Boğaziçi University

# Introductory Phys Labs

# WHEATSTONE BRIDGE

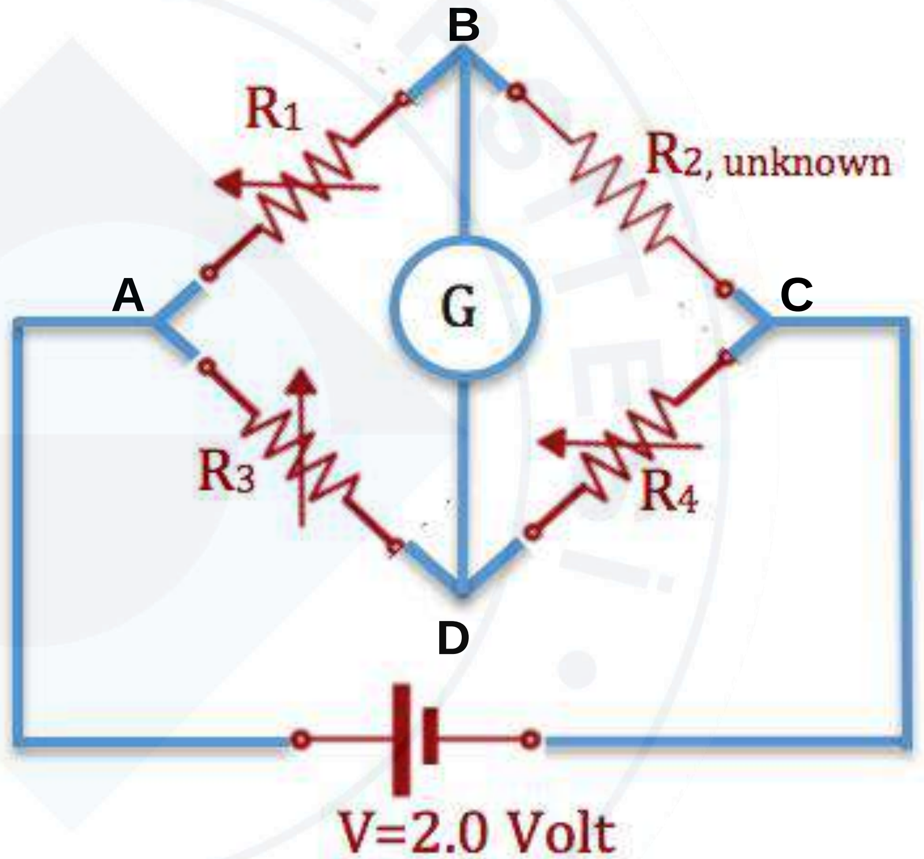
PHYL 201

# THEORY

# WHEATSTONE BRIDGE

**The Wheatstone Bridge is a combination of four resistances connected to give a null center value.**

**It was developed by Charles Wheatstone to measure unknown resistance values and as a means of calibrating measuring instruments, voltmeters, ammeters, etc., using a long resistive slide wire.**

