Laboratory Experiment 2
Series Circuits, Kirchoff's Voltage Law, Potentiometer

1. Construct the circuit shown in Figure 1. This circuit is used to find the **linear relation** between the voltage and current for a resistive circuit. In this circuit, the analog multimeter is connected as a voltmeter and the digital multimeter is connected as an ampermeter. The voltage supplied by the DC power source is adjusted at each step such that the voltage observed from the voltmeter increases nearly linearly (see Table 1 for the incremental changes in the voltage measurements). For each voltage value measured also measure the Ampermeter readings and fill Table 1 accordingly. Then select **two rows** of Table 1 (you'll see that the relation between voltage and current over a resistor nearly yields a constant slope line) and using the voltage and current measurements in these rows find the slope of the voltage-current relation over a resistor. Then using the measurements in Table 1, draw Voltage (in Volt) versus Current (in mAmp) to Figure 2 (indicate the data points you have taken in Table 1 in your plot). Circuit parameters are as follows: R_1= 1 kΩ and V_S has a variable voltage value between 10 volt and 20 volt
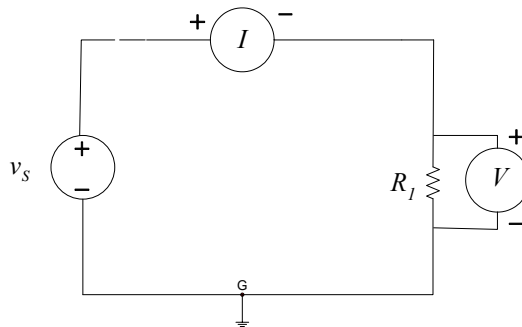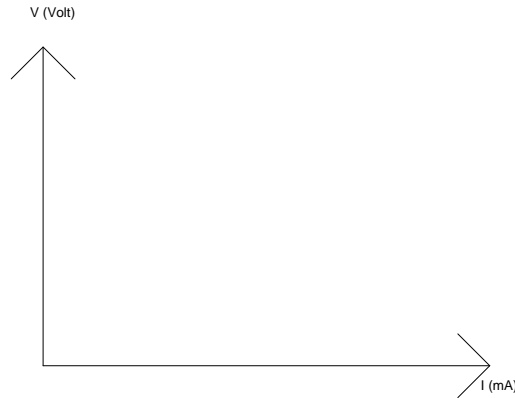
Figure 1: Circuit for current and voltage measurements

Table 1: Voltage and current measurements.

Measurement number	Voltage(Volt)	Current (mA)
1.	10	
2.	11	
3.	12	
4.	13	
5.	14	
6.	15	
7.	16	
8.	17	
9.	18	
10.	19	
11.	20	

Figure 2: Voltage versus current graph.

Questions:
- What does the slope you have found represents?
- If you take the reciprocal of the slope, what will you obtain, write its value? Does this entity have a scientific significant meaning?
- Compare your finding with Ohm's law.

2. In a series circuit with only resistive elements, the total equivalent resistance is equal to the summation of all the resistances of each resistive element. The circuit in Figure 3 is designed to show this relation. Construct the circuit in Figure 3 (don't forget that for resistance measurements the circuit should not be connected to any power supply and its terminals should not be connected to any other circuits or circuit portions), and measure the resistance values of each resistor by a digital multimeter (for each measurements you have to adjust the range of digital multimeter since the resistance values are very diverse from each other). Record your measurements on Table 2 (rows 1-4) accordingly. Then after each individual resistance measurement is completed, measure the total resistance of the circuit (you have to connect the multimeter probes to nodes A and E in the circuit shown in Figure 2). Record your last measurement also on Table 2 (rows 5). Lastly check whether the summation of the individual resistance values (row 1-4) is equal or close to the total resistance values (row 5). The circuit parameters are as follows: $R_1 = 1 \text{ k}\Omega$, $R_2 = 100 \text{ }\Omega$, $R_3 = 2.2 \text{ k}\Omega$, $R_4 = 1.8 \text{ k}\Omega$.
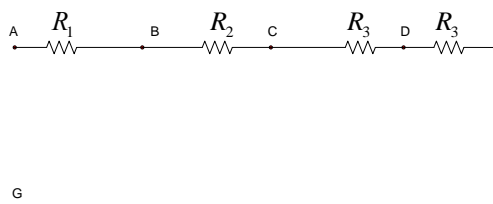
Figure 3: Circuit for resistance measurements.

