Saraswati

LAB MANUAL

PHYSICS

11

NEW SARASWATI HOUSE

Strictly in accordance with the latest core syllabus

Saraswati

LAB MANUAL
PHYSICS

For Class XI

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SYLLABUS

The record, to be submitted by the students, at the time of their annual examination, has to include

- Record of at least 15 experiments [with a minimum of 6 from each section], to be performed by the students.
- Record of at least 5 Activities [with a minimum of 2 each from Section A and Section B], to be demonstrated by the teachers.
- Report of the project to be carried out by the students.

Evaluation Scheme

Two experiments one from each section	8+8 Marks
Practical record (experiments and activities)	6 Marks
Investigatory Project	3 Marks
Viva on Experiments, Activities and Project	5 Marks
	30 Marks

SECTION A

Experiments

1. To measure diameter of a small spherical/cylindrical body and to measure internal diameter and depth of a given beaker/calorimeter using Vernier Callipers and hence find its volume.
2. To measure diameter of a given wire and thickness of a given sheet using screw gauge.
3. To measure volume of an irregular lamina using screw gauge.
4. To determine radius of curvature of a given spherical surface by a spherometer.
5. To determine the mass of two different objects using a beam balance.
6. To find the weight of a given body using parallelogram law of vectors.
7. Using a simple pendulum, plot $L\text{-}T^2$ graph and use it to find the effective length of second's pendulum.
8. To study variation of time period of a simple pendulum of a given length by taking bobs of same size but different masses and interpret the result.
9. To study the relationship between force of limiting friction and normal reaction and to find the co-efficient of friction between a block and a horizontal surface.
10. To find the downward force, along an inclined plane, acting on a roller due to gravitational pull of the earth and study its relationship with the angle of inclination (θ) by plotting graph between force and $\sin\theta$.

Activities

(For the purpose of demonstration only)

1. To make a paper scale of given least count, *e.g.,* 0.2 cm, 0.5 cm.
2. To determine mass of a given body using a metre scale by principle of moments.
3. To plot a graph for a given set of data, with proper choice of scales and error bars.
4. To measure the force of limiting friction for rolling of a roller on a horizontal plane.
5. To study the variation in range of a Projectile with angle of projection.
6. To study the conservation of energy of a ball rolling down on inclined plane (using a double inclined plane).
7. To study dissipation of energy of a simple pendulum by plotting a graph between square of amplitude and time.

SECTION B

Experiments

1. To determine Young's modulus of elasticity of the material of a given wire.
2. To find the force constant of a helical spring by plotting a graph between load and extension.
3. To study the variation in volume with pressure for a sample of air at constant temperature by plotting graphs between P and V, and between P and 1/V.
4. To determine the surface tension of water by capillary rise method.
5. To determine the coefficient of viscosity of a given viscous liquid by measuring terminal velocity of a given spherical body.

6. To study the relationship between the temperature of a hot body and time by plotting a cooling curve.
7. To determine specific heat capacity of a given solid by method of mixtures.
8. To study the relation between frequency and length of a given wire under constant tension using sonometer.
9. To study the relation between the length of a given wire and tension for constant frequency using sonometer.
10. To find the speed of sound in air at room temperature using a resonance tube by two-resonance positions.

Activities

(For the purpose of demonstration only)

1. To observe change of state and plot a cooling curve for molten wax.
2. To observe and explain the effect of heating on a bi-metallic strip.
3. To note the change in level of liquid in a container on heating and interpret the observations.
4. To study the effect of detergent on surface tension of water by observing capillary rise.
5. To study the factors affecting the rate of loss of heat of a liquid.
6. To study the effect of load on depression of a suitably clamped metre scale loaded (*i*) at its end (*ii*) in the middle.
7. To observe the decrease in pressure with increase in velocity of a fluid.

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SECTION B

SECTION-A

1. MEASUREMENT OF LENGTH

INTRODUCTION AND DEFINITIONS

Length is an elementary physical quantity. The length of an object can be measured up to an accuracy of 1 mm by a metre scale because the length of the smallest division made on the metre scale is 1 mm. This is called the least count of the metre scale, *i.e.,* least count of a metre scale is 1 mm.

