BRAC UNIVERSITY
Dept. of Computer Science and Engineering

CSE250L
Circuits and Electronics Laboratory

Student ID:	22299141	**Lab Section:**	16
Name:	Nafisa Hasan	**Lab Group:**	7

Experiment No. 2

Verification of KVL & KCL

Objective

The aim of this experiment is to use multi-loops and various branch circuits to verify Kirchhoff's voltage law (KVL) and Kirchhoff's current law (KCL).

Apparatus

- Multimeter
- Resistors (1 $k\Omega$ x 2, $2.2\ k\Omega$, $3.3\ k\Omega$, $4.7\ k\Omega$).
- DC power supply
- Breadboard
- Jumper wires

Part 1: KVL

Theory

KVL stands for Kirchhoff's Voltage Law, which is a fundamental principle used in electrical engineering and physics. **It states that the sum of all the voltages in a closed loop in a circuit is equal to zero** (Alternatively, it can be said that around any closed circuit the algebraic sum of the voltage rises equals the algebraic sum of the voltage drops).

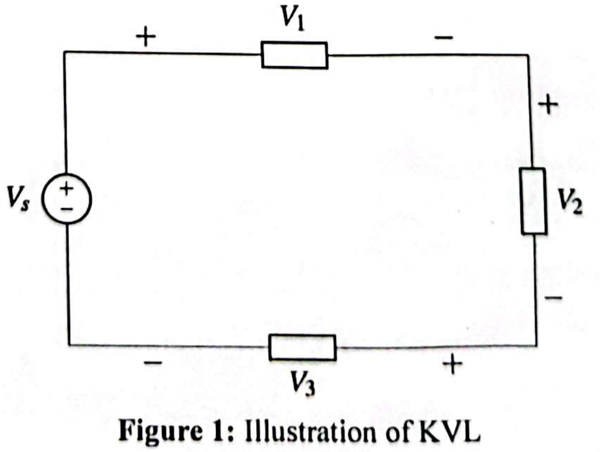

Figure 1: Illustration of KVL

To illustrate KVL, consider Fig. 1. The sign on each voltage is the polarity of the terminal encountered first as we travel around the loop. Let us start with the voltage source and go around the top, then voltages would be $-V_s + V_1 + V_2 + V_3$. Thus, KVL yields,

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Data Tables

Signature of Lab Faculty: Jishnu Mahmud Date: 10/02/24

** *For all the data tables, take data up to three decimal places, round to two, then enter into the table.*

Table 1: Resistance Data

For all your future calculations, please use the observed values only **(even for theoretical calculations).**

Notation	Expected Resistance	Observed Resistance (kΩ)
R_1	1 kΩ	1·001
R_2	2.2 kΩ	2·166
R_3	3.3 kΩ	3·228
R_4	4.7 kΩ	4·56

Table 2: Data for Loop 1 (Left sided loop)

In the following table, V_{R1} is the voltage drop across resistor R_1. Similar syntax applies to remaining resistors. Also, calculate the percentage of error between experimental and theoretical values of $\sum \Delta V$.

Observation	V_{s_1} (V) (from dc power supply)	V_{s_1} (V) (using multimeter)	V_{s_2} (V) (from dc power supply)	V_{s_2} (V) (using multimeter)	V_{R_1} (V)	$\sum \Delta V = -V_{s_1} - V_{R_1} + V_{s_2}$ (V)
Experimental	7	7·02	5	5·05	-1·97	0
Theoretical					-2	0

Absolute error = | ***Experimental value − Theoretical value*** **|**

Here, Absolute error in $\sum \Delta V$ calculation = 0

Table 3: Data for Loop 2 (Right sided loop)

In the following table, V_{R_2} is the voltage drop across resistor R_2. Similar syntax applies to remaining resistors. Also, calculate the percentage of error between experimental and theoretical values of $\sum\Delta V$.

