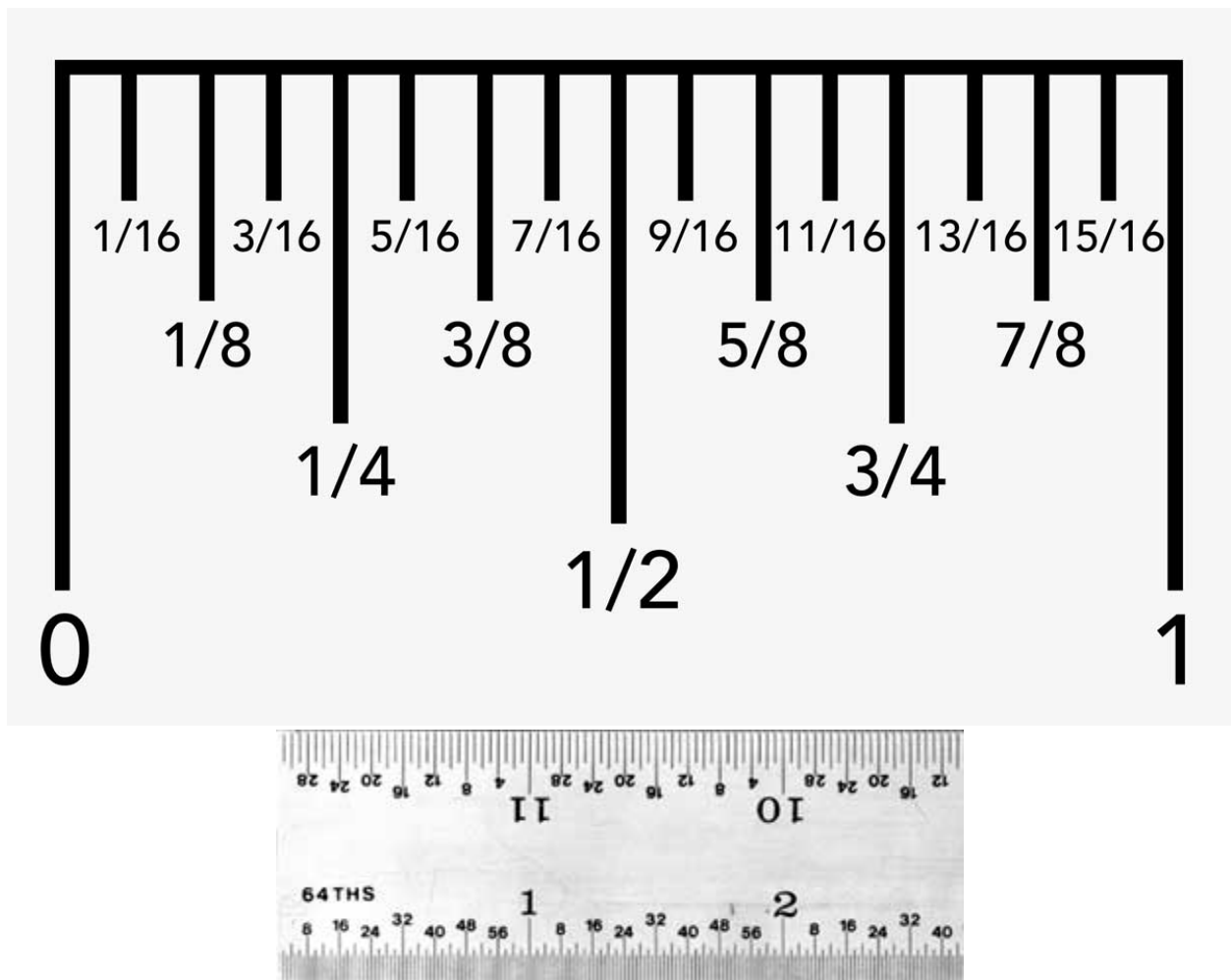
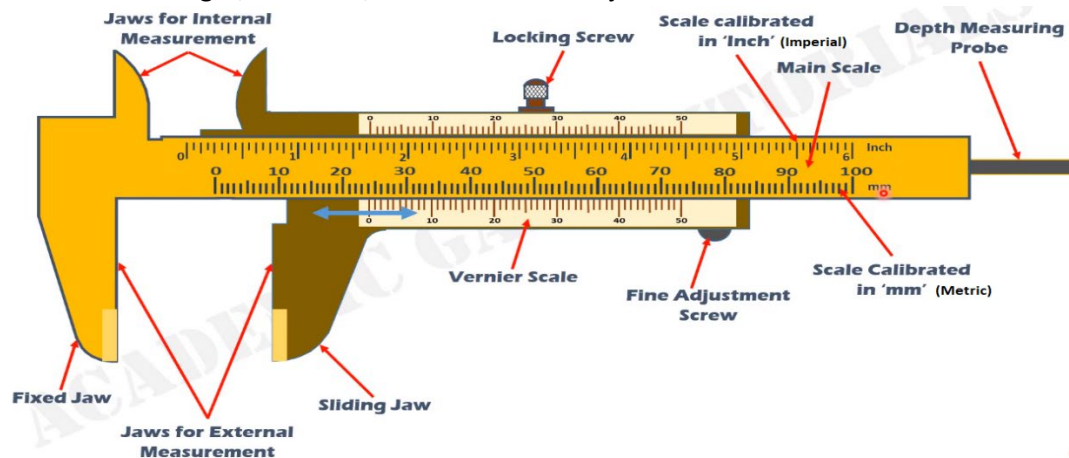


