Type of Laboratory note book:

The laboratory note book should be bound, hardback and contains around 80 pages. There must be an index page. Pages should be alternate blank and ruled.

How to prepare the laboratory note book:

A. Every page should be assigned a page number and that must be continuous.
B. The blank pages should be used for only figure and diagram.
C. The ruled pages should be used for text and tables, measurements, result etc.
D. At first the Experiment No. , Title of the experiment, Date of execution of the experiment and corresponding page no in the note book should be written in the index page of the laboratory note book.
E. The 1st page (ruled) of every experiment should begin with the following points.
    i) Section and stream:
    ii) Group Number:
    iii) Group Members:
    iv) Date:
    v) Title of the Experiment:
F. The next ruled page should contain the following points: Theory, Working formula, Apparatus used, Brief procedure, Observations / Measurements / Results including calculations, Error calculation (if any) and discussion / conclusion.
G. The corresponding figures, diagrams should be drawn on the blank pages opposite to the theory.
H. The content including text and figures of the experiments should be taken from the manual.

Safety guidelines for the students:

It will be necessary to follow procedures to ensure safety in the lab. Safety in the laboratory is very important. The experiments performed in the laboratory are designed to be as safe as practicable, but caution is always advised concerning the use of the equipments. When students arrive at the lab. at the commencement of each lab-class, it is very important that they should not touch or turn on the laboratory equipment until it has been assigned and explained by the Teacher or Instructor.

The equipment for the labs are set up for the students in advance, so they must resist the urge to play with the equipment when you arrive, as it may hurt themselves or others, or damage the equipment. There need intense safety for the equipment as it tends to be expensive and delicate too. Students are strictly advised not to try to fix the equipment by themselves.

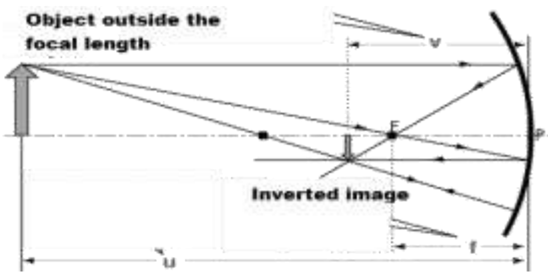
Experiment no: 01

Determination of the focal length of a concave mirror with help of optical bench

Theory:

A concave mirror forms image on the same side as the position of the object, hence its focal length 'f' is positive. Figure-1 shows an object (pin) on the left of the mirror at a distance greater than its focal length found in distant object method. The concave mirror is placed on the right end of the optical bench. An inverted image is formed by the same side of the object.

Working formula:



From the scale marked on the optical bench, the object distance (u) and the image distance (v) can be measured and focal length 'f' of the concave mirror can be determined using the formula

$$\frac{1}{u}+\frac{1}{v}=\frac{1}{f} \quad \text{or} \quad \frac{1}{v}=\frac{1}{f}-\frac{1}{u}$$

Figure. 1. Image formation by a concave mirror.

Changing the position of the object i.e. for different *u* value corresponding image distance *v* are measured and a collection of data in tabular form has been written.

A graph has been drawn *1/u* (along *x- axis*) vs *1/v* (along *y- axis*) and the graph will be a straight line not to pass through the origin. Obviously the intercept of the straight line on *x- axis* will give *1/f* and hence *f* can be found.

Procedure:

(1) Estimation of approximate focal length by *Distant object method*:

The given concave mirror facing a long distant object is placed on the stand and placed at one end of the optical bench. A white screen is adjusted in front of the mirror without blocking the light rays from the distant object (the screen should be placed in an angular direction to the mirror) till a clear inverted image is formed. The distance between the mirror and the screen gives an approximate value of the focal length '*f*'.

(2) Estimation of focal length by u-v method:

1. The mirror is properly placed at one extreme end of the optical bench so that the pointer of the stand of the mirror coincide with the Zero mark of the grooved scale.

