

Basic measurement techniques



The goal of this experiment is to demonstrate Measuring procedures, accuracy of measurement and reading accuracy using different tools.

Physics

Mechanics

Fabric & material properties



Difficulty level

easy



Group size

2



Preparation time

10 minutes



Execution time

10 minutes

Your local Partner

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General information

Application



Experimental setup

The measurement of different properties is the fundamental principle behind physics.

This experiment can be used to demonstrate Measuring procedures, accuracy of measurement and reading accuracy using different measuring tools.

Other information (1/2)

Prior knowledge



There is no prior knowledge necessary.

Main principle



Caliper gauges, micrometers and spherometers are used for the accurate measurement of lengths, thicknesses, diameters and curvatures. Measuring procedures, accuracy of measurement and reading accuracy are demonstrated.

Other information (2/2)

Learning objective



The goal of this experiment is to demonstrate Measuring procedures, accuracy of measurement and reading accuracy using different tools.

Tasks



1. Determination of the volume of tubes with the caliper gauge.
2. Determination of the thickness of wires, cubes, plates and foils with the micrometer.
3. Determination of the thickness of plates and the radius of curvature of watch glasses with the spherometer.

Equipment

Position	Material	Item No.	Quantity
1	Vernier calliper stainless steel 0-160 mm, 1/20	03010-00	1
2	Micrometer screw gauge 0 - 25 mm	03012-00	1
3	Spherometer	03017-00	1
4	Watch glass, dia.80mm	34572-00	1
5	Watch glass, dia.100 mm	34574-00	1
6	Watch glass, dia.125 mm	34575-00	1
7	Iron wire, d = 1.0 mm, l = 10 m	06104-01	1
8	Aluminium foil, set of 2 sheets	06270-00	1
9	Glass plate, 100 mm x 85 mm x approx. 1 mm	08203-00	1
10	Glass tube, straight, l=80 mm, 10/pkg.	36701-65	1
11	Glass tube, do=24 mm, di=21 mm, l=120 mm	45158-00	1
12	Cubes, set of 8	02214-00	1



Setup and Procedure

Setup and Procedure (1/7)

Vernier Caliper

The caliper gauge (sliding gauge) is the best known measuring tool for rapid and relatively accurate measurement. Inside, outside and depth measurements can be made. The accuracy which can be achieved is proportional to the graduation of the vernier scale. The measuring faces which are relevant to the taking of reading may be seen in Fig. 1. When the jaws are closed, the vernier zero mark coincides with the zero mark on the scale of the rule. The name "vernier" is given to an addition to a gauge which enables the accuracy of measurement (reading accuracy) of the gauge to be increased by 10 to 50 times. The linear vernier is a small rule which slides along a scale.

This rule is provided with a small scale which is divided into n equal divisions. The overall length of these divisions is equal to the length of $n - 1$ divisions on the main scale. Fig. 1 shows 39 divisions extending from 28 mm to 67 mm on the graduated scale, whereas the vernier scale has 20 divisions (every second mark on the vernier has been omitted meaning that $n = 2 \cdot 20$).

Setup and Procedure (2/7)

The work-piece to be measured is placed between the measuring faces and the movable jaw blade is then pushed with moderate pressure up against the work-piece. When taking the reading, the zero mark of the vernier is regarded as the decimal point which separates the whole numbers from the tenths. The full millimetres are read to the left of the zero mark on the main graduated scale and then, to the right of the zero mark, the vernier division mark which coincides with a division mark on the main scale is looked for. The vernier division mark indicates the tenths of a millimetre (Fig. 2).

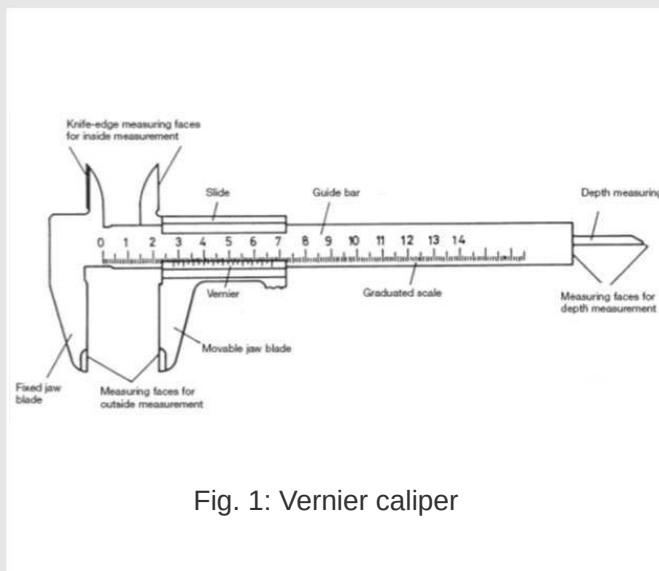


Fig. 1: Vernier caliper

Setup and Procedure (3/7)

