Engr098 Lab2

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Objective

Become familiar with a breadboard and the lab power supply, and review the measurements of voltage, current, and resistance using a digital multimeter (DMM). We built a simple LED–resistor series circuit, measured the supply/battery voltage and the resistor value, then replaced the LED with jumper wires to place the DMM in series and measure current safely. Finally, we compared the measured values with predictions from Ohm's law ($V = IR$) and basic power calculations ($P = VI$).

Part 1: Reading Resistors and the Connection Pattern of the Breadboard

(a) Identify the resistor by its markings

The resistor selected for the LED series circuit was marked $200\,\Omega$ (4-band color code: red–black–brown, tolerance gold).

(b) Compare markings vs. DMM readings

We measured three resistors with the DMM and computed the percent difference

$$\%\ \text{difference} = \frac{\text{reading} - \text{marking}}{\text{marking}} \times 100\%.$$

Marking	**Reading (DMM)**	**Difference (%)**
$200\,\Omega$	$205\,\Omega$	+2.5 %
$1\,\text{k}\Omega$	$1003\,\Omega$	+0.3 %
$5\,\text{k}\Omega$	$5090\,\Omega$	~ 2 %

Table 1: Resistor markings vs. measured values. Deviations are within typical 1 %–5 % tolerances.

(c) Meter range and breadboard connection pattern

- **DMM range:** The `2k` resistance range measures up to about 1999 Ω. We used `2k` for the 200 Ω and 1 kΩ parts, and switched to `20k` for the 5 kΩ part to avoid over-range. Selecting the smallest range above the expected value gives better resolution.
- **Breadboard pattern:** Each 5-hole column in the main area is internally connected; the center trench isolates the left and right halves. Power rails (red/blue) run horizontally along the edges (often split in the middle). Components in series must bridge different connected groups using jumper wires.

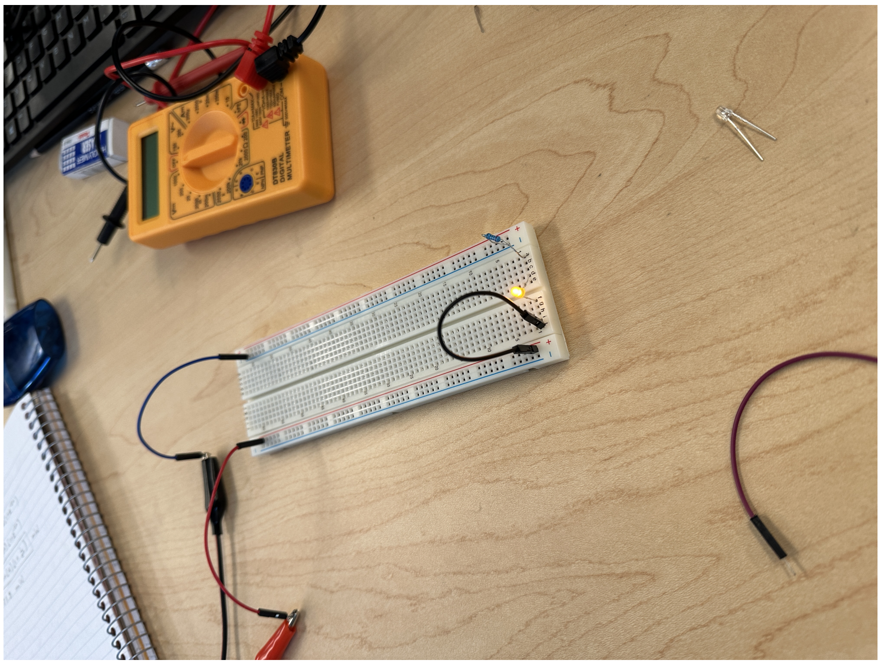

Figure 1: LED lit on the breadboard while mapping the connection pattern.

Part 2: Basic Series Measurements

(a) Nominal series resistor

Chosen value: 6 kΩ.

