Physics Laboratory Manual

For

Course Code: PHY-1204
Course Title: Physics Lab

Dept. of Computer Science & Engineering
IIUC

Contents

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Instructions for Students

Introduction

Physics is an experimental science. Advancements in physics throughout its history have come about mainly driven by experiments. For you, the physics lab will be an opportunity to have some fun with some hands-on experience with physics theories. Moreover, it will be an opportunity for you to develop and enhance your skills of experimental observation, data analysis and proper scientific documentation which are always important in a career in science and engineering. So please look forward to use your laboratory time for a gainful purpose.

This manual will provide the basic theoretical backgrounds and detail procedures of various experiments that you will perform in the lab. Before that, here are some specific instructions for you to follow while carrying out the experiments. It also outlines the approach that will be undertaken in conducting the lab. Please read carefully the followings.

Specific Instructions

1. You are expected to complete one experiement in each class. For that to happen, you will have to come to the laboratory with certain initial preparation. The initial preparation will involve a prior study of the basic theory of the experiement you are going to take up as well as the procedure to perform it so as to have a rough idea of what to do. In addition, it will also involve a partial preparation of the lab report in advance as mentioned later in this section.
2. You must bring with you the following materials to the lab: This instruction manual, A4 size papers for writing the lab report, graph sheets if necessary, pen, pencil, measuring scale, calculator and any other stationary items required. On the very first day of your lab class, bring also a file cover/folder with your name, roll no., brance name etc. writen on it clearly and submit it to the instructor. The folder will be used to store your laboratory reports regularly at the end of the classes. The folder with your reports will be kept in the laboratory and will be returned to you only after the course instructions are over.

3. The format of a lab report shall be as follows:
    a. The first sheet will contain your name, branch name, roll number, date and title of the experiment. The subsequent sheets will contain the followings in that order.
    b. The objective of the experiment, apparatus needed, and a brief theory with working formulas and figures or diagrams whenever necessary.
    c. Experimental observations. Data from experimental observations should be recorded in proper tabular format with well documented headings for the columns. The data tables should be preceded by the least counts of the instruments used to take the data and numerical value of any constant, if any, used in the table.
    d. Graphs whenever applicable.
    e. Relevant calculations, error analyses.
    f. Final results along with error estimates.
    g. Remarks if any.
    h. **Please DO NOT write the procedure of experiement anywhere.**
4. As part of the initial preparation mentioned earlier, you are required come to the lab ready with the items 3.a. and 3.b. above already writen in your report sheets. This will save valuable lab time and help you to complete the rest of the experiment within the alloted time.
5. After the completion of your data recording, switch off any power suply etc. used and put back the components of the apparatus in their proper places. Complete the rest of the relevant calculations and hand over the final report sheets to the instructor before leaving the lab.
6. Last but not the least - please handle the instruments with care and maintain utmost discipline and decorum in the lab.

• References

This manual was prepared with helps from several books, documentation provided by the equipments vendors, and from several documents shared by others on the website. Though it is not possible to mention all the individual sources, cited below is a list of books which students may also find helpful for further reading.

- “*Fundamentals of Physics*”, D. Halliday, R. Resnick and J. Walker, John Wiley and Sons, Inc., New York, 2001.
- *“Practical Physics”* , G . Ahmed and M. Shahabuddin, Hafiz Book Centre, Bangladesh, 1969.
- “*Practical Physics*”, G. L. Squires, Cambridge University Press, Cambridge, 1985.
- “*Laboratory Experiments in College Physics*”, C. H. Bernard and C. D. Epp, JohnWiley and Sons, Inc., New York, 1995.
- “*Practical Physics*”, R. K. Shukla and A. Srivastava, New Age Internationa (P) Limited,Publishers, New Delhi, 2006.

Experiment-1:

Name of the Experiment:

To determine the value of an unknown resistance by means of a post office box.

Theory:

If P and Q are the known resistances in the ratio arms and R that in the third arm the unknown resistance S in the fourth arm is obtained, when there is no deflection of the galvanometer, from the relation.

$$\frac{P}{Q} = \frac{R}{S}$$

$$\Rightarrow S = \frac{R \times Q}{P}$$

Apparatus:

1. P.O. Box
2. Unknown resistance
3. Power source (E)
4. Galvanometer (G),
5. Connecting wires, etc.

Circuit Diagram:

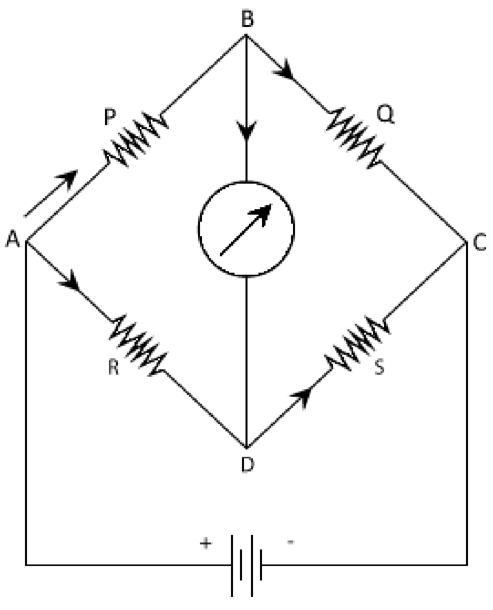


Figure: Wheatstone Bridge Network

Procedure:

(i) Connecting the galvanometer between D and K_2 of the P.O. box. K_2 being internally connected to the point B. Connecting the poles of the cell E through a rheostat. Rh to the point K_1 and C. K_1 being internally connected to A. Connecting the unknown resistance S the points C and D.

(ii) Take out resistances 10 and 10 from the ratio arms BA and BC. Saw that all other plugs in the box are tight. This means zero resistance in the third arm. Putting the maximum resistance in the rheostat. Press the battery key K_1 and then press the galvanometer. Next take out the infinity plug from the third arm and press the keys as done before. If opposite deflection is obtained then the connection is correct. If not check the connections again.

(iii) Then gradually reducing the resistance in the third arm until a resistance, say R_1, is found for which there is no deflection in the galvanometer when the circuit is closed. Then the unknown resistance S is given by

$$S = \frac{10}{10} R_1 = R_1 \text{ (say 5 ohms)}$$

(iv) If instead of null point, there is a deflection in one direction with R_1 and opposite deflection with (R_1+1) in the third arm, the unknown resistance is partly integral and partly fractional i.e.; it lies between 5 and 6 ohms.

(v) Then took the resistance of 100 ohms in the arms P (BA) keeping 10 ohms in the arm Q (BC) so that the ratio $\frac{Q}{P} = \frac{10}{100} = \frac{1}{10}$. Hence the null point should occur when the resistance in the third arm is of some value between 10 R_1 and 10 (R_1+1) i.e., between 50 and 60 {if R_1 =5). Observing the opposite deflection and as before narrow down the range to obtain the null point at R_2 = 53 (say). Then $S = \frac{53}{10} = 5.3$ ohms. In that case, the resistance is found correct to one decimal place.

(vi) If the null point cannot be obtained at this state also i.e., if opposite deflections are observed for R_2 and R_2 +1 (for 53 and 54) in the third arm, it lies between 5.3 and 5.4 ohms. Repeat the observations with 1000 ohms in P arm and 10 ohms in Q arm. The resistance in the third arm should between 530 and 540 for which opposite deflections will be obtained. Narrow down the range to obtain a null point at R_3 = 535 (say). Then $S = \frac{R}{100} = 5.35$ ohms (say). The resistance is now correct to two decimal place.

(vii) If even at this stage there are opposite deflections for a change of resistance of 1 ohm in the third arm, the unknown resistance can be determined to the third decimal place by proportional parts. But it is futile to expect that much accuracy from the P.O. box. However, if it is desired to go further, proceed as follows: Count the number of divisions for which the galvanometer is deflected when R_3 is put in the third arm. Suppose it is d_1 divisions to the left. If now for (R_3 +1) in the third arm. The deflection is d_2 to the right, then for a change of 1 ohm in the third arm, the pointer moves through d_1 + d_2 divisions. Hence to bring the pointer to zero of the scale a resistance $R_3 + \frac{d_1}{d_1 + d_2}$ is to be inserted in the third arm. Hence the value of the unknown resistance S is given by $S = \frac{1}{100}\left(R_1 + \frac{d_1}{d_1 + d_2}\right)$.

(viii) While taking the final reading with the ratio 1000:10 reverse the current and take mean value of S.

(ix) Then replace S by two unknown resistors and connect them individually as series and parallel.

(x) Attach the resistances r_1 and r_2 in series as like in fig. b and determine the equivalent resistance of the series combination by means of the P.O. Box. We have to show that relation (1) holds good.

(xi) After measuring the resistances in series, then connect the two resistances in parallel as shown in fig. b and determination the equivalent resistance of the parallel combination as before. We have to show that relation (2) holds good.

Experimental Data:

Table (a): Resistance of S: For ratio 1:1

Resistance in ohms			Direction of deflection	Remarks **S**
Arm **P**	Arm **Q**	Third arm **R**		
10	10			

Table (b): Resistance of S: For ratio 10:1

Resistance in ohms			Direction of deflection	Remarks **S**
Arm **P**	Arm **Q**	Third arm **R**		
100	10			

Calculations:

For ratio 1:1

$$\frac{P}{Q} = \frac{R}{S}$$

For ratio 10:1

$$\frac{P}{Q} = \frac{R}{S}$$

Percentage of Error:

Result:

Discussion:

Experiment-2:

Name of the Experiment:

Experimental verification of the laws of series and parallel connections of resistance by means of a post office box.

Theory:

Resistance are said to DC connected in series when they are connected with the end of one joined to the beginning of the next and so on shown in **figure: 2**.

The equivalent resistance to a number of resistances connected in series is equal to the sum of the individual resistance, i.e.

$$R = R_1 + R_2 + R_3 + \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots . (1)$$

When resistances are arranged with their respective ends connected to common terminals, they are said to be connected in parallel as shown in **figure: 3**.

The reciprocal of equivalent resistance to a number of resistances connected in parallel is equal to the sum of the reciprocals of the individual resistances, i.e.

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_2} + \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots . (2)$$

Measuring R_1, R_2, R_3, etc. separately and the equivalent the relation (1) and (2) may be verified.

