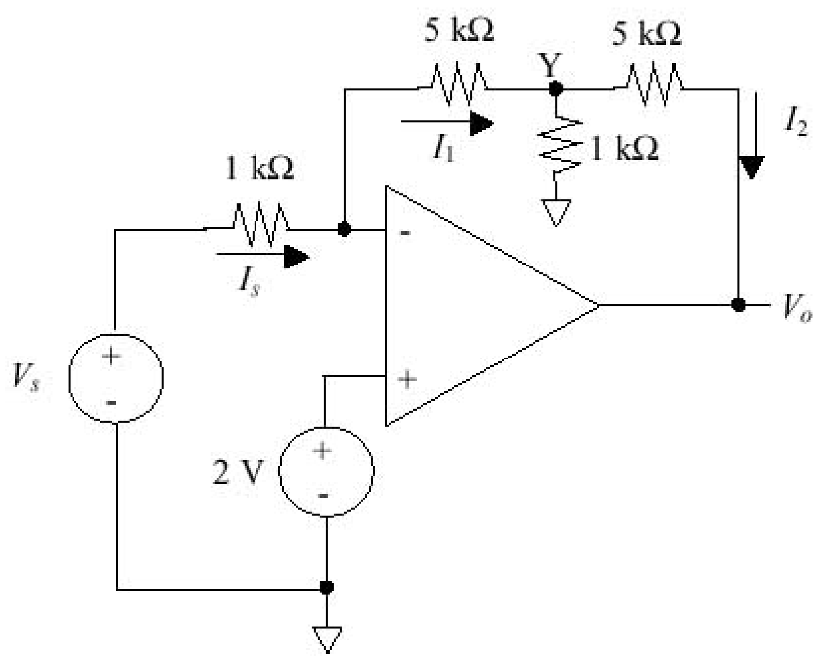






Answer to 1 (d):	I' = mA	V' = V

2. Op Amp Circuit [18 points]



(a) [3 pts.] Assuming that the op amp is operating in negative feedback as a high-gain differential amplifier, find an expression for Is as a function of Vs.

Answer to 2 (a):

(b) [3 pts.] Assuming that the op amp is operating in negative feedback as a high-gain differential amplifier, find an expression for I1 as a function of Vs.

Answer to 2 (b):

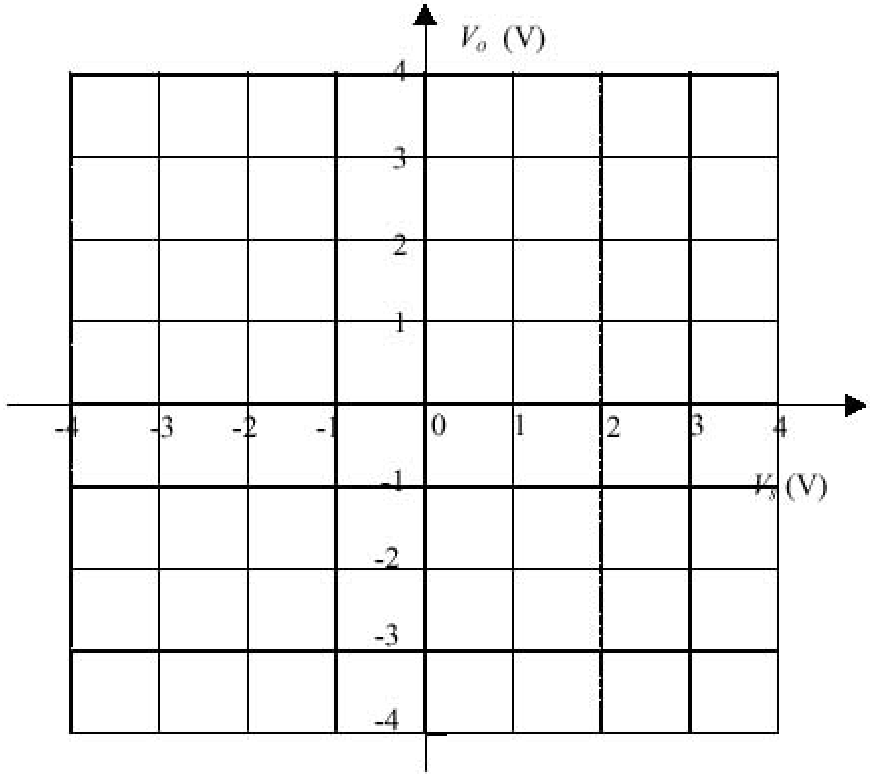
(c) [4 pts.] Assuming that the op amp is operating in negative feedback as a high-gain differential amplifier, find an expression for I2 as a function of Vs.

