Sem-1_2021-22

Physics Lab Manual

General Department

L. E. College, Morbi.

VISION

To provide quality engineering education and transforming students into professionally competent and socially responsible human beings.

MISSION

- To provide a platform for basic and advanced engineering knowledge to meet global challenges.
- To impart state-of-art know- how with managerial and technical skills.
- To create a sustainable society through ethical and accountable engineering practices.

My

Beloved Students

With all warm regards and wishes I am glad to present you this fruit of toil taken by the Professors of General Department. This manual is designed in such a way that it becomes useful in grooming you in a better way. It applies the concept that you study in your theory classes.

I hope this labour will inculcate in you the practical wisdom which you require in your professional life. This will widen your horizon and deepen your knowledge for the subject.

This is the toil taken for you by your professors keeping in mind your need as a student. They have tried their level best to form a uniform manual which is perhaps the first in Degree side. I am glad to have such a team of intellectuals who worked hard and converted the idea into reality. I congratulate them all. I feel proud that L. E. College, Morbi is the pioneer in generating manual for Degree students in General side.

I wish you the very success in your life and pray to Almighty to help us to groom you into a better Engineer……..

Principal,
L. E. College, MORBI

ૐ સહના વવતુ સહનૌભુનક્તુ સહવીર્યમ કરવા વહે

તેજસ્વીના વદી તમસ્તુ માં વિદ્ વિસા વહે

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Acknowledgements

We heartily extend our vote of thanks to the Principal, Prof. S. N. Pandya, L. E. College, Morbi to guide us and permit us to bring our vision into a reality. We are also grateful to our Head of the Department, Prof. R. S. Damor for his constant support and encouraging attitude.

Our special thanks are due to our entire staff member who supported us in compiling our work.

Last but not the least to Almighty for his blessings.

Compiled by:

- Dr. Sanjay Singhal, Asso. Professor
- Jayant Jogi, Asst. Professor
- Prashant Rathod, Asst. Professor

CERTIFICATE

This is to Certify that Shri/Kum.______________________________ Enroll. No.__________________ of B.E. ________________________ Class has Satisfactorily Completed the Course in Physics Practicals within Four Walls of LUKHDHIRJI ENGINEERING COLLEGE, MORBI.

Date of Submission__________ Staff in-charge_________________

Head of Department____

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Total surface area and Volume of the cylinder & Maximum Permissible Error - 01

Exp. No: 01 Date:

Aim:

Find the total surface area and volume of a cylinder and a cube and the max. permissible error in these quantities by measuring required dimensions by a vernier caliper. Write all final answers in CGS & MKS system.

Description of the Vernier Capiper and measuring the length of the given object:

The vernier caliper accurately measures the internal and external dimensions of objects. The inside jaws are used for internal measurements. The outside jaws are used for external measurements. The vernier caliper is shown in the figure (1).The vernier caliper have two scales.

1. The fixed scale in millimeter, known as main scale.

2. The sliding vernier scale.

- The boldface numbers on the fixed scale are centimeters.
- The tick marks on the fixed scale between the boldface numbers are millimeters.
- There are ten or twenty tick marks on the sliding scale. The left-most tick mark on the sliding scale will let you read from the fixed scale the number of whole millimeters that the jaws are opened.

The vernier calipers

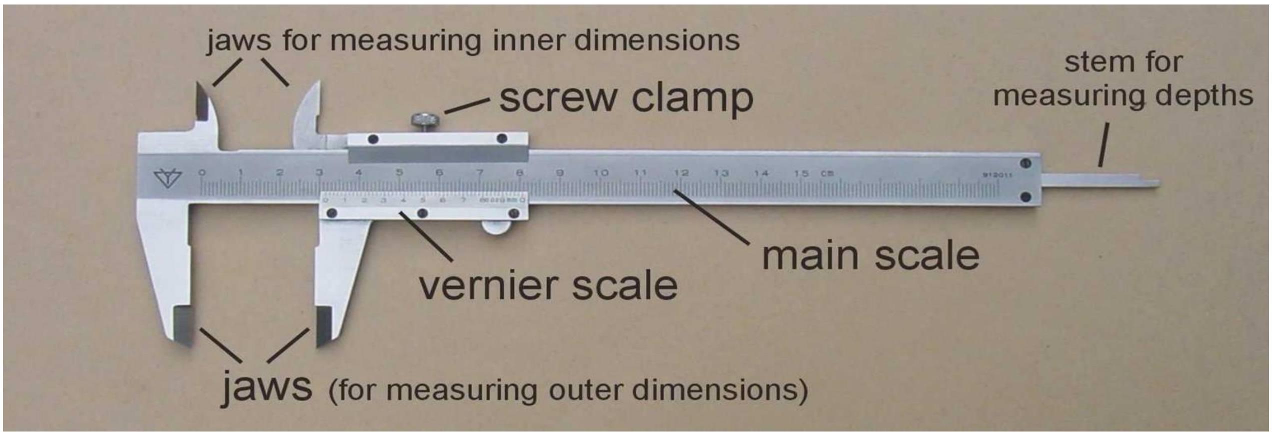


Figure 1.

<u>Theory:</u>

The minimum length that can be measured accurately by vernier calipers is known as **Least count (LC).**

The least count(LC) is found out by using the formula given below.

$$\text{LC} = \frac{\text{The value of one small division on main scale}}{\text{Total no of divisions on vernier scale}} = \_\_\_\_\_\_\_\_ \ cm$$

Total reading = Main scale reading (MSR) + [VSR × Least Count (LC)]

Where, VSR = The number of division of the vernier scale coinciding with any of the divisions on Main Scale.

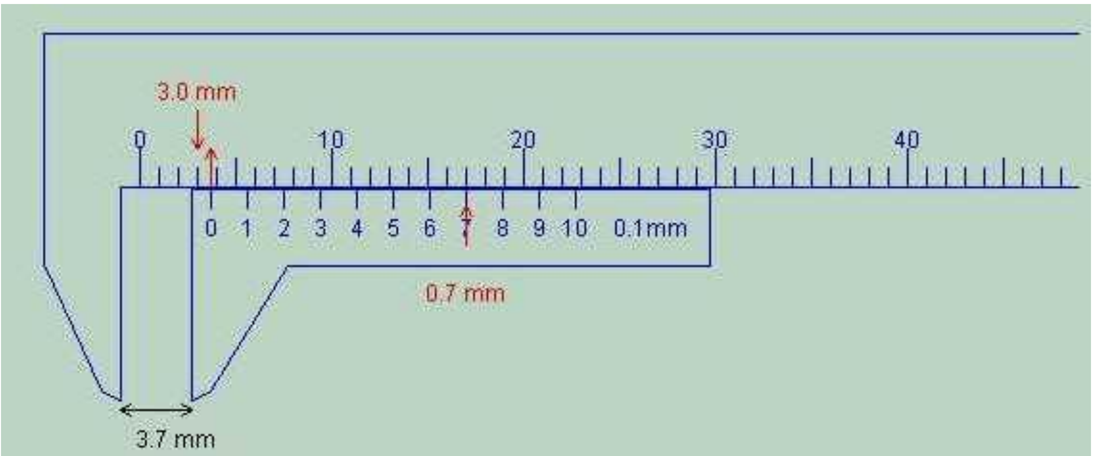


Figure 2: The reading here is 3.7 mm.