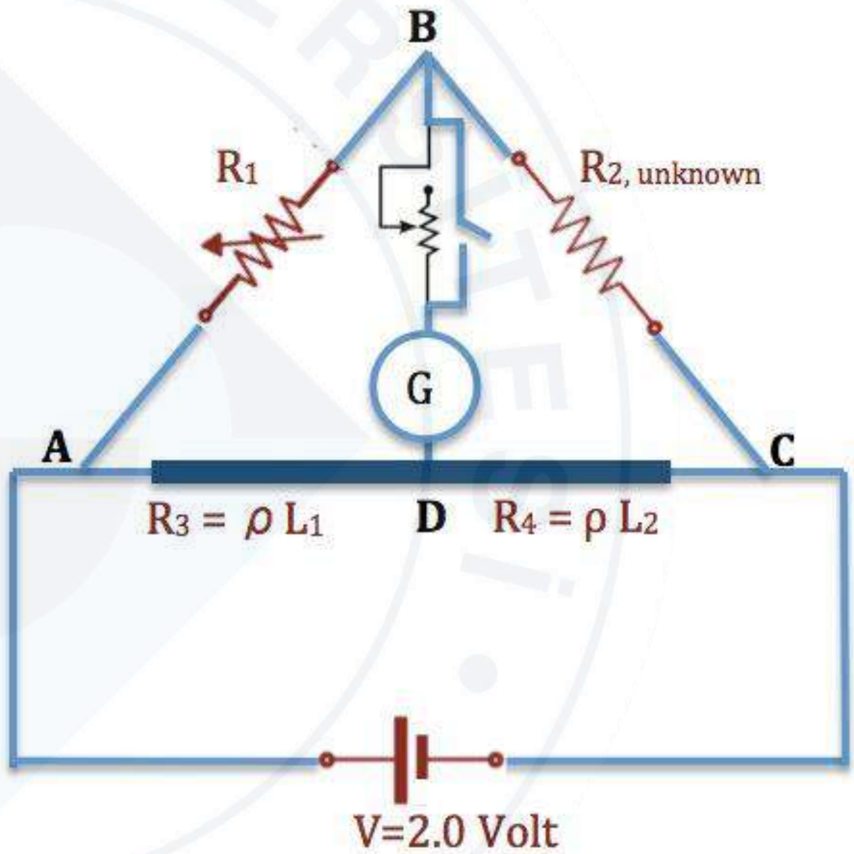


## WHEATSTONE BRIDGE

In Wheatstone bridge there are two pairs of resistors connected in parallel.

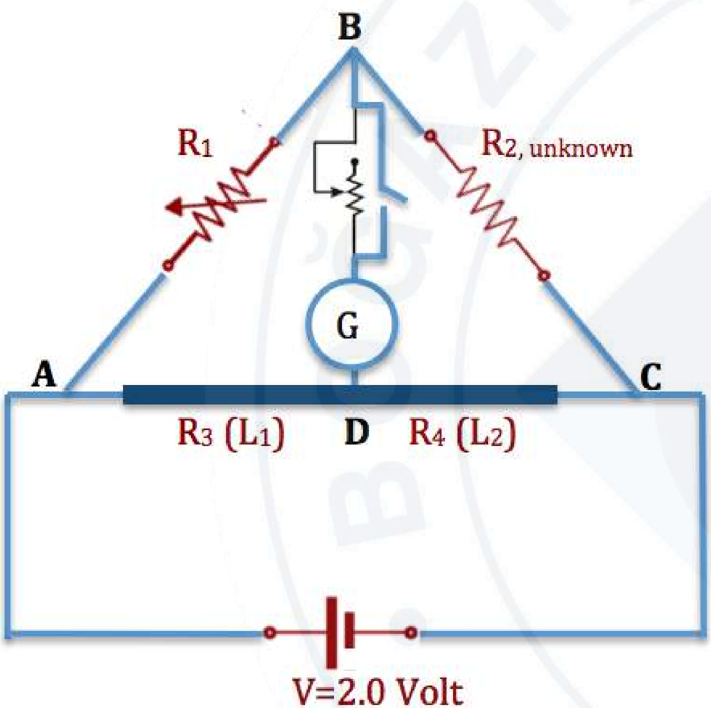
A galvanometer is connected between the points where individual resistors are connected together in each pair. To protect the galvanometer against excessive currents, a large resistance is connected in series with the galvanometer to short it out using a switch.

In slide-wire Wheatstone Bridge case one pair of resistors is simply a wire and the galvanometer is connected to a point on the wire with the help of a sliding connection.

