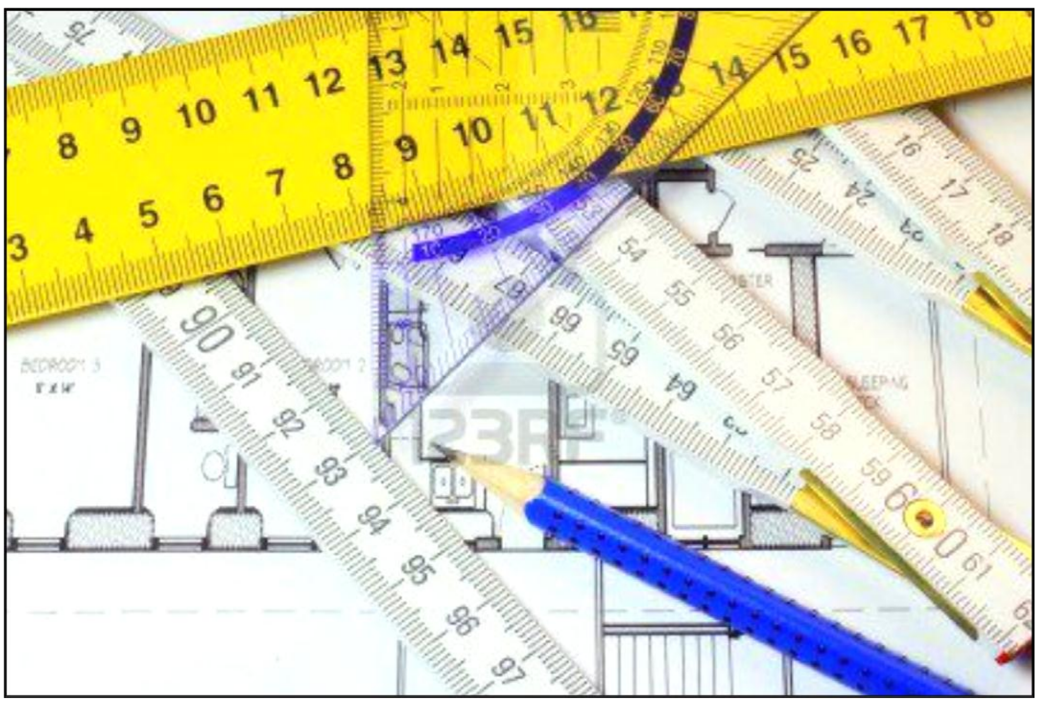
UNIT - 01

Units And Measurements



PHYSICS

Physics is the branch of science that deals with the properties of matter and the relationship between the energy and matter.

Physical Quantities

Any property that can be measured directly or indirectly with a certain instrument is called a physical quantity.

Ex: speed, length, time, temperature

All physical quantities can be divided into two groups.

- Fundamental physical quantities
- Derived physical quantities

Fundamental physical quantities

Physical quantities such as time, length and mass cannot be defined using any other physical quantities. So that the quantities like time, mass and length are considered as fundamental physical quantities. And their units are fundamental units.

There are 07 internationally recognized fundamental physical quantities.

Quantity	Units	Symbol
Time	Seconds	s
Length	Meters	m
Mass	Kilogram	kg
Thermodynamic temperature	Kelvin	K
Electric current	Ampere	A
Luminous intensity	candela	cd
Amount of substances	mole	mol

Derived physical quantities

Physical quantities that can be expressed in terms of fundamental physical quantities are called derived physical quantities. Units of derived physical quantities are expressed in terms of fundamental units. For the convenience of use, some derived quantities have special names and units.

Derived quantity	unit	name
Force	N	Newton
Pressure	Pa	Pascal
Power	W	watt

Laboratory Measuring Instruments

Least count

All measuring instruments consist of a scale. There is a least count that can be observed from the scale.

We can't take measurements with higher accuracy lower than the least count. For example, the least count of the meter ruler is 1mm and so that we can't take measurements with higher accuracy lowers than 1mm from the meter ruler.

