||JAI SRI GURUDEV||

# BGS SCIENCE ACADEMY

Agalagurki, Chickballapur – 562 101

# LABORATORY MANUAL

## B.Sc. PHYSICS

**For I – SEMESTER**

**Volume – 1**

**Paper -102**


**PREPARED BY TEAM OF PHYSICS DEPARTMENT**

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# EXPERIMENT : 1

## THERMISTER AS THERMOMETER - CALIBRATION

**Aim :** To Calibrate the given thermistor with standard thermistor , hence to find the temperature of the unknown liquid.

**Apparatus:** Thermistor , thermometer (0-110 ℃ range) ,multi-meter (200 Ohm's range)' Calorimeter , Water , unknown liquid.

**Principle:** The resistance of a thermistor increases with decreases in temperature has negative temperature co-efficient (α). The resistance varies exponentially with temperature.

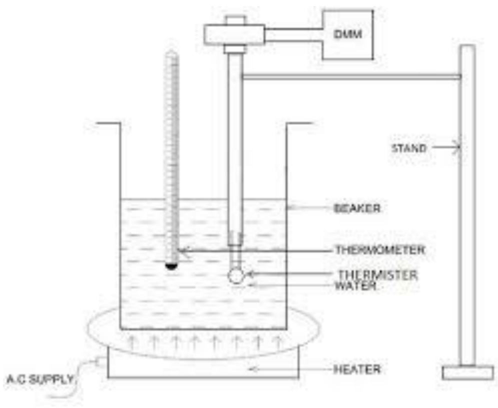
**Formula:** $\Omega\Delta R = \alpha\Delta t$

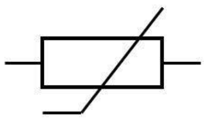
Where - $\Delta R$ is change in resistance (Ω),

$\Delta t$ is change in temperature ( ℃), and

α is temperature co-efficient of resistance of thermistor ( $℃^{-1}$).

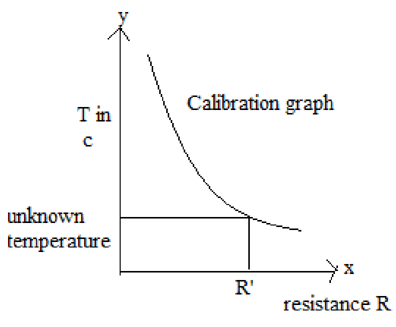
**Diagram:**



Thermistor symbol

**Expected Graph:**



**Procedure:** The experimental arrangement is made on shown in figure. Initial temperature of water in calorimeter is measured using 0-110 ℃ range thermometer and corresponding resistance in the multi-meter is recorded. The water is heated up to the thermometer of 85℃. The corresponding resister is noted using multi-meter. The values of temperature and respective resistance are tabulated for every fall in temperature reads 45℃. A graph of temperature, t (y-axis) versus R (x-axis) is plotted (Calibration graph). The thermistor is removed from the water and immersed in a liquid whose temperature is to be determined. The resistance ($R'$) for unknown liquid is noted,, and hence the temperature of unknown liquid is determined using calibration graph.

**Observation:** Initial Temperature of water: _____ ℃, corresponding resistance in the multi-meter: ___ ℃

**Tabular Column:**

| Temperature of water t in ℃ | Resistance of Thermistor R in Ω |
|---|---|
| 85 | |
| 80 | |
| 75 | |
| 70 | |
| 65 | |
| 60 | |
| 55 | |
| 50 | |
| 45 | |

**Calculations:**

The resistance ($R'$) for unknown liquid ________ Ω

The temperature of unknown liquid obtained from calibration graph is _____ ℃

**Result:** The given thermistor is calibrated with the standard mercury thermometer and calibration graph is plotted, Using which the temperature of unknown liquid is found to be _______ ℃

# EXPERIMENT : 2

## Study Of Thermocouple

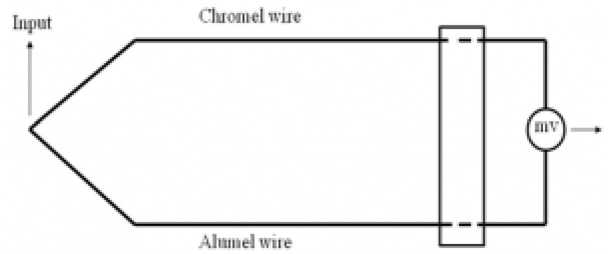
**Aim :** Analysis of thermo Emf in a Thermocouple.