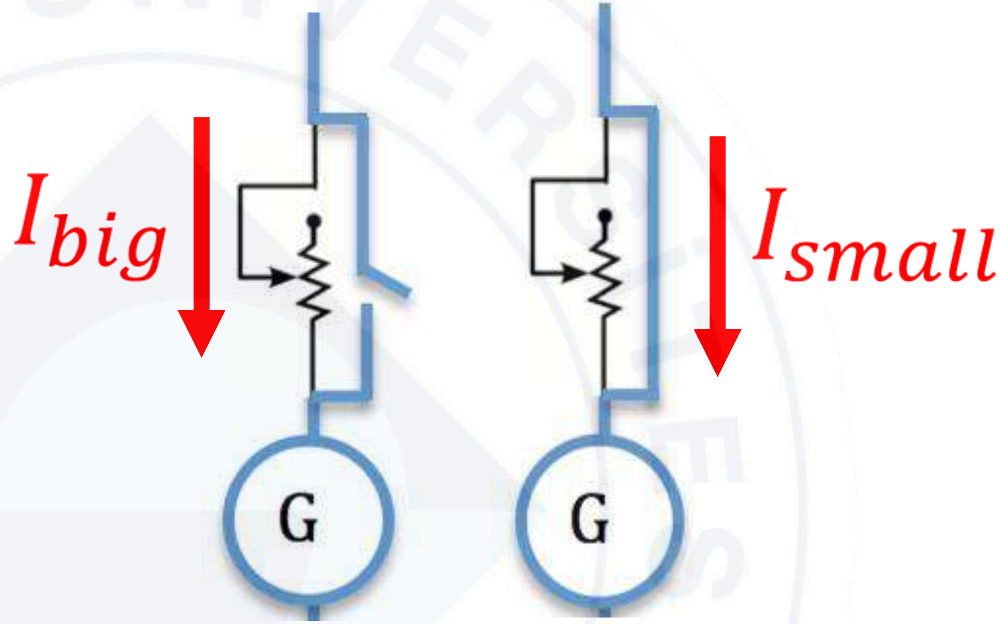



The Slide Wire Wheatstone Bridge

# WHEATSTONE BRIDGE




**The Slide Wire Wheatstone Bridge**




**Balance Condition:**

$$I = 0$$

$$V_B = V_D$$

The galvanometer is the device used for detecting the presence of a small current or a small voltage.

The galvanometer has following applications:

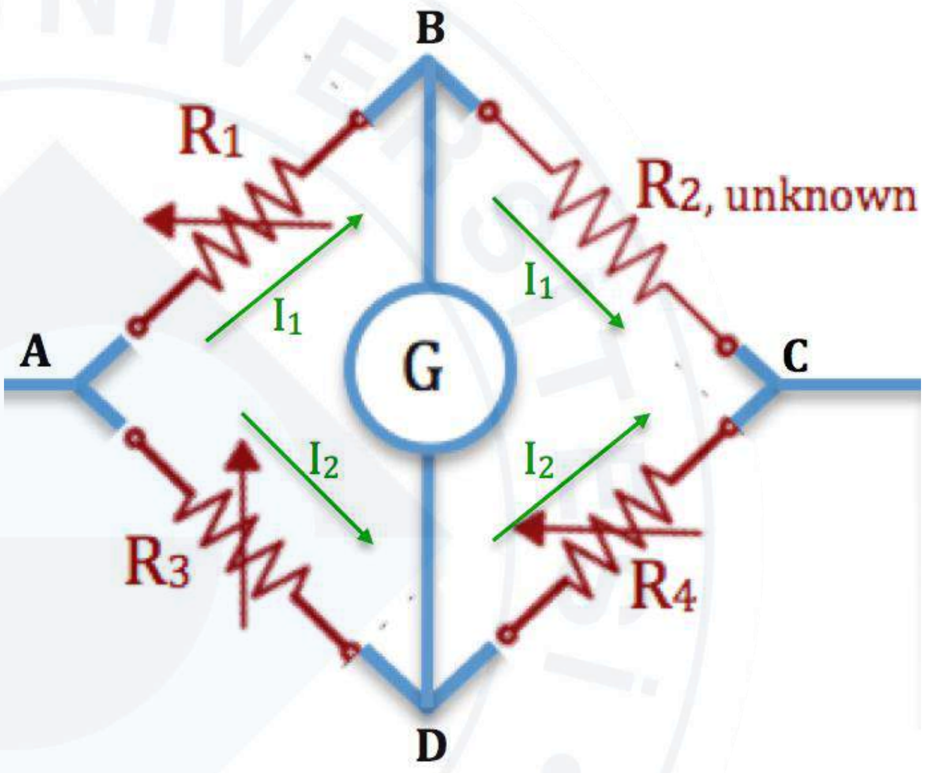
- It is used for detecting the direction of current flows in the circuit. It also determines the null point of the circuit. The null (zero) point means the situation in which no current flows through the circuit.
- It maybe used for measuring a very small current.
- The voltage between any two points of the circuit may also be determined by using a galvanometer.

Assuming that the resistances in the wire part of the circuit are $R_3$ and $R_4$ and the other part are $R_1$ and $R_2$ .

Then, adjusting the position of the sliding contact on the wire, the current through the galvanometer is brought to zero, namely

$$V_B = V_D$$

The current passing through the wire part is $I_2$ and the other part is $I_1$.



