SECTION - A

EXPERIMENT

AIM

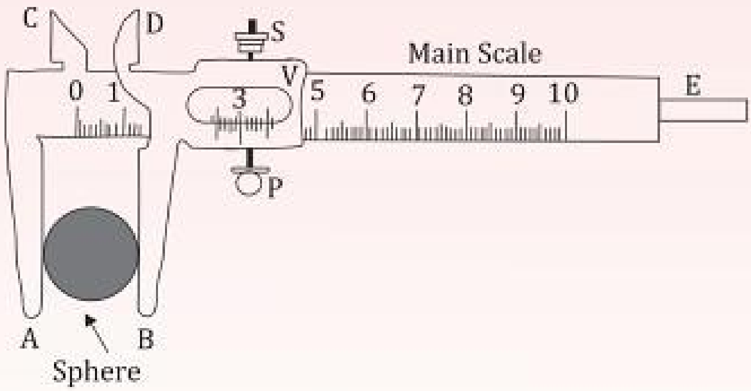
To measure the diameter of a small spherical/cylindrical body using Vernier caliper.

MATERIAL REQUIRED

Vernier Calliper, a small spherical body (say a bob) or a small cylindrical body (say a metallic cylinder), magnifying glass.

DIAGRAM

When the jaws on the main scale and the Vernier scale touch each other, the zero mark on the Vernier scale is in front of the zero mark on the main scale. Now you will notice that 10 divisions on the Vernier scale correspond to the 9 divisions on the main scale.



Thus, one division on the Vernier scale corresponds to $\frac{9}{10}$ mm or 0.9 mm, ie., the difference in the distance between two adjacent marks on the main scale and those on the Vernier scale is 1-0.9 = 0.1 mm which is the distance between the one division on the main scale and one division on the Vernier scale. This shows that the separation between the jaws on the main scale and the Vernier scale is 0.1 mm. It is the Vernier constant that can be measured with a precision of 0.1 mm.

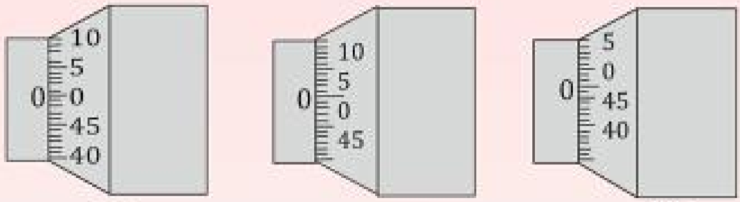
THEORY

To measure the length of a cricket pitch, length, breadth, and height of your classroom, etc. you use a meter scale. It is graduated in millimeters and centimeters. On the meter scale, the smallest division is one millimeter which is called the least count of the meter scale. With the help of the meter scale neither you can measure lengths less than 1 mm nor lengths with a precision of more than 1 mm. To measure the diameter (inner or outer) of a cylinder, a simple device called a caliper is used along with a meter scale as shown in Figure. French inventor Pierre Vernier (1580-1637) suggested the use of a small auxiliary scale (called Vernier scale) sliding along the main scale which measures length up to an accuracy of 0.1 mm. The smallest value of a physical quantity that can be measured accurately using an instrument is called the least count of the measuring instrument. Here the least count of small scale or a wooden meter scale available in the laboratory is 1 mm (or 0.1 cm). With the help of a protractor, you can measure the smallest angle of 1 degree. Therefore, the least count of a protractor is 1 degree. Similarly, you can find out the least count of a wristwatch, thermometer, etc.

ZERO ERROR

When the fixed stud A and movable stud B are brought in contact without applying any under pressure, and the zero of the circular scale does not coincide with the reference line, there is a zero error.

- **i. POSITIVE ZERO ERROR:** If zero of the circular scale is below the base line of pitch scale then error is positive zero error or negative correction
- **ii. NEGATIVE ZERO ERROR:** When zero of a circular scale is above the base line of the pitch scale then error is negative zero error or positive error



(a) No zero error (b) Positive zero error (c) Negative zero error

To get the correct reading, zero error with a proper sign is subtracted from the observed reading.

PROCEDURE

If the body is positioned between the jaws and the zero of the vernier scale is located ahead of the Nth division of the main scale, then the main scale reading (MSR) is equal to N.

