Name: _____ USC ID#: _____

I hereby affirm that all the answers below are my own. I have neither searched online nor taken assistance from any external entity.

_____
Student Signature Above

EE105 – Fall 2024
Midterm

Time Limit: 2 hours

Section 1:	/25
Section 2:	/25
Section 3:	/25
Total:	/75

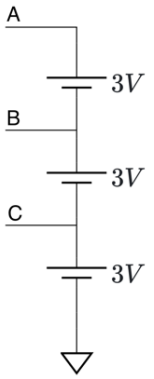
Total number of pages is 12 (including this page). Put your name on every page where noted

Name: _____ USC ID#: _____

Section A (25 points)

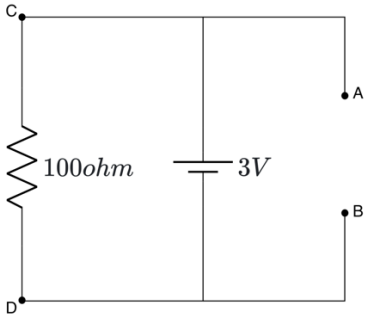
Question 1 (3 points)

Given the circuit diagram with nodes **A, B,** and **C**, each connected to **3V** sources as shown. Determine the voltages $\mathbf{V_A}$, $\mathbf{V_B}$, and $\mathbf{V_C}$ at the respective nodes with respect to the ground.



Question 2 (3 points)

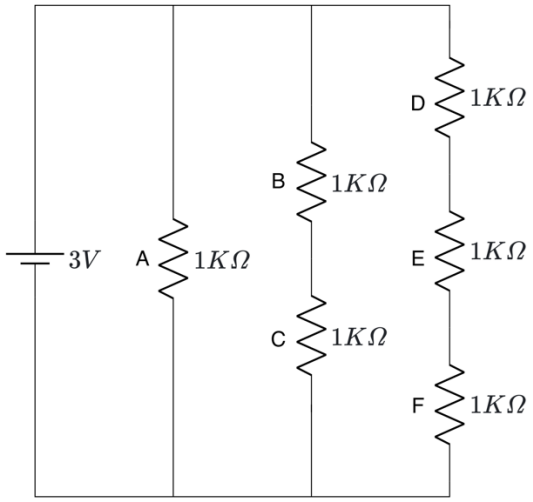
Given the circuit with nodes **A, B, C,** and **D** as shown. Calculate the following $\mathbf{V_{AB}}$, $\mathbf{I_{AB}}$, and $\mathbf{I_{CD}}$.



Name: _____ USC ID#: _____

Question 3(8 points)

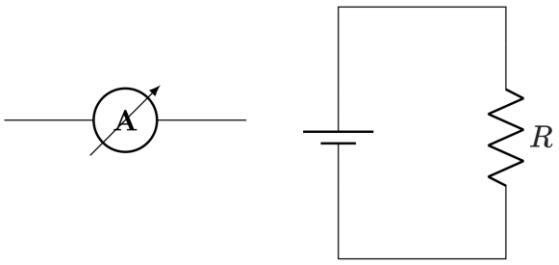
Given the circuit with six resistors connected to a **3V** voltage source as shown. Find voltages across the resistors (V_A, V_B, V_C, V_D, V_E, and V_F) and current through resistors (I_A, I_B, I_C, I_D, I_E, and I_F).



Name: _____ USC ID#: _____

Question 4 (3 points)

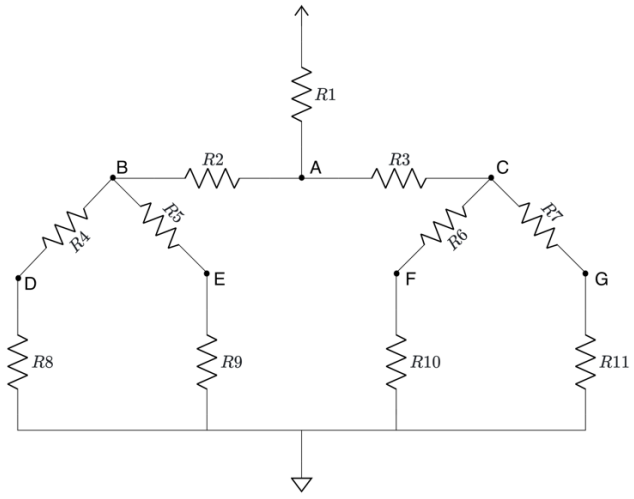
The circuit below contains a voltage source, and a resistor labeled **R**. Using the provided ammeter symbol, place the ammeter correctly in the circuit to measure the current $\mathbf{I_R}$. Redraw the modified circuit with the ammeter in place.