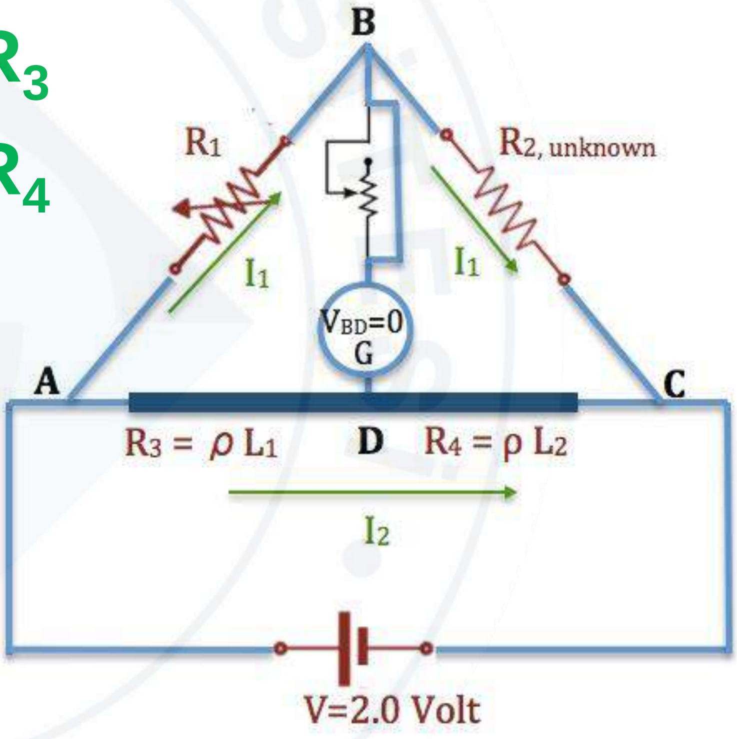

$$V_{AB} = V_{AD}$$

$$V_{BC} = V_{DC}$$

This means that the potential differences across the resistances opposing each other in each pair will be equal:

$$V_{AB} = V_{AD} \quad \rightarrow \quad I_1R_1 = I_2R_3$$

$$V_{BC} = V_{DC} \quad \rightarrow \quad I_1R_2 = I_2R_4$$




Dividing the first expression

by the second one, we get

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} = \frac{L_1}{L_2}$$

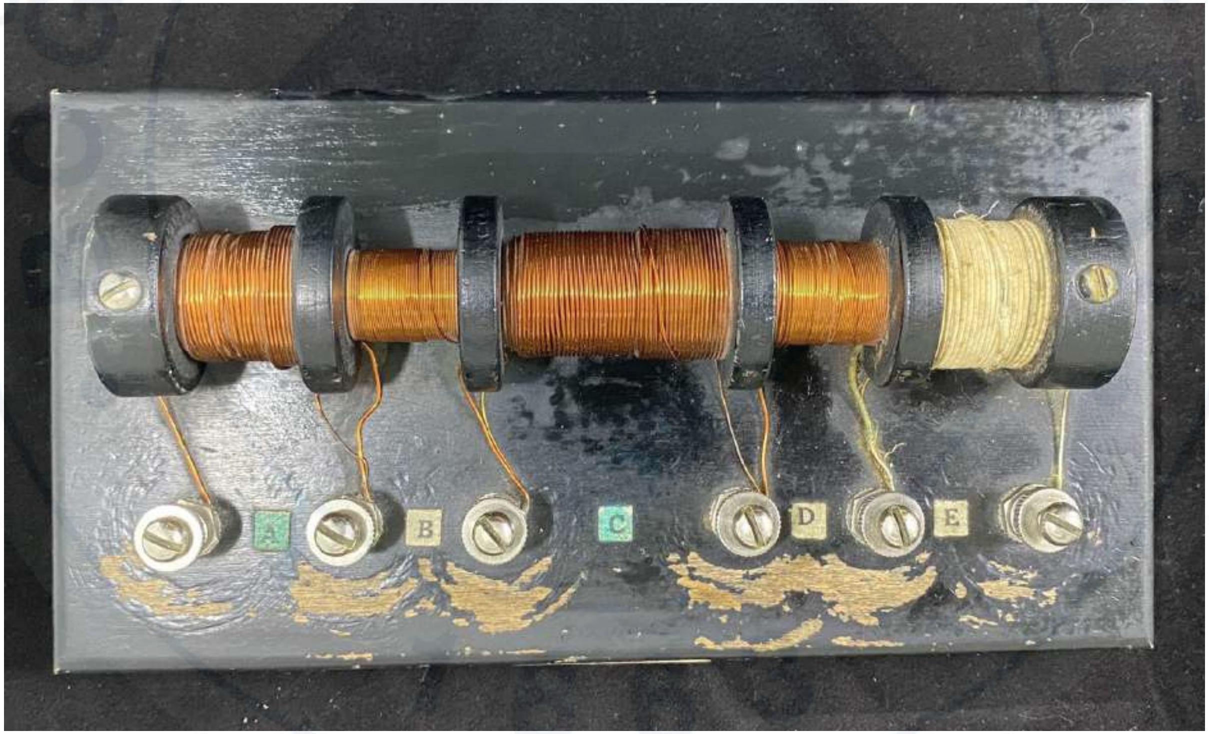
$L_2 = 100 - L_1$ *(we measure $L_1$)*

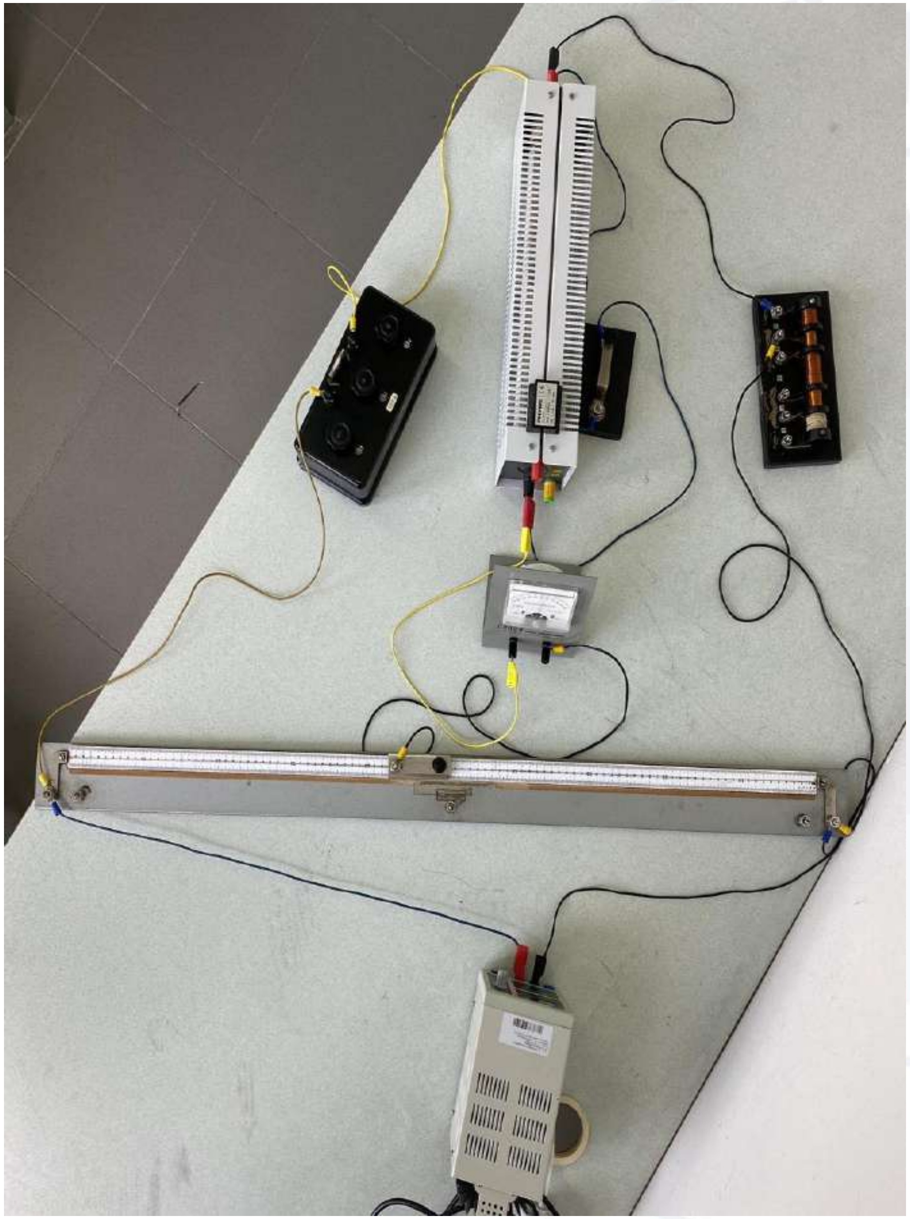
$R_2 = R_{unknown} = (L_2/L_1)\, R_1 = [(100-L_1)/ L_1]\, R_1$