Metre. The standard metre is defined as the distance which contains 1650763.73 wavelengths of orange-red light of krypton ($_{36}Kr^{86}$) source kept at the temperature of triple point of nitrogen (at the temperature of 63.18 K and at the pressure of 0.125×10^5 Nm^{-2}).

The simplest instrument used in the laboratory for measuring the small lengths is wooden metre scale. One can accurately measure only up to 1 mm with the help of metre scale.

While taking an observation with metre scale, some important precautions must be kept in the mind to avoid certain errors which arise due to wrong use of the metre scale:

1. The metre scale should be kept along the length of the object. The scale should never be inclined, inclined scale gives more length.
2. The edge of the object whose length is to be measured should coincide with a fixed mark on the scale.
3. The measurement should not be taken from zero mark of the scale because the edge of the scale is generally worn out.
4. The observation should be taken keeping one eye closed and the other eye directly over the mark. Observation with an inclined eye will be wrong due to the error of parallax. (See Fig. 1)
5. Now without disturbing the metre scale and the object move your eye to the other edge of the object and again take the observation. The difference between these two observations (readings) will give the actual length of the object.

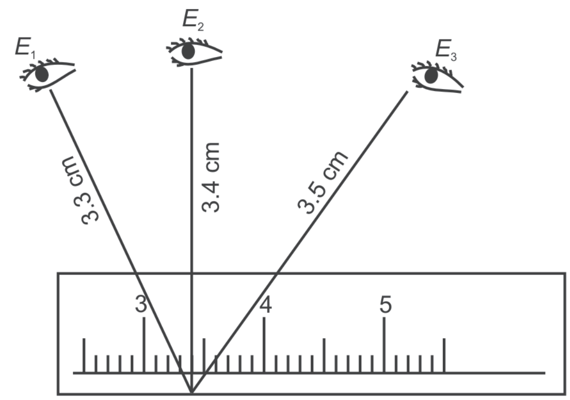

Fig. 1. Readings E_1 and E_3 are incorrect but E_2 is correct

To measure smaller length accurately up to $\left(\frac{1}{100}\right)$th or $\left(\frac{1}{1000}\right)$th of a centimetre the following instruments are used in the laboratory:

1. Vernier Callipers
2. Screw Gauge
3. Spherometer

VERNIER CALLIPERS

Vernier callipers was designed by a French mathematician Pierre Vernier which can accurately measure upto $\left(\frac{1}{100}\right)$th of a centimetre.

It consists of a main scale M and vernier scale V. The main scale M is fixed while vernier scale V slides along the main scale M as shown in Fig. 2. vernier scale is also known as auxiliary scale.

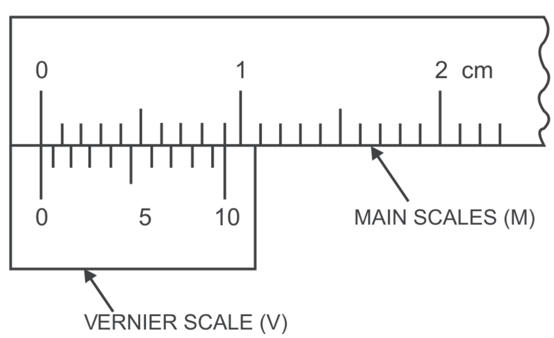

Fig. 2. Principle of Vernier Callipers

PRINCIPLE OF A VERNIER CALLIPERS

The difference between the values of one main scale division and one vernier scale division is called Vernier constant (V.C.).

