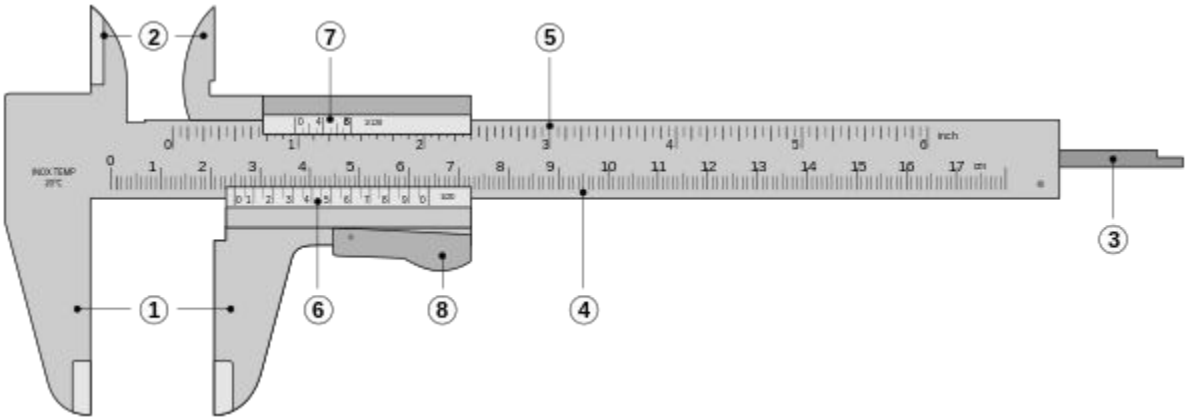
Precision Measuring Tools



1. **Outside large jaws**: used to measure external diameter or width of an object
2. **Inside small jaws**: used to measure internal diameter of an object
3. **Depth probe**: used to measure depths of an object or a hole
4. **Main scale**: scale marked every mm
5. **Main scale**: scale marked in inches and fractions
6. **Vernier scale** gives interpolated measurements to 0.1 mm or better
7. **Vernier scale** gives interpolated measurements in fractions of an inch
8. **Retainer**: used to block movable part to allow the easy transferring of a measurement

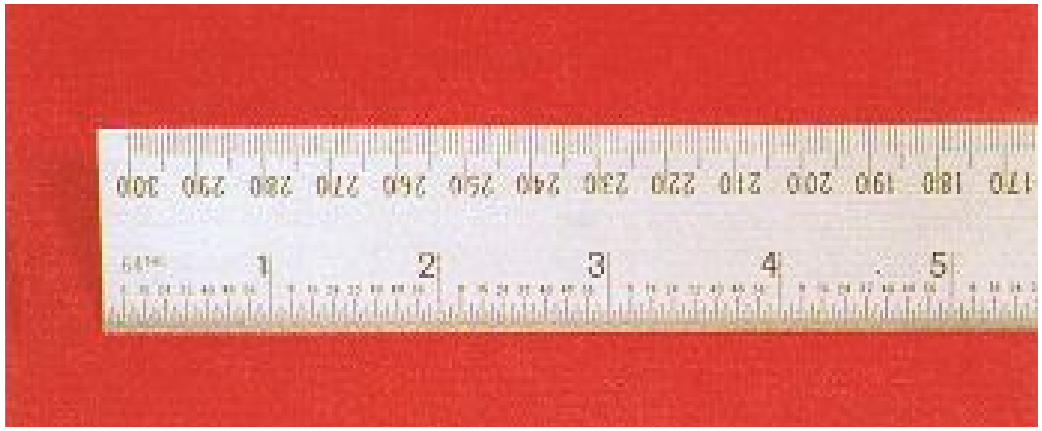
Learning Objectives

- Measure to 1/64" (.5 mm) with a steel rule,
- Measure to 0.001"(.02 mm) using Vernier measuring tools,
- Measure to .0001" (.0002 mm) using a Vernier micrometer caliper,
- Identify and use various types of gauges found in a machine shop,
- Use a dial test indicator,
- Employ the various helper measuring tools found in a machine shop.

Units of Measurement

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

In addition to using English 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).



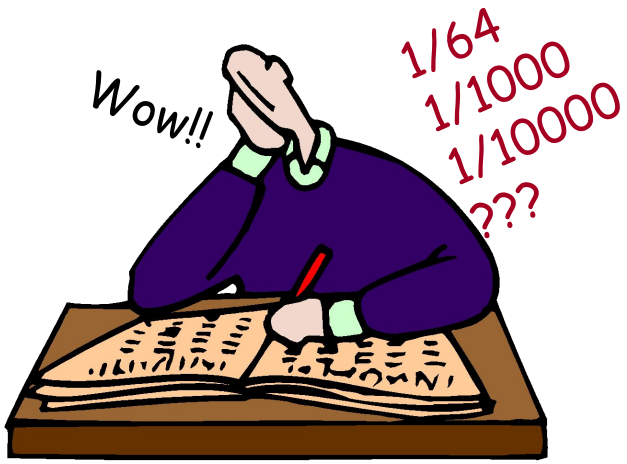
This rule can be used to make measurements in both Imperial Inch and SI Metric units.

Reading a Rule

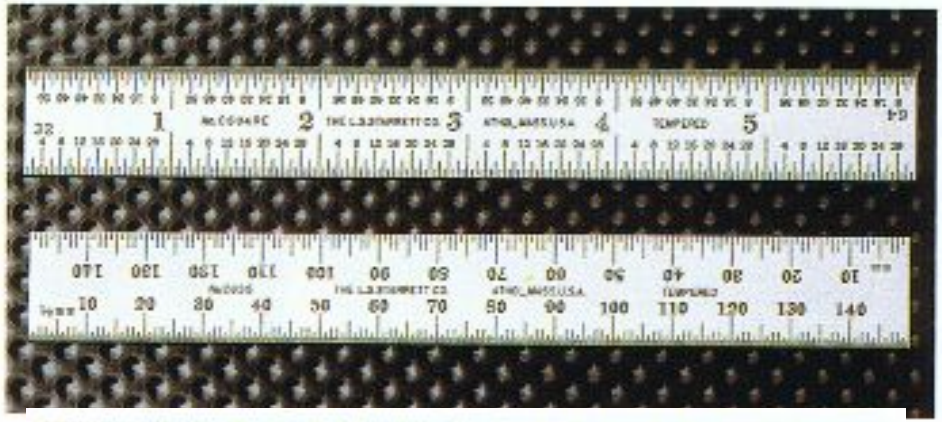
You must first learn to read a rule to 1/64" and 0.5 mm.

Then, you can progress through 1/1000" (0.001") and 1/100 mm (0.01 mm) by learning to use micrometer and Vernier-type measuring tools.

Finally, you can progress to 1/10,000" (0.0001") and 1/500 mm (0.002 mm) by using the Vernier scale on some micrometers.