# EXPERIMENT SETUP AND METHOD

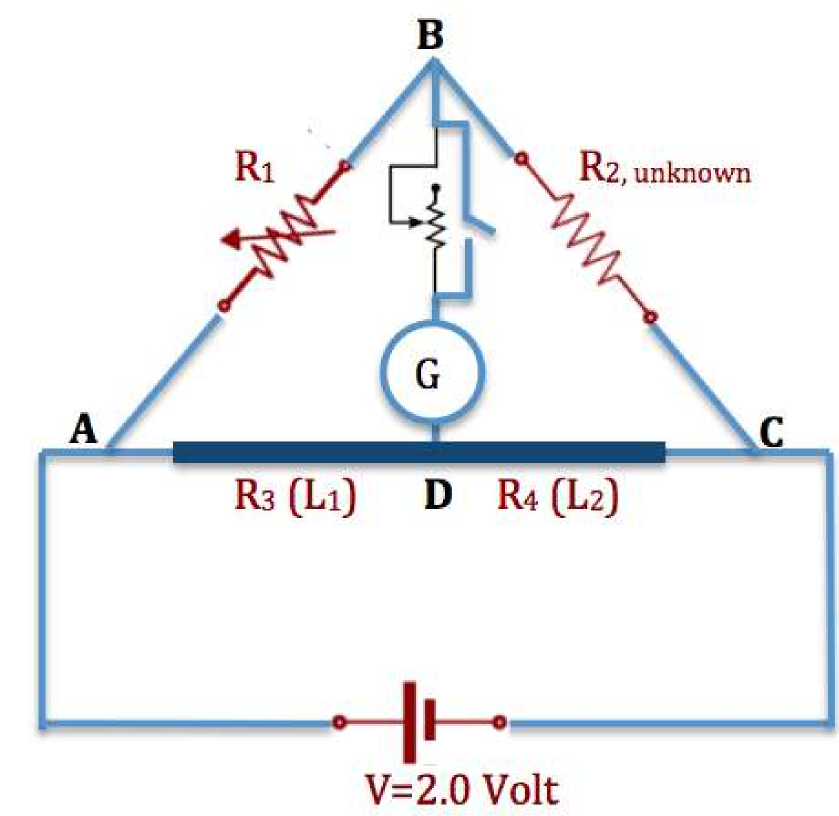
There are 5 different unknown resistors. We will connect those in place of $R_2$ in the Wheatstone Bridge circuit.

All 5 resistors are connected in series on the board.