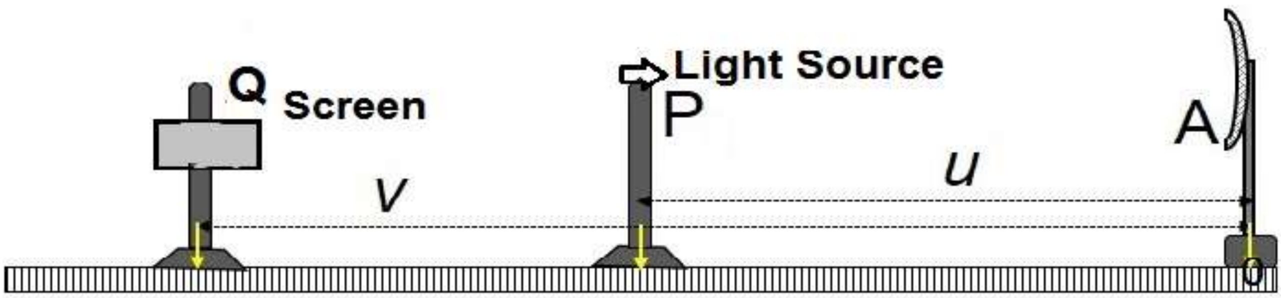


Figure 2: Position of the Mirror, light source and the screen on the optical bench.

2. The light source facing to the mirror is mounted on the optical bench making slightly high to that of the center line of the mirror.
3. The light source is adjusted between the f and 2f distance from the mirror and its position is noted.
4. The screen is placed on the optical bench beyond the light source and its position is adjusted such that a clear image of the object is seen on the screen. The screen position is noted form the scale.
5. The distance between the light source and the mirror (u) and the distance between the mirror and image screen (v) are calculated.
6. The value of u and v are noted for three different position of the light source within the range $f<u<2f$.
7. Experiment is repeated for three different values of image distance u greater than $2f$ i.e. the light source is placed beyond $2f$ and the screen is placed in between light source and mirror. Thus by measuring light source distance and screen distance from the mirror in each case, the readings are tabulated.
8. From the above data a graph is drawn between $1/u$ and $1/v$ and from the intercept of that graph $1/f$ is taken and then the value of focal length f is calculated.

Observations and measurements:

A. Estimation of approximate focal length by *Distant object method*: *f=………….cm*

B. Table for graph and estimation of focal length by graphical method:

No of observations		Position of the light source P u cm	Position of the screen Q v cm	Object distance u *in (meter)*	Image distance v *in (meter)*	$1/u$ $(m)^{-1}$	$1/v$ $(m)^{-1}$	From the intercept of the graph $1/f$ $(m)^{-1}$	Focal length of the mirror f $[1/\ (1/f)]$ *cm*
1.	$u < v$ $f< u < 2f$								
2.									
3.									
4.	$u > v$ $2f< u$								
5.									
6.									

Discussion:

I. The optical bench must be horizontal.
II. The exact image position on the screen is to be taken.
III. The light source should never be placed in between mirror and focal length of the mirror (u < f) otherwise virtual image will be formed.
IV. The aperture of the given mirror should be small, otherwise the image formed will be distorted.

Experiment No - 02

Determination of Unknown Resistance with help of Post Office Box

Theory:

The post office box (P O Box) is used to measure an unknown resistance and operates on the principal of Wheatstone's bridge. The box contains a number of coils of known resistance arranged in such a manner as to from the three arms of a Wheatstone's bridge

A post office (PO) box operates on the same principle as Wheatstone's bridge which consists of four resistances P, Q, R and S that are connected to each other as shown in the circuit diagram in Fig. 1. In this circuit, E is a voltage source, G is a galvanometer and K_1 and K_2 are two keys. If the values of the resistances are adjusted so that no current flows through the galvanometer (balance condition), then the resistances P,Q,R and S satisfy the relationship,

$$\frac{P}{Q} = \frac{R}{S} \qquad (1)$$

Working formula:

A PO box is a compact form of the Wheatstone bridge where the resistances with bride arms are inbuilt in a single unit and can be varied conveniently. Two of its arms (P and Q) have resistances which can be set to be at values 0, 10, 100 and 1000 ohms alternately. These two arms are used establish the ratio between the two sides of the bridge and are called ratio arms. A third bride arm is connected to a variable resistance which can be given a value from 0 to about 5000 ohms in convenient steps. The fourth arm can be connected to an unknown resistance whose value needs to be determined. S is the unknown resistance. When the Wheatstone bride is in balanced condition, then from Eq. (1) we get,

$$S = \frac{Q}{P}\, R \qquad (2)$$

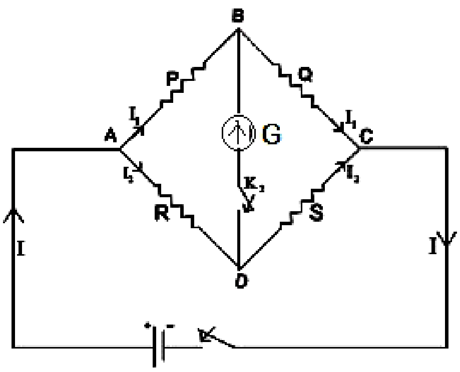


Figure 1: Wheatstone Bridge circuit.

Experimental setup:

The PO box experimental unit is as shown in Figure. 2. It has a DC voltage source, a galvanometer, Wheatstone bride arms with resistances P, Q *and* R. P and Q are the ratio arms each of which can be set at 0, 10, 100 and 1000 Ohms. R is consists of several resistances in series. The Resistance S which acts as an unknown resistance is connected as per circuit diagram.

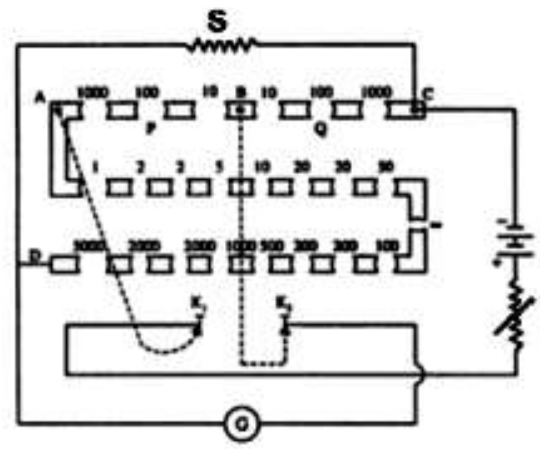


Figure 2: Post Office Box circuit with external unknown resistance and biasing.

Procedure:

1. The circuit connections are made as shown in the figure 2, Where

(i) The +ve terminal of the DC voltage is connected to the K_1 key through rheostat and the -ve terminal to 'C'.

(ii) Galvanometer is connected to terminal D and the key K_2.

(iii) The unknown resistance S is connected between the terminal C and D.

2. To check the circuit equal resistance has been put over P and Q and then deflections is noted for zero resistance and for infinite resistance on R arm. If for two cases the deflection occurs in opposite direction then the circuit is accurate. If not then all the keys are to be properly tightened.

3. If resistance in of P and Q are set 10 ohms each then P=Q and hence S=R. i.e. the same value as equal to S resistance should be put over R to get the no deflection on galvanometer. Therefore by choosing the proper R value for no deflection condition we can determine the unknown resistance S.

4. But if with P=Q=10 ohms, no suitable value of R is found for no defection, the obviously for the value of R′ (say) and (R′+1) in the third arm the galvanometer will show opposite deflection on galvanometer. Then it can be inferred that the unknown resistance S lies between R′ (say) and (R′+1).

5. Then keeping P=100 ohms and R=10 ohms suitable value of R is found for no defection on galvanometer. At this condition the value of S will be (R/10) since P/Q=10.

6. Then a different unknown value of S is taken and following the above procedural steps the value of the unknown resistance (S value) is evaluated.

Observation and Measurements: -

A. Determination of the value of unknown resistance:**

Resistance in P arm Ω	Resistance in Q arm Ω	Ration between P and Q	Resistance in R arm Ω	Deflection of the galvanometer	Value of unknown resistance, S Ω
10	10	1:1	0	left	Circuit OK
			$\propto$	right	
			…….	…….	
			……..		…...< S <…
100	10	10:1			
			……..	No deflection	S= R / 10=

Result: The value of unknown resistance, S = ………………. Ω

Discussion:

I. The battery key K_1 is to be pressed first and the key K_2 to avoid self-inductance in the coil of the resistances.

II. Resistance plug which are not in use must be tighten properly.

III. To avoid the insensitivity of galvanometer in higher ratio range the experiment is done under low ration range.

IV. All the terminal of the wires should be properly rubbed by a sand paper and they are properly connected to avoid the resistance appeared from loose connection.