Let us consider that n vernier scale divisions coincide with $(n - 1)$ main scale divisions. Hence n vernier scale divisions (V.S.D.) = $(n - 1)$ main scale divisions (M.S.D.)

or $$n \text{ V.S.D.} = (n-1) \text{ M.S.D.}$$

$$1 \text{ V.S.D.} = \frac{(n-1)}{n} \text{ M.S.D.}$$

By the definition of Vernier constant, we have Vernier constant (V.C.) = 1 M.S.D. – 1 V.S.D.

$$\text{V.C.} = 1 \text{ M.S.D.} - \frac{(n-1)}{n} \text{ M.S.D.}$$

$$\text{V.C.} = \left[1 - \left(\frac{n-1}{n}\right)\right] \text{ M.S.D.}$$

$$\text{V.C.} = \left(\frac{1}{n}\right) \text{ M.S.D.}$$

$$\text{V.C.} = \frac{\text{Value of smallest division on main scale}}{\text{Total no. of divisions on the vernier scale}}$$

The V.C. of an instrument always remains constant. The V.C. of the instrument gives the smallest length that can accurately be measured with the help of the instrument. The smallest value of a physical quantity which can be measured accurately with the instrument is called the least count (L.C.) of the instrument. In case of Vernier Callipers, Vernier constant is the least count of the Vernier Callipers.

VERNIER CONSTANT OF COMMONLY USED INSTRUMENTS

1. Vernier Callipers

In ordinary Vernier Callipers, we have value of one main scale division, *i.e.,*

$$1 \text{ M.S.D.} = 1 \text{ mm.}$$

Also $$10 \text{ V.S.D.} = 9 \text{ M.S.D.} \quad \text{or} \quad 1 \text{ V.S.D.} = \frac{9}{10} \text{ M.S.D.}$$

$$\text{V.C.} = 1 \text{ M.S.D.} - 1 \text{ V.S.D.} = 1 \text{ M.S.D.} - \frac{9}{10} \text{ M.S.D.}$$

$$= \left(1 - \frac{9}{10}\right). 1 \text{ M.S.D.} = \frac{1}{10}.1 \text{ M.S.D.} = \frac{1 \text{ mm}}{10} \qquad [1 \text{ M.S.D.} = 1 \text{ mm}]$$

$$\text{V.C.} = 0.1 \text{ mm} = 0.01 \text{ cm}$$

2. Vernier constant of Fortin's Barometer

In Fortin's barometer, 1 M.S.D. = 1 mm

$$20 \text{ V.S.D.} = 19 \text{ M.S.D.} \quad \text{or} \quad 1 \text{ V.S.D.} = \frac{19}{20} \text{ M.S.D.}$$

$$\text{V.C.} = 1 \text{ M.S.D.} - 1 \text{ V.S.D.} = 1 \text{ M.S.D.} - \frac{19}{20} \text{ M.S.D.} = \left(1 - \frac{19}{20}\right) \text{ M.S.D.}$$

$$= \frac{1}{20} \text{ M.S.D.} = \frac{1}{20} \text{ mm} \qquad [1 \text{ M.S.D.} = 1 \text{ mm}]$$

$$\text{V.C.} = 0.05 \text{ mm} = 0.005 \text{ cm}$$

3. **Vernier constant of Travelling Microscope**

In travelling microscope, 1 M.S.D. = 0.5 mm

$$50 \text{ V.S.D.} = 49 \text{ M.S.D.} \quad \text{or} \quad 1 \text{ V.S.D.} = \frac{49}{50} \text{ M.S.D.}$$

$$\text{V.C.} = 1 \text{ M.S.D.} - 1 \text{ V.S.D.} = 1 \text{ M.S.D.} - \frac{49}{50} \text{ M.S.D.} = \left(1 - \frac{49}{50}\right) \text{M.S.D.}$$

$$= \frac{1}{50} \text{ M.S.D.} = \frac{0.5}{50} \text{ mm} \qquad [1 \text{ M.S.D.} = 0.5 \text{ mm}]$$

$$\text{V.C.} = 0.01 \text{ mm} = 0.001 \text{ cm}$$

READING A VERNIER SCALE

Let Vernier constant of the Vernier callipers is 0.01 cm. It has 10 divisions on vernier scale and value of one main scale division (1 M.S.D.) is 1 mm. We want to measure a length AB. The A is coinciding with zero of main scale and B is coinciding with zero of vernier scale (Fig. 3).