Apparatus:

1. P.O. Box
2. Unknown resistance (2 or more)
3. Power source (E)
4. Galvanometer (G),
5. Connecting wires, etc.

Circuit Diagram:

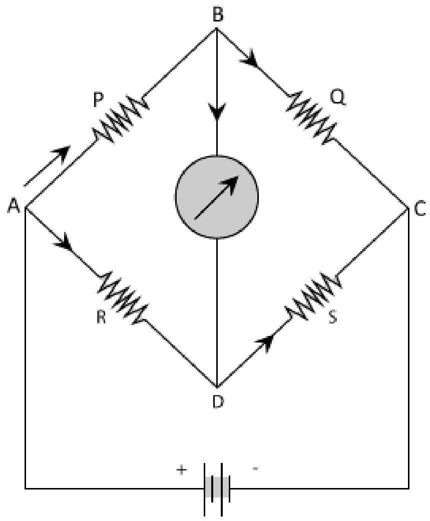


Figure 1: Wheatstone Bridge Network

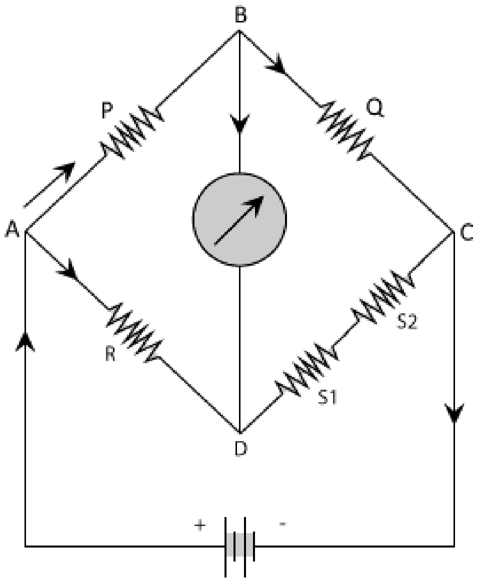


Figure 2: Wheatstone bridge Network
(Series Circuit)

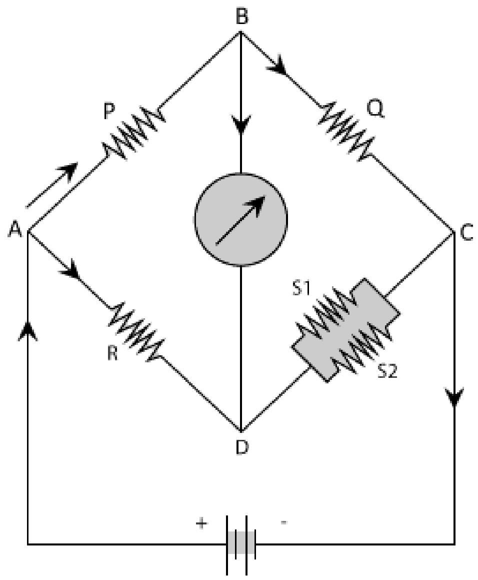


Figure 3: Wheatstone bridge Network
(Parallel Circuit)

Procedure:

(i) Connecting the galvanometer between D and K_2 of the P.O. box. K_2 being internally connected to the point B. Connecting the poles of the cell E through a rheostat. Rh to the point K_1 and C. K_1 being internally connected to A. Connecting the unknown resistance S the points C and D.

(ii) Take out resistances 10 and 10 from the ratio arms BA and BC. Saw that all other plugs in the box are tight. This means zero resistance in the third arm. Putting the maximum resistance in the rheostat. Press the battery key K_1 and then press the galvanometer. Next take out the infinity plug from the third arm and press the keys as done before. If opposite deflection is obtained then the connection is correct. If not check the connections again.

(xii) Then gradually reducing the resistance in the third arm until a resistance, say R_1, is found for which there is no deflection in the galvanometer when the circuit is closed. Then the unknown resistance S is given by

$$S = \frac{10}{10} R_1 = R_1 \text{ (say 5 ohms)}$$

(xiii) If instead of null point, there is a deflection in one direction with R_1 and opposite deflection with (R_1+1) in the third arm, the unknown resistance is partly integral and partly fractional i.e.; it lies between 5 and 6 ohms.

(xiv) Then took the resistance of 100 ohms in the arms P (BA) keeping 10 ohms in the arm Q (BC) so that the ratio $\frac{Q}{P} = \frac{10}{100} = \frac{1}{10}$. Hence the null point should occur when the resistance in the third arm is of some value between 10 R_1 and 10 (R_1+1) i.e., between 50 and 60 {if R_1 =5). Observing the opposite deflection and as before narrow down the range to obtain the null point at R_2 = 53 (say). Then $S = \frac{53}{10} = 5.3$ ohms. In that case, the resistance is found correct to one decimal place.

(xv) If the null point cannot be obtained at this state also i.e., if opposite deflections are observed for R_2 and R_2 +1 (for 53 and 54) in the third arm, it lies between 5.3 and 5.4 ohms. Repeat the observations with 1000 ohms in P arm and 10 ohms in Q arm. The resistance in the third arm should between 530 and 540 for which opposite deflections will be obtained. Narrow down the range to obtain a null point at R_3 = 535 (say). Then $S = \frac{R}{100} = 5.35$ ohms (say). The resistance is now correct to two decimal place.

(xvi) If even at this stage there are opposite deflections for a change of resistance of 1 ohm in the third arm, the unknown resistance can be determined to the third decimal place by proportional parts. But it is futile to expect that much accuracy from the P.O. box. However, if it is desired to go further, proceed as follows: Count the number of divisions for which the galvanometer is deflected when R_3 is put in the third arm. Suppose it is d_1 divisions to the left. If now for (R_3 +1) in the third arm. The deflection is d_2 to the right, then for a change of 1 ohm in the third arm, the pointer moves through $d_1 + d_2$ divisions. Hence to bring the pointer to zero of the scale a resistance $R_3 + \frac{d_1}{d_1 + d_2}$ is to be inserted in the third arm. Hence the value of the unknown resistance S is given by $S = \frac{1}{100}\left(R_1 + \frac{d_1}{d_1 + d_2}\right)$.

(xvii) While taking the final reading with the ratio 1000:10 reverse the current and take mean value of S.

(xviii) Then replace S by two unknown resistors and connect them individually as series and parallel.

(xix) Attach the resistances r_1 and r_2 in series as like in fig. b and determine the equivalent resistance of the series combination by means of the P.O. Box. We have to show that relation (1) holds good.

(xx) After measuring the resistances in series, then connect the two resistances in parallel as shown in fig. b and determination the equivalent resistance of the parallel combination as before. We have to show that relation (2) holds good.

Experimental Data:

Table (A): Resistance in Series Connection: For ratio 1:1

Resistance in ohms			Direction of deflection	Remarks **S**
Arm **P**	Arm **Q**	Third arm **R**		
10	10			

Table (B): Resistance in Series Connection: For ratio 10:1

Resistance in ohms			Direction of deflection	Remarks **S**
Arm **P**	Arm **Q**	Third arm **R**		
100	10			

Table (C): Resistance in Parallel Connection: For ratio 1:1

Resistance in ohms			Direction of deflection	Remarks **S**
Arm **P**	Arm **Q**	Third arm **R**		
10	10			

Table (D): Resistance in Parallel Connection: For ratio 10:1

Resistance in ohms			Direction of deflection	Remarks **S**
Arm **P**	Arm **Q**	Third arm **R**		
100	10			

Calculations:

The Resistance in Series:-

Experimental Data :

For ratio 10:1

$$\frac{P}{Q} = \frac{R}{S}$$

Theoretical Data:

$$S_t = S_1 + S_2$$

Percentage of Error:

The Resistance in Parallel:-

Experimental Data:

For ratio 10:1

$$\frac{P}{Q} = \frac{R}{S}$$

Theoretical Data:

$$\frac{1}{S_t} = \frac{1}{S_1} + \frac{1}{S2}$$

P*erc*entage of Error:

Result:

The Observed and calculated values of the equivalent resistances in Series and Parallel connection are closed to the absolute value of the resistances. By observation we found the resistance in series …. ohm and in parallel ……ohm; where the calculated value of this resistors in series …. ohm and in parallel…. ohm. They are equal within the limits of experimental error. Again there may be leakage on the P.O. Box or the plugs are loosely connected.

Discussion:

Experiment-3:

Name of the Experiment:

To determine the end corrections for a meter bridge.

Theory:

When a balance is obtained at the point N (say) of the wire applying the principle of Whetstone's networks, we get

$$\frac{P}{Q}=\frac{l\rho}{m\rho}=\frac{l}{m}=\frac{l}{100-l}-----------------(i)$$

Where P and Q are the resistance in the two gaps. l and m are the lengths of the bridge wire on the left and hand side of the balance point and ρ is the resistance per unit length of the wire.

