DEPARTMENT OF ELECTRONIC ENGINEERING

N.E.D. UNIVERSITY OF ENGINEERING AND TECHNOLOGY

SOLID STATE DEVICE

BATCH 2017-18

LAB SESSION # 9, 10

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ROLL # EL-17062 SECTION: C

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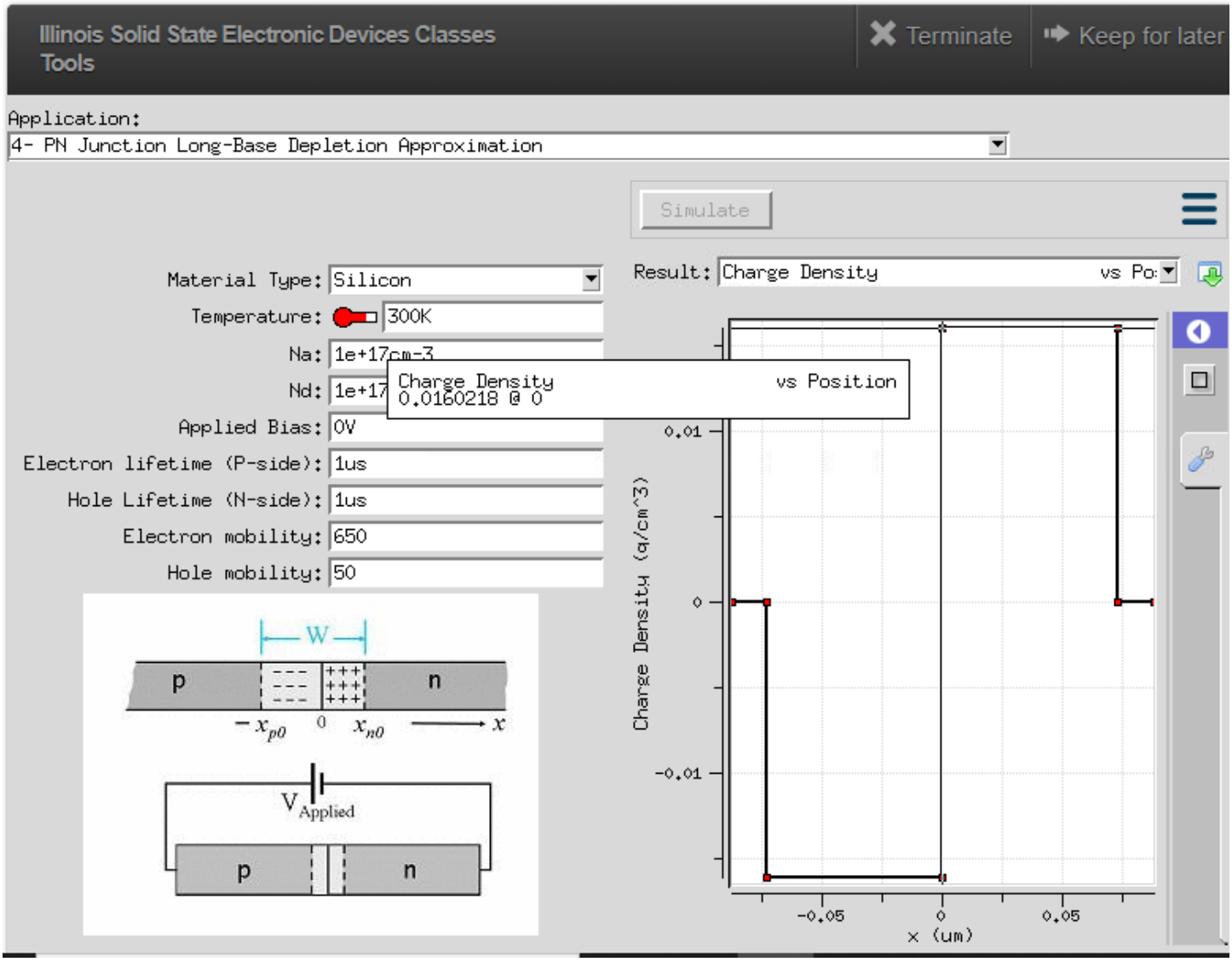
LAB # 09

Task No.01: - Consider an equally doped unbiased PN junction diode

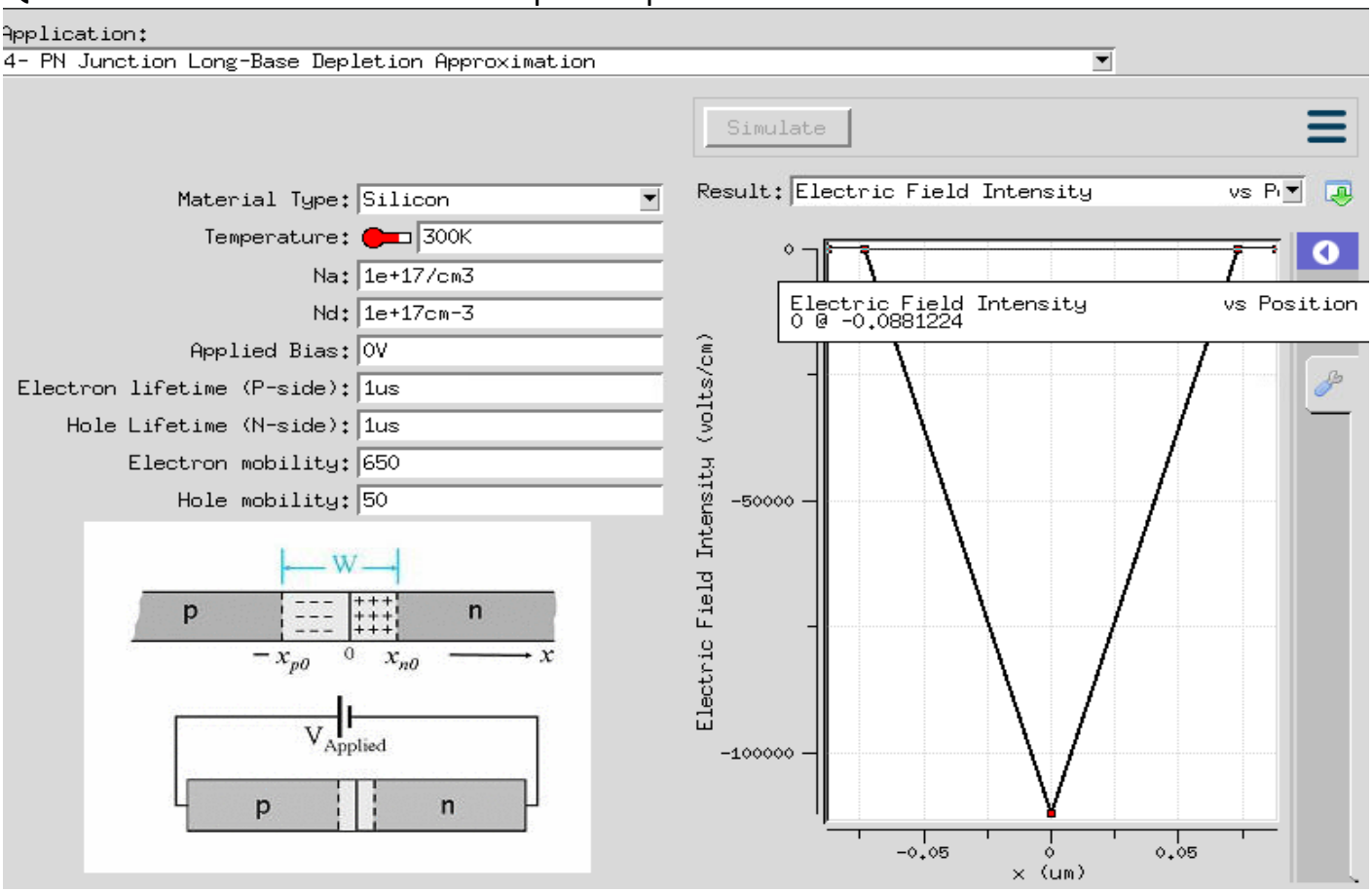
Q.1: - Observe charge density with respect to position



Q.2: - Write down the value of charge density in depletion region

Ans: 0.01602168

Q.3: - Observe electric field with respect to position

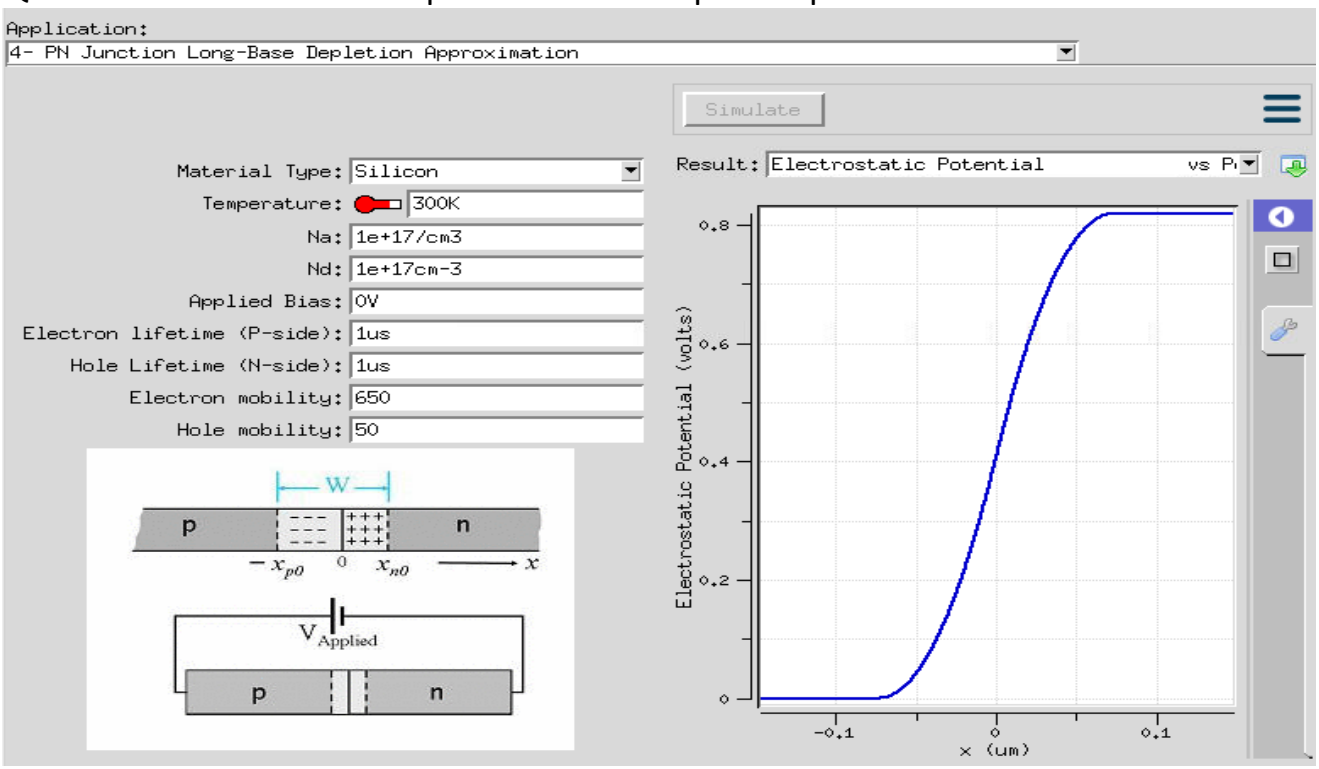


Q.4:- Maximum electric field is at -0.0881224 position.