Experiment No: 03

Qualitative investigation of series and parallel resistance in circuits with help of digital multimeter

Theory:

If two resistors of resistance R_1 and R_2 are connected "one by one" then the combination is called series as in Figure 1. In series connection since there is only path to flow electrons each one resistance "sees" the same current but different potential drop across them. If two resistor of resistance R_1 and R_2 are connected in "side by side" as shown in Figure 2 then the combination of resistors are called parallel. When resistors are in parallel, the current flowing from the source will come to a junction where it has a "choice" as to which branch to take. Therefore, they "see" different amounts of current but each of them will experience the same potential difference (voltage).

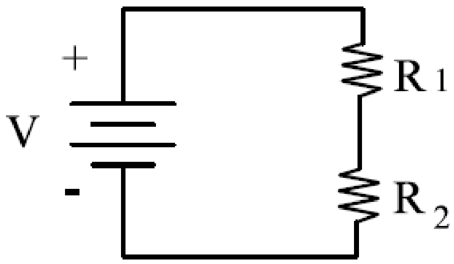


Figure 1: Circuit for resistances connected in series.

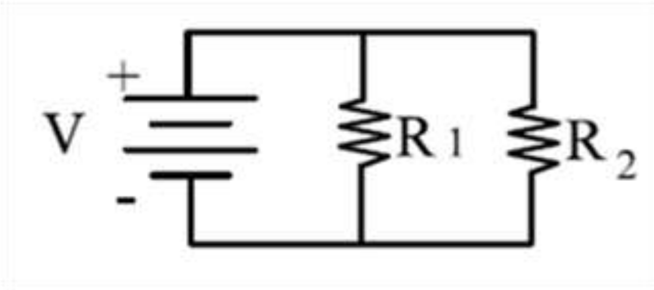


Figure 2: Circuit for resistances connected in parallel.

For both of the cases the effective resistance, known as equivalent resistance R_{eq} of the circuit is determined by some special rules. Figure 3 shows the equivalent circuit with the two resistors replaced by an equivalent single resistor for both series and parallel combination.

Working formula:

If I current flowing through a circuit and produces a potential drop V then according to Ohms law the resistance, $R = V/I$. With extension of the Ohm's law it can be shown that the equivalent resistance for series combination is

$$R_{eq} = R_1 + R_2.$$

Similarly the equivalent resistance for parallel combination is given by $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$

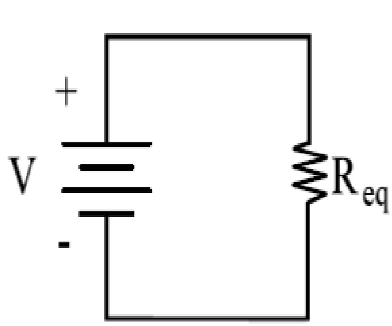


Figure 3: The circuit containing the equivalent resistance.

Aim of the experiment:

The aim of the experiment is to validate the laws of equivalent resistance for series and parallel combination of the resistances and to study the differences between experimental and theoretical consideration. In the first art of this experiment we will study the properties of resistors, which are connected "in series". The parallel combination of resistances will be studied thereafter.

Procedure:

A. Measurement of currents and voltages in series circuit:

1. The circuit (as in Figure 4) is prepared with help of two variable resistance, serve as R_1 and R_2, one dc power supply one two keys. One digital multimeter is taken for measuring the voltage and corresponding current.

2. Two set of resistance is to be put as R_1 and R_2.

3. The potential drop across the individual resistances and across both is measured by tapping the multimeter in volt mode across the resistances. This will give us V_1, V_2 and V respectively for R_1, R_2 and the entire combination.

