

Experiment 2a. Vernier Caliper

Can you divide a millimeter into 20 equal parts?
Essentially, a vernier does that exactly.

Objective:

To measure the length and diameter of a cylinder, determine its mass, and calculate its volume and density.

Apparatus:

Vernier caliper, a cylinder and a balance.

Theory:

Least count of a vernier caliper, the smallest length that can be accurately measured with it, is equal to the length of the smallest main scale division divided by the number of divisions on the vernier scale.

Procedure:

1. Find s , the length of the smallest division of the main scale of the vernier caliper.

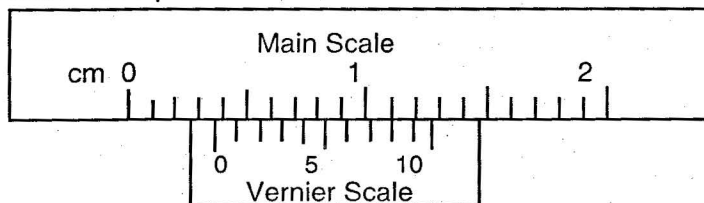


Figure 1

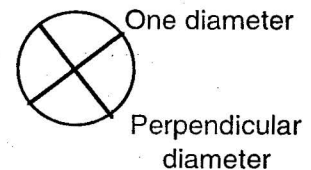


Figure 2

2. Count n , the number of divisions on the vernier scale of the caliper.
3. Note that a length equal to $n-1$ divisions of the main scale is divided into n equal parts. Thus the least count of the vernier, $l.c. = s/n$.
4. Learn to read the vernier caliper. The reading of any length taken with a vernier caliper consists of two parts:
 - (a) Main scale reading which is the reading of the main scale division just to the left of (or coinciding with) the vernier zero. In the above diagram, the main scale reading, $m = 0.3$ cm.
 - (b) Vernier scale reading which is the number of division of the vernier scale that coincides with some main scale division. In the above diagram, the vernier scale reading, $v = 8$.

The reading of length (being measured with a vernier caliper)

$$= \text{main scale reading} + \text{vernier reading} \times \text{least count}$$

$$= m + v \times l.c.$$

$$= 0.3 + 8 \times 0.01 \text{ (where } l.c. = 0.01 \text{ cm)}$$

$$= 0.38 \text{ cm}$$

5. Bring the 'jaws' of the vernier caliper together. If the zero of vernier scale coincides with the zero of the main scale, there is no zero error in the instrument. However if the zero of the vernier scale does not coincide with the zero of the main scale, there is zero error. To find the zero error, take the vernier reading (p). Now if the vernier zero is on the right of the zero of the main scale, the zero error is positive and its value is $+ p \times l.c.$ If the vernier zero is on the left of the zero of the main scale, the zero error is negative and its value is $- (n-p) \times l.c.$

Remember that the zero error is always subtracted algebraically from the readings.

6. Take six readings for the length of the cylinder.
7. Take 4 pairs of readings for the diameter of the cylinder. To obtain a pair of readings for diameter, measure one diameter, rotate the cylinder through 90° and then measure the perpendicular diameter (Fig. 2).
8. Find the least count of the balance and take two readings for the mass of the cylinder.

Note that a vernier and a micrometer enable us to measure lengths correct to some fraction of the smallest main scale division without actually subdividing the smallest main scale divisions into a number of equal parts.

Use cgs units in this experiment.

Experiment 2b. Micrometer

A step ahead of the vernier - a micrometer can essentially divide a millimeter into 100 equal parts.

Objective:

To determine the diameter of a wire with a micrometer.

Apparatus:

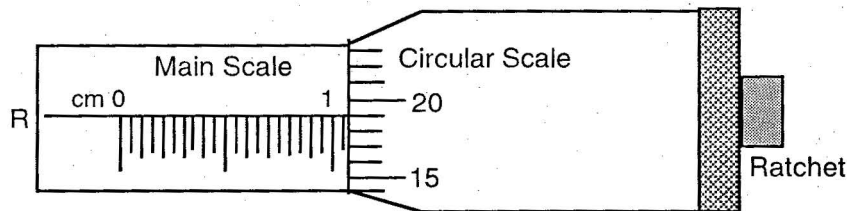
A micrometer, a piece of wire.

Theory:

The pitch of a screw is defined as the length traversed by the screw when it is given one complete rotation. The least count of a micrometer, the smallest length that can be accurately measured with it, is equal to the pitch of its screw divided by the number of divisions on its circular scale.

Procedure:

1. Find the length of the smallest division of the main scale of the micrometer. Count the total number of divisions (n) on the circular scale of the micrometer.



2. Make the edge of the thimble (on which the circular scale is engraved) coincide with some division of the main scale by rotating the thimble and record the main scale reading. Take the reading of the circular scale division which is closest to the reference line R (along which the main scale is engraved). Give 4 complete revolutions to the micrometer screw and again take the main scale reading. Find d , the difference between the two main scale readings. This is the distance through which the edge of the thimble (micrometer screw) moves in 4 complete rotations, and thus the pitch of the micrometer screw, $p = d/4$.
3. The least count of the micrometer is found by dividing the pitch by the number of divisions on the circular scale. Thus

Least count of the micrometer = $\frac{p}{n}$.

