Vernier calipers

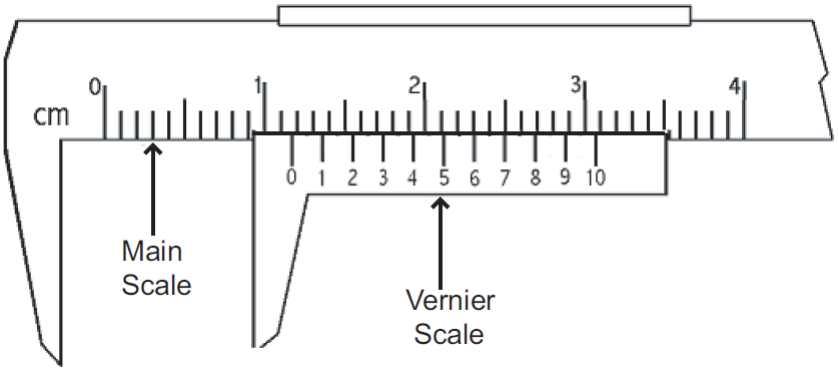


Figure 1: Vernier calipers. (Figure not to scale)

Uses:

- To measure diameter of small sphere/cylindrical body.
- To measure the dimensions of a given regular body.
- To measure the internal diameter and depth of a given cylindrical object like beaker/glass and hence to calculate its volume.

Vernier calipers mainly consists of main scale and vernier scale. See figure (1).

Principle:
The difference in the magnitude of one main scale division (MSD) and one vernier scale division (VSD) is called the least count of the instrument, as it is the smallest distance that can be measured using the instrument.
Principle of vernier:
n^{th} vernier scale division is equal to $(n-1)^{\text{th}}$ main scale division.

$$\boxed{n(\text{VSD}) = (n-1)\text{MSD}.}$$

For $n = 10$:

$$10 \text{ VSD} = 9 \text{ MSD}.$$

This means the vernier calipers is constructed in such a way that when the zero of the veriner scale coincides with zero of the main scale, 10^{th} division of the vernier scale coincides with 9^{th} division of the main scale.

Least count:
Least count of the vernier calipers is the minimum non-zero value it can measure.

$$\boxed{\text{Least count (LC)} = \frac{\text{Value of one MSD}}{\text{Number of VSD.}}}$$

When 1 MSD = 0.1 cm, number of VSD = 10, we have
LC = 0.01 cm.

How to take readings in vernier calipers?

- See where the zero of the vernier is on the main scale. Suppose the zero of the vernier is on 1.1 cm on the main scale, then Main Scale Reading (MSR) = 1.1 cm.

- Next, see which division of the vernier scale is perfectly coinciding with the main scale division. If 5^{th} division is coinciding then Coinciding Vernier Division CVD = 6. If zero itself is coinciding then CVD = 0. (Note: When zeroth division of vernier scale coincides, its 10^{th} division will also coincide.) CVD is always a positive integer. If the number of vernier divisions is 10, then CVD is between 0 and 10.
- After noting MSR and CVD use the formula to calculate the total reading.

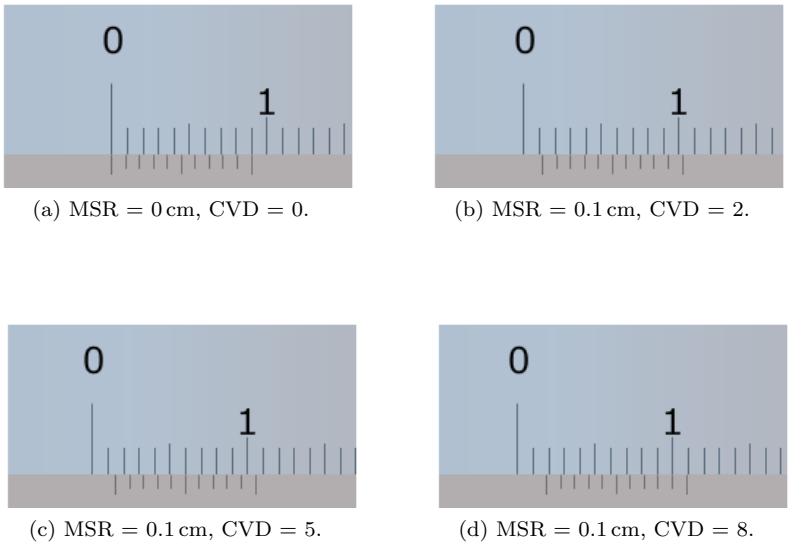
  Formula:

$$\boxed{\text{Total reading (TR)} = \text{MSR} + (\text{CVD} \times \text{LC})\,.}$$

- Example
  MSR = 1.1 cm, CVD = 6 and LC = 0.01 cm.
  $\therefore$ TR = 1.16 cm.

The same procedure holds even while taking readings in traveling microscope. For traveling microscope, least count is different from that of vernier calipers.
For traveling microscope, value of one MSD is 1/20 cm. The number of vernier divisions is 50. Therefore, LC = 0.001 cm.

You can learn about Vernier calipers using online simulator here
https://amrita.olabs.edu.in/?sub=1&brch=5&sim=16&cnt=4



(a) MSR = 0 cm, CVD = 0. (b) MSR = 0.1 cm, CVD = 2.

(c) MSR = 0.1 cm, CVD = 5. (d) MSR = 0.1 cm, CVD = 8.

Figure 2: Sample reading in Vernier calipers

Notice that as the zero of the vernier moves from lower division towards higher division on the main scale, the CVD increases. If N denotes the total number of vernier scale divisions then we have three situations:

- If zero of vernier is near lower division of the main scale, CVD is less (CVD $< N/2$).
- If zero of vernier is in between lower and higher division of the main scale, CVD is about half the total number of vernier divisions (CVD $\approx N/2$).
- If zero of vernier is near higher division of the main scale, CVD is more (CVD $> N/2$).

This is shown in figure (2).

Exercise

- **What is least count of an instrument?**
- **What is least count of Vernier calipers?**
- **How is least count of Vernier calipers calculated?**
- **How to take main scale reading?**
- **How to take coinciding vernier division?**
- **If least count of an instrument is** $0.01\,\mathrm{cm}$**, then can we measure** $0.003\,\mathrm{cm}$ **on that instrument?**