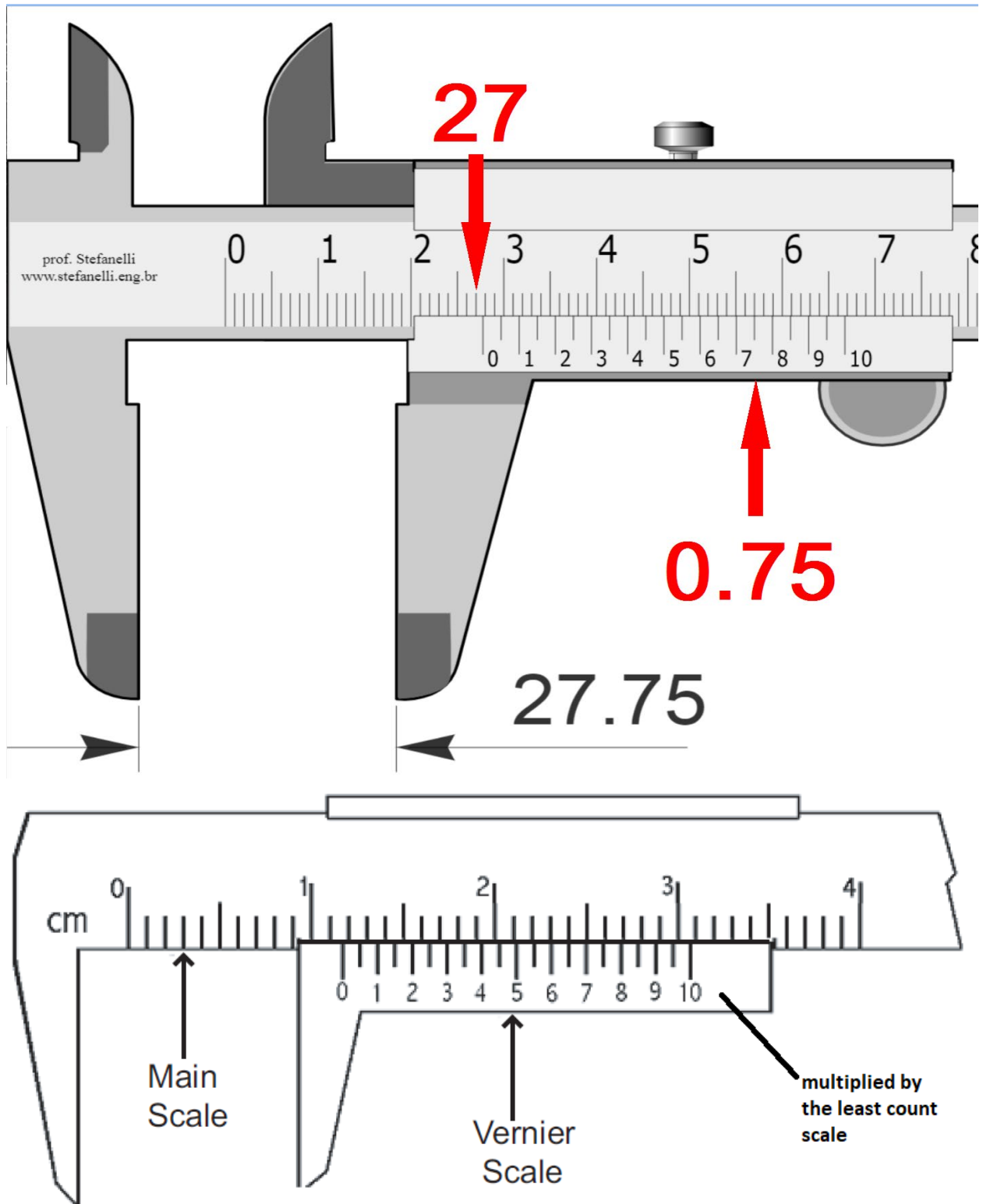
Precision Measuring Tools:

- Precision Ruler:



- Vernier Sliding Caliper:
Used to measure Height, Diameter, Width of a small object:





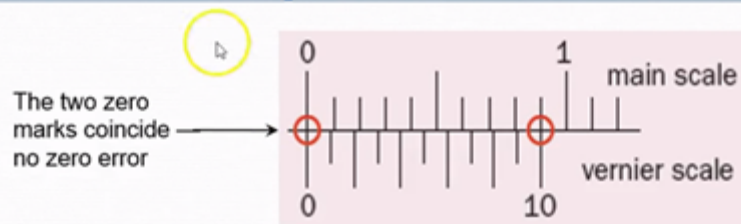
- The least count of the Vernier Scale:
50 Divisions of vernier scale = to 49 divisions of main scale

Least Count = 1 main scale division or ratio – 1 vernier scale division or ratio = 1 mm – 49/50 mm = 1 mm – 0.98 mm = 0.02 mm

0.02 mm is the least value that can be measured by vernier caliper

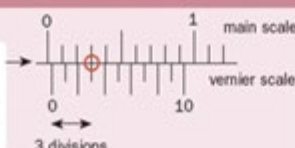
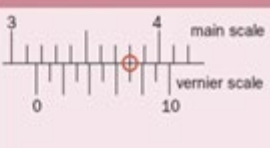
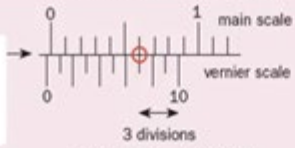
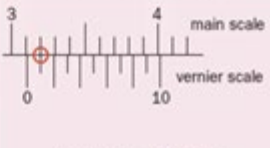
- Dimension to be measured = Main Scale Reading + (Vernier Scale Count x Least Count)
- Zero Errors:

Vernier Caliper – Zero Error

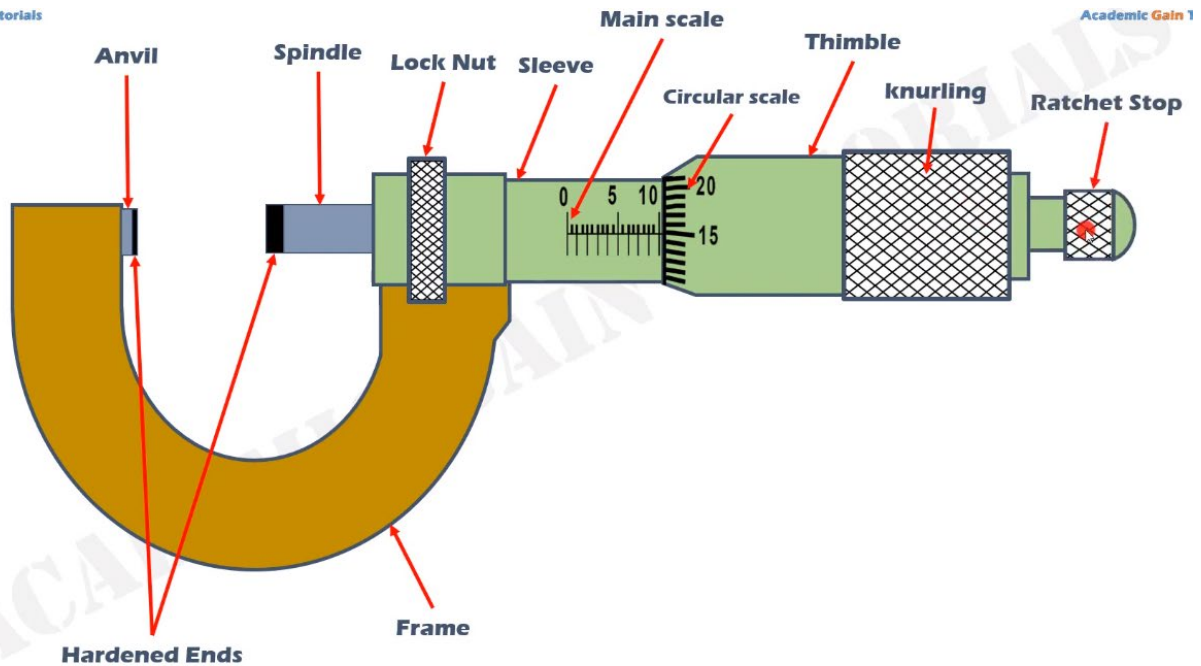


- For the reading to be accurate, there should be **no zero error**.
- The two zero marks on the main scale and the vernier scale must form a straight line, when the jaws are completely closed.