(b) DMM reading and tolerance

Measured with the DMM: 6.10 kΩ. Percent difference:

$$\%\Delta = \frac{|\text{reading} - \text{marking}|}{\text{marking}} \times 100\% = \frac{|6.10 - 6.00|}{6.00} \times 100\% \approx 1.7\%.$$

(c) Node voltages in series (LED + resistor)

Supply $V_S = 10\,\mathrm{V}$. Using an LED forward drop of about $1.6\,\mathrm{V}$,

$$v_0^{(\text{calc})} \approx 1.6\,\mathrm{V}$$
$$v_1^{(\text{calc})} = V_S - v_0^{(\text{calc})} \approx 8.4\,\mathrm{V}$$

Measured:

$$v_0^{(\text{meas})} = 1.58\,\mathrm{V}, \qquad v_1^{(\text{meas})} = 8.03\,\mathrm{V}.$$

(d) Series current

Measured series current: $1.5\,\mathrm{mA}$. (For reference, using the measured resistor value and the assumed LED drop: $I^{(\text{calc})} = \dfrac{V_S - v_0}{R} = \dfrac{10 - 1.6}{6.10 \times 10^3} \approx 1.38\,\mathrm{mA}$.)

(e) Equivalent resistance from $V = IR$

Using the supply and measured current,

$$R_{\text{eq}} = \frac{V_S}{I} = \frac{10\,\mathrm{V}}{1.5\,\mathrm{mA}} = 6.67\,\mathrm{k\Omega}.$$

This is higher than the measured $6.10\,\mathrm{k\Omega}$ resistor by about $0.57\,\mathrm{k\Omega}$ ($\approx 9\%$), which is expected because the LED is not an ohmic element—its forward drop effectively adds to the series resistance at this current. Small differences also come from supply sag and meter resolution.

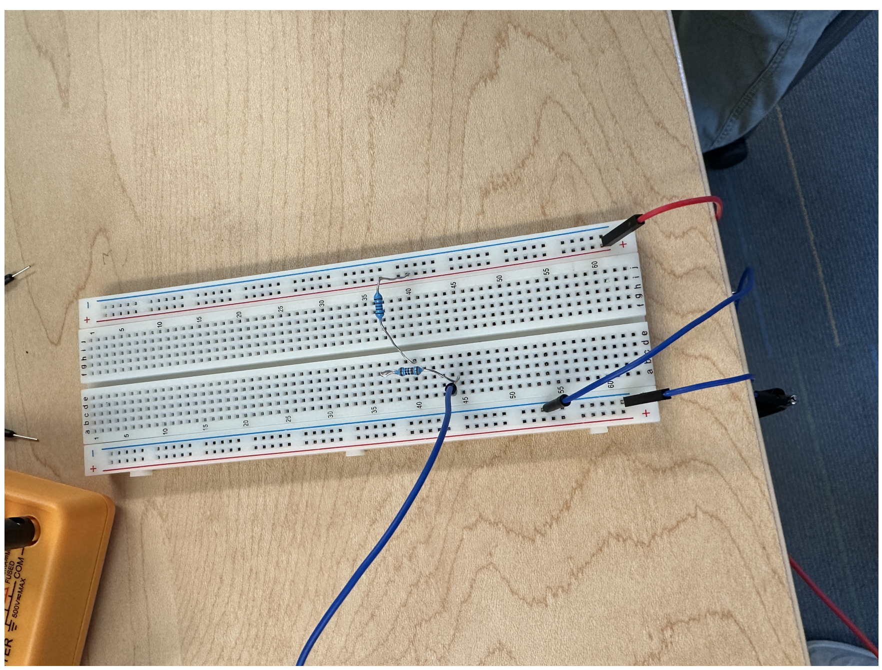

Figure 2: Basic series setup for voltage and current measurements.

Part 3: Basic Parallel Measurements

(a) Branch resistor

Choose one branch resistor $R_0 = 909\,\Omega$ (nominal).

(b) DMM reading and tolerance

Measured $R_0 \approx 920\,\Omega$.

$$\%\Delta = \frac{|920 - 909|}{909} \times 100\% \approx 1.2\%.$$

(c) Target total current

Set the supply to $V = 10\,\mathrm{V}$ and target a total current of $I_{\mathrm{tot}} = 10\,\mathrm{mA}$.

(d) Target equivalent resistance

Using $V = IR$,

$$R_{\mathrm{eq,target}} = \frac{V}{I_{\mathrm{tot}}} = \frac{10\,\mathrm{V}}{10\,\mathrm{mA}} = 1.00\,\mathrm{k\Omega}.$$

For two resistors in parallel, $\frac{1}{R_{\mathrm{eq}}} = \frac{1}{R_0} + \frac{1}{R_1}$. (We chose a second branch resistor R_1 so the pair is near $1\,\mathrm{k\Omega}$.)