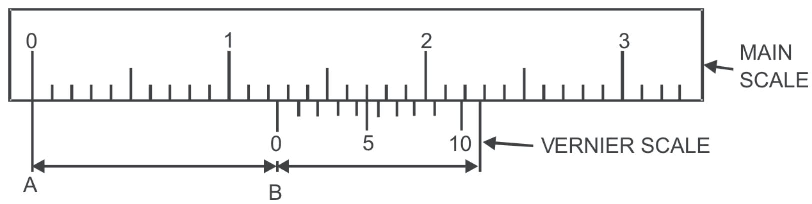

Fig. 3. Reading of a Vernier scale

From Fig. 3 it is clear that length AB is between 1.2 cm and 1.3 cm as the zero of vernier scale is between 1.2 cm and 1.3 cm. The enlarged view of Fig. 3 is shown in Fig. 4.

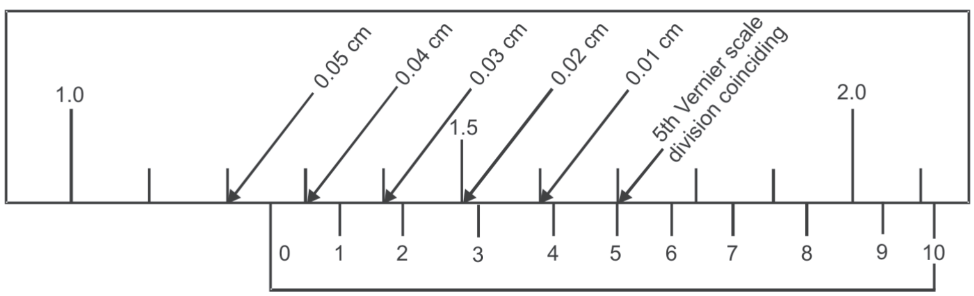

Fig. 4. Reading of a vernier scale with 5th division coinciding

Let 5th division of vernier scale is exactly coinciding with some division of the main scale. Therefore AB can be given as

$$\text{AB} = 1.2 \text{ cm} + 5 \times (\text{V.C.})$$

$$= 1.2 \text{ cm} + 5 \times 0.01 \text{ cm}$$

$$\text{AB} = 1.25 \text{ cm}$$

The vernier scale reading can be taken as:

1. First take the main scale reading (N) before on the left of zero of the vernier scale.
2. Find out which number (n) of vernier scale division is exactly coinciding with any of the main scale division.
3. Now multiply n with Vernier constant (V.C.).
4. The required length of the object is = $N + n \times$ V.C.

CONSTRUCTION AND WORKING OF VERNIER CALLIPERS

The main parts of the Vernier Callipers are:

1. **Main scale.** The main scale M of Vernier Callipers is made of steel. It is graduated in mm and cm on one side and inches and tenth of an inch on the other side.

2. **Vernier scale.** The Vernier scale V slides along the main scale M. It can be fixed at any position with the help of the screw S. Vernier scale has ten equal divisions. Ten divisions of the Vernier scale are equal to nine divisions of the main scale.
3. **Movable jaws.** It has two jaws AB and CD projected at right angle to the main scale. These two jaws are called movable jaws. The jaws A and C are used to measure the internal diameter of a hollow object, while jaws B and D are used to measure the lengths or diameters of objects that are gripped between them.

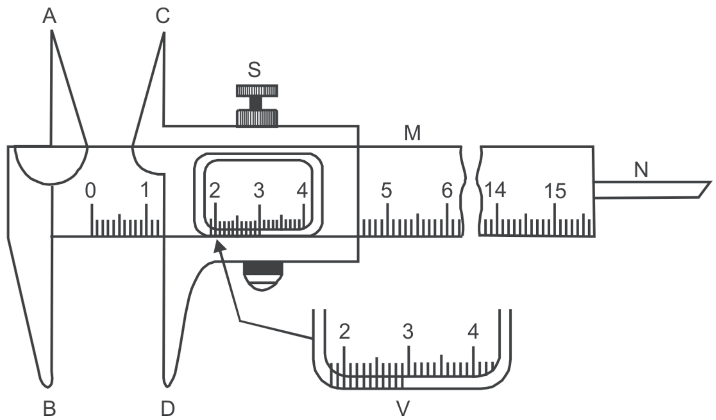

Fig. 5. Vernier Callipers

4. **Strip.** The strip N is attached to the vernier scale. This strip is used to measure the depths of the hollow objects.