Correcting Zero Errors

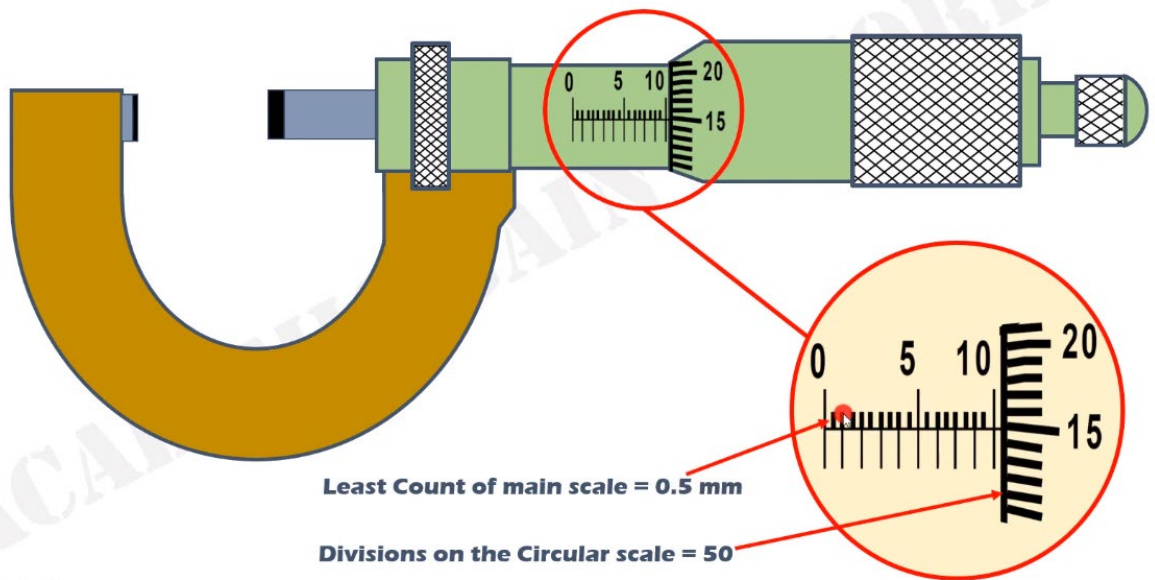
Type of zero error	Example of observed reading	Corrected reading
Positive zero error  The zero mark of the vernier scale is slightly to the right of the main scale. 3 divisions Zero error = +0.03 cm	 Reading = 3.17 cm	$3.17 - (+0.03)$ $= 3.14 \text{ cm}$
Negative zero error  The zero mark of the vernier scale is slightly to the left of the main scale. 3 divisions Zero error = -0.03 cm	 Reading = 3.11 cm	$3.11 - (-0.03)$ $= 3.14 \text{ cm}$

- Micrometer Instrument:

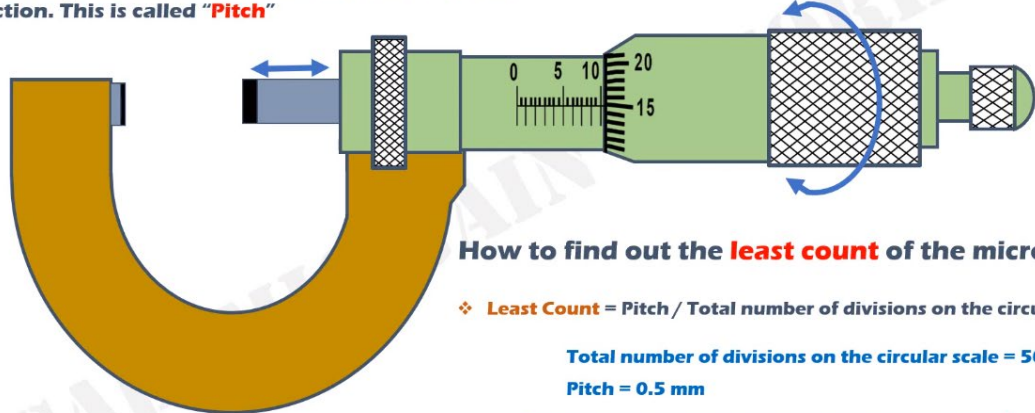


Thimble: used to adjust for hard movement of the spindle.