Observation	V_{s_2} (V) (from dc power supply)	V (V) (using multimeter)	V_{R_2} (V)	V_{R_3} (V)	V_{R_4} (V)	$\sum\Delta V = -V_{s_2} + V_{R_2} + V_{R_3} + V_{R_4}$ (V)
Experimental	5	5.05	1.075	1.64	2.33	-5×10^{-3}
Theoretical			1.09	1.12	2.32	0

Here, Absolute error in $\sum\Delta V$ calculation = $\boxed{5\times10^{-3}}$

Questions

1. Let us take a look at Circuit 1 again. If we remove the 5V voltage source (V_{s_2}) from the middle, the remaining circuitry contains only one big loop (often referred to as the outer loop). Let us examine if KVL holds true for the outer loop too.

(a) Do you think KVL will be applicable to the outer loop?

☑ Yes ☐ No

Justify your answer.

The whole loop will traverse based on 7V. KVL will be applicable to the outer loop.

(b) Use the values of V_{R_1}, V_{R_2}, V_{R_3}, V_{R_4}, V_{s_1} from Tables 2 & 3 to verify your answer from the above question.

$$\sum\Delta V = -V_{s_1} - V_{R_1} + V_{R_2} + V_{R_3} + V_{R_4} = \boxed{-5\times10^{-3}}$$

Did KVL hold true for the outer loop?

☑ Yes ☐ No

Here, absolute error in $\sum\Delta V$ calculation = $\boxed{5\times10^{-3}}$

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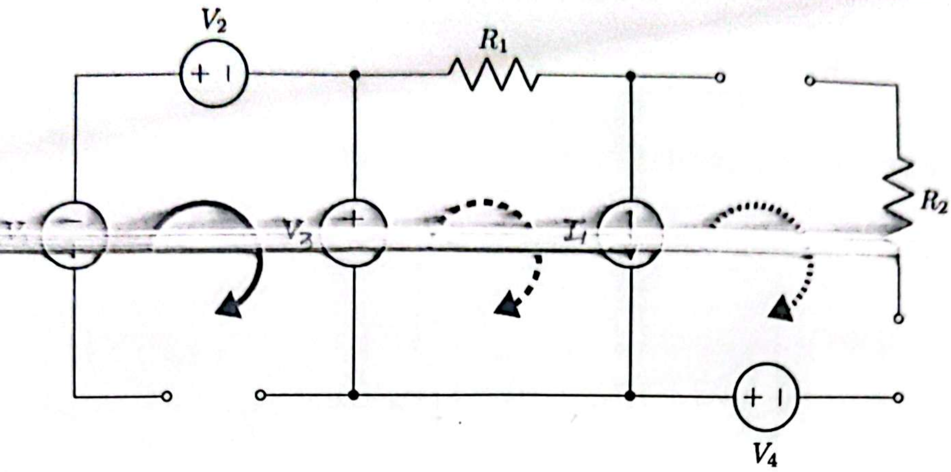
2. For the following circuit,



(a) Which of the pathways in the circuit shown above is/are loop(s)?

☐ path made up of V_1, V_2, V_3, and an open circuit, indicated by the **solid** arrow.

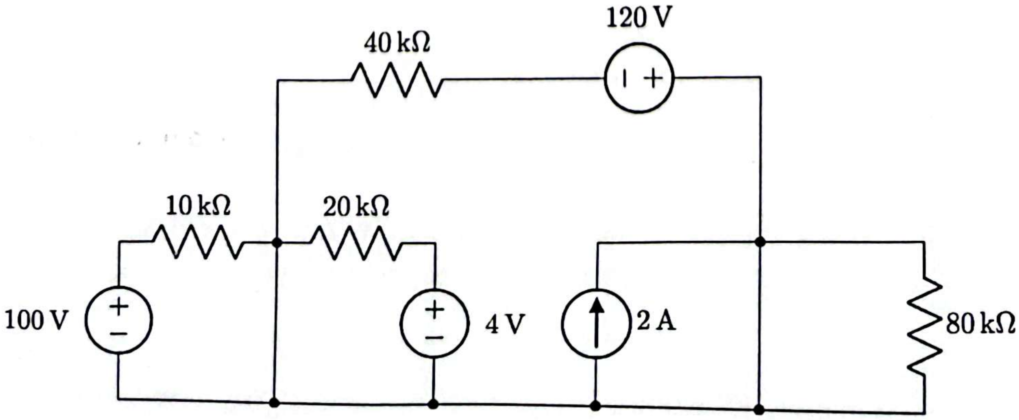
☐ path made up of V_3, R_1, and I_1, indicated by the **dashed** arrow.