WORKING OF A VERNIER CALLIPERS

Before taking the reading from the Vernier Callipers, one should know the Vernier constant (V.C.) of the Vernier Callipers which has been already discussed in the previous articles. After determination of Vernier constant, the zero error is determined.

Zero error. When the jaws AB and CD are made to touch each other, and if the zero mark of vernier scale exactly coincides with the zero mark of the main scale, then in this situation the instrument is free from any error. In other words the instrument has no zero error. This is shown in Fig. 6.

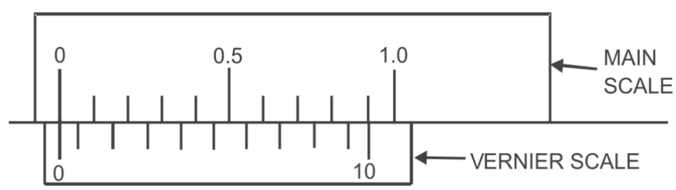

Fig. 6. Zero error nil

However when we use the Vernier Callipers, due to the wear and tear of the jaws there may be some manufacturing defect, when the jaws AB and CD are made to touch each other, the zero mark of the vernier scale may not be in the same straight line with the zero mark of the main scale. This situation gives rise to an error which is called zero error. Zero error is always algebraically subtracted from the observed reading. Zero error is of two types:

1. Positive zero error.
2. Negative zero error.

1. **Positive zero error.** Zero error is positive when zero of vernier scale lies to the right of the zero of the main scale, when jaws AB and CD are made to touch each other. To find out the zero error read the main scale reading (N) on the left of the zero of the vernier scale and note down which number of vernier scale division (n) is coinciding with any main scale division. In Fig. 7, we have

Main scale reading (N) = 0.0 cm

No. of vernier scale division coinciding (n) = 3

Zero error = 0.0 + 3 × (V.C.)

= 0.0 + 3 × 0.01 cm

= + 0.03 cm

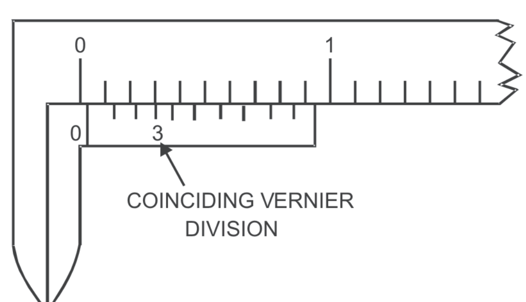

Fig. 7. Positive zero error

This error is algebraically subtracted from the observed reading to get the corrected reading.

Corrected reading = Observed reading – Zero error

= Observed reading – 0.03 cm.

2. **Negative zero error.** If the zero mark of the vernier scale is slightly on the left of the zero mark on the main scale when two jaws AB and CD are made to touch with each other, the zero error is negative. It is shown in Fig. 8.

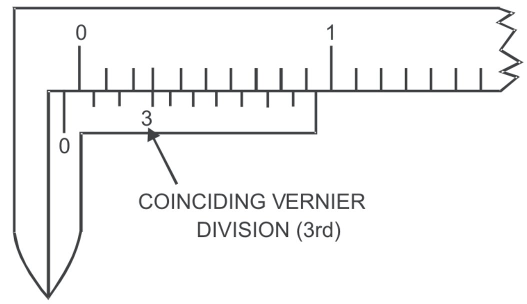

Fig. 8. Negative zero error

To determine the negative zero error, again read the main scale reading (N) and note down which number of vernier scale division (n) is coinciding with any main scale division.