Ratchet Stop: used to adjust Spindle movement slightly.



- When the Thimble completes its one revolution, then the Spindle moves 0.5 millimeter in the axial direction. This is called "**Pitch**"



How to find out the **least count** of the micrometer?

❖ **Least Count** = Pitch / Total number of divisions on the circular scale

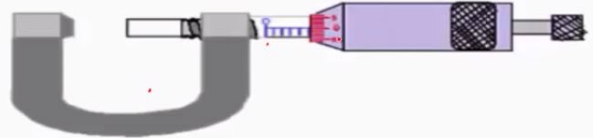
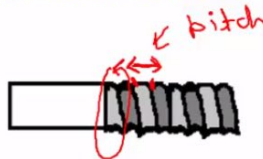
Total number of divisions on the circular scale = 50

Pitch = 0.5 mm

Thus, Least Count = $0.5 \text{ mm} / 50 = 0.01 \text{ mm}$

Pitch-

- Pitch is the Distance moved by Screw in one Rotation.

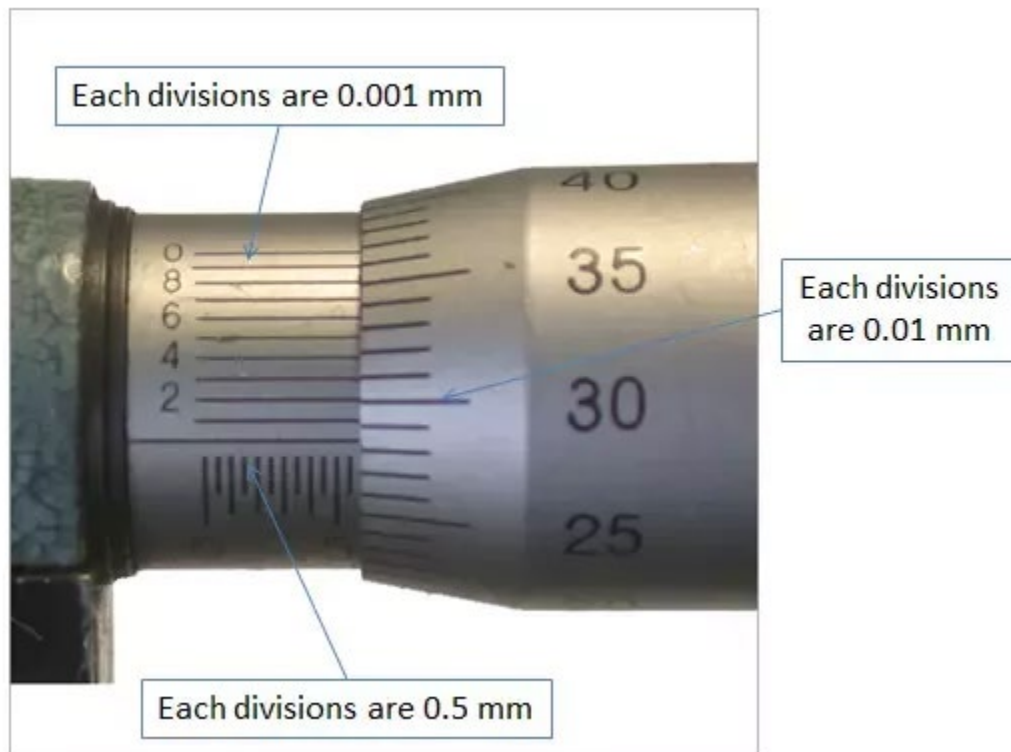


$$\text{Pitch} = \frac{\text{Distance moved by Thimble on main Scale}}{\text{Number of rotations}}$$

❖ **Dimension to be measured** = Main Scale Reading + (Circular Scale Reading X Least Count)