☐ path made up of V_4, I_1, R_2 and two open circuits, indicated by the **dotted** arrow.

(b) Based on your choices in (a), how would you define a loop?

A loop is a closed path going through the elements of a circuit. For drawing a loop, selecting any node as a starting point and it will travel every element and come back to its starting point.

3. How many loops can you make for the following circuit? How many of them are 'Dependent' and how many are 'Independent'? [*Hint: identify the nodes and redraw a simplified version of the circuit.*]



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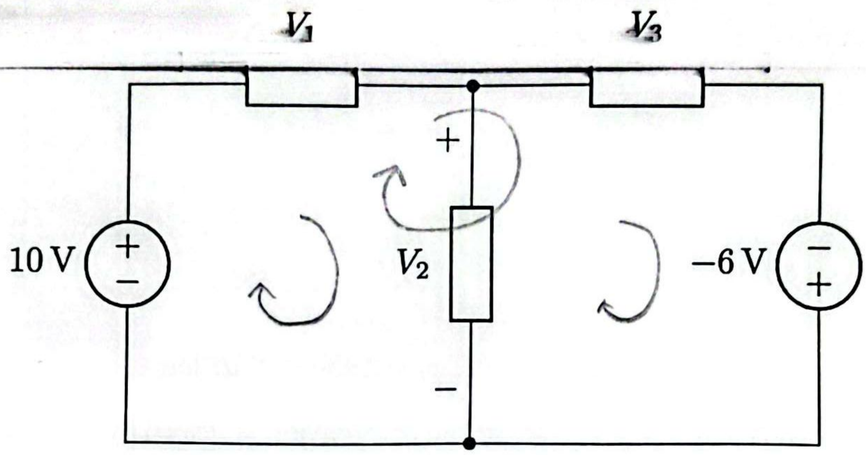
Number of independent loops = 3

Number of dependent loops = 3

4. For the following circuit,



(a) How many loops may KVL be applied along? Mark the loops in the circuit diagram.

3 loops

(b) List all of the equations obtained by applying KVL along the number of loops mentioned in (a).

$V_1 + V_2 - 10 = 0$ —— (I)

$-V_3 + 6 - V_2 = 0 \Rightarrow V_2 + V_3 - 6 = 0$ —— (II)

$V_1 - V_3 - 4 = 0$ —— (III)

(c) Can you observe any relationship among the equations? Is it possible to deduce any equation from the others? If so, show the deduction.

They donot have a common relationship and thus any equation can't be deduced from them.

(d) Now, have you been able to solve the simultaneous equations to get V_1, V_2, and V_3?

☐ Yes ☑ No

If yes, what are they? If not, why are the equations not solvable and what is your conclusion?

It is not possible to solve the equations.

Part 2: KCL

Theory

KCL stands for Kirchhoff's Current Law, which is another fundamental principle used in electrical engineering and physics. It states that the total current entering a node in a circuit must equal the total current leaving the node. In other words, KCL states that the algebraic **sum of currents entering and exiting a node is equal to zero.** This law is also essential for analyzing circuits and predicting the behavior of electrical systems.