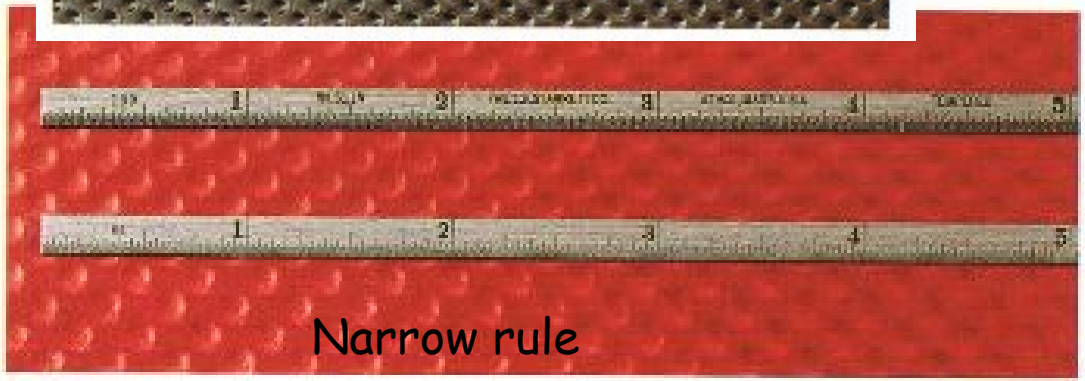


Different Types of Rules

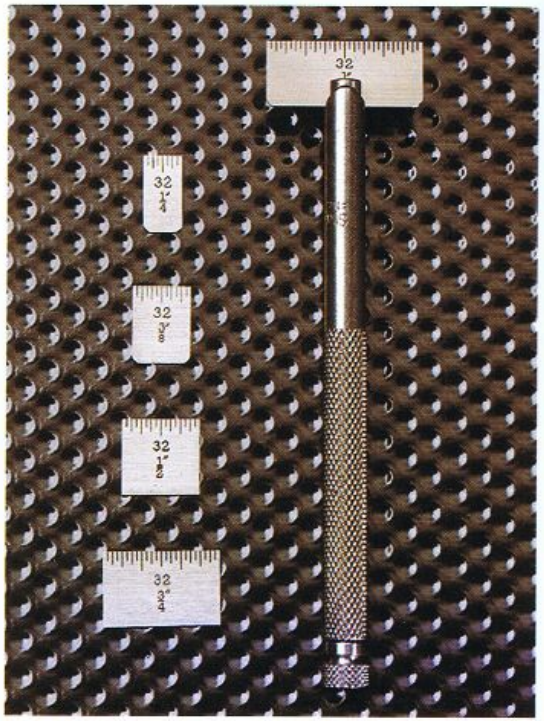


6" steel rule

Rule with adjustable hook



Narrow rule



Small rules with holder

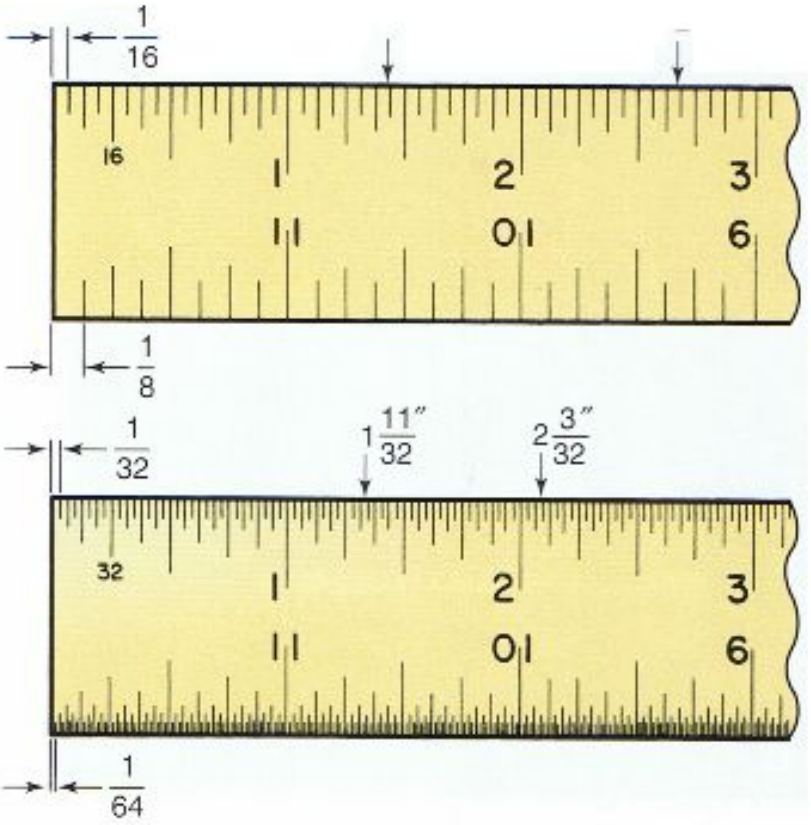
Reading the Rule (Imperial Inch)

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, <u>every fourth</u> graduation is numbered on the 1/32 edge, and <u>every eighth</u> graduation on the 1/64 edge.

To become familiar with the rule, begin by measuring objects on the 1/8 and 1/16 scales. Once you become comfortable with these scales, begin using the 1/32 and 1/64 scales.



Some rules are graduated in 10ths, 20ths, 50ths, and 100ths!!

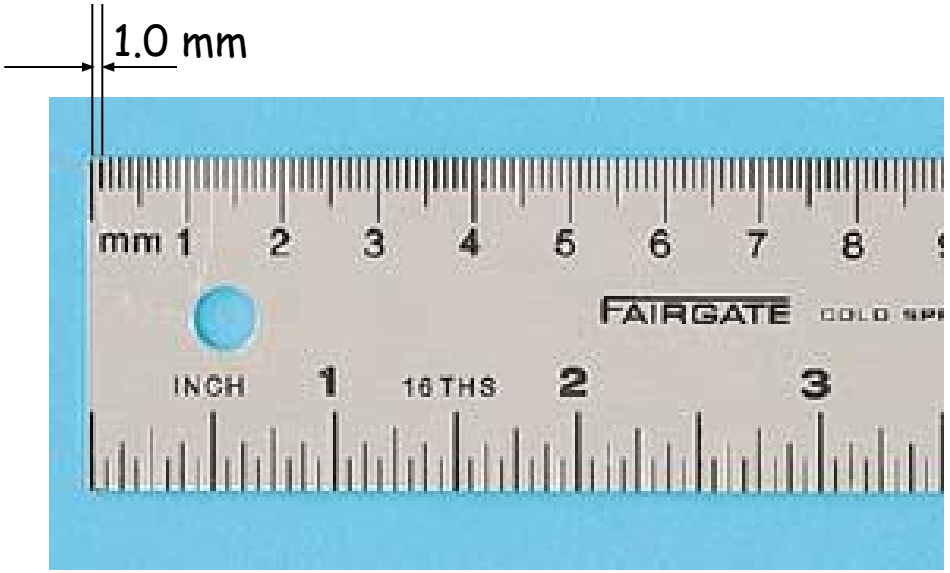
<u>Fractional measurements</u> are *always* <u>reduced to the lowest terms</u>. A measurement of 14/16" is reduced to 7/8", 2/8" becomes 1/4", and so on.

