Using a caliper gauge with vernier

Objects of the Experiment

- Determination of an outside, an inside-, and a depth dimension by means of a caliper gauge.
- Improvement of the measuring accuracy by means of a vernier.

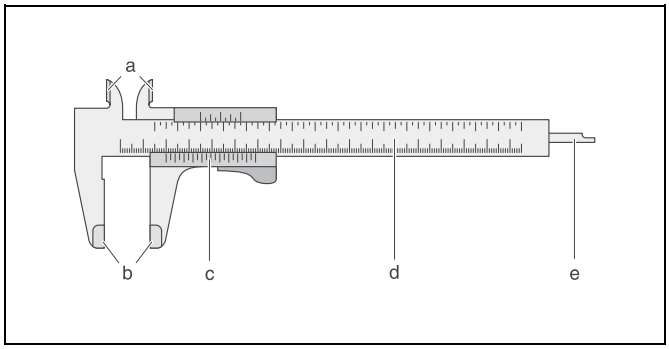
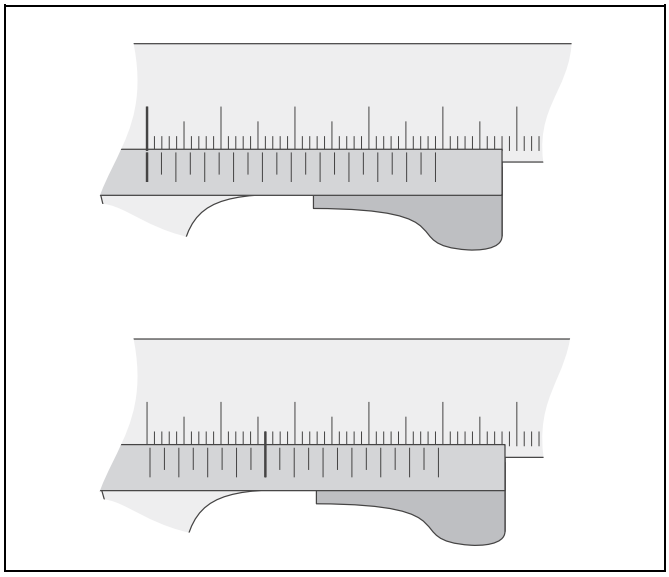


Fig. 1 Caliper gauge with a vernier
a acute measuring shank
b long measuring shank
c slide with vernier
d ruler with a millimeter scale
e feeler for depth measurements

Fig. 2 Using a vernier
above: zero-position,
below: setting 0.40 mm



Principles

Measuring lengths is one of the oldest measuring difficulties. Therefore simple methods of measuring lengths are well known. For smaller lengths e.g. the caliper gauge often finds its use. It consists of a ruler with millimeter scale to which the measuring shank 1 has been attached at a right angle. The ruler simultaneously serves as a guide for the caliper gauge which carries measuring shank 2. The zero-mark of the gauge coincides with the zero-mark of the ruler if both measuring shanks are in contact.

There are two types of measuring shanks 1 and 2 available. Long measuring shanks serve to determine outside dimensions while acute measuring shanks measure inside dimensions. By means of an additional feeler, depth measurements can be performed (see Fig. 1).

In order to increase the measuring accuracy, a vernier scale has been engraved on the slide. Its long graduation marks show a distance of 3.9 mm. In zero-position the distance between the first long vernier line and the 4-mm-line of the ruler amounts to 0.1 mm, that of the second long vernier line to the 8-mm-line 0.2 mm and so on. When the slide is moved out of zero-position e.g. by 0.4 mm, the fourth long vernier line must coincide with a line of the ruler. This device allows for a reading accuracy of 0.1 mm. If also the additionally engraved short vernier lines are used, the reading accuracy is doubled once again (see Fig. 2).

Various dimensions x of a workpiece are being determined several times during the test. Apart from the mean value of the sample

$$\bar{x} = \frac{1}{n} \cdot \sum_{i=1}^{n} x_i \qquad \text{(I)}$$

n: number of individual measurements

also the standard deviation of the sample is calculated.

$$s_x = \frac{1}{n-1} \cdot \sum_{i=1}^{n} (x_i - \bar{x})^2 \qquad \text{(II)}$$

The latter is a measure for the spread of the individual measurements around the mean value [1]. It is being compared to the read-out accuracy of the caliper gauge.

Apparatus

1 Precision caliper gauge 311 54

additionally required:

1 Workpiece with outside-, inside- and depth dimensions
or
1 Saddle base 300 11

Setup and carrying out the experiment

a) Determination of an outside dimension:

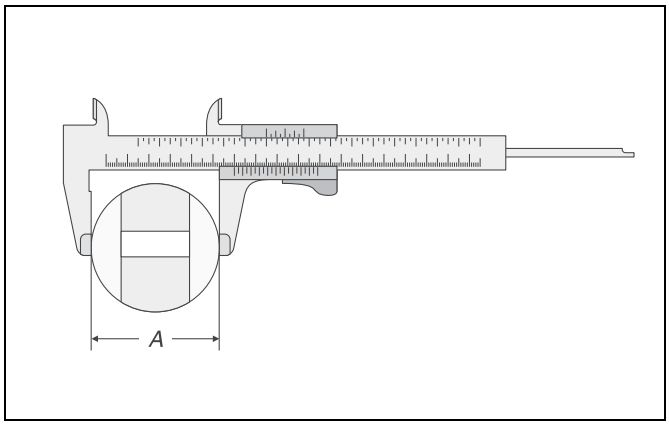


Fig. 3 Determination of an outside dimension with the long measuring shanks

– Loosen the catch of the gauge, bring the object to be measured between the long measuring shanks and push the measuring shanks into close contact without tilting.
– Estimate the outside dimension *A* on the millimeter scale and follow up with a more precise vernier reading.
– Remove caliper gauge, reset, and repeat measurement.