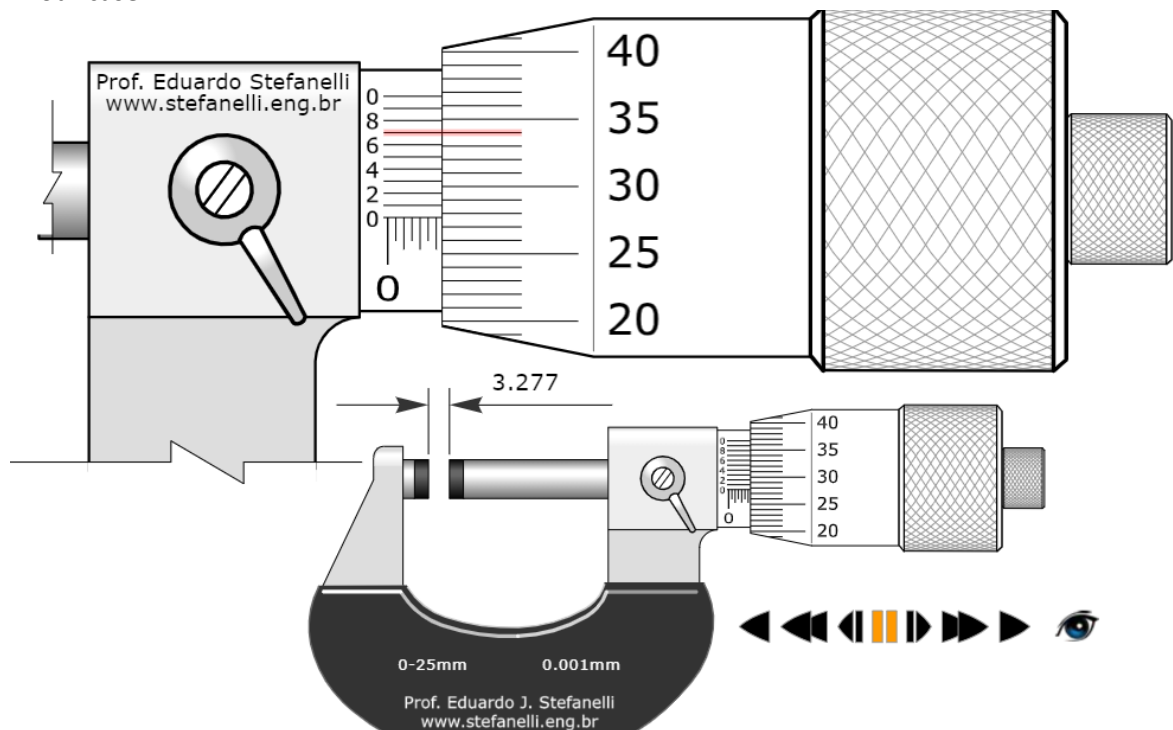
Note :

For more accurate micrometers we have a 3rd scale which can measure up to 0.001:



So, to calculate Dimension to be measured = Main scale reading + (circular scale reading x 1st least count) + (circular scale reading x 2nd least count)

In our case:



Dimension to be measured = $3\text{mm} + (27 \times 0.01) + (7 \times 0.001) = 3.277\text{mm}$

https://www.stefanelli.eng.br/en/virtual-micrometer-thousandth-millimeter-simulator/#swiffycontainer_2 (for thousands millimeter micrometer)

<https://www.stefanelli.eng.br/en/simulator-virtual-micrometer-hundredths-millimeter/> (Hundredths millimeter micrometer)

Metric Micrometers Vernier Scales

• measures to 0.002mm

Starrett

Metric Micrometers Vernier Scales

Diagram illustrating the measurement scale of a micrometer. The scale is divided into two main sections: the Sleeve and the Thimble.

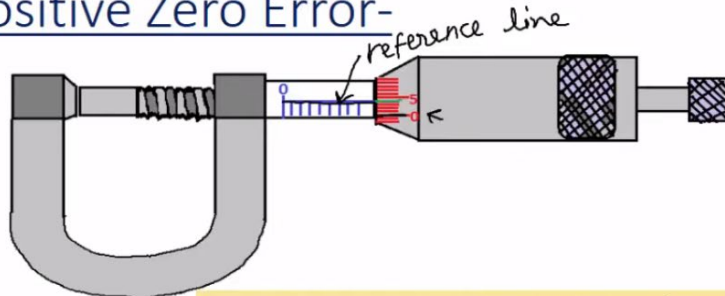
- Sleeve:** The main scale on the left, marked in millimeters (0, 5, 10, 15). The text "Sleeve" is written below the scale.
- Thimble:** The circular scale on the right, marked from 0 to 25. The text "Thimble" is written vertically next to the scale.
- Measurement:** The diagram shows a measurement of approximately 10.5 mm. The thimble scale is highlighted in red, and the text "measures to 0.001mm" is written next to it.
- Starrett:** The brand name "Starrett" is written in a stylized font at the bottom right.

Errors:

Least count is the lowest limiting value of the measuring instrument. Suppose the least count of a screw gauge is given 0.01 cm, so we can measure length up to 0.01 cm, below that we can't measure the length. Hence maximum possible error is 0.01 cm. it is nothing but least count. So least count is considered as maximum possible error.