Answer to 2 (c):

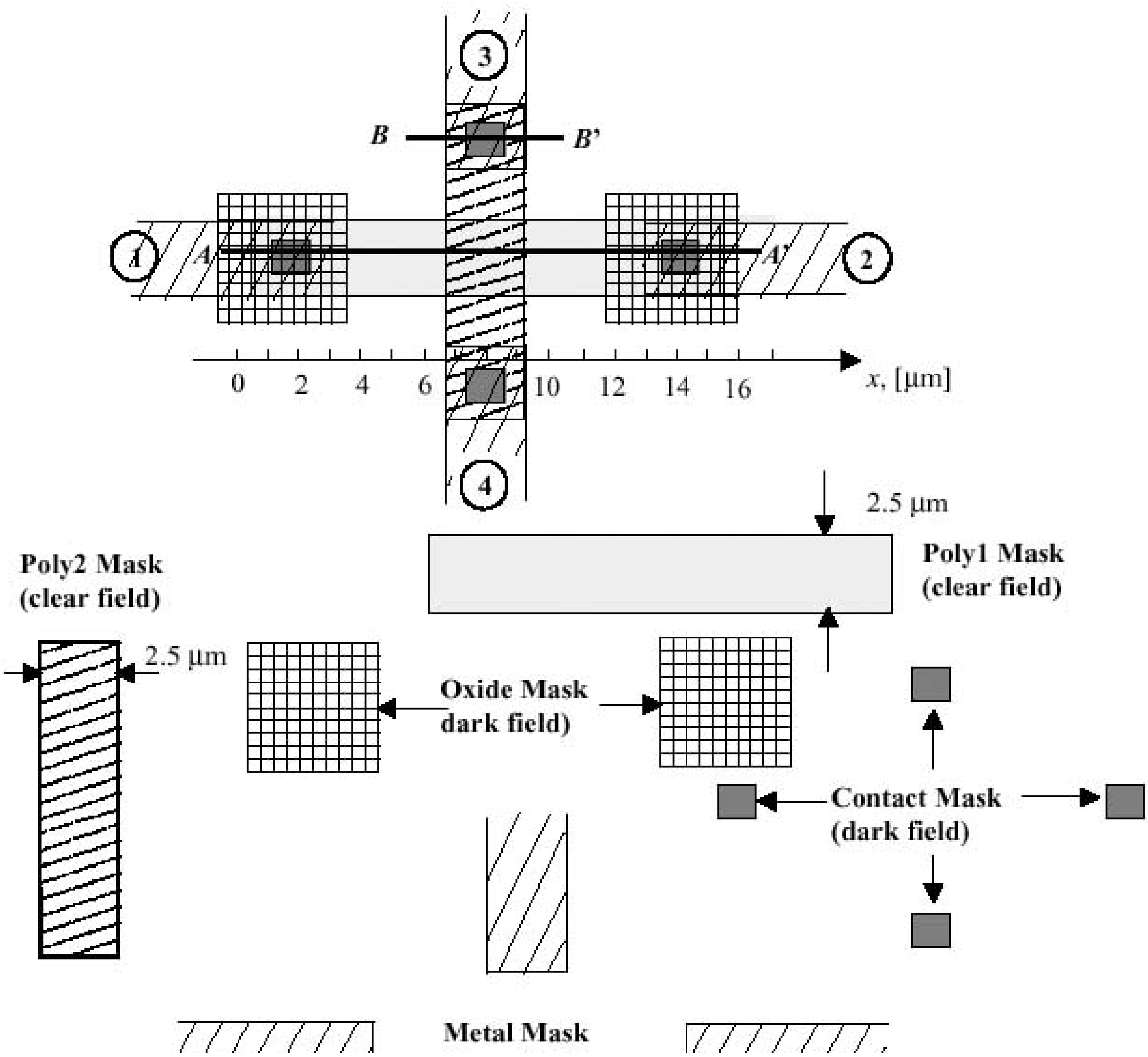
(d) [4 pts.] Assuming that the op amp is operating in negative feedback as a high-gain differential amplifier, find an expression for Vo as a function of Vs.

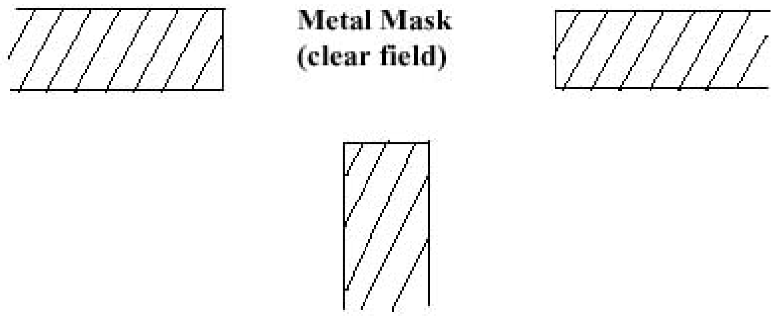
Answer to 2 (d):

(e) [4 pts.] The power supplies for the op amp are + 4 V and – 4V, implying that the output voltage Vo must satisfy -4V <= Vo <= 4V. Plot the output voltage Vo as a function of the input voltage Vs over the range -4V <= Vs <= 4V for this op amp circuit on the graph below. If you couldn't solve part (d), you can assume for this part that Vo = 3.5 Vs + 2 V, which is, of course, not the correct answer to (d).



