

Intro to ECSE

Quiz 1 Solutions

Fall 2024

1.	/10
2.	/14
3.	/16
Total	/40

Name _____

RIN _____

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. Work through a problem in terms of variables, then substitute numerical values when you are ready to solve it.

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.

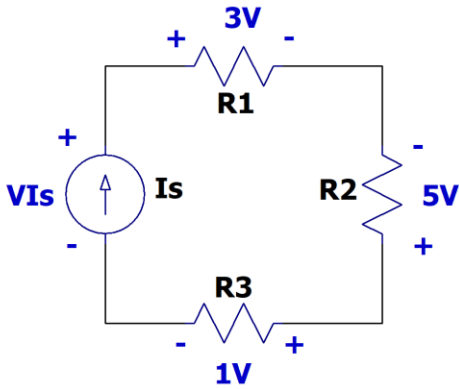
Problem 1 [10 pts]: Proof of Skills and Electric Circuit Concepts

- a) [2 pts] True or False: Ohm's law governs the relationship between voltage and current for ALL types of circuit elements. Circle one:

True

False

- b) [2 pts] KVL: Determine the voltage drop across the current source V_{I_s} in the circuit below.



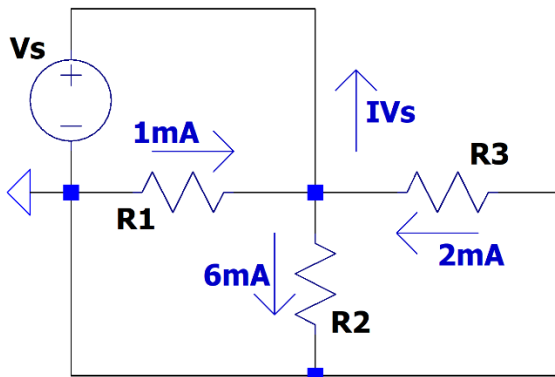
$$-V_{I_s} + 3V - 5V + 1V = 0$$

$$-V_{I_s} = 1V$$

$$V_{I_s} = -1V$$

$$V_{I_s} = -1V$$

- c) [2 pts] KCL: Determine the current flowing through the voltage source I_{V_s} in the circuit below.



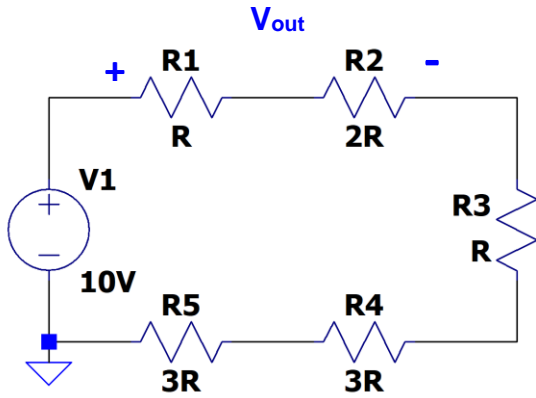
$$1mA - I_{V_s} + 2mA - 6mA = 0$$

$$-I_{V_s} = 3mA$$

$$I_{V_s} = -3mA$$

$$I_{V_s} = -3mA$$

d) [2 pts] Voltage Dividers: Calculate V_{out} in the circuit below.

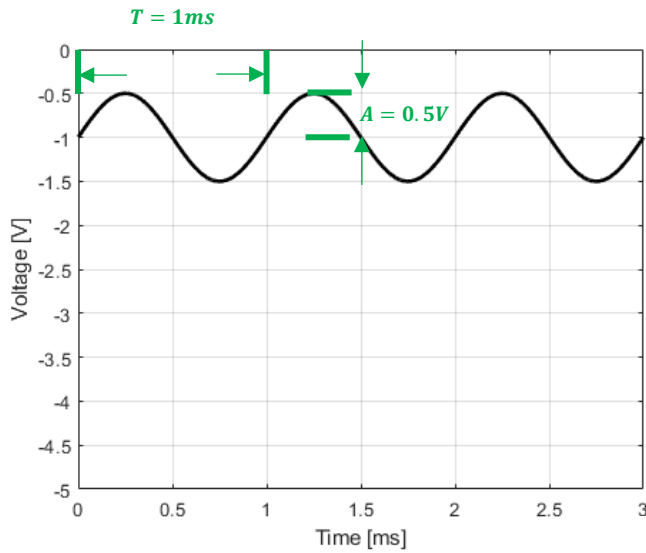


$$V_{out} = V_1 \frac{R1 + R2}{R1 + R2 + R3 + R4 + R5}$$

$$= V_1 \frac{3R}{10R} = 10V * \frac{3}{10} = 3V$$

$V_{out} = 3V$

e) [2 pts] Determine the *amplitude* and *frequency* of the sinusoidal voltage measurement below.