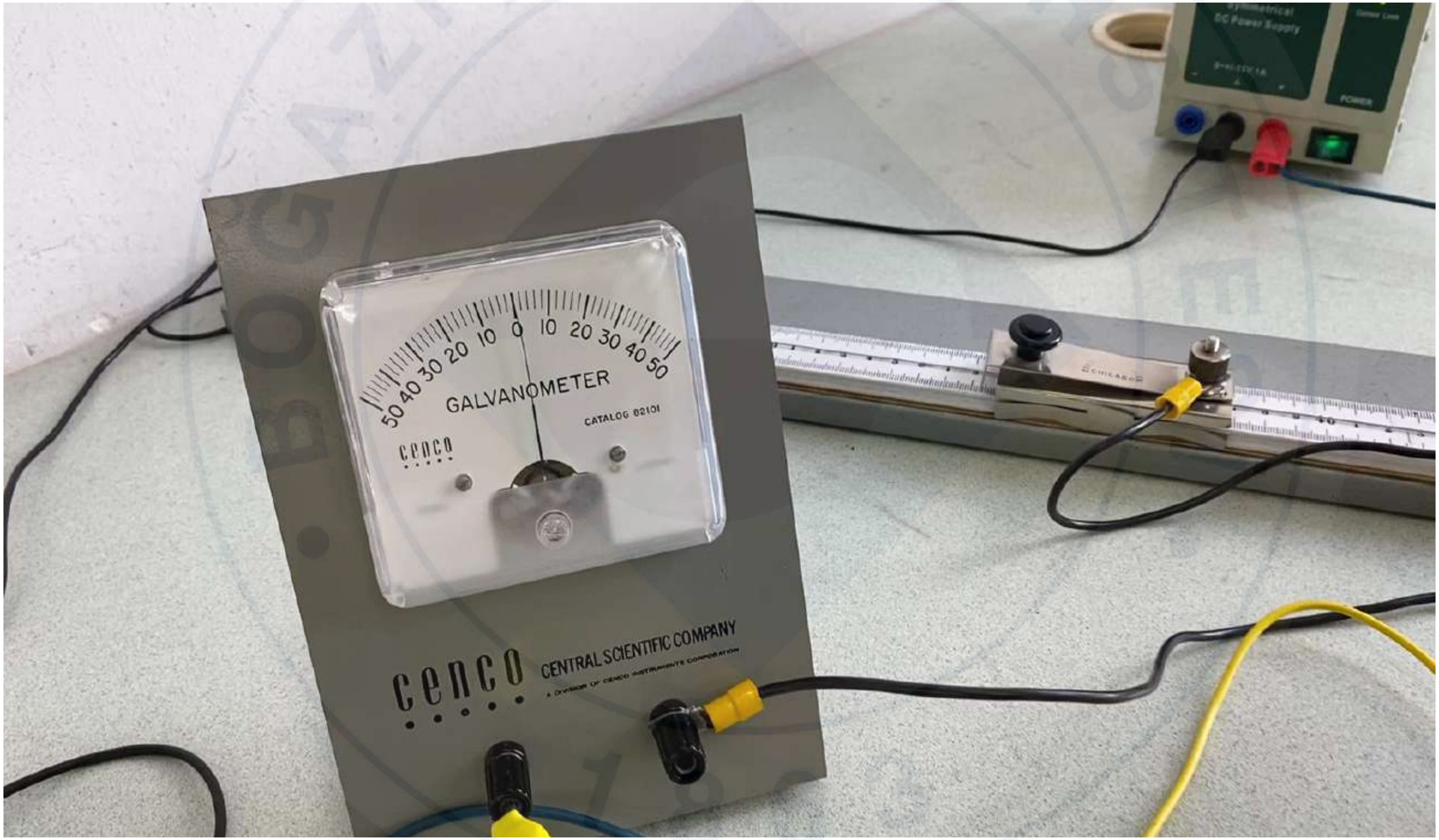




Here is the circuit in detail:



**Adjusting the position of the sliding contact on the wire, the current through the galvanometer is brought to zero.**



# DATA-TAKING

Record your readings into table.