3. IC resistor crossover [14 points]

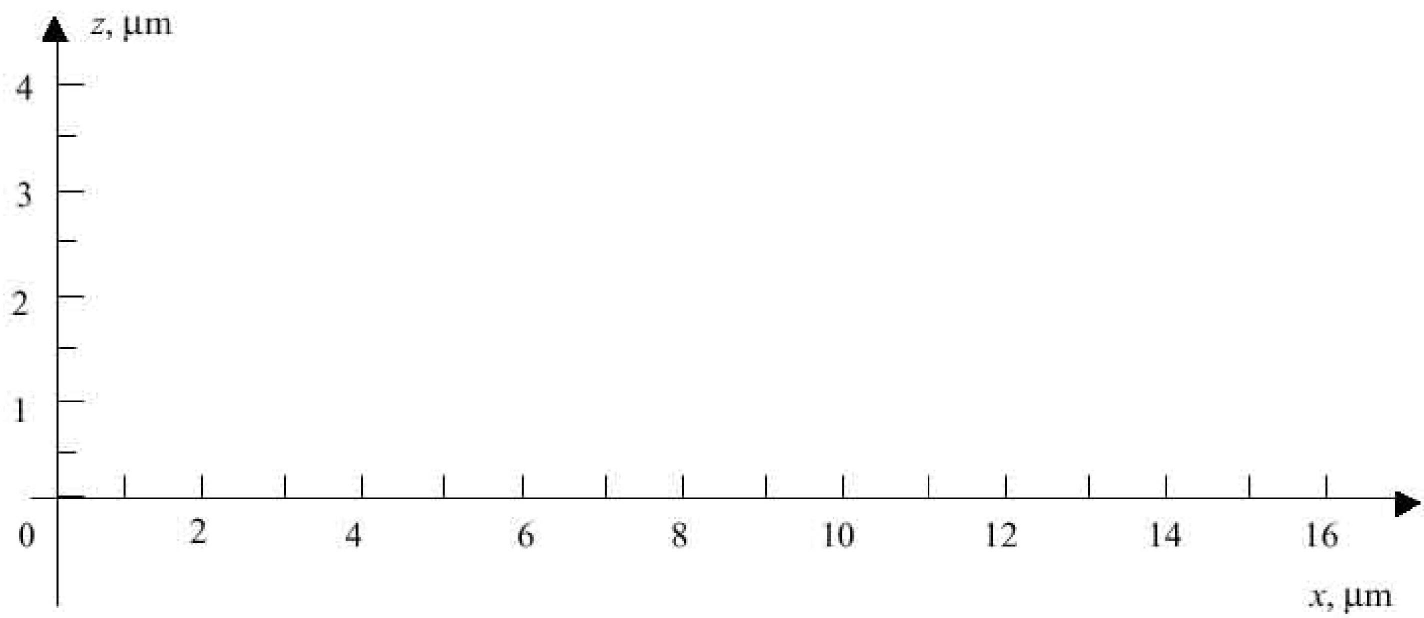




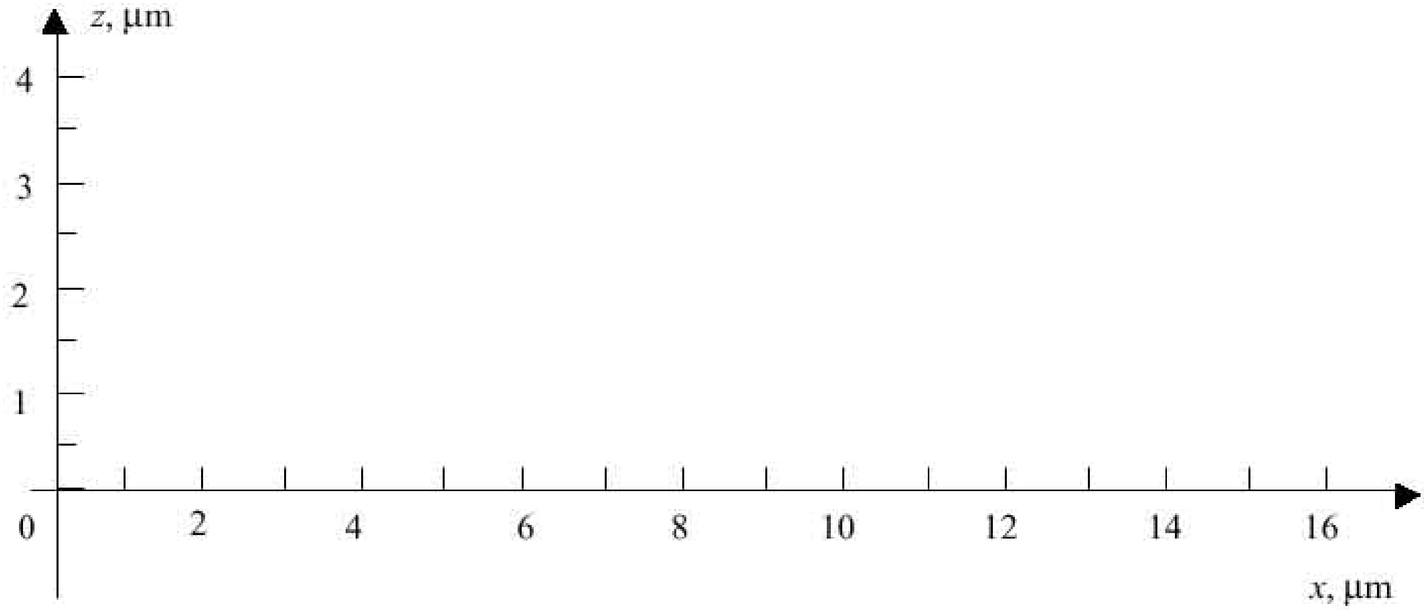
Process Sequence:

1. Starting material: n-type silicon wafer with donor concentration 10 17 cm -3 .
2. Deposit 750 nm (= 0.75 mm) of silicon dioxide on the wafer.
3. Deposit 500 nm of n-type polysilicon and pattern it with the Poly1 mask (clear field).
4. Deposit 100 nm of silicon dioxide.
5. Deposit 500 nm of n-type polysilicon and pattern it with the Poly2 mask (clear field).
6. Pattern the 100 nm-thick silicon dioxide layer from step 4 with the Oxide mask (dark field).
7. Deposit 500 nm of silicon dioxide and pattern it with the Contact mask (dark field).
8. Deposit 500 nm of aluminum and pattern with the Metal mask (clear field).