Usually there is some resistance at the two end of the bridge wire due to soldering by which the wire is joined to the copper plates. The bridge wire id also seldom exactly one meter in length; the end of the wire from which length is measured may not exactly coincide with zero of the meter scale. These errors are known as end errors. Due to these errors, equation (i) has to be modified. The corrections are actually calculated in terms of two definite length x and y are called end-corrections. Equations (i) then becomes

$$\frac{P}{Q}=\frac{(l+x)\rho}{(m+y)\rho}=\frac{l+x}{(100-l)+y}---------------(ii)$$

If the two resistances P and Q are interchanges, a new balance is obtained at N, if L is the length of the wire at N from the left hand side (i.e., from zero), then

$$\frac{Q}{P}=\frac{L+x}{(100-L)+y}------------------------(iii)$$

Calling the ratio $\frac{P}{Q}=$ r and by solving the equation (ii) and (iii) we get,

$$x=\frac{rL-l}{1-r}\ \textbf{and}\ \ y=\left(\frac{L-rl}{1-r}-100\right)--------------(iv)$$

Apparatus:

1. A meter bridge
2. Power source (E)
3. Commutator (K)
4. Two resistance boxes
5. Galvanometer (G),
6. Connecting wires, etc

Circuit Diagram:

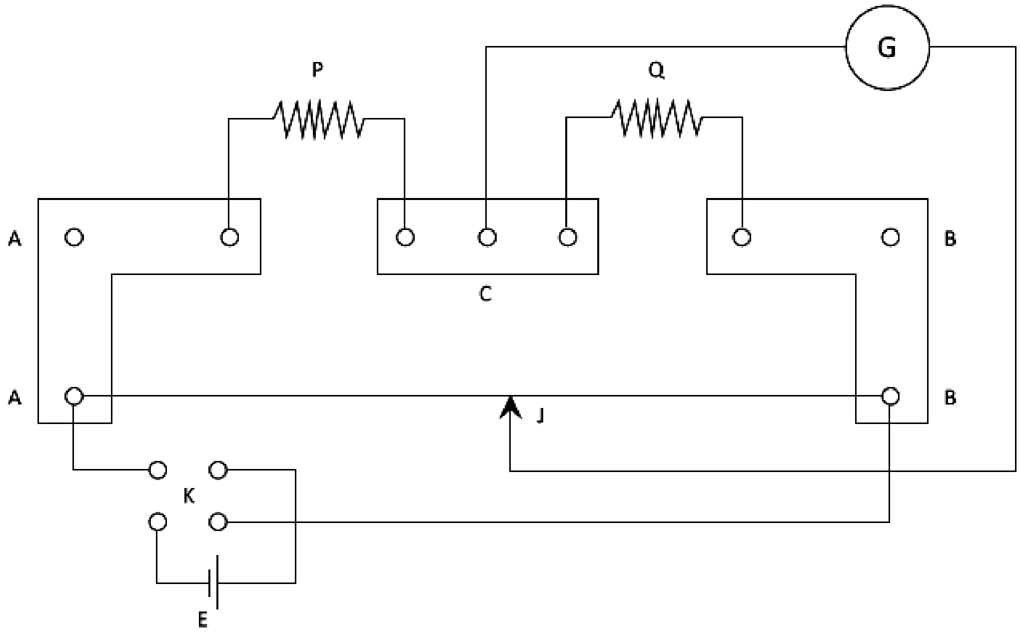


Fig: The Meter Bridge Network

Procedure:

(i) We connected the network as shown is Fig. For checking the corrections of the connections, we put the jockey in the contact with the end A and end B of the bridge wire. And we found opposite directions. So the directions of the connections were correct.

(ii) Then we put a resistance in the left gap P and another resistance Q in the right gap.

(iii) After that we tried to find out the balance point again.

(iv) Then we put a 1(say) ohm resistance in the left gap and 5(say) ohm resistance in the right gap (P=1, Q=5) and we observed the balance point. After that we reverse the connection and again observed the balance point. So that, we find the length ‘l’.

(v) Then we interchanged the resistances as like in the left gap P=5(say) ohm and in the right gap Q=1(say) ohm. Also observed the balance point in direct and reverse connection. So that, we find the length ‘L’

(vi) Then we used almost two terms as P: Q ratio as 1:10 and 1:15 and repeated the whole operations.

(vii) Finally we calculated x and y from equation (iv) and then their mean values of x and y.

Experimental Data:

No of Obs	Resistance is ohms		Ratio	Balance Points			x cm	y cm	mean x cm	mean y cm
	Left gap	Right gap	$r = \frac{P}{Q}$ $\frac{1}{r} = \frac{P}{Q}$	Direct cm	Reverse cm	Mean cm				
1	P=1 Q=5	Q=5 P=1	$r = \frac{1}{5}$ $\frac{1}{r} = 5$							
2	P=1 Q=10	Q=10 P=1	$r = \frac{1}{10}$ $\frac{1}{r} = 10$							
3	P=1 Q=15	Q=15 P=1	$r = \frac{1}{15}$ $\frac{1}{r} = 15$							

Calculations:

Deflection for total length=

1) For observation no.-01: x_1=……………….. y_1= ………………..
2) For observation no.-02: x_2 =……………….. y_2= ………………..
3) For observation no.-03: x_3 =……………….. y_3=………………..

Mean, x =…………… and Mean, y =…………….

Result:

Discussion:

Experiment no.-4:

Name of the Experiment: To Determine the Value of g, Acceleration Due to

Keywords: Superior of compound pendulum over simple pendulum, Gravity and gravitation, Center of Mass and Center of gravity, Gravitational mass and inertial mass, Frictional force, Center of suspension and Center of Oscillation.

Theory: Compound pendulum is a rigid body of any shape free to turn about a horizontal axis. In Fig. 1, G is the centre of gravity of the pendulum of mass M, which performs oscillations about a horizontal axis through O. When the pendulum is at an angle θ to the vertical, the equation of motion of the pendulum is $l\omega = Mgl\sin\theta$ where, ω is the angular acceleration produced,1 is the distance OG and I is the moment of inertia of the pendulum. For small amplitude of vibrations, $\sin\theta = \theta$, so that $l\omega = Mgl\theta$.

Hence the motion is simple harmonic, with period of vibrations,

$$T= 2\pi\sqrt{\frac{I}{Mgl}}$$

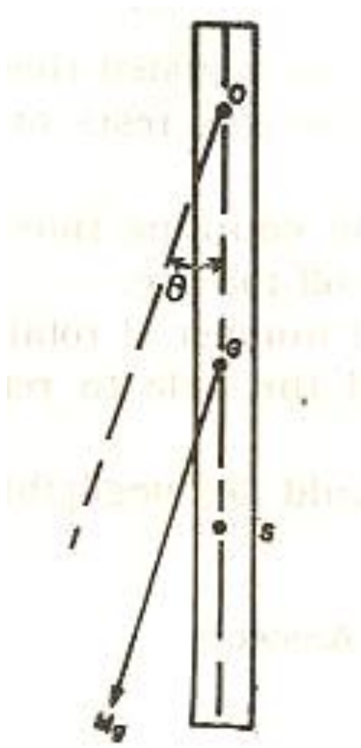


Fig.-1

If K is the radius of gyration of the pendulum about an axis through G parallel to the axis of oscillation through O, from the Parallel axes Theorem,

$1 = M (K^2 + l^2)$, and so

$$T= 2\pi\sqrt{\frac{k^2+l^2}{gl}} = 2\pi\sqrt{\frac{\frac{k^2+l^2}{l}}{g}} \quad ....(1)$$

Since the periodic time of simple pendulum is given by

$T=2\pi\sqrt{\frac{L}{g}}$ the period of the rigid body (compound pendulum) is the same as that of a simple pendulum o f length

$$L = \frac{k^2+l^2}{l} \quad ....(2)$$

This length L, is known as the length of the simple equivalent pendulum. The expression for L can be written as a quadratic in (1). Thus from (2)

$$l^2 - lL + k^2 = 0 \quad ....(3)$$

This gives two values of l (l_1 and l_2) for which the body has equal times of vibration. Form the theory of quadratic equations,

$l_1+l_2 = L$ and $l_1l_2 = k_2$

As the sum and products of two roots are positive, the two roots are both positive. This means that there are two positions of the centre of suspension on the same side of C. G. about which the periods (T) would be same. Similarly there will be two more points of suspension on the other side of the C. G. about which the time periods (T) will again be the same. Thus, there are altogether four points, two on either side of the C. G. about which the time periods of the pendulum are the same (T). The distance between two such points, asymmetrically situated on either side of the C. G., will be the length (L) of the simple equivalent pendulum. If the length OG in Fig. 1 is l_1 and we measure the length GS = $\frac{k^2}{l_1}$ along OG produced, then obviously $\frac{k^2}{l_1} = l_2$ or, OS = OG +GS = $L_1 + L_2 = L$

The period of oscillation about either O or S is the same. The point S is called the centre of oscillation. The points O and S are interchangeable i.e., when the body oscillates about O or S, the time period is the same. If this period of oscillation is T, then from the expression $T = 2\pi\sqrt{\frac{L}{g}}$ we get $g = 4\pi^2 \frac{L}{T^2}$

By finding L graphically, and determining the value of the period T, the acceleration due to gravity (g) at the place of the experiment can be determined.

Apparatus:

i. A bar pendulum,
ii. A small wedge,
iii. Meter scale and stop-watch.

Procedure:

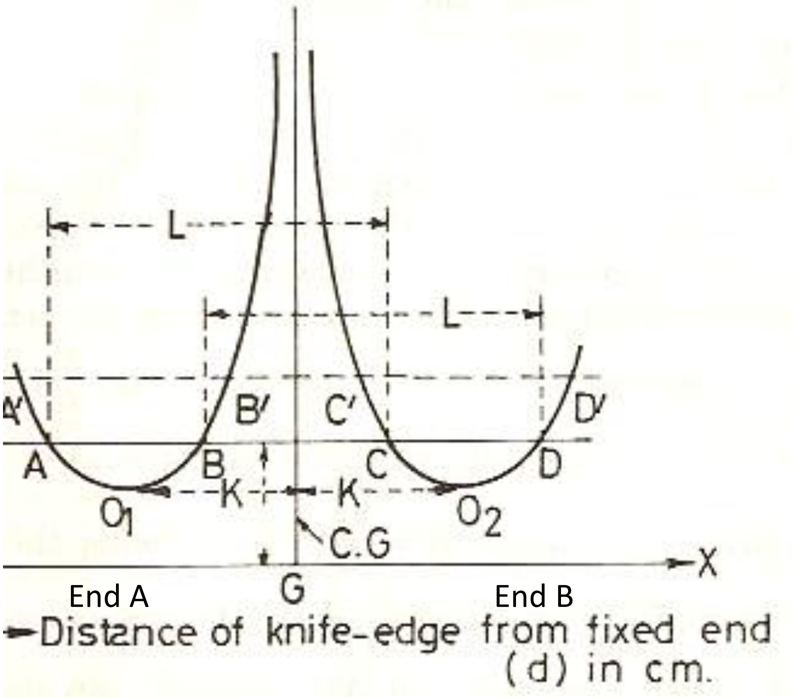
1. Find out the center of gravity G of the bar by counting the total no of holes existing in the bar. If the total no of holes is odd, middle one is the center of gravity G of the bar. Consider one end is A and the other one is B.
2. Insert the metal wedge in the first hole of the bar towards A and measure length of first hole from the center of gravity. In the same way measure length of the holes 2, 3,............. of end A from the center of gravity.
3. Set the bar to oscillate taking care to see that the amplitude of oscillations is not more than 4°. Record time for 30 oscillations.
4. In the same way, suspend the bar at holes 2, 3.................and each time note times for 30 oscillations for each hole of end A.
5. When the middle point of the bar is passed, set the bar to oscillate so that the end B is now on the top.
6. Again measure length of each hole of end B from the center of gravity as point (2). Also note times for 30 oscillations for each hole of end B as points (3) & (4).
7. Now calculate time period T from the time recorded for 30 oscillations for both ends A and B.
8. On a plane and large graph paper, plot two curves (one for the reading of end A and other for the reading of end B) with length as abscissa and period T as ordinate with the origin at the middle of the paper along the abscissa.
9. Draw a line ABCD parallel to the abscissa such that it intersects the two curves at A, B, C and D.
10. Find out length of AC and BD from the curves. Calculate L by averaging the length of AC and BD.
11. Find out the corresponding time-period T from the graph and calculate ‘g’ using the formula, g $= \frac{4\pi^2 L}{T^2}$.