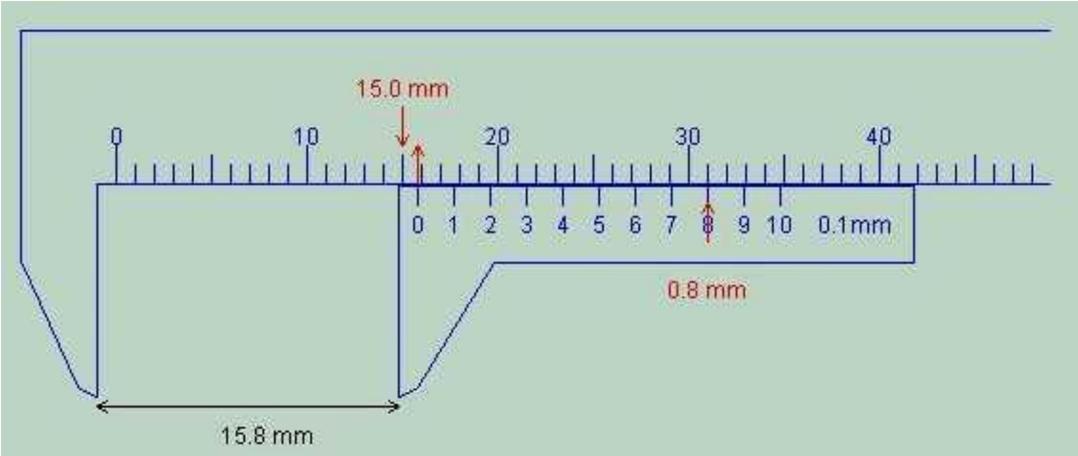
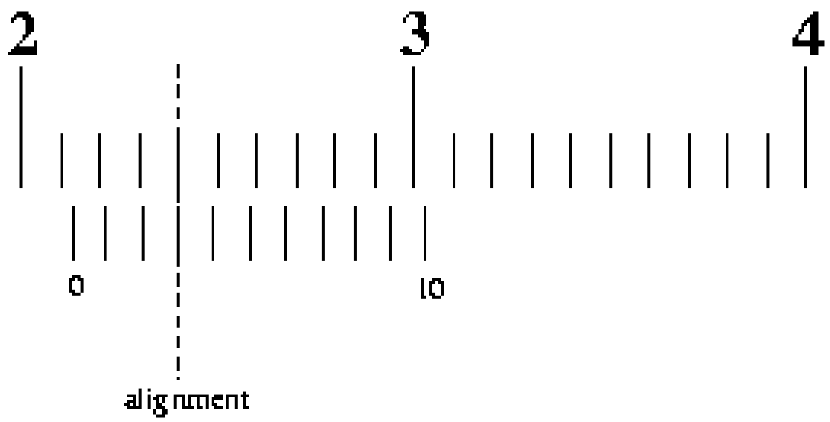


Figure 3: The reading here is 15.8 mm.



<u>Procedure:</u>

1. The object to be measured is placed between the outside jaws.
2. The sliding vernier scale is moved along the main scale until the object is lightly held by the jaws.
3. The main scale reading and the vernier scale coincidence are then taken and noted in the tabular column given below.

Observations for Cylinder

Dimension to be measured	Sr. No.	Main Scale Reading (MSR) (cm)	Vernier Scale Reading (VSR)	VSR×LC (cm)	Total Reading = MSR + (VSR×LC) (cm)	Mean Reading (cm)
Diameter of the cylinder	1					
	2					
Height of the cylinder	1					
	2					

Observations for Iron block

Dimension to be measured	Sr. No.	Main Scale Reading (MSR) (cm)	Vernier Scale Reading (VSR)	VSR×LC (cm)	Total Reading = MSR + (VSR×LC) (cm)	Mean Reading (cm)
Length of the Iron block	1					
	2					
Breadth of the Iron block	1					
	2					
Thickness of the Iron block	1					
	2					

Result for Cylinder:

The curved surface area of given cylinder A_1 =

The cross section area of given cylinder A_2 =

Total surface area of cylinder A =

The volume of the given cylinder V =

Result for Iron block:

Total surface area of given Cuboid A =

The volume of the given Cuboid V =

How to calculate Maximum probable error:

1. First you write the working formula in terms of all the quantities that you have measured. Consider all the parameters supplied by us as constant. Suppose you want to measure y and your formula is $y = \frac{a^3 x^\eta k^\alpha}{b^n z^\beta}$, in which a and b are supplied.
2. Now, you need to find out $\frac{dy}{y}$ to do so first you take log of the working formula and differentiate it:

Then you neglect errors in the supplied parameters and consider the fact that error is always additive and change the negative signs accordingly and express it in %.

$$\frac{dy}{y} = 3\frac{da}{a} - n\frac{db}{b} + \eta\frac{dx}{x} + \alpha\frac{dk}{k} - \beta\frac{dz}{z}$$

$$= \eta\frac{dx}{x} + \alpha\frac{dk}{k} - \beta\frac{dz}{z} \text{ (as a and b are constant)}$$

maximum probable error is

$$\frac{dy}{y} \times 100\% = \left(\eta\frac{dx}{x} + \alpha\frac{dk}{k} + \beta\frac{dz}{z}\right) \text{(as error is always additive, sign of dz is changed)}$$

While considering the value of dx, dy etc. you have to be careful about the measurement process. For example, suppose you measure the length of the cap of a pen with a mm scale then you measure the reading at both the end of the cap, and in both side you can make an error of 1 mm and consequently dx = 2mm

How to calculate Maximum probable error in the curved surface area and volume of the cylinder:

$$Curved\,surface\,area\,of\,the\,cylinder,\ A_1 = 2\pi rL$$

$$Log A_1 = \log(2\pi rL)$$

$$partialy\,differenentiating;\ \frac{\delta A_1}{A_1} = 0 + \frac{\delta r}{r} + \frac{\delta L}{L}$$

$$\delta A_1 = A_1\left(\frac{\delta r}{r} + \frac{\delta L}{L}\right)$$

$$Cross\,Section\,area\,of\,the\,cylinder,\ A_2 = 2\pi r^2$$

$$Log\ A_2 = \log(2\pi r^2)$$

$$differenentiating;$$

$$\frac{\delta A_1}{A_1} = 0 + \frac{2}{r}\delta r, \quad \delta A_1 = A_1\left(\frac{2}{r}\delta r\right)$$

$A_{total} = A_1 + A_2$ & $\delta A_{total} = \delta A_1 + \delta A_2$

$$V = \pi r^2 L$$

$$\log(V) = \log(\pi r^2 L) = \log\pi + \log r^2 + \log L$$

$$Differentiating;$$

$$\frac{\delta V}{V} = 0 + \frac{2}{r}\delta r + \frac{1}{L}\delta L$$

$$\delta V = V\left(\frac{2}{r}\delta r + \frac{1}{L}\delta L\right) =$$

Result for total surface area and max. permissible error and volume and max. permissible error of a cylinder:

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Sign. ____________________

Viva voce:

Q1. What is least count of an instrument?

Q2. If one small division of the main scale of a screw guage is 0.5mm and the total no of division on the rotating scale are 50. What will be the LC of screw gauge?

Q3. What are the formulae for total surface area and volume of a cylinder and a cuboids?

Q4.What is the difference between systematic error and random error?

Q5. What is the difference between precision and accuracy?

Resonance Tube Experiment – 2

Aim: To obtain the length of air column (l) for 1st resonance for four different frequencies using resonance tube. Draw the graph of l → (1/f) and obtain end correction. Also obtain the corrected length of the air column (L) for 1st resonance for different frequencies.

Apparatus: Resonance Tube, Tuning Forks, Vernier calipers.

Procedure:

Start your experiment with the tuning fork having max. frequency. Now hit the tuning fork on the rubber pad put that vibrating tuning fork on the mouth of the resonance tube. Adjust the height of the air column in the resonance tube in such a way that a louder sound (sound with max. intensity) come out from the resonance tube. Stop adjusting the height of the air column when the louder sound is heard. Now note down that height of the air column in observation table as l.

Now repeat the same procedure for other tuning forks given to you.

Theory:

When the frequency of external periodic force becomes equal to the natural frequency of the system, resonance takes place and at that time system vibrates with max. amplitude.

In our case when we are adjusting the length of the air column means we are adjusting the natural frequency of it, because natural frequency of any system is inversely proportional to its length.

So, when we here a louder sound from the resonance rube, it means that natural frequency of the air column becomes equal to the frequency of the tuning fork and resonance is taking place.