That means we cannot express readings like, 12.34 cm, 13.68 cm.But we can express readings like, 10.4 cm, 47.9 cm.

The maximum error that can occur by a measuring instrument is equal to the least count. In our laboratory measurement is considered to be sufficient if the percentage error is 1% or less than that.

$$\text{Fractional error} = \frac{\text{Least count}}{\text{Reading}}$$

$$\text{Percentage error} = \frac{\text{Least count}}{\text{Reading}} \times 100\%$$

The least count of the meter ruler is 1mm. when the meter ruler is used to measure a length of 10 cm, the percentage error is;

$\frac{1}{100} \times 100\% = 1\%$

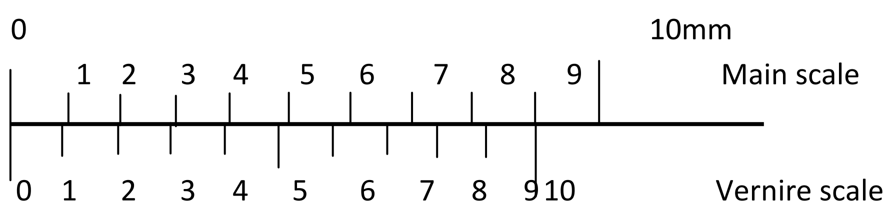
Therefore the accuracy obtained from a meter ruler is not sufficient in lengths shorter than 10 cm. in such situations, an instrument with a least count lower than 1mm should be used.

Laboratory length measuring instruments

- Meter ruler
- Vernire caliper
- Micro meter screw gauge
- Spherometer
- traveling microscope

Vernire caliper

Meter ruler gives measurements with the accuracy of 1 mm. when the accuracy of 1 mm is not sufficient for a measurement; venire caliper is used instead of meter ruler.



A simple vernire scale is shown in the figure. The main scale is calibrated in 1 mm divisions. The total length of the vernire caliper is equal to 9 mm length of the main scale. And it is divided into 10 divisions. Then the length of 1 vernire division is equal to 9/10 mm = 0.9 mm.

When the zero of the vernire scale and the main scale coincides as shown in the figure,

- Space between main scale 1 and vernire scale 1 = 0.1
- Space between main scale 2 and vernire scale 2 = 0.2
- Space between main scale 3 and vernire scale 3 = 0.3

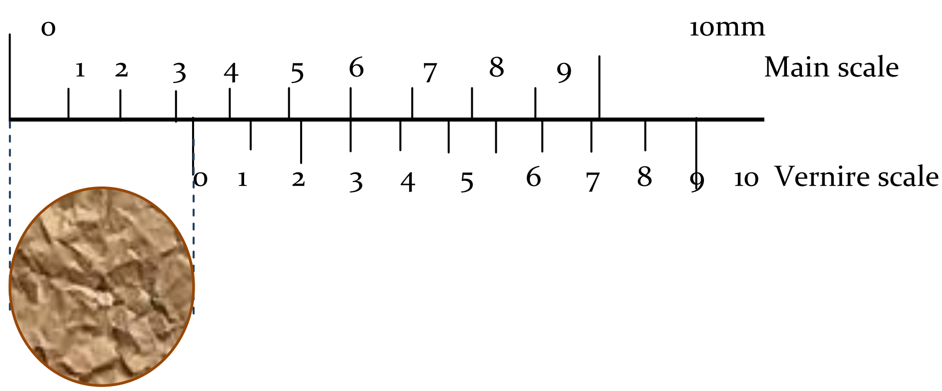
when the vernire scale is slide towards right until the 1 of the main scale, then the distance traveled by the vernire scale is equal to 0.1 mm. therefore the least count of the instrument is equal to 0.1 mm.

In order to take a reading,

- Calculate the least count at first.
- Record the number which correspond to the last line on the main scale which falls before the zero of the vernire scale.
- Count to the right on the vernire scale until you reach a vernire line which coincide with a line on the main scale and record the number of that vernire line. (Vernire coincidence number) and multiply it with the least count.