b) Determination of an inside dimension:

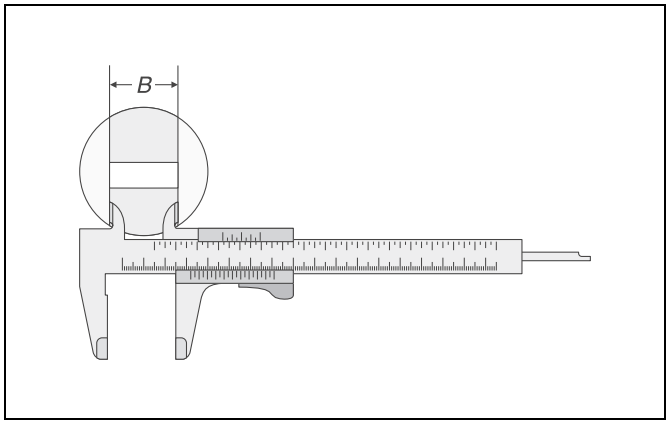


Fig. 4 Determination of an inside dimension with the acute measuring shanks

– Loosen the catch of the gauge. Guide the object to be measured over the acute measuring shanks and slide the measuring shanks apart so that they ride up on the inside plane without tilting.
– Estimate the inside dimension *B* on the millimeter scale and follow up with a more precise vernier reading.
– Remove caliper gauge, reset, and repeat measurement.

c) Determination of a depth:

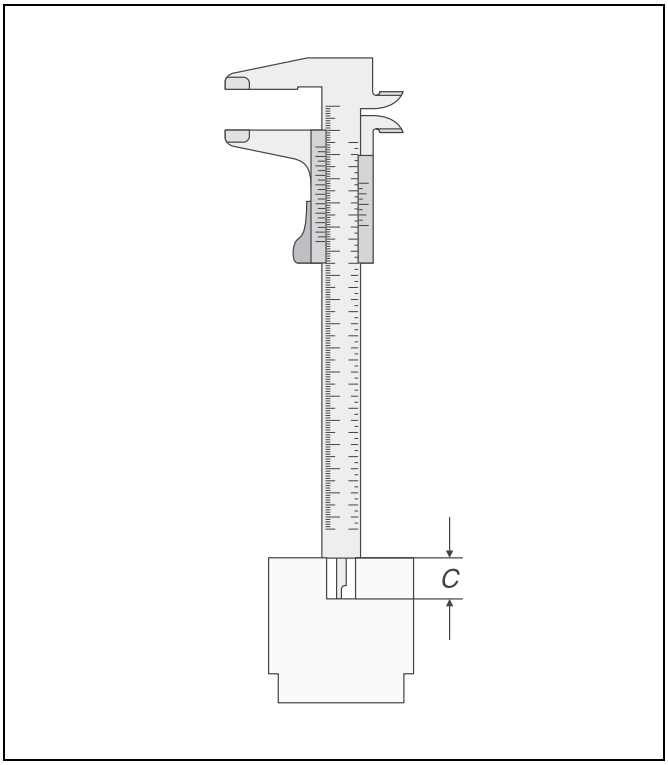


Fig. 5 Performing a depth measurement by means of a feeler

– Loosen the catch of the gauge. Set the ruler on the edge of the hole and by moving the slide lower the feeler until it makes contact with the base.
– Estimate the depth *C* on the millimeter scale and follow up with a more precise vernier reading.
– Remove caliper gauge, reset, and repeat measurement.

Measuring Example and Evaluation

a) Determination of an outside dimension:

Tab. 1: Individual measuring results of the outside measurement *A*

i	Millimeterscale	Vernier	$\frac{A_i}{mm}$
1	60	2.0	60.20
2	60	1.5	60.15
3	60	2.5	60.25
4	60	2.5	60.25
5	60	2.0	60.20

Mean value: 60.21 mm
Standard deviation: 0.04 mm
Reading accuracy: 0.05 mm

b) Determination of an inside dimension:

Tab. 2: Individual measuring results of the inside measurement *B*

i	Millimeterscale	Vernier	$\frac{B_i}{mm}$
1	30	2.0	30.20
2	30	6.0	30.60
3	30	2.5	30.25
4	30	7.0	30.70
5	30	3.0	30.30

Mean value: 30.41 mm
Standard deviation: 0.22 mm
Reading accuracy: 0.05 mm

c) Determination of a depth:

Tab. 3: Individual measuring results of the depth measurement *C*

i	Millimeterscale	Vernier	$\frac{C_i}{mm}$
1	18	0.5	18.05
2	17	5.5	17.55
3	17	8.0	17.80
4	17	9.0	17.90
5	17	2.0	17.20

Mean value: 17.70 mm
Standard deviation: 0.33 mm
Reading accuracy: 0.05 mm

Bibliography

[1] P. R. Bevington and D. K. Robinson, Data Reduction and Error Analysis for the Physical Sciences, McGraw Hill College Div.