1- Zero Error:

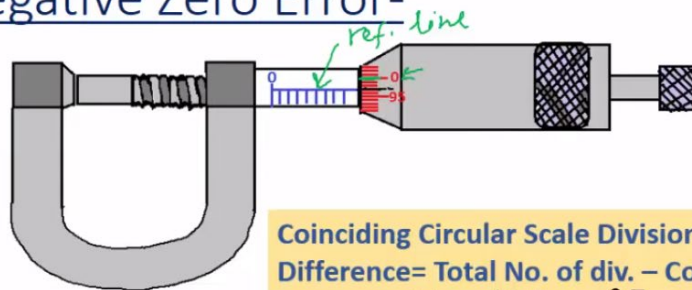
Positive Zero Error-



Coinciding Circular Scale Division = 4

$$\begin{aligned}\text{Zero Error} &= (\text{Coinciding Circular Scale Division}) \times \text{Least Count} \\ &= 4 \times 0.01 \text{ mm} \\ &= 0.04 \text{ mm}\end{aligned}$$

Negative Zero Error-



Coinciding Circular Scale Division = 97

$$\begin{aligned}\text{Difference} &= \text{Total No. of div.} - \text{Coinciding Division} \\ &= 100 - 97 = 3\end{aligned}$$

$$\begin{aligned}\text{Zero Error} &= (\text{Difference}) \times \text{Least Count} \\ &= 3 \times 0.01 \text{ mm} \\ &= -0.03 \text{ mm}\end{aligned}$$

Vernier caliper vs Micrometer:

Caliper can measure up to (0.02 mm -20um-0.001''-1mils) if it's accurate in normal conditions it can measure up to 0.1 mm or 100 um range while micrometer can measure up to (0.001mm-1microns) if it's accurate and in normal conditions (0.01 mm or 10 um)

Caliper can take interior measure while micrometer can't you will need an interior micrometer and its scale is small.

2- Errors due to temperature:

- when taking small measurements in um you have to consider a the temperature expansion coefficient of the material

$$dl = L_0 \alpha (t_1 - t_0)$$

dl = change in object length (m, inches)

L_0 = initial length of object (m, inches)

α = linear expansion coefficient (m/m°C, in/in°F)

t_0 = initial temperature (°C, °F)

t_1 = final temperature (°C, °F)