$$f = \frac{1}{T} = \frac{1}{1 \times 10^{-3}s} = 1000 \text{ Hz}$$

Frequency: **1000 Hz**

Amplitude: **0.5 V**

Problem 2 [14 pts]: Circuit Analysis – Circuit Reduction Method

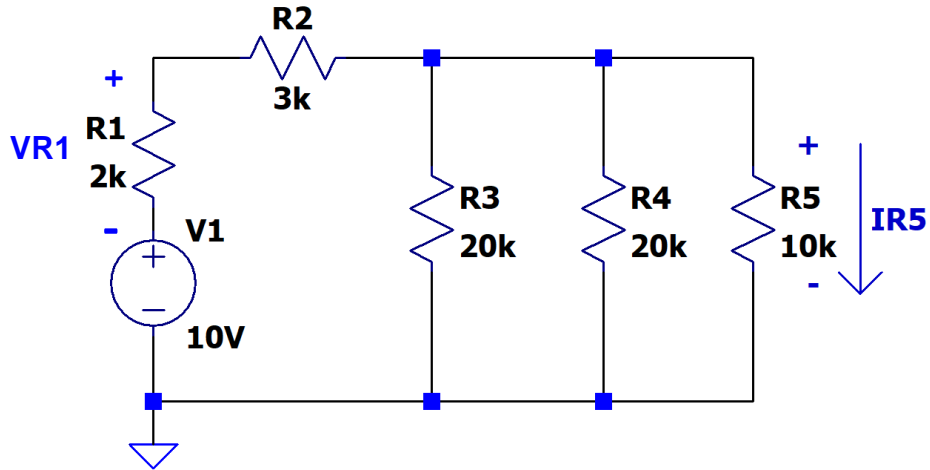


Figure 1

- a) [2 pts] In the circuit above, which resistors are in *series* with each other? Do not combine resistors before answering this question.

Resistors in series:

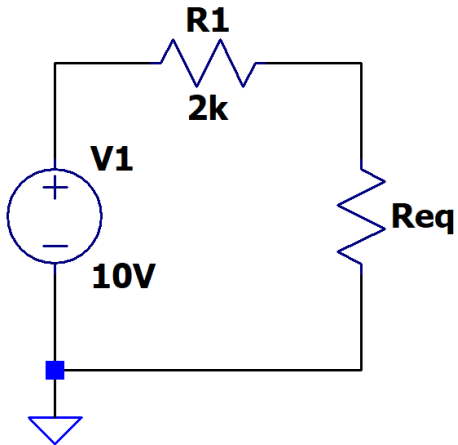
R_1 and R_2

- b) [2 pts] In the circuit above, which resistors are in *parallel* with each other? Do not combine resistors before answering this question.

Resistors in parallel:

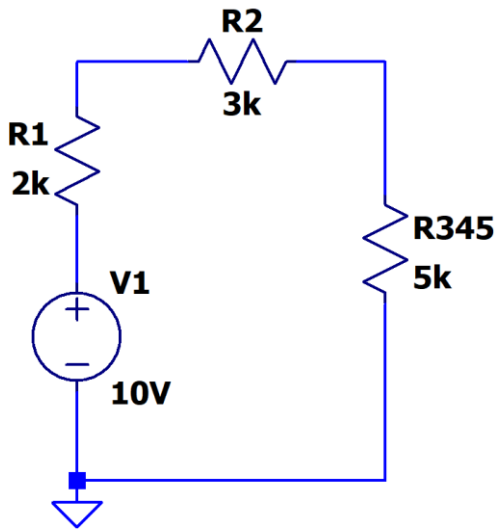
R_3 , R_4 and R_5

- c) [4 pts] Using the circuit reduction method, calculate the value of R_{eq} , so that the circuit in Figure 1 is simplified to the circuit shown below. Redraw your circuit for each step of the circuit reduction process for full credit.



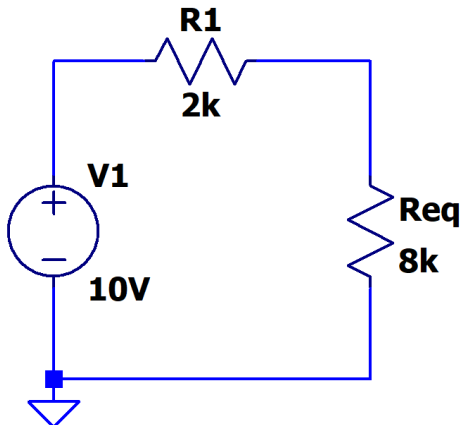
Combine R3, R4 and R5 in parallel:

$$R_{345} = R3 || R4 || R5 = \frac{1}{\frac{1}{10k\Omega} + \frac{1}{20k\Omega} + \frac{1}{20k\Omega}} = 5k\Omega$$



Combine R345 and R2 in series:

$$R_{eq} = R_{345} + R2 = 5k\Omega + 3k\Omega = 8k\Omega$$



$$R_{eq} = 8k\Omega$$

d) [3 pts] Calculate V_{R1} , the voltage drop across resistor $R1$ in Figure 1.

$$V_{R1} = V_1 \frac{R1}{R1 + R_{eq}} = 10V \frac{2k\Omega}{2k\Omega + 8k\Omega} = 2V$$

$$\mathbf{V_{R1} = 2V}$$

e) [3 pts] Calculate I_{R5} , the current flowing through resistor $R5$ in Figure 1.

$$V_{R345} = V_{R5} = V_1 \frac{R345}{R1 + R2 + R345} = 10V \frac{5k\Omega}{2k\Omega + 3k\Omega + 5k\Omega} = 5V$$

$$I_{R5} = \frac{V_{R5}}{R5} = \frac{5V}{10k\Omega} = 0.5mA$$

$$\mathbf{I_{R5} = 0.5mA}$$

Problem 3 [16 pts]: Circuit Analysis – KVL/KCL/Ohm’s Law Method

You **must** solve this problem using the KVL/KCL/Ohm’s Law method to receive full credit (no circuit reduction).

