IE-352
Manufacturing Processes – 2
Summer - 2013

Lecture (2)
Machining Fundamentals – Measurement

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Outline

1. Units of Measurement
2. The Steel Rule
3. The Micrometer Caliper
4. The Vernier Micrometer
5. Vernier Measuring Tools
6. Vernier Scale
7. Gages

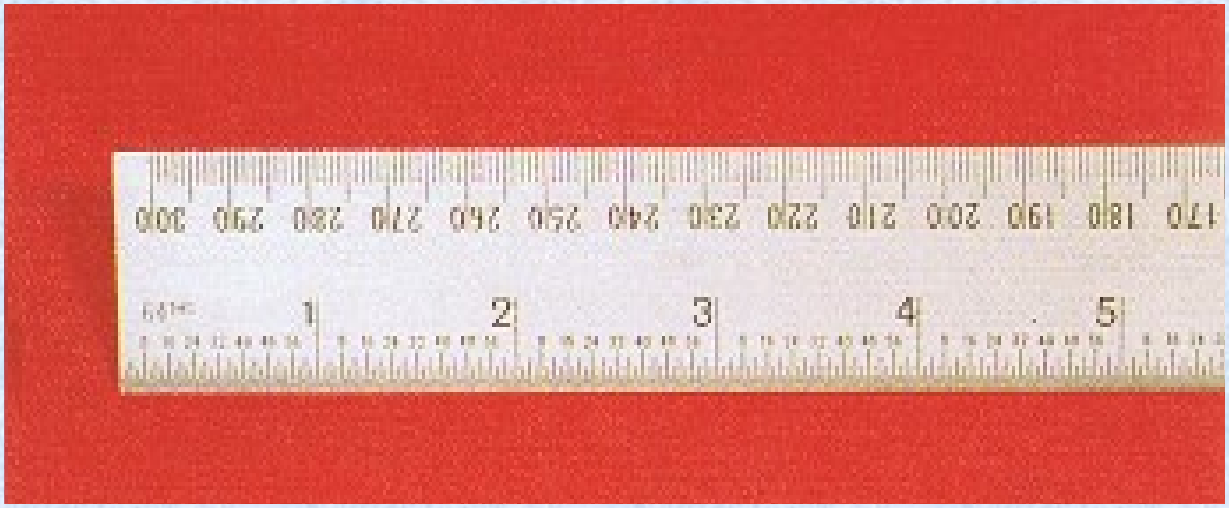
Units of Measurement

The science that deals with systems of measurement is called ***metrology.***

In addition to using US Conventional units of measure (inch, foot, etc.), industry is gradually converting to metric units of measure (millimeter, meter, etc.), called the ***International System of Units*** (abbreviated SI).

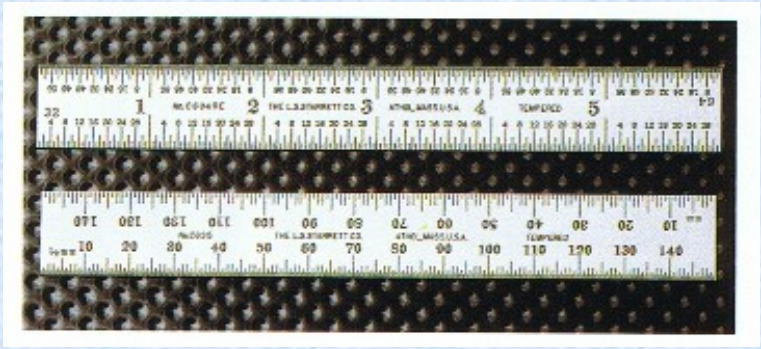
A micrometer is one-millionth of a meter (0.000001 m).

This rule can be used to make measurements in both US Conventional and SI Metric units.



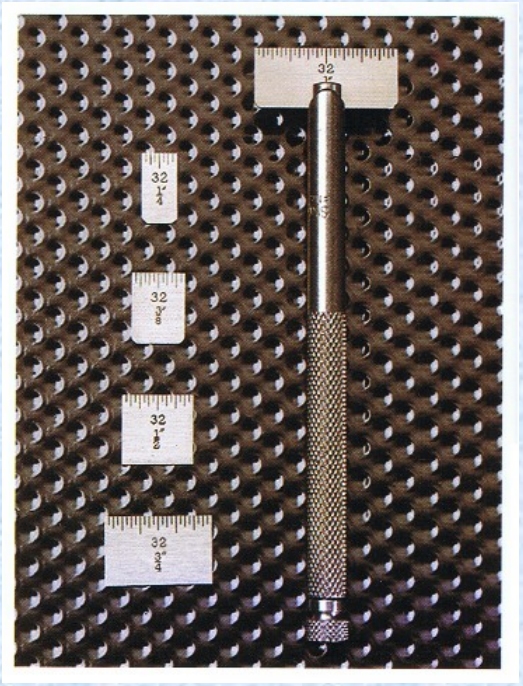
The Steel Rule

A steel rule can measure to 1/64” (.5 mm)



6” steel rule

Narrow rule



Small rules with holder

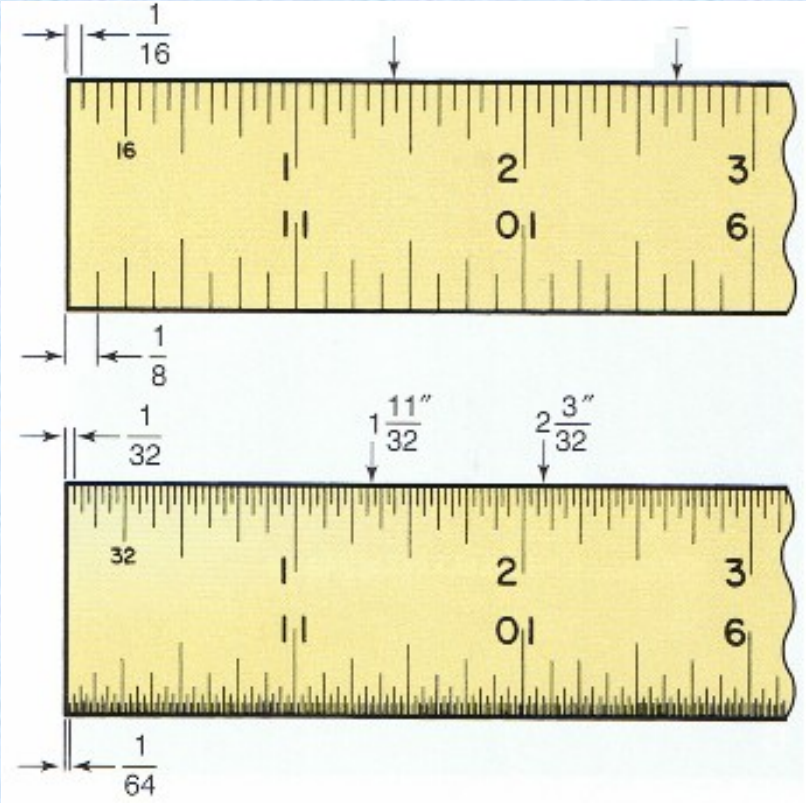
Figure 1. Different types of rules

Reading the Rule (US Conventional)

This figure shows the different fractional divisions of the inch from 1/8 to 1/64.

The lines representing the divisions are called ***graduations***.

On many rules, every fourth graduation is numbered on the 1/32 edge, and every eighth graduation on the 1/64 edge.



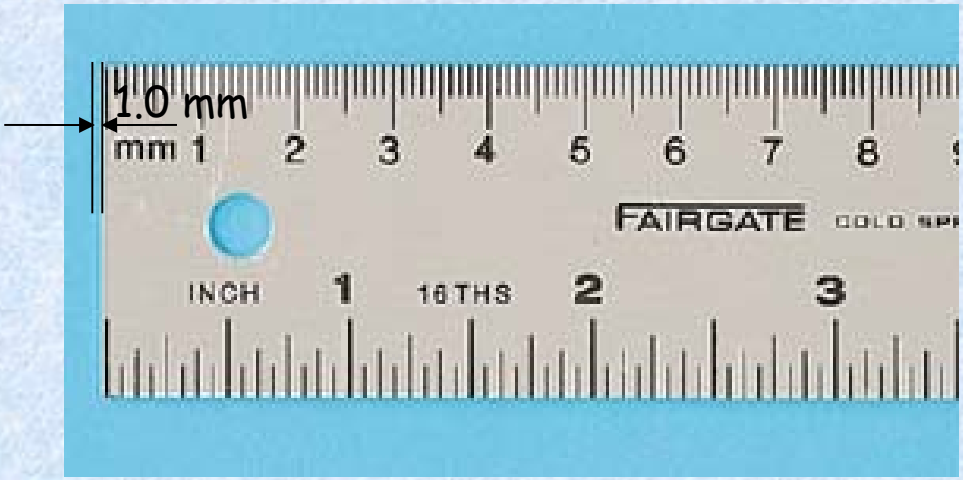
Fractional measurements are *always* reduced to the lowest terms. A measurement of 14/16" is reduced to 7/8", 2/8" becomes 1/4", and so on.

Reading the Rule (Metric)

Most metric rules are divided into millimeter or one-half millimeter graduations.

They are numbered every 10 mm (1 cm).

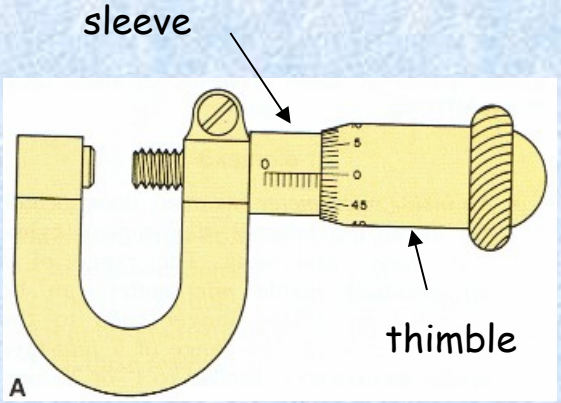
The measurement is determined by counting the number of millimeters.



The Micrometer Caliper

A Frenchman, Jean Palmer, devised and patented a measuring tool that made use of a screw thread, making it possible to read measurements quickly and accurately without calculations.

It consists of a series of engraved lines on the sleeve and around the thimble.



The *micrometer caliper,* also known as a "mike," is a precision tool capable of measuring to 0.001" or 0.01 mm.

