Name: ____________________
Date: ____________________
Course ____________________
Instructor: ____________________

DC EXPERIMENT 5

Kirchhoff's laws

OBJECTIVES

1. Understand the basics of Kirchhoff's current and voltage law through experiments
2. Gain more practical skills on building circuits on breadboard

EQUIPMENT REQUIRED

Instruments	Components	Tools
Power Supply Digital Multimeter	3.3kΩ Resistor × 1 1kΩ Resistor × 3	Breadboard Conducting Wires Wire Stripper

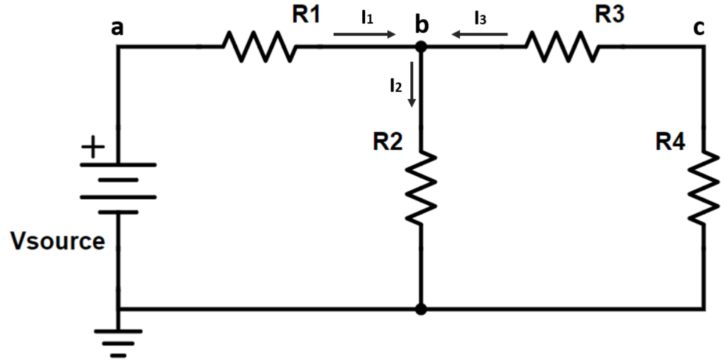
EQUIPMENT ISSUED

Check if your group has been issued with the instruments listed above. Note down the manufacturer model number for the instrument you used (if you don't know where to find it, ask your instructor). Also, note down your lab group number.

Item	Manufacturer Model #	Lab Group #
Power Supply [MEGO] Digital Multimeter [ZOYI]		

THEORY

A node is a junction where more than two elements are connected. Therefore strictly, 'a' and 'c' are not nodes. According to Kirchhoff's current law, for at any node in a circuit, the algebraic sum of all currents entering that node equals to 0. For example, at node 'b' in Figure 1, the sum of I_1, I_2 and I_3 is zero. The reason for I_2 being negative is that it exits from node 'b'.

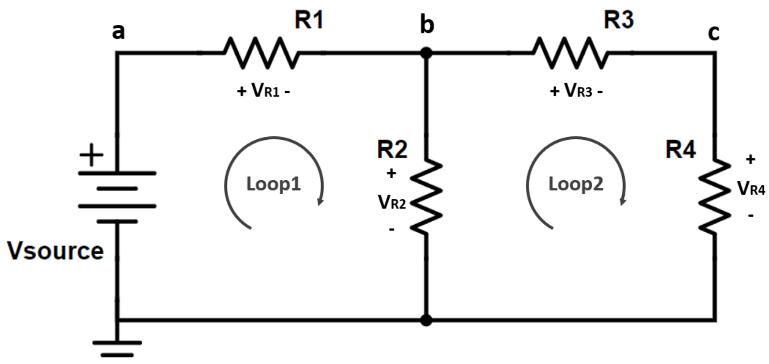


Node b:

$$i_1 + (-i_2) + i_3 = 0$$

Figure 1:

A loop is a closed path in a circuit. Kirchhoff's voltage law states that at for any loops in a circuit, the algebraic sum of all voltages in this loop is zero. In Figure 2, the voltages for loop1 and loop2 all summed to zero. The negative signs are because of being opposite in direction of the loop arrow. If loop direction of (-, +) is defined as positive, then (+, -) will be negative.



Loop1:

$$V_{source} + (-V_{R1}) + (-V_{R2}) = 0$$

Loop 2:

$$V_{R2} + (-V_{R3}) + (-V_{R4}) = 0$$

Figure 2:

OVERVIEW

Kirchhoff's laws are fundamental concepts in circuits, and it can be extended to practical circuit analysis techniques. These techniques are usually taught in Electrical Circuits under university/college curriculum. Here, the goal for this lab is to help you perceive Kirchhoff's laws from experimental perspective and get a general sense of how to deal with more complicated circuits.

PROCEDURE

1. The circuit to be implemented is shown in Figure 3. You will need to measure voltages and currents, take a minute to think about how to implement the circuit on your breadboard.