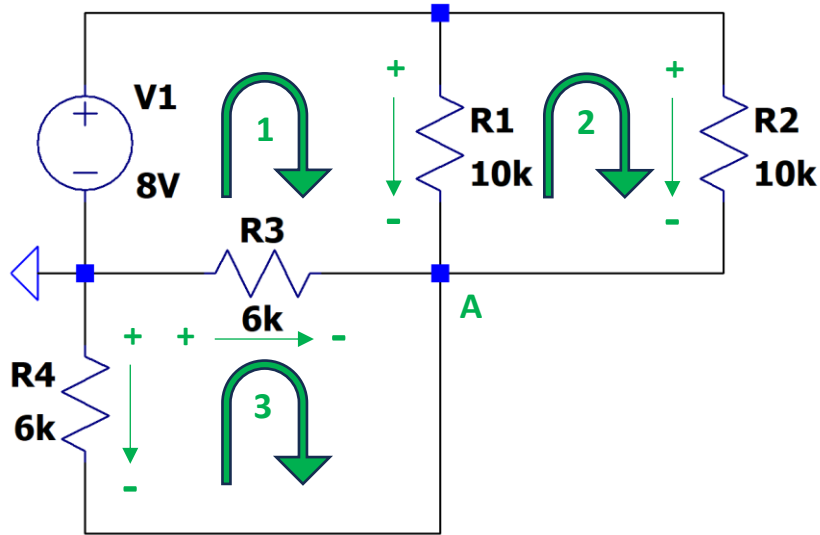


Figure 2

- a) [2 pts] Draw reference marks on your circuit diagram. See diagram.
- b) [2 pts] How many unknowns are in this circuit? Do not combine resistances.

Number of unknowns:
4 unknowns

- c) [2 pts] How many *good* nodes are there in the circuit? Label them on the circuit diagram and write the label names of the good nodes in the box below.

Number of good nodes: 1	Names of good nodes: A
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- d) [2 pts] How many *good* loops are there in the circuit? Label them on the circuit diagram and write the label names of the good loops in the box below.

Number of good loops: 3	Names of good loops: 1, 2, 3
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- e) [4 pts] Write the linearly independent equations that will solve for all unknowns in the circuit in terms of **current** – the final form for each of your equations *must* be expressed in terms of current. Leave your equations in terms of variables.

KVL: Loop 1: $-V_1 + V_{R1} - V_{R3} = 0 \rightarrow R_1 I_{R1} - R_3 I_{R3} = V_1$

Loop 2: $-V_{R1} + V_{R2} = 0 \rightarrow -R_1 I_{R1} + R_2 I_{R2} = 0$

Loop 3: $-V_{R4} + V_{R3} = 0 \rightarrow R_3 I_{R3} - R_4 I_{R4} = 0$

KCL: Node A: $I_{R1} + I_{R2} + I_{R3} + I_{R4} = 0$

KVL Equations:

$$R_1 I_{R1} - R_3 I_{R3} = V_1$$

$$-R_1 I_{R1} + R_2 I_{R2} = 0$$

$$R_3 I_{R3} - R_4 I_{R4} = 0$$

KCL Equations:

$$I_{R1} + I_{R2} + I_{R3} + I_{R4} = 0$$

- f) [4 pts] Write the equations in matrix form $Ax = b$, giving your final answer in terms of numerical values for circuit elements. *Note:* you do not have to solve the matrix equation to obtain a numerical answer for the unknowns, but you may if you'd like to check your answer. If you do choose to solve the matrix equation, that work will not be graded.

$$A = \begin{bmatrix} R_1 & 0 & -R_3 & 0 \\ -R_1 & R_2 & 0 & 0 \\ 0 & 0 & R_3 & -R_4 \\ 1 & 1 & 1 & 1 \end{bmatrix}, \quad x = \begin{bmatrix} I_{R1} \\ I_{R2} \\ I_{R3} \\ I_{R4} \end{bmatrix}, \quad b = \begin{bmatrix} V_1 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

Matrix A =

$$\begin{bmatrix} 10000 & 0 & -6000 & 0 \\ -10000 & 10000 & 0 & 0 \\ 0 & 0 & 6000 & -6000 \\ 1 & 1 & 1 & 1 \end{bmatrix}$$

Vector x =

$$\begin{bmatrix} I_{R1} \\ I_{R2} \\ I_{R3} \\ I_{R4} \end{bmatrix}$$

Vector b =

$$\begin{bmatrix} 8 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$