When fitted with a Vernier scale, it will read to 0.0001" or 0.002 mm.

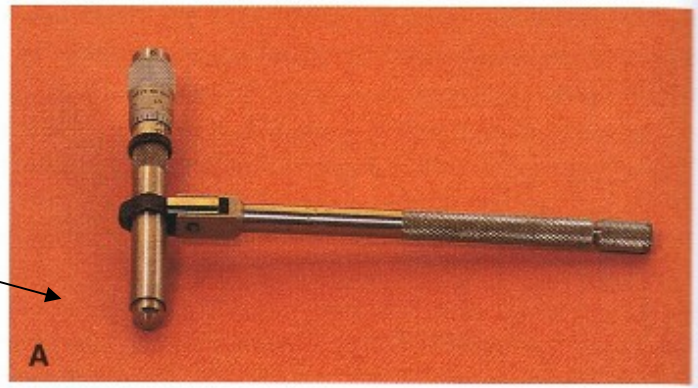
Types of Micrometers

An *outside micrometer* measures external diameters and thickness,

outside

An *inside micrometer* has many uses, including measuring internal diameters of cylinders, rings, and slots.

- The range of a *conventional inside micrometer* can be extended by fitting longer rods to the micrometer head.
- The range of a *jaw-type inside micrometer* is limited to 1″ or 25 mm. The jaw-type inside micrometer has a scale graduated from right to left.



inside

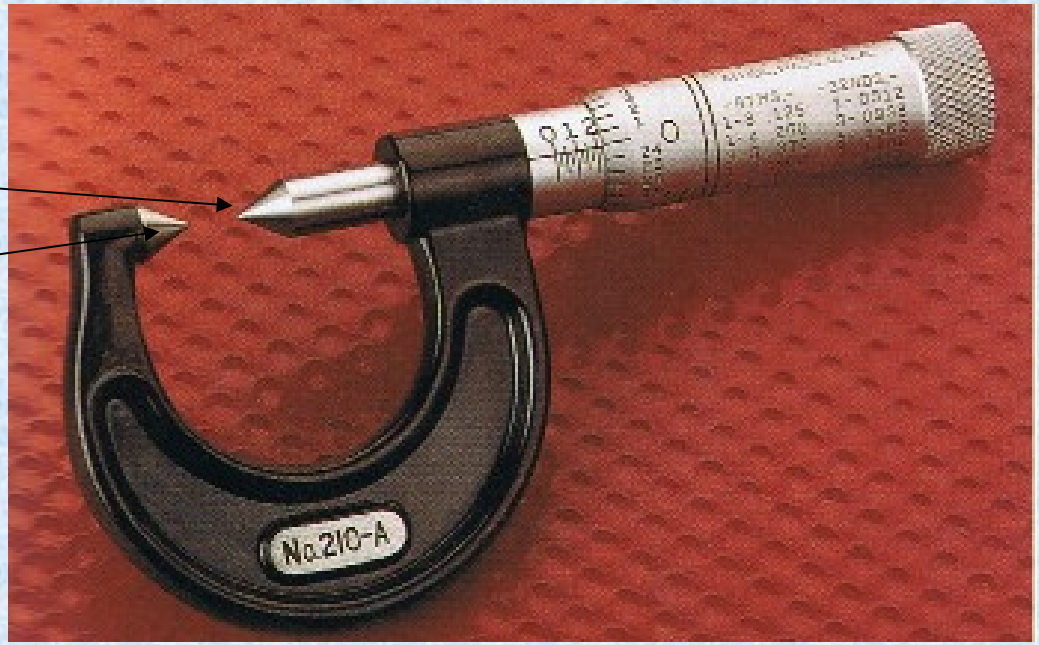
The divisions on the sleeve are numbered in the reverse order of a conventional outside micrometer.

Types of Micrometers

A *micrometer depth gage* measures the depths of holes, slots, and projections. The measuring range can be increased by changing to longer spindles. Measurements are read from right to left.

Types of Micrometers

A *screw-thread micrometer* has a pointed spindle and a double-V anvil shaped to contact the screw thread.



It measures the pitch diameter of the thread, which equals the outside (major) diameter of the thread minus the depth of one thread.

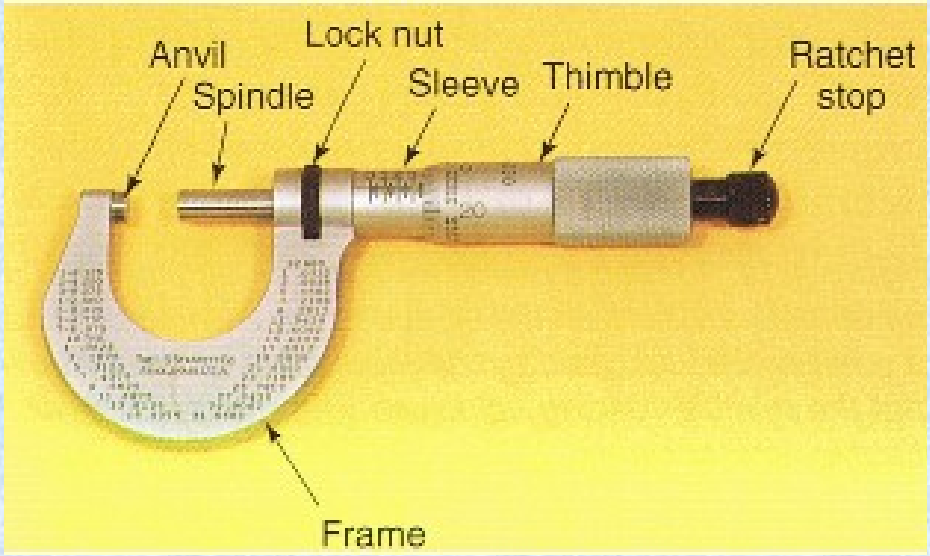
Reading an Inch-Based Micrometer

A micrometer uses a very precisely made screw thread that rotates in a fixed nut.

The screw thread is ground on the ***spindle*** and is attached to the ***thimble***.

The spindle advances or recedes from the *anvil* as the thimble is rotated.

The threaded section has 40 threads per inch; therefore, each revolution of the thimble moves the spindle 1/40" (0.025").



Reading an Inch-Based Micrometer

Every fourth division is numbered, representing 0.1", 0.2", etc.

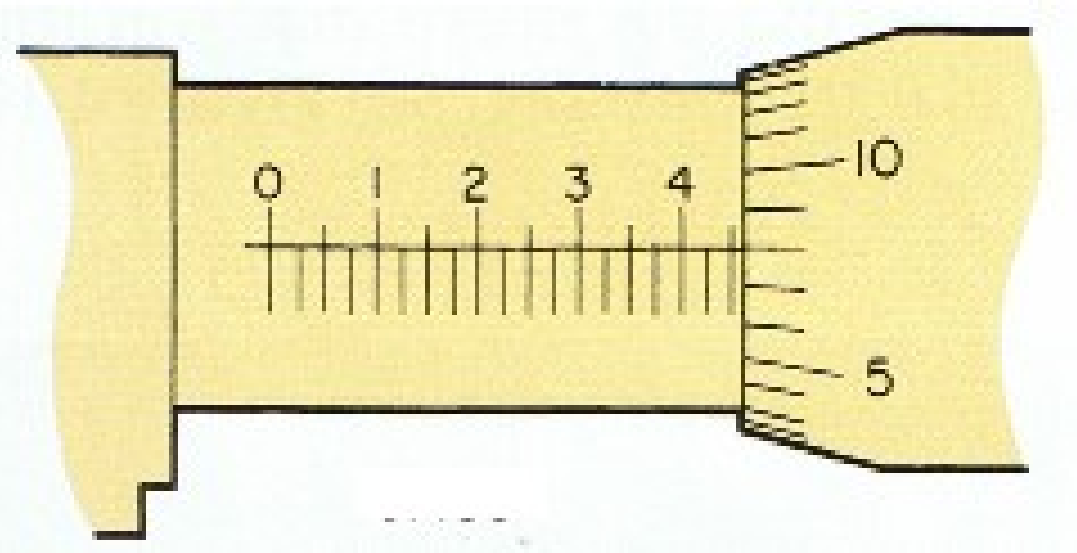
The line engraved lengthwise on the sleeve is divided into 40 equal parts per inch (corresponding to the number of threads per inch on the spindle). Each vertical line equals 1/40", or 0.025".

The beveled edge of the thimble is divided into 25 equal parts around its circumference. Each division equals 1/1000" (0.001").

On some micrometers, every division is numbered, while every fifth division is numbered on others.

- The micrometer is read by recording the highest number on the sleeve (1 = 0.100, 2 = 0.200, etc.).
- To this number, add the number of vertical lines visible between the number and thimble edge (1 = 0.025, 2 = 0.050, etc.).
- To this total, add the number of thousandths indicated by the line that coincides with the horizontal sleeve line.