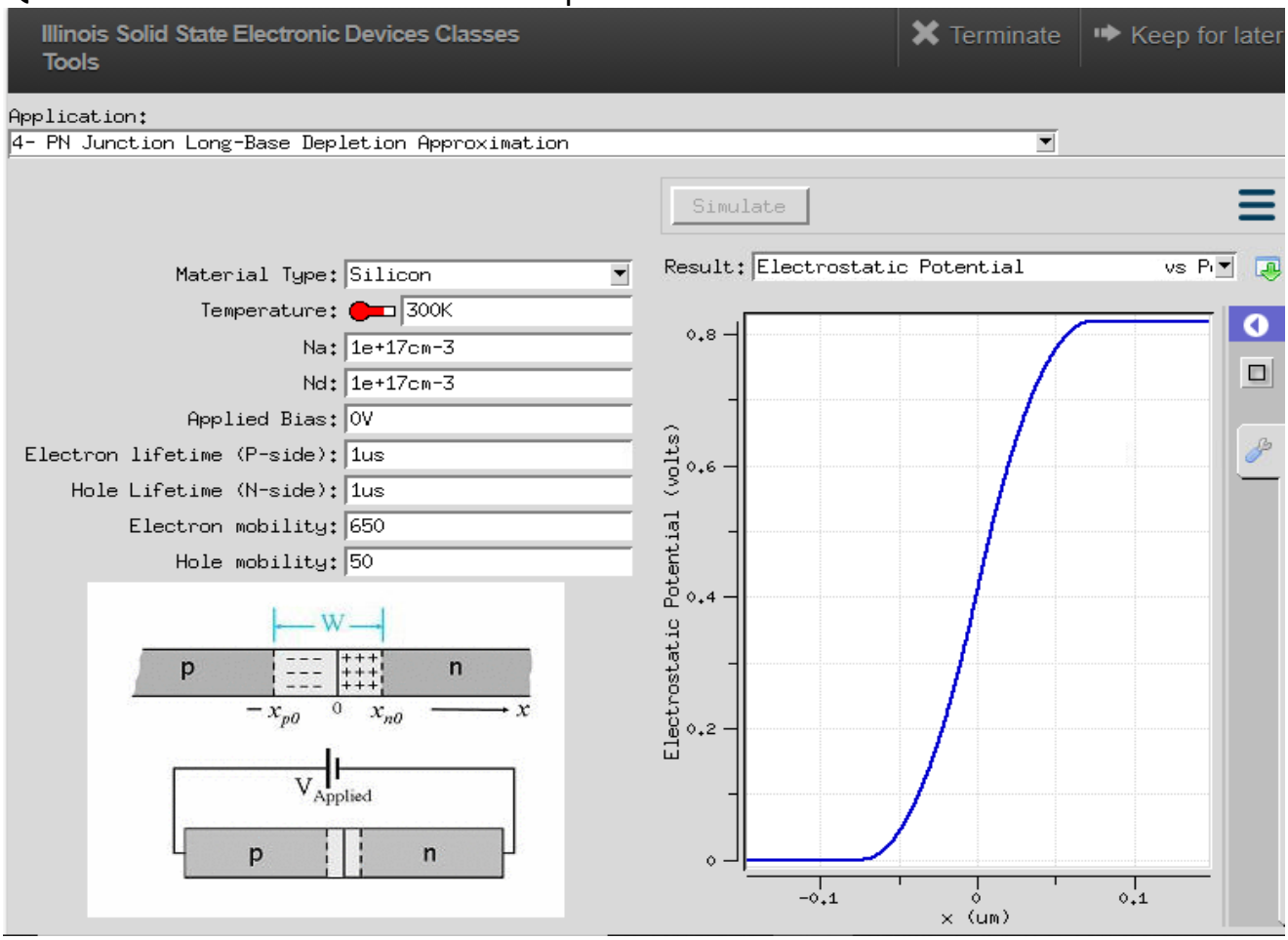
Q.5: - Write down the value of maximum electric field.

Ans: Zero is maximum electric field.

Q.6:- View the electrostatic potential with respect to position

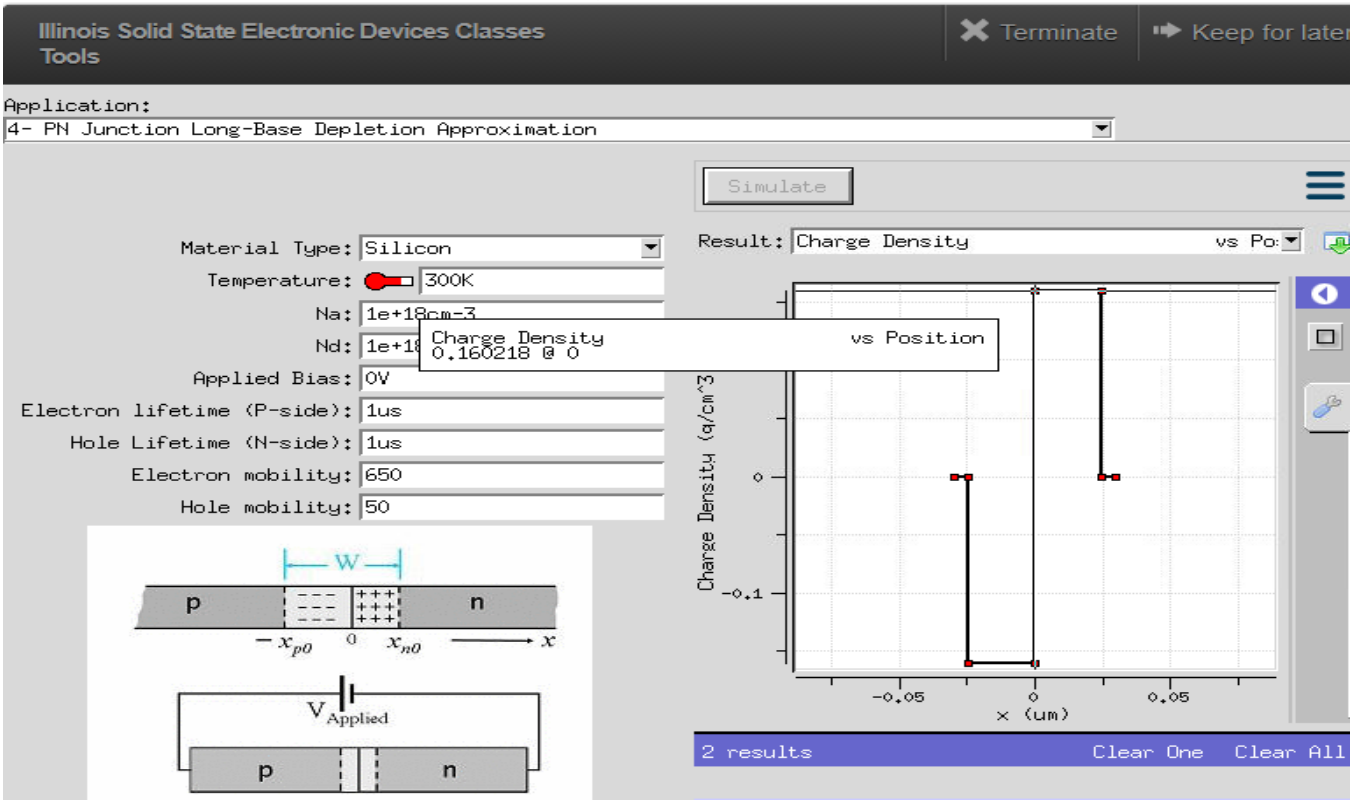


Q.7:- Write down the value of built in potential.



<u>Task No.2:</u> - Again consider an equally doped unbiased PN junction diode (but this time doping should be higher than task No.1)

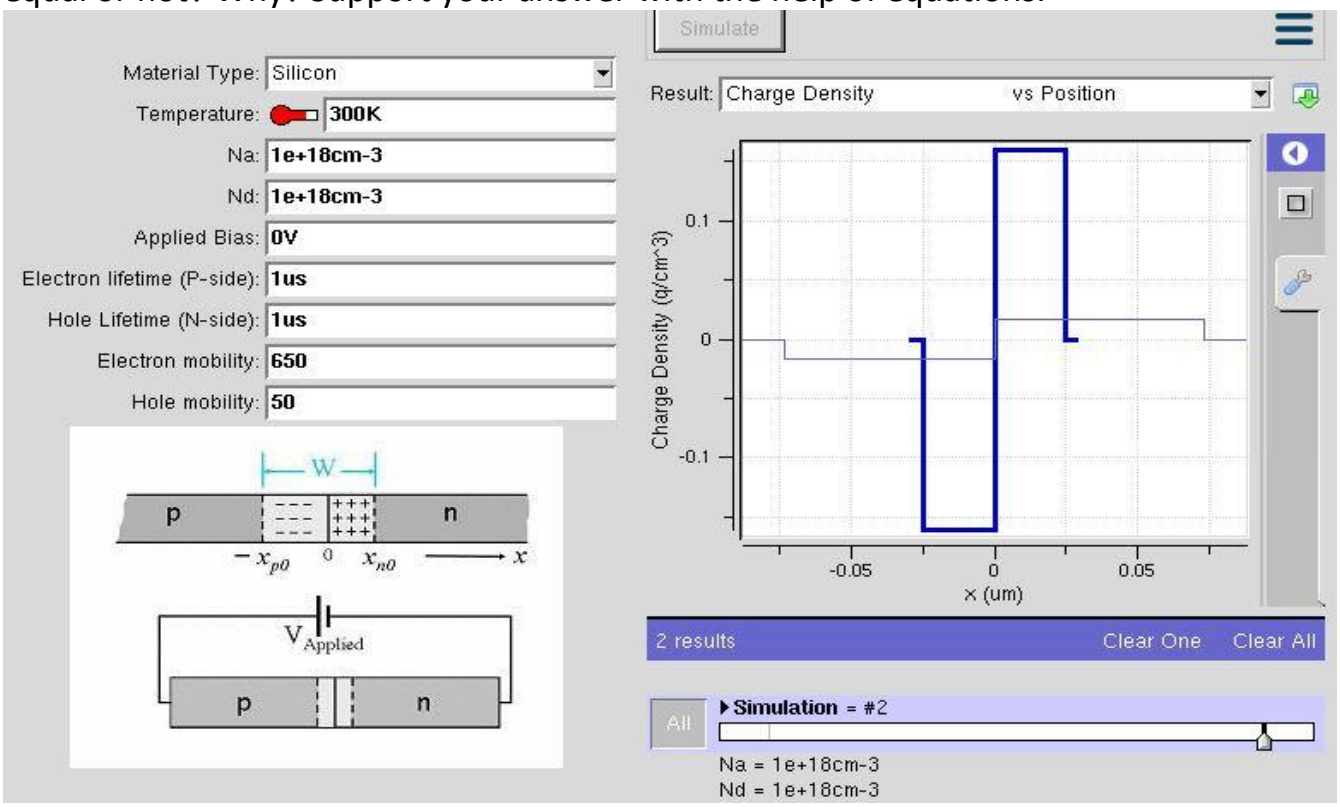
Q.1: - Observe simulated result of charge density with respect to position



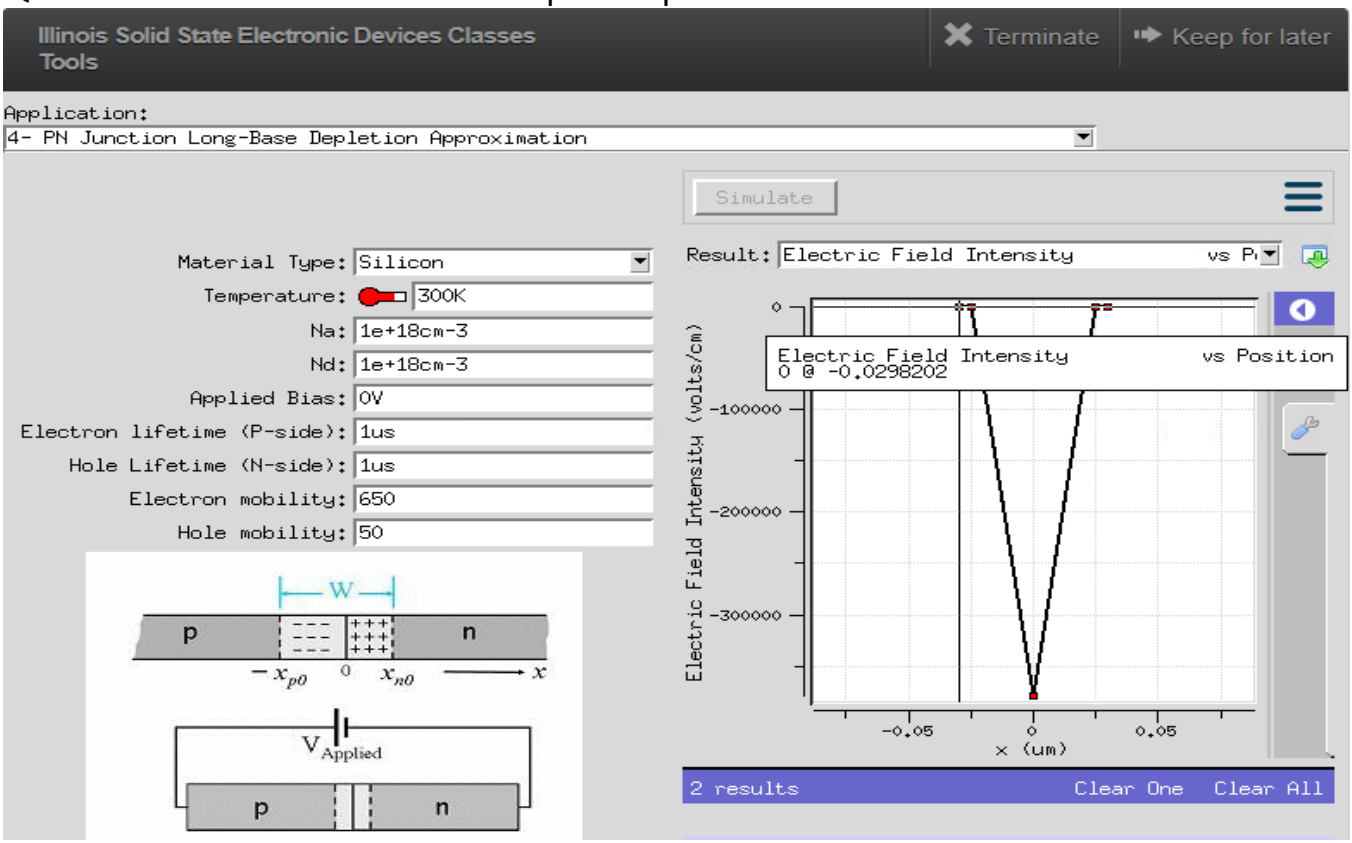
Q.2: - Write down the value of charge density