This is the decimal value of your reading.

Final reading = Value on main scale + vernire coincidence number × least count

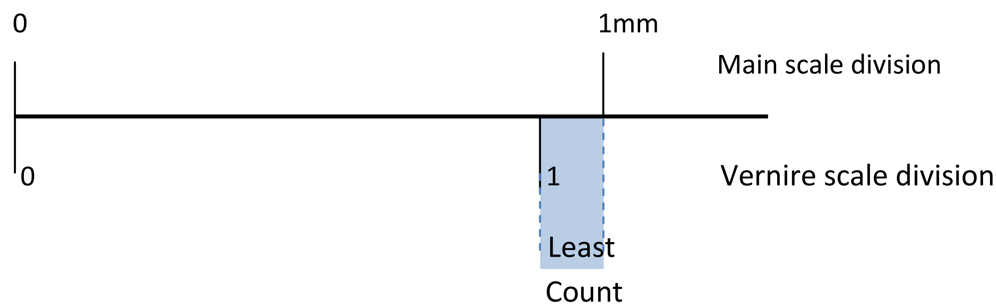


Reading shown in the above vernire arrangement = 3+ (3×0.1)

= 3.3 mm

Determination of the least count

- First determine the total length of the vernire scale using the main scale.
- Then calculate the length of a one vernire division by dividing the length of vernire scale from number of vernire divisions.
- Difference of successive main scale division and vernire scale division is equal to the least count.



$$\text{Least count} = \frac{\text{Total length of vernire scale}}{\text{Number of divisions on vernire scale}}$$

Simple vernire caliper

Here the vernire scale of 9 mm is divided into 10 divisions. The length of one main scale division is equal to 1mm.

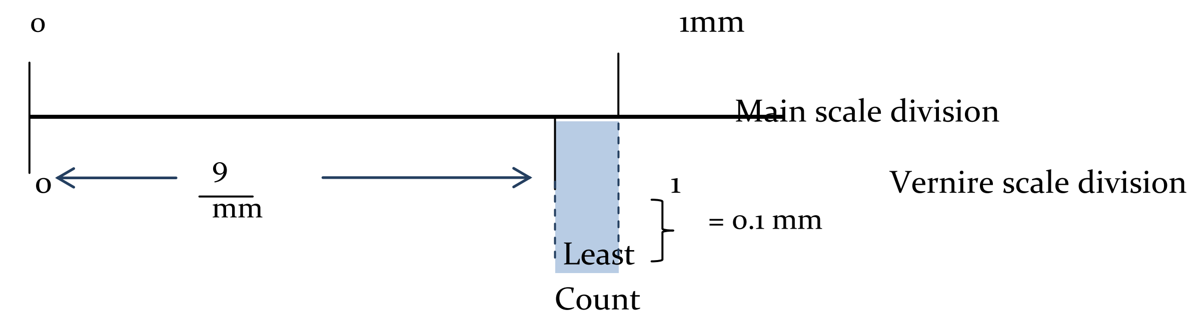
Total length of vernire scale = 9 mm

Number of vernire divisions = 10

Length of one vernire division = $\frac{9}{10}$

Length of one main scale division = 1 mm

Least count = $1 - \frac{9}{10}$ mm = 0.1 mm



More sensitive vernier caliper

Here the main scale is graduated into 0.5 mm divisions and 49 main scale divisions are equal to the total length of the vernier scale consist of 50 equal divisions.

