ECE 2 Midterm
(120 points maximum, there are 10 bonus points)
16 November 2020

Name: _____ID #_____

Do not communicate with anyone, by any means during the test and for 24 hours afterward except the instructor or TA (by Campuswire).
This test is open book, open note, open internet. The only restriction is on communicating with another person.
You have 2.5 hours to complete the test (including download and upload). (I expect you to start at a time shortly after 4 pm (PST) and finish at a time within 2 hours of the start time leaving enough time to upload.) The time at which you turn in the test will be recorded. Anything after 6:30 pm will be considered late and will incur a penalty unless there are extreme extenuating circumstances (which will be reviewed on a case-by-case basis).

Academic Integrity Statement –

I affirm that I have abided by the UCLA student code of conduct during the entire period of the test and submission (from 4 pm to 6:30 pm PST, Monday, 16 November). Specifically, I am affirming section 102.01a: which reads (in part): "failure to observe the expressed procedures or instructions of an academic exercise (e.g. examination instructions…) [is considered cheating]"

Signature _____

Read the question and the possible answers before attempting any calculations. Be sure to write and sign your name on the first page.

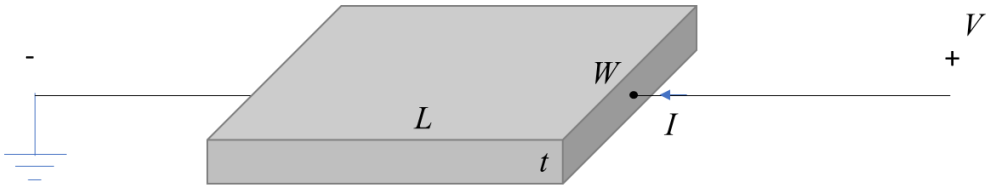
Section 1 (60 points) Multiple choice – The multiple-choice part of the exam is on CCLE in the Week 7 tab. It will open at 4 pm and stay open from 4:00 to 6:30 pm. Please be sure to submit it when you have completed it. It should take less than 1 hour. There is nothing to print out and nothing to upload. There is no partial credit (except that a few of the questions have a 2nd best answer that gets you about 25% credit). You may want to have a pad and paper and your calculator handy when you are working the problems.

Section 2 (60 points) Problems – Section 2 will be attached to this cover sheet in a PDF document and will also be found on CCLE in the Week 7 tab. My preference is that you print it out and do all of your work on the test pages. When you are finished upload it as you would upload homework. If you cannot print, work the problems on blank pages clearly indicating which part of which problem you are working. Then upload as usual.

Section 2: Problems (60 points)

Show your work. Full credit for the correct answer with work shown. Sensible answers get partial credit; answers orders of magnitude off do not. Generous partial credit for an incorrect answer with the correct ideas if clear and brief (without extraneous or irrelevant equations).

1. (30 pts) Resistance, resistivity, conductivity, current.



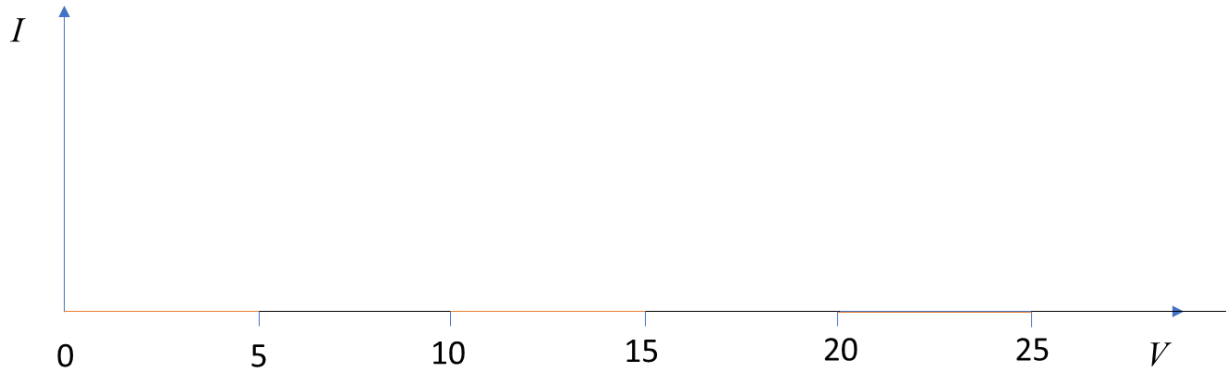
Resistor	Doping (N_d)	L (μm)	W (μm)	t(μm)
A	10^{18}	1	10	0.1
B	10^{18}	10	10	0.1

Consider semiconductor resistors at 300K with the geometry depicted above. The table lists specifications for two such resistors, "A" and "B". Assume both resistors are silicon for parts (a, b and c). Please answer the following questions for both resistors and be sure to indicate clearly which answer is for which resistor (with "A" and "B" labels).

a) (5 pt) What is the approximate resistivity?

