Name PID

UNIVERSITY OF CALIFORNIA, SAN DIEGO

Electrical and Computer Engineering Department

ECE 65 – Spring 2022

Components and Circuits lab

Final Exam

- Closed books, four double-sided cheat sheets, and calculators are allowed
- Electronic devices are not allowed.
- Please put all answers in the provided sheets.
- You can use the back of every page as a scratch paper.
- Please submit your handwritten solutions to Gradescope by 2:40 pm.

Please do not begin until you are told to do so.

Show your work and good luck!

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Problem 1.

Design an op-amp circuit **using only one op-amp** and assuming ideal op-amps to implement the function of

$$v_o = 2v_1 - 2v_2 - 4v_3$$

in which v_1, v_2, and v_3 are three input voltages and v_o is the output voltage.

Show your work.

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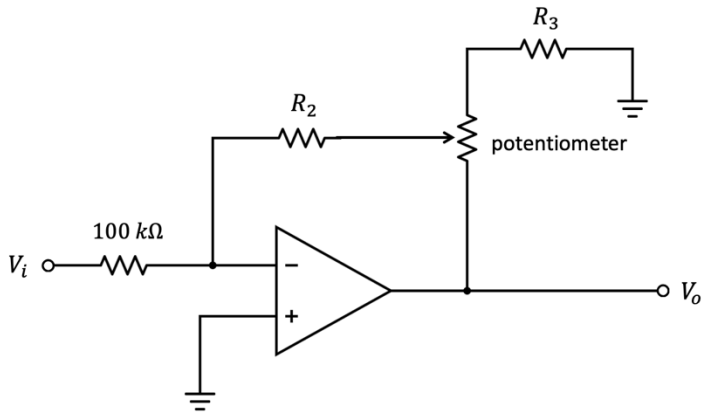
Problem 2.

Design the following circuit (find R_2 and R_3) such that the voltage gain can be varied between $-1\ V/V$ and $-100\ V/V$. Assume that the op-amp is ideal, and you have a $100\ k\Omega$ potentiometer.



Show your work.

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Problem 3.

a) Design a diode circuit to add $+2\ V$ DC shift to a sinusoidal input voltage with peak amplitude of $10\ V$ and frequency of $2\ kHz$. You should use regular PN junction diode(s) **and** Zener diode(s) in your design. Assume $V_{D0} = 0.7\ V$ and $V_Z = 3.3\ V$.

- Drawing the circuit is enough for this part.

b) Find the output at

i. $t = 100\ \mu s$

ii. $t = 450\ \mu s$

- You need to show your work on how you found the output voltage at these two time points.

c) Draw the output waveform for $0 \leq t \leq 1\ ms$.

Show your work.

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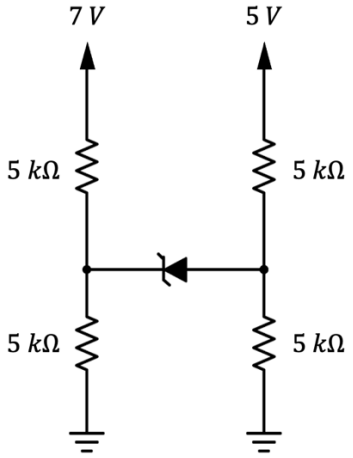
Problem 4

Find the current through the diode and the voltage across it in the below circuit.

Assume $V_{D0} = 0.7\ V$ and $V_Z = 2\ V$.



Show your work.

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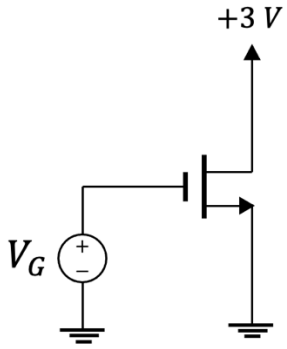
Problem 5

The MOSFET in the below circuit has $V_t = 1\ V$ and $\mu C_{ox}\frac{W}{L} = 1.5\ mA/V^2$, and $\lambda = 0$.



a) Sketch (approximately) the graph of I_D vs V_G with V_G varying in the range of 0 V to 5 V. Label your graph.

b) Write I_D equation(s) for the various portions of the resulting graph.

Show your work.

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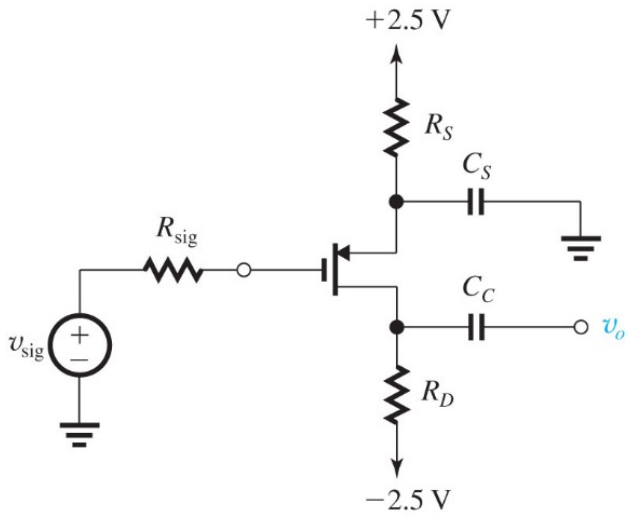
Problem 6.

The MOSFET in the following amplifier circuit has $|V_t| = 0.6\,V$. Neglect the early effect in the bias and signal circuits, and assume the capacitors are short for the signal circuit.

a) Find R_S and R_D to bias the transistor at $I_D = 0.3\,mA$ and $V_{OV} = 0.4\,V$ and achieve the voltage amplifier gain of $A_V = -12\,V/V$. (Capacitors are short for the signal circuit)

b) Find the largest $\hat{v}_{sig}$ ($\hat{v}_{sig}$ shows the peak amplitude of the sinusoid v_{sig}) that the amplifier can handle while remaining in the saturation region. Find the peak amplitude of the corresponding signal at the output?

c) If $\hat{v}_{sig}$ is limited to 10 mV, what value can R_D be increased to while maintaining saturation region operation (R_S does not change)? What is the new value of A_V?



Show your work.

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