Experimental Data:

Table.1: Determination of time period T and the distance of the point of suspension from the end A and end B:

At the top	Hole no.	Distance form G	Time for 30 Oscillations	Mean Time	Time Period T
End A	1		i)---sec ii)---sec iii)---sec		
	2		i)---sec ii)---sec iii)---sec		
	3 etc.		i)---sec ii)---sec iii)---sec		
End B	1		i)---sec ii)---sec iii)---sec		
	2		i)---sec ii)---sec iii)---sec		
	3 etc.		i)---sec ii)---sec iii)---sec		

Graph:



Calculation:

From the Graph,

Length AC = -------cm

Length BD = ------cm

Mean Length, L = $\frac{AC + BD}{2}$ = -----cm

Corresponding time-Period, T = ----sec

Acceleration due to gravity, g = $\frac{4\pi^2 L}{T^2}$ = -------cm/sec^2

Result:

The value of acceleration due to gravity, g = ------cm/sec^2

Discussions:

Experiment-5:

Name of the Experiment:

Calibration of a meter bridge wire.

Theory:

It is often assumed that the meter bridge wire is uniform in cross-section and hence that the resistance per unit length of its constant throughout its length. In practical measurement it is better not make such assumptions. The purpose of the calibration of a meter bridge wire is to reduce the reading of the bridge to what they would have been if the wire would be uniform throughout its length.

Apparatus:

1) A meter bridge,
2) Cell (E),
3) Commutator,
4) Two Jockeys,
5) Zero-center Galvanometer (G),
6) Connecting wires, etc.

Circuit Diagram:

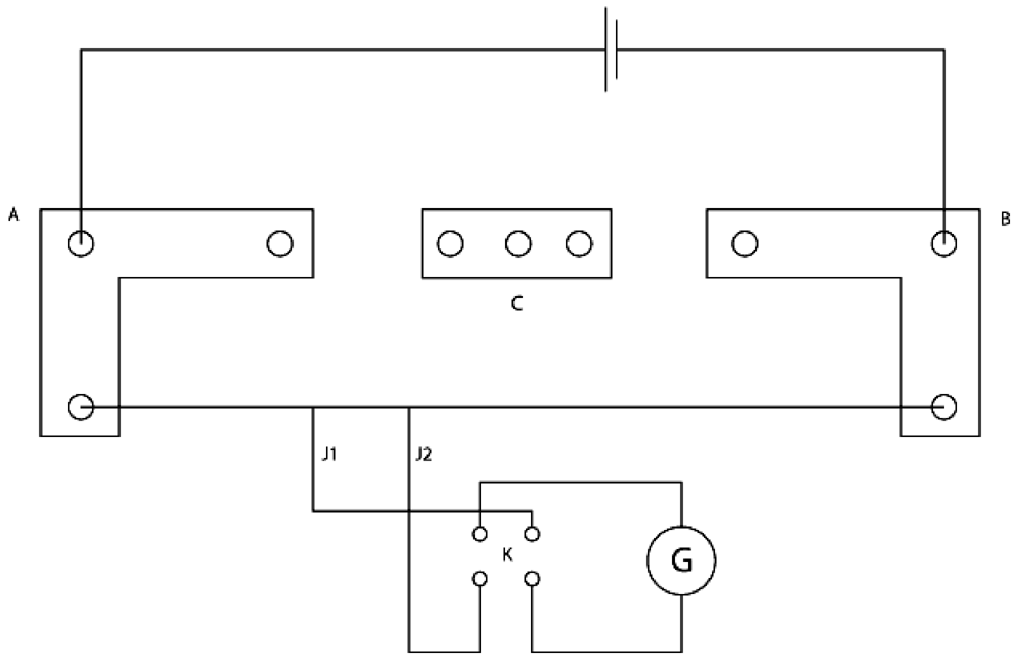


Fig.: A meter bridge with two jockeys

Circuits-Connections:

The positive of a battery E is connected to one end of the bridge wire through the key K_1 and the negative of battery id connected with the other end of the wire. The galvanometer terminals are connected to the opposite terminals of a commentator K, the two other terminals of which are connected to two jockeys J_1 and J_2 (fig).

Procedure:

i) After completing the connection of the apparatuses with the meter bridge, then at first we tried to find out the deflection of the galvanometer to the opposite sides.

ii) Then we put Jockey J_1 in contact with metal strip to which the left end of the wire and the right jockey J_2 on the 10 cm mark and obtained the deflections for the direct and reverse currents.

iii) Then we put the jockey J_2 fixed at 10cm mark place and the left jockey J_1 at 20 cm mark and again obtained the deflections for the direct and reverse currents.

iv) Again we put the jockey J_1 at 20 cm mark and the right jockey J_2 at 30 cm mark and obtained the deflections.

v) Then we proceeded this way with the jockeys 10 division apart until J_2 put at 90 cm mark and J_1 on the metal strip to which the right end of the wire is connected and took the final reading.

vi) We also determined the effective lengths of the wire from the left end to the right contact point in each case. If D_n is the galvanometer deflections when the jockeys were placed at the two ends of the wire i.e., for a length 100 cm of the wire and D were the deflections for an apparent length of the wire, then the effective length is given be .

vii) We have drawn a graph with the apparent length as abscissa and effective length as ordinate. It is a straight line.

Experimental Data:

No of Obs	Point of contact		Deflections			Total length from zero	Deflection for total length	Effective length
	J_1	J_2	Direct	Reverse	Mean			
1	Strip	10			$d_1=$	10	$d_1=D_1=$	
2	20	10			$d_2=$	20	$D_1+d_2=D_2=$	
3	20	30			$d_3=$	30	$D_2+d_3=D_3=$	
4	40	30			$d_4=$	40	$D_3+d_4=D_4=$	
5	40	50			$d_5=$	50	$D_4+d_5=D_5=$	
6	60	50			$d_6=$	60	$D_5+d_6=D_6=$	
7	60	70			$d_7=$	70	$D_6+d_7=D_7=$	
8	80	70			$d_8=$	80	$D_7+d_8=D_8=$	
9	80	90			$d_9=$	90	$D_8+d_9=D_9=$	
10	Strip	90			$d_{10}=$	100	$D_9+d_{10}=D_{10}=$	

Calculations:

Deflection for total length=

1) Effective length for 10 cm = $\frac{100}{D_{10}} \times D_1 =$
2) Effective length for 20 cm = $\frac{100}{D_{10}} \times D_2 =$
3) Effective length for 30 cm = $\frac{100}{D_{10}} \times D_3 =$
4) Effective length for 40 cm = $\frac{100}{D_{10}} \times D_4 =$
5) Effective length for 50 cm = $\frac{100}{D_{10}} \times D_5 =$
6) Effective length for 60 cm = $\frac{100}{D_{10}} \times D_6 =$

7) Effective length for 70 cm = $\frac{100}{D_{10}} \times D_7 =$

8) Effective length for 80 cm = $\frac{100}{D_{10}} \times D_8 =$

9) Effective length for 90 cm = $\frac{100}{D_{10}} \times D_9 =$

10) Effective length for 100 cm = $\frac{100}{D_{10}} \times D_{10} =$

Result:

We have drawn a graph with the apparent length as abscissa and effective length as ordinate. It represents a straight line.

Discussion:

Experiment no-6:

Name of the Experiment: To Determine the Moment of Inertia of a Fly-wheel about the Axis of Rotation.

Key words: Angular momentum, Moment of inertia, Radius of gyration, Parallel & Perpendicular axis theorem, Center of mass & center of gravity, etc.

Theory: Fig.1 shows a mass M, attached by means of a string to the axle of a fly-wheel radius r, the moment of inertia of which, about its axis of rotation, is I. The length of the string is such that it becomes detached from the axle when the mass strikes the floor. In falling a distance h, the potential energy of the mass has been converted into kinetic rotation and translation energy. If ω be the maximum angular velocity of the wheel, F the amount of work done against friction per revolution and n_1 the number of revolutions made while the mass falls the distance h, the loss in potential energy of M = gain in kinetic energy of M + gain in K. E of flywheel + work done against friction.

So, $Mgh = \frac{1}{2}Mr^2\omega^2 + \frac{1}{2}I\omega^2 + n_1F$..(1)

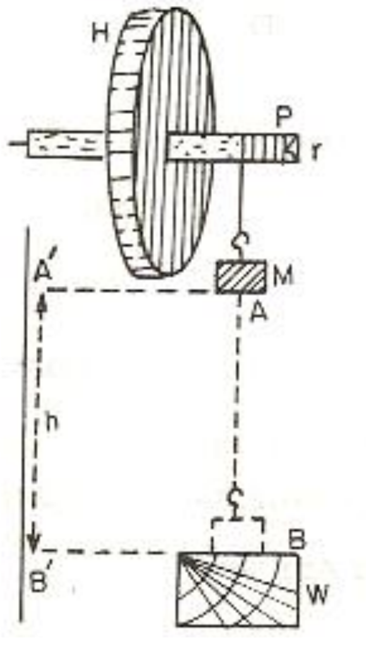


Fig.1

After the mass strikes the ground the wheel executes a further n_2 revolutions and the angular velocity gradually decreases to zero. The rotational kinetic energy $\frac{1}{2}I\omega^2$ has been used up in overcoming frictional forces, hence

$Fn_2 = \frac{1}{2}I\omega^2$ ....(2)

If n_2 revolutions take a time t, then the average angular velocity ω_a is given by $\omega_a = \frac{2\pi n_2}{t}$

Since the angular velocity decreases uniformly from a maximum ω to a minimum of zero, the average angular velocity ω_a is also given by $\omega_a = \frac{\omega + 0}{2} = \frac{\omega}{2}$

Also the motion is uniform, hence $\frac{\omega}{2} = \frac{2\pi n_2}{t}$

i.e. $\omega = \frac{4\pi n_2}{t}$ ....(3)

From equations (1), (2) and (3) it follows that

$$I = \frac{2Mgh - M\omega^2 r^2}{\omega^2 (1 + \frac{n_1}{n_2})} \quad \text{……….........................(4)}$$

Apparatus:

i. Fly-wheel,
ii. Weights,
iii. Cord,
iv. Stop-watch and slide callipers.