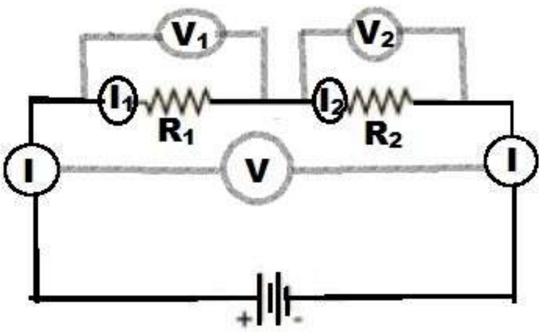


Figure 4: Circuit for series resistance combination with all measurable parameters.

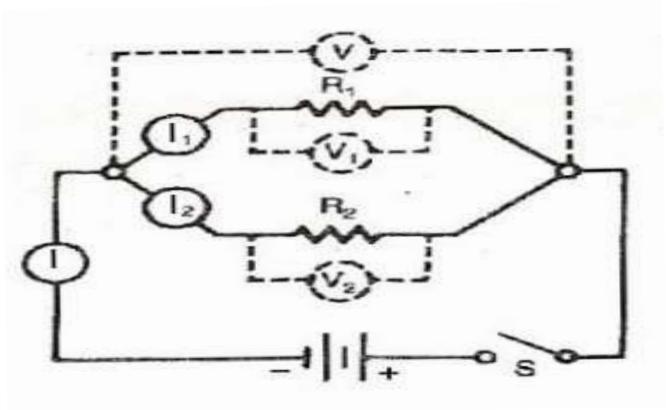


Figure 5: Circuit for parallel resistance combination with all measurable parameters

4. The current through the resistance are made by tapping the multimeter in series with the resistances and we get the current I_1, I_2 and I respectively through R_1, R_2 and the entire combination.

B. Measurement of currents and voltages in parallel circuit:

1. The circuit (as in Figure 5) is prepared with help of two variable resistance, serve as R_1 and R_2, one dc power supply one two keys. One digital multimeter is taken for measuring the voltage and corresponding current.

2. Two set of resistance is to be put as R_1 and R_2.

3. The potential drop across the individual resistances and across both is measured by tapping the multimeter in volt mode across the resistances. This will give us V_1, V_2 and V respectively for R_1, R_2 and the entire combination.

4. The current through the resistance are made by tapping the multimeter in series with the resistances and we get the current I_1, I_2 and I respectively through R_1, R_2 and the entire combination.

Observations and Measurements:

A. Table for series resistance:
(All resistances are in Ω, currents are in A and potential differences are in V)

R_1	R_2	I	V_1	V_2	V	$R_{1exp}= V_1/I$	$R_{2exp}= V_2/I$	$R_{Th} = R_1 + R_2$	$R_{exp} = R_{1exp} + R_{2exp}$	$R_{ac}=V/I$

B. (i) Check $V_1 + V_2 = V$? **(ii) Compare R_{Th}, R_{exp} and R_{ac}.**

C. Table for parallel resistance:
(All resistances are in Ω, currents are in A and potential differences are in V)

R_1	R_2	I_1	I_2	I	V	R_{1exp}= V/ I_1	R_{2exp}= V/ I_2	R_{Th} = $R_1 \| R_2$	R_{exp} = $R_{1exp} \| R_{2exp}$	R_{ac}=V/I

D. (i) Check, $I_1 + I_1 = I$? **(ii) Compare R_{Th}, R_{exp} and R_{ac}**

Discussion:

I. The power supply is turned on only after proper checking of the circuit is done.
II. When using the multimeter in current measuring mode the range must be set to a value higher than the current in the circuit to avoid damaging the meter and the meter is inserted with the correct "polarity" that is with the positive terminal connected to the high potential side of the circuit (positive of the meter facing the positive of the power supply).
III. When the multimeter is used for potential drop measurement the proper inputs for voltage i.e. the DC volts function (V) is to be fixed and right polarity is to be chosen.
IV. All the terminal of the wires should be properly rubbed by a sand paper and they are properly connected to avoid the resistance appeared from loose connection.