Table 2: Resistance measurements

Measurement no:	Between nodes	Resistance value
1.	A and B	
2.	B and C	
3.	C and D	
4.	D and E	
5.	A and E	

3. Kirchoff's voltage law states that in a closed circuit the algebraic sum of all the voltage drops at each circuit element should be equal to 0. Since this summation is an algebraic summation, the polarities of the circuit elements are important. For validating this property, we'll use the circuit in Figure 4. Construct the circuit in Figure 4. Use digital multimeter as voltmeter and make voltage measurements for the circuit according to the probe connections shown in Table 3 and fill up the table. Then at the last step, find the total algebraic voltage drop over the closed circuit. The circuit parameters are as follows: R_1= 1 kΩ, R_2= 100 Ω, R_3= 2.2 kΩ, R_4= 1.8 kΩ and V_S=10 Volt.

Figure 4: Circuit for voltage measurements.
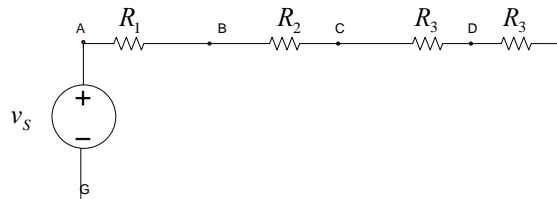
Table 3: Voltage measurements.

Measurement No:	Probe connections		Voltage	Probe connections		Voltage
	Red probe	Black probe		Black probe	Red probe	
1	A	B	V_{AB}=	A	B	V_{BA}=
2	B	C	V_{BC}=	B	C	V_{CB}=
3	C	D	V_{CD}=	C	D	V_{DC}=
4	D	E	V_{DE}=	D	E	V_{ED}=
5	E	A	V_{EA}=	E	A	V_{AE}=

$$V_{total\_drop} = V_{AB} + V_{BC} + V_{CD} + V_{DE} + V_{EA}$$

$$V_{total\_drop} = V_{BA} + V_{CB} + V_{DC} + V_{ED} + V_{AE}$$

Questions:
- Why the voltage drops are zero in both of the total voltage drop calculations.

Potentiometer: Potentiometer is a kind of variable resistor. This resistor has 3 terminals. Two of the terminals are constant terminals (terminals numbered as 1 and 2 as in Figure 4) and one terminal is the adjustable terminal (terminal numbered as 3 in Figure 4). Between constant terminals there is always the nominal resistance value of the resistor inside the potentiometer). However, the resistance between the terminals 1 and 3 and the resistance between the terminal 2 and 3 changes when the shaft of the potentiometer is turned clockwise and anticlockwise. Hence between the terminals 1 and 3 and also between terminals 2 and 3, we might observe different resistance values depending on the position of the shaft of the potentiometer.

4.1. In this section, we'll use a potentiometer whose nominal resistance value 10 kΩ. First adjust the digital multimeter for resistance measurements and measure the resistance values according to Table 4 and fill up the table.

Table 4: Resistance measurements for different potentiometer settings

Potentiometer shaft position	R_{12}	R_{13}	R_{23}
Clockwise			
Anti-clockwise			
Mid-point			

4.2. Now, using the potentiometer construct the circuit in Figure 5 (use DC power supply to provide 10 Volt DC to the circuit so $V_S=10$ Volt). This time adjust the digital multimeter for DC voltage measurements and measure the potential difference values in the circuit according to Table 5 and fill up the table.

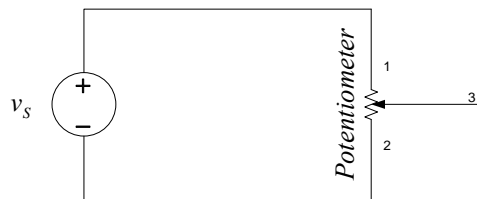**Figure 4:** Circuit for voltage measurements over potentiometer.

Table 5: Voltage measurements for different potentiometer settings.

Potentiometer shaft position	V_{12}	V_{13}	V_{23}
Clockwise			
Anti-clockwise			
Mid-point			

Questions:
- How does the voltage vary when the potentiometer shaft is turned clockwise?
- How does the voltage vary when the potentiometer shaft is turned anti-clockwise?
- How does the resistance vary when the potentiometer shaft is turned clockwise?
- How does the resistance vary when the potentiometer shaft is turned anti-clockwise?