**Apparatus:** Thermocouple, Thermometer, Millivoltmeter.

**Thermocouple :**

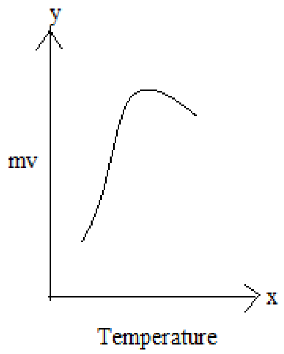
When a pair of electrical conductors (metals) are joined together, a thermal emf is generated when the junction are at different temperatures. This phenomenon is known as the Seekbeck effect. Such a device is called a thermocouple. The resultant emf developed by the thermocouple is in the milivolt range when the temperature difference b/w the junction is 100 ℃. To determine the emf of a thermocouple as a function of the temperatures, one junction is maintained at some constant reference temperature, such as ice-water mixture at a temperature of 0 ℃. The thermal emf, which can be measured by a digital voltmeter as shown in the figure 1, is proportional to the temperature difference b/w the two junctions. To calibrate such thermocouple the temperature of the second junction can be varied using a constant temperature bath and the emf recorded as a function of the temperature b/w difference b/w the two two nodes.

**Diagram:**




**Tabular Column:**

| SL.NO. | TEMPERATURE in $t^0c$ | Voltage (mv) |
|---|---|---|
| | | |
| | | |




## Main features of the kit

1. Inbuilt digital mill voltmeter 0-200 millivolts.
2. Inbuilt oven with separate on/ off switch.
3. Circuit diagram printed on the panel.
4. Copper constantan thermocouple is provided with special
5. Attachment and connecting leads.
6. A thermometer 0-100 ℃ is also provided.

## Procedure:

1. Place the thermocouple attachment carefully on the oven so that the junction of the thermocouple should so inside the hole of the oven properly.
2. Also place the thermometer inside the hole of the oven as shown in the Figure.
3. Connect the leads of thermocouple with the sockets of mollivoltmeter by taking care of proper polarity.
4. Switch on the instrument and also switch on the oven on/off switch.
5. Wait for some time till then the readings in the meter reaches the Maximum value and stops increasing.
6. Now switch off the oven on/off switch and records the readings in the table with decreasing value of temperature in the thermometer.
7. Plot the graph in temperature and millivolts.

**Result:** Temperature versus thermo emf is plotted & straight line in the graph shows that it obeys seeback effect

# EXPERIMENT : 3

## NEWTON'S LAW OF COOLING

**Aim :** To determine the specific heat of liquid by the method of cooling.

**Apparatus :** Calorimeter with an insulated box , thermometer , stop clock, physical balance , Weight box , Water and liquid.

**Principle:** Newton's law of cooling states that the rate at which heat is lost by radiation from a hot body is proportional to difference of Temperature b/w the hot body and the surrounding medium.

Amount of heat lost by a body temperature of $(\theta_2-\theta_1)$

**Formula:** Let $t_{water}$ and $t_{oil}$ be the time taken by water and oil of equal volume to fall the temperature from $\theta_2\,^0C$ to $\theta_1\,^0C$ under identical Conditions then.

$$\frac{[m1cc + (m2-m1)\ cw\ ]\ (\theta2-\theta1)}{t_1} = \frac{[m1cc + (m3-m1)\ coil\ ]\ (\theta2-\theta1)}{t_2}$$

Specific heat of liquid, $\left[\frac{\text{Coil= m1cc+m2}-\text{m1cw}}{m_3-m_1}\right]\frac{t_2}{t_1} - \frac{mc_1}{(m_3-m_1)}$

Where $C_c$= Specific heat of copper calorimeter in $Jkg^{-1}$= 386 $Jkg^{-1}k^{-1}$

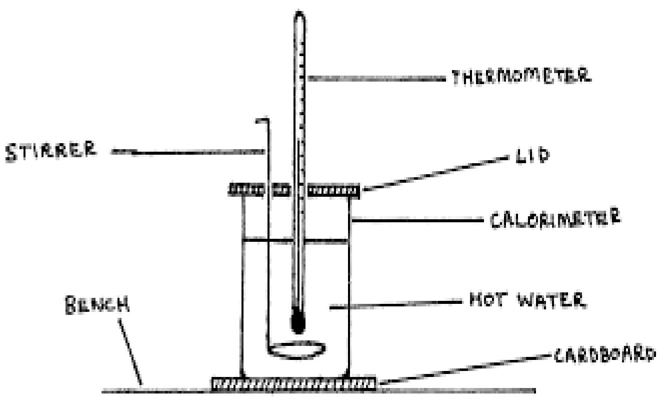
$C_w$= Specific heat of water= 4200 $Jkg^{-1}k^{-1}$