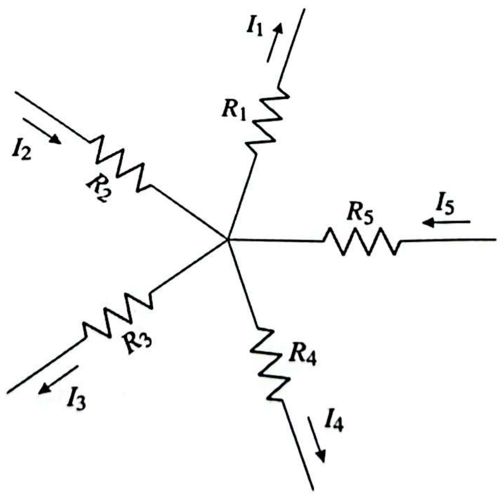


Figure 2: Illustration of KCL

To illustrate KCL, consider Fig. 2. Here, we can see 5 branches connected to 1 node. The exiting currents are I_1, I_3, I_4 and the entering currents are I_2, I_5. Applying KCL gives,

$$\Sigma i = I_1 + (-I_2) + I_3 + I_4 + (-I_5) = 0$$

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Data Tables

Signature of Lab Faculty: Jishnu Mahmud **Date:** 10/02/24

** ***<u>For all the data tables, take data up to three decimal places, round to two, then enter into the table.</u>***

Table 4: Resistance Data

For all your future calculations, please use the observed values only **(even for theoretical calculations).**

Notation	Expected Resistance	Observed Resistance (kΩ)
R	1 kΩ	
R_1	1 kΩ	
R_2	2.2 kΩ	
R_3	3.3 kΩ	

Table 5: Data from Circuit 2

In the following table, I_1 is the current through resistor R_1. Similar syntax applies to remaining resistors. The voltage supplied to the complete circuit is denoted by V_s and the current being supplied to the whole network is denoted as I_s.

Observations	V_s (V) (from dc power supply)	V_s (V) (using multimeter)	V_R (V)	$I_s = \frac{V_R}{R}$ (mA)	V (V)	$I_1 = \frac{V}{R_1}$ (mA)	$I_2 = \frac{V}{R_2}$ (mA)	$I_3 = \frac{V}{R_3}$ (mA)	$\Sigma i = -I_s + I_1 + I_2 + I_3$ (mA)
Experimental	5	5.04	3.22	3.22	1.83	1.83	0.86	0.56	0.03
Theoretical			3.22	3.22	1.81	1.87	0.842	0.558	0

Here, Absolute error in $\sum i$ calculation = 0.03

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Questions

5. Kirchoff's current law (KCL) states that *the algebraic sum of branch currents flowing into and out of a node is equal to zero*. This is a consequence of another principle.

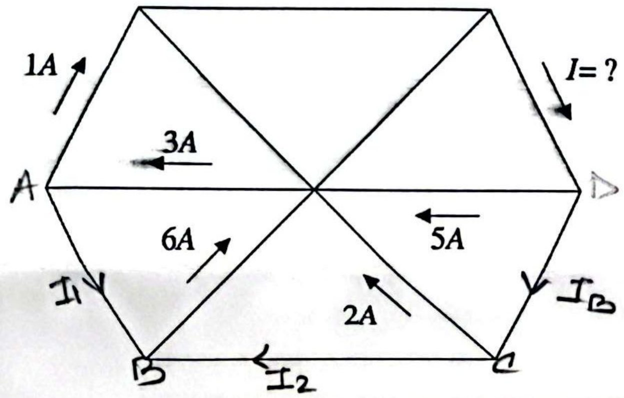
   Which principle is it?

   ☐ Conservation of Energy ☑ Conservation of Electric Charge ☐ None of them

   Why is your selection valid?

   The total current or charge entering a node must be equal to the total current or charge leaving the node.