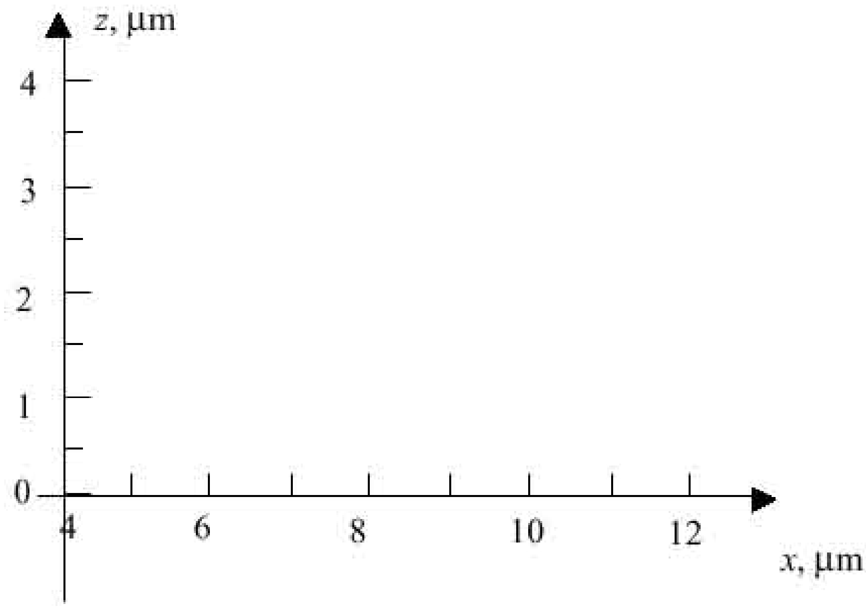
(a) [3 pts.] Sketch carefully the cross section A - A' after step 4. The silicon wafer surface is located at z = 0 on the graph. Identify all layers clearly on your sketch.



(b) [4 pts.] Sketch carefully the cross section A - A' after step 8. The silicon wafer surface is located at z = 0 on the graph. Identify all layers clearly on your sketch. z, mm



(c) [4 pts.] Sketch carefully the cross section B – B' after step 8. The silicon wafer surface is located at z = 0 on the graph. Identify all layers clearly on your sketch.



(d) [3 pts.] What is the numerical value of the capacitance between the two polysilicon layers in fF? Given: the permittivity of silicon dioxide is 3.45 x 10 -13 F/cm.