Exp. No. 6:
Kirchhoff's Rules

Objective:

To verify ***Kirchhoff's rules*** applied to ***a two-loop circuit.***

Equipment:

Three carbon resistors **(R_1= 200, R_2= 300, and R_3 = 120 ohms)**, two-terminal dc power supply **(5 V and 10 V)**, multi-meters, a calculator, and a few connecting wires with alligator clips

Theory:

To solve for unknown currents in multi-loop circuits**, we use** Kirchhoff's ***rules.*** There are two rules:

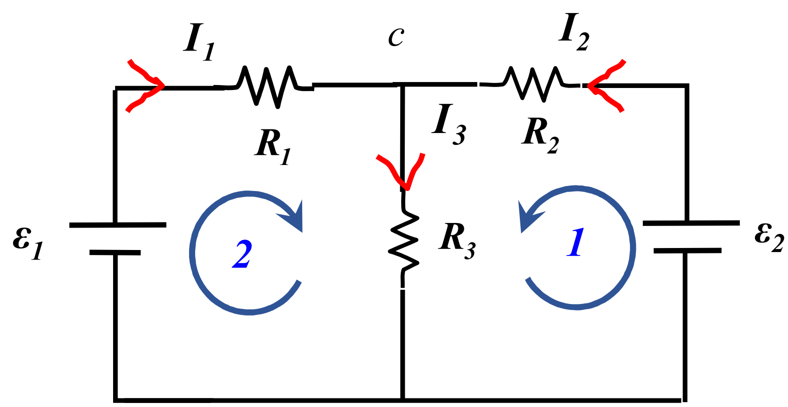


Fig.1: Two-loop Circuit

(a) Kirchhoff's Junction Rule or current rule

"The sum of currents going toward a junction is equal to the sum of currents leaving that junction." In other words,

$$\sum \mathbf{I}_{\text{in}} = \sum \mathbf{I}_{\text{out}}$$ (Due to the Conservation of charge)

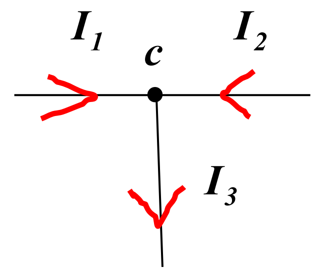
the algebraic sum of currents to and away from a junction is zero.

A *junction* is a *point of connection of 3 or more wires*. At the *Junction c in Fig. 1.* *I_1 and I_3 leaves Junction c* and is given a (-) sign. *I_2 go toward Junction c,* it is given (+) sign.

$$I_3 = I_1 + I_2 \qquad (1)$$

(b) Kirchhoff's Loop Rule

This rule states that ***"the sum of voltage jumps and drops across the elements of any closed loop is zero."***



$$I_3 = I_1 + I_2$$

Fig.2

Kirchhoff's Current Rule at the Junction c

$$\sum_{\substack{colsed\\loop}} \Delta V = V_{cc}$$ (Conservation of energy)

Voltages due to the battery ***V,*** we write the voltage across that resistor as the product ***RI.***

1) Rule for Batteries*:** As we trace a closed loop in either direction, if we go from (-) to (+) ***across a battery, it is a voltage jump and we write ***+ε*** for that battery**.** If we happen to go from (+) to (-) of it, it is a voltage drop and we write it as ***-ε*.**

2) Rule for Resistors*:** *If we trace in the direction of I, we write* ***-RI (a voltage drop) across resistor R, *and if our tracing direction opposes I, we write* ***-RI (a voltage jump) across resistor R.***

"***voltage jump*" means *higher voltage*** , then write the product ***RI*** with a (**+**) sign**.** ***If our trace direction agrees with the assumed current I***, it is ***like losing potential*** and the product ***RI deserves a (-) sign, "voltage drop".***

For the circuit shown in Figure 1:

For loop (1) $\sum_{c} V = 0$ $\varepsilon_1 - I_1R_1 - I_3R_3 = 0$

$5 - 200I_1 - 120I_3 = 0$ or $5 = 200I_1 + 120I_3$ (1-1)