$m_1$= Mass of the calorimeter in kg

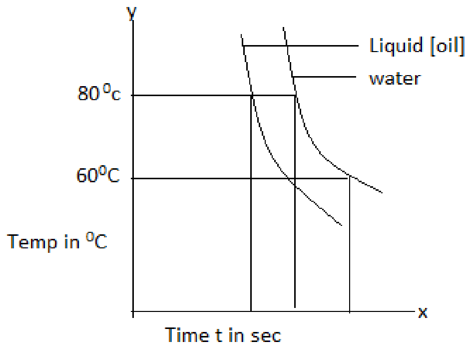
$m_2$= Mass of the calorimeter t mass of water in kg

$C_{oil}$= Specific heat of oil in $Jkg^{-1}k^{-1}$

**Diagram:**




**Graph:**




**PROCEDURE:** The mass of the empty copper calorimeter is found using a balance. A known volume of hot water at about 80 $^0$C is taken in the calorimeter and it is kept in the insulated water and time ($t_1$) is noted for every $^1/_2$ $^0$C fall the temperature till the temperature of water reaches 60$^0$C. The mass of the calorimeter with water ($m_2$) is weighed. Next the water is replaced by equal volume of hot oil. The thermometer is introduced into the oil and time ($t_2$) is noted for every $^1/_2$ $^0$C fall of temperature [ from 80 $^0$C to 60$^0$C ] The mass of calorimeter with oil ($m_3$) is weighed. The value of specific heat of oil ($c_{oil}$) is calculated by using formula.

**Observation:**

Mass of the empty calorimeter $m_1$ = ----------

Mass of the calorimeter + water m2 = --------

Mass of the calorimeter + oil m3 = ----------

Specific heat of copper calorimeter Cc= --------

Specific heat of water Cw = ------------

Time taken by water to fall the temperature from 86$^0$C to 60 $^0$C t1= -----------sec

Time taken to fall the temperature from 86$^0$C to 60 $^0$C t2 = ----------sec

**Calculation:**

**Result:** Specific heat of $c_{oil}$ = ----------- $Jkg^{-1}k^{-1}$-

# EXPERIMENT: 4

## VISCOSITY Of LIQUID

**Aim:** To determine the coefficient of viscosity of given liquid castor oil by storks method.

**Apparatus:** A long cylindrical glass tube, castor oil , stop clock, small steel balls of different radii, screw gauge, meter bridge.

**Formula:**

Co-efficient of viscosity of a liquid = $\eta = \frac{2}{9} g(\rho - \sigma)[\frac{r^2}{v}]_{mean}$ = ---------$NSm^{-1}$

Where,

g = is the acceleration due to gravity

$\rho$ = is the density of steel ( 7740 kg m )

σ = is the density of castor oil (960 kg m)

r = is the radius of the steel ball

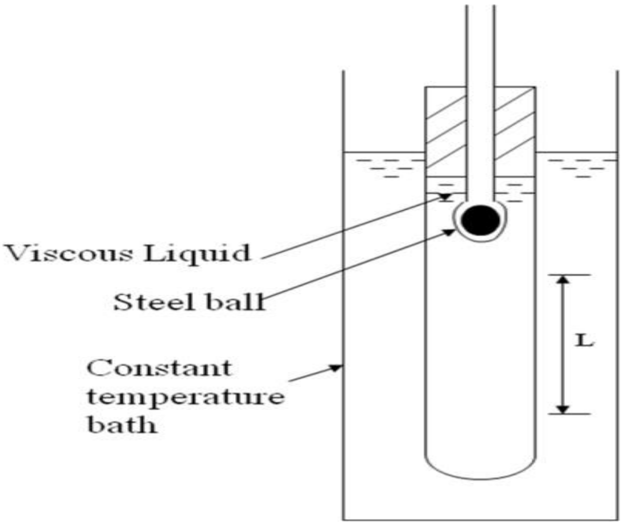
**Procedure:**

- The liquid where co-efficient viscosity is to be determined is taken in a tall and wide glass jar as shown in the figure. Two marks say x and y are drawn on the jar. The distance b/w them (1)is noted.
- A steel ball whose radius us already determined using a screw gauge is gently dropped into the jar. The time taken by the steel ball ( t) to travel the distance xy is found out using a stopwatch the terminal velocity of the ball is determined using the formula $v=\frac{l}{t}$
- The experiment is repeated for steel balls of different radii . The value of $[\frac{r^2}{v}]$ is calculated in each trial. The co-efficient of viscosity of the given liquid is calculated using the formula [1] mentioned.