Question 5 (8 points)

a. Apply Kirchhoff's Current Law (KCL) at nodes A, B, C, D, E, F, and G in the given circuit. Write the current equations for each respective node. Assume the currents through resistors R1, R2, R3, R4, …, R11 as I1, I2, I3, I4, …, I11.

b. If I1 = 1A, Calculate the values of currents I2, I3, I4, I5, I6, I7, I8, I9, I10, and I11. All the resistors in the below circuit have equal resistance.

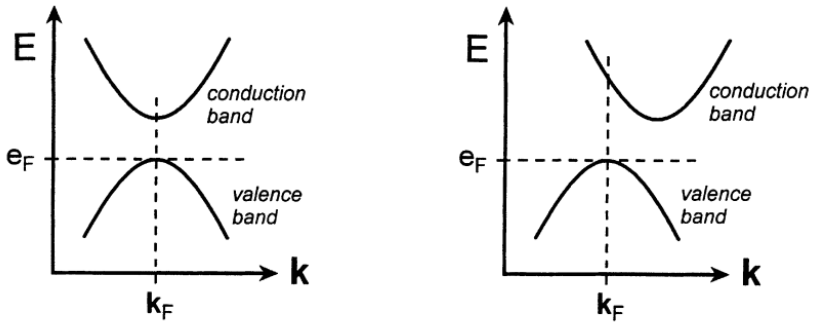


Name: _____ USC ID#: _____

Section B (25 points)

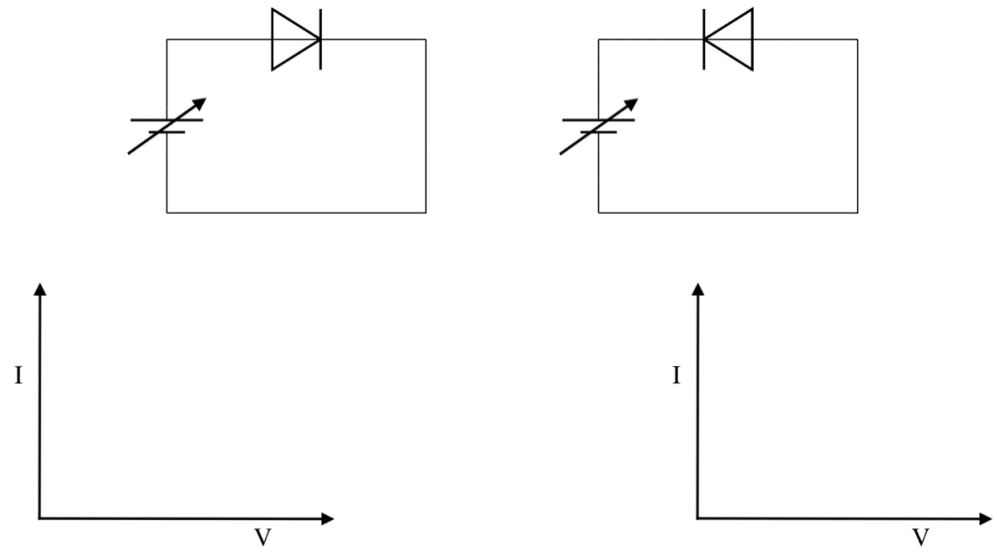
Question 6 (3 points)

The graph below shows the band structure of two different semiconductors. Identify which semiconductor would be more suitable for optoelectronic applications. Explain your reasoning.