Procedure:

1. Tie a weight Mg at one end of the cord and wrap other end of the cord with the rod of the fly-wheel that is called the axle.

2. Rotate the wheel round the axle until the weight is at just below the rim and count the rotation n_1 to rise up the weight.

3. Then allow the weight to go down and count the rotation N until the wheel becomes rest. Start a stop watch just when the cord slips off the peg and stop to record when the wheel becomes rest. It is the time t. Calculate the rotation n_2 by subtracting n_1 from N i.e. $n_2 =$ (N-n_1).

4. Use different masses and calculate n_1, n_2 and t following the procedure of (1), (2) & (3). Take at least three observations in each case and find mean values of n_1, n_2 and t.

5. Measure diameter of the axle at two mutually perpendicular directions by slide callipers and determine the radius r.

6. Use the equation, $I = \frac{2Mgh - M\omega^2 r^2}{\omega^2 (1 + \frac{n_1}{n_2})}$ [where, $\omega = \frac{4\pi n_2}{t}$ and h is the length of the cord] for calculating the moment of inertia

Experimental Data:

Table. 1: Determination of n_1, n_2 and t:

No of Obs.	Mass M	Height h	No of revolutions n_1	Mean n_1	No of revolutions n_2	Mean n_2	Time t	Mean t	I	Mean I
1 2 3	200gm (say)									
1 2 3	300gm (say)									

Table. 2: Determination of radius of the axle:

Vernier Constant (V.C.) of the slide callipers = $\frac{s}{n}$ (where ,s is the value of one small division of the main scale and n is the no divisions existing in the vernier scale)= -----mm

No of Obs.	M.S. reading	V.S. reading	Fractional reading V.S x V.C.	Total reading Diameter, D	Radius $\frac{D}{2}$	Mean radius r
1						
2						
3						

Calculation:

Angular Velocity, ω = $\frac{4\pi n_2}{t}$

The moment of inertia, I = $\frac{2Mgh - M\omega^2 r^2}{\omega^2 (1+\frac{n_1}{n_2})}$ = ------------gm.cm^2

Result:

The moment of inertia of the fly- wheel is = ------- gm.cm^2

Discussions:

Experiment-7:

Name of the Experiment:

To determine the unknown resistance of the material of a wire by a meter bridge.

Theory:

According to the diagram P and Q is the known and unknown resistance respectively and l be the distance of the null point measured from the left end A of the meter bridge, then the principle of the Wheatstone's network we get,

$$\frac{\mathrm{P}}{\mathrm{Q}} = \frac{l}{(100 - l)}$$

$$\mathrm{Q} = \frac{\mathrm{P}(100 - l)}{l} - - - - - - -(\mathrm{i})$$

Apparatus:

1) A meter bridge
2) Power source (E)
3) Commutator (K)
4) Resistance box (P)
5) The Specimen wire (X)
6) Galvanometer (G)
7) Connecting wires, etc.

Circuit Diagram:

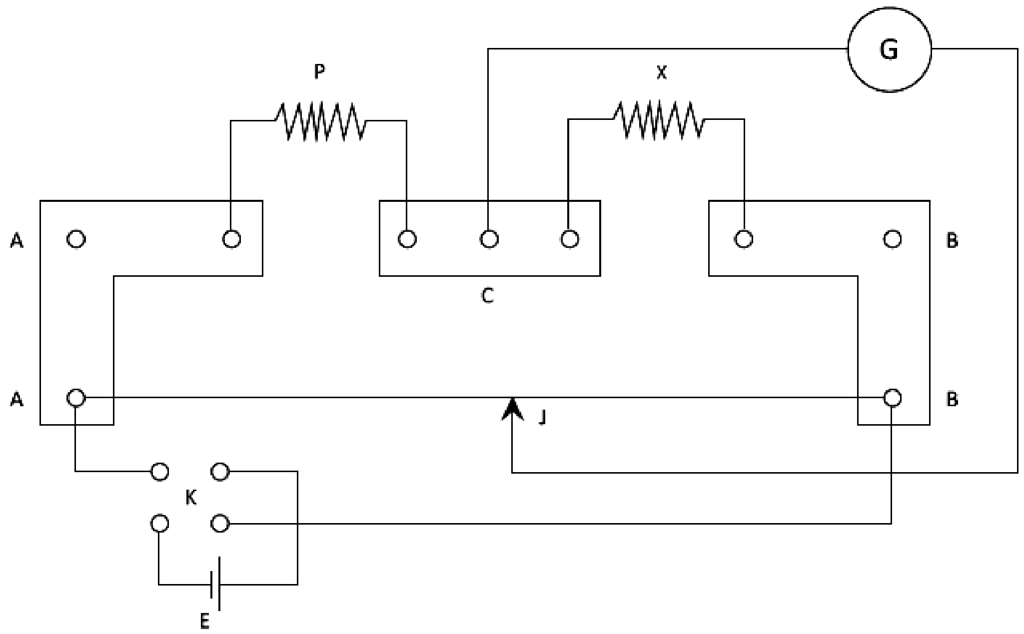


Fig: The Meter Bridge Network for Unknown Resistance

Procedure:

(i) After making connections as shown in the Fig. Before putting the specimen wire, folded half inch of it at each end and put the folded portion within the binding screws of the right gap. In the left gap we put resistance box (Shunt) R. Then insert 0.2 ohm resistance in the left gap and moving the sliding contact. If the deflections are on the opposite directions, the connections have been correctly made.

(ii) We moved the jockey along the bridge wire until the galvanometer deflection is almost zero. Null point is being approached.

(iii) Then we started to take the readings of the experiment, along the bridge wire we moved the jockey from the left end to the right end and tried to find out the null point by the galvanometer. When we found the no deflection from the galvanometer, then we took the length of the null point i.e., l.

(iv) For the true experiment, we took two readings for the known resistance as like as direct and reverse connection. Firstly we took the directly reading and then we took the reverse ones.

(v) Then we took more known resistances, repeating the operations, every time reversing and directing the current. Then calculate the mean value of Q.

(vi) Then we carefully took the length L of the wire between the two bends with a meter scale.

(vii) Finally we measured the diameter (d) of the wire with the screw gauges at several places with mutually perpendicular readings at each place

Experimental Data:

Known resistance P ohm	Balance point (for l) cm			(100-l) cm	$Q = \frac{P(100-l)}{l}$ ohm	Mean Q ohm
	Direct	Reverse	Mean			
2						
4						
6						
8						
10						

Calculations:

Deflection for total length=

1) For 1st observation: $Q_1 = \frac{P(100-l)}{l} =$
2) For 2nd observation: $Q_2 = \frac{P(100-l)}{l} =$
3) For 3rd observation: $Q_3 = \frac{P(100-l)}{l} =$
4) For 4th observation: $Q_4 = \frac{P(100-l)}{l} =$
5) For 5th observation: $Q_5 = \frac{P(100-l)}{l} =$

Mean, Q = ……………………..

Result:

The unknown resistance of the wire is ………………….. Ohm.

Discussion:

Experiment-8:

Name of the Experiment:

To determine the specific resistance of the material of a wire by a meter bridge.

Theory:

According to the diagram P and Q is the known and unknown resistance respectively and l be the distance of the null point measured from the left end A of the meter bridge, then the principle of the Wheatstone's network we get,

$$\frac{P}{Q} = \frac{l}{(100 - l)}$$

$$Q = \frac{P(100 - l)}{l} - - - - - - -(i)$$

If now L is the length of the experimental wire in centimeters then,

$$Q = \frac{\rho L}{\Pi r^2}$$

$$\text{Or, } \rho = \frac{Q\Pi r^2}{L} - - - - - - -(ii)$$

Where ρ is the specific resistance of the material of the wire and r is the radius of the cross-section of the wire.

Apparatus:

1) A meter bridge
2) Power source (E)
3) Commutator (K)
4) Resistance box (P)
5) The Specimen wire (X)
6) Galvanometer (G)
7) Connecting wires, etc.

Circuit Diagram:

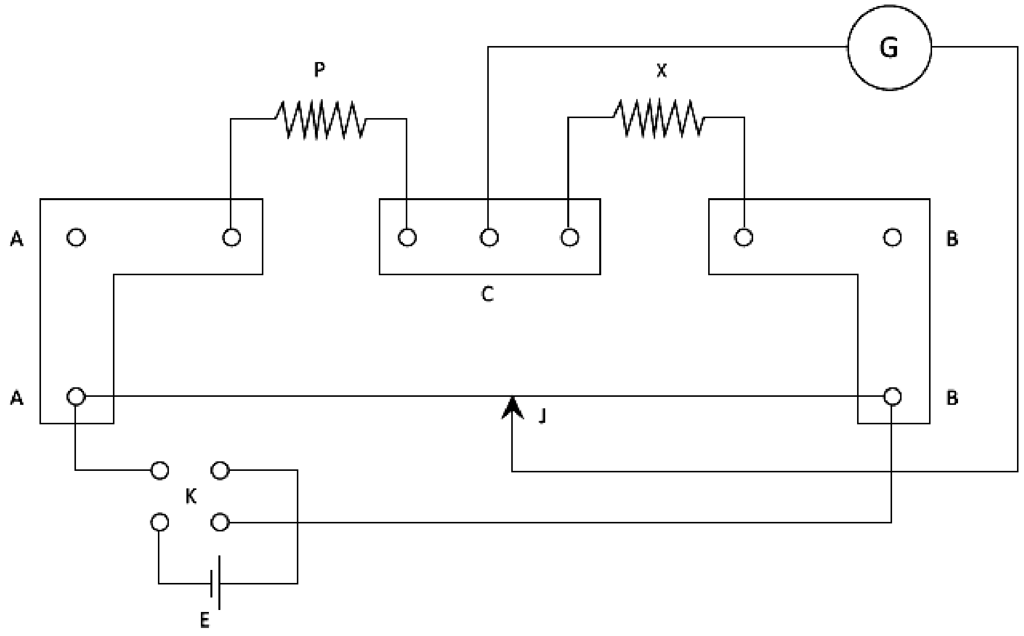


Fig: The Meter Bridge Network for Specific Resistance

Procedure:

(i) After making connections as shown in the Fig. Before putting the specimen wire, folded half inch of it at each end and put the folded portion within the binding screws of the right gap. In the left gap we put resistance box (Shunt) R. Then insert 0.2 ohm resistance in the left gap and moving the sliding contact. If the deflections are on the opposite directions, the connections have been correctly made.