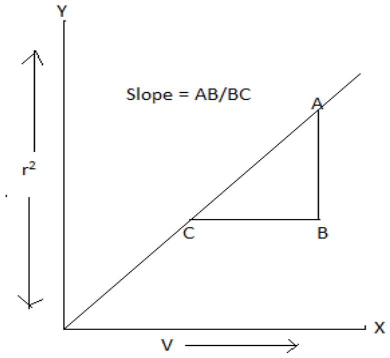
**Part-2 :**

- A graph of ($r^2$) versus (v) is drawn, the slope of the graph is determined. The value of co-efficient of viscosity is determined using the formula [2] mentioned above.

**Diagram:**




**Graph:**




**Part 1 :** Distance b/w the marks x & y (l) = _____m

**Part 2 : To determine the radius of the steel ball**

Zero error ZE= -2 divisions

Pitch $= \frac{Distance\ uncovered}{no.of\ rotation\ given} = \frac{1}{1} = 1mm$

Least count LC = $\frac{pitch}{no.of\ HSD} = \frac{1}{100} = 0.01mm$

Total reading TR = PSR+ [HSR-ZE] LC

**Tabular Column:**

| Ball no. | PSR mm | HSD div | Diameter of the ball TR in mm | Radius of the ball r = $\frac{d}{2}$ mm into $10^{-6}$ | Time taken (t)in sec | Terminal velocity v=$\frac{l}{t}$ $ms^{-1}$ $*10^{-2}$ | $[\frac{r^2}{v}]$ $*\frac{10^{-6}}{10^{-2}}$ |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |

**Calculation:**

**Result:** The value of co-efficient of viscosity of the given liquid is found to be

By Calculation η = ----------$NSm^{-2}$

By graph η = ----------$NSm^{-2}$

# EXPERIMENT: 5

## SURFACE TENTION AVD INTERFACIAL TENSION

**Aim:** To determine a) Surface tension of water,

b) The interfacial tension b/w water and kerosene by drop weight method.

**Apparatus:** A glass fitted with a rubber tube, glass tube, beaker, stand, stop clock, screw gauge, pinch cock.

**Formula:** a) Surface tension of water $T_1 = \frac{mg}{3.8R}$ ----$Nm^{-1}$

Where, m = average mass of one drop of water

R = external radius of glass tube

g = acceleration due to gravity

b) Interfacial Tension b/w kerosene water $T_2 = \frac{mg}{3.8R}[1-\frac{p_2}{p_1}]$ ----$Nm^{-1}$

Where, m = mass of one drop of water formed inside kerosene

g = acceleration due to gravity

R = external radius of glass tube

$P_1$ & $P_2$ = densities of water and kerosene

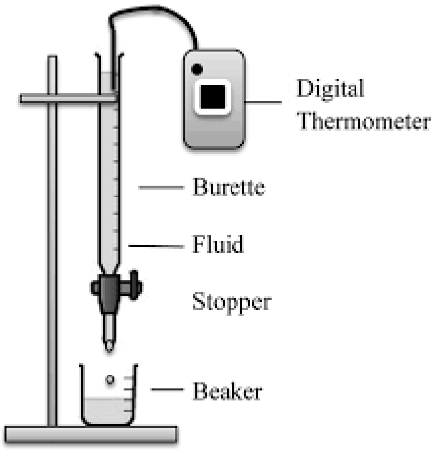
**Procedure:** **Part:1**

- The experimental arrangement is shown in the fig. (a). A beaker is arranged under the glass tube. The water is collected in the weighed beaker dropping from the funnel. The stop clock is adjusted to such that the liquid drops are formed slowly [8-10 drops per minute] A known mo. of drops are collected [ say 25 drops] in the beaker.
- The mass of the beaker with water is again found the difference gives the mass of 25 drops of water from this mass of each drops of water is calculated.
- The procedure is repeated and the average mass of m of single drop of water is calculated. Also the external radius of the glass tube is accurately determined using a screw gauge.
- The surface tension of water at laboratory temperature is calculated using formula (1) mentioned above .

**Part:2**

- The mass of the beaker with kerosene oil is found the beaker is placed below the glass tube such that water drops are formed inside the kerosene oil as shown in the fig (b)
- 25 drops of water is collected in the kerosene and the mass of each is determined. The experiment is repeated as before.
- The interfacial tension b/w water and erosene is calculated using formula (2)

**Diagram:**




**Observation:**

**Part-1: Radius of the glass tube (R)**

Zero error ZE = ------------

$$\text{pinch} = \frac{Distance\ uncovered}{No.of\ rotations\ given} = \frac{1}{2} = 1\text{mm}$$

$$\text{Least count LC} = \frac{pinch}{No.of\ HSD} = \frac{1}{100} = 0.01\text{mm}$$