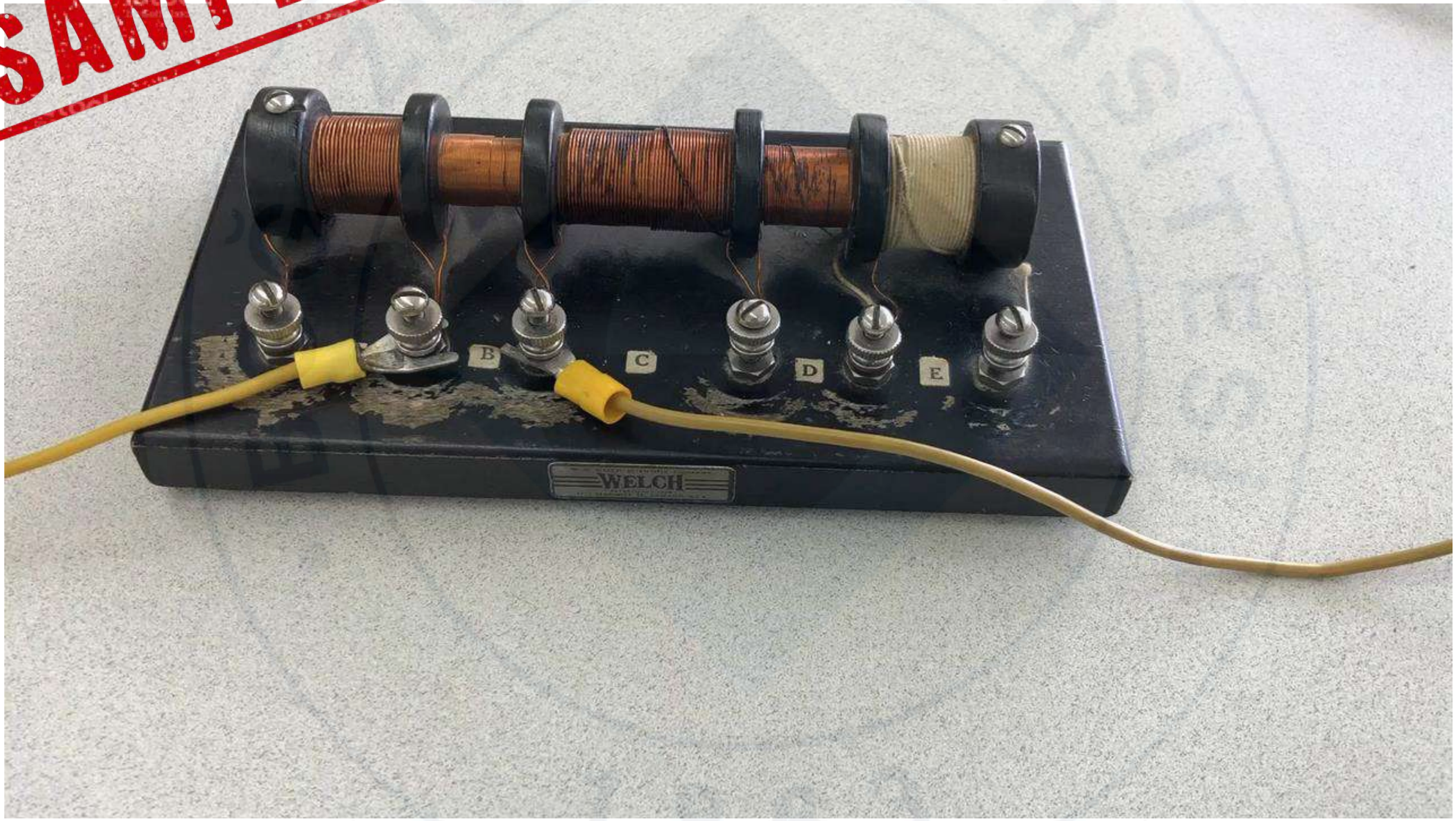
## DATA-TAKING

| Name of the Resistance* | $R_1$ (   ) (Resistance Box) | $L_1$** (   ) # of Significant Figures = | $L_2$ (   ) # of Significant Figures = |
|---|---|---|---|
| $R_A$ | | | |
| $R_B$ | | | |
| $R_C$ | | | |
| $R_{Series}$ (A and C) | | | |
| $R_{Parallel}$ (A and C) | | | |

* Ignore unknown resistances D and E! $R_1$ can be different for different unknown resistances.

** $L_1$ should be in the interval 10.0 cm < $L_1$ < 90.0 cm. Otherwise, change $R_1$ and retry!

# WHEATSTONE BRIDGE



# SERIES CONNECTION OF 2 RESISTORS

Series connection: $R_{ser} = R_A + R_C$

# PARALLEL CONNECTION OF 2 RESISTORS

**Parallel connection:** $1/R_{parallel} = 1/R_B + 1/R_D$


# CALCULATIONS

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## CALCULATIONS

| Symbol | Calculations (show each step) | Result |
|---|---|---|
| $R_A$ = | ........................................................... | |
| $R_B$ = | ........................................................... | |
| $R_C$ = | ........................................................... | |
| $R_{Series}$ = | ........................................................... | |
| $R_{Parallel}$ = | ........................................................... | |

$$R_x = \frac{(100.0 - L_1)}{L_1} R_1$$

**Use this formula to calculate each of the unknown resistances.**

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## CALCULATIONS

| Symbol | Calculations (show each step) | Result |
|---|---|---|
| $R_{Series}$ = *(expected)* | ............................................... | .............. |
| $R_{Parallel}$= *(expected)* | ............................................... | .............. |

Use the theoretical formulae for equivalent resistance to calculate

## RESULTS

| | | |
|---|---|---|
| % Error for $R_s$ : | ........................................ | ............. |
| % Error for $R_{//}$ : | ........................................ | ............. |

Accept the expected values as the true values