LAB 07 — 03/13/2025

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Introduction:

Circuits are incredibly versatile, with the ability to perform simple tasks, people have developed circuits for almost any purpose, from turning on a light to performing complex calculations. While these can seem incredibly daunting, almost every circuit relies on similar components exploiting the same core principals. Today we move to understand circuits themselves, seeing how different components compose different circuits, alongside building a few practical ones, all while keeping in mind some of the concepts we've already proven.

Problem 1: First Steps - How Does A Multimeter Measure Resistance

Materials:

- Circuit Board
- Multimeter
- Alligator Clips

Methods/Procedures:

Measure the resistance and length of a 1kΩ resistor. Connect that resistor to a voltage source then measure the current and voltage across the resistor using the multimeter.

Data/Results:

The resistance was measured at 979Ω, the voltage at 2.5V, and the current at 2.53mA. The resistance of the wire was measured at .7Ω. The length of the resistor was measured at 6.49mm.

Data Analysis:

The measured values agree closely with experimental values calculated using Ohm's law. The resistance of the wire is lower than the tolerance of the resistor and as such does not matter at all. The electric field inside of the resistor is $E = \frac{V}{L}$ where L is the length of the resistor. This results in a value of E of 385.21V/m. Using the equation $F = qE$ results in a force on the electron of 6.17×10^{-17}N.

Problem 2: Voltage Divider

Materials:

- Circuit Board
- Multimeter

- Alligator Clips

Methods/Procedures:
Make a circuit consisting of two 10kΩ resistors in series connected to a voltage source. Use the multimeter to measure the voltage across each resistor, the current in the system, and the resistance of each resistor.

Data/Results:
The voltages and resistances across R_1 and R_2 were 1.23V and 10kΩ and 1.25V and 9.93kΩ respectively. The current through the circuit was 0.12mA.

Data Analysis:
The voltage is very nearly split in half, this is why the circuit is called a voltage divider. It divides the voltage over each branch to be proportional to the resistance of the branch. The equation is pictured below in figure 1.

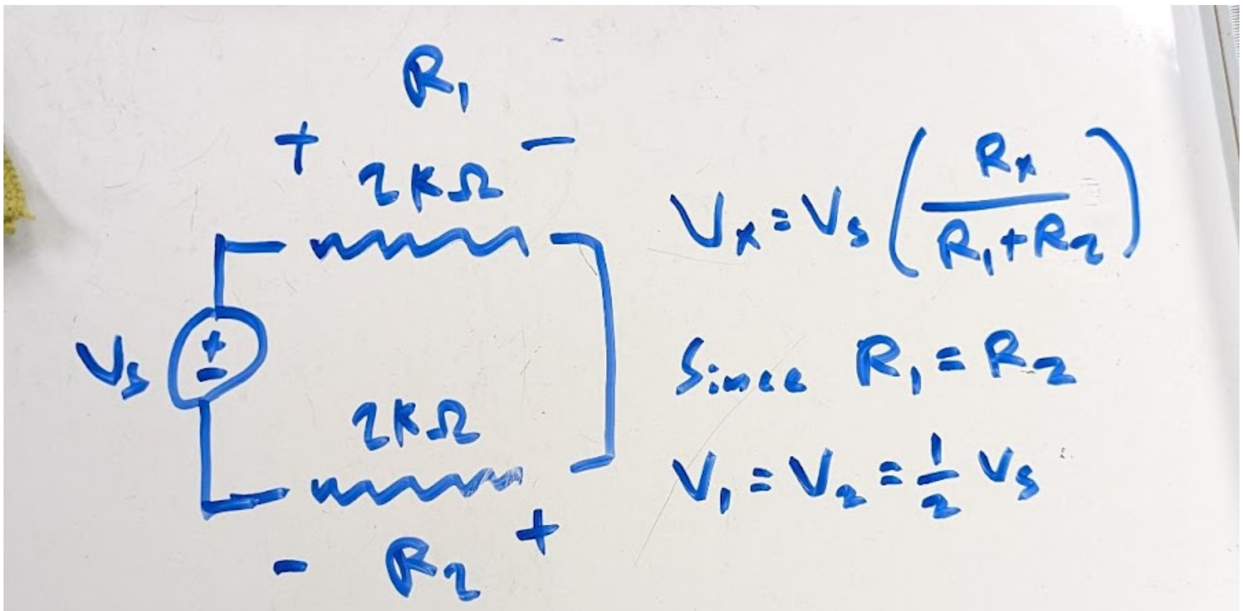


Figure 1

Problem 2.2: Voltage Divider Part II

Materials:
- Circuit Board
- Multimeter
- Alligator Clips

Methods/Procedures:
Use the voltage divider equation to determine the proper resistance values according to the desired specifications. Assemble a voltage divider configuration with the 10kΩ resistor and the selected resistor.

Data/Results:
The voltage measured across the 10kΩ resistor was 2.03V.

Data Analysis:
The resistance was determined to be 2.5kΩ by doing a current divider and solving for R in the equation $2 = 2.5\frac{10}{10+R}$. The resistor actually used was 2.2kΩ because it was the closest to 2.5kΩ. The measured voltage is within the 2% boundary.

Problem 2.3: Voltage Divider Part III: The Photo-Resistor

Materials:
- Circuit Board
- Multimeter
- Alligator Clips

Methods/Procedures:
The photoresistor was placed in parallel with a 2kΩ resistor and the voltage across it was measured until the value stabilized, both when covered and uncovered.