Experiment no: 04

Determination of the focal length of a convex lens with help of optical bench

Theory:

A convex lens is placed facing the object and the image screen is placed on the other side of the lens. Figure-1 shows an illuminated object placed on the left hand side of the optical bench. An inverted real image of the object is formed as shown in Figure-1. When the object is located at a location beyond the distance 2f from the optical centre of the lens, a real and inverted image will always be located somewhere in between the 2f distance and the focal point on the other side of the lens. If the object's position lies in between distance 2f and distance f from the optical centre of the lens then a real, inverted and magnified image is formed at a point beyond 2f from the optical centre on the other side of the lens.

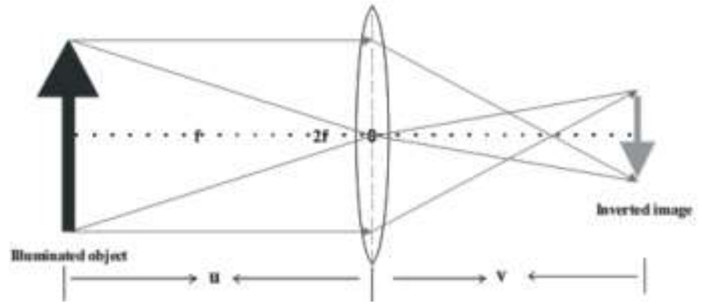


Figure 1: Formation of image by a convex lens.

Working formula:

The distance between the object and the lens is the object distance, u, and the distance between the image screen and the lens is the image distance, v. The image produced by a convex lens is real and the focal length of the lens is positive and is given by

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

According to the new Cartesian sign convention, u is negative but v is positive. Therefore the equation becomes

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f} \quad \text{or} \quad \frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

Changing the position of the object i.e. for different *u* value corresponding image distance *v* are measured and a collection of data in tabular form has been written.

A graph has been drawn *1/u* (along *x- axis*) vs *1/v* (along *y- axis*) and the graph will be a straight line not to pass through the origin. Obviously the intercept of the straight line on *x- axis* will give *1/f* and hence *f* can be found.

Procedure:

A. Determination of approximate focal length by the distant object method:

Approximate value of the focal length of the thin convex lens is obtained by focusing the image of a distant object. It can be found by obtaining a sharp image of the distant light source on a screen or a sheet of paper placed on the other side of the lens and measuring the distance between the lens and the image with a scale. This distance is a rough estimate of the focal length, f of the convex lens.

B. Determination of focal length by the u-v method:

1. The lens is placed on the optical bench at the middle of the optical bench and its position on the grooved scale is noted.
2. The light source facing to the lens is mounted on the optical bench making collinear with the center of the lens.
3. The light source is adjusted between the f and 2f distance from the lens and its position is noted.
4. The screen is placed on the optical bench opposite to the object and its position is adjusted such that a clear image of the object is seen on the screen. The screen position is noted form the scale.
5. The distance between the object and the lens (*u*) and the distance between the object and image screen (*v*) are calculated.
6. The value of *u* and *v* are noted for three different position of the light source within the range $f<u<2f$.

7. Experiment is repeated for three different values of image distance *u* greater than *2f* and measuring *v* in each case, the readings are tabulated.

8. From the above data a graph is drawn between *1/u* and *1/v* and from the intercept of that graph *1/f* is taken and then the value of focal length *f* is calculated.

Observations and Measurements:

(A) Rough estimation of focal length by distant object method:

The distance between the lens and screen = cm; Focal length of the convex lens f = cm

(B) Table for graph and estimation of focal length by graphical method:

No of Observations	Position of the image	Position of the Lens P (cm)	Position of the Light source Q (cm)	Position of the image screen R (cm)	Distance between the lens and the object (u) (P~Q) cm	Distance between the lens and the image screen (v) (P~R) cm	Object Distance u *(Meter)*	Image Distance v *(Meter)*	$1/u$ $(m)^{-1}$	$1/v$ $(m)^{-1}$	From the intercept of the graph $1/f$ $(m)^{-1}$	Focal length of the Lens f $[1/(1/f)]$ cm
1.	f<u < 2f											
2.												
3.												
4.	u > 2f											
5.												
6.												