Ans: 0.160218

Q.3: - Compare the charge density of task number 1 and 2. Attach simulation results. Are they equal or not? Why? Support your answer with the help of equations.



Q.4: - Observe electric field with respect to position

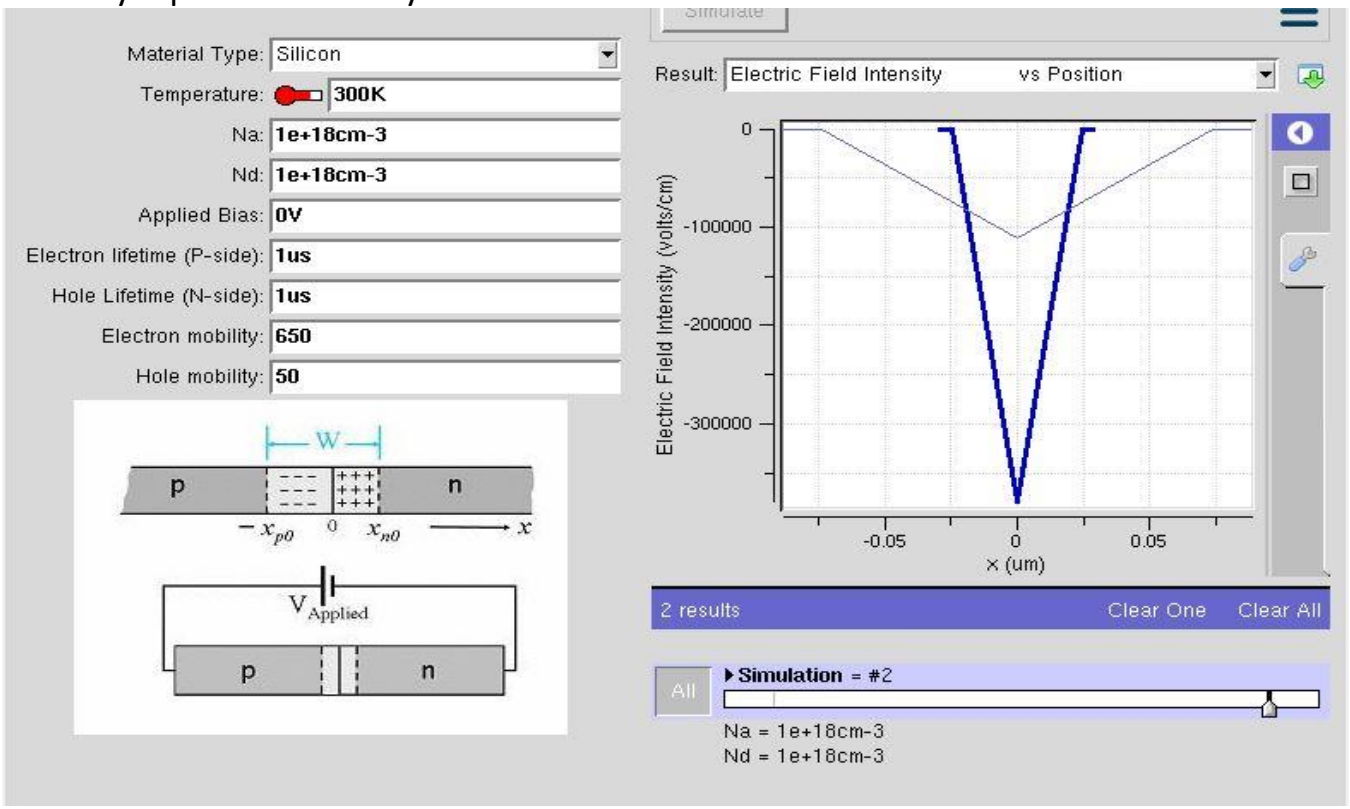


Q.5:- Maximum electric field is at ___-0.0248502_____ position.

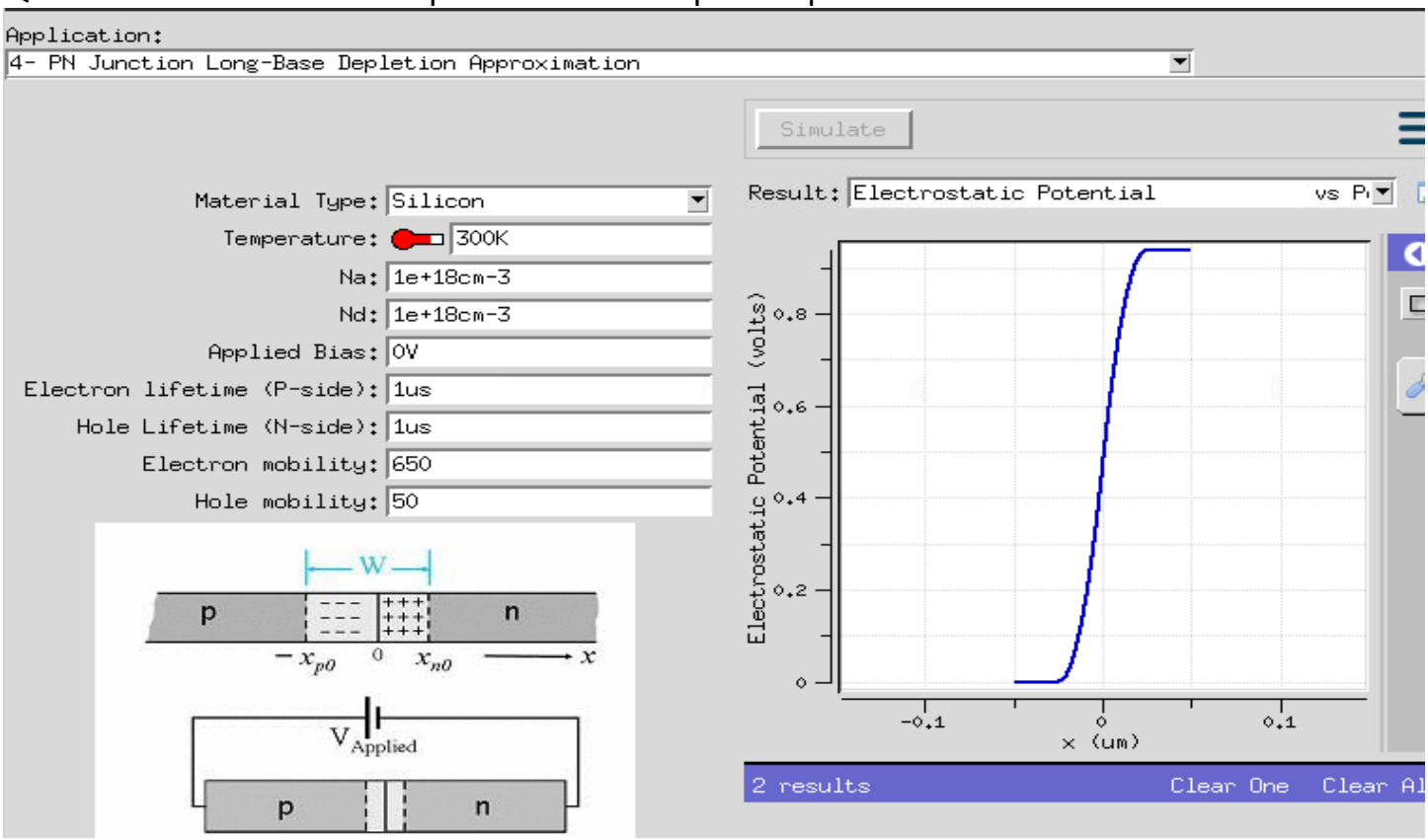
Q.6: - Write down the value of maximum electric field.

Ans: zero is of maximum electric field.

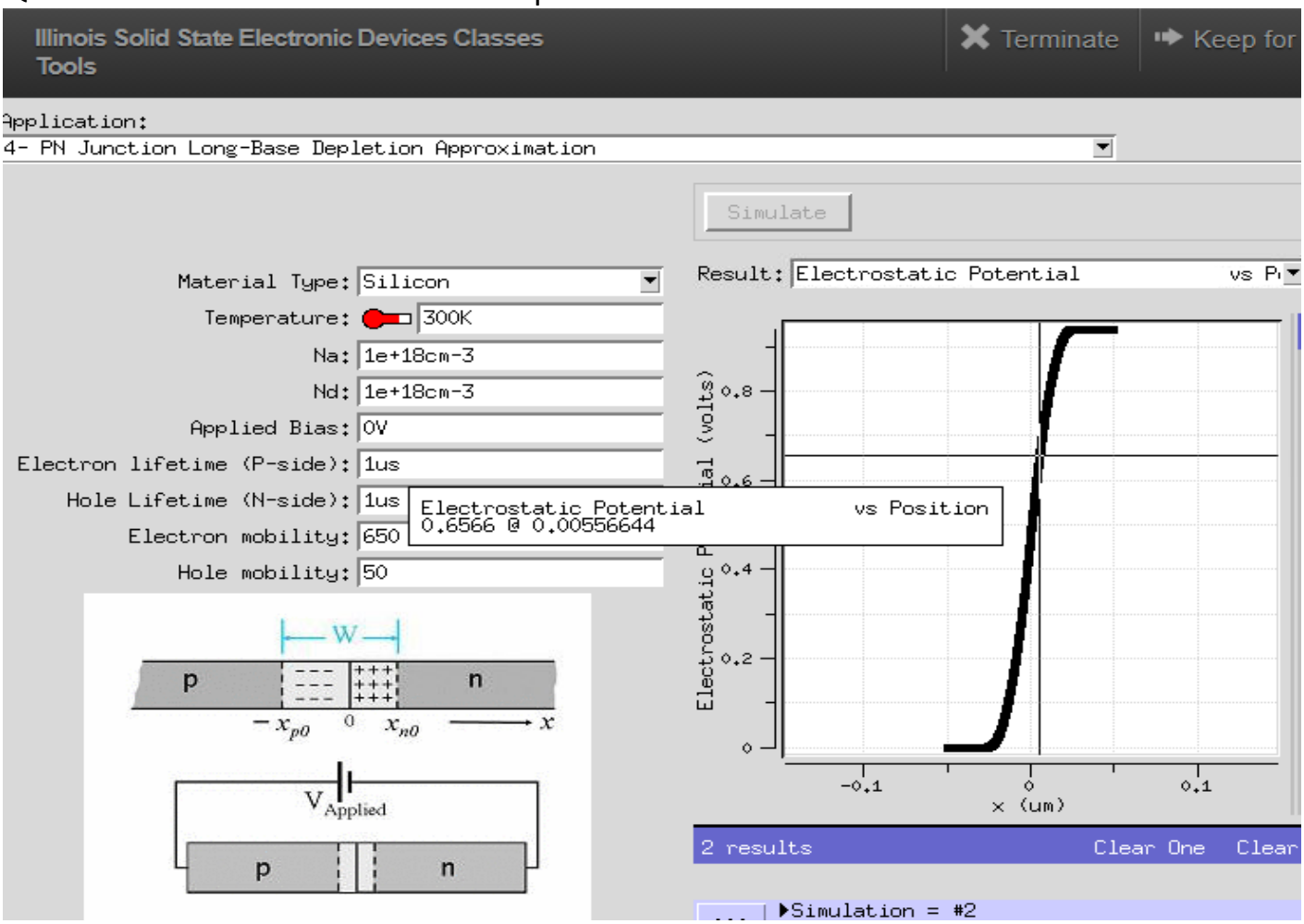
Q.7: - Compare the maximum electric field of task number 1 and 2. Attach simulation results. Are they equal or not? Why?