Example 1



Add the readings from the sleeve and the thimble:

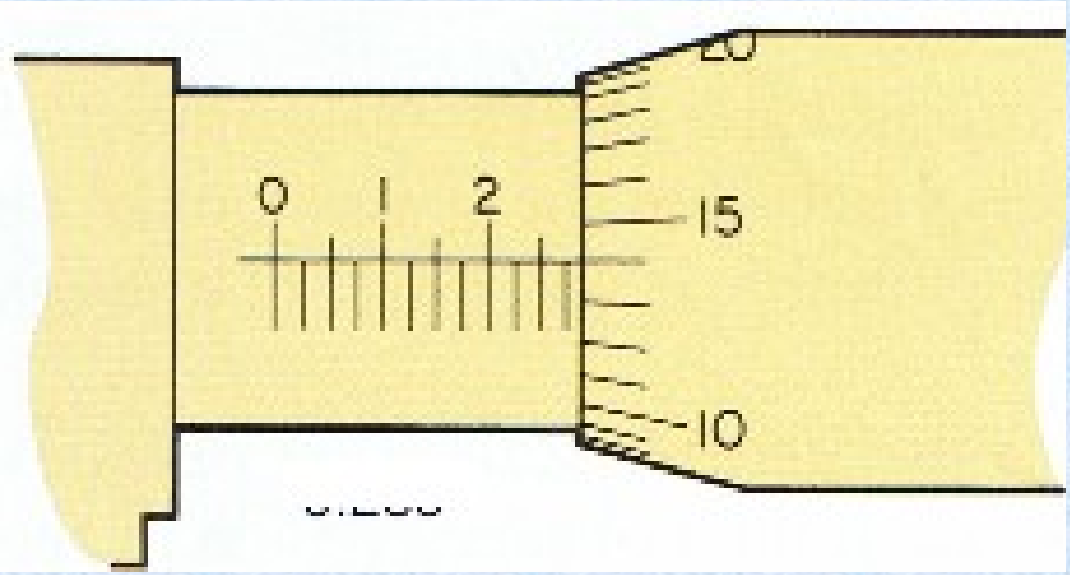
4 large graduations: 4 X 0.100 = 0.400

2 small graduations: 2 X 0.025 = 0.050

8 thimble graduations: 8 X 0.001 = 0.008

Total mike reading = 0.458"

Example 2



Add the readings from the sleeve and the thimble:

2 large graduations: 2 X 0.100 = 0.200

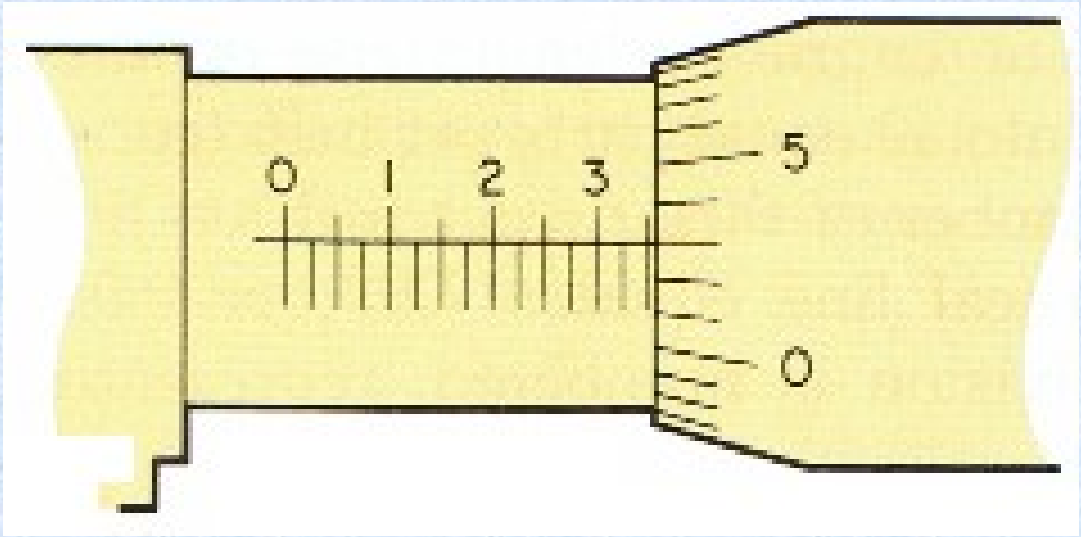
3 small graduations: *3* X 0.025 = 0.075

14 thimble graduations: *14* X 0.001 = <u>0.014</u>

Total mike reading = 0.289"

Test yourself!

Read this micrometer:



Add the readings from the sleeve and the thimble:

3 large graduations: 3 x 0.100 = 0.300

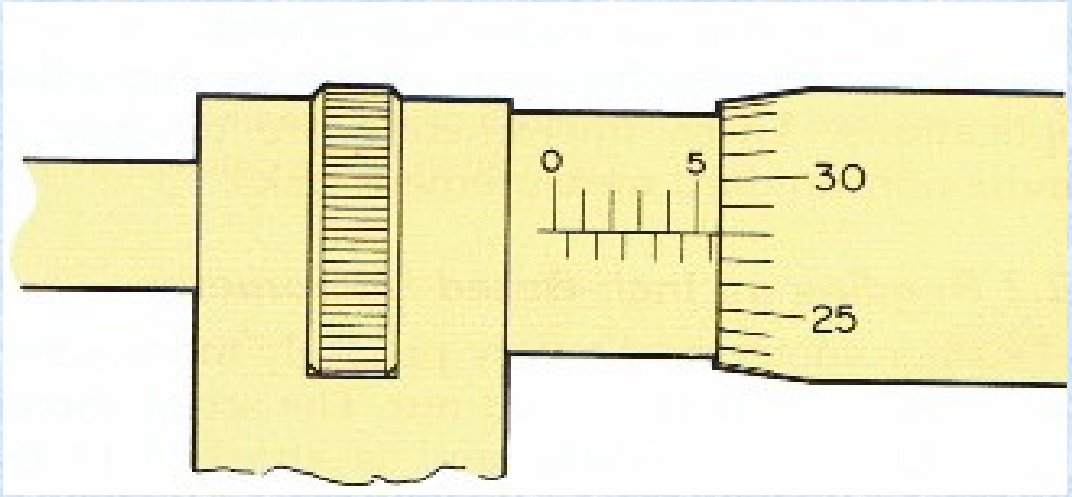
2 small graduations: 2 x 0.025 = 0.050

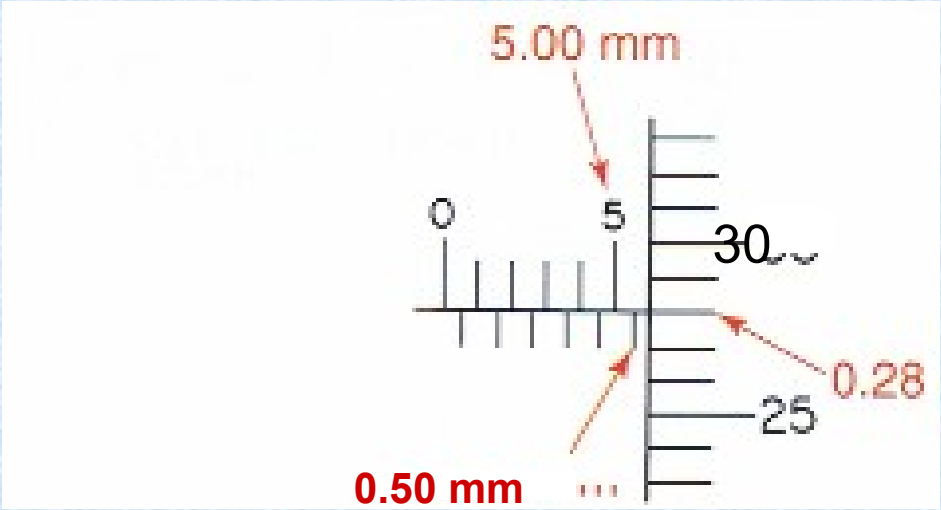
3 thimble graduations: 3 x 0.001 = <u>0.003</u>

Total mike reading = 0.353"

Reading a Metric-Based Micrometer

Follow the same rule:

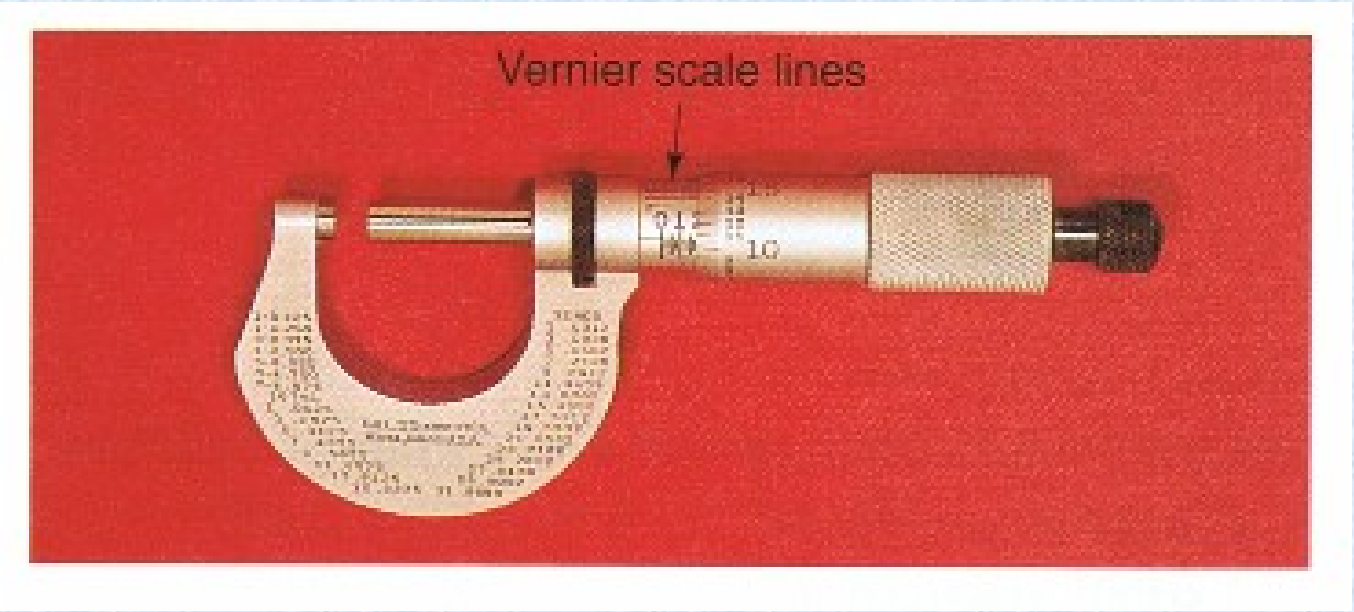




5.00
0.50
<u>0.28</u>

Reading is 5.78 mm

The Vernier Micrometer



On occasion, it is necessary to measure more precisely than 0.001". A Vernier micrometer caliper is used in these situations.