Discussion:

I. The optical bench must be horizontal and properly marked with the length scale.
II. The aperture of the given lens should be small, otherwise the image formed will be distorted.
III. The light source must not be kept between lens position and it's focal length.

Experiment no: 05

Determination of Resistance per Unit Length, ρ, of the Carey Foster's bridge

Theory:

The Carey Foster's bridge is an electrical circuit based on the Meter Bridge that can be used to measure small resistances. The Cary Foster operates on the principal of Wheatstone's bridge which consists of four resistances P, Q, X, Y and a meter Bridge that are connected to each other as shown in the circuit diagram in Figure. 1. In this circuit, there is a voltage source, G is a galvanometer. The Carey Foster Bridge is a modified form of the meter bridge in which the effective length of the wire is considerably increased by connecting a resistance in series with each end of the wire. Point D is an electrical contact that can be moved along the wire, thus varying the magnitudes of resistances R and S.

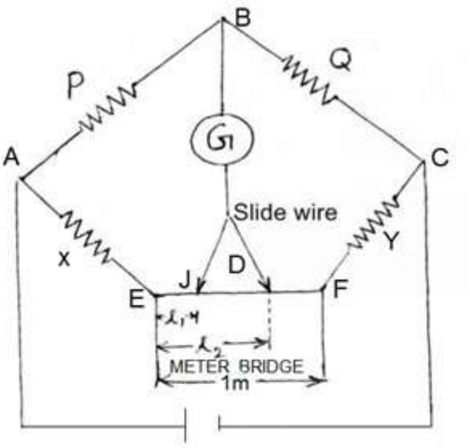


Figure 3: Carey Foster's bridge circuit.

Experimental Setup: The circuit diagram for the experiment is shown in *Figure 1* and the experimental setup is shown in *Figure 2*. There are four gaps in this arrangement. The standard resistances, P and Q, of equal value each are connected in the inner gaps 2 and 3. The known resistance, i.e., the resistance box X and the unknown resistance Y (or metal strip) are connected in the outer gaps 1 and 4, respectively. The meter bridge wire is EF which is one meter long. Since the wire has uniform cross-sectional area, the resistance per unit length is the same along the wire. The galvanometer G is connected between terminal B and the jockey J which is a knife edge contact that can be moved along the meter wire EF and pressed to make electrical contact with the wire.

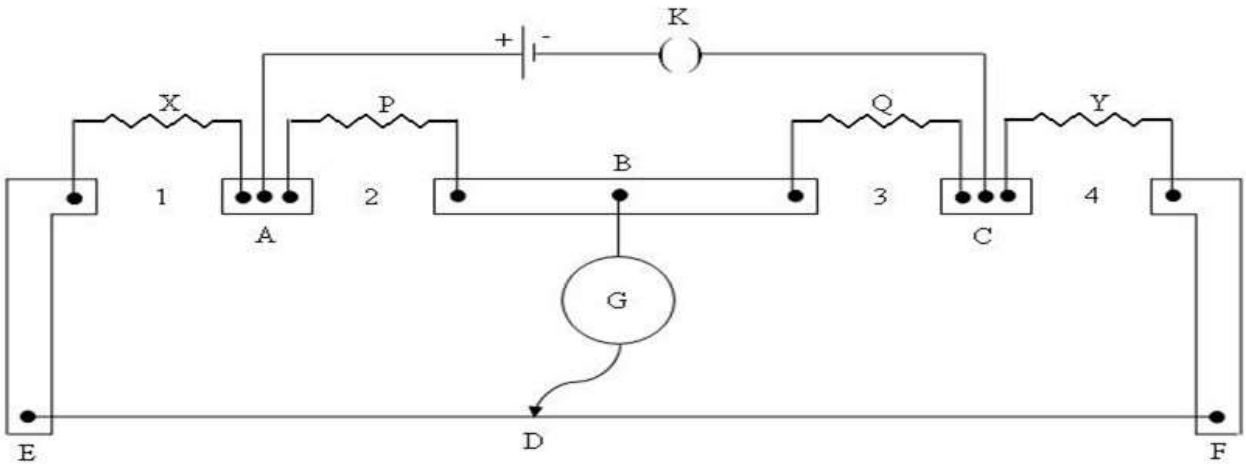


Figure 4: Cary Foster's bridge circuit with biasing.