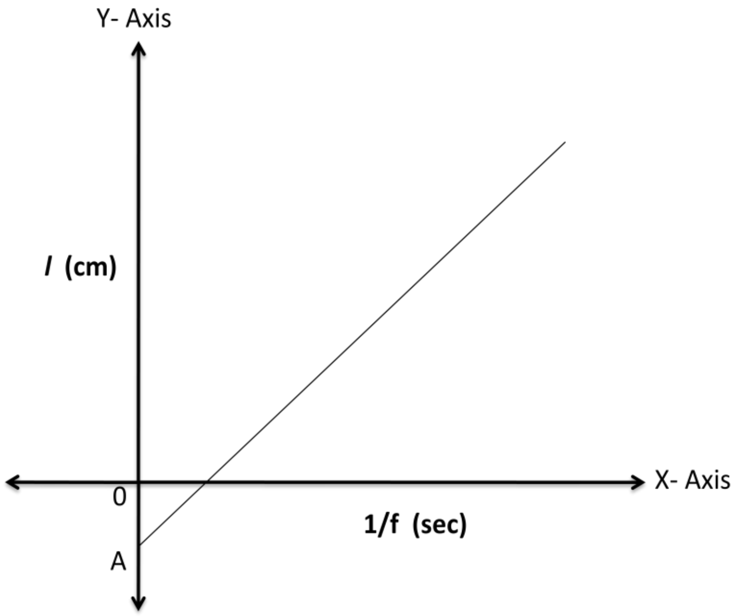
Observations:

(1) Least count of vernier calipers = 0.01 cm
(2) Inner diameter of resonance tube… d = _______ cm

Observation Table:

Sr. No.	Freq. (f) in Hz	Length of air column at the time of resonance			1/f
		l_1 (cm)	l_2 (cm)	Average l (cm)	Hz^{-1} or sec
1					
2					
3					
4					

Graph: l → **1/f**



Here, distance 0A on the graph is known as the **End correction.**

Calculations :

(1) Corrected length of the air column at the time of resonance…

$L = l + OA$, where, OA = End correction obtained from graph

(2) Theoretical value of corrected length…

$L = l + (0.3)\, d$, where, $[(0.3)\, d]$ =Theoretical value of End Correction

(1) $L_1 = l_1 + OA$

(2) $L_2 = l_2 + OA$

(3) $L_3 = l_3 + OA$

(4) $L_4 = l_4 + OA$

(1) $L_1 = l_1 + (0.3)\ d$

(2) $L_2 = l_2 + (0.3)\ d$

(3) $L_3 = l_3 + (0.3)\ d$

(4) $L_4 = l_4 + (0.3)\ d$

Result: ____

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Sign. ____________________

Viva voce:

Q1. What are longitudinal and transverse waves?

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Q2. How sound is produced? What kind of wave it is?

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Q3. What is resonance of sound?

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Q4. At the time of thunderstorm, light and sound originate at the same time but you see light first then you hear sound? Why?

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Q5. Draw and show amplitude and wavelength of a wave?

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Velocity of sound in air by Resonance Tube method – 3

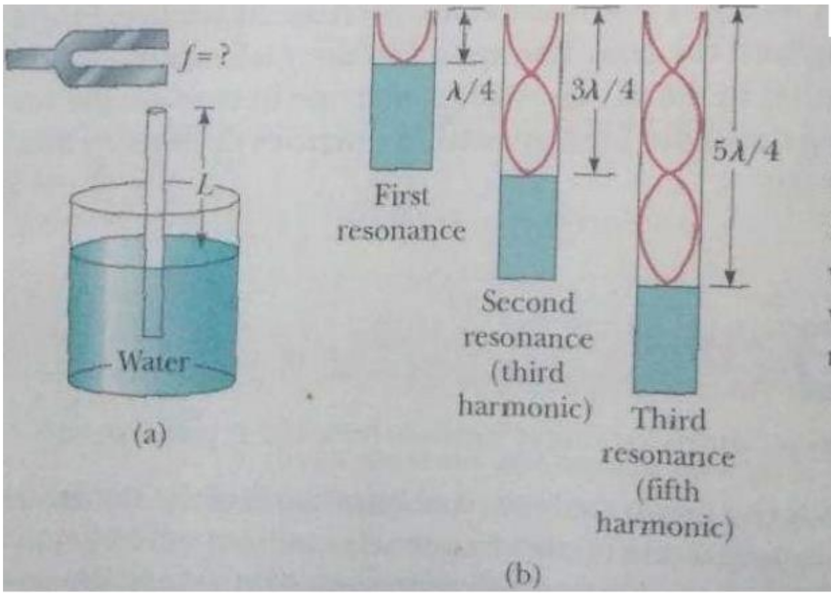
Aim: To compare the frequencies of the tuning forks using resonance tube. Also obtain the velocity of sound from 1^{st} - resonance.

Apparatus: Resonance Tube, Tuning Forks, Vernier calipers.

Procedure:

Start your experiment with the tuning fork having max. frequency. Now hit the tuning fork on the rubber pad put that vibrating tuning fork on the mouth of the resonance tube. Adjust the height of the air column in the resonance tube in such a way that a louder sound (sound with max. intensity) come out from the resonance tube. Stop adjusting the height of the air column when the louder sound is heard. Now note down that height of the air column in observation table as l.

Now repeat the same procedure for other tuning forks given to you.



(a) Apparatus for demonstrating the resonance of sound waves in a tube closed at one end. The length, L, of the air column is varied by moving the tube vertically while it is partially submerged in water. (b) The first three resonances of the system.

Theory:

When the frequency of external periodic force becomes equal to the natural frequency of the system, resonance takes place and at that time system vibrates with max. amplitude. In our case when we are adjusting the length of the air column, we are adjusting the natural frequency of it, because natural frequency of any system is inversely proportional to its length.

So, when we here a louder sound from the resonance tube, it means that natural frequency of air column has become equal to the frequency of tuning fork and resonance is taking place.

Observations:

(1) Least count of vernier calipers = 0.01 cm
(2) Inner diameter of resonance tube… d = _______ cm

Observation Table:

Sr. No.	Freq. (f) in Hz	Length of air column at the time of resonance			Corrected length $L = l + (0.3)d$ (cm)
		l_1 (cm)	l_2 (cm)	Average l (cm)	
1	$f_1 =$				$L_1 =$
2	$f_2 =$				$L_2 =$
3	$f_3 =$				$L_3 =$
4	$f_4 =$				$L_4 =$

Calculations :

(1) Comparison of the frequencies of the two tuning forks:

(i) $f_1/f_2 = L_2/L_1$

(ii) $f_3/f_4 = L_4/L_3$

(2) Velocity of SOUND…

$$v = f\ \lambda$$

where, λ = Wavelength of the sound wave

$$v = f\ (4L)$$

(Because for 1st – Resonance, λ = 4L)

(I) $v_1 = f_1\ (4L_1)$

(ii) $v_2 = f_2\ (4L_2)$

(iii) $v_3 = f_3\ (4L_3)$

(iv) $v_4 = f_4\ (4L_4)$

(3) Average Velocity… $v = \frac{v_1+v_2+v_3+v_4}{4}$

Result: ____

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Sign. ____________________

Viva voce:

Q1. What are infrasonic, audible and ultrasonic waves?

Q2. What is the relation between wavelength, frequency and velocity of a wave?

Q3. When a wave enters from one medium of lower density to a medium of higher density, name the parameter out of wavelength, frequency and velocity that will not change and why?

Q4. What are standing waves? How they are formed?

Q5. Write the applications of ultrasonic waves?

Deflection of Magnetometer Experiment - 4

Aim: To find the magnetic moment (M) of given magnet by magnetometer. (From two different position Gauss-A and Gauss-B of magnetometer). Also obtain the pole strength (m) of the magnet.

Apparatus: Magnetometer, Magnet.