(e) Branch currents and check

Measured branch currents:

$$I_{R_0} \approx 0.94\,\mathrm{mA}, \qquad I_{R_1} \approx 9.31\,\mathrm{mA}.$$

Total current (KCL in parallel):

$$I_{\mathrm{tot,meas}} = I_{R_0} + I_{R_1} = 10.25\,\mathrm{mA} \quad \text{(about 2.5\% high vs. the 10 mA target).}$$

As an internal consistency check,

$$R_{\mathrm{eq,meas}} = \frac{V}{I_{\mathrm{tot,meas}}} = \frac{10\,\mathrm{V}}{10.25\,\mathrm{mA}} \approx 0.976\,\mathrm{k\Omega},$$

which is within a few percent of the $1\,\mathrm{k\Omega}$ design goal. Small differences come from resistor tolerances and meter resolution.

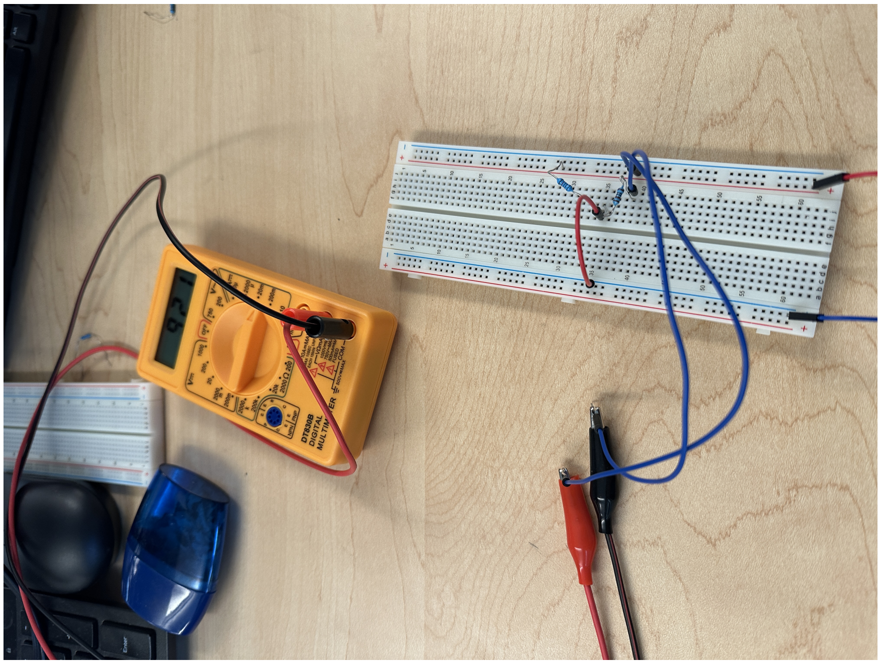

Figure 3: Parallel setup: two branches sharing the same 10 V across them; currents add.

Conclusion

In this lab we used a breadboard, a lab power supply, and a DMM to build and test simple resistor circuits. The DMM readings for our resistors were close to their markings (within a few percent), which matches typical tolerances. In the **series** LED circuit with $V_S = 10\,\mathrm{V}$, we expected about 1.6 V across the LED and the rest across the $\sim 6\,\mathrm{k\Omega}$ resistor; we measured $v_0 \approx 1.58\,\mathrm{V}$, $v_1 \approx 8.03\,\mathrm{V}$, and $I \approx 1.5\,\mathrm{mA}$, close to the calculated 1.38 mA. In the **parallel** test, the branch currents ($\sim 0.94\,\mathrm{mA}$ and $\sim 9.31\,\mathrm{mA}$) added to 10.25 mA, giving an equivalent resistance near $1\,\mathrm{k\Omega}$ as designed. Small differences were explained by resistor tolerance, the LED's non-ohmic drop, contact resistance on the breadboard, supply variation, and meter resolution.

Overall, we created circuits that matched the predictions from Ohm's law and basic KCL/KVL, and we practiced safe, correct use of the DMM (voltage across components; current with the meter in series). These results verify our calculations and show that our setup and measurements were sound.