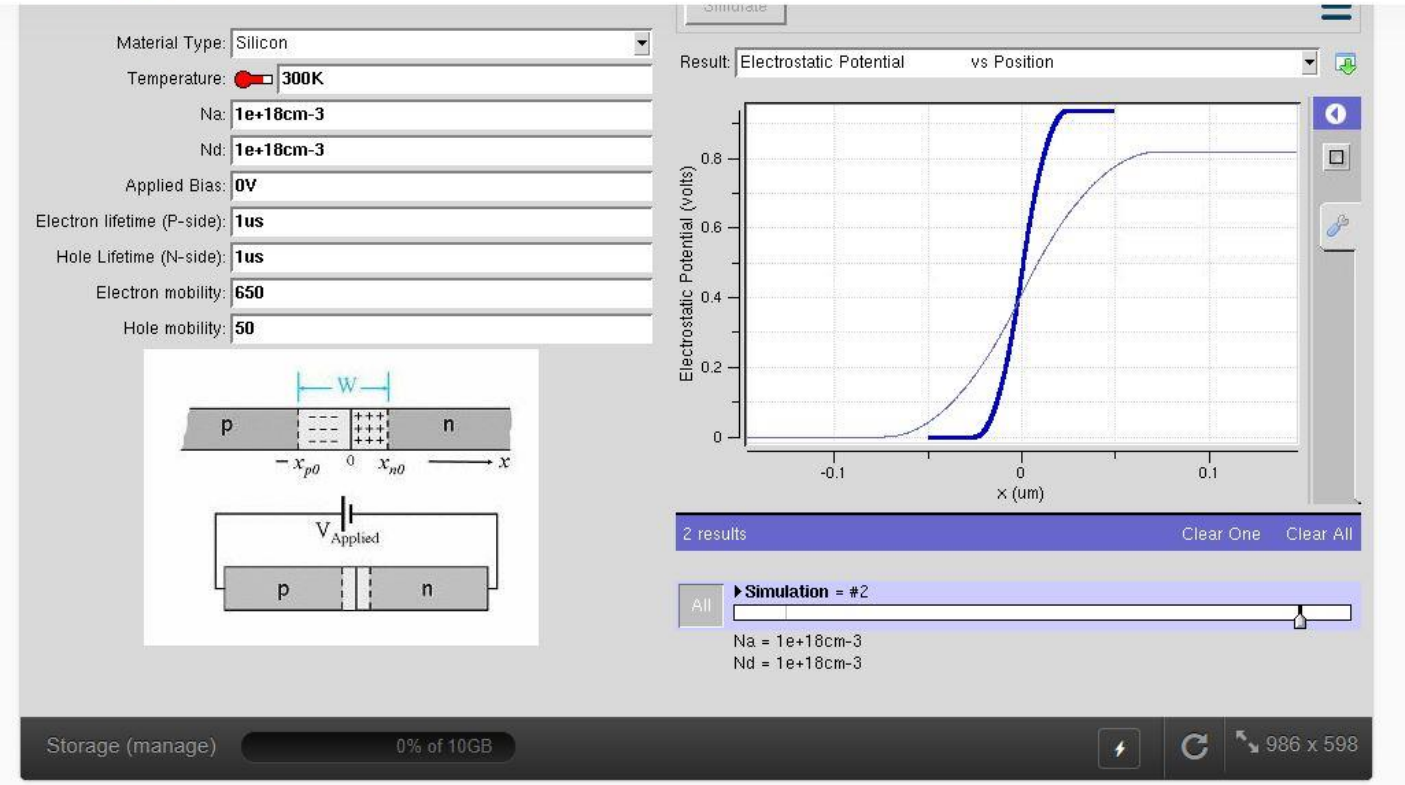
Q.8: - View the electrostatic potential with respect to position



Q.9:- Write down the value of built in potential.

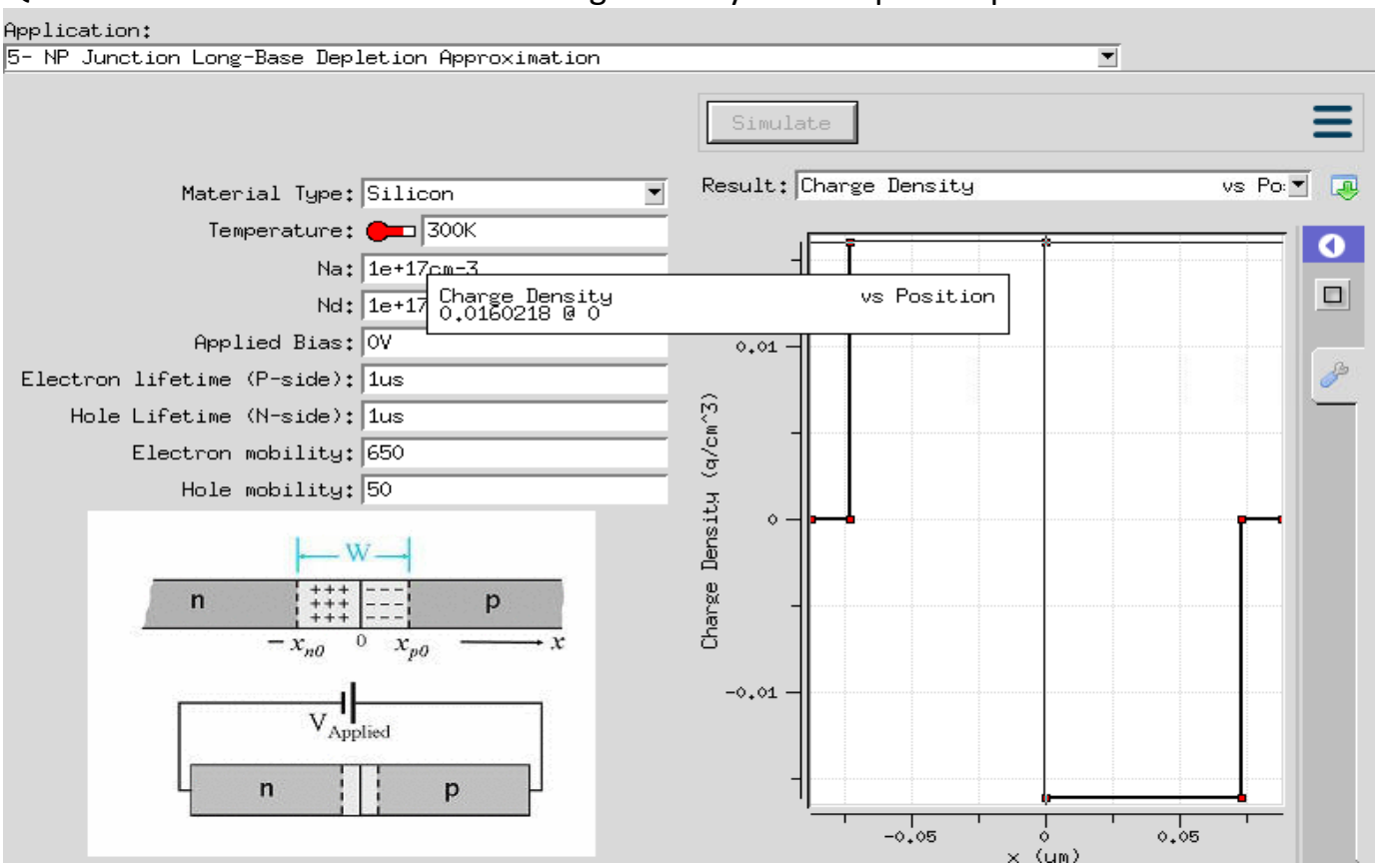


Q.10: - Compare the built-in potential of task number 1 and 2. Attach simulation results. Are they equal or not? Why?



<u>Task No.03:</u> - Consider an equally doped unbiased NP junction diode

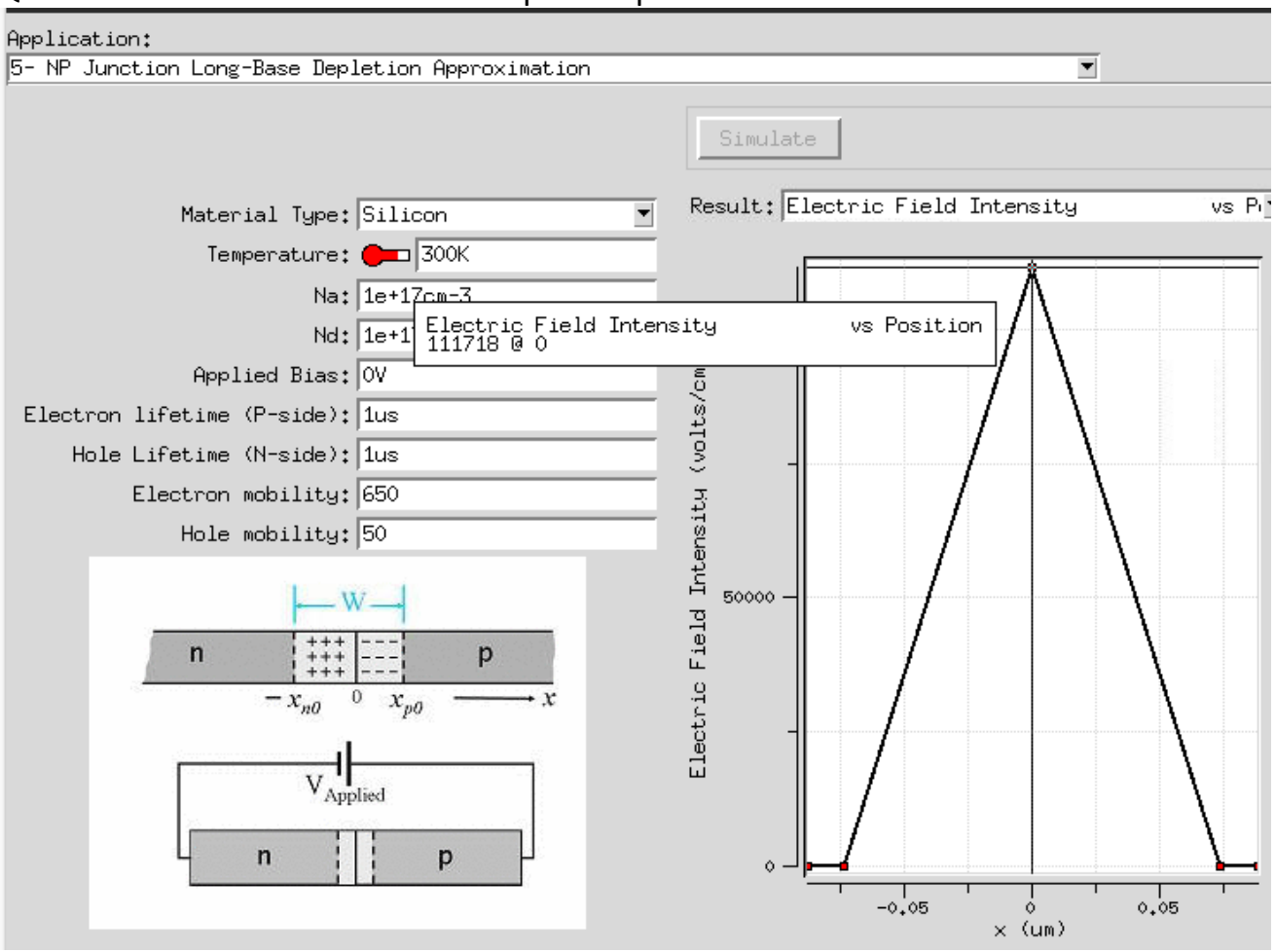
Q.1: - Observe simulated result of charge density with respect to position



Q.2: - Write down the value of charge density in depletion region.