Procedure:

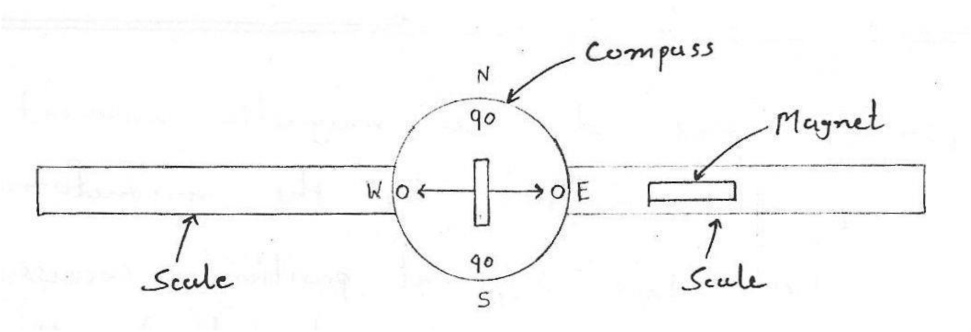
First set the magnetometer in Gauss-A position and then put the magnet at a distance **d** on the arm of the magnetometer as shown in fig.-1. Distance **d** should be selected in such a way that magnetometer show a deflection between 30˚ and 60˚. Now note down the deflection shown by the magnetometer as θ_1 and θ_2 then reverse the direction of the poles of the magnet and note down the deflection as θ_3 and θ_4. Now put the magnet on the opposite arm and repeat the experiment in a similar way and note down the deflections as θ_5 , θ_6 , θ_7 , and θ_8 . Now calculate **Magnetic moment** and **Pole strength.**

Now set the magnetometer in Gauss-B position and repeat the experiment in a similar way.

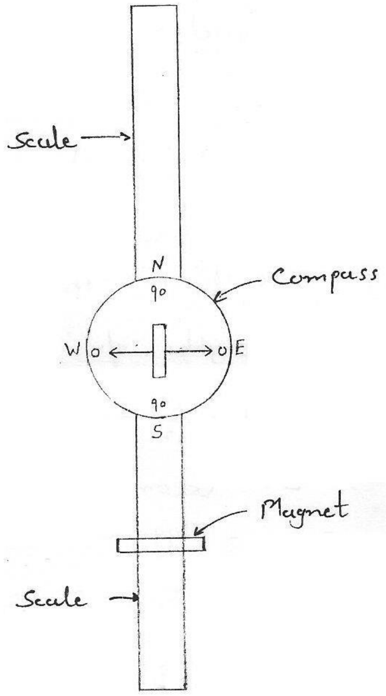
Theory:

The **Magnetic moment** is a measure of the strength of the magnet. Its unit is **Gauss.cm³**. For a magnet of **Pole strength 'm'** and length **2l** the magnetic moment **M=2ml** and points from the South Pole to the North Pole of the magnet.

- **Gauss-A Position of Magnetometer:**



- **Gauss-B Position of Magnetometer:**



- **Observations:**

(1) Magnetic field intensity of the earth… H = 0.36 Gauss
(2) Magnetic length of the magnet… $2l$ = 5L/6 = __________ cm
l = ___________cm
Where, L = Geometric length of the magnet = __________ cm

- **Observation Table for Gauss-A Position :**

Sr. No.	Distance d (cm)	Deflection of Magnetometer								Avg. θ	tanθ	Magnetic Moment $M = \frac{(d^2-l^2)^2}{2d} .H .\tan\theta$
		θ_1	θ_2	θ_3	θ_4	θ_5	θ_6	θ_7	θ_8			
1.												
2.												

- **Observation Table for Gauss-B Position :**

Sr. No.	Distance d (cm)	Deflection of Magnetometer								Avg. θ	$\tan\theta$	Magnetic Moment M = $(d^2+l^2)^{3/2}$.H.tanθ
		θ_1	θ_2	θ_3	θ_4	θ_5	θ_6	θ_7	θ_8			
1.												
2.												

- **Calculations:**

(1) Magnetic Moments for Gauss-A position

(2) Magnetic Moments for Gauss-B Position

(1) $M_A = \frac{(d^2-l^2)^2}{2d}$. H . tanθ	(2) $M_B = (d^2+l^2)^{3/2}$. H . tanθ
(i)	(i)
(ii)	(iii)

(1) $M_{A,avg.} = \frac{M_{A,1}+M_{A,2}}{2}$	(2) $M_{B,avg.} = \frac{M_{B,1}+M_{B,2}}{2}$

(3) **Pole Strength** of the magnet… m = M/2l
(For both Gauss-A & Gauss-B Positions)

For Gauss-A :	For Gauss-B :
$m_A = \frac{M_{A,avg.}}{2l}$	$m_B = \frac{M_{B,avg.}}{2l}$

Result: ____
____
____
____

Sign. ____________________

Question for Viva Voce:

Q1. What is the value of magnetic field of earth on the surface of it? How magnetic field is created by earth?

Q2. How much magnetic field is produced by the bar magnet, you are using?

Q3. Can you separate a monopole from the magnet?

Q4. What are the ways to produce magnetic field? Explain.

Q5. What do you find in your experiment?

Friction Experiment – 5

Aim: To determine the coefficient of kinetic (rolling) friction between plane and roller.

Apparatus: Inclined plane, Roller, Scale pan, String, Set of weights, Scale.

Procedure:

Take the inclined plane and set an angle of inclination θ_1. Now put the block on the inclined plane and put some weight in the scale pan in such a way that block moves up along the inclined plane with a constant speed. Note down that weight for that angle and calculate the **Coefficient of friction.**

Now, repeat the experiment for the angles θ_2 and θ_3 .

Theory:

When a force **F** tends to slide a body along a surface, a frictional force from the surface acts on the body. The frictional force is parallel to the surface and directed so as to oppose the sliding. It is due to bonding between the body and the surface.

If the body does not slide, the frictional force is a static frictional force $\mathbf{f_s}$. If there is sliding, the frictional force is a kinetic (dynamic) frictional force $\mathbf{f_k}$. If the body is rolling then the frictional force is known as rolling frictional force $\mathbf{f_r}$.

- Three properties of friction:

(1) If the body does not move, then the static frictional force $\mathbf{f_s}$ and the component of **F** that is parallel to the surface are equal in magnitudes and $\mathbf{f_s}$ is directed opposite that component. If that parallel component increases, magnitude f_s also increases.

(2) The magnitude of $\mathbf{f_s}$ has a maximum value $f_{s,max}$ that is given by $f_{s,max} = \mu_s N$. Where, μ_s is the coefficient of static friction and N is the magnitude of the normal reaction. If the component of **F** that is parallel to the surface exceeds $f_{s,max}$ then the body slides on the surface.

(3) If the body begins to slide on the surface, the magnitude of the frictional force rapidly decreases to a constant value f_k given by $f_k = \mu_k N$. Where, μ_k is the coefficient of kinetic friction.

The magnitude of the coefficients of frictions relative to each other is given by $\mu_s > \mu_k >> \mu_r$. Where, μ_r is coefficient of rolling friction.

✓ **Note:** Here, quantities shown bold are vector quantities.

Observations:

(1) Weight of the roller… M = ________ gm

(2) Gravitational acceleration… g = 980 cm/s^2

- **Observation Table:**

Sr. No.	Angle of Inclination of the Plane (θ) in degrees	Hanging weight to start the motion upward m_1 (gm)	Hanging weight to start the motion downward m_2 (gm)	Avg. Effort $m = m_1 + m_2$ (gm)	$\cos\theta$	$\sin\theta$	Coefficient of Kinetic (rolling) Friction $\mu = \frac{mg - Mg\sin\theta}{Mg\cos\theta}$
1.	$\theta_1 =$ _____						$\mu_1 =$ _______________
2.	$\theta_2 =$ _____						$\mu_2 =$ _______________
3.	$\theta_3 =$ _____						$\mu_3 =$ _______________

Calculation:

- Coefficient of Kinetic Friction: $\mu = \dfrac{mg - Mg \sin\theta}{Mg \cos\theta}$

(1)

(2)

(3)

- **Average of Coefficient of Kinetic (rolling) Friction**:

$$\mu_{avg} = \frac{\mu_1 + \mu_2 + \mu_3}{3}$$

Result: ____

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Sign. ____________________

Question for Viva-Voce:

Q1. What is coefficient of friction? What is the difference between static and dynamic friction?

Q2. Which one is easier pushing or pulling? Explain by a free body force diagram.