In the case where the nth division of the vernier scale aligns with any division of the main scale, the vernier scale reading (VSR) corresponds to that alignment, i.e.

$$\text{V.S.R.} = n \times (\text{L.C.})$$
$$= n \times (\text{V.C.})$$
$$\text{Total reading, T.R.} = \text{M.S.R.} + \text{V.S.R.}$$
$$= N + n \times (\text{V.C.})$$

1. Determine the vernier constant (V.C.), also known as the least count (L.C.), of the vernier calipers and document the process step by step.
2. Bring the movable jaw BD into close contact with the fixed jaw AC and ascertain the zero error. Conduct this procedure three times and document the results. If there is no zero error, record it as nil.
3. Open the jaws, position the sphere or cylinder between the two jaws A and B, and adjust the jaw DB to securely grip the body without applying undue pressure. Secure the screw S attached to the vernier scale V.
4. Take note of the position of the zero mark on the vernier scale in relation to the main scale. Record the main scale reading just before the zero mark of the vernier scale; this reading (N) is referred to as the main scale reading (M.S.R.).
5. Record the number (n) corresponding to the vernier scale division that aligns with a division on the main scale.

6. Conduct steps 4 and 5 again, but this time, rotate the body by 90° to measure the diameter in a perpendicular direction.
7. Repeat steps 3, 4, 5, and 6 for three distinct positions. Document the observations for each set in a tabular format.
8. Calculate the total reading and apply any necessary zero correction.
9. Determine the mean of the various diameter values and present the result with the appropriate unit.

OBSERVATIONS

1. Determination of Vernier Constant (Least Count) of the Vernier Calipers

$$1 \text{ M.S.D.} = 1 \text{ mm}$$
$$10 \text{ V.S.D.} = 9 \text{ M.S.D.}$$
$$\therefore 1 \text{ V.S.D.} = \frac{9}{10} \text{ M.S.D.} = 0.9 \text{ mm}$$

Vernier Constant, V.C. = 1 M.S.D. -1 V.S.D. = $(1 - 0.9)$mm = 0.1mm = 0.01cm.

2. Zero error
   i. ____ cm
   ii. ____ cm
   iii. ____ cm

Mean zero error (e) = ____ cm.

Mean zero correction (c) = $-e$ = ____ cm.

TABLE FOR DIAMETER (D)

S. No.		Vernier Scale Reading		Total Reading	
	Main Scale Reading (N) (cm)	No. of Vernier division coinciding (n)	Value [n × (V. C.)]	Observed $D_0 = N + n \times V.C.$	Corrected $D = D_0 + c$
1.					D_1 =
2.					D_2 =
3.					D_3 =

CALCULATIONS

Mean corrected diameter:

$$D = \frac{D_1 + D_2 + D_3}{3}$$

RESULT

The diameter of the given sphere/cylinder is _______ cm.

PRECAUTIONS

1. Ensure the vernier scale moves smoothly along the main scale and consider applying oil if needed to facilitate this motion.
2. Thoroughly determine and accurately record the vernier constant and zero error.
3. Securely but gently grip the body between the jaws, avoiding any excessive pressure exerted by the jaws.
4. Take observations perpendicular to the object at a single location and repeat the process at a minimum of three different locations.

SOURCES OF ERROR

1. There is a possibility that the vernier scale might be inadequately secured to the main scale.
2. The alignment of the jaws may deviate from being perpendicular to the main scale.
3. The scale markings may exhibit inaccuracies or lack clarity.
4. Observations may be affected by parallax, introducing errors in the readings.

VIVA VOCE

Q1. What is the aim of your experiment?

Ans. To measure the diameter of a small cylindrical body using Vernier calipers as given by the examiner.

Q2. What is the Vernier scale?

Ans. Vernier is a small scale that can slide along the main scale of a measuring instrument.

Q3. What is the use of the Vernier scale?

Ans. Vernier is used to measuring length accurately up to a fraction of a millimeter, i.e., 0.1 mm.

Q4. Why is it called the Vernier scale?

Ans. It was invented by French mathematician Pierre Vernier. After his name, this scale is called Vernier scale.

Q5. How will you define the least count of Vernier calipers?

Ans. The least count of the Vernier caliper is the least distance that can be measured by it.

Q6. What is the difference between the terms Vernier constant and the least count of Vernier caliper?

Ans. The least count of Vernier caliper is known as the Vernier constant.

Q7. What is the least count of Vernier calipers given to you?

Ans. Its least count is 0.1 mm.

Q8. Can there be errors in the Vernier caliper?

Ans. Yes.

Q9. When will you say that there is an error in the instrument?

Ans. On bringing the jaws of Vernier calipers in contact, if the zero mark of the Vernier scale does not fall in line with the zero of the main scale, the instrument is said to possess zero error.

Q10. Can you talk about the various types of zero error?

Ans. Yes, there are two types of zero errors, viz. positive zero error and negative zero error.