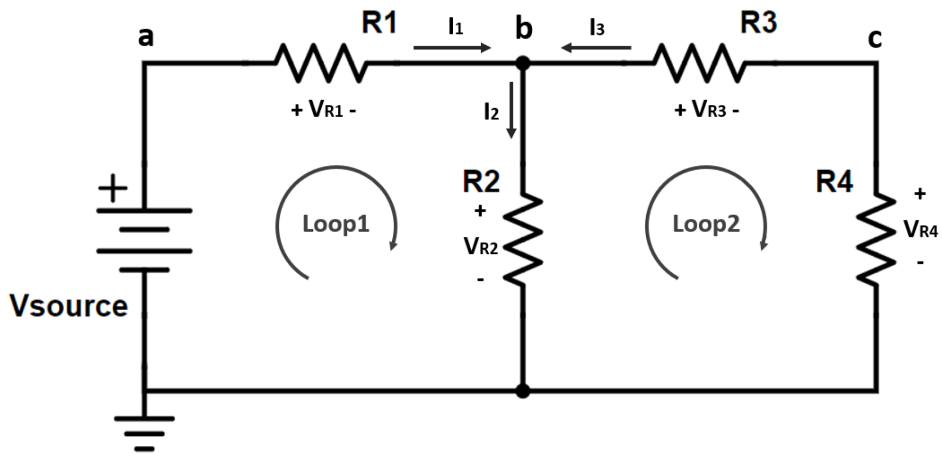


Figure 3: Circuit diagram

2. Now starting to construct the circuit. For resistors, use the following values: R1=R3=R4=1kΩ, R2=3.3kΩ. Set power supply output voltage to 9V. The suggested breadboard connection is shown in Figure 4.

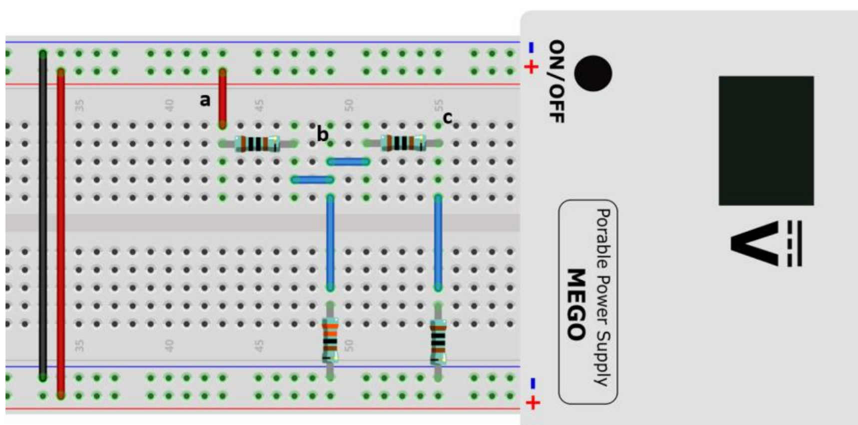


Figure 4:

3. Set the DMM in DC voltage mode and measure V_{source}, V_{R1}, V_{R2}, V_{R3} and V_{R4}. Then record measurement results in Table 1 column 2. Watch out the polarity while measuring ('+' goes to Red terminal, '-' goes to Black terminal.

4. Set the DMM in [mA] current mode and replace the blue jumper wires to measure I_1, I_2 and I_3. Watch out the polarity while measuring ('arrow tail' goes to Red terminal, 'arrow head' goes to Black terminal). Record measurement results in Table 1 column 4. [Note: some results could be negative].

TABLE 1

Step 3	Voltage (V)	Step 4	Current (mA)
V_{source}		I_1	
V_{R1}		I_2	
V_{R2}		I_3	
V_{R3}			
V_{R4}			

EXERCISES

1. Using the voltage measurement results from Table 1, write the KVL equation for loop 1 and loop 2. Substitute your measured voltages in your equations and see if the results are close enough to zero. Are your experimental results good enough to verify KVL?

2. Write the KVL equation for the outer loop, namely $V_{source} \rightarrow a \rightarrow b \rightarrow c \rightarrow$ground. Also, substitute your measured voltages in your KVL loop equation, is this result valid?

3. Using the current measurement results from Table 1, write the KCL equation at node b. Is your result valid (sums up to zero)?

4. The sentence “Ruler A is 10cm longer than Ruler B” is mathematically equivalent to the sentence “Ruler A is –10cm shorter than Ruler B”. This concept can be used to illustrate how to determine the current directions in a circuit.

   In Figure 3 circuit diagram, the current directions of I_1, I_2 and I_3 are arbitrarily assigned. To determine the actual current direction, you must look at the numerical result of the calculation or measurement. For example, if the measurement value is positive, then the assigned current is in the same direction of the actual current, and vise versa. In Table 2, determine the actual current flow through each element the circuit.

TABLE 2

Element	Assigned Current Direction	Measured Current Value (mA)	Actual Current Direction
Vsource	Ground to a		
R1	a to b		
R2	b to ground		
R3	c to b		
R4	ground to c		