Q3. Three objects a ring, a disk and a cylinder rolls down on an inclined plane. Which one reaches first on ground?

Q4. Why it's difficult to drive a car on the ice floor as compared to a normal road?

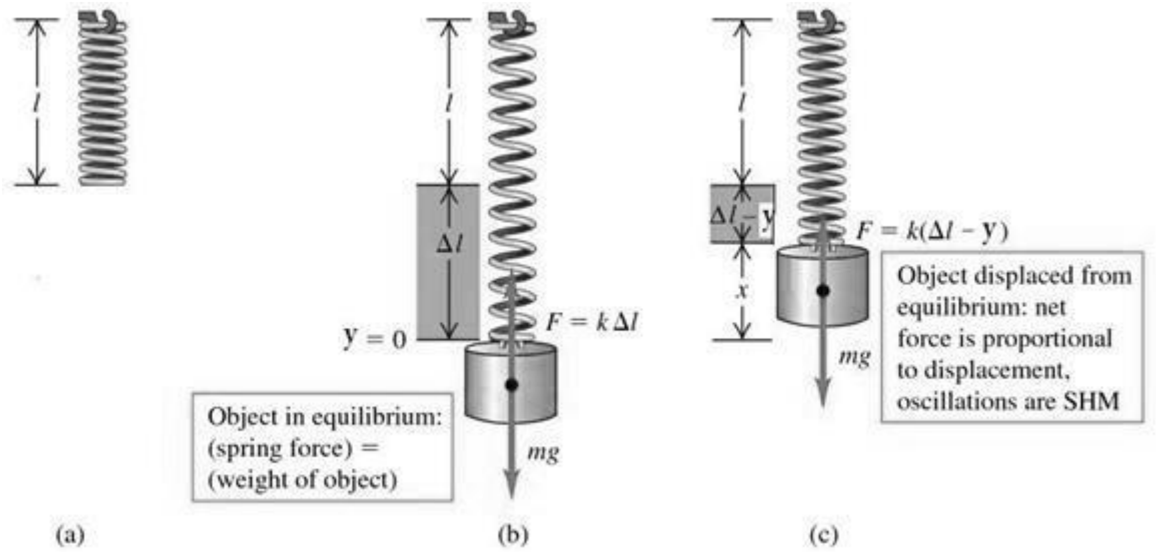
Q5. What is the principle of conservation of energy?

Force Constant of Spring - 6

Aim: To determine the force constant (k) of a given spring.

Apparatus: Spiral spring, Balance, Weight box, Stand, Meter scale, Stop watch.

- **Diagram:**



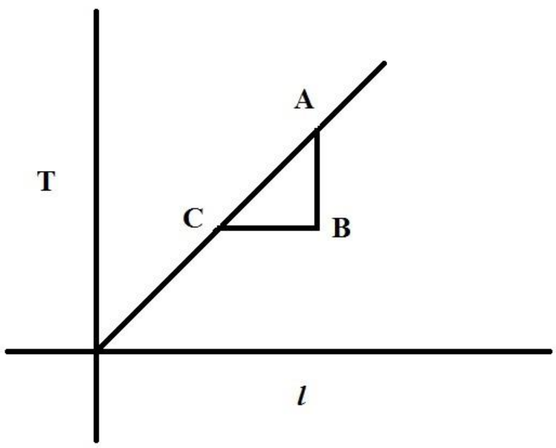
Procedure:

First hang the spring to a stand and attach the mass at the lower end of the spring such that the spring will be in equilibrium. Now hang the weights one by one till the maximum load is reached. In each case, the reading of increased length of the spring is noted. The weights are then removed one by one and the reading of increased length of the spring is noted in each case of unloading. Find mean (average) increase in length of the spring and calculate the force constant of the given spring using the equation given in the observation table. Also find the value of force constant of the given spring using the graph of T vs. l.

- **Observation Table:**

Sr. No.	Mass Suspended at the end of the spring m (gm)	Tension produced in the spring T=mg (dyne)	Increase in length of the spring during loading x (cm)	Increase in length of the spring during unloading y (cm)	Mean $l = \frac{x+y}{2}$ (cm)	Force constant $k = \frac{T}{l}$ (dyne/cm)
1.	m_1 = _______	T_1 = _______			l_1 = ____	k_1 =______
2.	m_2 = _______	T_2 = _______			l_2 = ____	k_2 =______
3.	m_3 = _______	T_3 = _______			l_3 = ____	k_3 =______
4	m_4 = _______	T_4 = _______			l_4 = ____	k_4 =______

- **Graph:**



$$k = Sloope = \frac{AB}{BC}$$

- **Calculations:** $Force\ constant \ldots\ \boldsymbol{k = \frac{T}{l}}$

(1) $\boldsymbol{k_1 = \frac{T_1}{l_1}}$

(3) $\boldsymbol{k_3 = \frac{T_3}{l_3}}$

(2) $\boldsymbol{k_2} = \frac{\boldsymbol{T_2}}{\boldsymbol{l_2}}$

(4) $\boldsymbol{k_4} = \frac{\boldsymbol{T_4}}{\boldsymbol{l_4}}$

- **Average of Force constant**:

$$\mathrm{k_{avg}} = \frac{\mathrm{k}_1 + \mathrm{k}_2 + \mathrm{k}_3 + \mathrm{k}_4}{4}$$

Result: ____

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Sign. ____________________

Question for Viva Voce:

Q1. Write down the formula for time period of a mass-spring system.

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Q2. What is Hooke's law?

Q3. If you have two springs one is light weight and other is heavy, whose spring constant will be high? Explain.

Q4. If you change the length of a spring, will its force constant change? Explain.

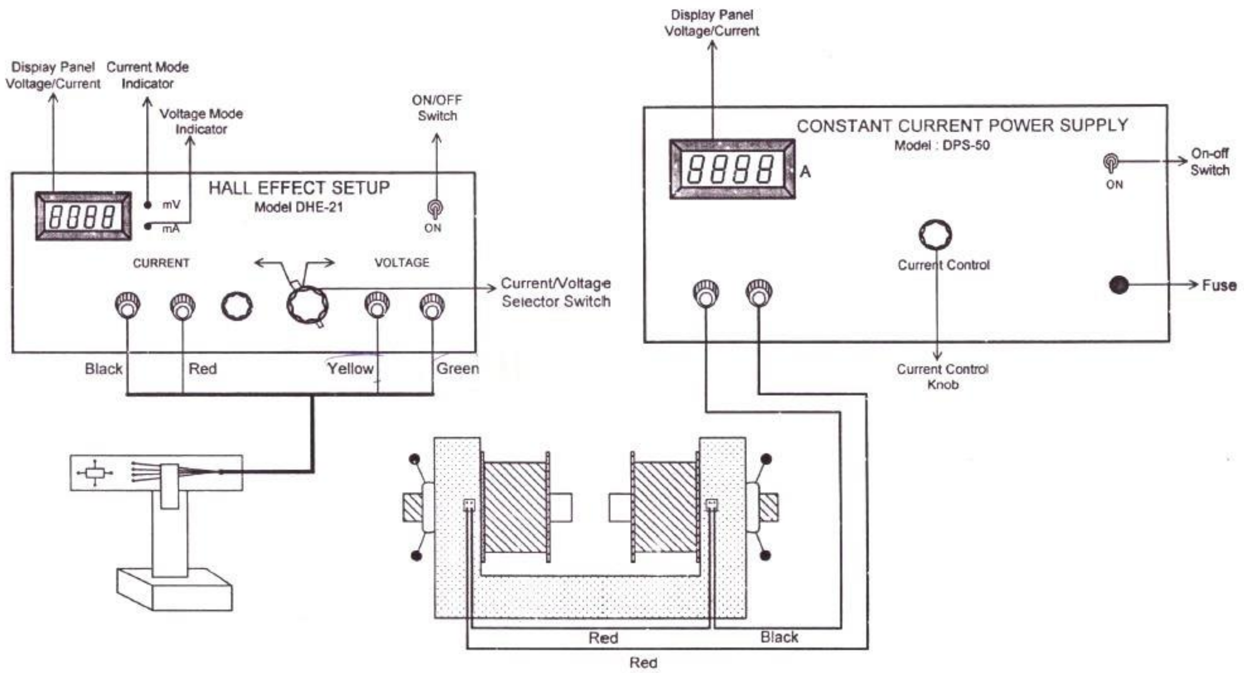
Q5. Develop the SHM equation of mass spring system.