Total reading TR= PSR + ( HSD -ZE ) LC

**Tabular Column**

| Trial no. | PSR mm | HSD in div | TR in (mm) |
|---|---|---|---|
| 1 | | | |
| 2 | | | |

$TR_{mean}$ = ------mm = --------× $10^{-3}$m

Here, mean radius R= ---------× $10^{-3}$m

**Part-2: To determine surface tension.**

1. Mass of empty beaker , $m_1$ = -----kg = -----× $10^{-3}$kg
2. Mass of beaker + 25 drops of water, $m_2$ = ----× $10^{-3}$kg
3. Mass of beaker + 50 drops of water, $m_3$ = -----× $10^{-3}$kg
4. Mass of the beaker + 75 drops of water = $m_4$---------× $10^{-3}$kg
5. Mean mass of 25 drops of water = -------× $10^{-3}$kg
6. Average mass of one drop of water m = ------- × $10^{-3}$kg

| Trail no. | Mass of 25 drops of water in kg |
|---|---|
| 1 | $M_2$-$M_1$ = |
| 2 | $M_3$-$M_2$ = |
| 3 | $M_4$-$M_3$ = |

**Part:3**

1. Mass of empty beaker + kerosene $m_1$= ------- × $10^{-3}$k
2. Mass of beaker + kerosene + 25 drops of water $m_2$= -------- × $10^{-3}$kg
3. Mass of beaker + kerosene + 50 drops of water $m_3$ = -------- × $10^{-3}$kg
4. Mass of the beaker + kerosene + 75 drops of water = $m_4$---------×$10^{-3}$kg
5. Mean mass of 25 drops of water = -------× $10^{-3}$kg
6. Average mass of one drop of water m = ------- × $10^{-3}$kg

**Tabular Column:**

| Trial no. | Mass of 25 drops of water in kg |
|---|---|
| 1 | $M_2$-$M_1$ = |
| 2 | $M_3$-$M_2$ = |
| 3 | $M_4$-$M_3$ = |

**Result :** The value of Surface tension of water = $T_1$ = --------

Interfacial tension b/w kerosene in water = $T_2$ = -----------$Nm^{-1}$

# EXPERIMENT : 6

## CONSERVATION OF ENERGY

**Aim :** To verify the law of conservation of energy in the gravitational field.

**Apparatus :** Inclined plain with a channel, metal sphere , cylindrical , disc , metal scale and stop watch

**Principle :** A body placed at the top of n inclined plane has potential energy to roll down the inclined plane . The potential energy gets converted into rotational kinetic energy and translational kinetic energy.

**Formula :** Potential energy = Rotational energy + Translational kinetic energy

$$\text{ie, } mgh = \frac{1}{2}mv2 + \frac{1}{2}Tw^2$$

where , h = height of the inclined plane in m,

v = Linear velocity of the body = s/t ms-1

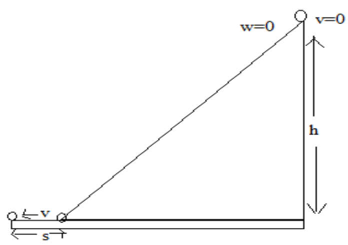
w = Angular velocity of the body = v/r rads-1

I = Moment of inertia of the rolling body about the axis of rotation in kgm2

g = Acceleration due to gravity in ms-2

**Procedure :** The mass (m) & radius (r) of the solid sphere are measured. The height (h) of the inclined Plane above the horizontal distance (s) from the foot of the inclined plane and end point of horizontal plane is measured , the solid sphere is allowed to roll down the inclined plane when the sphere reaches, the foot of the inclined plane , the time stop watch is started. The time (t) taken to cover the distance (s) is noted. The experiment is repeated for 3 trails and mean time is calculated. The linear speed v is calculated using relation, v = s/t The experiment is repeated with hallow sphere / cylinder / disc and also by changing the height (h) of the inclined plane. Readings are tabulated. The potential energy and kinetic energy are calculated.

**Diagram:**




**Observation:**

1. Determination of MI of solid sphere, hallow sphere/cylinder.

| Object | Mass m in Kg | Radius 'r' in m | MI about axis of rotation I in $Kgm^2$ |
|---|---|---|---|
| Solid sphere | | | $I=\frac{2}{5}mr^2$ |
| Hallow sphere | | | $I=\frac{2}{5}mr^2$ |
| Hallow cylinder | | | $I=\frac{1}{2}mr^2$ |

2. Determination of linear velocity (V) and angular velocity (w)

| Object | Distance travelled S in m | Time taken to travel the distance s in sec | | | | Linear velocity v=s/t in $ms^{-1}$ | Angular velocity w=v/r in $rads^{-1}$ |
|---|---|---|---|---|---|---|---|
| | | $t_1$ | $t_2$ | $t_3$ | Mean t in sec | | |
| Solid sphere | | | | | | | |
| Hallow sphere | | | | | | | |
| Hallow cylinder | | | | | | | |

3. Determination of PE translational KE and rotational KE

| Object | Height of inclined plane in m | PE= mgh in J | Rotational KE $E_R=\frac{1}{2}IW^2$ in J | Translational KE $E_f= \frac{1}{2}mv^2$ in J | PE= $E_R+E_f$ |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

**Result:** In all cases, it is observed potential energy= rotational Kinetic energy+ translational kinetic energy

The principle of conservation of energy is verified.