Question 7 (4 points)

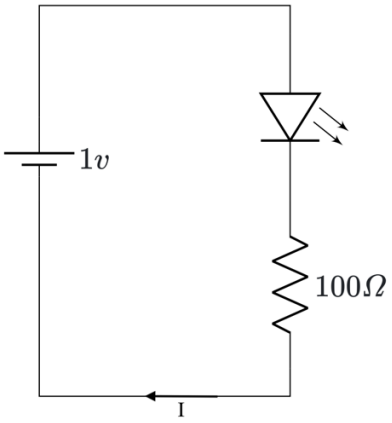
The diode shown below is arranged in two different configurations with a variable voltage source that provide 0 to +3V. Draw the IV characteristics of the diode for each configuration. Use the provided empty plots to answer the question.

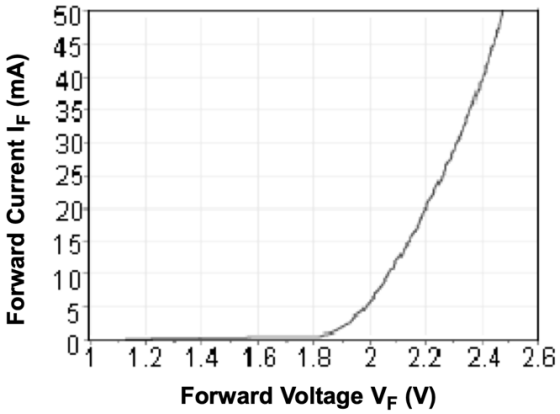


Name: _____ USC ID#: _____

Question 8 (3 points)

An LED is connected to a 1V voltage source in series with a 100-ohm resistor, as shown below. Using the provided LED characteristic curve, determine the value of I (the current through the LED).





Question 9 (4 points)

In a photodiode, identify the region where light is captured. Draw a diagram of the photodiode and indicate the light-capturing region.

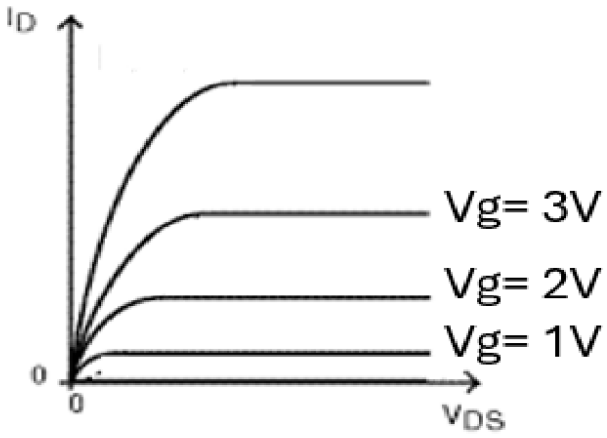
Name: _____ USC ID#: _____

Question 10 (3 points)

The diagrams below show two different configurations of photodiodes. Identify which configuration is more effective for capturing light. Explain the reason for your choice.

Question 11 (3 points)

The curve below shows the VDS vs. ID characteristics of a MOSFET. **Label** and **mark** the different regions of operation on the curve (e.g., cutoff, triode, and saturation regions). Use the provided graph for labeling; no need to draw a new graph.

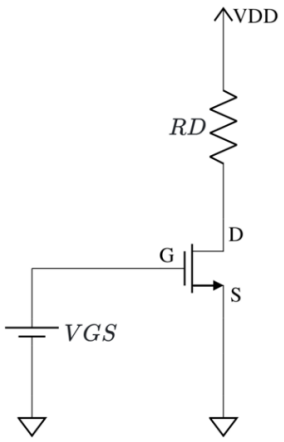


Name: _____ USC ID#: _____

Question 12 (5 points)

An NMOS is arranged in the configuration shown below. Calculate the voltage across the resistor RD and the current through RD. Use the following parameters for your calculations:

VDD = 8V, VGS = 3V, VTh = 1V, RD = 1KΩ, and $\frac{\mu n \cdot Cox \cdot Z}{2L}$ = 0.2 $\frac{mA}{V^2}$.