Study of Hall Effect - 7

Aim: To find number density (n) & mobility (μ) of the charge carriers and the Hall coefficient (R_H) for a given material.

Apparatus: N-type or P-type semiconductor specimen, Electromagnets with constant current power supply, Hall voltage measuring device, Gauss meter.

- **Circuit Diagram:**



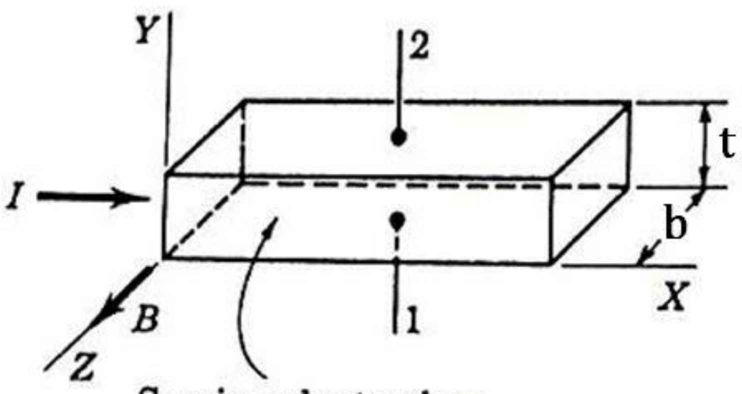
Panel Diagram of Hall Effect Experiment, HEX-21

Procedure:

- First connect the constant current power supply to the electromagnet.
- Set the desired magnetic field, say 600 gauss, between the poles of the electromagnet by increasing the current passing through it.
- Use digital gauss meter to measure the magnetic field between the poles of the electromagnet.

- Connect the specimen probe to Hall Effect Setup so that the current passing through the specimen remains parallel to its length, and Hall voltage should be measured across the thickness of the specimen.
- Insert the Hall Effect probe (Specimen) into the magnetic field in such a way that it remains perpendicular to the magnetic field lines.
- Measure the values of Hall voltage V_{H1} and V_{H2} using Hall Effect setup for different values of current (passing through the specimen) as given in the observation table. Here, V_{H1} and V_{H2} are the values of the Hall voltages for two opposite magnetic field directions.
- Find the average of V_{H1} and V_{H2}.
- Repeat the experiment for other two values of the magnetic field.
- Draw the graph and do the necessary calculations.

Theory:



- We have a rectangular slab of an N-type semiconductor material.
- Magnetic field is along positive Z-direction and electric current is along positive X-direction.
- Under the influence of this magnetic field, force experienced by the electrons is given by

$$\vec{F}_B = -\,e\,(\vec{v}_d \times \vec{B})$$

$$\therefore F_B = -e\,v_d\,B\sin 90°$$

$$\therefore F_B = -e\,v_d\,B \qquad \dots (1)$$

Where, e = magnitude of charge of electrons, and

v_d= drift speed of electrons

- Due to this force electrons are drifted towards negative Y-direction.
- Thus bottom side of the specimen becomes negatively charged.
- On the other hand, topside of the specimen becomes positively charged because of the loss of electrons.
- Due to this positive and negative charges developed on the opposite faces, a potential difference is developed which is called Hall Voltage (or Hall Potential), which establishes an electric field E_H known as Hall Electric field across the specimen along negative Y-direction.
- The force acting on the electrons due to the Hall electric field is given by

$$F_E = - e \cdot E_H \qquad \text{... (2)}$$

- At equilibrium forces due to the electric field and magnetic field balances each other. Thus,

$$F_E = E_B$$

$$- e \cdot E_H = - e \cdot v_d \cdot B \quad \text{\{from eqn. (1) and (2)}$$

$$\therefore \; E_H = B \cdot v_d \qquad \text{... (3)}$$

- Now,

$$E_H = \frac{V_H}{b}$$

Where, b = width of the specimen

$$\therefore \; \frac{V_H}{b} = B \cdot v_d \qquad \text{\{From equation (3)}$$

$$\therefore V_H = B \cdot v_d \cdot b \qquad \text{... (4)}$$

- If J is the current density, then

$$J = \frac{I}{A}$$

$$\therefore J = \frac{I}{b \cdot t}$$

but, J can also be expressed by

$$J = -n_e \cdot v_d \cdot e$$

$$\therefore v_d = -\frac{J}{e \cdot n_e}$$

- Now, substituting the value of v_d in eqn. (4), we get

$$V_H = (B) \cdot \frac{-J}{e \cdot n_e} \cdot b$$

$$\therefore V_H = \frac{-B \cdot J}{e \cdot n_e} \cdot b \qquad \ldots (5)$$

$$\therefore E_H \cdot b = \frac{-B \cdot J}{e \cdot n_e} \cdot b$$

$$\therefore E_H = \frac{-B \cdot J}{e \cdot n_e} \qquad \ldots (6)$$

- <u>Hall Coefficient:</u>

  - Hall coefficient, for N-type semiconductors, is given by

$$R_H = \frac{-1}{e \cdot n_e}$$

  - Hall coefficient, for P-type semiconductors, is given by

$$R_H = \frac{1}{e \cdot n_h}$$

Here, n_h is the number density of holes.

- Therefore, in terms of Hall coefficient RH, equations (5) and (6) can be written as follows.
    - ✓ For N-type materials

$$V_H = R_H \cdot B \cdot J \cdot b$$

$$\therefore R_H = \frac{V_H}{B \cdot J \cdot b}$$

and

$$E_H = R_H \cdot B \cdot J$$

$$\therefore R_H = \frac{E_H}{B \cdot J}$$

    - ✓ For P-type materials

$$V_H = R_H \cdot B \cdot J \cdot b$$

$$\therefore R_H = \frac{V_H}{B \cdot J \cdot b}$$

and

$$E_H = R_H \cdot B \cdot J$$

$$\therefore R_H = \frac{E_H}{B \cdot J}$$

- <u>Mobility:</u>

- Conductivity for an N-type materials is given by

$$\sigma_e = \mu_e \cdot n_e \cdot e$$

Where, μ_e is the mobility of electrons.

$$\therefore \mu_e = \frac{\sigma_e}{n_e \cdot e}$$

$$\therefore \mu_e = -R_H \cdot \sigma_e \qquad \{ \text{Because } R_H = \frac{-1}{e \cdot n_e} \text{ for N-type}$$

- Similarly, conductivity for P-type materials is given by

$$\sigma_h = \mu_h \cdot n_h \cdot e$$

Where, μ_h is the mobility of holes.

$$\therefore \mu_h = \frac{\sigma_h}{n_h \cdot e}$$

$$\therefore \mu_h = R_H \cdot \sigma_h \qquad \{ \text{Because } R_H = \frac{1}{e \cdot n_h} \text{ for P-type}$$