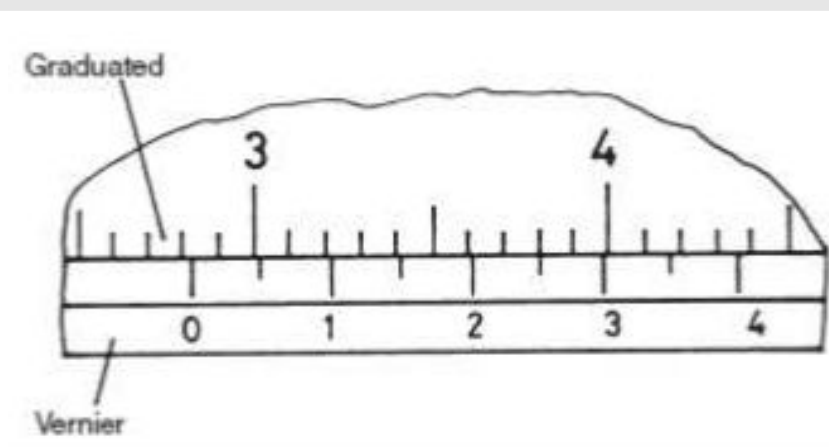


Fig. 2: Reading off 28 on the graduated scale and 25 on the vernier scale gives 28.25 mm.

Setup and Procedure (4/7)

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Micrometer

With the micrometer (Fig. 3) (micrometer screw gauge), the accuracy of measurement can be increased by one order of magnitude. The work-piece to be measured is placed between the measuring faces, then the measuring spindle is brought up to the work-piece with the rapid drive (ratchet, thumb screw). When the rapid drive rotates idly, the pressure required for measurement has been reached and the value can be read off. The whole and half millimetres are read off on the scale barrel, the hundredths of millimetres on the micrometer collar. If the micrometer collar uncovers a half-millimetre, this must be added to the hundredths.

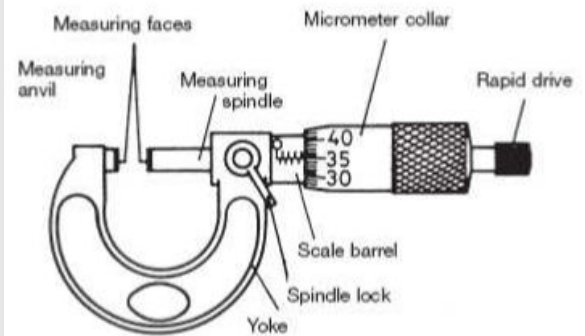


Fig. 3: Micrometer, reading off 4.35 mm.

Setup and Procedure (5/7)

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Spherometer

More accurate relative measurements of parallel surfaces (plate thickness) and curvatures of spherical surfaces can be made with the spherometer. The spherometer is used for the measurements of the radius of the curvature of the spherical surfaces. In addition, the thickness of plates and the differences in level between surfaces can be found in a convenient manner. The device has a tripod with three measuring points which form an equilateral triangle. The probe of the dial gauge is located in the centre of this triangle. The distance between the tip of the probe and the plane defined by the three measuring points can be read on the dial gauge. The measurement accuracy is better than 0.01 mm.

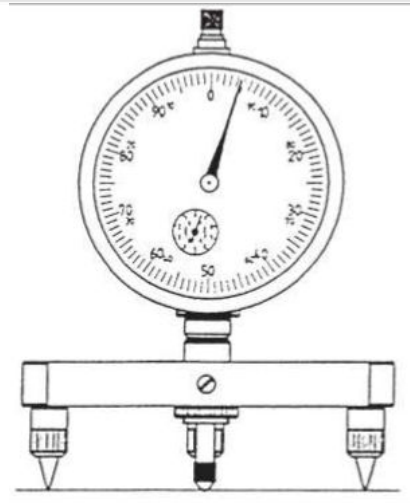


Fig. 4: Spherometer

Setup and Procedure (6/7)

Operation

There are four threaded holes available on each leg of the tripod for the acceptance of the three measuring points. The points must all have the same separation from the central probe. In order to achieve a high accuracy of measurement, the points are screwed in positions as far outwards as possible. Consideration should be given to the limits set by the size of the surface to be investigated. The dial gauge latches into the tripod at two precisely defined positions.

The upper position for the dial gauge is used for the measurement of curvature of convex surfaces; in this case the black figures on the gauge scale are used. If the dial gauge is pushed downwards in the tripod until it latches, then concave surfaces can be measured using the red figures. It is important to check the zero-point adjustment after matching the gauge position to the measurement task in hand. To adjust the zero point the spherometer is placed on the flat surface of the included glass plate and the scale on the dial gauge is rotated using the knurled ring. Vertical pressure on the spherometer should be avoided during the reading.

Setup and Procedure (7/7)

Once this preparatory step has been completed, the device is placed on the surface whose radius is to be measured and the difference in height h is measured. One revolution of the large pointer corresponds to 1 mm (1 subdivision corresponds to 0.01 mm). The number of revolutions is given by the small pointer. The maximum measurement displacement is 10 mm. The radius of curvature R of a spherical surface is obtained from the measured difference in height according to the equation

$$R = \frac{a^2 + h^2}{2h}$$

where a is the distance of the measuring points from the centre of the system. The following figures are given for the four possible positions of the measuring points from the inside towards the outside, labelled with 1 to 4:

Pos.	1	2	3	4
<u>a [mm]</u>	15.0	25.0	32.5	40.0

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Evaluation

Evaluation

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The different measuring tools are used to determine different volumina, material strengths, as well the curvature of surfaces.