

# Intro to ECSE

## Quiz 2

Fall 2023

<b>1.</b>	<b>/12</b>
<b>2.</b>	<b>/13</b>
<b>3.</b>	<b>/8</b>
<b>4.</b>	<b>/15</b>
<b>Total</b>	<b>/48</b>

Name \_\_\_\_\_

RIN \_\_\_\_\_

Section \_\_\_\_\_

Notes:

**SHOW ALL WORK. BEGIN WITH FORMULAS, THEN SUBSTITUTE VALUES AND UNITS.** No credit will be given for numbers that appear without justification.

Use the backs of pages if there is not enough room on the front.

For partial credit on some questions, you may want to re-draw circuit diagrams as you simplify the circuits.

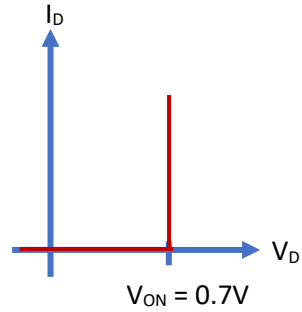
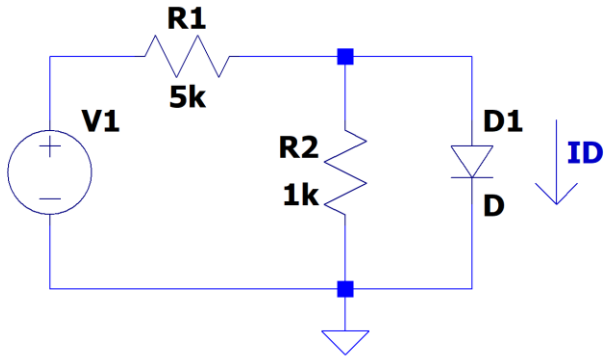
Many problems can be solved using more than one method. check your answers by using a second method.

At least skim through the entire quiz before you begin and then start with the problems you know best. The proctor will only answer clarification questions where wording is unclear or where there may be errors/typos. No other questions will be responded to.

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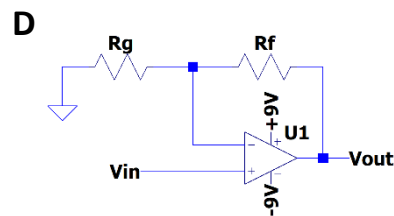
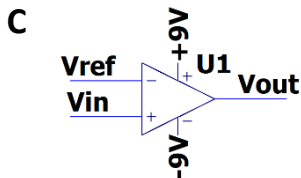
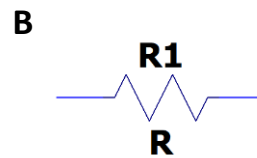
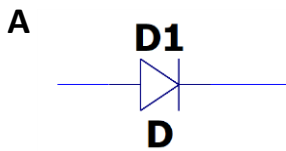
**Problem 1 [12 Points]: Miscellaneous Concepts and Short Answer Questions**

1.1 [2 pts] What is the minimum value of  $V_1$  that will cause current to flow through the diode such that  $I_D > 0$ ? Assume the simple ideal diode model and  $V_{ON} = 0.7V$ .



$$V_1 \geq \underline{\hspace{2cm}} V$$

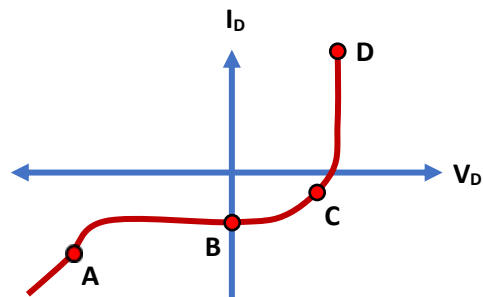
1.2 [2 pts] Which of the following circuit blocks or elements are always considered to be functionally non-linear? Circle all that apply. *Note: this means without applying any techniques to make them look linear.*



1.3 [2 pts] Which of the following are true about measuring currents and voltages? Circle all that apply.