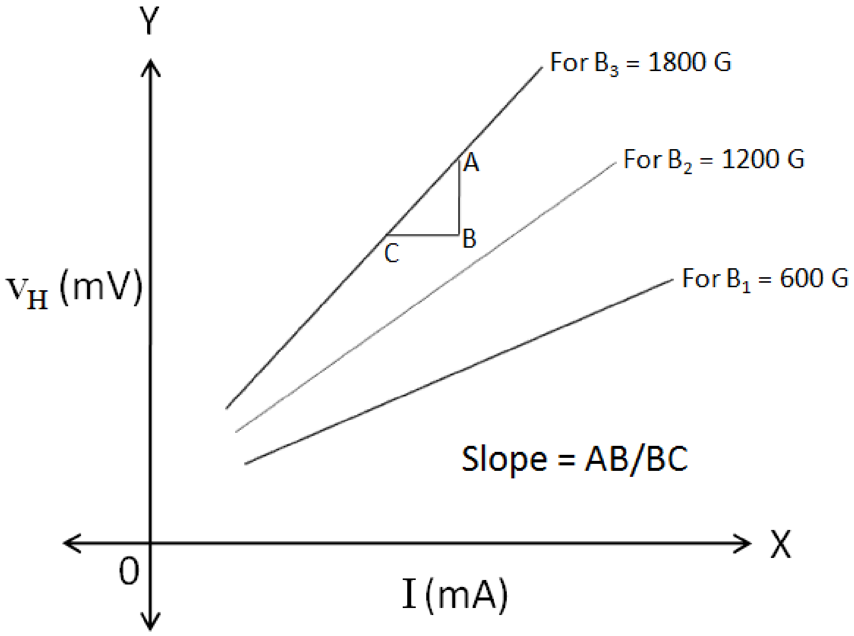
- **<u>Observations:</u>**

(1) Thickness of the specimen… t = <u>0.5</u> mm
(2) Conductivity of the specimen… σ_e = <u>10</u> Ω^{-1} m^{-1}
(3) Magnitude of the charge of the electron… e = <u>1.6×10^{-19}</u> C

- **Observation Table:**

Sr. No.	Magnetic field B (gauss)	Current Passing through the specimen I (mA)	Hall Voltage (mV)		Average Hall Voltage V_H (mV)	Hall Coefficient $R_H = \frac{V_H \cdot t}{I \cdot B}$ (m^3/C)
			V_{H1} (For +I,+B)	V_{H2} (For +I,-B)		
1.						
2.						
3.						
4.						
5.						
1.						
2.						
3.						
4.						
5.						
1.						
2.						
3.						
4.						
5.						
Average Hall Coefficient… $R_{H,avg}$:						

- **Graph:**



$R_H = [\,(Slope) \times \frac{t}{B}\,]$

- **Calculations:**

Hall coefficient…

(1) $R_H = \frac{V_H \cdot t}{I \cdot B}$, and (2) $R_H = [\,(Slope) \times \frac{t}{B}\,]$ **{from graph**

(1) Number density of charge carriers… $n_e = \frac{-1}{e \cdot R_{\mathrm{H,avg}}}$

(2) Mobility of the charge carriers… $\mu_e = -R_{\mathrm{H,avg}} \cdot \sigma_e$

Result: ____

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Sign. ____________________

Viva Voce:

Q1. What is Hall Effect?

Q2. How will you determine the direction of the force exerted on charge carriers?

Q3. What is Hall coefficient? What is the unit of it?

Q4. What do you mean by mobility of a charge carrier? How it depends on electrical conductivity?

Q5.What are the utilities of Hall effect?

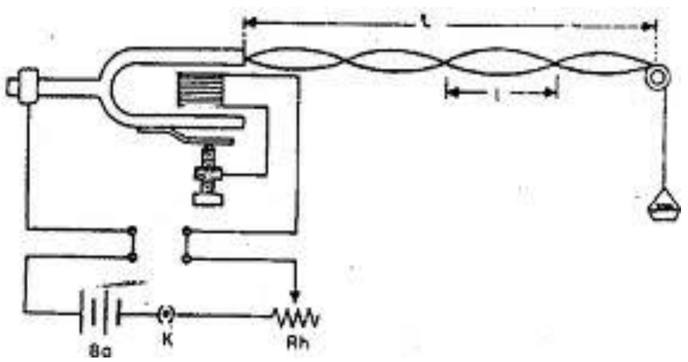
Melde’s Experiment - 8

Aim: To find the frequency of the wave and the frequency of the tuning fork by Melde’s experiment.

Apparatus: Melde’s experiment apparatus

- **Circuit Diagram:**

Transverse mode



Procedure:

Set Melde’s experiment apparatus as shown in circuit diagram in longitudinal position and switch **ON** the power supply, put some weight in scale pan and adjust the length of the string in such a way that you find some loops on the string (e.g. 2 loops). Now rotate the apparatus by 90˚ so that it is set for ‘B’ position, for the same values of weight in pan and for the same length of the string, the number of loops created in ‘B’ position are double (e.g. 4 loops) than in ‘A’ position. Note down these readings in observation table. Repeat the experiment for other values of weight in scale pan.

Theory:

This is an easy and efficient method by which nodes and antinodes formed on a string can be demonstrated.

A tuning fork is fitted in a wooden block. A long string or thread of cotton is taken. One end of this string is tied to one of the prongs of the tuning fork and the second end of this string passes over a smooth pulley in such a way that a small pan can be hang on it. Small weights are put in the pan to create tension in the string. This arrangement is shown in the circuit diagram.

The fork is set into vibrations by lightly hitting the prong of the tuning fork on which the string is not tied or by connecting an electric supply as shown in the circuit diagram. Thus the transverse vibrations are produced in the string and by adjusting the length and/or weights in the pan, these vibrations are reflected from the point of contact between the string and the pulley and a number of loops appear on the string, as shown in the circuit diagram.

When the prongs of the tuning fork vibrate in a plane, parallel to the direction of propagation of the waves, it is called **'A' position** or **longitudinal position.**

If the tuning fork, along with the wooden block is rotated through 90˚, so that the plane of vibration of the tuning fork is normal (i.e. at right angles) to the direction of propagation, it is called **'B' position** or **transverse position.**

For the same length and same weight in the pan (i.e. for the same tension) the number of loops in 'B' position is double than in 'A' position.

Thus, either in 'A' position or in 'B' position, standing transverse waves are generated in the string with a series of nodes and antinodes at equal distances.

The equation connecting number of loops (n or n'), length of the string (*l*), tension in the string (T), mass per unit length of the string (m) and frequency of the string (f) is as follows.

$$\boldsymbol{f} = \frac{\boldsymbol{n}}{\boldsymbol{2l}}\sqrt{\frac{\boldsymbol{T}}{\boldsymbol{m}}} \text{ .... (For 'A' position)}$$

$$\boldsymbol{f'} = \frac{\boldsymbol{n'}}{\boldsymbol{2l}}\sqrt{\frac{\boldsymbol{T}}{\boldsymbol{m}}} \text{ .... (For 'B' position)}$$

If the frequency of tuning fork is **F**, then for 'A' position $\mathbf{f} = \frac{\mathbf{F}}{\mathbf{2}}$ and for 'B' position $\mathbf{f'} = \mathbf{F}$.

In the above equations, if all the quantities on the R.H.S. are known, the frequency of the tuning fork $\mathbf{F}$ can be calculated.

- **Observations:**

(1) Gravitational acceleration… g = 9.8 m/s^2

(2) Mass per unit length of the string… m = ________ kg/m

(3) Mass of the scale pan… M_1 = ________ kg

Observation Table:

Sr. No.	Total mass suspended at the end of the string… $M=M_1+M_2$ (kg)	Tension created in the string… $T=Mg$ (N)	Length of the vibrating string		Average length… l (m)	No. of loops created on the string…		Frequency of the vibrating string…		Relation between f and f'
			l_1 (m)	l_2 (m)		In Longitudinal Mode… n	In Transverse Mode… n'	In Longitudinal Mode… $f=\frac{n}{2l}\sqrt{\frac{T}{m}}$	In Transverse Mode… $f'=\frac{n'}{2l}\sqrt{\frac{T}{m}}$	
1.										
2.										
3.										
4.										

Here, M_2 = the weight put in the scale pan

Calculations:

$f = \frac{n}{2l}\sqrt{\frac{T}{m}}$ .... (For 'A' position)

$f' = \frac{n'}{2l}\sqrt{\frac{T}{m}}$ .... (For 'B' position)

Result: ____

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Sign. ____________________

Viva Voce:

Q1. Why doesn't bulb in your house get on/off with frequency of AC electricity supplied to it?

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Q2. What is the formula of frequency of AC used in this experiment?

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Q3. Draw the AC current with respect to time. Draw rms current also.

Q4. What is the rms value of voltage? 220 volt supply in your house is rms or max. value of voltage?

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Q5. Can we tap the electricity generated during thunderstorm. Explain.