(ii) We moved the jockey along the bridge wire until the galvanometer deflection is almost zero. Null point is being approached.

(iii) Then we started to take the readings of the experiment, along the bridge wire we moved the jockey from the left end to the right end and tried to find out the null point by the galvanometer. When we found the no deflection from the galvanometer, then we took the length of the null point i.e., l.

(iv) For the true experiment, we took two readings for the known resistance as like as direct and reverse connection. Firstly we took the directly reading and then we took the reverse ones.

(v) Then we took more known resistances, repeating the operations, every time reversing and directing the current. Then calculate the mean value of Q.

(vi) Then we carefully took the length L of the wire between the two bends with a meter scale.

(vii) Finally we measured the diameter (d) of the wire with the screw gauges at several places with mutually perpendicular readings at each place.

Experimental Data:

(A) Reading for the balance point (Q):

Known resistance P ohm	Balance point (for l) cm			(100-l) cm	$Q = \frac{P(100-l)}{l}$ ohm	Mean Q ohm
	Direct	Reverse	Mean			
2						
5						
7						
9						
11						

(B) Readings for diameter of the wire (d):

No of obs	Linear scale reading cm	Circular scale reading	Least count cm	Fractional part cm	Total d cm	Mean d cm	Radius r cm
1							
2							
3							

Calculations:

Radius of the wire:

Length of the wire:

1) For 1st observation: $Q_1 = \frac{P(100-l)}{l} =$

2) For 2nd observation: $Q_2 = \frac{P(100-l)}{l} =$

3) For 3rd observation: $Q_3 = \frac{P(100-l)}{l} =$

4) For 4th observation: $Q_4 = \frac{P(100-l)}{l} =$

5) For 5th observation: $Q_5 = \frac{P(100-l)}{l} =$

Mean, Q = ……………………..ohm

The Specific resistance of the wire, $\rho = \frac{Q\Pi r^2}{L} =$

Result: The specific resistance of the wire is ………………………… Ohm. cm

Discussion:

Experiment no-9:

Name of the Experiment: To determine the frequency of a Tuning fork by Melde's Experiment.

Key words: Resonance, Formation of Stationary waves, Progressive wave, Laws of transverse vibration, free & forced vibration, Vibration of a string fixed at both ends, etc.

Theory: Let one end B of the string, which may be a piece of stout thread or thin cord, be attached to one prong of the F. The fork is screwed vertically on a wooden base W at the edge of a table. The other end A passes over a small pulley and is attached to a scale pan S (Fig.-01)

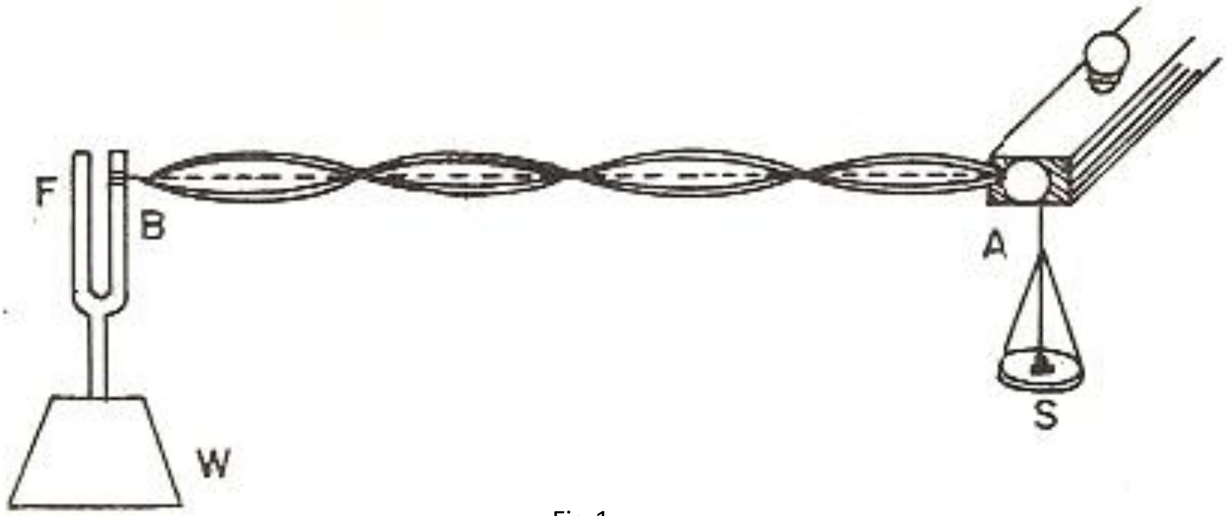


Fig-1

The string will be set into vibration by setting the tuning fork into vibration .As a result waves will proceed along the length of the string and will be reflected back on reaching the fixed end of the string .The superposition of the direct and reflected waves will form stationary waves, in which the extreme fixed ends of the string will always be nodes and in between them there may be one or more antinodes (Fig. -01) depending on the tension to which the string is subjected or the length of the string .Now by suitably adjusting the tension or the length, the frequency n of the fork may be made to be equal to the frequency nt of the fundamental or any one of the higher tones of the string. When this happens a resonance is said to have occurred between the fork and particular mode of vibration of the fundamental then $\lambda = 2l$, where l is the length of the string. The frequency of the fork will then be given by the relation.

$$n = n' = \frac{1}{\lambda}\sqrt{\frac{t}{m}} = \frac{1}{2l}\sqrt{\frac{t}{m}}$$

where m is the mass per unit length of the vibrating string in grammes and t is the tension applied to the string and is expressed in absolute units, i.e., dynes or poundals.

Now the motion of the prongs of the fork, which sets the string in resonant vibration may be in two different directions:

In a direction perpendicular to the length of the string i.e., transverse position (Fig. 02a) and

In a direction along (Parallel) the length of the string i.e., longitudinal position (Fig.-02b)

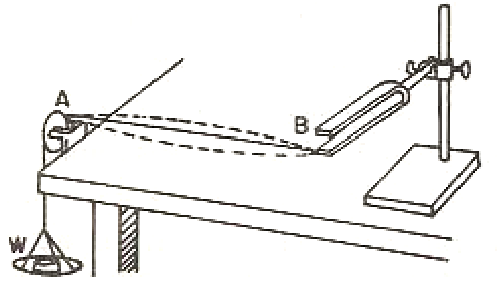


Fig-2 (a)

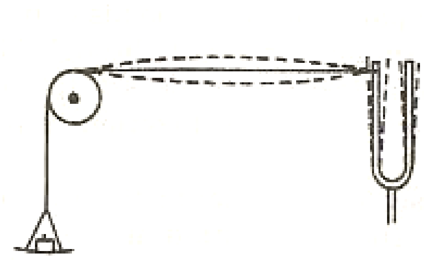


Fig-2 (b)

In the transverse case, the frequency n of the fork is the same as nt, the frequency of the string while in the longitudinal case it is twice as great .This is because in the longitudinal case, the vibration is produced by the alternating pulls upon the end of the string by the prong of the fork. Each movement of the prong to the right pulls the string tight, i.e., the string is stretched and this occurs in the middle of the swing, i.e., twice in every vibration .Thus in this case, the frequency of the string is half that of the fork, or in other words, the frequency of the fork is twice the frequency of the string.

Therefore, for transverse position, the frequency n of the fork is

$$n = n' = \frac{1}{\lambda}\sqrt{\frac{t}{m}} = \frac{1}{2l}\sqrt{\frac{t}{m}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (1)$$

where l is the length of a segment or loop between two consecutive nodes of the string.

For longitudinal position,

$$n = 2n' = \frac{2}{2l}\sqrt{\frac{t}{m}} = \frac{1}{l}\sqrt{\frac{t}{m}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (2)$$

Thus by altering the tension t and hence the wavelength one should be able to determine the frequency of a tuning fork.

Apparatus:

i. Melde's apparatus
ii. Thread , ,
iii. Metre scale
iv. Weight box,
v. Adaptor,
vi. Scale pan,
vii. Connecting wires, etc.

Procedure:

1. Weight the scale pan. Clamp the tuning fork in longitudinal position at one edge of the table. Fix a pulley over a clamp, screwed at other edge of the table. Fasten a thread, about a metre long, to the tip of the point and pass the other end over the pulley. Hang the scale pan to this end and put some small weights on it so that the thread is lightly stretched.