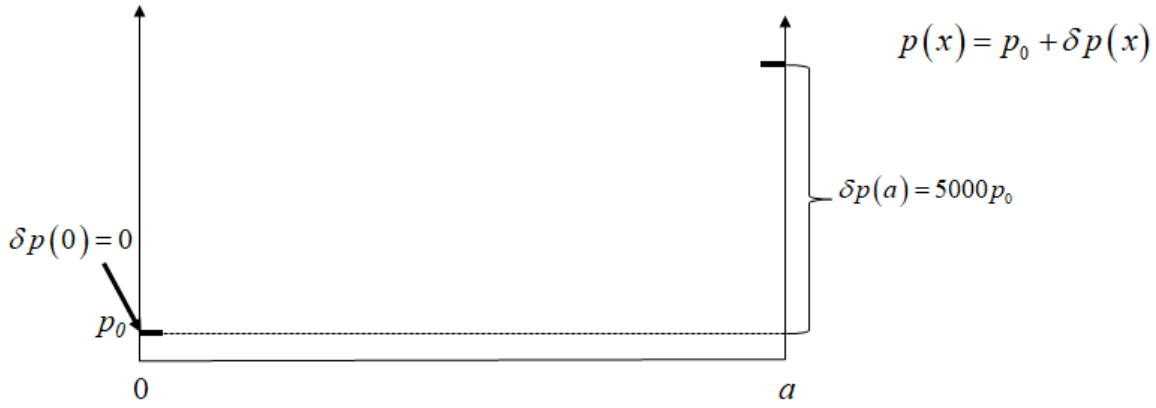
b) (10 pt) What is the resistance?

c) (15 pt) Calculate the current at 25V and plot the current and voltage for both resistors on the axes below over the full range from 0 to 25 Volts. Add a linear scale to the current axis with the correct units (don't change the voltage axis). Be sure to label the two traces "A" and "B" corresponding to the two resistors. Qualitative features over the range of voltage are important. Quantitative precision is less important.



d) (Bonus 5 pts) Suppose that resistor B were made of a different, but intrinsic semiconductor at room temperature. Is it possible for the resistance to be lower than the resistance you found in part b (Yes/No)? If not, why not. If yes, identify the semiconductor and explain.

2. (30 pts) Diffusion in long and short base diodes.
A slice of moderately doped n-type semiconductor (~ 10^{16} to 10^{17}) has the boundary conditions shown. At one end there is a steady supply of excess holes, $\delta p(a) = 5000 p_0$, and at the other end the hole concentration is at its equilibrium value, that is, $\delta p(0) = 0$.



Please sketch the excess hole concentration from x=0 to x=a for the following cases with different diffusion lengths. Please be sure to identify the three traces with the proper letter a), b) or c). (Traces *not labeled* lose about half the credit). Traces a and b do not need to be numerically precise but they must have the correct characteristics. See the details in c for the third trace. (I'm looking for qualitative details of each and relationships between the three.)

a. (5 pts) $L_p = 10a$
b. (5 pts) $L_p = a/10$

c. (10 pts) Solve for the excess holes for a third case, $L_p = 5a$ and include each of these parts: Write down the appropriate differential equation. Write down the general solution. Apply the boundary conditions and simplify $\delta p(x)$ as much as possible in terms of a (not L_p) and other given parameters. Sketch the function on the axes above and label it "c" (It does not need to be numerically precise).

(more space on the next page)

d. (10 pts) For the case you solved in part c, find the hole diffusion current as a function of x (and physical constants), $J_p(x)$. Also find the ratio of the current at the two ends $J_p(0)/J_p(a)$ (The ratio should just be a number. Also be sure $J_p(x)$ and the ratio have the proper sign).