Working formula:

The four points A, B, C and D in the circuit diagram of Carey Foster Bridge in Figure 2 exactly correspond to the points labeled A, B, C and D in the circuit diagram of *Figure 1*,. If the balance point is located at a distance l_1 from E, then we can write the condition of balance as

$$\frac{P}{Q} = \frac{R}{S} = \frac{X + l_1\,\rho}{Y + (100 - l_1\,)\rho} \text{ ----------(i)}$$

If the positions of *X* and *Y* are interchanged, i.e., *X* is put in right gap and *Y* in left gap, and the balance point is found at a distance l_2 from E, then the balance condition becomes

$$\frac{P}{Q} = \frac{R}{S} = \frac{Y + l_2\,\rho}{X + (100 - l_2\,)\rho} \text{-------------(ii)}$$

Since P=Q the right hand side of (i) and (ii) are same. On adding 1 with right side of each expression we get

$$\frac{X + l_1\rho + Y + (100 - l_1)\rho}{Y + (100 - l_1)\rho} = \frac{Y + l_2\rho + X + (100 - l_2)\rho}{X + (100 - l_2)\rho}$$

On simplifying we get that numerators are equal. Hence the denominators will be also equal and we get

$$X + (100 - l_2\,)\rho = Y + (100 - l_1\,)\rho$$

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

Now if the value of the resistance Y is taken as zero i.e. the resistance is replaced by metal strip then the resistance per unit length is given by $(l_2\, - l_1\,) = X/\rho$

Now for different values of X a set of null points are achieved and hence a set of (l_2 - l_1) is tabulated. From these data a graph is to be drawn as *X* in *x-axis* and (l_2 - l_1) along *y-axis* . The graph will be a straight line through origin and from the slope of the graph we may obtain the value of $1/\rho$ and hence the value of ρ *i.e. resistance per unit length* can be calculated.

Procedure:

1. The circuit connections are made as shown in the figure 2.

(i) The +ve terminal of the DC voltage is connected to the terminal 'A' and the -ve terminal to 'C'.

(ii) Galvanometer is connected to terminal B and the Jokey K..

(iii) The *P* and *Q* are taken as equal valued resistance.

(iv) The resistance *X* , which is a resistance box is connected between A and E.

(iii) The resistance Y is replaced by a metal strip and is connected between the terminal C and F.

2. To check the circuit is correct the Jokey is connected at extreme left end and then at extreme right end of the bridge. If for two cases the deflection occurs in opposite direction then the circuit is accurate. If not then all the keys are to be properly tightened.

3. Some low value in *X* is given.

4. The the jokey J is moved from left side to right side of the bridge and the no deflection point is noted. This is l_1.

5. Now for six different values of *X*, different value of null point i.e. l_1 is noted.

6. Now the metal strip *Y* and resistance box *X* is interchanged i.e *Y* is connected to gap 1 and *X* is connected to gap 4.

7. Then the Step 3 to 6 is repeated for the same values of *X* as previous. This will gives the values of l_2 .

Observation and Measurements: -

Determination of the value of resistance per unit length of the wire:

Sr. no. of Obs	Resistance in resistance box X in Ω	When X is at left Position of null point from left in scale l_1 *cm*	When X is at right Position of null point from left in scale l_2 *cm*	The difference between the two null point position $(l_2 - l_1)$ *cm*	The slope of the graph $1/\rho$ (cm/Ω)	ρ *i.e.* *R*esistance per unit length (Ω / cm)
1.						
2.						
3.						
4.						
5.						
6.						
7.						

Discussion:

I. The P and Q resistances are to be taken as moderate valued and exactly equal.
II. Resistance plug which are not in use must be tighten properly.
III. When both the X and Y are taken as metal strip then the null point should appears at about 50 cm.
IV. All the terminal of the wires should be properly rubbed by a sand paper and they are properly connected to avoid the resistance appeared from loose connection.