# EXPERIMENT : 7

## Dependence of the Period on the Amplitude of Oscillation

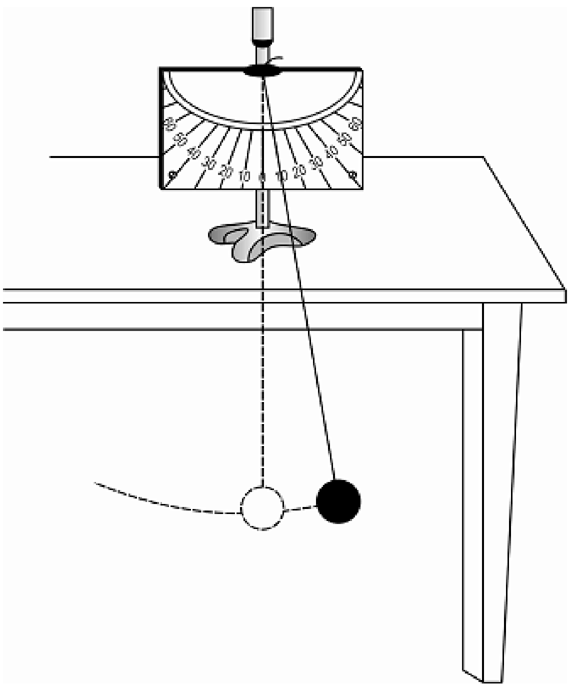
**Apparatus:** Bob, protractor, thread etc...

**Principle:**

In practice a simple pendulum is realized by suspending a heavy metallic bob from a rigid support by means of an ordinary string. It can freely oscillate to and fro about the point of suspension in a plane. The maximum displacement of the bob on either side of its equilibrium position is called the **amplitude** of oscillation. The time taken by the pendulum to complete one oscillation is called **time period**.

**Procedure:**

To study the effect of amplitude of oscillation on the period of the pendulum, we have to keep the length of the string and the mass of the bob constant in this part of the experiment. First, fix a protractor as shown in Fig. You may work with a length of about 1.5 m and in the beginning take the angular amplitude in the range 5°. This ensures simple harmonic motion (SHM). Note the time for 30 oscillations and record it in Observation Table. Repeat it at least three time and compute the period of oscillation. Compare your observations. Next, take larger angular amplitudes of say, 20°, 30°, 40°, 50° and 60° and determine the time period in each case.



## Observation Table: Variation of time period with angular amplitude & Period of a Pendulum

Number of complete oscillations counted each time (*N*) = 30

Length of the pendulum = ……………………………m

Time period **T=t/30**

| S.No. | Angular amplitude (degree) | Time for *N* (=30) oscillations (s) | | | | Time period (s) |
|---|---|---|---|---|---|---|
| | | (i) | (ii) | (iii) | (Mean) | |
| 1. | | | | | | |
| 2. | | | | | | |
| 3. | | | | | | |
| 4. | | | | | | |
| 5. | | | | | | |
| 6. | | | | | | |

### Result:

1. For small angular amplitudes, the period of the simple pendulum is………..s

2. For large angular amplitudes, the period of the simple pendulum is…………s

## **Experiment**:8

# FUNDAMENTALS

## VERNIER CALLIPERS

**Aim:** To measure diameter of a small spherical body.

**Apparatus** : Vernier callipers , Spherical Bob.

**Principle**: The magnitude of n vernier scale division is equal to the magnitude of (n-1) number of main scale division.

