Lab Name

Zack Garza

Physics 210L
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***Abstract*—**
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CONTENTS

I. THEORY

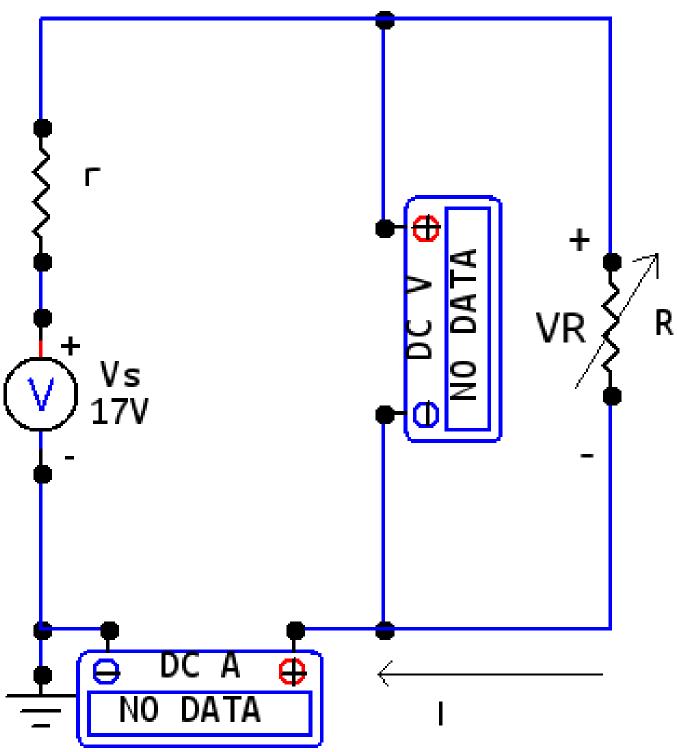

Figure 1. Diagram of circuit used in this experiment. R represents a variable load resistance, while r simulates the internal resistance of the power supply. I is the uniform current that flows through all three components of the circuit.

Kirchoff's Voltage Law states that the sum of the potential differences in a closed loop is equal to zero, such that

$$\sum V_{\text{Loop}} = 0.$$

For the circuit shown, the potential difference V_R across the load resistor can be found using this equation. Summing the voltages and rewriting them using $V = iR$ (according to Ohm's Law) yields

$$\begin{aligned} \epsilon - V_r - V_R = 0 &\Rightarrow \\ V_R = \epsilon - V_r &\Rightarrow \\ V_R = \epsilon - ir& \end{aligned} \tag{1}$$

where the current i is identical throughout the circuit, as its elements are wired in series, and r is the power supply's internal voltage.

The power released by the resistor R can also be expressed in terms of the known quantities $\epsilon, r,$ and R. From the power equation, it is known that $P = iV$. Because the current i is uniform everywhere, it can be related to the source voltage and the equivalent resistance of the entire circuit. Taking the source voltage to as ϵ and the equivalent resistance as $r + R$ and substituting it into the power equation yields

$$\begin{aligned} P = iV, V = iR \Rightarrow P = \frac{i^2}{R} &\Rightarrow \\ P_R = \left(\frac{\epsilon}{r+R}\right)^2 R &\Rightarrow \\ P_R = \epsilon^2 \frac{R}{(r+R)^2}&. \end{aligned} \tag{2}$$

Calculating the point at which maximum power transfer occurs requires taking the derivative of Equation 2 with respect to the load resistance. This results in

$$\frac{\partial P}{\partial R} = \epsilon^2 \left(\frac{(r+R^2) - 2R(R+r)}{(R+r)^4}\right).$$

Maximizing the power transferred to the load resistor requires setting this derivative equal to zero, which occurs when.

$$r + R^2 = 2R(R+r).$$

Solving this expression for R then forces the following condition to be true in order to maximize the power delivered to the load resistor R:

$$R = r. \tag{3}$$

II. METHODOLOGY

1) The circuit was constructed as shown in Figure 1, where r was a known resistor and R was a variable resistor box.
2) Digital voltmeters and ammeters were wired to measure V_R and i.
3) The power supply was set to 17.00 V, and its actual terminal voltage was measured.

4) The known resistor r was measured with an ohmmeter.
5) The resistance of the variable load was incremented, and at each point data was taken for the voltage and current through R.
6) Extra data points were taken at resistances approaching that of the known resistor.

III. Data

$$r = .549\ \text{k}\Omega$$
$$\epsilon_{\text{Meas}} = 17.02\ \text{V}$$

A. *Linear Fit of V_R vs. i*

$$\text{Internal Resistance } r = \underline{(571 \pm 2)\Omega}$$
$$\text{Source EMF } \mu_{\text{Theory}} = \underline{(16.99 \pm .04)\text{V}}$$

$$\%\ \text{Difference in } \epsilon = \underline{0.2\%}$$
$$\%\ \text{Difference in } r = \underline{3.9\%}$$

B. *Comparison of R_{Calc} and Resistance Box Values*

Filler text.

C. *Polynomial Fit of P_R vs. R_{Calc}*

$$r = \underline{(573.2 \pm 0.7)\Omega}$$
$$\%\ \text{Difference} = \underline{0.38\%}$$

IV. Analysis

1) *How can you determine the value for $R_{Calculated}$ that gives $P_{R\text{-}Max}$?*
2) *What are the possible discrepancies between the values of r obtained from the two function fits?*