Ans: 0.0160218

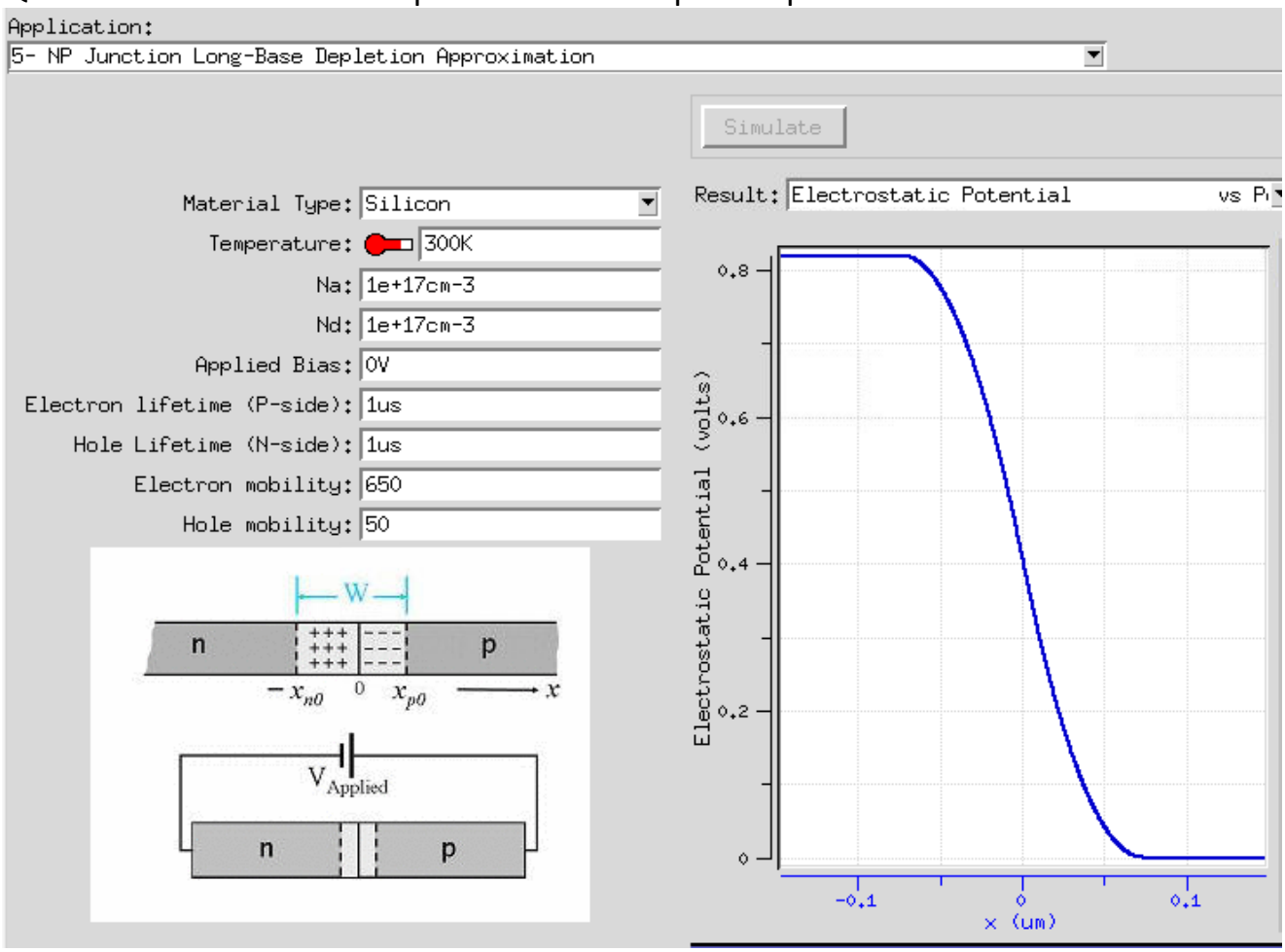
Q.3: - Observe electric field with respect to position



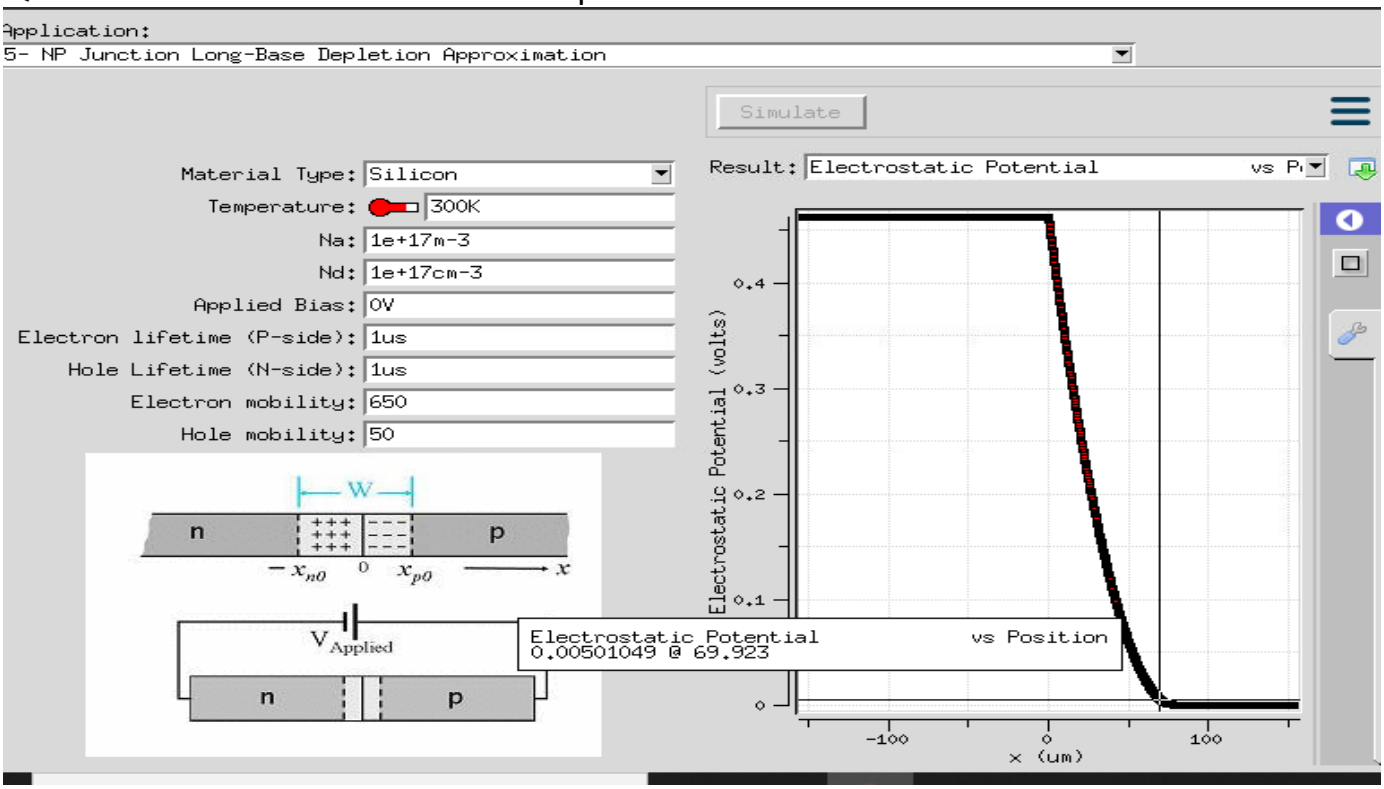
Q.4: - Write down the value of maximum electric field.

Ans: 111718

Q.5:- View the electrostatic potential with respect to position



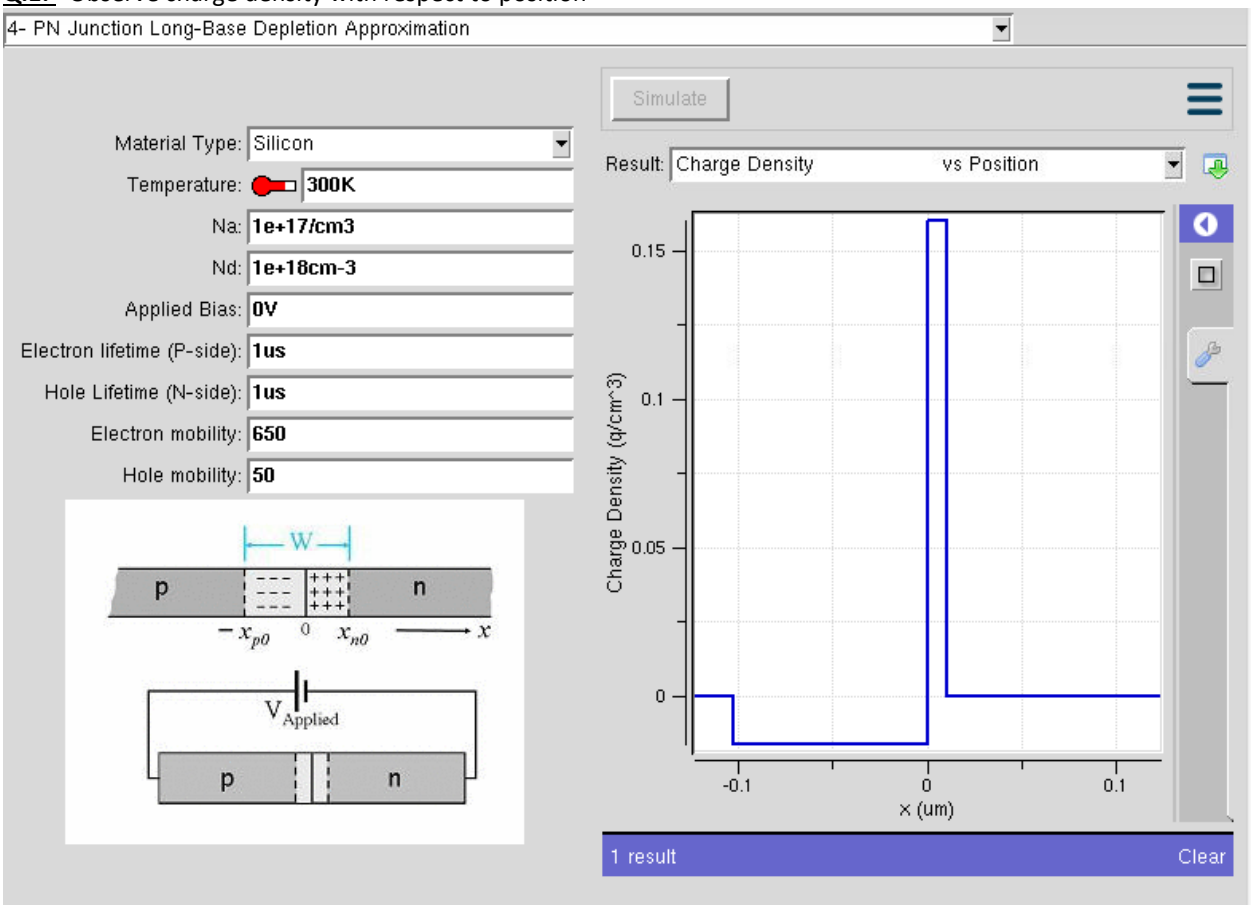
Q.6:- Write down the value of built in potential.