In case of negative zero error, the number of vernier scale division (n) coinciding with the main scale division is subtracted from total number of divisions on the vernier scale and then this difference is multiplied by the Vernier constant (V.C.). In Fig. 8 we have:

Main scale reading (N) = 0.0 cm

No. of vernier scale division coinciding = (n) = 3

$$\text{Zero error} = 0.0 \text{ cm} - (10 - 3) \times \text{V.C.}$$
$$= 0.0 \text{ cm} - (10 - 3) \times 0.01 \text{ cm}$$
$$= -\,0.07 \text{ cm}$$

Corrected reading = Observed reading – Zero error
= Observed reading – (– 0.07 cm)
= Observed reading + 0.07 cm.

MEASUREMENT BY VERNIER CALLIPERS

The object whose length or diameter is to be measured is placed between two jaws B and D. The movable jaw is adjusted till it gently touches the object. Let x cm be the reading of the main scale and n the number of vernier scale division coinciding with any of the main scale division, then the observed reading is

$$\text{Observed reading} = x \text{ cm} + n \times (\text{V.C.})$$

To obtain corrected reading, the zero error with its proper sign is subtracted from the observed reading.

EXPERIMENT 1

AIM

To measure the diameter of a small spherical/cylindrical body and to measure internal diameter and depth of a given beaker/calorimeter using Vernier callipers and hence find its volume.

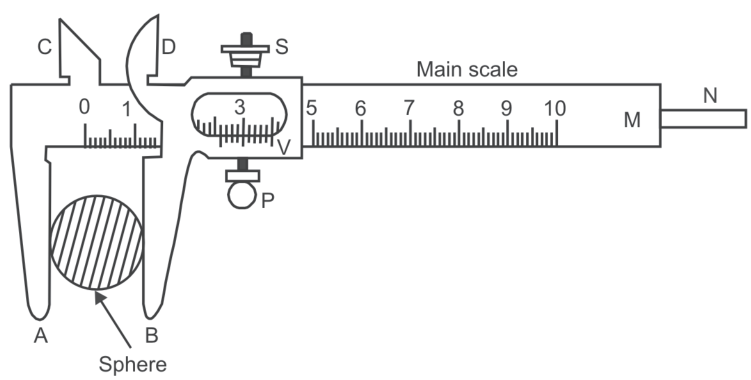

Fig. 9. Vernier callipers, measuring diameter of a sphere

YOU NEED

1. Vernier callipers 2. Spherical body (pendulum bob) or a cylinder. 3. A beaker or a calorimeter.

THEORY

When the body is placed between the two jaws A and B, the main scale reading is x and if n is the number of vernier scale division coinciding, then the observed reading is given as

Observed reading = $x + n$ (V.C.)

Volume of beaker or calorimeter = V = Internal area of cross-section × Depth

$$V = \pi\left(\frac{d}{2}\right)^2 \times h \qquad \text{or} \qquad V = \frac{\pi d^2 h}{4}$$

where d is the internal diameter of beaker or calorimeter, and
h is the depth of beaker or calorimeter.

HOW TO DO

(*a*) Measurement of Diameter of a Cylinder or Sphere

1. Determine the Vernier constant (V.C.) of the Vernier Callipers as discussed earlier.
2. Bring the movable jaw BD in close contact with the fixed jaw AC and determine the zero error. Take atleast three readings. Record the zero error. If there is no zero error, then record zero error nil.
3. Place the sphere or cylinder between the two jaws AC and BD, and adjust the jaw BD so that it gently grips the body between the two jaws. Now tight the screw S attached to the vernier scale V.
4. Take the main scale reading, *i.e.,* note the position of zero mark of the vernier scale V on main scale. For this record the main scale reading just before the zero mark of the vernier scale. This reading x is called main scale reading (M.S.R.).
5. Note the number of vernier scale division (n) which coincides with some division of the main scale. The coinciding number is to be counted from the zero end of vernier scale.
6. Find the product of n and V.C., y which is called vernier scale reading (V.S.R.). Add V.S.R. and M.S.R. to obtain diameter of the sphere or cylindrical object.
7. Repeat the observations for the diameter at least three times, for three different positions of the sphere or cylinder. Record the observation in the table.
8. To obtain the corrected diameter, subtract the zero error algebraically from the observed diameter.