Total length of vernire scale = 0.5 mm

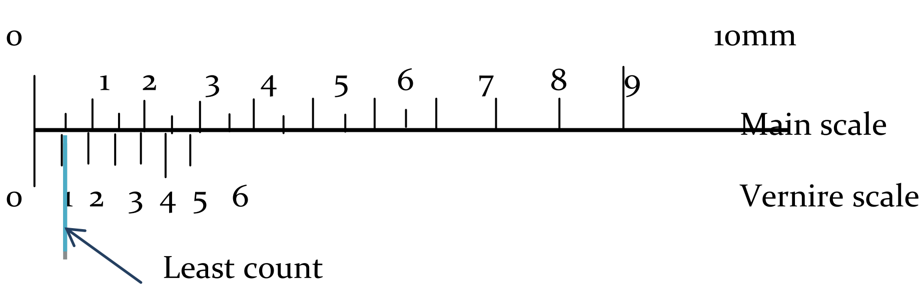
Total length of vernier scale = 0.5 mm ×49

Number of vernire divisions = 50

Length of one vernire division $= \frac{49}{2 \times 50}$

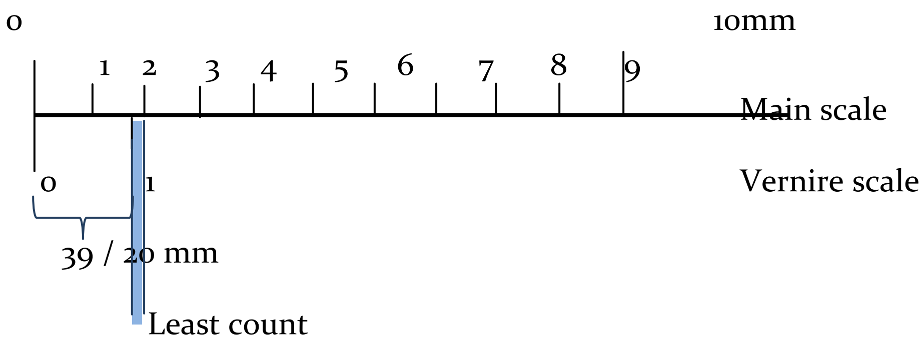
Length of one main scale division = 1 mm

Least count = $\frac{1}{2} - \frac{49}{50 \times 2}$ mm $= \underline{\underline{0.01 \text{ mm}}}$



Extended vernire caliper

Here the length of the vernire division is 39 mm and it is divided into 20 equal divisions. Then the length of one vernire division is equal to 39/ 20 mm.



39

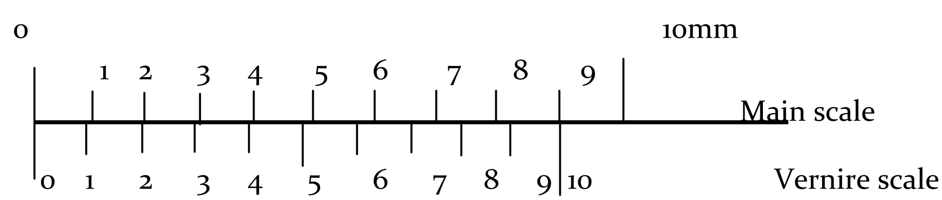
Least count = 2 mm mm

= 0.05 mm

A sliding vernier caliper is shown in the figure above. Its shaded part is called 'fixed jaw'. Main scale is marked on the fixed jaw. And vernire scale is marked on the sliding jaw scale. Lock nut is used to keep the sliding jaw stationary. When the jaws are closed together, zero of the vernire scale and zero of the main scale coincide with each other. Then the jaws will exist in position as follows.

Zero error

In an accurate vernire caliper, when the jaws are closed together, zero of the vernire scale and zero of the main scale coincides. Then it should display as below.

