

E&M Lab

Kirchhoff's rules

1. Objective:

- To verify Kirchhoff's rules

2. Material

- A 6-V battery, a 1.5-V battery, circuit board, resistors and ammeter.

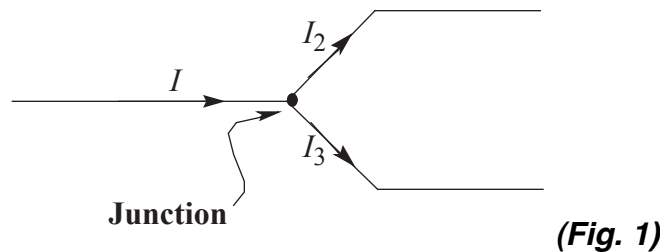
3. Theory

Many circuits cannot be analyzed by the series-parallel method. An example of these circuits is shown in figure 3. In this case, it is not possible to reduce the circuit to a single loop. The procedure for analyzing these more complex circuits is greatly simplified by the use of Kirchhoff's rules.

Kirchhoff's Junction Rule

The sum of all the currents going into a junction must equal the sum of all the currents going out of the junction.

If we apply this rule to the junction shown in *figure 1*, we obtain $I = I_2 + I_3$



It is possible that the assumed direction of current used to write the equations, might not be the actual direction of current in the circuit. In that case, when solving the equations, the value of that current will be found to be negative.

Kirchhoff's Voltage Rule

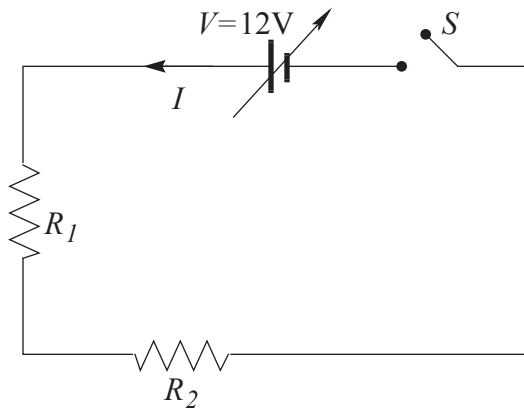
The algebraic sum of the potential differences across all elements around any closed loop must be zero. When applying this rule, we imagine traveling around the loop and considering changes in potential. You should note the following sign convention when using the second rule:

Because charges move from the high-potential end of a resistor toward the low-potential end, if a resistor is traversed *in the direction of the current*, the potential difference across the resistor is $\Delta V = -IR$ (potential drop).

If a resistor is traversed in the *direction opposite the current*, the potential difference across the resistor is $\Delta V = +IR$ (potential rise).

If a battery or power supply is traversed from high to low potential, the potential difference is negative (potential drop). If it is traversed from low to high potential, the potential difference is positive (potential rise).

For example, in *figure 2* below, if one applies the voltage rule along this loop in the counter-clockwise direction, one finds the equation: $+(12\text{ V}) - IR_1 - IR_2 = 0$. (there is no potential difference across a switch when closed)

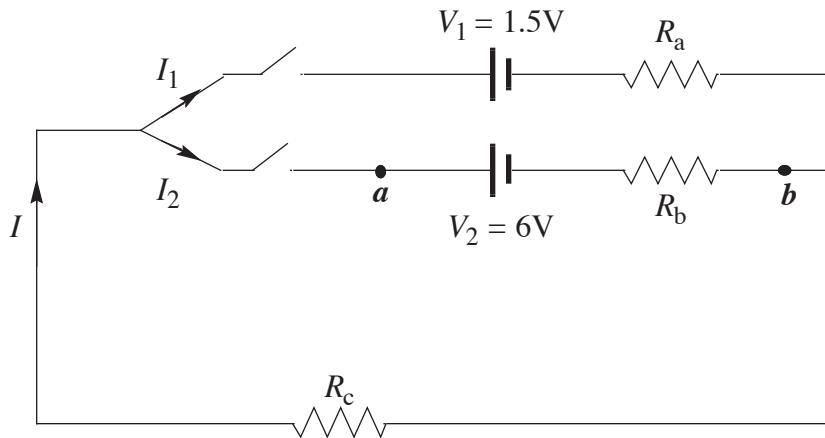


(Fig. 2)

If however, one applies the voltage rule around this loop in the clockwise direction, one finds the equation: $-(12\text{ V}) + IR_2 + IR_1 = 0$.

4. Procedure and data collection

1. Use the multimeter to measure the resistance of each resistor.
2. Connect the circuit as shown in figure 3 below. Leave two connections open, one at each battery.



(Fig. 3)

3. Once your circuit has been verified, close the two connections and measure the terminal voltage of the batteries. Once this is done disconnect one terminal of each battery so that they will not “drain”.
4. With the terminal voltages measured, apply Kirchhoff’s rules and calculate the currents I_1 , I_2 , and I_3 . Use the assumed direction of currents shown in **figure 3**.
5. Use the calculated currents and calculate V_{ba} , i.e. $V_b - V_a$.
6. Close the two disconnected connections again and with the ammeter measure the current passing through each resistor. When measuring the current, place the **COM** connector to the point you assume to be at the lowest potential, using the direction of currents in **fig 3**. This will be important to compare the signs of the measured currents with the calculations. **Remember**: an ammeter is always connected in series.
7. Measure V_{ba} with a voltmeter. **Remember**: a voltmeter is always connected in parallel.

5. Data analysis

- Compare the calculated and the measured values of currents.
- Compare the calculated and measured value of V_{ba} .

6. Report

- Show all your results in **ONE SINGLE** table. Include in this table the % difference between measured and calculated values.
- Write the equations used to calculate the currents in the circuit.
- Discuss discrepancies and identify the sources of errors.