Measurement of basic constants (Item No.: P2110105)

Curricular Relevance

Area of Expertise:	Education Level:	Topic:	Subtopic:	Experiment:
Physics	University	Mechanics	Measurement Techniques	Measurement of basic constants

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Easy	10 Minutes	10 Minutes	2 Students

Additional Requirements:

Experiment Variations:

Keywords:

length, thickness, diameter, inner diameter, curvature, vernier

Overview

Short description

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.

Fig. 1: Experimental set-up: Measurement of basic constants: length, thickness, diameter and curvature.

Equipment

Position No.	Material	Order 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, d=80 mm	34572-00	1
5	Watch glass, d=100 mm	34574-00	1
6	Watch glass, d=125 mm	34575-00	1
7	Iron wire, d=1.0 mm, l=10 m	06104-01	1
8	Aluminium foil, set of 4 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

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.

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Set-up and procedure

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. 2. 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 n divisions is equal to the length of $n-1$ divisions on the main scale. Fig. 2 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 $n = 2 \cdot 20$).

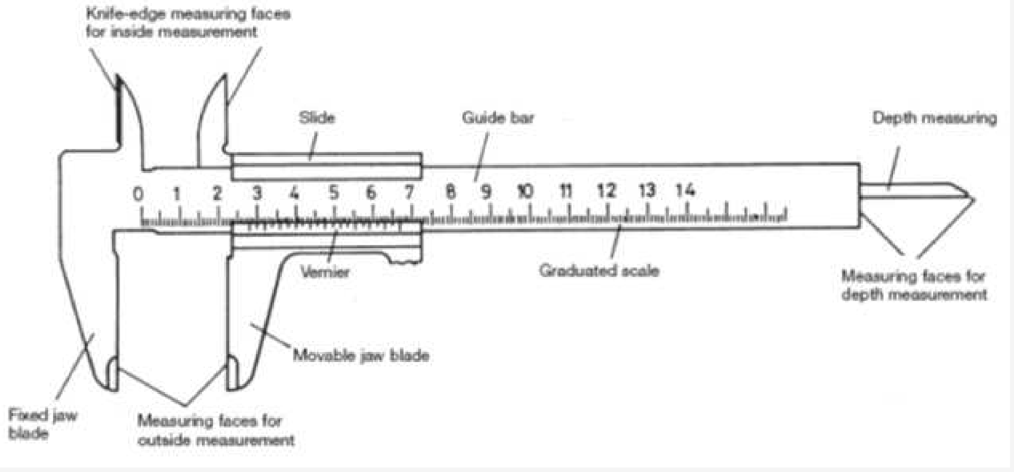

Fig. 2: Vernier caliper.

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. 3).

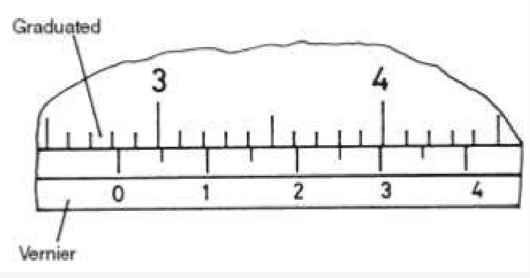

Fig. 3: Reading off 28 on the graduated scale and 25 on the vernier scale gives 28.25 mm.

Task

Use the vernier caliper to determine the volume of the provided glass tubes.

Micrometer

With the micrometer (Fig. 4) (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.

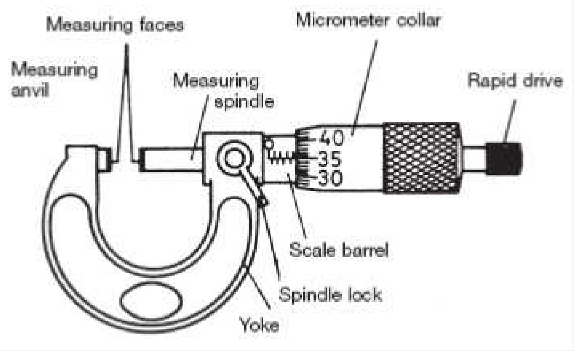

Fig. 4: Micrometer, reading off 4.35 mm.

Task

Use the micrometer to determine the thickness of various provided materials: cubes, plates, foils and wires.

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 $10^{-2}\,\mathrm{mm}$.

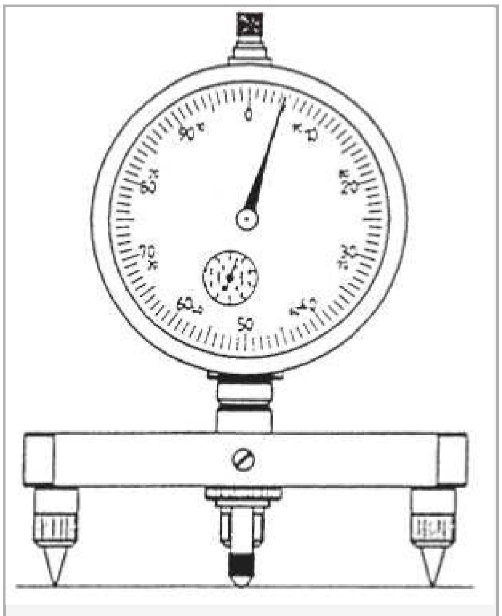
Fig. 5: Spherometer

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.

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 $1\,\mathrm{mm}$ (1 subdivision corresponds to $10^{-2}\,\mathrm{mm}$). The number of revolutions is given by the small pointer. The maximum measurement displacement is $10\,\mathrm{mm}$. The radius of curvature R of a spherical surface is obtained from the measured difference in height h according to the equation

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

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.	a / mm
1	15.0
2	25.0
3	32.5
4	40.0

Task

First, use the spherometer to measure the height of the provided glass plate. Afterwards, determine the curvature of the watch glasses.