- a) When measuring **current**, the multimeter is placed in **series** with the circuit element whose current you want to measure.
- b) When measuring **current**, the multimeter is placed in **parallel** with the circuit element whose current you want to measure.
- c) When measuring **voltage**, the multimeter is placed in **series** with the circuit element whose current you want to measure.
- d) When measuring **voltage**, the multimeter is placed in **parallel** with the circuit element whose current you want to measure.

1.4 [2 pts] Shown below is the IV characteristic of a fictional device. Where is the differential resistance  $R_{diff}$  approximately zero? Circle all that apply.



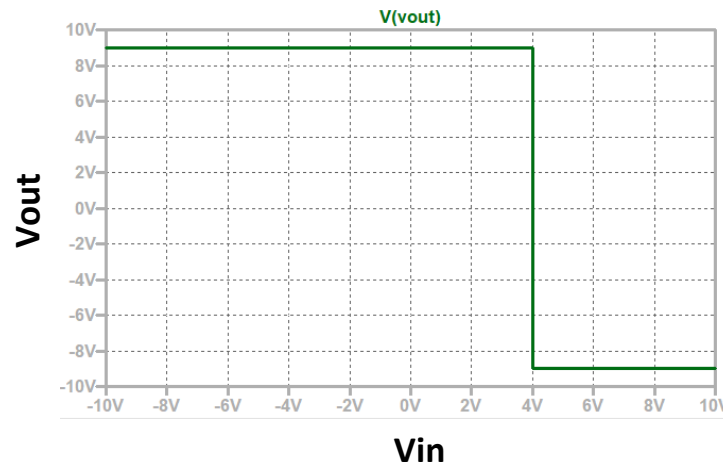
Point A

Point B

Point C

Point D

1.5 [4 pts] The transfer characteristic for a comparator circuit is shown below. Using the transfer characteristic, answer the following questions:



- i. Which type of comparator is this?
  
  
  
  
  
  
  
  
  
  
- ii. What is the reference voltage for this comparator?
  
  
  
  
  
  
  
  
  
  
- iii. What is the  $V_{s^+}$ , the positive (or larger) supply voltage for the comparator?
  
  
  
  
  
  
  
  
  
  
- iv. What is the  $V_{s^-}$ , the negative (or smaller) supply voltage for the comparator?

**Problem 2 [13 Points]: Nodal Analysis**

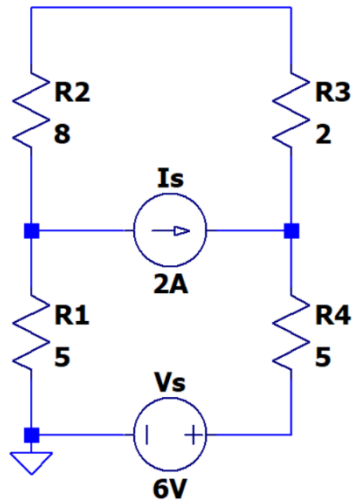


Figure 1

- [2 pts] How many voltage nodes in total (both known and unknown) are in this circuit? Label them on the circuit schematic.
- [2 pts] Which of these nodal voltages are already known (if any)? Write their numerical values on the circuit schematic.
- [2 pts] How many linearly independent equations are needed to solve for all unknowns in this circuit?

d. [3 pts] Write down the KCL equation for each node in terms of the nodal voltages you labeled on the schematic in 1.a and 1.b.

e. [4 pts] Write the equations from 1.d in matrix form with numerical values for circuit elements inserted (i.e. numbers for all resistances, known voltages, and known currents). You do not need to numerically solve the matrix equation.

### Problem 3 [8 Points]: Superposition

Solve for  $V_{R1}$ , the voltage across  $R1$ , in the circuit below *using the superposition method* of circuit analysis.

