EXPERIMENT No. – …….

Experiment Title: - Carey Foster's Bridge Experiment

Aim: - To determine the **resistance per unit length of the bridge wire** of a Carey Foster's bridge, and to use it as the foundation for finding unknown small resistances or the specific resistance of a wire.

Practical Significance: -

The **Carey Foster Bridge experiment** is of great practical importance because it provides a highly accurate method for measuring very small differences between nearly equal resistances and determining the **resistance per unit length of a uniform wire**. The concepts learned through this experiment form the foundation for the calibration of electrical instruments, testing of standard resistors, quality control in electrical manufacturing, and research involving precision resistance measurements. It also enhances students' analytical and problem-solving abilities, making it an essential Engineering Physics laboratory experiment.

Relevant program outcomes: The most relevant Program Outcomes are-

PO1: Engineering Knowledge

Apply the fundamental principles of Physics, Electrical Science, and Mathematics to understand the working principle of the Carey Foster Bridge and determine the resistance per unit length of a uniform wire.

PO2: Problem Analysis

Analyse the experimental data, identify sources of error, and interpret the results to accurately determine the resistance per unit length using bridge balance equations.

PO4: Investigation of Complex Problems

Conduct the experiment systematically by making precise observations, performing calculations, analysing results, and drawing valid conclusions based on experimental evidence.

PO5: Modern Tool Usage

Use laboratory instruments such as the Carey Foster Bridge, galvanometer, resistance box, battery eliminator, jockey, and measuring scale effectively to perform accurate electrical measurements.

PO9: Individual and Team Work

Perform the experiment individually or collaboratively while sharing responsibilities, maintaining effective communication, and ensuring proper coordination during laboratory work.

PO10: Communication

Prepare a clear and well-organized laboratory record, present observations and calculations systematically, and effectively communicate the experimental findings.

PO12: Life-long Learning

Develop an appreciation for precision measurement techniques and cultivate the habit of continuous learning about electrical instrumentation, calibration methods, and advanced measurement technologies.

Relevant Course outcomes:

Students will be able to describe the principle and working of the Carey Foster Bridge.

Practical learning outcomes:

Use Carey Foster's Bridge,

1. To understand the working principle of Carey Foster's Bridge.
2. To determine the resistance per unit length of the bridge wire.
3. To compare nearly equal resistances accurately.
4. To learn null-deflection measurement techniques.
5. To minimize measurement errors using resistance interchange.

Practical Skills Developed:

1. **Experimental Setup:** Assemble and operate the Carey Foster Bridge correctly.
2. **Instrument Handling:** Use the galvanometer, resistance box, jockey, and bridge wire safely and accurately.
3. **Measurement Skills:** Measure balance lengths and determine the resistance per unit length of the wire.
4. **Observation Skills:** Locate the null point accurately and record observations systematically.
5. **Analytical Skills:** Perform calculations, analyse results, and identify experimental errors.
6. **Problem-Solving Skills:** Troubleshoot common issues to obtain accurate measurements.
7. **Reporting Skills:** Prepare clear observation tables, calculations, and conclusions.
8. **Laboratory Safety:** Follow safe laboratory practices and handle electrical equipment responsibly.

Relevant affective domain related outcomes:

1. Receiving: -Demonstrates awareness of the objectives of the experiment, laboratory safety rules, and the importance of laser safety precautions.

2. Responding: - Actively participates in performing the experiment by following the prescribed procedure and laboratory instructions with interest.

3. Valuing: - Appreciates the importance of precision, accuracy, and systematic observation in determining the angular divergence of a laser beam.

4. Organization: - Integrates safe laboratory practices, proper instrument handling, and systematic data recording into the experimental work.

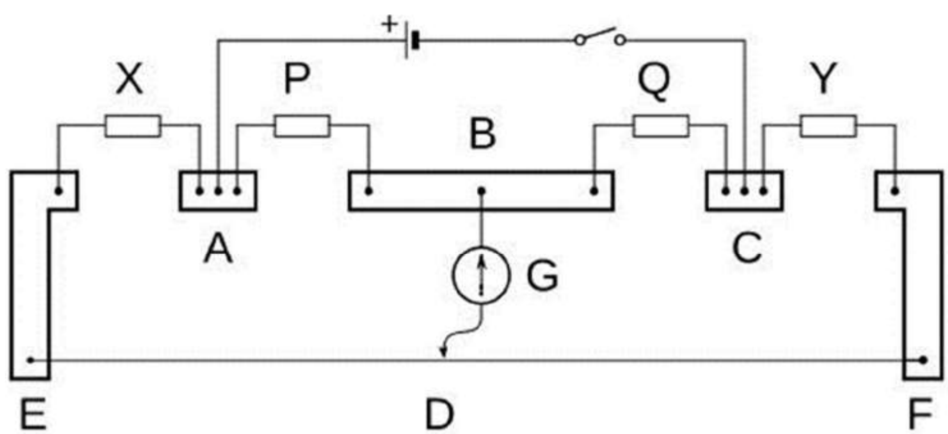
5. **Characterization (Internalization): -** Consistently demonstrates responsibility, discipline, ethical laboratory practices, and a scientific attitude while handling laser equipment and interpreting experimental results.