$$I_D = \frac{Z\mu_n}{L} C_{ox} \left[(V_G - V_T) V_{DS} - \frac{V_{DS}^2}{2} \right] \quad \text{Linear}$$

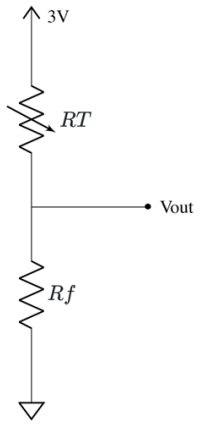
$$I_{D,sat} = \frac{Z \mu C_{ox}}{2L} (V_G - V_T)^2 \quad \text{Saturation}$$

Name: _____ USC ID#: _____

Section C (25 points)

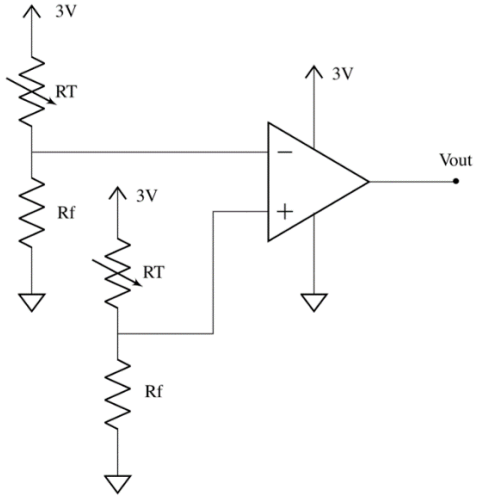
Question 13 (4 points)

The circuit below includes a thermistor. Solve the equation for RT (thermistor resistance). The solution should be expressed as a function of V_{out}.



Question 14 (3 points)

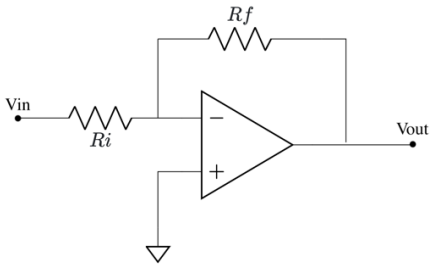
An operational amplifier (Op-Amp) is connected to two distinct resistor networks as illustrated below. Calculate the output voltage (Vout). Assume that the amplification factor (A) is equal to 1.



Name: _____ USC ID#: _____

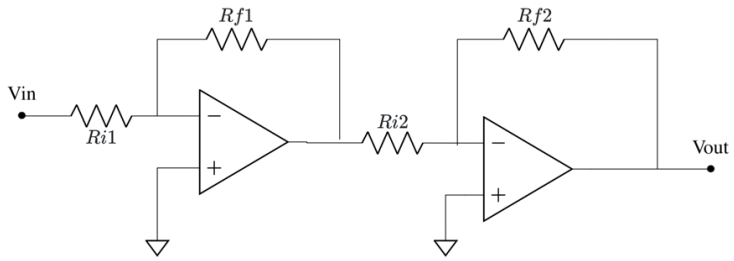
Question 15 (4 points)

An operational amplifier (Op-Amp) is connected with resistors as shown below. Derive the expression for the output voltage (Vout) in terms of the input voltage (Vin).



Question 16 (6 points)

Two operational amplifiers (Op-Amps) are connected in a cascaded configuration as illustrated in the circuit below. Derive the expression for the output voltage (Vout) in terms of the input voltage (Vin).



Name: _____ USC ID#: _____

Question 17 (3 points)
Remember the oximeter from your demo board used during the class? Identify all the systems involved in capturing data from the physical world and displaying it on a computer. Fill in the provided blank blocks to complete the system diagram.

Question 18 (3 points)
Using the provided information, calculate the oxygenation (SpO2) of the person:
Red_{AC} = 40mV, Red_{DC} = 600mV, NIR_{AC} = 20mV, and NIR_{DC} = 300mV
SpO_2 = 110 – 25 x ROS, determine if the person requires supplemental oxygen based on the calculated SpO2?

Question 19 (2 points)
How many LEDs are required for the oximeter with oxy- and dexoy-hemoglobin optical absorbance depicted in the graph? Explain your rationale.