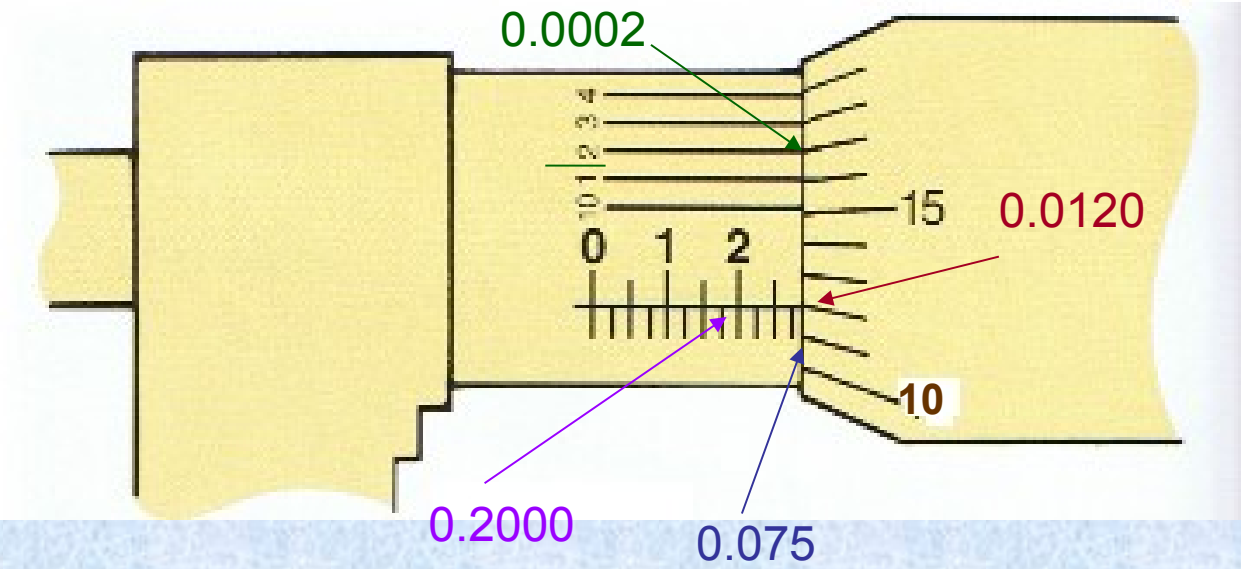
This micrometer has a third scale around the sleeve that will furnish the 1/10,000" (0.0001") reading.

Reading a Vernier Micrometer

The Vernier scale on the sleeve has 10 parallel lines that occupy the same space as 10 lines on the thimble. The lines are numbered 1 to 10.

The difference between the spaces on the sleeve and those on the thimble is one-tenth of a thousandth of an inch.

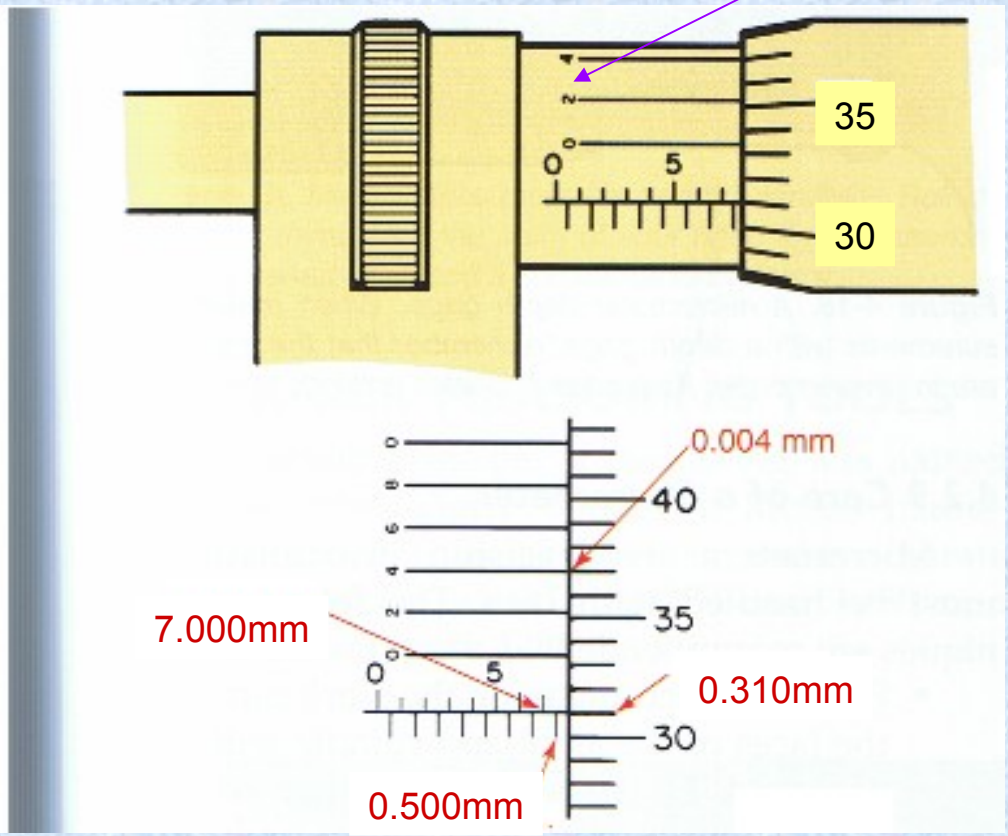
To read the Vernier scale, first obtain the thousandths reading, then observe which of the lines on the Vernier scale coincides (lines up) with a line on the thimble. Only one of them can line up (*If the line is 1, add 0.0001 to the reading; if line 2, add 0.0002 to the reading, etc.*).



0.2000+
0.0750
0.0120
0.0002
0.2872"

Reading a Metric Vernier Micrometer

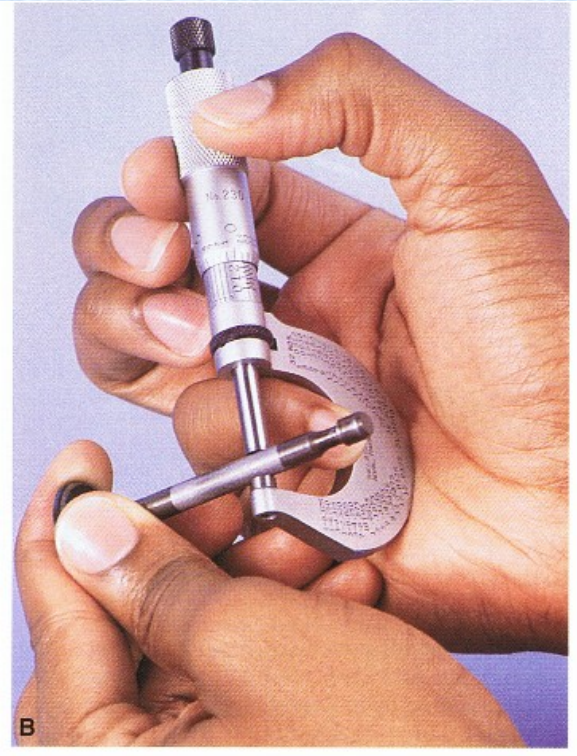
Metric Vernier micrometers are read in the same way as standard metric micrometers. However, using the Vernier scale on the sleeve, an additional reading of two-thousandths of a millimeter can be obtained.



7.000
0.500
0.310
<u>0.004</u>
Reading is 7.814 mm

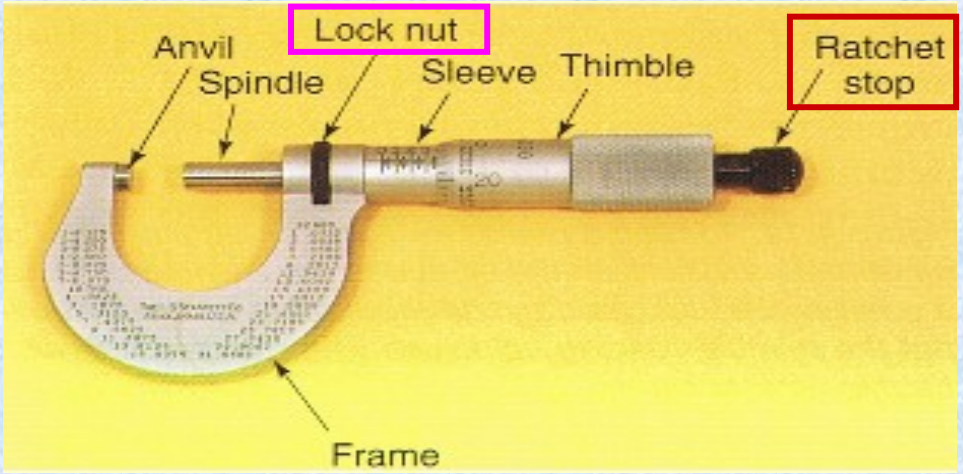
Using the Micrometer

The proper way to hold a micrometer: The piece being measured is placed into position, and the thimble rotated until the part is clamped *lightly* between the anvil and spindle.



Using the Micrometer

Some micrometers have features to help regulate pressure:
A *ratchet stop* is used to rotate the spindle. When the pressure reaches a predetermined amount, the ratchet stop slips and prevents further spindle turning.



A *lock nut* is used when several identical parts are to be gaged. The nut locks the spindle into place. Gaging parts with a micrometer locked at the proper setting is an easy way to determine whether the pieces are sized correctly.

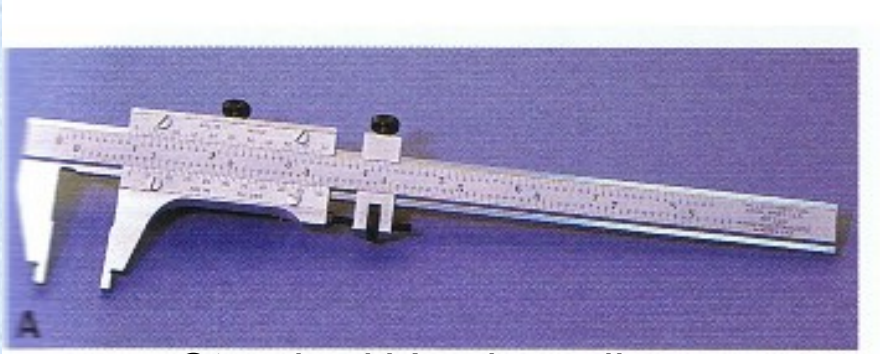
Vernier Measuring Tools

The Vernier principle of measuring was named for its inventor, Pierre Vernier, a French mathematician.

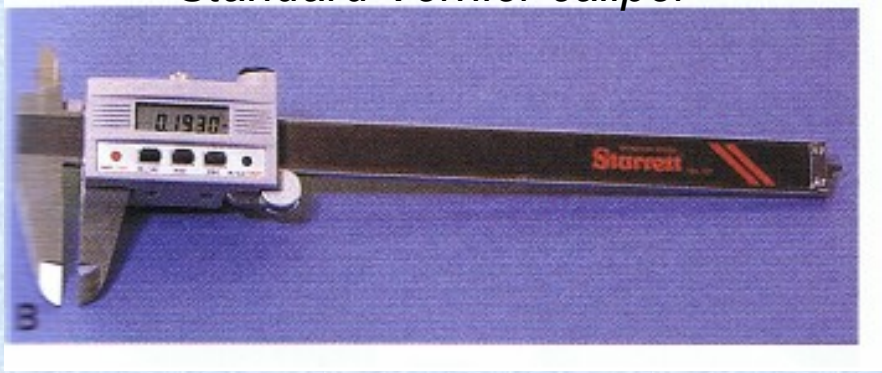
The ***Vernier caliper*** can make accurate measurements to 1/1000" (0.001") and 1/50 mm (0.02 mm).