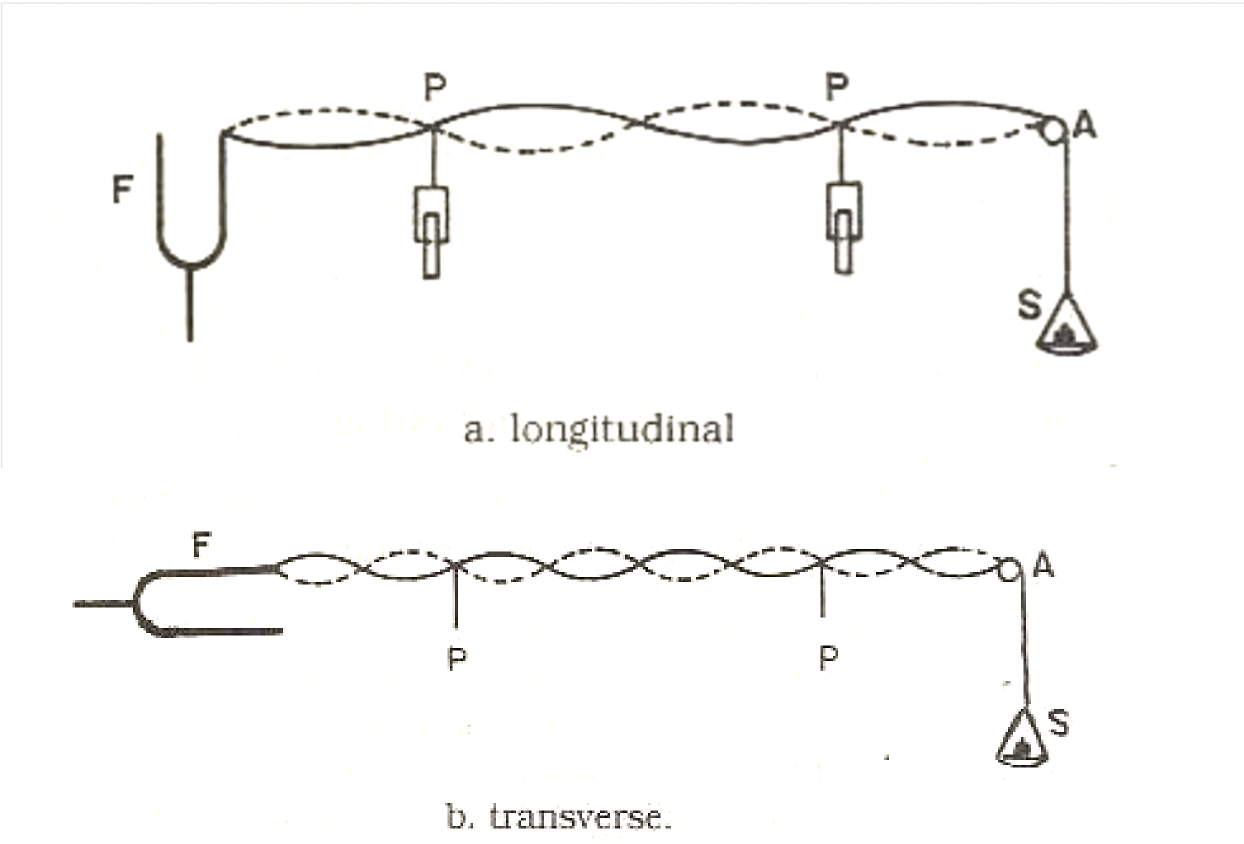


Fig-3

2. Set the fork into vibration by electrical method. This will set the thread into vibration and several nodes and loops, Fig.-01 will appear. Note the total number of loops along the entire length of the thread. Increase or decrease the weight until the loops are well defined, i.e., the amplitude of

the loops are maximum, the nodal points are fixed in position-they do not change their position during the vibration and the loops are of equal length. When this happens, resonance occurs between the fork and the particular mode of vibration of the string (Fig.-03 a and b). During this procedure, fractional weights (milligram weights) should be used. Care should be taken all the time so that the total number of loops does not change. The weight for which the loops are most well defined is the weight to be used in calculation for the given number of loops.

3. Take the total length G which when divided by the number of loops gives the length l of a segment. Thus $l = \frac{G}{N}$ and $\lambda = 2l$ for this particular weight. If T is the sum of the weight of the scale pan and weights put on it, then t = Tg.

4. Increase the weight in the scale pan when the total numbers of loops between the two fixed ends become different. Note this number. Taking care that this number does not change. Repeat the operations described in (2) and (3) to determine the new length l of a segment. In this way go on increasing the weight on the pan step by step. The number of loops will decrease with increasing weights. Note the total number of loops for each new weight and determine the corresponding l in the manner described in (2) and (3).

5. Now set the tuning fork in transverse position and repeat the whole process to determine the corresponding l.

6. Calculate the frequency n of the given fork with the help of equations (1) and (2) and take the mean.

Experimental Data:

(A) Mass of the scale pan, w=………gm

(B) Reading for the mass (m) per unit length of the thread : Length of the sample thread (a) …………cm

(b) …………cm

(c) …………..cm

Mean length, L, =……….cm

Mass of the thread, M =……..gm

Mass per unit length of the thread.

$m = \frac{M}{L} =$ ………………gm/cm.

(C) Longitudinal position.

No. of obs.	Total no of loops between the fixed ends (N)	Load on the scale pan (w_t) gm	Tension $T = Wg$ $= (w + w_t)g$ *dynes*	Distance between the pins (G)	Length of a segment $l = \frac{G}{N}$	$\frac{T}{l} =$ cons.	Frequency of the string $n' =$	Frequency of the fork $n = 2n'$ Vibrations per sec
1								
2								
3								

Mean frequency in the longitudinal position =…………………………vibration /sec

(D) Transverse position.

No. of obs.	Total no of loops between the fixed ends (N)	Load on the scale pan (w_t) gm	Tension $T = Wg$ $= (w + w_t)g$ *dynes* n	Distance between the pins (G)	Length of a segment $l = \frac{G}{N}$	$\frac{T}{l} =$ cons.	Frequency of the string $n' =$	Frequency of the fork $n = n'$ Vibrations per sec
1								
2								
3								

Mean frequency in the transverse position =……………vibration /sec

Mean frequency of the fork =……………vibration /sec.

Results:

The frequency of the Tuning fork is = ... vibration/sec

Discussions:

Experiment no-10:

Name of the Experiment: To Determine the Young's Modulus by the Flexure of a Beam (Bending Method)

Key words: Elasticity, Young's modulus, Cantilever, Bending moment, Stress-strain diagram, Poisson's ratio, etc.

Theory: If a rectangular beam of breadth b and depth d is supported near its two ends by two knife-edges separated by a distance l and if a load of mass m acting at a point of the bean equidistant from the knife-edges produces a depression y_0 then the Young's modulus of the material is given by $Y=\frac{mgl^3}{4bd^3y_0}$ where, g is the acceleration due to gravity.

Apparatus:

i. Rectangular beam,
ii. Spherometer,
iii. Suitable weights,
iv. Hanger on which weights are placed,
v. Screw gauge
vi. Meter scale.

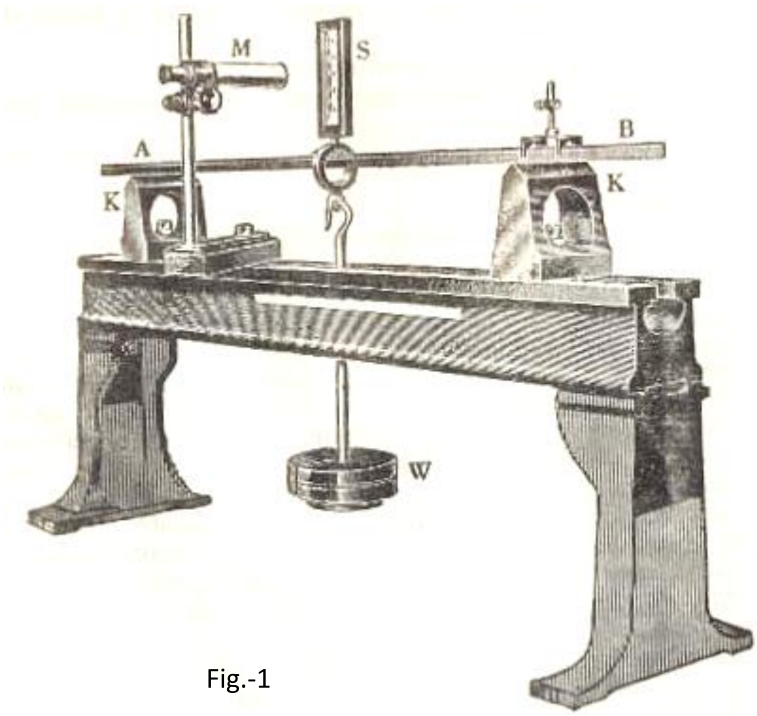


Fig.-1

Procedure:

1. Set the rectangular beam on two strong knife-edges separated by a suitable distance and determines middle point of the beam. If the beam is one meter long, point of distance 50cm from either end of the beam is middle point.

2. Place hanger at the middle point of the beam.

3. Take main scale reading and circular scale reading by spherometer for 0 kg load.

4. Then place a load of 0.5kg on the hanger. The scale goes down. Take main scale reading and circular scale reading for the load. Go on increasing the load by 0.5 kg and take at least five reading.

5. Repeat the procedure by decreasing the load by 0.5kg and record the main scale reading and circular scale reading for each load in the table.

6. Find depression for load increasing and load decreasing separately and then take mean values.

7. Measure distance between the knife-edges with a meter scale to get length l of the beam.

8. Measure the values of breadth b and depth d of the beam at 3 different points with a screw gauge and take mean value.

10. Draw a graph with load in gm along abscissa and depression in cm along ordinate. Draw a line so that it passes through the origin. From the slop of this line find out the load m and the corresponding depression y_0 to calculate the value of Y using the formula, $Y = \frac{mgl^3}{4bd^3 y_0}$.