LAB # 10

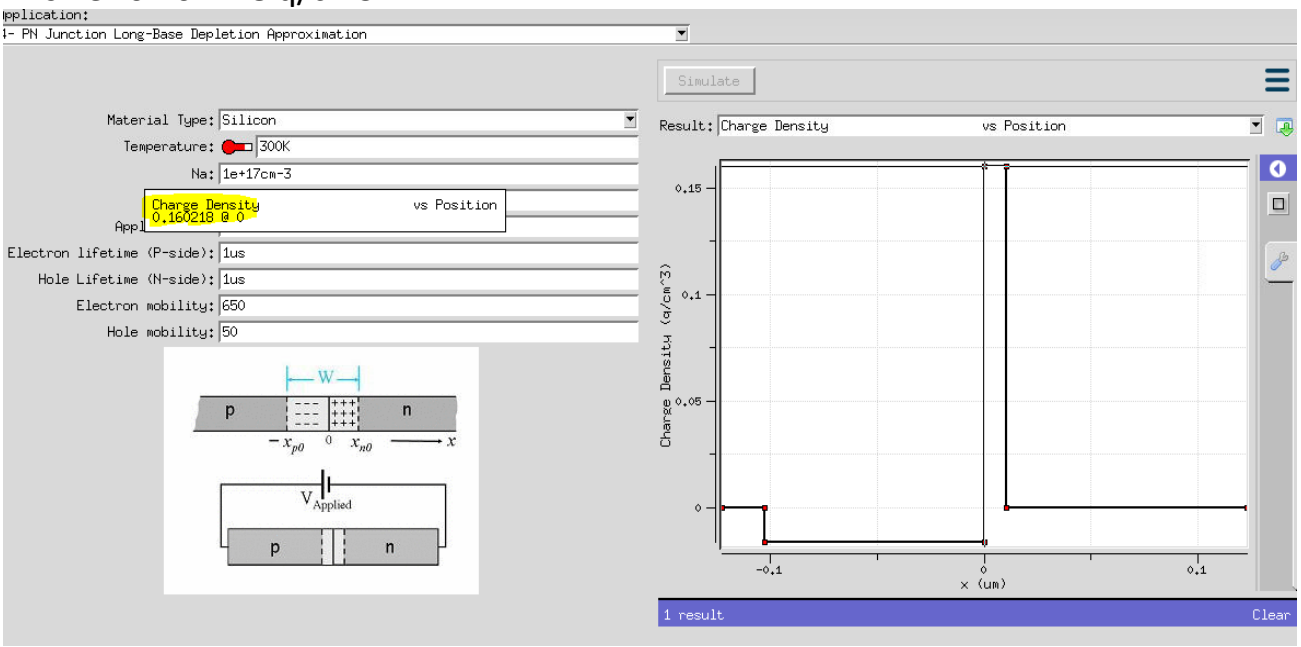
Task No.01: - Consider a n^+-p junction under equilibrium

Q.1: - Observe charge density with respect to position

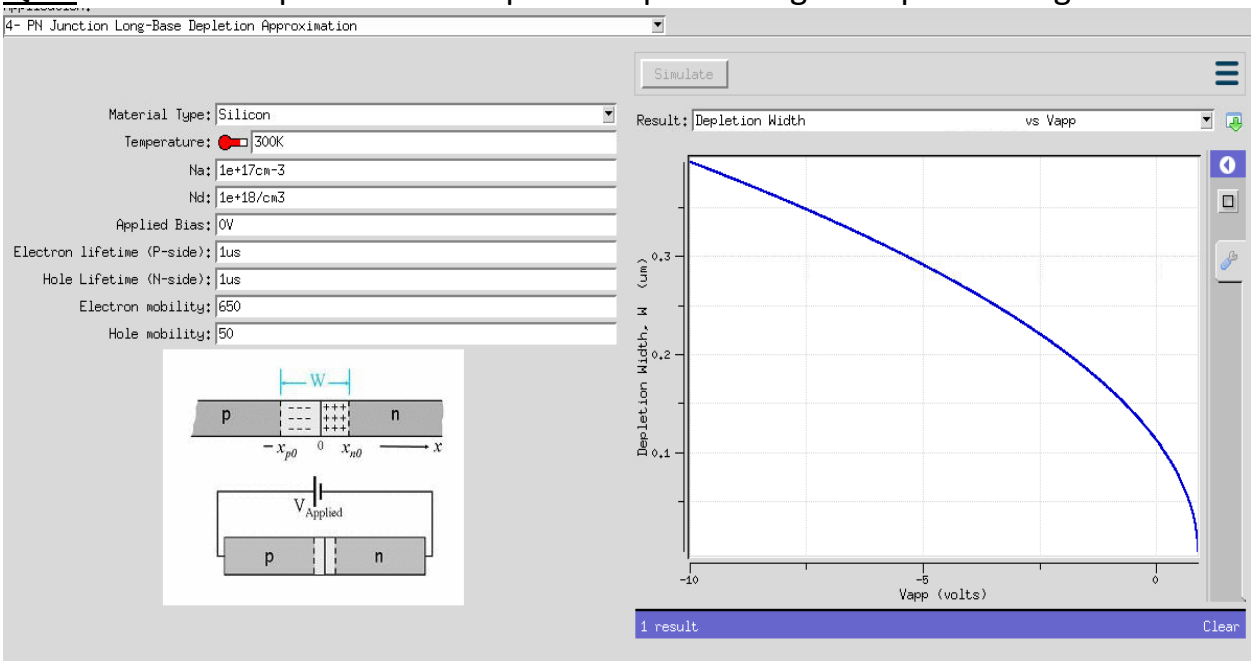


Q.2: - What is the value of charge density?

Answer:0.162218 q/cm3



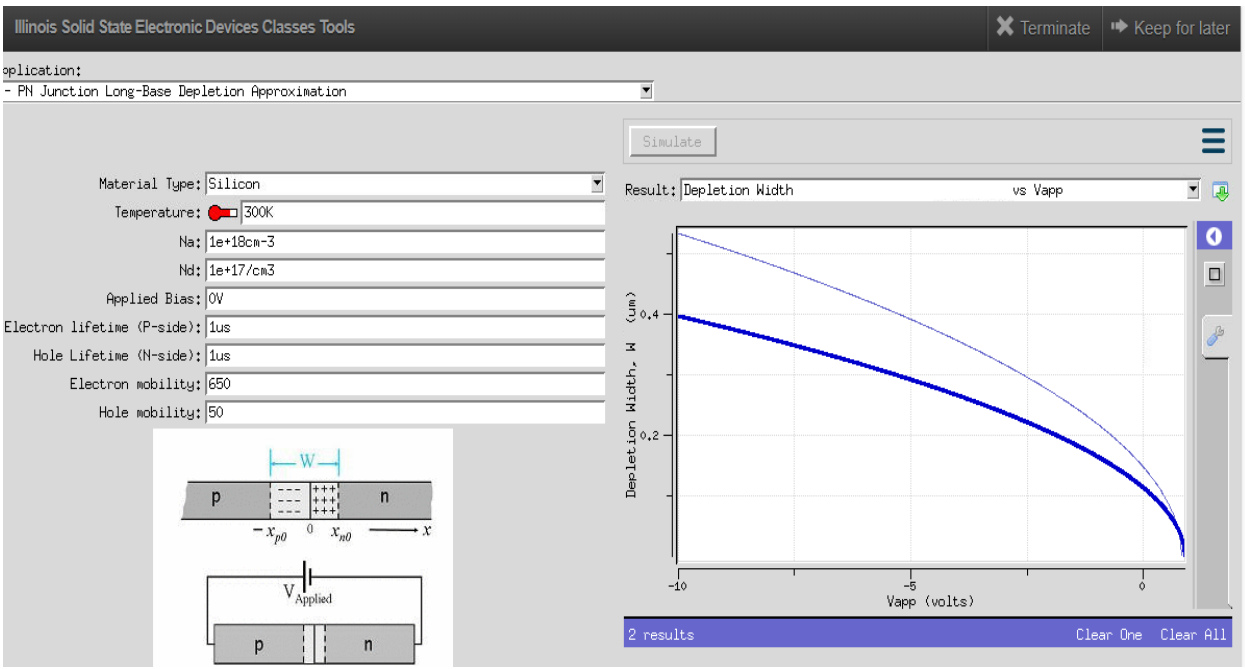
Q.3: - What is the penetration depth of depletion region in p and n regions?



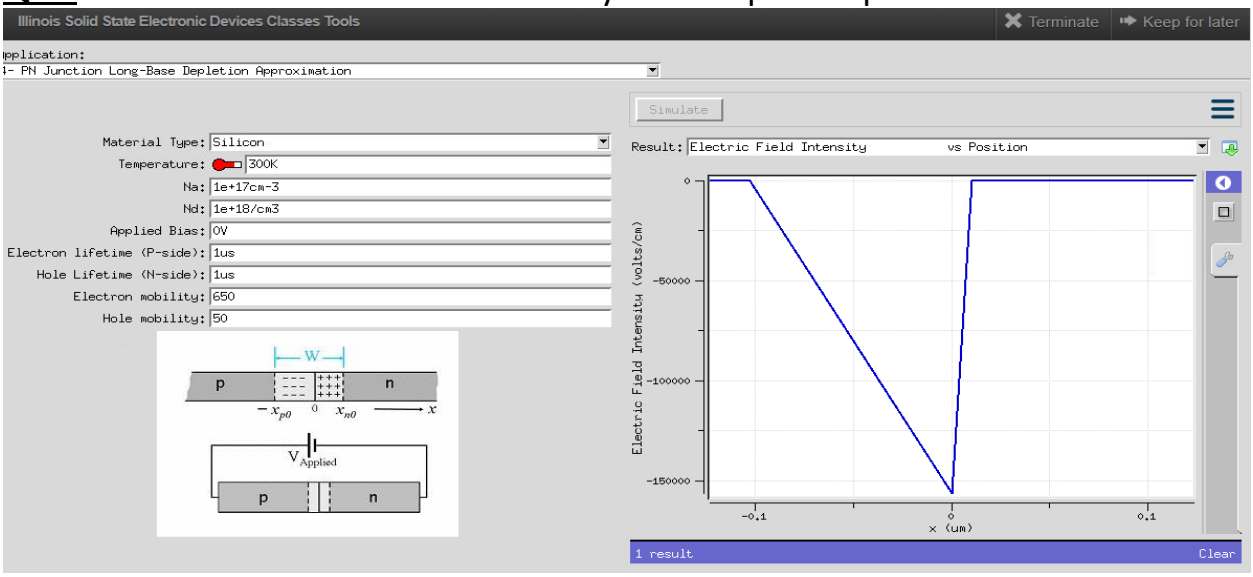
Q.4: - Is the penetration depth of depletion region in p and n regions is same for an equally doped PN junction and a p^+-n junction diode? Yes/No. Support your idea with the help of equations. Also attach simulation results.

No ,results are not equal because width depends upon doping concentration as can be seen from equation,

$$W = \left[\frac{2K_s\varepsilon_o}{q}\left(\frac{N_a + N_d}{N_aN_d}\right)V_{bi}\right]^{1/2}$$

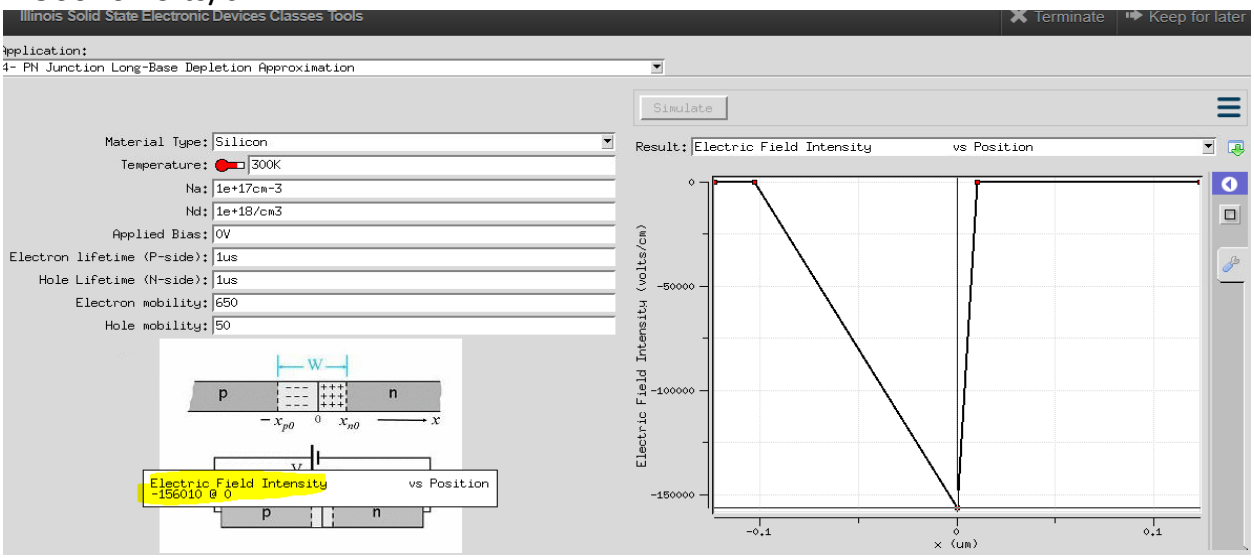


Q.5: - Observe the electric field intensity with respect to position.