n V.S.D = (n-1) M.S.D

### (a) To measure the diameter of a small spherical

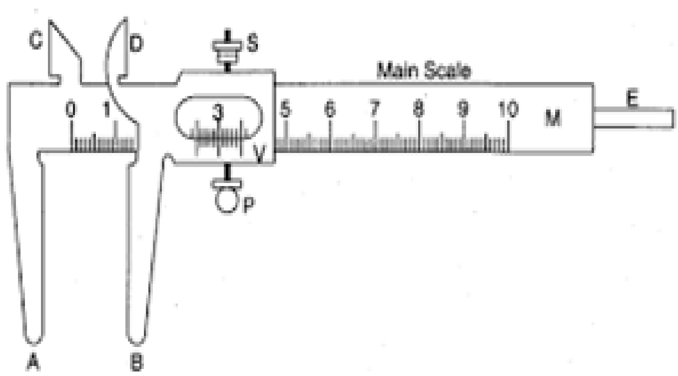
**Formula: 1**) Least Count = $\frac{value\ of\ 1\ MSD}{Total\ no.of\ VSD}$

2) TR=MSR+(CVD+LC)

Where, TR = Total Reading MSR = Main scale reading

CVD = Coinciding Vernier Division LC = Least Count

**Diagram:**




**Procedure :**

a) The least count and zero error of the callipers is found.

b) The Spherical body whose diameter D to be measured is held b/w the lower jaws of the Vernier callipers firmly.

c) When the lower jaws P and Q are in contact firmly. the position of the vernier zero with respect to main scale zero is noted. if the vernier zero coincides with the main scale zero there is no zero error. if not so, there is zero error. The zero error will be positive or negative based on whether the vernier scale zero lies either to right or the left of main scale zero.

The number (n) of the vernier scale division coinciding with some division of the main scale is noted. Then zero error (ZE) = n x LC

a) The Position of the vernier scale zero against the main scale is noted. Note down main scale reading (MSR) just to the left of vernier scale zero.

b) The number of particular vernier scale division with same division of the main scale is noted. This gives coinciding Vernier scale division(CVD).

c) The total reading calculated using the formula TR=MSR+(CVD X LC) this gives diameter.

d) The experiment is repeated for different positions of the object and readings are tabulated.

e) The mean diameter of the object is found

f) Zero error is subtracted from the mean diameter to get the corrected diameter D.

## **Observation :-**

value of 1 MSD = ----- cm
Total number of VSD = ____

$$LC = \frac{value\ of\ 1\ MSD}{Total\ no.of\ VSD} = \_\_\_ = \text{-----}\ cm$$

## **Tabular Column :**

| Object | Diameter | Trial no. | MSR in cm | CVD | TR in cm | Mean TR in cm |
|---|---|---|---|---|---|---|
| Spherical Ball | Diameter | 1 | | | | |
| | | 2 | | | | |
| | | 3 | | | | |

Mean TR = _________ cm

**Calculations:**

**Result:** Diameter D of the spherical body = _____cm = _______m

# Screw Gauge

**Aim:** Measure diameter of a given wire

**Apparatus:** wire, screw gauge.

**Principle:** The linear distance moved by the screw is directly proportional to the rotation given to the screw gauge.

**Formula:** **1)** TR=PSR+(HSR x LC)

TR= Total reading

PSR= Pitch scale reading

HSR= Head scale reading

LC = Least count

**2)** $LC = \frac{Pitch}{Total\ No.of\ head\ scale\ division}$

$$Pitch = \frac{Distance\ moved\ on\ the\ pitch\ scale}{No.of\ complete\ rotations\ given\ to\ the\ screw\ head}$$

**Procedure:**

a) A known number of rotations given to the screw head N, distance moved on the pitch scale is noted and pitch is calculated.
b) The total number of divisions on the head scale is noted.
c) Least Count is found.
**d)** When the studs A and B are in contact firmly, the position of the zero of the head scale observed. The number n of head scale division which are below or above the reference line of the pitch scale is counted. Then zero error **(ZE = ± n x LC).**
e) The given wire is firmly held between the two studs by rotating the screw head.

f) The number of divisions uncovered completely and pitch scale is noted as pitch scale reading PSR.
g) The number of head scale division which coincides with the reference line of pitch scale is noted as head scale reading HSR.
h) The total reading is calculated using the formula TR= PSR+(HSR x LC) which gives diameter of the wire
i) .The experiment is repeated for different position of the wire and the reading are tabulated.
j) The mean diameter of the wire is found.
k) The zero error subtracted from mean diameter to get corrected value of the wire.