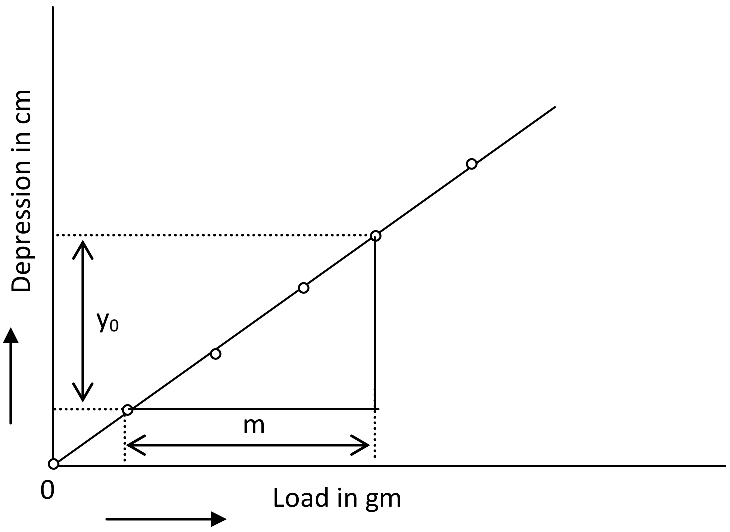
Experimental Data:

$$\text{Least Count (L.C.) of the screw gauge} = \frac{\text{Pitch}}{\text{No of divisions in the circular scale}}$$

a) Table 1. Determination of depression (y_o):

No of Obs.	Load in Kg	Reading for								Mean Depression(y_o) in cm
		Load increasing				Load decreasing				
		m.s.	c.s.	Total in cm	depression in cm	m.s.	c.s.	Total in cm	depression(y_o) in cm	
1										
2										
3										
4										
5										

Graph 1:



b) Length of the beam l between the two supporting knife edges:

i)-----------cm ii) --------------cm iii) ------------------cm

Mean length, l = ----------cm

c) Breadth of the beam:

i)-----------cm ii) --------------cm iii) ------------------cm

Mean breadth, b = ----------cm

d) Depth of the beam

i)-----------cm ii) --------------cm iii) ------------------cm

Mean depth, d = ----------cm

e) From the graph

When load, m = ---------gm

Depression, y_0 = --------cm

Calculation:

The Young's Modulus, $Y = \dfrac{mgl^3}{4bd^3 y_0}$ = ----------dynes/cm

Result:

The value of young modulus is ----------dynes/cm^2

Discussions:

Experiment no. : 11

Name of the Experiment: To Determine the Spring Constant and Effective Mass of a Given Spiral Spring and Hence to Calculate the Rigidity Modulus of the Material of the Spring.

Key words: Effective mass, spring constant, graphs detail, Vibration of a loaded spring, Elasticity, etc.

Theory: If a spring be clamped vertically at the end p, and loaded with a mass m_0 at the other end A, then the period of vibration of the spring along a vertical line is given by

$$T = 2\pi\sqrt{\frac{m_0 + m}{k}} = 2\pi\sqrt{\frac{M}{k}} \quad \text{-----------------------(1)}$$

where m is a constant called the effective mass of the spring and k, the spring constant i.e., the ratio between the added force and the corresponding extension of the spring.

How the mass of th ibrating system can be shown as follows. Consid undergoing simple harmonic motion. At the insta with velocity v_0 as shown in fig.-1

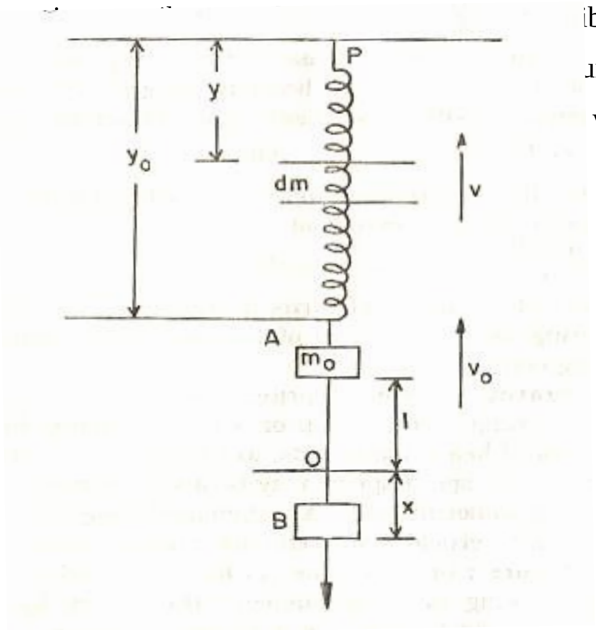


Fig.-1

At this same instant an element dm of the mass m of the spring will also be moving up but with a velocity v which is smaller than v_0. It is evident that the ratio between v and v_0 is just the ratio between y and y_0 . Hence, $\frac{v}{y} = \frac{v_0}{y_0}$ i.e., $v = \frac{v_0}{y_0} y$.

The kinetic energy of the spring alone will be $\int_0^O \frac{1}{2} v^2 dm$.

But dm may be written as $\frac{m}{y_0}dy$, where m is the mass of the spring.

Thus the integral equals to $\frac{1}{2}(\frac{m}{3})v_0^2$. The total kinetic energy of the system will then be

$\frac{1}{2}(m_0+\frac{m}{3})v_0^2$ and the effective mass of the system is, therefore, $m_0+\frac{m}{3}$.

Hence $m'=\frac{1}{3}$ m.....................(2)

Where m' = effective mass of the spring and m = true mass of the spring. The applied force m_0g is proportional to the extension within the elastic limit. Therefore mg=kl.

Hence 1=$\frac{g}{k}m$ .... (3)

If n is the rigidity modulus of the material of the spring then it can also be proved that

n= $\frac{4NR^3k}{r^4}$ ....(4)

where N = number of turns in the spring. R = radius of the spring and r = radius of the spring and k= spring constant.

Apparatus:

i. Spiral spring,
ii. Convenient masses with hanging arrangement,
iii. Hook attached to a rigid framework of heavy metal rods,
iv. Weighing balance,
v. Stop-watch and scale.

Procedure:

1. Suspend the spring by a hook attached to a rigid framework of heavy metal rods.
2. Measure the length of the spring with a scale.
3. Add suitable weight to the free end of the spring so that it extend to the position O (Fig.1). Find extension by subtracting actual length of the spring from the length measured due to add the weight and note the position O.
4. Pull the load from the position O to a moderately low position Band then let it go. The spring will now execute simple harmonic motion and vibrate up and down about the position O. With a stop watch take the time of 30 complete oscillations. Calculate time period T in sec/vibration.
5. Repeat operations (3) & (4) at least 5 sets of loads.

6. For the determination of spring constant k, draw a graph with added loads m_o in grams along abscissa and the extensions of the spring in cm along the ordinate.

7. For the determination of effective mass m', draw another one graph with added loads m_o in grams along abscissa and T^2 along the ordinate.

8. From the first graph determine the slope of the line by choosing two points on it, one near the origin with coordinates x_1 gm and $y_1$cm and the other near the upper end of the line with coordinates x_2 gm and y_2 cm. (x_2-x_1) is the mass m and the corresponding extension is ($y_2 - y_1$) cm. Then calculate spring constant using the formula, $k = \frac{F}{y} = \frac{mg}{y} = \frac{x_2 - x_1}{y_2 - y_1} g$.

9. The second graph T^2 vs m_o does not pass through the origin. The intercept of the resulting line on the mass-axis give m', the effective mass of the spring.

10. Count the number of turns in the spring. With the help of slide callipers, find out the inside and outside diameters of the spring. Make several observations and take the mean values. If D is the outside diameter and d is the inside diameter then mean radius of the spring is given by $\frac{D+d}{4}$.

11. Also measure the radius of the wire of the spring with a screw-gauge. A number of values are to be taken at different points and then find out the mean value of radius.

12. With the help of the equation, $n = \frac{4NR^3k}{r^4}$ [where N is the no of turns, R is the radius of the spring, k is the spring constant and r is the radius of the wire of the spring] calculate the rigidity of modulus of the material of the spring.

Experimental Data:

a) Length of the spring L = -----------cm

b) Determination of extensions and time periods

No of Obs.	Loads m_0 in gms	Extension in cm	No of Vibration	Total time in sec	Period T in sec	T^2 sec^2

c) Mass of the spring, m =--------gms

d) No of turns N in the spring = ---------------

e) External diameter of the spring (mean), D = --------------cm

Internal diameter of the spring (mean), d = ---------------cm

Radius of the spring, R = $\dfrac{D+d}{4}$ cm

f) Radius of the wire of the spring (mean) r = -----------cm

Graphs:

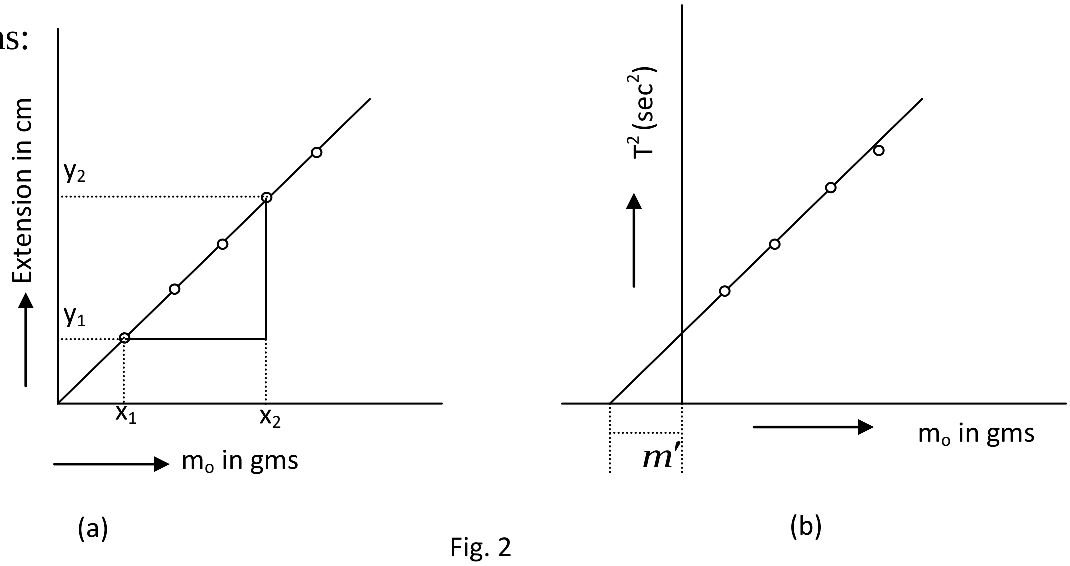


Fig. 2

Calculation:

From graph 2(a), $\dfrac{x_2 - x_1}{y_2 - y_1}$ = ----------gm/cm

So, spring constant, $k = \dfrac{F}{y} = \dfrac{mg}{y} = \dfrac{x_2 - x_1}{y_2 - y_1} g$ = ------------------ dynes/cm

Modulus of rigidity of the wire, $n = \dfrac{4NR^3k}{r^4}$ = ---------dynes/cm^2

Results:

1. Spring constant k = ------------------ dynes/cm
2. Effective mass (from graph 2(b)), m'= -----------gm
3. Modulus of rigidity of the wire, n = ----------dynes/cm^2

Discussions:

Experiment no-12:

Name of the Experiment: To determine the resistance of a galvanometer by half deflection method.

(G. Ahmed and M. Shahabuddin, “Practical Physics " Hafiz Book Centre, 1969.)