Reading the Rule (Metric)

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

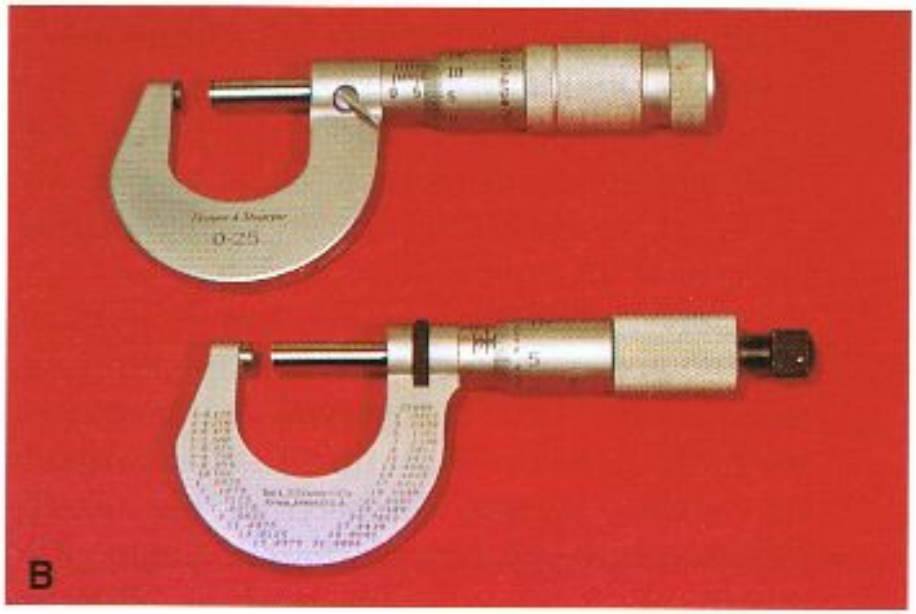
They are numbered every 10 mm (1 cm).

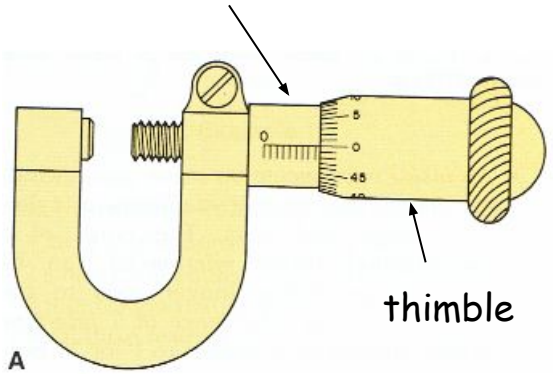
The measurement is determined by counting the number of millimeters.



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





The *micrometer*, also known as a mic pronounced "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.

The device, called *Systeme Palmer*, is the basis for the modern micrometer.

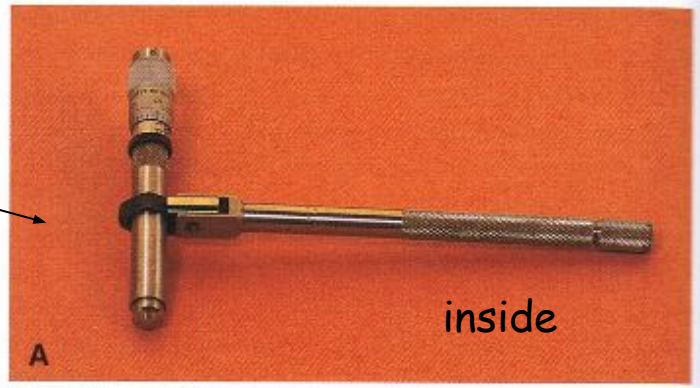
Types of Micrometers

An *outside micrometer* measures external diameters and thickness,

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.

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

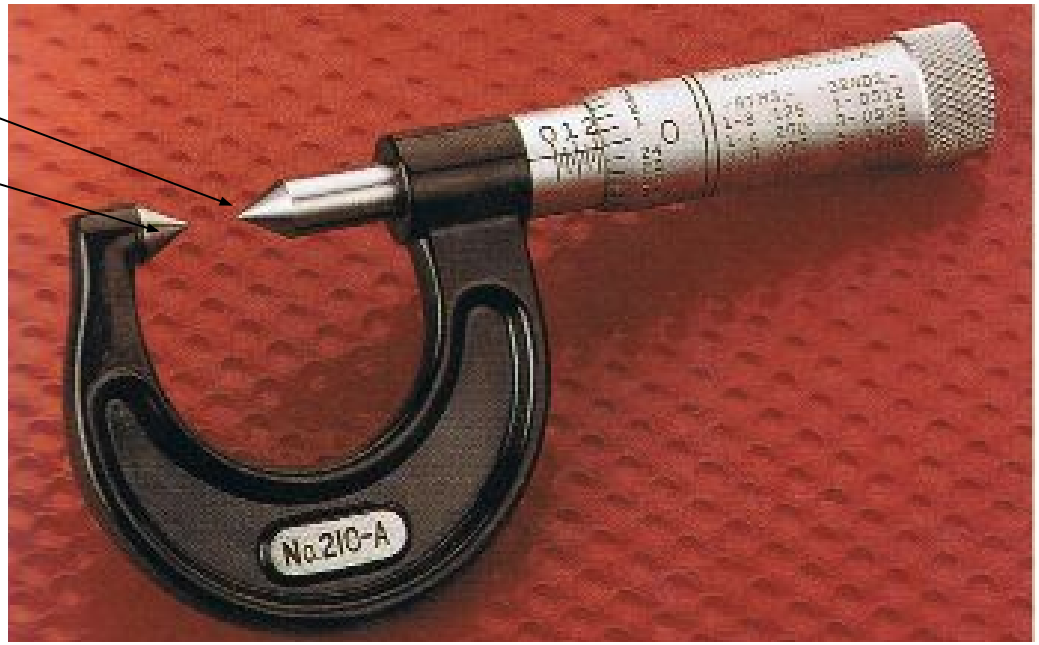


Types of Micrometers

A *micrometer depth gauge* 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.

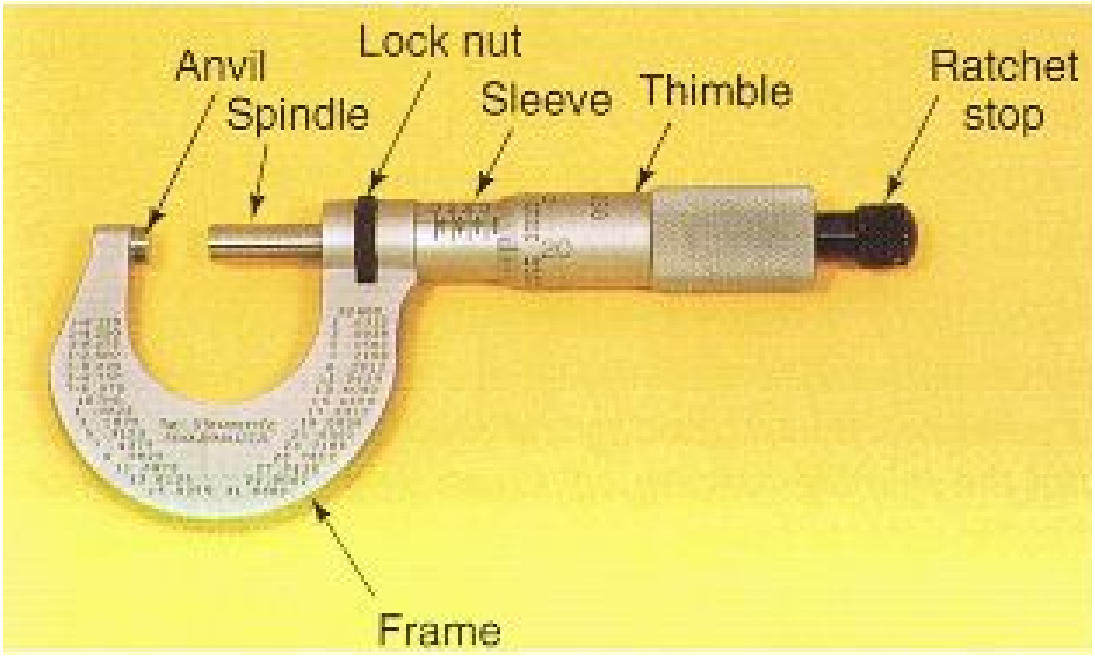


It measures the pitch diameter of the thread, which equals the outside (major) diameter of the thread minus the depth of one thread.