EXPERIMENT NO. 1-B

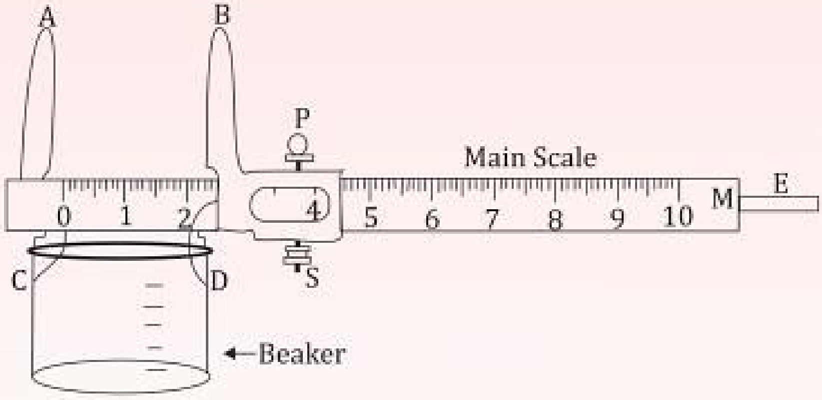
AIM

To measure the internal diameter and depth of a given beaker/calorimeter using Vernier caliper and hence, find its volume.

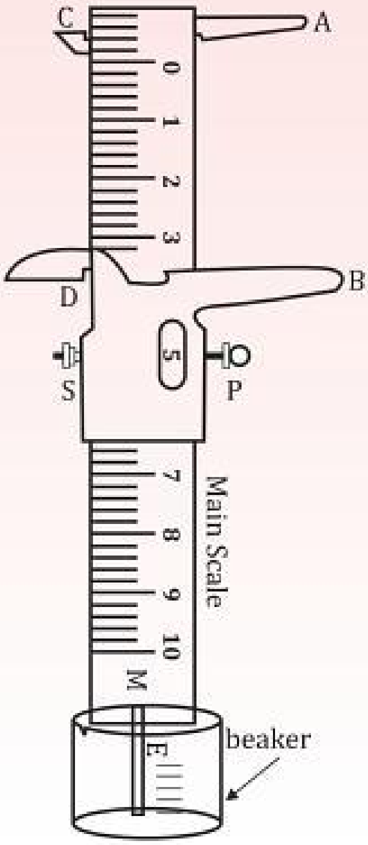
MATERIAL REQUIRED

Vernier Caliper, a beaker or calorimeter, magnifying glass.

DIAGRAM



Internal diameter of beaker



Depth of beaker

THEORY

The difference in the magnitude of one Main Scale Division (MSD) and one Vernier Scale Division (VSD) is called least count of vernier caliper.

i.e. $n\,(\text{VSD}) = (n-1)\,\text{MSD}$

$$\text{Least Count (LC)} = \frac{\text{Magnitude of the smallest division on main scale}}{\text{Total number of small divisions on vernier scale}}$$

The upper jaws of the Vernier caliper are used for measuring the internal diameter of a hollow cylindrical vessel and a thin strip is used for measuring the depth of the vessel.

Therefore,

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

$$V = \pi\left(\frac{D}{2}\right)^2 \times d$$

Where,

D = Internal diameter of beaker or calorimeter

d = Depth of the beaker or calorimeter

The jaws C and D are selected to measure the internal diameter of a beaker or calorimeter.

PROCEDURE

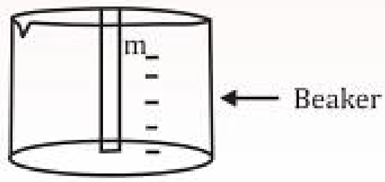
1. Ascertain the vernier constant (V.C.), which is essentially the least count of the vernier calipers and document this process in a step-by-step manner.
2. Align the movable jaw BD with the fixed jaw AC, ensuring close contact, and determining zero error. Conduct this procedure three times and document the results. If no zero error is present, note it as "nil."

MEASUREMENT OF INTERNAL DIAMETER

1. Put the beaker/calorimeter on the two jaws C and D of Vernier caliper in such a way that the jaws just touch the beaker or calorimeter from inside without any undue pressure on the walls and tighten the screw attached to the vernier scale gently.
2. Note the position of the zero mark on the vernier scale concerning the main scale and record the main scale reading just prior to the zero mark. This recorded reading, denoted as the Main Scale Reading (M.S.R.), is crucial.
3. Observe the vernier scale to identify the number (n) corresponding to a vernier scale division aligning with a main scale division.
4. Repeat the fourth and fifth steps by rotating the vernier calipers by 90° when measuring the internal diameter in a perpendicular direction.
5. Calculate the total reading and factor in any zero-correction required.

