Homework 2 EE 105 SP 2025 – Due 3/12/2025 11:59 pm

Problem 1: Explain the key differences between conductors, semiconductors, and insulators in terms of their electrical conductivity and band structure.

Problem 2: An n-type semiconductor sample has a resistivity of 0.5 Ω·cm. If the sample is 2 cm long with a cross-sectional area of 0.1 cm^2, calculate its resistance. Now, imagine that I modify the semiconductor so that it is doped with 10 times ***fewer*** donors. What would the new resistance be, assuming the same geometry and carrier response to electric field (called mobility).

Problem 3: Describe the crystal structure of silicon and explain how it contributes to its semiconductor properties. Describe why silicon and other materials, such as InP, InAs, GaAs, etc are semiconductors.

Problem 5: A silicon diode is forward-biased with a voltage of 0.7 V at room temperature (300 K). Calculate the diode current if the reverse saturation current I_0 = 1 nA.

Problem 6: Explain the significance of the invention of the transistor in the development of modern electronics.

Problem 7: A MOSFET has a threshold voltage VT = 1 V. If the gate voltage VG = 3 V and the drain-source voltage VDS = 2 V, determine the operating region of the MOSFET.

Problem 8: Describe how a CMOS inverter works and explain its advantages in digital circuits.

Problem 9: Design two different CMOS logic gates to implement the following two truth tables. Recall what we discussed about pull up and pull down networks, and how we ca

Truth Table

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

Truth Table

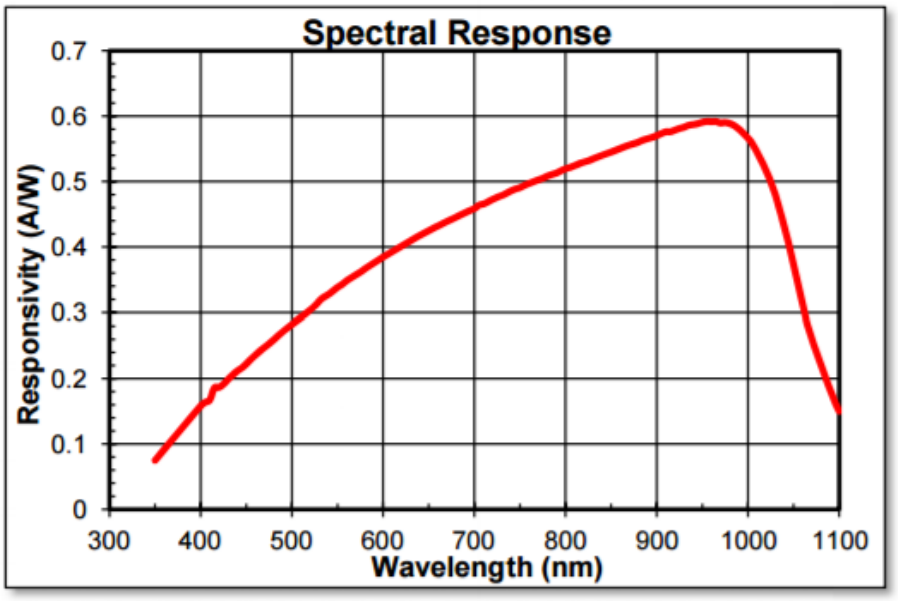
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

Problem 10: Explain the ideal characteristics of an operational amplifier and discuss how real op amps deviate from these ideal properties. Include in your explanation the concepts of open-loop gain, input impedance, and output impedance.

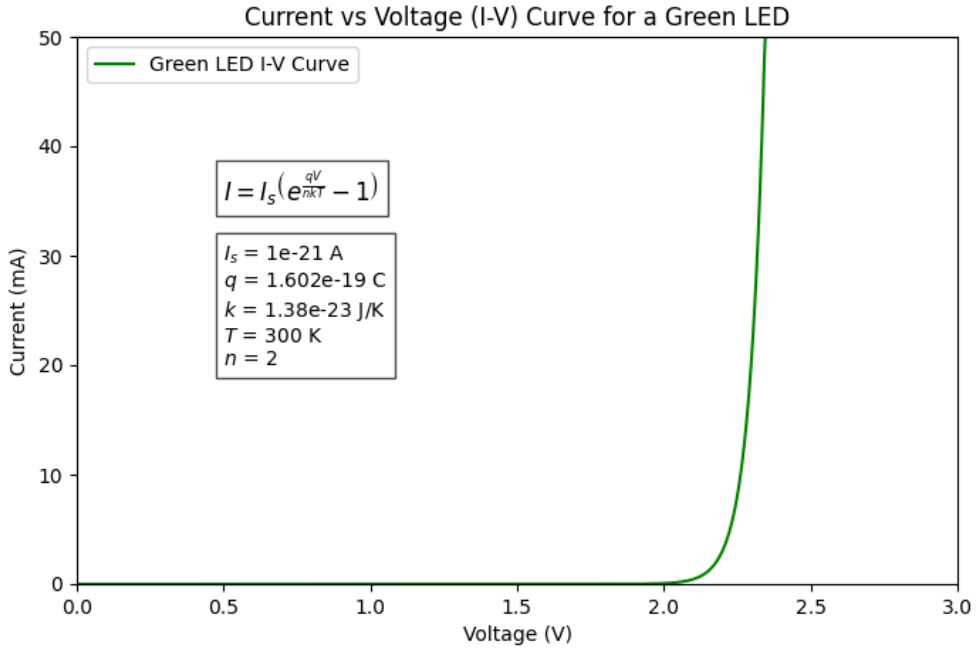
Problem 11: An inverting amplifier circuit uses an op amp with a 10 kΩ feedback resistor (Rf) and a 2 kΩ input resistor (Rin). If the input voltage is +0.5 V: a) Calculate the output voltage b) What happens to the output voltage if the input voltage polarity is reversed? c) Explain why this configuration is called an "inverting" amplifier

Problem 12: Design a non-inverting amplifier circuit that produces a gain of exactly 4.75. Specify the resistor values you would use if you have standard resistors available in the E24 series. Calculate the expected output voltage if an input of 1.2 V is applied to your circuit.

Problem 13: Imagine you have a green LED (emission wavelength = 532 nm), and a silicon photoetector with a responsivity as shown below.



Your LED has a diode I-V curve as shown below. Assume a quantum efficiency of current to photon generation of 30%.



Now, calculate what the current in the photodiode will be as a function of the current in the LED, assuming that 10% of the light emitted by the LED falls on the photodiode.

If the dark current in the LED is 10^{-10} A, what is the minimum amount of voltage you will need to apply to the LED in order to be able to measure anything on the photodetector?