Since each thread micrometer is designed to measure only a limited number of threads per inch, a set of thread micrometers is necessary to measure a full range of thread pitches.

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.

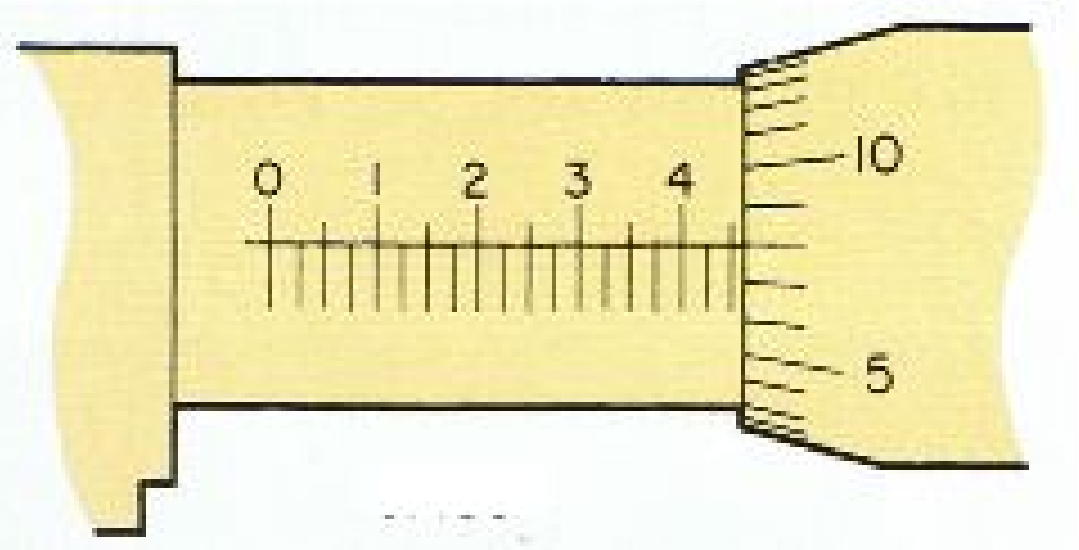
The line engraved lengthwise on the sleeve is divided into 40 equal parts per inch (corresponding to the number of threads per inch on the spindle). Each vertical line equals 1/40", or 0.025".

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.

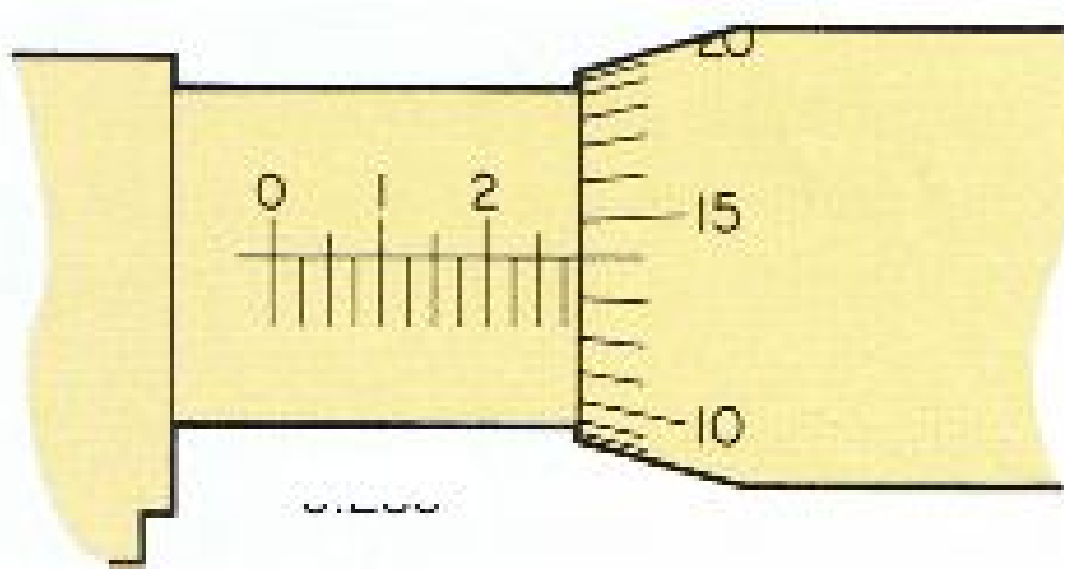
Example 1



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 = <u>0.008</u>
Total mike reading	= 0.458"

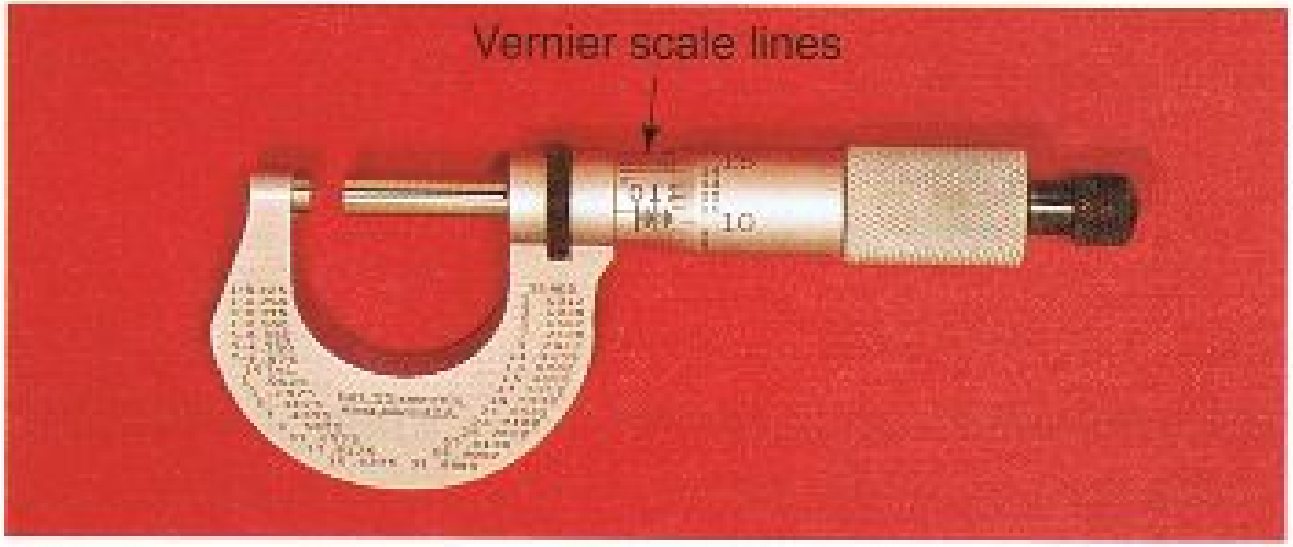
Example 2



Add the readings from the sleeve and the thimble:

2 large graduations:	2X 0.100=0.200
3 small graduations:	3X 0.025=0.075
14 thimble graduations:	14X 0.001= 0.014
Total mike reading	= 0.289"

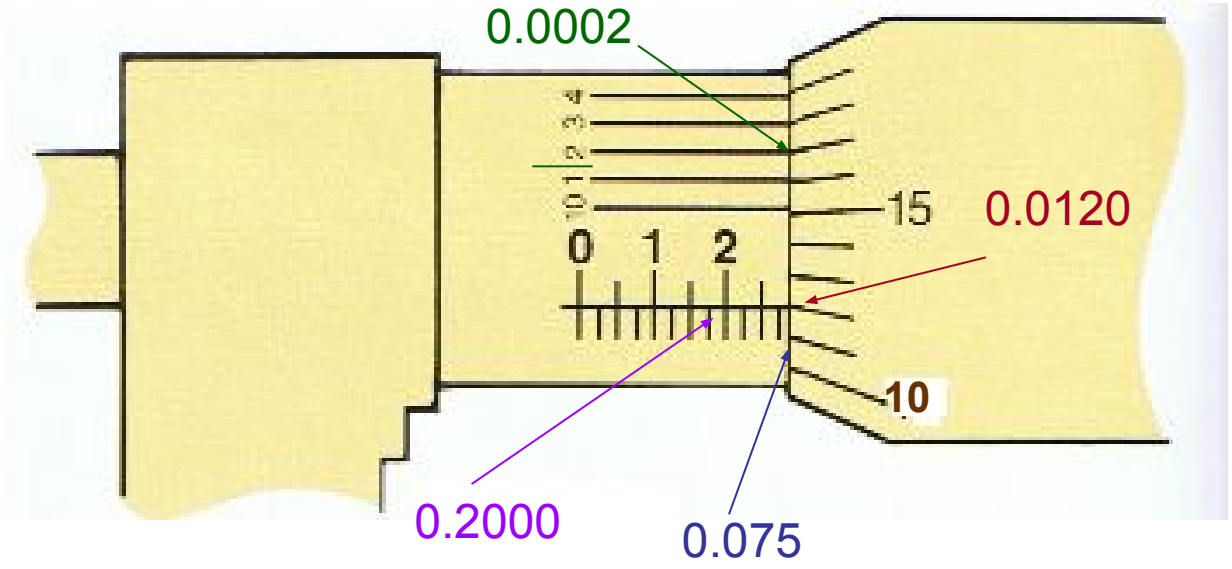
Reading a Vernier Micrometer



On occasion, it is necessary to measure more precisely than 0.001".
A Vernier micrometer 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

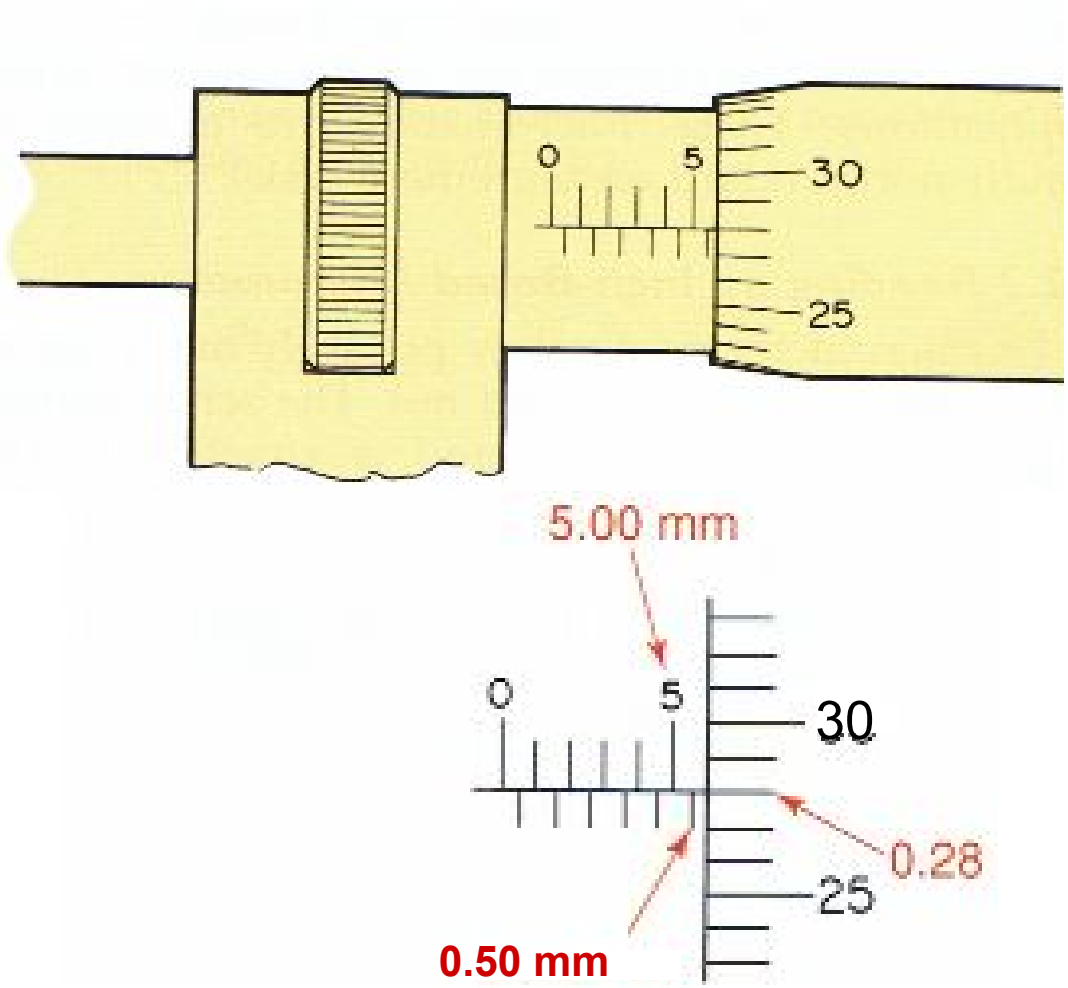
The Vernier scale has 11 parallel lines that occupy the same space as 10 lines on the thimble.
The lines around the sleeve are numbered 1 to 10.
The difference between the spaces on the sleeve and those on the thimble is one-tenth of a thousandth of an inch.
To read the Vernier scale, first obtain the 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 an Metric-Based Micrometer