Data/Results:
The resistance when the photoresistor was covered was measured at 21kΩ and the voltage was 1.75V whereas the uncovered photoresistor measured at 3.3kΩ and .65V.

Data Analysis:
By definition a photoresistor's resistance is dependent on its exposure to light, which was demonstrated here. The correlation between resistance and light is negative.

Problem 3: A timing circuits

Materials:
- Circuit Board
- Multimeter

- Alligator Clips

Methods/Procedures:
For this problem, we put a resistor and capacitor in parallel, charged the capacitor with a switch until the voltage across it is 2.5 V, then we released the switch and measured the decay time. This was repeated a few times and the average time was used to calculate tau.

Data/Results:
Average decay from 2.5 V to 1 V: 4.75 s.

$\tau = t / \ln(2) =$ **6.85**

Data Analysis:
This time constant makes sense for the small capacitor tested. A larger capacitor would likely have a large time constant, as it would be able to store greater charge.

Problem 4: Transistor Switch

Materials:
- Circuit Board
- Multimeter
- Alligator Clips

Methods/Procedures:
Assemble circuit according to the diagram provided in the lab manual.
Measure Current running through the LED and at the base of the transistor.

Data/Results:
Current across LED: 3.27 mA when on, 0.00, when off

Current across Base: 0.11mA when on, 0.00, when off

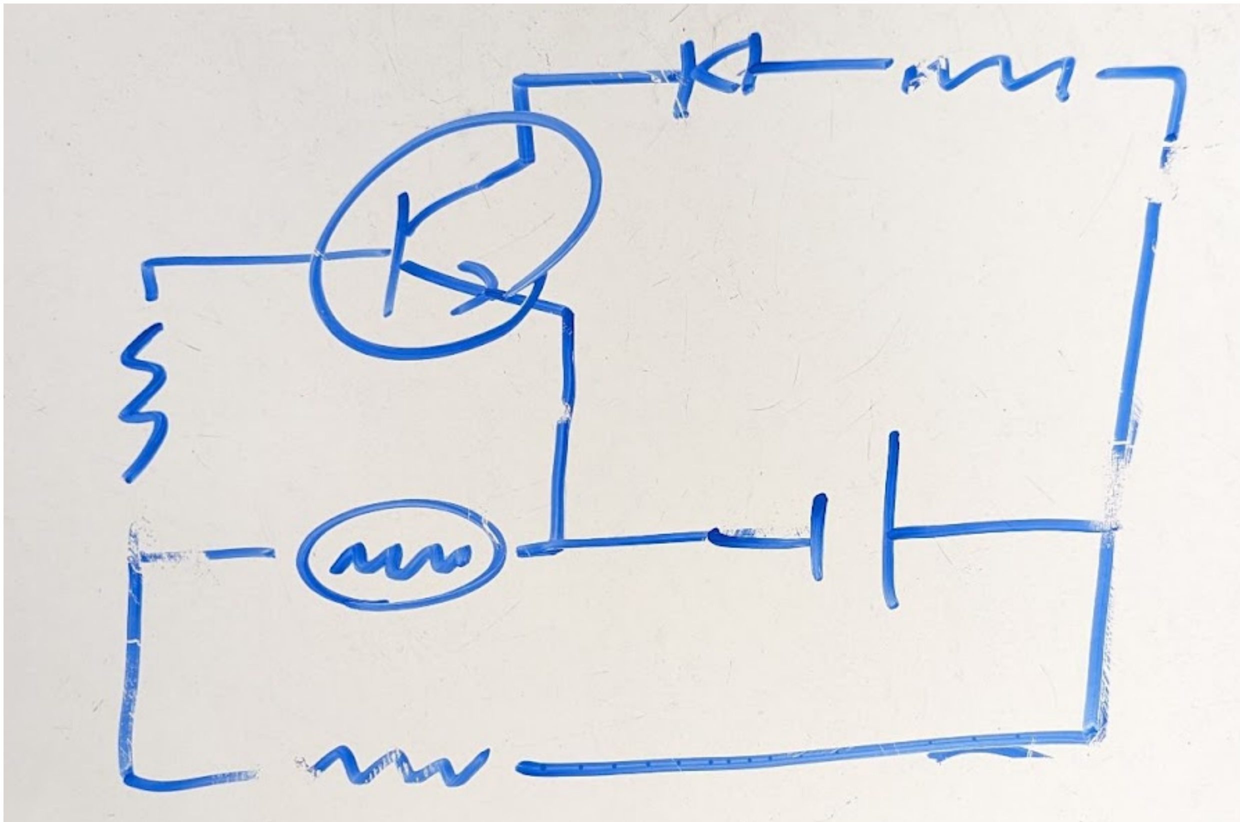
Data Analysis:
The LED has a higher current flow, this is due to the transistor, which does not need much current applied to allow current to flow along the other loop, having been designed for logical processes.

Challenge 1: Night Light

Materials:
- Circuit Board

- Multimeter
- Alligator Clips

Data/Results



Data Analysis:

The circuit functioned as expected after the resistor values were chosen to create the paths of least and most resistance necessary for the circuit to function.

Conclusion:

In this lab, we constructed several circuits to understand how the placement of certain components can impact the way a circuit functions. We constructed and predicted the behavior of a voltage divider circuit, learning how changing the resistance limits both the current and voltage, allowing us to calculate the needed resistance for a desired voltage of 2V, which we calculated to be 2.5k Ohms. We experimented with half life of a circuit, helping us to calculate the true capacitance of our circuit to be 6.85. These practical circuits we experimented with may seem simple, but the systems we've designed can be scaled up to create complicated circuits to complete advanced tasks.