(*b*) Measurement of Internal Diameter

9. Insert the jaws P and Q (Fig. 10) in the interior of calorimeter and adjust the position of movable jaw so that P and Q touch the walls of the calorimeter gently. Tight the screw S attached to the vernier scale.
10. Note the position of the zero of the vernier scale on the main scale. This reading is called main scale reading (x).
11. Note the number of vernier scale division (n) which is coinciding with some division of the main scale.
12. Repeat the observations for internal diameter three times by changing the position of the calorimeter and record the observations.

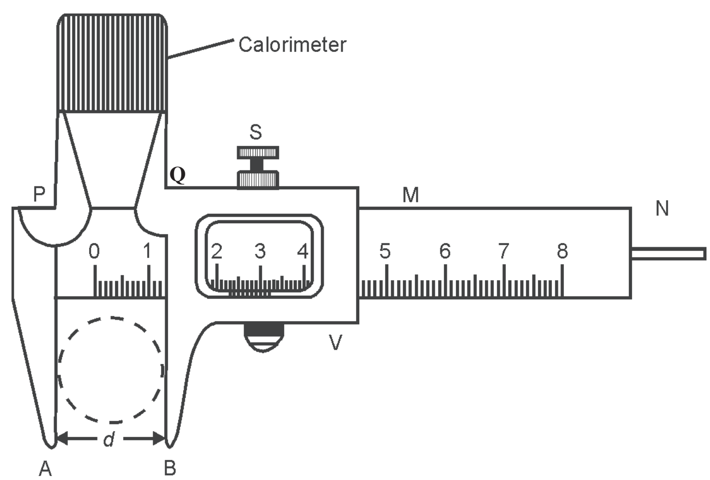

Fig. 10. Measurement of internal diameter of a calorimeter

13. Find the corrected mean value of internal diameter by applying the zero error.

(*c*) Measurement of Depth

14. To measure the depth of the calorimeter, use strip N of the Vernier Callipers.
15. Keep the edge of main scale of Vernier Callipers on the upper edge of the calorimeter so that strip N is able to go inside the calorimeter along its length as shown in Fig. 10.
16. Now move the sliding jaw till the end of the strip N touches the bottom of the calorimeter gently.
17. To get correct depth repeat the steps 10 to 13 at the four different positions along the circumference of the upper edge of the calorimeter.

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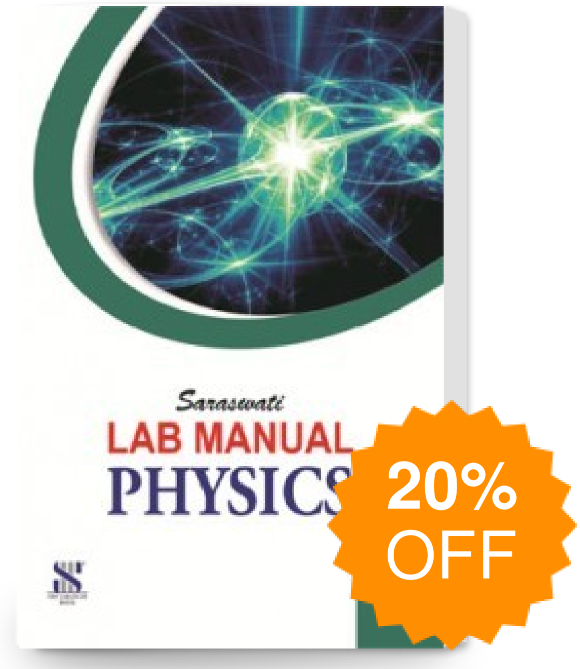

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