6. Using KCL, determine the current *I* for the following circuit.



at A, $-1+3+I_1=0$ $\therefore I_1 = -2$ (leaving)

at B, $2-6+I_2=0$ $\therefore I_2 = 4$ (entering)

at C, $-4-2+I_3=0$ $\therefore I_3 = 6$ (entering)

at D, $-6+5+I=0$ $\therefore I = 11$

$\therefore I = 11A$

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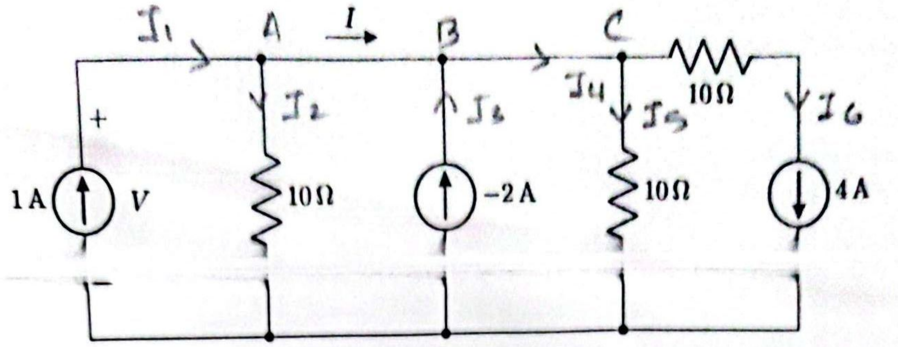
7. For the following circuit, determine the current I using only KCL and Ohm's Law.



Here, $I_2 = I_5 = \frac{V}{10}$

KCL at A,

$I_1 - I - I_2 = 0$

$\therefore I = 1 - V/10$ —(1)

KCL at B,

$I + I_3 - I_4 = 0$

$I_4 = I - 2$ —(11)

KCL at C,

$I_4 - I_5 - I_6 = 0$

$I_4 = V/10 + 4$

$I - 2 = V/10 + 4$

$I - 2 = 1 - I + 4$

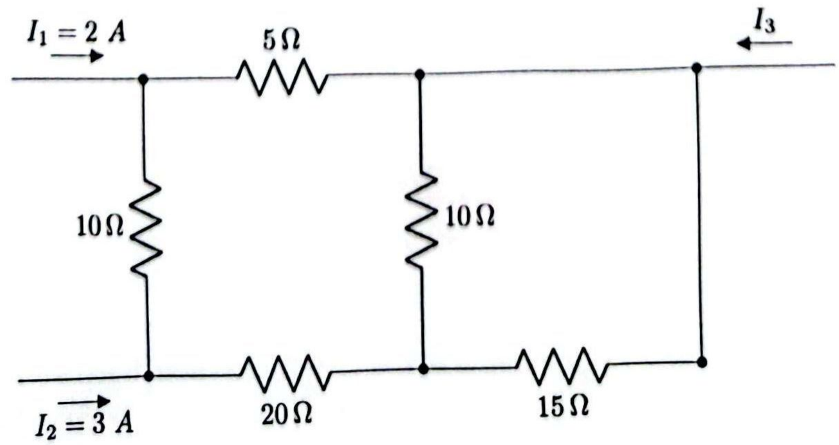
$\therefore I = 3.5A$

8.

(a) "KCL must always be applied at a node". The statement is-

☑ True ☐ False

(b) Using KCL only, determine the value of I_3 if $I_1 = 2\ A$ and $I_2 = 3\ A$ in the circuit shown below.



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Since, I_1, I_2 & I_3 all of them entering the circuit. According to KCL,

$$I_1 + I_2 + I_3 = 0$$

$$2 + 3 + I_3 = 0$$

$$I_3 = -5A$$

Report

1. Fill up the theoretical parts of all the data tables.
2. Answer to the questions.
3. Discussion *[your overall experience, accuracy of the measured data, difficulties experienced and your thoughts on those]*. Start write from below the line.

Discussion :

The practical application of theoretical circuit analysis proves that the experiment offered was educational. The measured values almost alligned with the expected values. Designing the appropriate circuits and ensuring precise connections required careful attention to the details.

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