The final length of the object can be calculated as

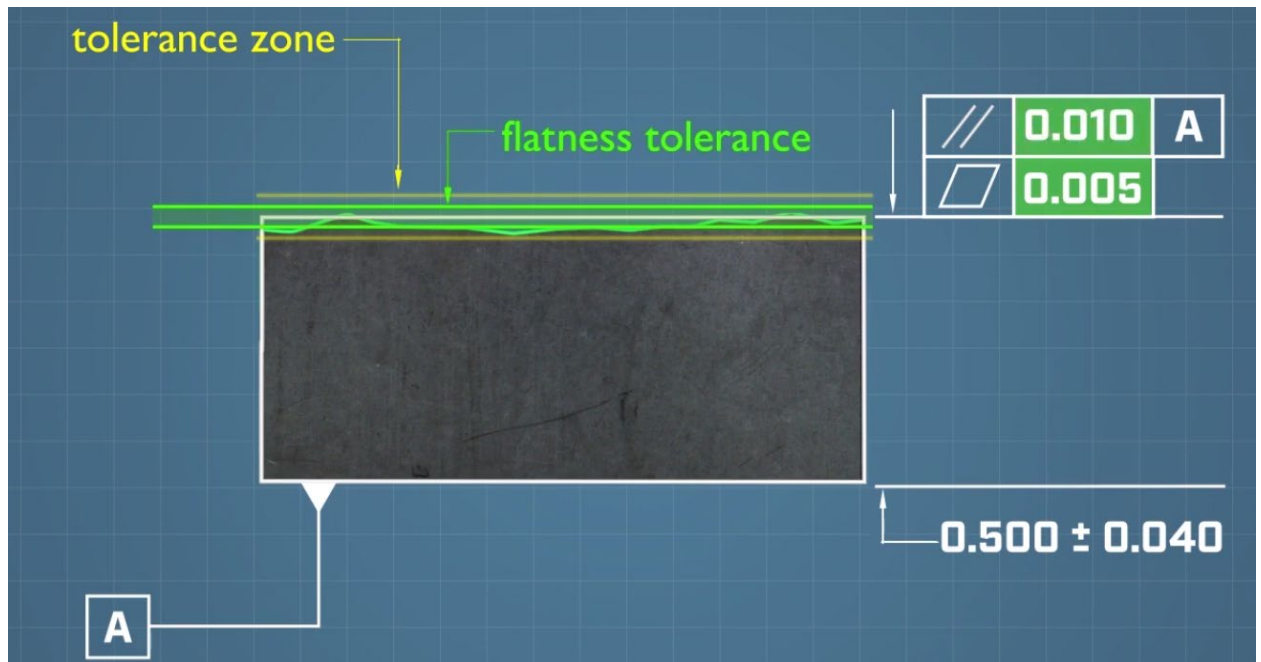
$$L_1 = L_0 + dl$$

$$= L_0 + L_0 \alpha (t_1 - t_0) \quad (2)$$

where

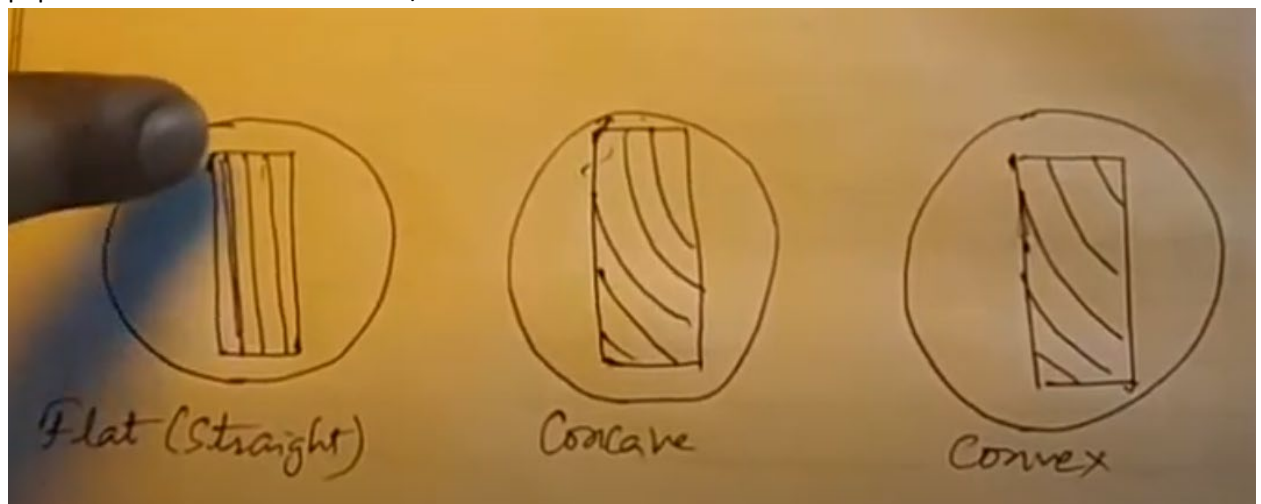
L_1 = final length of object (m, inches)

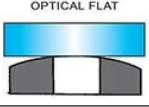




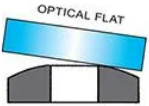




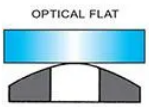




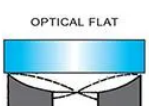




3-error due to flatness and parallelism:



Here we have acceptable parallelism tolerance = 0.010 and flat tolerance as we can see is smaller 0.005 which will help us achieve better parallelism.

To measure both we can use optical parallel to measure both with a known monochromatic source light with a known wavelength so we take the number of lines and multiply by $\lambda/2$ this will give us the flatness and according to shape of line we can know the nature of surface and for parallelism we take the number of red lines on first side spindle side and on anvil side which should be 1 and we subtract the two for example we have 4 lines on spindle and 1 on anvil so the parallelism difference is $3 \times \lambda/2$ for more info check for the used method



Surface geometry		1 Light band 0.00029mm	2 Light bands 0.00058mm	3 Light bands 0.00087mm	9 Light bands 0.00261mm
Convex or Concave Surface parallel to flat Symmetrical Pattern					
Convex With concave surface band will curve in opposite direction Non-Symmetrical Pattern					
Cylindrical Convex or Concave Symmetrical Pattern					
Saddle Shaped Symmetrical Pattern					

<https://www.kemet.co.uk/products/flatlapping/monochromatic-light-source>

https://www.youtube.com/watch?v=G_G8KWbFzXk&t=415s

Notes:

- always store in case clean with soft piece of cloth and alcohol , and leave the teeth slightly open or put a piece of cloth or paper.