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Young’s Modulus of a material by Searle’s Apparatus - 9

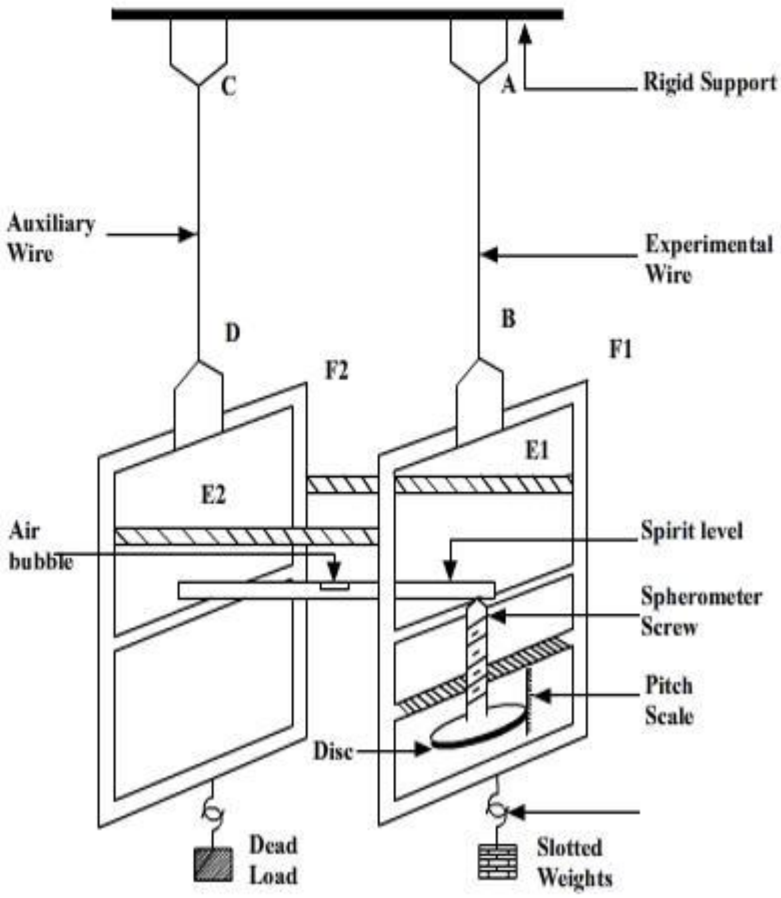
Objective: To find the Young’s modulus of elasticity of the material of a given wire using Searle’s apparatus.

Apparatus and Materials Required:

- Searle’s apparatus, Two long steel wires of same length and diameter, A metre scale, A set of 1/2 Kg slotted weights, 1 Kg weight hanger, 1 Kg dead load.

Theory

Searle’s apparatus: Searle’s apparatus consists of two metal frames F1 and F2 as shown in following figure. Each frame has a torsion head at the upper side and a hook at the lower side. These frames are suspended from two wires AB and CD of same material, length and cross-section. The upper ends of the wires are screwed tightly in two torsion heads fixed in the same rigid support. A spirit level rests horizontally with one end hinged in the frame F2. The other end of the spirit level rests on the tip of a spherometer screw, fitted in the frame F1. The spherometer screw can be rotated up and down along a vertical pitch scale marked in millimeters. The two frames are kept together by cross bars E1 and E 2.



Searle's apparatus works on the principle of Hooke's law. Hooke's law can be expressed in terms of stress and strain. Stress is the force on a unit area within a material that develops as a result of the externally applied force. Strain is the relative deformation produced by stress.

Hooke's Law

Hooke's Law states that within the limit of elasticity, stress applied is directly proportional to strain produced. That is, the extension produced in a wire is directly proportional to the load attached to it.

If a wire of length **L** and radius **r** be loaded by a weight **Mg** and if ***l*** is the extension produced,

$$Normal\,Stress = \frac{Mg}{\pi r^2} \qquad (1)$$

$$Longitudinal\,Strain = \frac{l}{L} \qquad (2)$$

Hence, Young's modulus

$$Y = \frac{Normal\,Stress}{Longitudinal\,Strain} \qquad (3)$$

$$Y = \frac{Mg / \pi r^2}{l / L}$$

$$Y = \frac{MgL}{\pi r^2 l}$$

Where, L– Length of the wire, l- Extension for a load M
r- Radius of the wire, g- Acceleration due to gravity

The Procedure

- Two wires of the same material, length and diameter have their ends tightened in torsion screws A,B, C and D as shown in Fig.
- Wire AB becomes the experimental wire and CD becomes the auxiliary wire.
- Suspend a 1 kg dead load from hook of frames F1 and F2.
- The weight hanger at F1 is loaded and unloaded 3 or 4 times, so that the experimental wire AB comes under elastic mood.
- Now, each wire has been loaded equally with 1 kg. The pitch and the least count of the spherometer are determined.

- The central screw is adjusted in such a way that the air bubble in the spirit level is exactly at the centre. The head scale reading of the spherometer is noted for zero weight in the weight hanger attached to the frame F1.
- A half kg of weight is now added to the weight hanger attached to the frame F1.
- The air bubble moves away from the centre. The spherometer screw is adjusted so that the air bubble comes back to the centre. The spherometer reading is noted.
- The load is increased in steps of half kg (maximum load should be less than the breaking stress) and the corresponding spherometer reading is noted.
- The same procedure is repeated for unloading the weights in steps of half kg. From these observations the extension, l for a load M can be determined.
- Young's modulus can be calculated using the equation (3)

Simulator Procedure (as performed through the Online Labs)

- Select the environment from the drop down list.
- Select the material of the wire from the drop down list.
- Change the radius of the wire using the slider.
- Change the length of the wire using the slider.
- Change the weight in the weight hanger using the slider.
- Once the weight has been added to the weight hanger, the bubble in the sprit level moved to its extreme end.
- Click on the right/left arrow button on the bottom right side to move the spherometer upward/downward to adjust the bubble to the center.
- Note down the number of rotations and fractional rotations from the spherometer and the value from the scale.
- Calculate the extension, l, of the wire form the values.
- Calculate the Young's modulus of the wire using the formula, $Y = MgL/\pi r^2 l$.
- To verify your result click on the 'Show result' check box.
- To redo the experiment, click on the 'Reset' button.

Observations:

To find the diameter of the wire using a screw gauge.

Distance moved by the screw for 4 rotations, x =………mm

Pitch of the screw, P =…………… mm

Number of divisions on the circular scale, N=................

Least Count (L.C) of the screw gauge = ……………………….mm

SN	PSR(mm)	HSR(div)	Total Reading=PSR+ HSR $\times$ L.C = mm
Mean Diameter, d			

Radius of the experimental wire, r = d/2 =............mm = ……x 10^{-3}m

Length of the experimental wire, L =………..cm =…………x10^{-2}m

Least count of Spherometer = 0.01 mm

SlNo	Load on hanger,M(kg)	Spherometer Screw reading			Extension,l for a loadM=2 kg(mm)
		On loading, x (mm)	On unloading,y(mm)	Mean, $z = \frac{x+y}{2}$ (mm)	
1	0				
2	.5				
3	1				
4	1.5				
5	2				z5-z1
6	2.5				z6-z2
7	3				z7-z3
8	3.5				z8-z4
Mean extension, l					

The Calculations :

Mean extension for 2 kg load, l = ……………x10^{-3} m

Load, M = 2 kg

Young's modulus,

$$Y = \frac{MgL}{\pi r^2 l}$$

= …………………………Nm^{-2}

Viva Voce:

Q1. What is Young's modulus?

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Q2. What is the property of a body by virtue of which it tends to regain its original size and shape by the removal of applied force is called?

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Q3. Out of (i) Shearing stress, (ii) Tensile Stress, (iii) Compressive Stress comes under the category of longitudinal stress?

____

____

Q4. When the density of a material increases, what will happen to its Young's modulus?

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Q5. The ratio of radius of two wires is 2:1. If the same force is applied to both of them, the extension produced is in the ratio 2:3. What will be the ratio of their lengths?

____