Kirchhoff's laws

Objective: Study circuit networks with Kirchhoff's laws.

Introduction:

A complex circuit can be a network of components, such as the bridge circuit shown in Figure 1, in which the resistors are not simply in series or in parallel. Ohm's law still applies, however it is difficult to calculate the voltages and currents with Ohm's law alone in such a circuit. Instead, Kirchhoff's laws are convenient to study complex circuits. Kirchhoff's laws include two parts.

Loop rule: $\sum_{i=1}^{N} V_i = 0$. (1)

Junction rule: $\sum_{i=1}^{N} I_i = 0$ (2)

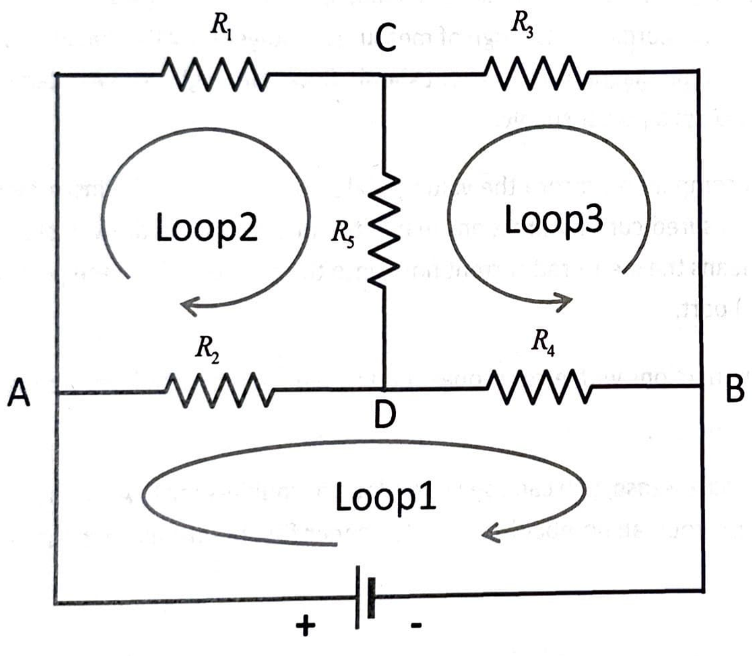

Figure 1. Bridge circuit. This is the same type of circuit as in Example 26.6 in your textbook.

The loop rule applies to any closed loop, such as, Loops 1, 2, or 3 indicated in Figure 1. The sum of voltages of all components (including power supply) in a loop should be zero. This ensures the conservation of energy in a loop. It also means that some of the measured voltage values will be positive, and some negative. If you follow the arrow in a loop, then when the arrow goes through a component from high to low voltage, V is positive; and if from a low to high voltage, V is negative.

Junction is a point in circuit where more than two wires connect, such as point A, B, C, or D in Figure 1. At a junction the sum of the currents in all wires should also be zero, while current flowing in and out are defined with opposite signs (for example flowing in is positive, out negative, or vice versa). Junction rule means that charge is conserved at any point in a circuit.

Experiment:

Step1. Pick five resistors with nominal values as $R_1 = 220\Omega$, $R_2 = 1k\Omega$, $R_3 = 5.1k\Omega$, $R_4 = 2.2k\Omega$, and $R_5 = 1k\Omega$. Measure the actual resistances; don't worry about their corresponding uncertainties. Make the circuit according to the diagram in Figure 1 without the power supply and measure the overall equivalent resistance.

Step2. Connect the power supply, turn it on, and set it to 15V. Measure the voltage of each component (including power supply) and record the values, measurement scales, and calculate the instrument uncertainties. Make sure you know which end is positive/negative. Mark "+/-" sign for high/low voltage on each component in the circuit diagram. A positive reading on a voltmeter means the positive port is connected to the point in circuit with higher voltage than the point connected the "Com" (negative) port. A negative reading means the opposite. According to the sign of measured voltage draw the current flow direction for every component in the circuit diagram. The current should flow from high to low voltage in a resistor, and low to high voltage through a power supply.

Step3. Measure the current of each component, record the values, scales, and calculate the instrument uncertainties. Make sure that the measured-current directions match the directions you drew in step 2. A positive reading on an ammeter means the measured current flows into the ammeter from the positive port and out of the "Com" (negative) port.

Step4. Check all three loops and four junctions with error propagation to see if Kirchhoff's laws are met or not. Show your calculation.

NOTE: If a measured V or I does not make sense, you can use Ohm's law to trouble-shoot. Also, the group lab report is a worksheet, so use your lab notebooks as scratch paper first before filling it out (a clean copy should be graded).