EE105 – Microelectronic Devices and Circuits
Spring 2026, Homework #6

Assigned: **March 3, 2026**
Due: **March 10, 2026 at 11:59 PM on Gradescope**

1 Notes

Upload your notes from Lectures 12 and 13.

2 Problem Set

2.1 Problem 1: P-N Junctions and Capacitance

You have a sample p-n junction at room temperature. For this sample, you know that

$$N_A = 4 \times 10^{16}\,\text{cm}^{-3}$$

and

$$N_D = 8 \times 10^{16}\,\text{cm}^{-3}.$$

(a) Determine the total depletion width and the one of each region when a bias voltage of $V_D = 0$ V is applied from the p-side to the n-side.

(b) We apply a reverse bias voltage of $V_D = -3$ V. Calculate the new total depletion width and the one of each region.

(c) Calculate the capacitance of the junction from part (a) and (b).

(d) Consider the acceptor concentration becomes $N_A = 10^{20}\,\text{cm}^{-3}$. This type of junction is referred to as a one-sided junction.

Determine the new depletion width and the junction capacitance as function of V_D. Make simplifications where appropriate and comment on the relationship between V_D and the depletion width/ junction capacitance.

2.2 Problem 2: Diode Operation and I-V Characteristic

You are given a diode to use in your circuit. You do not have any information about the component. When forward biased with a voltage of 0.7 V, you measure $I_D = 1$ mA.

(a) What is the reverse bias current of this device?

(b) You are now asked to sink 100 mA of current with this diode. By how much should you increase the forward voltage from 0.7 V to obtain this current?

(c) You fear that 100 mA is too high of a current for a single diode to sink over a long period of time. So instead, you decide to put 10 of the diodes in parallel to generate the desired 100 mA. By how much should you increase the forward voltage from 0.7 V to obtain this current?

(d) If instead of a diode we had given you a photodiode, what test could you setup to characterize the short-circuit current I_{SC} and determine the forward voltage required to achieve a certain current? You may use equations/graphs to explain your reasoning.

2.3 Problem 3: NPN BJT

Consider a NPN transistor. The emitter is connected to ground (0 V) and the collector is biased with a 12 V voltage source. The current in the collector is measured to be 1 μA when a 0.7 V bias is applied across the base-emitter diode.

(a) What voltage should be applied at the base to obtain 1 mA of current in the collector?

(b) If $\beta = 100$, what is the current in the emitter?

(c) Is the collector current due to mostly holes or electrons? Explain why.

(d) If I were to disconnect the emitter from ground and apply a separate bias voltage to it instead, what region of operation do I risk entering and at what bias voltage to the emitter? Hint: Consider the voltage supply for the emitter has a limit of 12 V.