The design of the tool permits measurements to made over a large range of sizes. It is manufactured as a standard item in 6", 12", 24", 36", and 48" lengths. The 6", 12" sizes are most commonly used.

SI Metric Vernier calipers are available in mm, 300 mm, and 600 mm lengths.

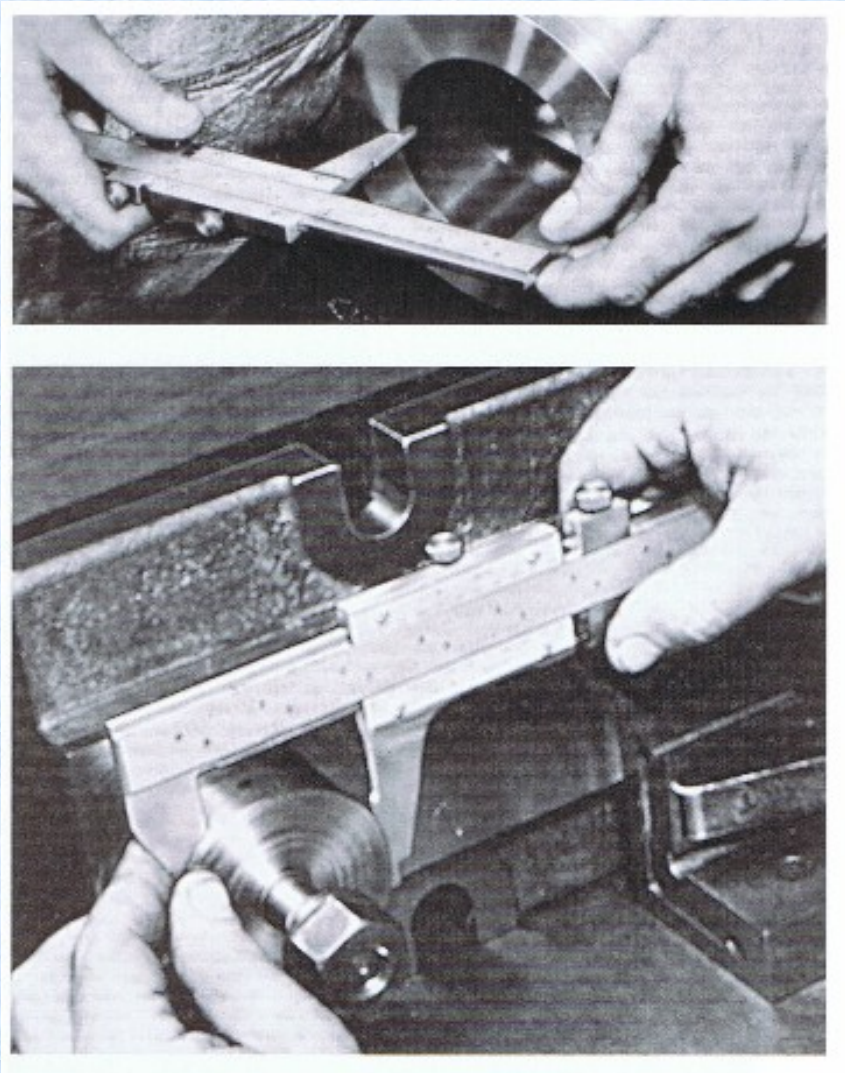


Standard Vernier caliper



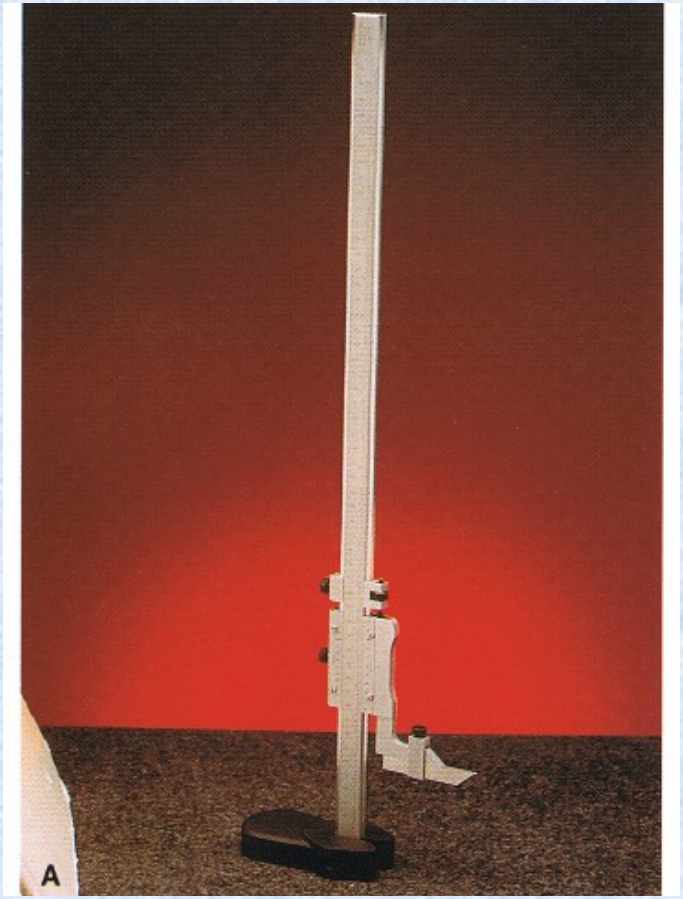
Modern digital calipers

Vernier Measuring Tools

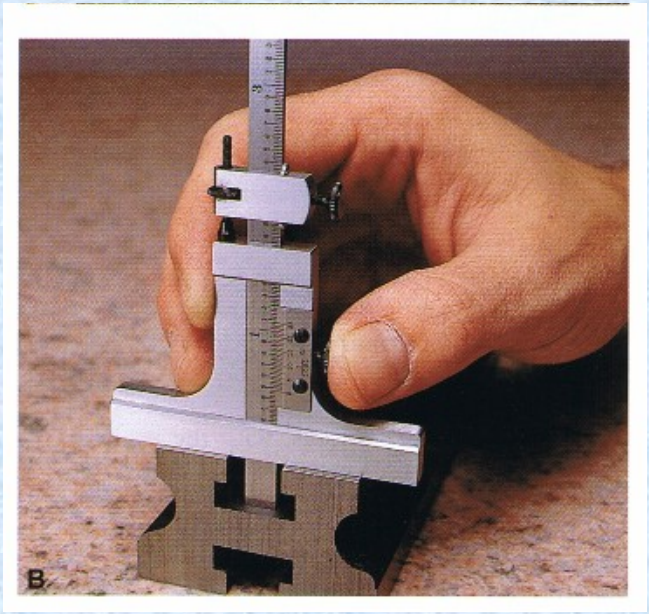


Vernier calipers can be used to make both internal and external measurements.

