ECE 101L

LAB 1: Fundamental Circuit Theory Laws

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Section A

1 Introduction

1.1 Purpose of Experiment

We are doing this experiment to investigate and verify the fundamental laws (and derived quantities) of KVL and KCL. In the first circuit, we will experimentally apply KVL and KCL to a DC circuit to gain theoretical confidence and experimental skill using the lab power supply and digital voltmeter (DVM). The lamp circuit will introduce nonlinear resistances, and we will test current and voltage changes through a circuit with one set lamp.

1.2 Background Theory

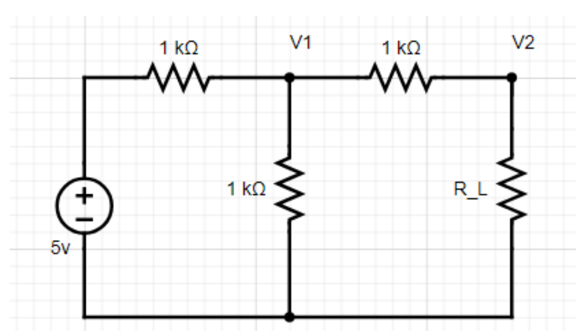
Kirchoff's two fundamental Laws, voltage and current, KVL and KCL, form the basis of all circuit theory. Knowing voltages and currents, their ratio gives us the useful property of resistance in Ohms [R or Ω], while their product gives us power flow in watts [W].

The KVL law is: $$\sum_{k=1}^{n} V_k = 0$$

The KCL law is: $$\sum_{k=1}^{n} I_k = 0$$

1.3 Expected Results

We consider the following circuit:



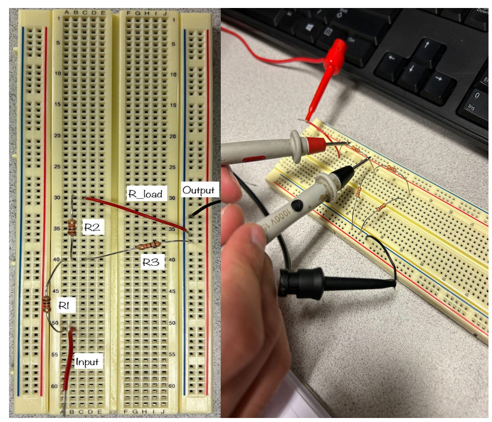
Nodal Analysis at V_1 : $$\frac{V_1 - V_{\text{source}}}{R_1} + \frac{V_1}{R_3} + \frac{V_1 - V_2}{R_2} = 0$$

Nodal Analysis at V_2 : $$\frac{V_2 - V_1}{R_2} + \frac{V_2}{R_{\text{load}}} = 0$$

Theoretical Values, with R_1, R_2, and R_3 =1 are as follows:

R_{load} kΩ	V_1 V	V_2 V	I_1 mA	I_2 mA	I_3 mA	P_1 mW	P_2 mW	P_3 mW	P_L mW
0	1.667	0	3.333	1.667	1.667	11.108	2.778	2.778	0
1	2	1	3	1	2	9	1	4	1
10	2.391	2.174	2.609	0.2174	2.391	6.807	0.047	5.717	0.473
100	2.488	2.463	2.51	0.0246	2.488	6.300	0.000605	6.190	0.061

2 Results and Analysis



We build the following circuit for $R_{\text{load}} = 0$:

We replace the R_{load} wire with resistors for 1, 10 and 100 kΩ and the circuit remains the same, with actual values of $R_1 = 0.9896$, $R_2 = 0.9859$, and $R_3 = 0.9866$.

Experimental Values are as follows:

R_{load} kΩ	V_1 V	V_2 V	I_1 mA	I_2 mA	I_3 mA	P_1 mW	P_2 mW	P_3 mW	P_L mW
0.0001	1.667	0.0001	3.3357	1.680	1.6791	11.127	2.8224	2.8194	0.0003
0.987	2.0682	1.0341	2.9318	1.0341	1.8977	8.595	1.069	3.6012	1.069
9.653	2.3879	2.1637	2.6121	0.224	2.3831	6.823	0.0502	5.8636	0.5017
95.687	2.4871	2.4613	2.513	0.0257	2.4786	6.3152	0.000662	6.143	0.065536

3 Error Analysis

With % error calculated as follows, $\% \text{ Error} = 100 * \frac{\text{Calculated} - \text{Measured}}{\text{Calculated}}$*, we find:*

R_{load} kΩ	Value	Theoretical	Measured	% Error
0	V_1 V	1.667	1.667	0
0	V_2 V	0	0	100
0	I_1 mA	3.333	3.33357	0.0072
0	I_2 mA	1.667	1.680	0.78
0	I_3 mA	1.667	1.6791	0.73
0	P_1 mW	11.108	11.127	0.17
0	P_2 mW	2.778	2.8224	1.598
0	P_3 mW	2.778	2.8194	1.49
0	P_{L} mW	0	0.0003	100