MEASUREMENT OF DEPTH

1. To measure the depth of beaker or calorimeter, we must keep the right edge of the main scale on the upper edge of the beaker or calorimeter.
2. Repeat the above steps for different positions along the circumference of the upper edge of the beaker.
3. Now, find the total reading and apply zero correction.
4. Taking mean of two different values of internal diameter and four different values of depth.
5. Calculate the volume by using proper formula.
6. Continuously slide the movable jaw of the vernier calipers until the strip makes contact with the bottom of the beaker. Ensure that the alignment is precisely perpendicular to the bottom surface. Subsequently, secure the vernier calipers in place by tightening the screw.



Depth of beaker

OBSERVATIONS

1. Determination of Vernier Constant (Least Count) of the Vernier caliper

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

$$10\ \text{V.S.D.} = 9\ \text{M.S.D.}$$

$$\therefore 1\ \text{V.S.D.} = \frac{9}{10}\ \text{M.S.D.} = 0.9\ \text{mm}$$

$$\text{Vernier constant, V.C.} = 1\ \text{M.S.D.} - 1\ \text{V.S.D.} = (1 - 0.9)\ \text{mm}$$

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

2. Zero error

(i) ____ cm

(ii) ____ cm

(iii) ____ cm

Mean zero error (e) = ____ cm

Mean zero correction (c) = − (e) = ____ cm

TABLE FOR THE INTERNAL DIAMETER (D)

S. No.		Vernier Scale Reading		Total Reading	
	Main Scale Reading (N) (cm)	No. of Vernier division coinciding (n)	Value $[n \times (V.C.)]$	Observed $D_0 = N + n \times V.C.$	Corrected $D = D_0 + c$
1.					D_1 =
2.					D_2 =
3.					D_3 =
4.					D_4 =

TABLE FOR THE DEPTH (d)

S. No.	Position		Vernier Scale Reading		Total Reading	
		Main Scale Reading (N) (cm)	No. of Vernier division coinciding (n)	Value $[n \times (V.C.)]$	Observed $D_0 = N + n \times V.C.$	Corrected $d = D_0 + c$
1.	at A					d_1 =
2.	at B					d_2 =
3.	at C					d_3 =
4.	at D					d_4 =

CALCULATIONS

Mean corrected internal diameter,

$$D = \frac{D_1 + D_2 + D_3 + D_4}{4} = \ldots\ldots \text{cm}$$

Mean corrected depth,

$$d = \frac{d_1 + d_2 + d_3 + d_4}{4} = \ldots\ldots \text{cm}$$

Volume of beaker/calorimeter $= \pi \left(\frac{D}{2}\right)^2 d = \ldots\ldots \text{cm}^3$

RESULT

The volume of the beaker/calorimeter is ___ cm^3.

PRECAUTIONS

Same as in Experiment 1A.

SOURCES OF ERROR

Same as in Experiment 1A.

VIVA VOCE

Q1. What is the definition of angular vernier?

Ans. It is an instrument which is used for measuring fraction of a degree of an angle. It is usually provided in sextants and spectrometers, which measure angular displacement.

Q2. What is the principle on which vernier works?

Ans. The number of vernier scale divisions coinciding with the main scale divisions should be either one less or one more.

$$1 \text{ Vernier scale division} = \frac{1 \text{ main scale division}}{\text{Number of divisions on vernier scale}}$$

Q3. One can undertake an exercise to know the level of skills developed in making measurements using vernier caliper. Objects such as bangles/kanga's, marbles whose dimensions can be measure using a thread indirectly. So, to judge the skills acquired through comparison of results, obtain the conclusion by both the methods?

Ans. Since a vernier caliper is an instrument which is used to measure small measurements like thickness of doors, etc. It means that the measurements taken by Vernier caliper are more precised. While in the case of bangles, kangas or marbles, the use of thread can measure their dimensions but not as accurate as vernier caliper. So, while using a thread, there will always be a point of approximation in the answer.

Q4. How does a vernier decrease the least count of a scale?

Ans. The least count of a vernier caliper can be decreased by increasing the total number of divisions on Vernier scale.

Q5. How can you find the thickness of the sheet used for making a steel tumbler using Vernier caliper?

Ans. Measure the internal diameter (D_i) and external or outer diameter (D_0) of the tumbler. Then, the thickness of the sheet, $D_f = \frac{D_0 - D_i}{2}$

Q6. What is the relation between the precision and the least count of an instrument?

Ans. The least count of an instrument is always inversely proportional to its precision. it means that lesser the least count, more will be the precision of the instrument.

Q7. What is the function of the thin sliding strip attached to the sliding jaw of Vernier calipers?

Ans. The iron strip is used to determine the depth of a vessel like calorimeter, etc.

Q8. On the main scale of a travelling microscope 1 cm is divided into 20 divisions. What is the least count of the main scale of this device?

Ans. 0.5 mm as 1 cm on main scale is divided into 20 divisions.