Vernier Measuring Tools



Height gage

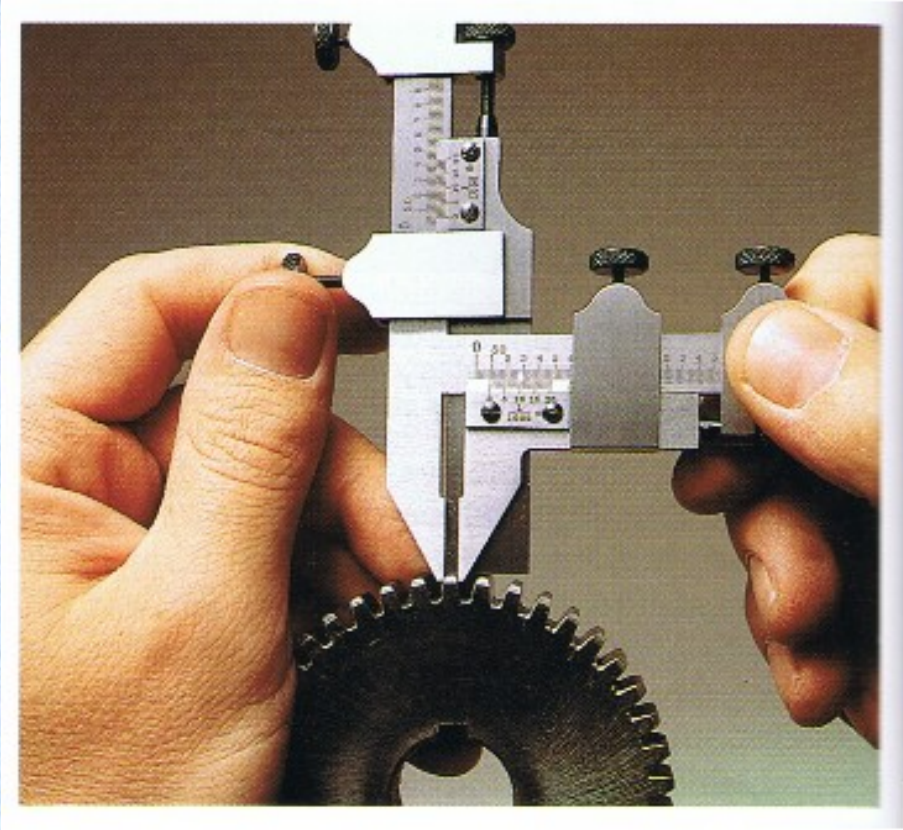


Depth gage

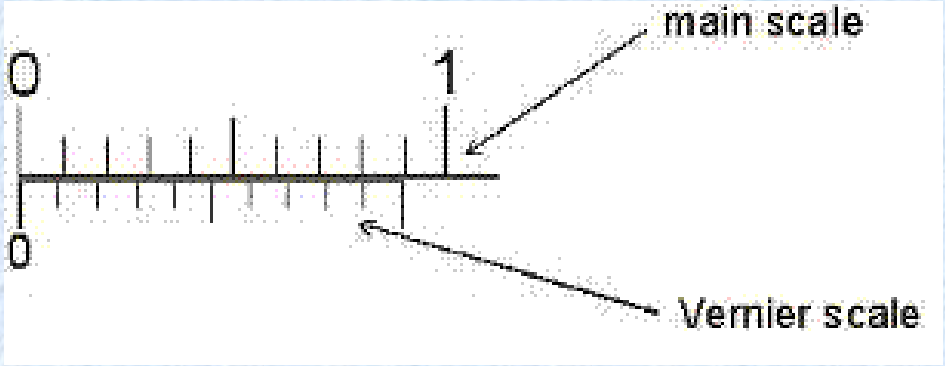
Digital gage

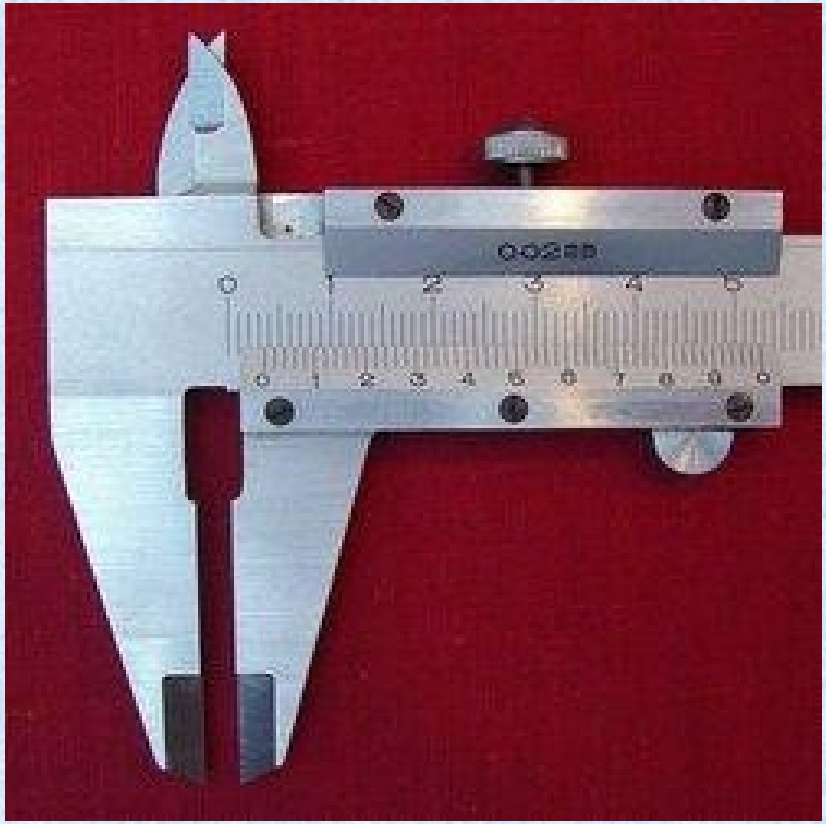
Vernier Measuring Tools

Gear tooth Vernier calipers are used to measure gear teeth, form tools, and threaded tools.



Vernier Scale





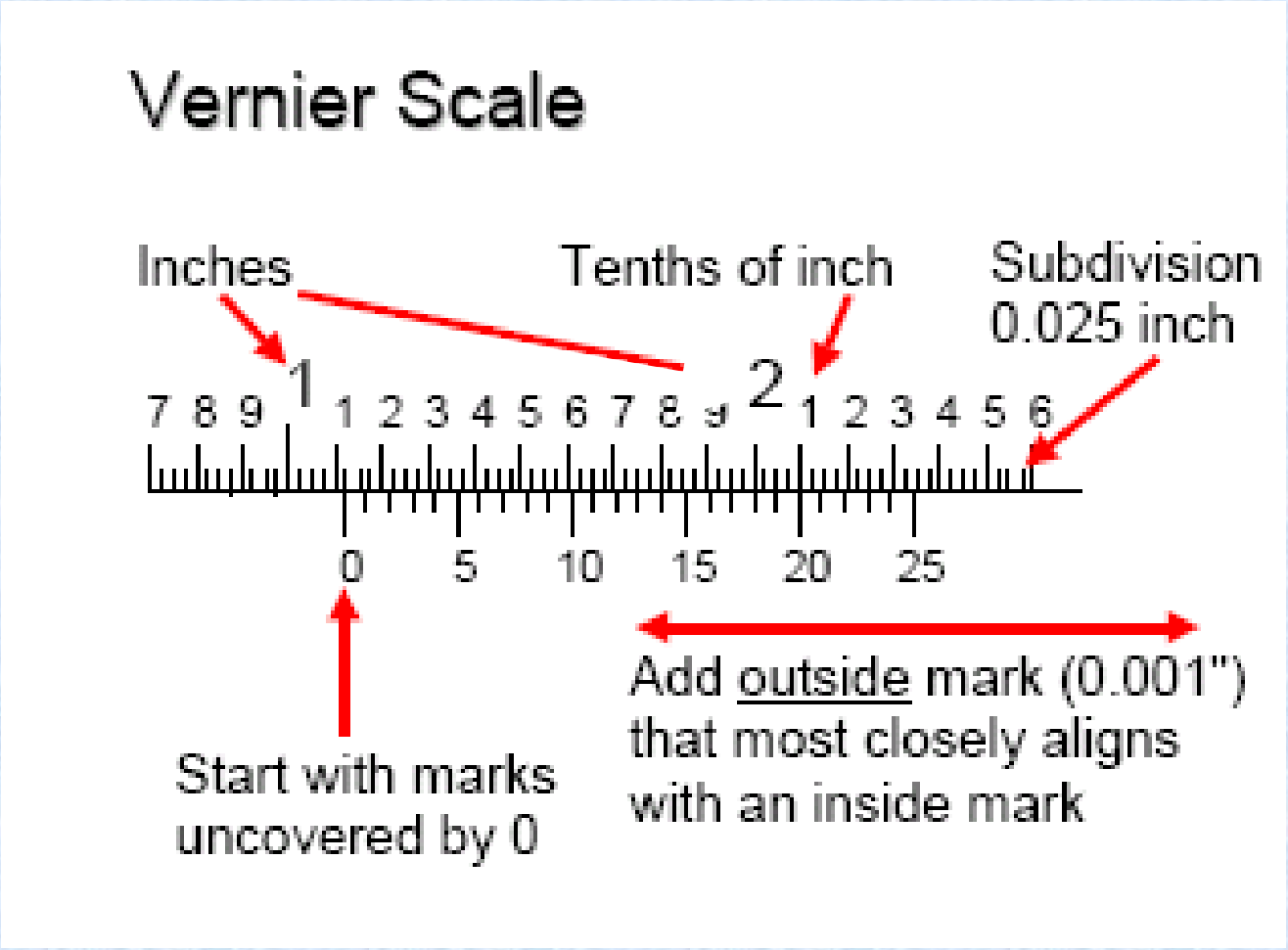
Reading an Inch-based Vernier scale

Two measuring tools are available:

- 25-division Vernier plates.
- It can be read to 0.001".
- Vernier plate is graduated into 40 equal parts.
- Each graduation is 1/40" or 0.025.
- Every four divisions = 0.1"

- 50-division Vernier plates.
- It can be read to 0.001".
- Vernier plate is graduated into 50 equal parts.
- Each graduation is 1/50" or 0.02.
- Every five divisions = 0.1"

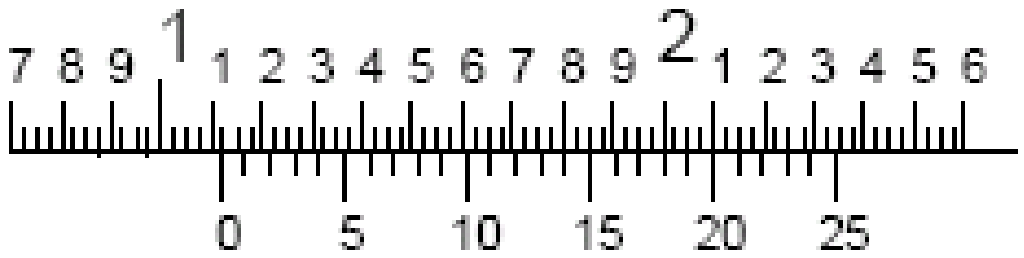
25-division Vernier plates



Every four divisions = 0.1"

25-division Vernier plates

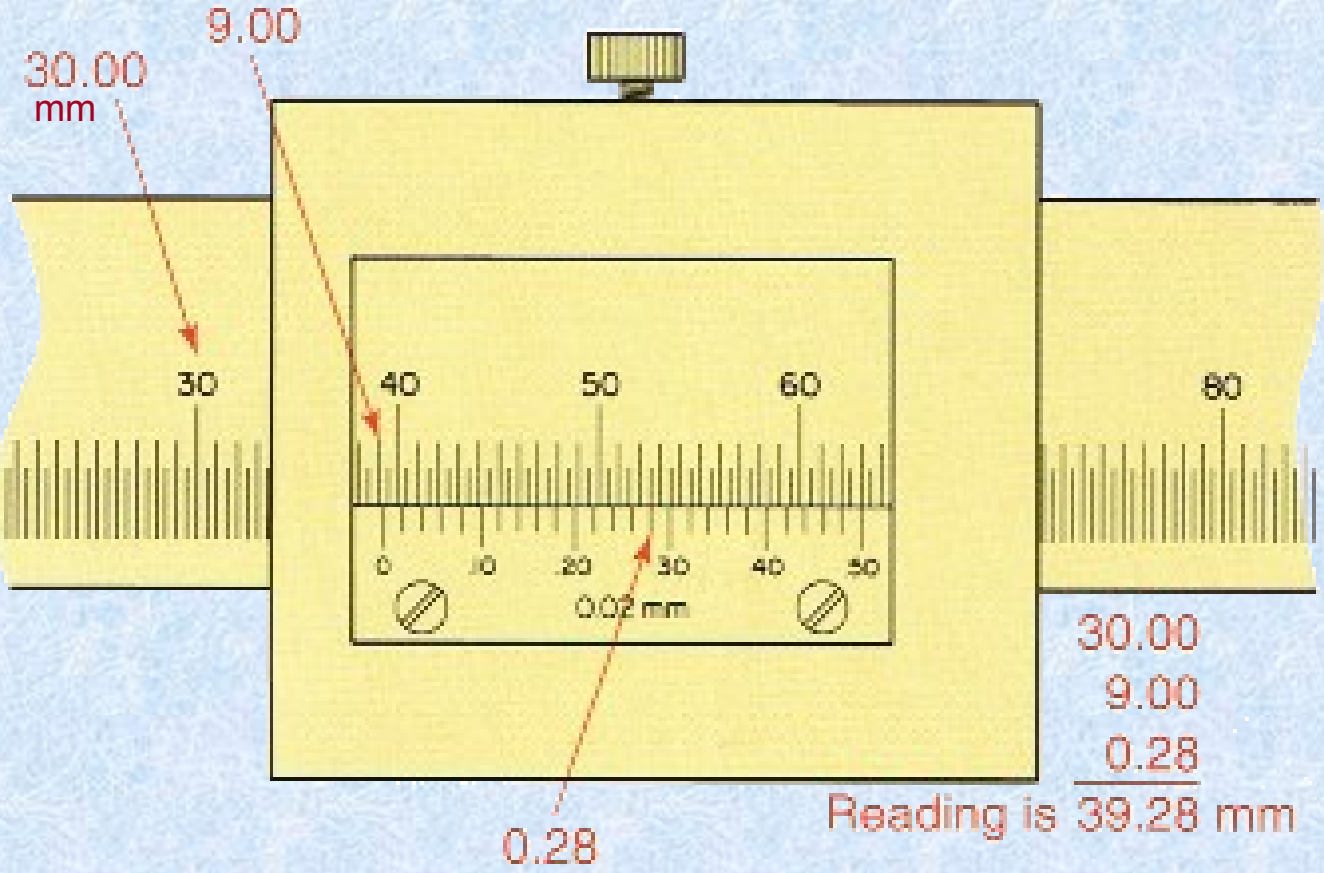
What is the current reading?