Theoretical Background: -

Carey Foster's bridge is a clever variation of the ordinary meter bridge. It was designed to overcome the biggest weakness of the meter bridge — the unavoidable *end resistances* at the copper strips and connecting terminals, which throw off any measurement of small resistances. In an ordinary meter bridge, these end errors are simply ignored, but when you're measuring resistances of just a fraction of an ohm, ignoring them is not an option.

The **Carey Foster bridge principle** is a direct modification of the classic Wheatstone bridge network. It consists of four resistance arms arranged in a loop.

In this specific bridge layout, two equal, steady resistances (P and Q) are placed in the inner gaps. The unknown resistance (X) and a known standard resistance (Y) occupy the outer gaps, connected directly across a uniform slide wire EF of length $L = 100$ cm.



When the bridge is perfectly balanced at a null point distance l_1 from the left end, the relation is given by:

$$\frac{P}{Q} = \frac{X + \alpha + l_1\rho}{Y + \beta + (100 - l_1)\rho}$$

Where:

- α and β are the end-resistances at the left and right copper strips respectively.
- ρ is the **resistance per unit length of Carey Foster bridge wire**.

By interchanging the positions of X and Y in the outer gaps, we shift the balance point to a new length l_2:

$$\frac{P}{Q} = \frac{Y + \alpha + l_2\rho}{X + \beta + (100 - l_2)\rho}$$

Equating these two balance conditions allows us to completely cancel out the unknown end corrections (α and β). The final simplified formula yields:

$$Y = X - \rho(l_2 - l_1)$$

If we intentionally make one side a perfect short-circuit ($Y = 0$) by using a thick copper strip, the equation simplifies beautifully to allow us to calculate ρ:

$$\rho = \frac{X}{l_2 - l_1}$$

FORMULA USED:

1. Resistance per unit length of wire of bridge;

$$\rho = \frac{X}{(l2 - l1)} \text{ ohms/cm}$$

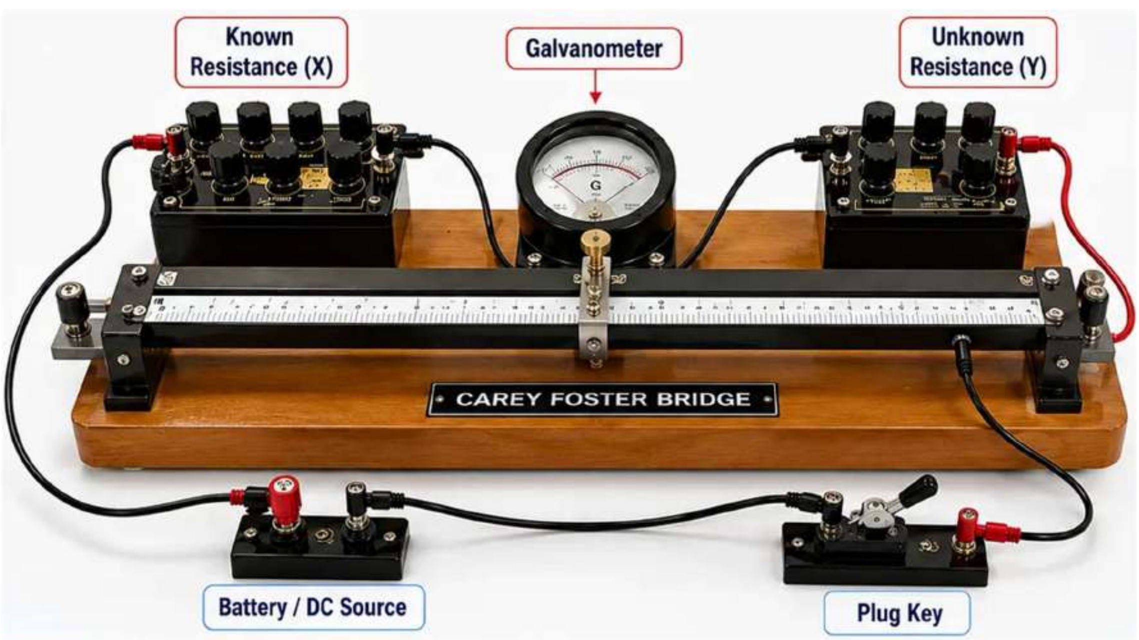
Where $l1$ = balancing length on the bridge wire measured from the left and when known resistance X is connected in left gap of the bridge and zero resistance is connected in right gap of the bridge and $l2$ = balancing length on the bridge wire measured from the left end on interchanging the position of X and Y.

2. **Unknown resistance of the given wire / resistance,**

$$Y = X - (l2 - l1)\,\rho$$

Where X = known resistance connected in the left gap. Y = the resistance of wire connected in the right gap. *l1 and l2* respectively are the balancing length of the bridge wire measured from the left end, before and after interchanging positions of X and Y.