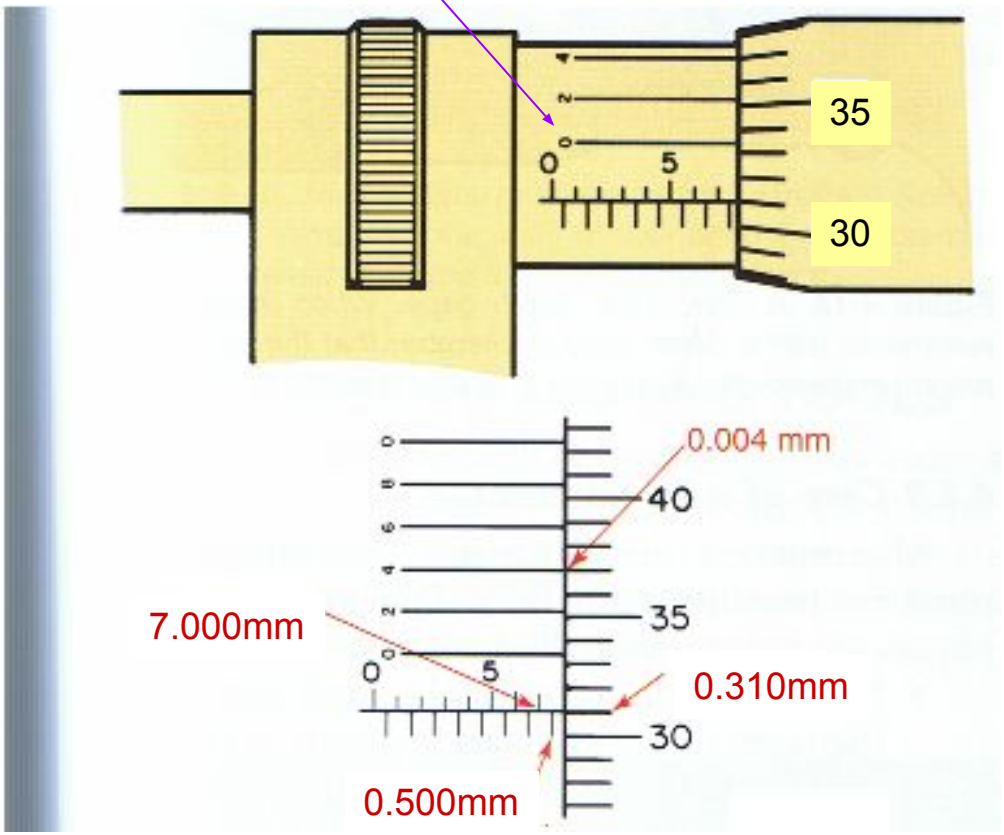
Follow the same rule:



5.00
0.50
<u>0.28</u>
Reading is 5.78 mm

Reading a Metric Vernier Micrometer

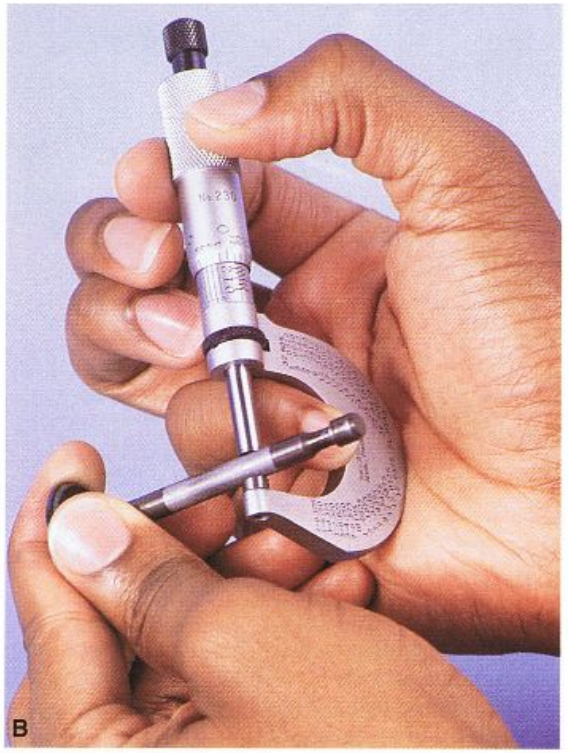
Metric Vernier micrometers are read in the same way as standard metric micrometers. However, using the Vernier scale on the sleeve, an additional reading of two-thousandths of a millimeter can be obtained.



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

Using the Micrometer

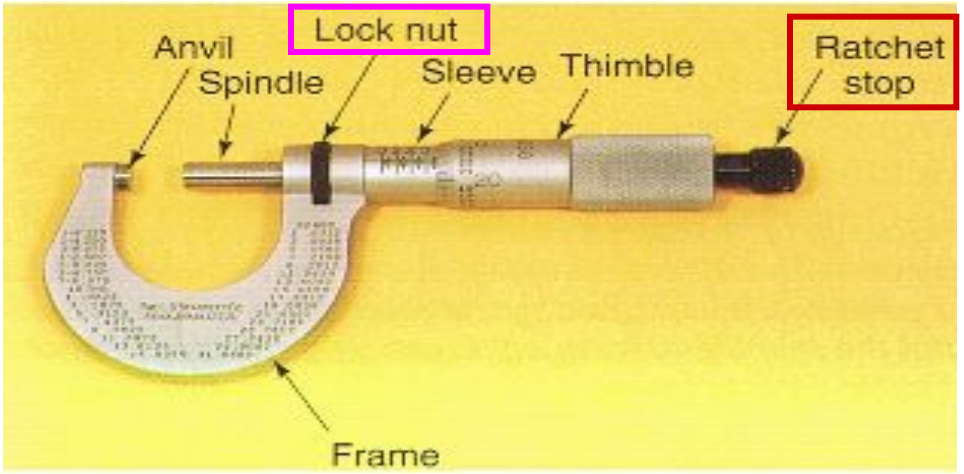
The proper way to hold a micrometer: The work is placed into position, and the thimble rotated until the part is clamped *lightly* between the anvil and spindle.



When the piece being measured must also be held, position the micrometer as shown, with a finger in the micrometer frame.

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.

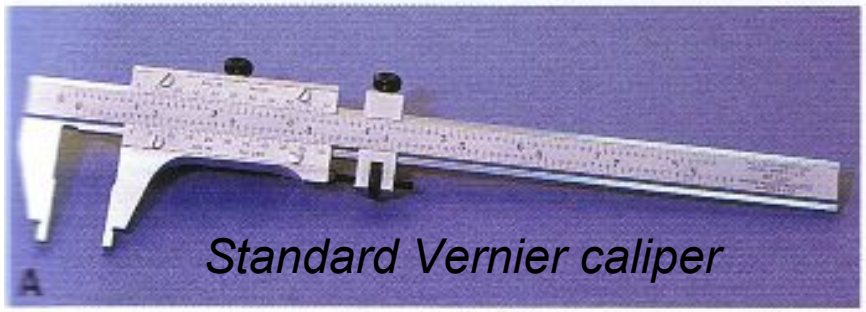


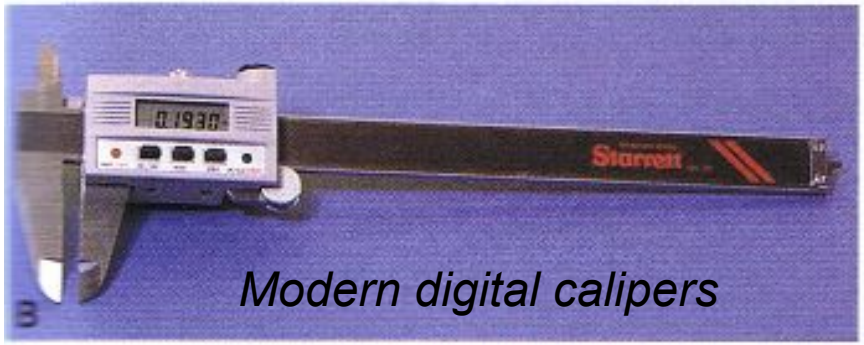
A *lock nut* is used when several identical parts are to be gaged. The nut locks the spindle into place. Gauging parts with a micrometer locked at the proper setting is an easy way to determine whether the pieces are sized correctly.