1.0 1.0 +
1 x 0.1 = 0.1
1 x 0.025 = 0.025
20 x .001= 0.020
1.145"

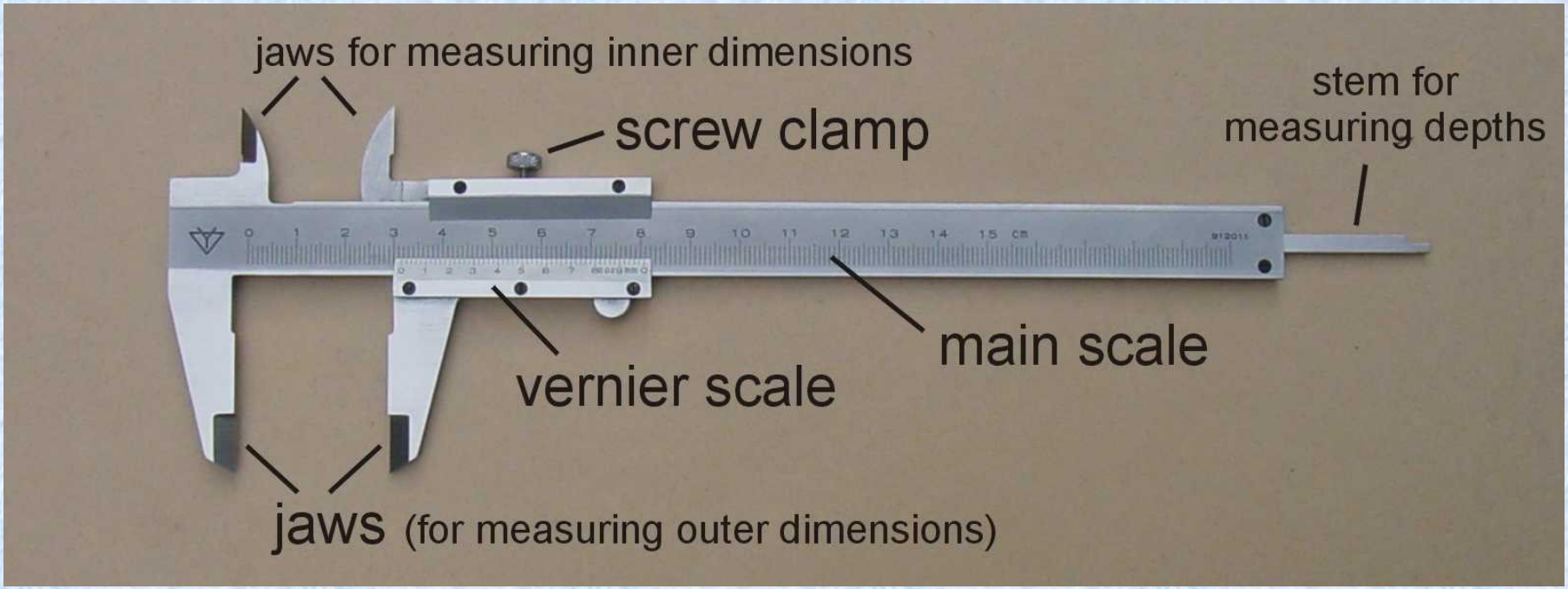
Remember that for a 50-division one, the principle is the same, except that one graduation on the Vernier scale is 0.0008" (0.02/25).

Reading a 25-division metric-based Vernier scale



Readings on the scale are obtained in units of two hundredths of a millimeter (0.02 mm) .

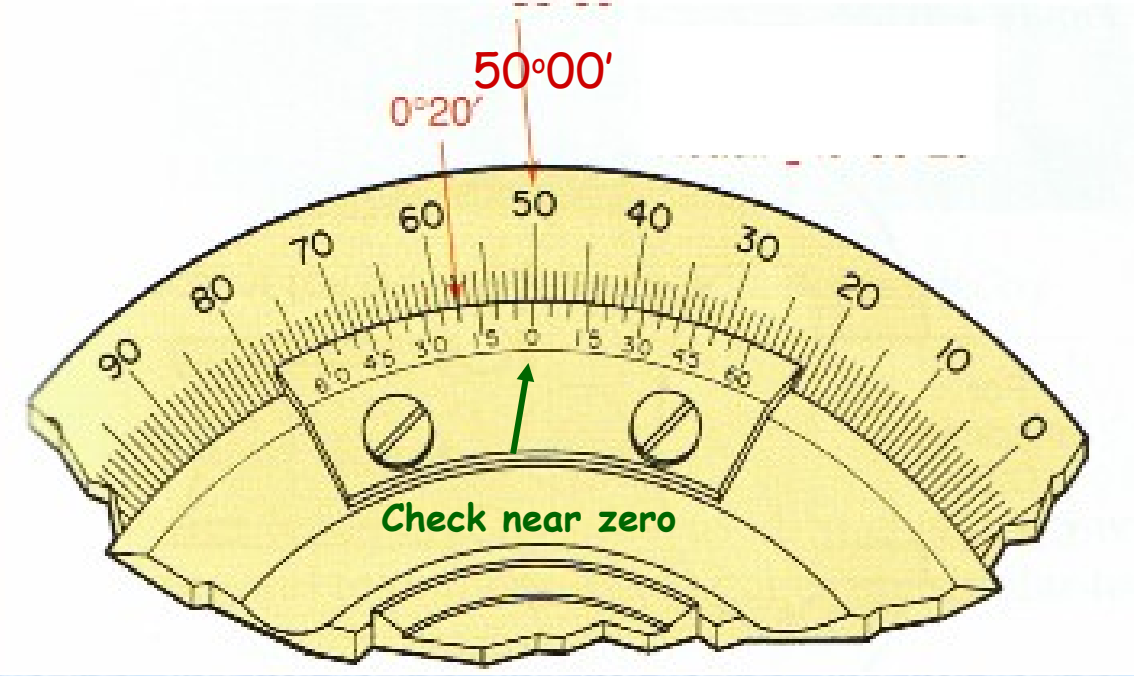
Vernier Caliper



Dial Calipers

Dial calipers provide direct readings of measurements.

Universal Bevel Protractor



$50^{o}\ 00' +$
$0^{o}\ 20'$
$50^{o}\ 20'$

Degree (°) — Regardless of its size, a circle contains 360°. Angles are also measured by degrees.

Minute (′) — A minute represents a fractional part of a degree. If a degree is divided into 60 equal parts, each part is one minute. A foot mark (′) is used to signify minutes (e.g. 30°15′).

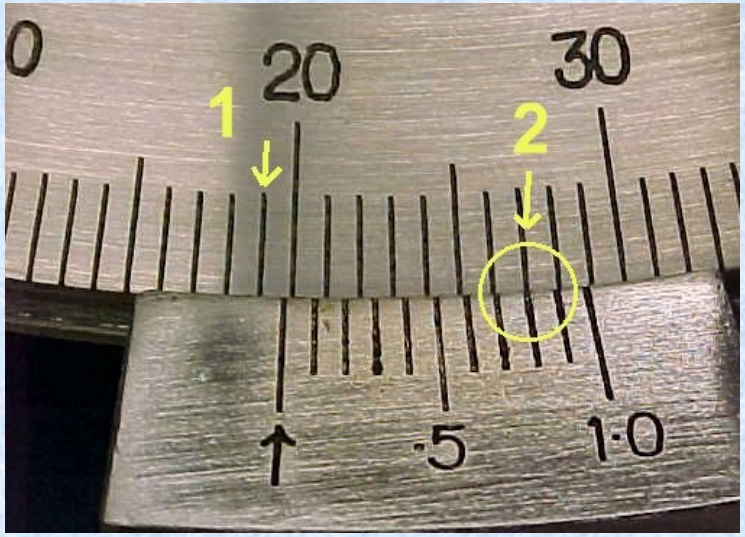
Second (″) — Minutes are divided into smaller units known as seconds. There are 60 seconds in one minute.

Vernier scale for reading the angle

This Vernier scale allows the angle to be read to an accuracy of about 0.05 degrees.

1- Begin by reading the integer of the angle directly – here, this is 19 degrees. Use the next smallest number below the line pointed-to by the arrow ("1" in the figure shown).

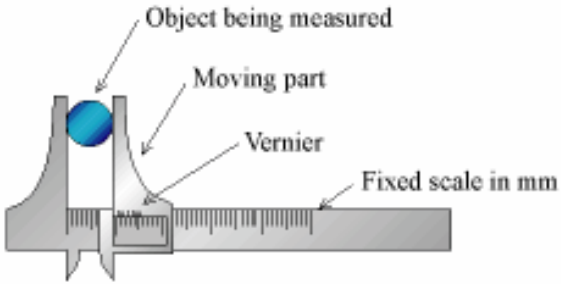
2- Next, the fractional angle can be read using the Vernier. Simply follow the lines across on the Vernier scale (the outside) until you locate the ONE which best lines-up with a line (any line) on the circular inner scale.