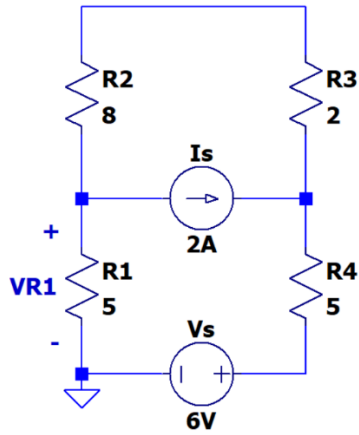


Figure 2

- a. [3 pts] Find  $V_{R1_{V_s}}$ , the voltage across  $R1$  due to  $V_s$  only.

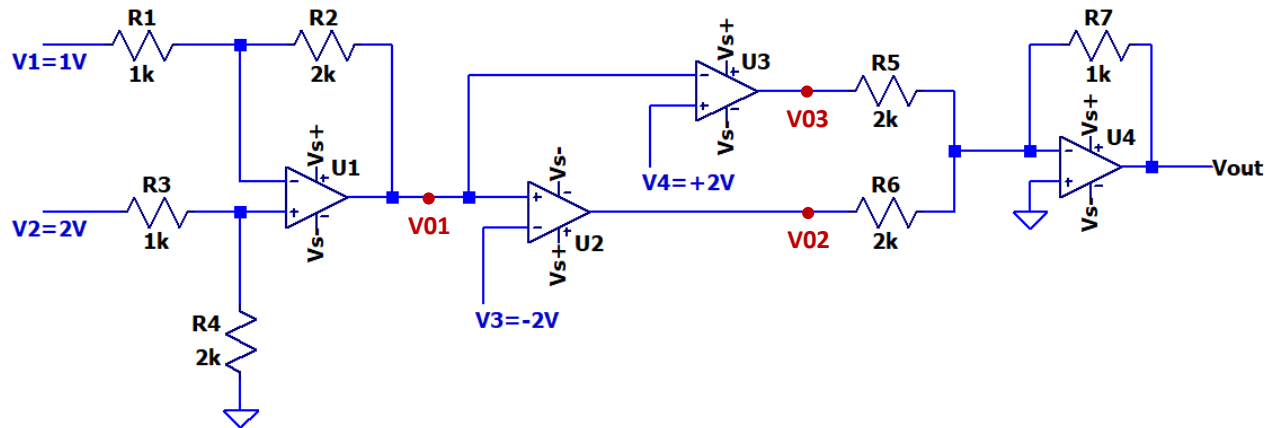
b. [3 pts] Find  $VR_{1I_s}$ , the voltage across R1 due to  $I_s$  only.

c. [2 pts] Using  $VR_{1V_s}$  and  $VR_{1I_s}$ , find  $VR_1$  as indicated in Figure 2 above.



**Problem 4 [15 Points]: Cascaded Op-Amp Circuit**

Determine the value of  $V_{out}$ . The supply voltages  $V_{s+}$  and  $V_{s-}$  for the op-amps are  $+5V$  and  $-5V$ .



a. [3 pts] Identify how many stages are in this op-amp circuit. Draw a box around each stage and label them "Stage 1", "Stage 2", etc.

b. [4 pts] Label each stage of the circuit with what type of circuit it is. *Note:* for all stages, be sure to specify if it is "non-inverting" or "inverting" when applicable.

c. [4 pts] For each stage, write the transfer function as a numerical value. In cases in which a transfer function cannot be written for a stage, state this clearly, and write the expression for the output voltage of that stage in terms of the input voltage instead. *Hint:*  $V_{in}$  for a stage may be the sum or difference of two voltages; in this case, also state what you consider to be  $V_{in}$  for that stage.

d. [4 pts] Calculate  $V_{out}$ .

- e. [4 pts] Bonus: Write the expression for  $V_{out}$  in terms of  $V_1$  and  $V_2$  in general. In your own words, what is the function of this circuit (overall, what does it do)?