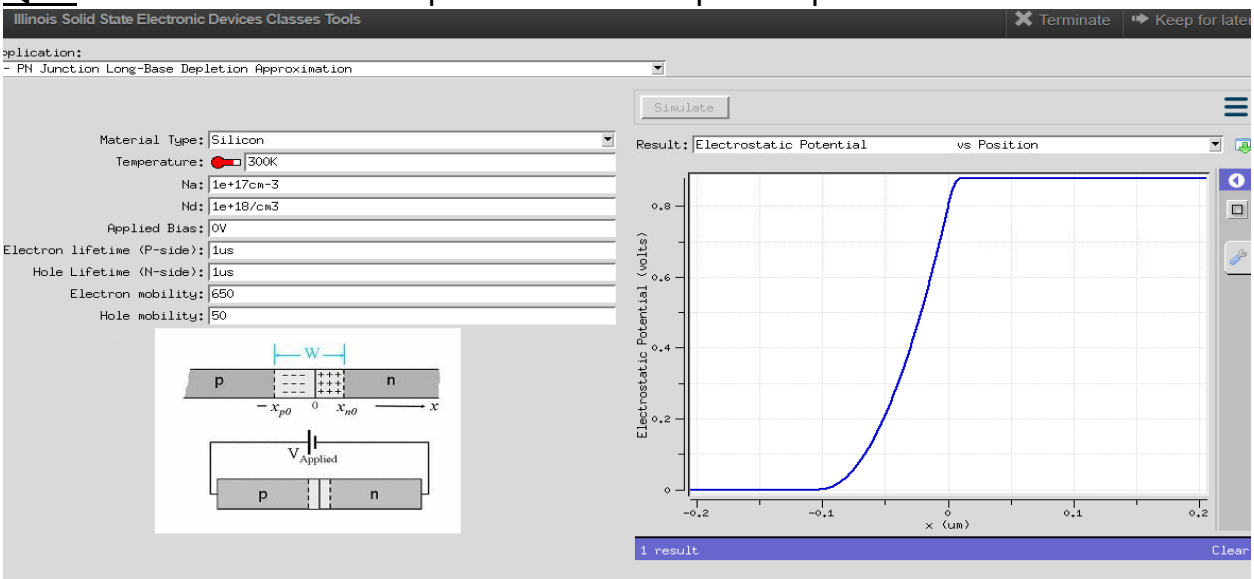


Q.6: - Write down the value of maximum electric field.

-156010 volts/cm

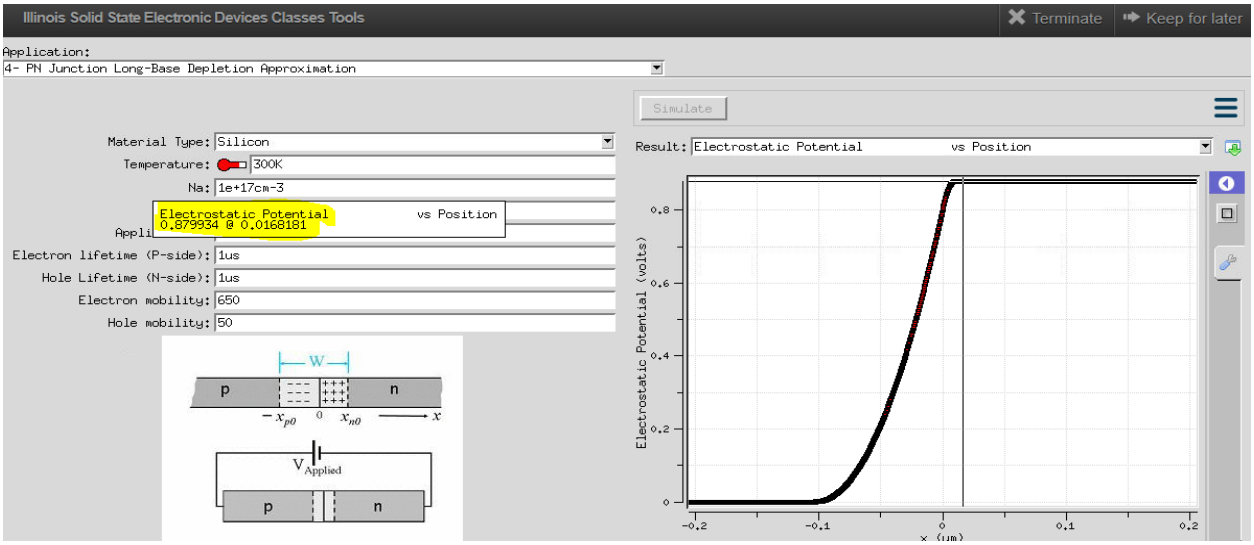


Q.7: - Observe electrostatic potential with respect to position.



Q.8: - Specify the value of built-in-potential.

Answer: 0.879934 volts



Q.9: - Is the built-in-potential same for an equally doped PN junction and a p^+-n junction diode? Yes/No. Support your idea with the help of equations. Also attach simulation results

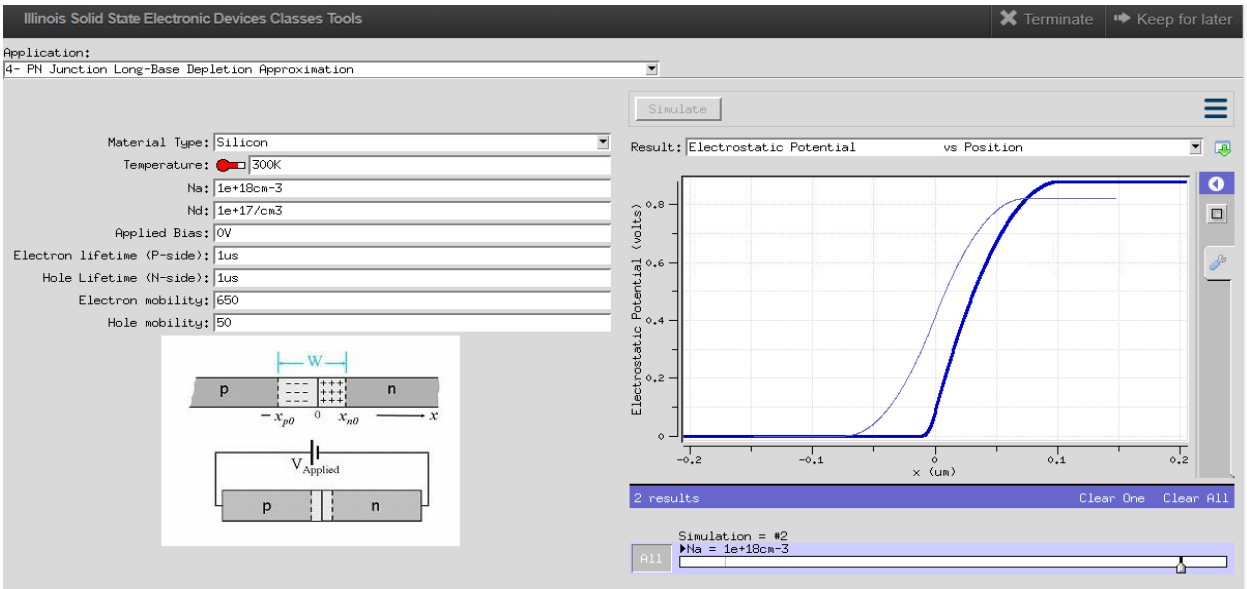
$$V(x) = 0 \ldots\ldots\ldots\ldots -x_p < x$$

$$V(x) = \frac{qN_a}{2K_s\varepsilon_o}(x_p + x)^2 \ldots\ldots\ldots\ldots -x_p \le x \le 0$$

$$V(x) = V_{bi} - \frac{qN_d}{2K_s\varepsilon_o}(x_n - x)^2 \ldots\ldots\ldots\ldots 0 \le x \le x_n$$

$$V(x) = V_{bi} \ldots\ldots\ldots\ldots x > x_n$$

$$V_{bi} = \frac{kT}{q} ln\left[\frac{N_a N_d}{n_i^2}\right]$$

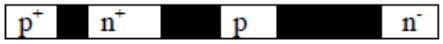


No, the graphs are not same. Also from the equation we can see that potential depends on doping concentration.

Q.10: - During first 3 years of your undergraduate studies, have you ever used any semiconductor device that have a p^+-n junction? Yes/No. If yes then give example

yes, BJT and MOSFET.

Q.11: - Let's assume that you have a semiconductor device that has 4 regions and thus 3 junctions as shown below



Potential drop across three junctions is

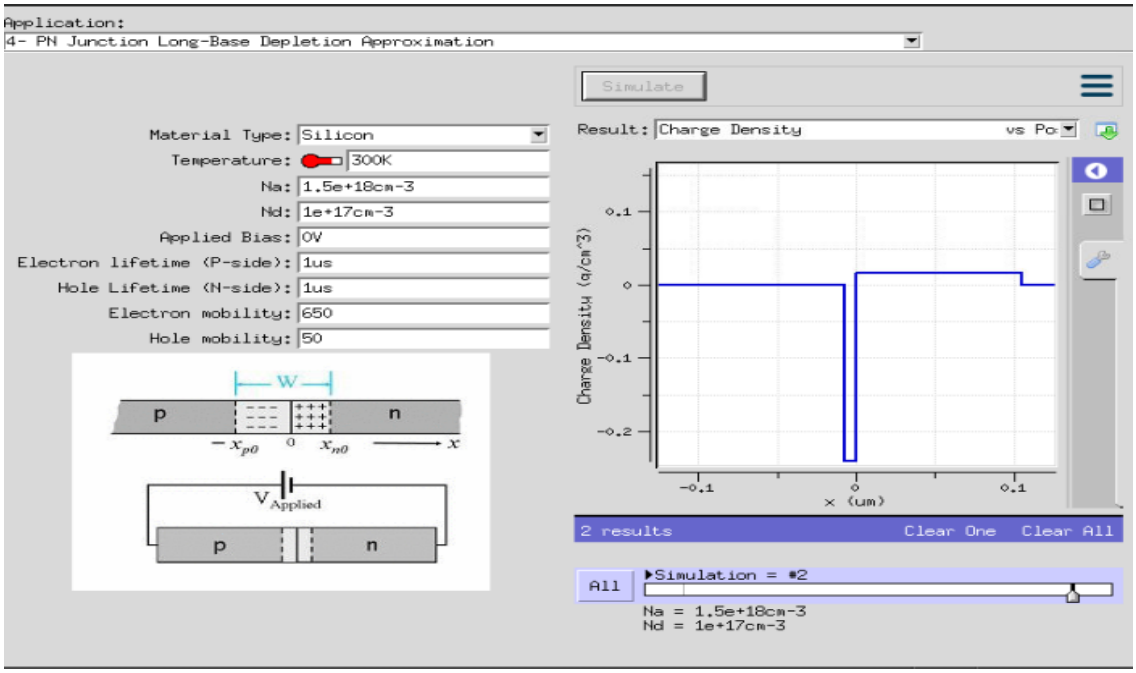
1) 0.61V
2) 0.89V
3) 0.77V

From these drops how can you identify the four regions?