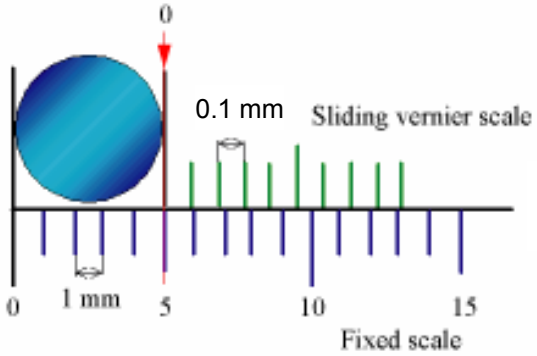


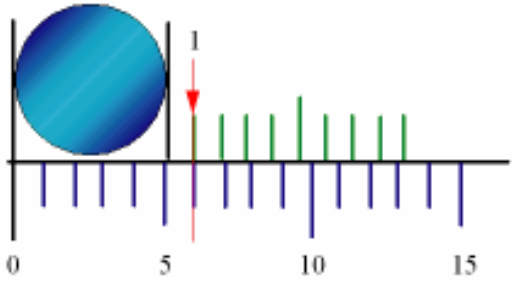
19.8 degrees

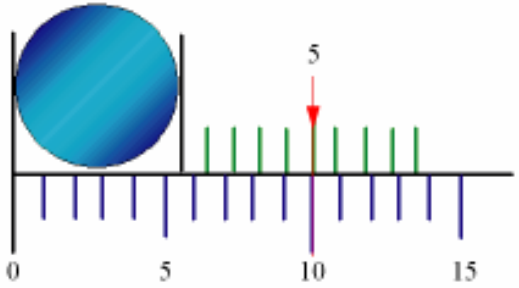
Test yourself!

Read each Vernier:









Gages

Gaging involves checking parts with various gages.

Gaging simply shows whether the piece is made within the specified tolerances.

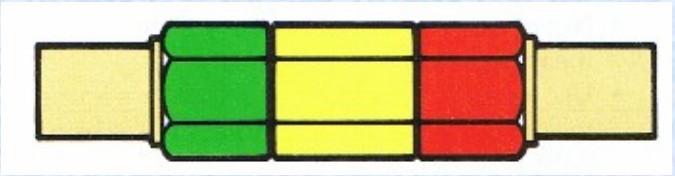
Examples of Gages: plug gages, ring gages, snap gage, thread gage, and optical gages.

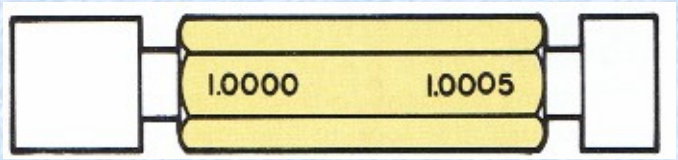
When great numbers of an item with several critical dimensions are manufactured, it might not be possible to check each piece.

It then becomes necessary to decide how many randomly selected pieces must be checked to ensure satisfactory quality. This technique is called ***statistical quality control***.

Plug Gage

Plug gages are used to check whether hole diameters are within specified tolerances.





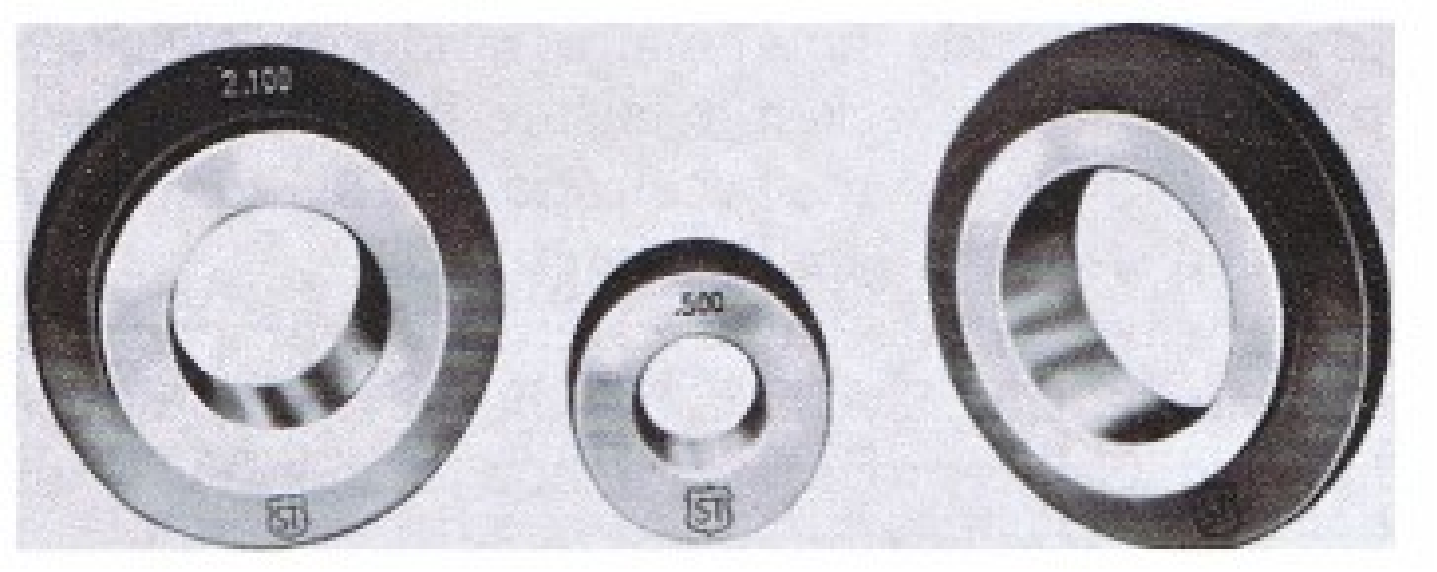
*A double end cylindrical plug gage has two gaging members known as **go** and **no-go** plugs.*

- *The **go plug** should enter the hole with little or no interference.*
- *The **no-go plug** should not fit.*

Ring Gage

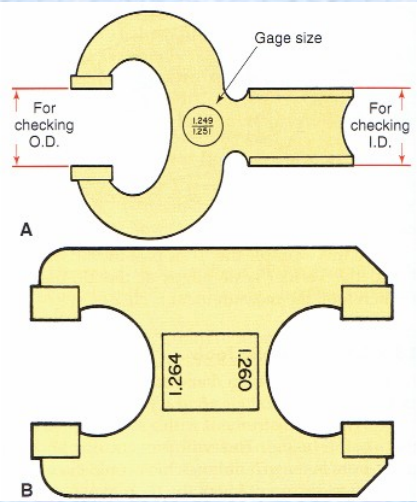
External diameters are checked with ring gages.

The go and no-go ring gages are separate units, and can be distinguished from each other by a groove cut on the knurled outer surface of the no-go gage.

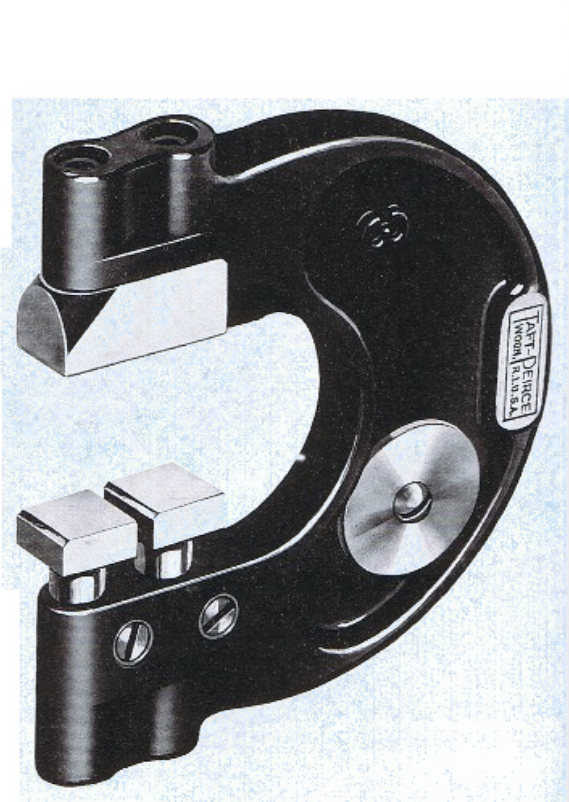


Snap Gage

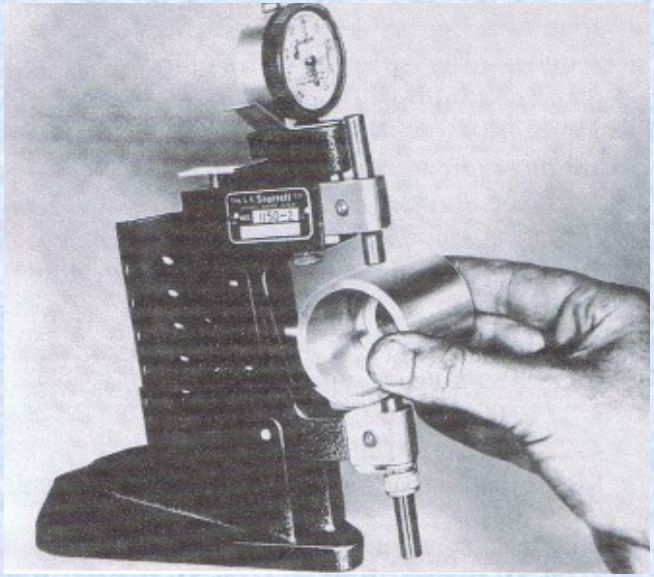
A *snap gage* serves the same purpose as a ring gage. Snap gages are designed to check internal diameters, external diameters, or both. There are three general types:



A *non-adjustable snap gage* is made for one specific size.



An *adjustable snap gage* can be adjusted through a range of sizes.



A *dial indicator snap gage* measures the amount of variation in the part measurement .

Please Visit the following webpages

http://en.wikipedia.org/wiki/Micrometer

http://www.stefanelli.eng.br/en/index.html **very good**

http://members.shaw.ca/ron.blond/index.html **very good**

http://longislandindicator.com/p7.html **(calibration of gages)**