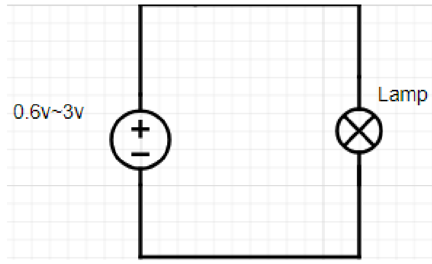
R_{load} kΩ	Value	Theoretical	Measured	% Error
1	V_1 V	2	2.0682	3.41
1	V_2 V	1	1.0341	3.41
1	I_1 mA	3	2.9318	2.27
1	I_2 mA	1	1.0341	3.41
1	I_3 mA	2	1.8977	5.12
1	P_1 mW	9	8.595	4.5
1	P_2 mW	1	1.069	6.9
1	P_3 mW	4	3.6012	9.97
1	P_{L} mW	1	1.069	6.9

R_{load} kΩ	Value	Theoretical	Measured	% Error
10	V_1 V	2.391	2.3879	0.13
10	V_2 V	2.174	2.1637	0.474
10	I_1 mA	2.609	2.6121	0.119
10	I_2 mA	0.2174	0.224	3.036
10	I_3 mA	2.391	2.3831	0.33
10	P_1 mW	6.807	6.823	0.235
10	P_2 mW	0.047	0.0502	6.809
10	P_3 mW	5.717	5.8636	2.564
10	P_{L} mW	0.473	0.5017	6.068

R_{load} kΩ	Value	Theoretical	Measured	% Error
100	V_1 V	2.488	2.4871	0.0036
100	V_2 V	2.463	2.4613	0.069
100	I_1 mA	2.51	2.513	0.12
100	I_2 mA	0.0246	0.0257	4.472
100	I_3 mA	2.488	2.4786	0.378
100	P_1 mW	6.300	6.3152	0.241
100	P_2 mW	0.000605	0.000662	9.421
100	P_3 mW	6.190	6.143	0.759
100	P_{L} mW	0.061	0.000662	7.436

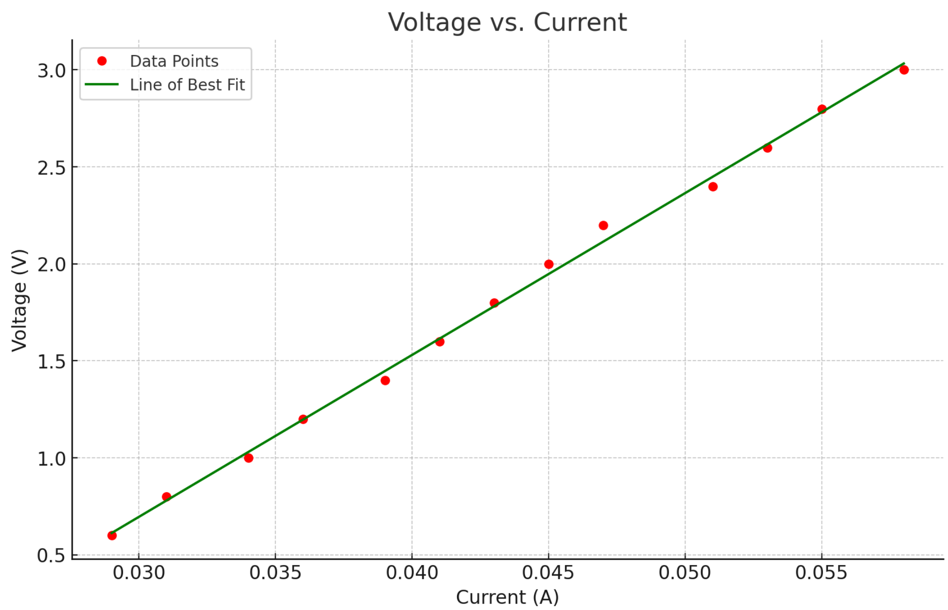
Part II

We observe the following lamp circuit:



Experimental values are as shown:

Voltage	Current
0.6v	0.029A
0.8v	0.031A
1v	0.034A
1.2v	0.036A
1.4v	0.039A
1.6v	0.041A
1.8v	0.043A
2v	0.045A
2.2v	0.047A
2.4v	0.051A
2.6v	0.053A
2.8v	0.055A
3v	0.058A



Conclusion

Through this lab we learned nodal analysis alongside the KVL and KCL laws. We used breadboards, resistors, and wires to run our experimental values after calculating theoretical values of voltage, current, and power dissipated for the given circuit, where we observed a relatively small % error. We then observed current as voltage changes through a simple lamp circuit, finding a linear and positively-correlated relationship.