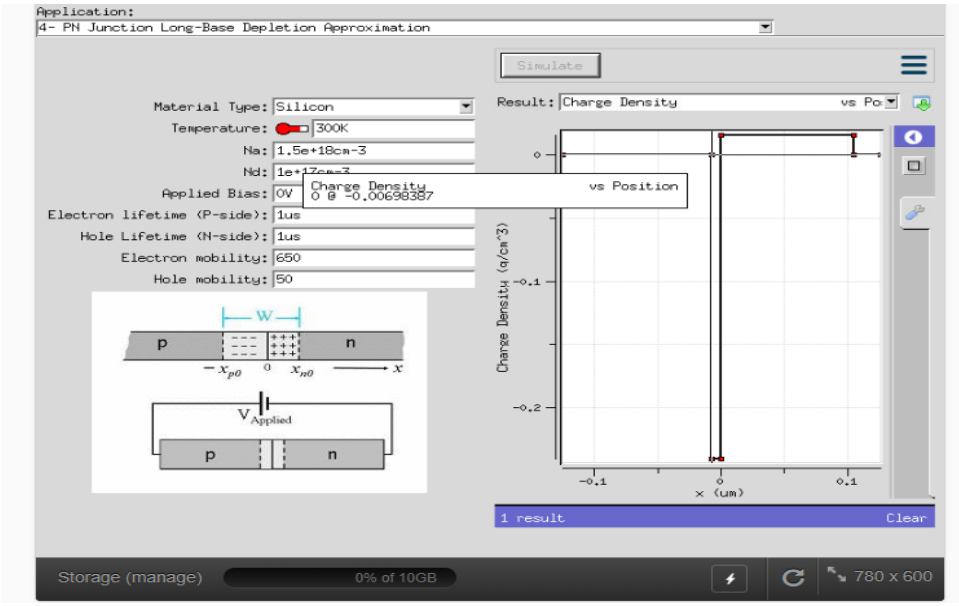
Answer:
P+ and n+ will have 0.89 V
N+ and p will have 0.77 V
P and n- will have 0.61V

Task: 2

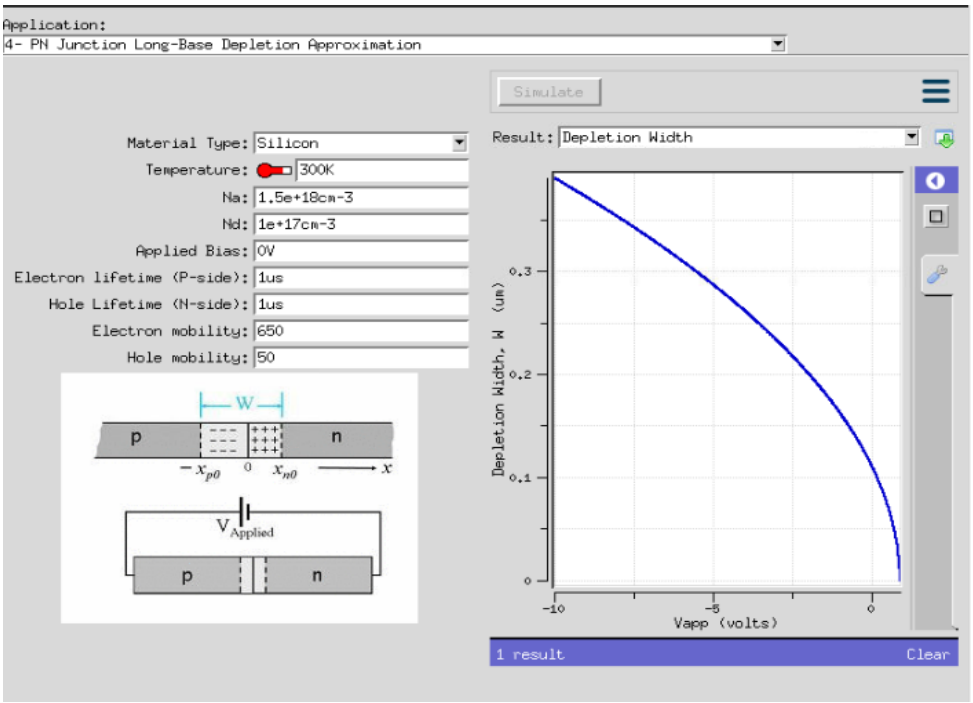
Q1: Observe charge density with respect to position



Q2: What is the value of charge density?



Q3: What is the penetration depth of depletion region in p and n regions?

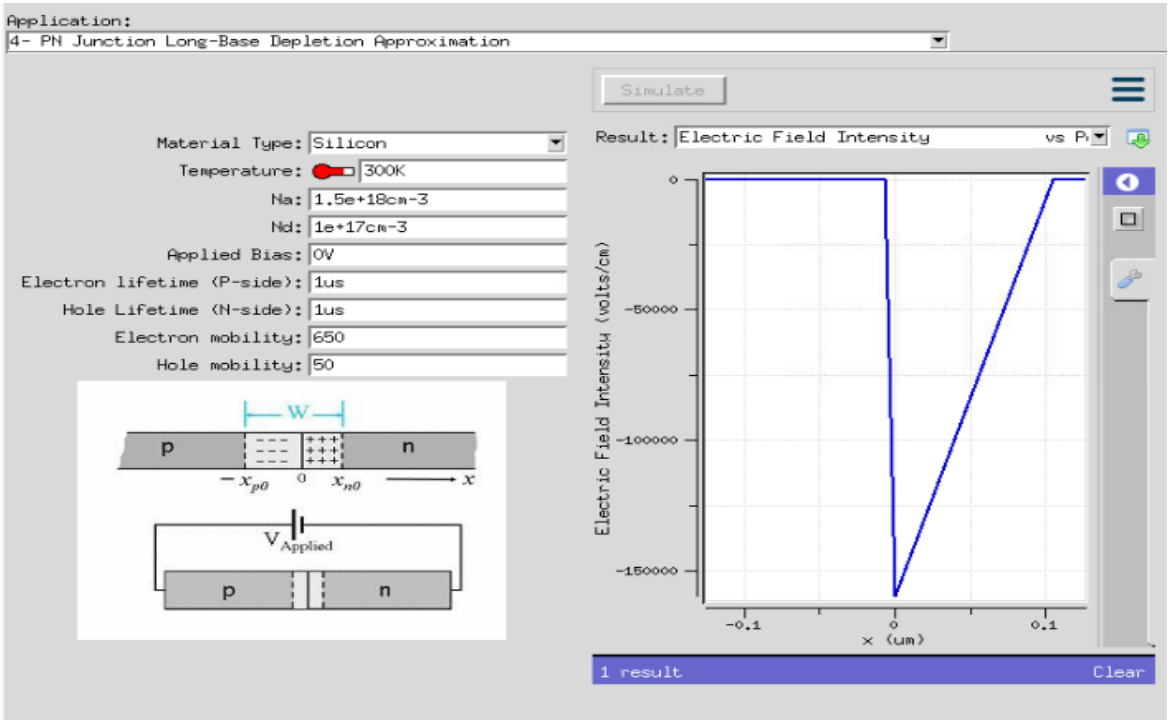


Q4: In PNP transistor emitter base junction is intentionally made p^+-n rather than p-n. What's the purpose behind this unequal doping?

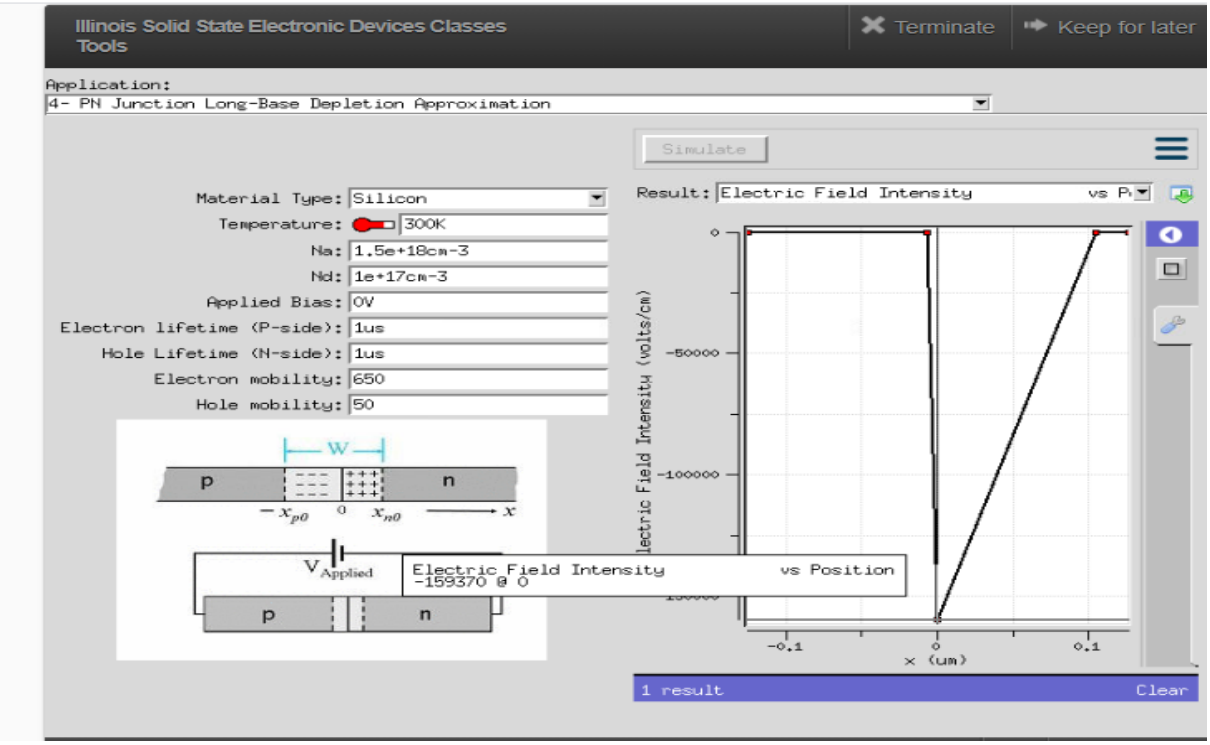
In a bipolar junction transistor, current flows from the emitter to the collector and then out from the collector.

The reason the emitter is the most heavily doped region is because it serves to inject a large amount of charge carriers into the base, which then travels into the collector, so that switching or amplification can occur

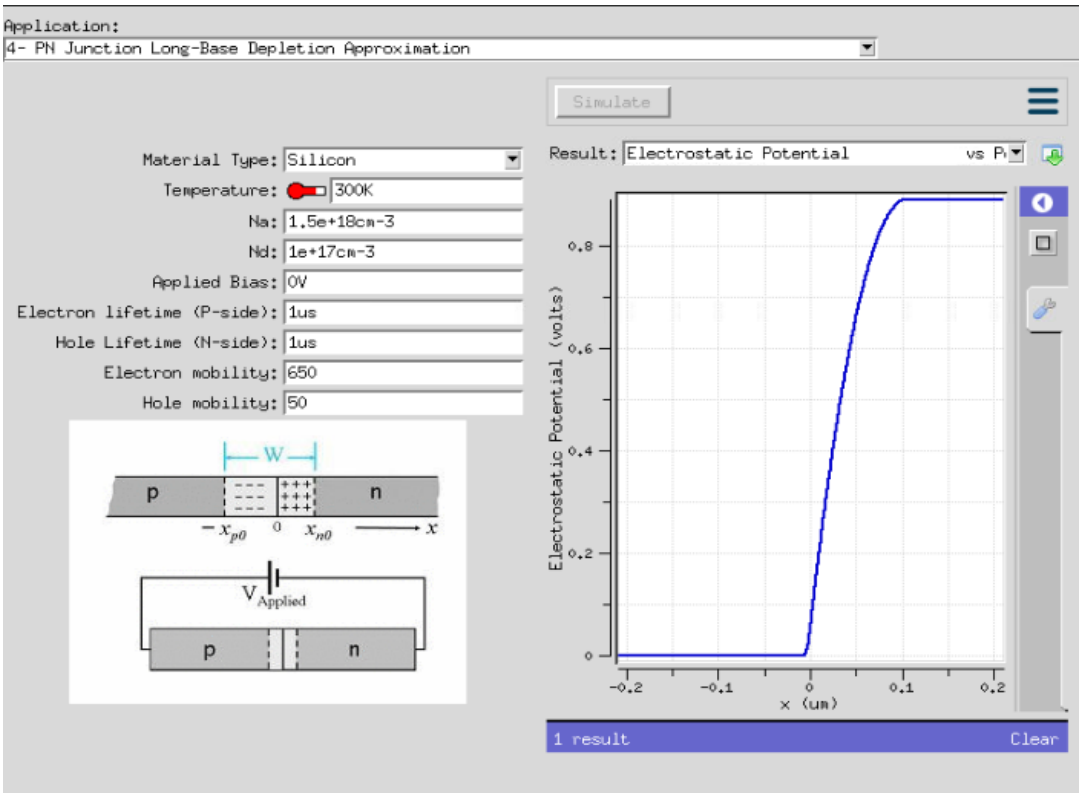
Q5: Observe the electric field intensity with respect to position.



Q6: Write down the value of maximum electric field.
Value of maximum electric field: -159370



Q7: Observe electrostatic potential with respect to position



Q8: Specify the value of built-in-potential.