## Diagram:

## Observation

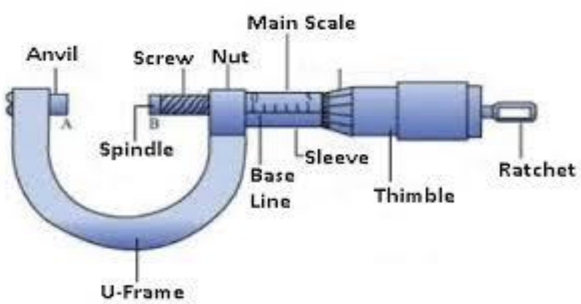
Pitch = $\frac{Distance\ moved\ on\ the\ pitch\ scale}{No.of\ complete\ rotations\ given\ to\ the\ screw\ head}$

Pitch = ------ = ___mm

Total number of divisions on head scale = ______

LC = $\frac{Pitch}{Total\ No.of\ head\ scale\ division}$

LC= ------ = ____mm



## Tabular column:

| Object | Dimension | Trial No | PSR in mm | HSR | TR in mm | Mean TR in mm |
|---|---|---|---|---|---|---|
| Wire | Diameter | 1 | | | | |
| | | 2 | | | | |
| | | 3 | | | | |

Mean diameter = _____mm

Corrected diameter (D) = Mean diameter - ZE

= ------- mm = ------- m

## Calculation:

**Result:** The diameter of the given wire as measured by the screw gauge

= ____mm _____m

## **<u>Experiment</u>: 9**

# Work Done By a Variable Force

**Aim:** To determine the work done on the spring by a variable force bringing about an extension of the spring.

**Apparatus:** Spring , Stand , Scale pan , Weights , Scale. **Principle:** Consider a vertical spring hang vertically with one end rigidly clamped when a force $\vec{F}$ is applied at the free end it produces an extension $\vec{e}$ when the spring is in equilibrium , an internal spring force Fs comes into play , Which balances within the limits of elasticity.

Where K is the spring constant

$$\vec{F} \,\alpha\, \vec{e}$$

or $\vec{F} = -K\vec{e}$ , Where K is the spring constant

In equilibrium

$$|\vec{F_s}| = |\vec{F}| = K\vec{e}$$

The workdone by the applied force in strecting the spring from an extension $e_1$ to $e_2$ is given by ,

$$W = \int_{e_1}^{e_2} F.de = \int_{e_1}^{e_2} Kede = {}^{1}/_{2}\, \mathrm{K}\ ( e_2{}^2 - e_1{}^2)$$

If we measure 'e' for variable values of , then workdone can be calculated by the area under the F-e curve ,

**Formula:**

$$W = {}^{1}/_{2}\ \mathrm{K}\ ( e_2{}^2 - e_1{}^2)\text{.........J}$$

Where,

W = Workdone is extending spring from $e_1$to $e_2$ in Joules

K= is the spring constant in Nm and =

slope of the straight line = $\frac{y}{\lambda}$= $\frac{AB}{BC}$= ……

$e_1$and $e_2$ is the extension of the spring.

**Procedure:**

- The upper end of the spring is fixed to a stand and is suspended vertically.
- The spring is extended by hanging a load from the free end (say 100gm) [pan + weight]
- The scale reading from the top of the spring to the pointer $x=x_0$ is measured using the scale as shown in the figure.
- The mass in the scale pan is increased in steps of 20gm (0.02kg) up to 0.3kg and the corresponding scale reading x are measured and recorded in the tabular column.
- The average value of x is calculated each time, for load increased and load decreasing.
- The corresponding stretched force F=mg and the corresponding extension of the spring $e=x-x_0$ are calculated and tabulated.
- A graph of F along y-axis and e along x-axis is plotted we get a straight line passing through the origin.
- The work done on the spring is bringing about an extension from $e_1$ to $e_2$ when the stretching force increases from $F_1$ to $F_2$ is given by the area under the curve.
- The slope of the graph gives K, the spring's constant. The work done in bringing about an extension of the spring from $e_1$ to $e_2$ is given by the formula.

$$\int W = \frac{1}{2} K\ (e_2{}^2 - e_1{}^2)$$

**Tabular Column:**

| Trial No | Mass in scale pan(Kg)m | Scale reading of the pointer in m | | Mean $x = \frac{x_1+x_2}{2}$ m | Stretching force F=mg (N) 9.8 | Extension e =($x_1$-$x_0$) m |
|---|---|---|---|---|---|---|
| | | Load increasing $X_1 x10^{-2}$ | Load decreasing $X_2 x10^{-2}$ | | | |
| 1 | W=0 | | | | | |
| 2 | W+ | | | | | |
| 3 | W+ | | | | | |
| 4 | W+ | | | | | |
| 5 | W+ | | | | | |
| 6 | W+ | | | | | |
| 7 | W+ | | | | | |

**Calculation:**

$W = {}^1/_2$ K ( $e_2{}^2$-$e_1{}^2$).........J

Graph:

$W = \frac{1}{2}(F_1+F_2)\ (e_2-e_1)$

**Result:**

The work on the spring in bring about an extension from
$e_1$=……… to $e_2$………..
W=…………..J (from graph)
W=…………..x$10^{-2}$J (from formula)

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