PHYSICS 1040L LAB
WHEATSTONE BRIDGE
SERIES & PARALLEL RESISTANCES

Object: To learn how to operate a Wheatstone Bridge and to verify the formulas for the combination of resistances.

Apparatus: Slide wire Wheatstone Bridge, decade resistance box, unknown resistors, galvanometer and a battery or power supply.

Theory: A Wheatstone Bridge is 4 resistors connected in the form of a square with galvanometer connected across one diagonal and a voltage source across the other, as shown in the circuit below.

When the Galvanometer indicates zero current, the bridge is balanced. In this condition, the current, $I$, branches at A with one part, $I_B$, passing through point B and the remainder, $I_C$, passing through point C.

The two parts recombine at point D. Since no current flows through the galvanometer, G, under these conditions, the voltage drop from A to B must be the same as that from A to C.

Similarly, the voltage drop from B to D must be the same as that from C to D. Thus:

$$I_B R_1 = I_C R_4 \text{ and } I_B R_2 = I_C R_3 \quad (1)$$

Figure 1: Wheatstone bridge
\[
\frac{R_1}{R_2} = \frac{R_4}{R_3} \quad \text{or} \quad R_1 \frac{R_3}{R_2} = \frac{R_4}{R_2} \quad (2)
\]

In practice, only one resistance is unknown and the others are known and variable.
In the slide wire Wheatstone Bridge, two of the resistances are the two ends of the wire divided by the sliding contact. (See Fig 2)

In the diagram, the slide wire is represented by \(R_4\) and \(R_3\), and the sliding contact is the point C.
Since the resistance per unit length of the slide wire is constant, the length of the two ends of the slide wire, \(L_4\) and \(L_3\), may be substituted for \(R_4\) and \(R_3\), respectively.
If, also, an unknown resistor, \(X_n\), is inserted in place of \(R_1\), and a standard resistor, \(R_s\), inserted in place of \(R_2\), the above expression may be written:

\[
X_n = R_s \left( \frac{L_4}{L_3} \right). \quad (3)
\]
Fig. 3: Bridge For Determining Unknown Resistance

Figure 4: Sliding Contact Switch on CENCO Bridge.
Figure 5: Left end of bridge.

Figure 6: Right end of bridge
Figure 7: Xₙ Unknown Resistor Board

Figure 8: Rₛ DECADE RESISTANCE BOX
Fig. 9 Physical Layout Of Circuit

Figure 10: Galvanometer
Procedure and Data Analysis

1. Choose resistors $R_1$, $R_2$, and $R_3$ from your unknown resistors board and record their labels. Note you must use 3 resistors (Your choice from resistors B, C, D, and E) for resistors $R_1$, $R_2$, and $R_3$. **DO NOT USE RESISTORS A OR F.**

2. The approximate values of B, C, D, E, are 10, 50, 120 and 500 Ω, **BUT NOT IN ANY PARTICULAR ORDER**

3. Connect the circuit as shown in Fig 9. You may look at your data page for a simplified drawing of the circuit. Use resistor $R_1$ for THE FIRST unknown resistor.

4. You **MUST make sure** to always keep the resistance $R_s$ on the decade resistance box set to at least 10 or 20 Ohms at all times. **Never set it to zero!**

5. Position the sliding contact on the ruler between 0.4 and 0.6 m

6. Set the decade resistance box to one of the resistances listed above. You are using the decade resistance box as your course adjustment.

7. Now touch the contact switch to the wire.

8. Is the galvanometer any where the Zero point on the scale?
9. If it is, adjust the slide wire contact switch back and forth between 0.4 and 0.6 m. until the galvanometer reads Zero.

10. If the galvanometer does not read Zero at any point where you touch the contact switch to the wire, it usually means that \( R_s \) is not adjusted to the approximate value of the unknown resistor.

11. Change the value of \( R_s \) and try to balance the circuit again.

12. When the circuit is balanced, temporarily disconnect the Decade Resistance Box from the circuit by unplugging the Banana Plug wires.

13. Measure the resistance of \( R_s \) using the Ohmmeter setting of the multimeter. The Ohmmeter setting has the Greek letter \( \Omega \) next to it.

14. Plug the Decade Resistance box back into the circuit.

15. Record your data for the length and \( R_s \).

16. Repeat the steps 5 -15 for \( R_2 \) and \( R_3 \).

17. Connect \( R_1 \), \( R_2 \), and \( R_3 \) in series (see diagram on your data page and below). Repeat steps 5 - 15 with the series combination.

18. Connect \( R_1 \), \( R_2 \), and \( R_3 \) in parallel (see diagram on your data page and below) Repeat steps 5 - 15 with the parallel combination.

19. Calculate the equivalent resistance for the series connection from the individual measurements of \( R_1 \), \( R_2 \), and \( R_3 \). Find the percent difference between the measured and calculated values.

20. Calculate the equivalent resistance for the parallel connection from individual measurements of \( R_1 \), \( R_2 \), and \( R_3 \). Find the percent difference between the measured and calculated values.

21. In your report do not forget to show examples of all calculations, use proper units, round the answers, and make a conclusion about your findings.
Figure 12: Example of a Series connection on resistor board. Yours might not look exactly like this.

Figure 13: Example of a parallel connection. Yours might not look exactly like this.