Vernier Measuring Tools

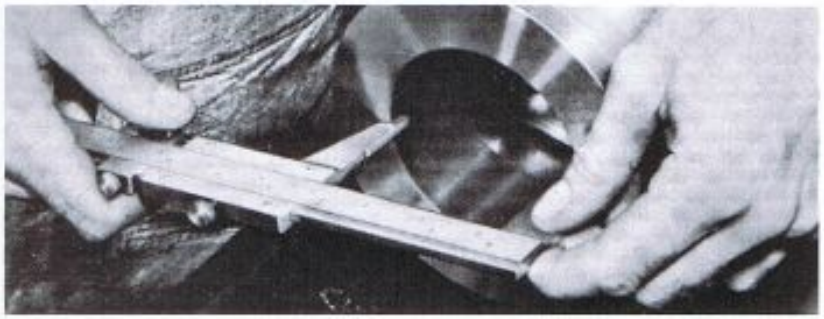
The Vernier principle of measuring was named for its inventor, Pierre Vernier, a French mathematician.
The ***Vernier caliper*** can make accurate measurements to 1/1000" (0.001") and 1/50 mm (0.02 mm).

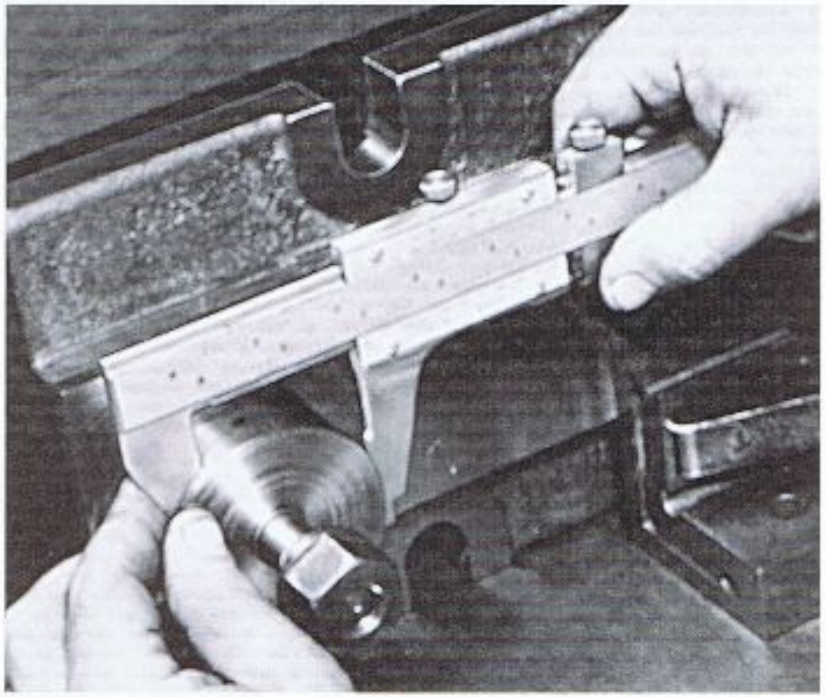
The design of the tool permits measurements to made over a large range of sizes. It is manufactured as a standard item in 6", 12", 24", 36", and 48" lengths.
SI Metric Vernier calipers are available in mm, 300 mm, and 600 mm lengths.
The 6", 12" sizes are most commonly used.