Calculate the least count (*l.c.*) of the micrometer.

4. Learn to read the micrometer. A micrometer reading consists of two parts:

(a) Main scale reading which is the reading of the main scale division just to the left of (or coinciding with) the edge of the thimble. In the above diagram, the main scale reading, $m = 1.05$ cm.

(b) Circular scale reading which is the number of circular scale division that is closest to the reference line. In the above diagram, the circular scale reading, $c = 19$.

The reading of length (being measured with a micrometer)

= main scale reading + circular scale reading \times least count

= $m + c \times l.c.$

= $1.05 + 19 \times 0.001$ (where $l.c. = 0.001$ cm)

= 1.069 cm

5. Find the zero error. Bring the plane ends of the micrometer in contact and take the circular scale reading. If the edge of the thimble is at the zero of the main scale and the circular scale reading is zero, there is no zero error in the instrument. If the circular scale reading is c and the edge of the thimble is to the right of the zero of the main scale, the zero error is positive and it is equal to $c \times l.c.$ Otherwise, the zero error is negative and its value is $(c-n) \times l.c.$

Remember that zero error is always subtracted algebraically to obtain the correct length.

6. Take 4 pairs of readings for the diameter of the wire. In each case, take the reading for one diameter, rotate the wire through 90° and then measure the perpendicular diameter (Fig. 2).

Note that most micrometers have a ratchet which is used to tighten up the object being held between the plane ends of the instrument with the same force each time. Application of an unnecessarily large force is also avoided by this arrangement.

Use cgs units in this experiment.

Experiment No. 2: Pre-Lab Questionnaire

1. In the measurement of length of a cylinder, the main scale reading of a vernier caliper is 1.5 cm, the vernier reading is 6, and the least count of the vernier is 0.01 cm. Find the reading of the length of the cylinder.
2. The edge of the thimble of a micrometer moves a distance of 0.2 cm when it is given four complete revolutions. (a) Find the pitch of the micrometer. (b) If the number of divisions on the circular scale are 50, calculate the least count of the micrometer.
3. Using a vernier caliper of least count 0.01 cm, the length of a cylinder measured to be 3.76 cm, and its diameter, 1.28 cm. (a) Find the volume of the cylinder. (b) Calculate the probable percent error in the length. (c) Calculate the probable percent error in the radius. (d) Calculate the probable percent error in the volume.

Experiment No. 2

Name:

Marks:

Partner:

Remarks:

Section:

Date Submitted:

Title:

Objective:

Theory/Formulas:

Data Sheet

a. Vernier Caliper:

Length of the smallest division on the main scale, s =Number of divisions on the vernier scale, n =Least count of the vernier caliper, *l.c.* =]

Zero error =

Readings for the length of the cylinder:

No.	Length L_i	$L_i - L_{avg}$	$(L_i - L_{avg})^2$

Average length, L_{avg} =Standard deviation in L , σ =Standard error in L , σ_m =Probable percent error in L =

Readings for the diameter of the cylinder:

No.	One diameter	Perpendicular diameter	Average reading

Average reading for the diameter =

Diameter of the cylinder, corrected for zero error =
 Probable percent error in the diameter of the cylinder =
 Mass of the cylinder:
 Least count of the balance =
 Reading 1 =
 Reading 2 =
 Average mass of the cylinder =
 Probable percent error in the mass of the cylinder =

Calculations:

Volume of the cylinder =

$$\text{Density of the cylinder} = \frac{\text{Mass}}{\text{Volume}} =$$

Standard value of the density of the cylinder =

Percent error in the experimental value of density =

Probable errors:

Probable error in the volume of the cylinder

= probable percent error in length

+ 2(probable percent error in diameter)

=

Probable percent error in the density of the cylinder

= probable percent error in mass + probable percent error in volume

=

b. Micrometer:

Length of the smallest main scale division of the micrometer

=

Distance traveled by the micrometer screw in 4 rotations =

Pitch of the micrometer screw =

Number of divisions on the circular scale of the micrometer =

Least count of the micrometer =

Zero error = divisions = cm

Readings for the diameter of the wire:

For thin wires, it may be more convenient to take the circular scale reading with the wire between the plane ends and the circular scale reading with the plane ends in contact. The product of the difference between the two readings and the least count gives the diameter. In this case, the correction for zero error is not necessary.

No.	One diameter	Perpendicular diameter	Average reading

Average reading for the diameter =

Diameter of the wire, corrected for zero error =

Experiment No. 2: Questions

1. Why are several readings taken for each physical quantity?
2. A single reading taken with a meter stick for the length of a cylinder is 5.5 cm. What is the probable percent error in the reading?
3. The following readings were taken with a meter stick for the length of a cylinder: 5.5 cm, 5.3 cm, 5.4 cm, 5.5 cm and 5.6 cm. Calculate the standard deviation of the mean, the stand error and the probable percent error.
4. How many significant figures should be given in reporting the length of the cylinder in question 3?
5. If the radius of the cylinder in question 2 is 2.4 ± 0.2 cm and its mass is 32.6 ± 0.5 gm, what will be the probable percent error in the density of the cylinder? What will be the probable error in density? How many significant figures should be given in reporting the density?

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