Experimental set-up: -



Resources required: -

S. No.	Name of equipment	Specifications/Purpose	Quantity	Remark
1	Carey Foster Bridge	with a uniform 1 metre bridge wire mounted on a scale	1	
2	Standard resistance box		1	
3	Known resistance		1	
4	Unknown resistance		1	
5	Galvanometer		1	
6	Jockey		1	
7	Battery eliminator (or DC source)		1	
8	Plug key		1	
9	Connecting wires		1	

Precautions: -

1. All plug connections must be clean, tight, and free of oxide layers.
2. The jockey should be tapped gently on the wire, never dragged or pressed hard — this can scratch the wire and change its uniform cross-section.
3. The key should be inserted only while taking a reading, to avoid unnecessary heating of the wire.
4. Try to keep the balance point between the 40 cm and 60 cm marks for maximum sensitivity.
5. Avoid parallax error while reading the position of the jockey on the scale.
6. Ensure the bridge wire has uniform cross-section along its entire length; a non-uniform wire introduces systematic error.

Experimental Procedure:

The experiment is carried out in two parts:

Part A: To Determine the Resistance per Unit Length of the Bridge Wire

1. Connect the circuit as shown in the experimental setup.
2. Connect the galvanometer to the bridge.
3. Select a known resistance X using the resistance box (band switches) on the left side. Set the resistance Y = 0 Ω on the right side.
4. The terminals P and Q are already connected internally; therefore, no additional connection is required.
5. Connect the bridge to the AC mains supply and switch it ON using the power switch.
6. Press the jockey key and slowly slide the jockey along the bridge wire to locate the position where the galvanometer shows zero (or minimum) deflection.
7. Note the balance length l_1 from the left end of the bridge wire using the meter scale.
8. Interchange the resistances by setting X = 0 Ω on the left side and selecting the same resistance value on the right side.

9. Again, slide the jockey to obtain the null point and note the new balance length l_2.
10. Calculate the resistance per unit length of the bridge wire using

$$\rho = \frac{X}{(l_2 - l_1)}\ \Omega/\text{cm}$$

where, X= Known resistance (Ω), l_1= First balance length (cm)
l_2= Second balance length (cm)

11. Repeat the experiment for different values of X and calculate the average value of ρ.

Part B: To Determine the Resistance of the Given Wire (Unknown Resistance)

1. Connect the unknown resistance (or the given wire) to the Y terminal on the right side of the bridge.
2. Select a suitable known resistance X using the resistance box on the left side.
3. Switch ON the bridge and locate the null point by sliding the jockey while pressing the jockey key.
4. Record the first balance length l_1.
5. Interchange the resistances and again locate the null point.
6. Record the second balance length l_2.
7. Calculate the unknown resistance Y using

$$Y = X - (l_2 - l_1)\rho$$

where, X= Known resistance (Ω), ρ= Resistance per unit length of the bridge wire (Ω/cm)

8. Repeat the experiment with different values of X and calculate the average value of Y for greater accuracy.

Observations Table: -

1. To determine the resistance per unit length of the bridge wire:

S. No.	Known Resistance X (in ohms)	Balance Length l_1(cm)	Balance Length l_2(cm)	$(l_2 - l_1)$ (In cm)	$\rho=\frac{X}{(l_2-l_1)}$ in ohm/cm
1.					
2.					
3.					

2. For resistance of given wire / unknown resistance:

S. No.	Known Resistance X (in ohms)	Balance Length l_1(cm)	Balance Length l_2(cm)	$(l_2 - l_1)$ (In cm)	$Y = X - (l_2 - l_1)\rho$ ohms
1.					
2.					
3.					

Calculations:

Mean resistance per unit length:

$$\rho_{mean} = \frac{\rho_1 + \rho_2 + \rho_3}{3} = \cdots \ \ \Omega/\text{cm}$$

Mean value of unknown resistance:

$$Y_{mean} = \frac{Y_1+Y_2+Y_3}{3} = \cdots \ \ \Omega$$

Results:

1. The resistance per unit length of Carey foster's Bridge wire = _______ohms
2. Resistance of the given resistance wire / unknown resistance = _____ ohms

Conclusion and recommendations:

Conclusion: -
The **Carey Foster's Bridge experiment** is one of the most accurate methods for determining the **resistance per unit length of a uniform bridge wire**. By comparing two nearly equal resistances and observing the shift in the balance point after interchanging them, the experiment minimizes systematic errors and delivers highly reliable results.
It also strengthens the understanding of bridge circuits, null methods, and precision electrical measurements. Because of its simplicity, sensitivity, and accuracy, Carey Foster's Bridge continues to be an essential experiment in engineering physics and electrical laboratory courses.

Recommendations: -

1. Ensure all electrical connections are tight and secure before switching on the power supply.
2. Locate the null point carefully by moving the jockey slowly to obtain accurate balance lengths.
3. Press the jockey key gently to avoid damaging the bridge wire.
4. Repeat the experiment with different values of the known resistance $X$and use the average result for better accuracy.
5. Record all observations systematically and perform calculations carefully to minimize experimental errors.
6. Compare the experimental results with theoretical expectations and discuss possible sources of error.
7. Switch OFF the power supply after completing the experiment and keep the apparatus clean for future use.