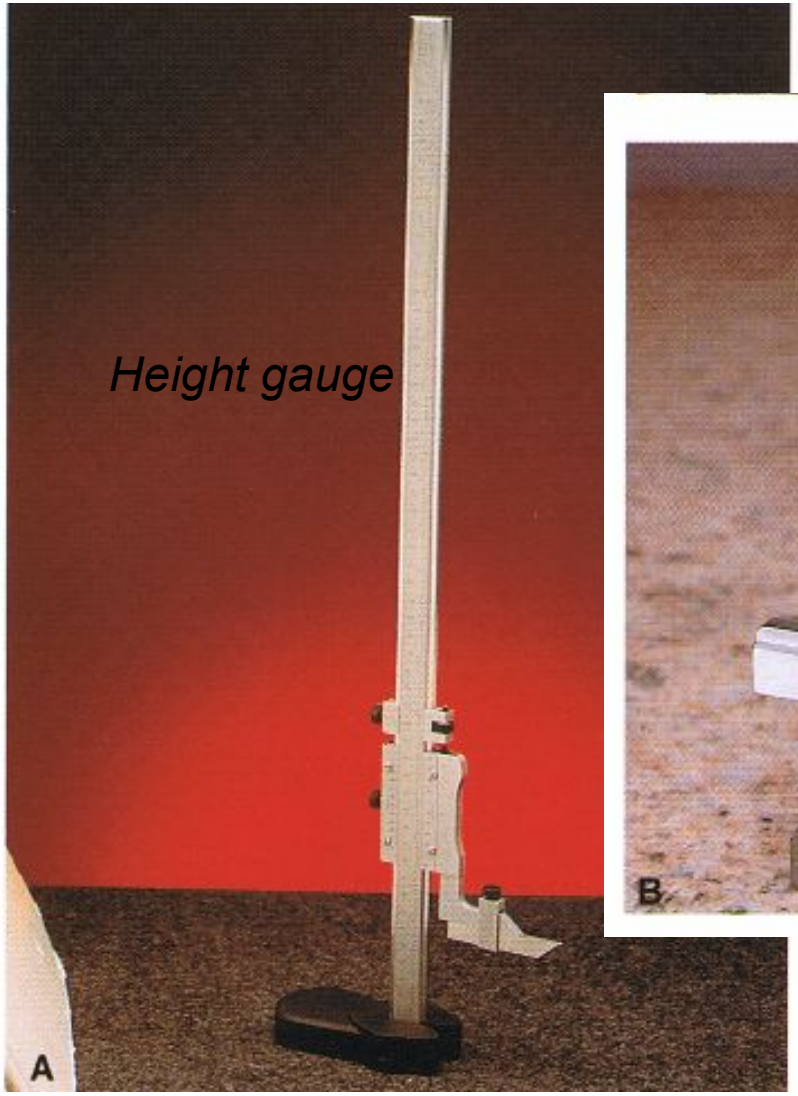
Vernier Measuring Tools



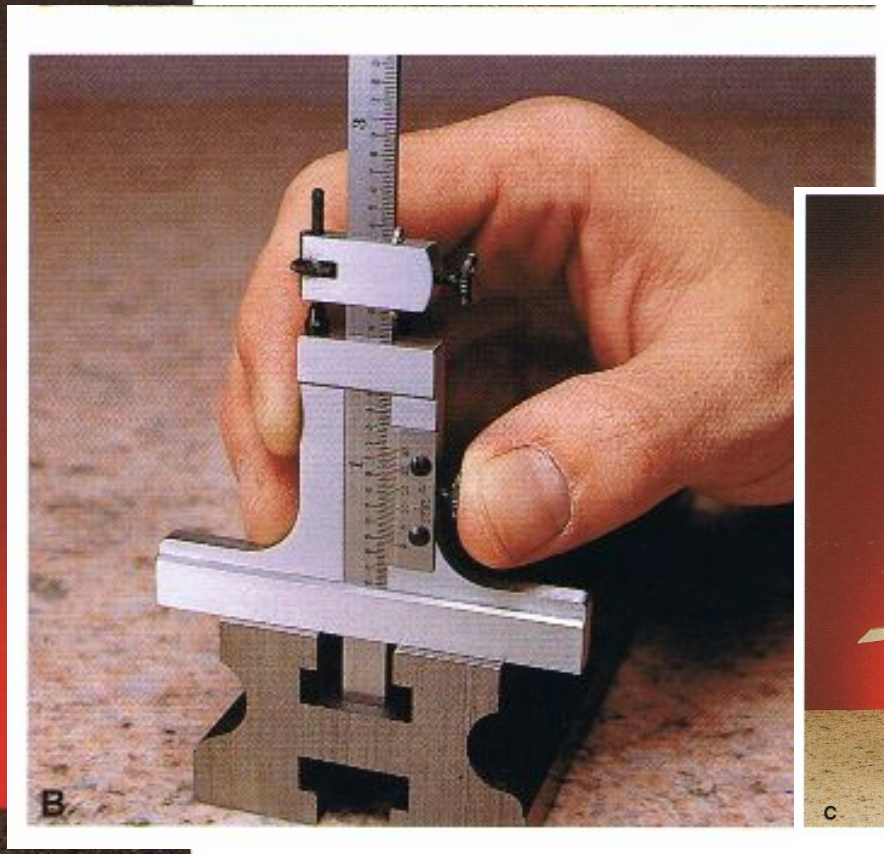


Vernier calipers can be used to make both internal and external measurements as well as depth.

Vernier Measuring Tools



Height gauge

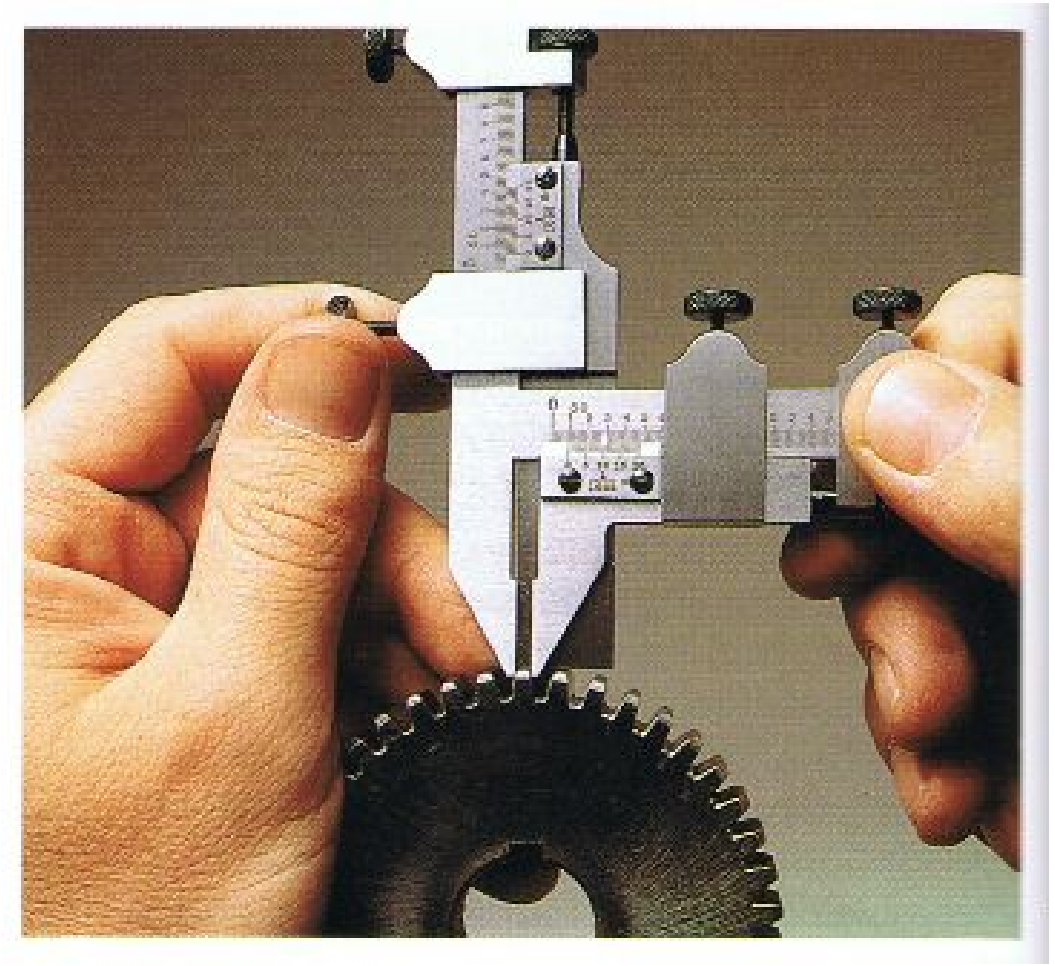


Depth gauge

Digital gauge

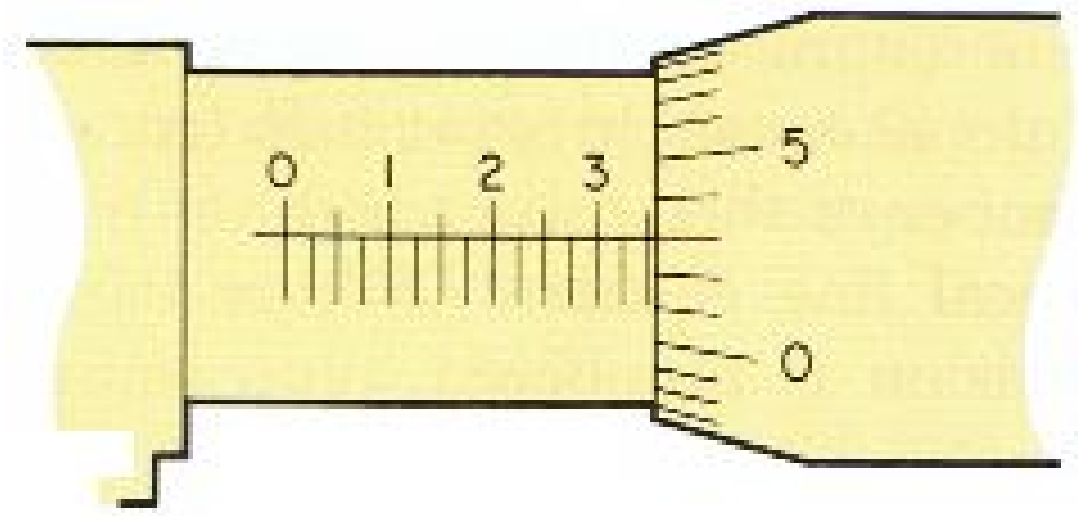
Vernier Measuring Tools

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



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 = 0.003
Total mike reading = 0.353"