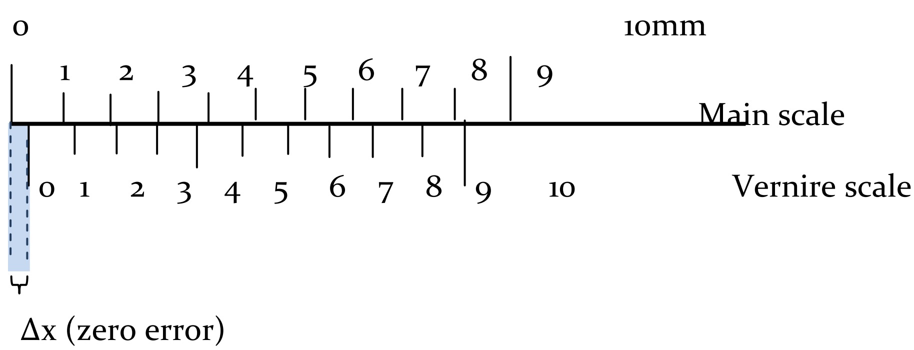


But if the 'zero' of the vernire scale does not coincide with the zero of the main scale when the jaws of the vernire caliper are closed; then we call that the instrument has a 'zero error'. Before taking any reading the zero error of the instrument should be determined and a correction should be done according to the zero error.

Positive zero error

When the jaws of the vernire caliper are closed, and the zero mark of the vernire scale is in the right of the main scale it is said that the instrument has a 'positive zero error'.

In this case zero error of the instrument must be subtracted from the reading to get the correct reading. This correction is called negative correction.



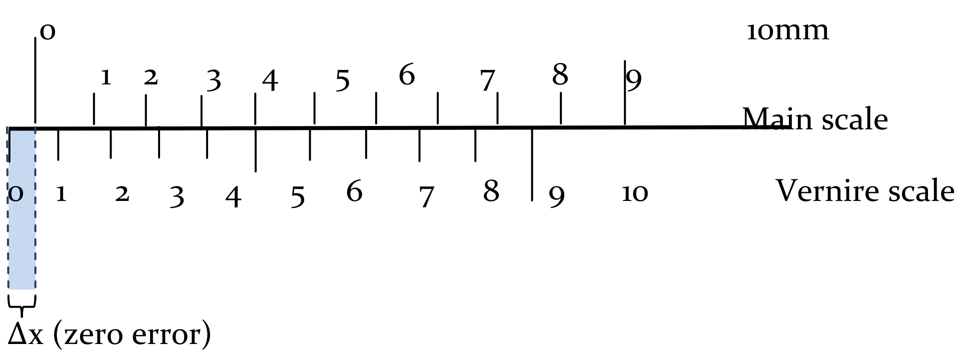
Zero error of the instrument = 0.3 mm.

Correction = -0.3 mm

Negative zero error

When the jaws are closed, if the zero of the vernire scale is on the left of the zero mark of the main scale, then the instrument has a negative zero error.

In this case the zero error must be added to the reading in order to get a correct reading. This is called as positive correction.



Zero error of the instrument = 0.5mm. Correction = +0.5 mm

Circular vernire scales

Circular vernire scale is used to measure angles and readings can be taken with accuracy of 1 minute. In this case, the main scale is a protractor with $^1/_2$ $^{\circ}$ divisions. Vernier scale has 30 divisions and coincide with 14 $^1/_2$ $^{\circ}$ .that means the vernire scale coincide with29 main scale divisions.

Micro meter screw gauge

Pitch and screw

Every screw advance through a constant distance when it gives a full rotation. This distance is called the pitch of the screw.

Consider a screw that has a screw pitch 1 mm and 100 equal divisions on the head.

When the head of the screw is rotated through one circular scale division, then the linear distance moved by the screw is equal to 1/100 mm. this is the least count of the screw.

$$\text{Least count} = \frac{\text{Pitch of the screw}}{\text{No. of divisions in the circular scale}}$$

In this instrument 'sleeve' consist of 'linear mm scale' and the 'thimble' consist of circular scale which has 50 or 100 equal divisions.

When the 'anvil' and 'spindle' ends are brought into contact, the zero of the 'circular scale' should coincide with the zero of the 'linear scale'. If the zero of the both scales do not coincide, the instrument has a zero error.

In order to take a reading,

- Determine the least count of the instrument.
- Record the reading shown in the main scale.
- Determine the line on the circular scale which coincide with the main scale and multiply it by least count.

Reading = Main scale Reading + Coincidence number On Circular scale × least count

Zero error

When the anvil and the spindle of the instrument touch together, the the zero of the circular scale should coincide with the zero of the main scale as shown in the following figure. If not it is said that the instrument has a zero error.