For loop (2) $\varepsilon_2 - I_2R_2 - I_3R_3=0$

$10- 300I_2 - 120I_3 = 0$ or $10= 300I_2 +120I_3$ (2-1)

$10 =300(I_3 - I_1) +120I_3$ $10=-300I_1+ 420I_3$ (2-2)

$I_1= (5-120I_3)/200$ (1-2)

$I_2= (10-120I_3)/300$ (2-3)

$I_3 =(5-120I_3)/200 + (10-120I_3)/300$

$=0.025 -0.6I_3 + 0.033 - 0.4 I_3$

➔ $0.058 = 2I_3$ ➔ $I_3 = 0.029$ A= 29 mA

$I_2 = 0.33-0.4 I_3$ $I_1 = 0.025 - 0.4 I_3$

Procedure

Construct the two-loop circuit as shown in ***Fig. 3.***

Chose R1**, **R_2**,* and ***R_3. ***Let $\varepsilon_1 = 5V$ and $\varepsilon_2 = 5V$.***

Measure the ***3 different currents*** using the ammeter.

Measure the output voltage of batteries and across each resistor record.

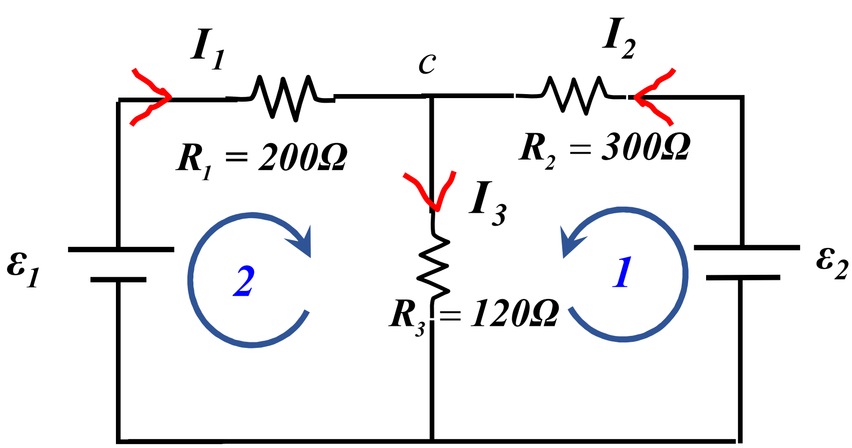


Fig.3: Two-loop Circuit

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Kirchhoff's Rules

Name: …………………………………………….. Day and Date: ………………….

Student's No.: ……………………………..… Sec: ………………………………..

Partners Names: …………………………………………………………………...

Data: **$\mathcal{E}_1$ = 5V,** **$\mathcal{E}_2$ = 10 V**

Resistors in Ω	R_1	R_2	R_3
	200 Ω	**300Ω**	**120Ω**

Currents (A)	I_1	I_2	I_3
Calculated			
Measured via Ammeter			

Q1. Use the **measured values** of currents to prove that $I_3 = I_1 + I_2$.

Voltages (V)	V_1	V_2	V_3
Calculated IR			
Measured via Voltmeter			

Q2. Use the measured values of voltages to prove the closed loop rule $\sum_C \Delta V = 0$. (e.g. is $\mathcal{E}_1 - V_1 - V_3 = 0$ **loop1**) and same for **loop2.**

Q3. In the **Fig.3.** Find the reading of ammeters A_1 and A_2.

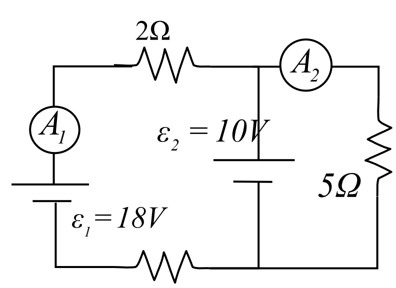

Fig.3