UNIT 1 MEASUREMENT

Warm greetings:

Dear students,

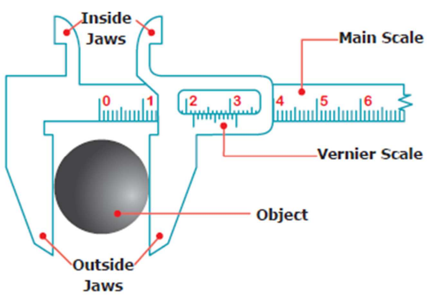
Welcome all. In this section of Science I class you get to learn about the Vernier Caliper and Screw Gauge.

Introduction:

In our daily life, we use metre scale for measuring lengths. They are calibrated in cm and mm. The smallest length which can be measured by metre scale is called least count. Usually the least count of a scale is 1 mm. We can measure the length of objects upto 1 mm accuracy with this scale. By using vernier caliper we can have an accuracy of 0.1 mm and with screw gauge we can have an accuracy of 0.01 mm.

Description of Vernier caliper

- ❖ The Vernier caliper consists of a thin long steel scale graduated in cm and mm called main scale.
- ❖ To the left end of the main scale an upper and a lower jaw are fixed perpendicular to the bar. These are named as fixed jaws.
- ❖ To the right of the fixed jaws, a slider with an upper and a lower moveable jaw is fixed.
- ❖ The slider can be moved or fixed to any position using a screw. The Vernier scale is marked on the slider and it moves along with the movable jaws and the slider.
- ❖ The lower jaws are used to measure the external dimensions and the upper jaws are used to measure the internal dimensions of the objects.
- ❖ The thin bar attached to the right side of the Vernier scale is used to measure the depth of hollow objects.



Usage of Vernier caliper:

The first step in using the Vernier caliper is to find out its least count, range and zero error.

a) Least count

$$\text{Least count of the instrument (L.C)} = \frac{\text{Value of one main scale division}}{\text{Total number of vernier scale division}}$$

The main scale division will be in centimeter, further divided into millimetre. The value of the smallest main scale division is 1 mm. In the Vernier scale there will be 10 divisions.

$$\therefore \quad \text{L.C} = \frac{1\text{mm}}{10} = 0.1\text{mm} = 0.01\text{cm}$$

b) Zero error

Unscrew the slider and move it to the left, such that both the jaws touch each other. Check whether the zero marking of the main scale coincides with that of the zero of the vernier scale. If they coincide then there is no zero error.

If they do not coincide with each other, the instrument is said to possess zero error. Zero error may be positive or negative. If the zero of a vernier is shifted to the right of main scale, it is called positive error. On the other hand, if the zero of the vernier is shifted to the left of the zero of main scale, then the error is negative.

Positive zero error

Figure 1.3 shows the positive zero error. From the figure you can see that zero of the vernier scale is shifted to the right of the zero of the main scale. In this case the reading will be more than the actual reading. Hence, this error should be corrected. In order to correct this error, find out which vernier division is coinciding with any of the main scale divisions. Here, fifth vernier division is coinciding with a main scale division. So,

positive zero error = +5 .

LC = +5 X0.01 = 0.05 cm and

the zero correction is negative. Hence, zero correction is –0.05 cm.

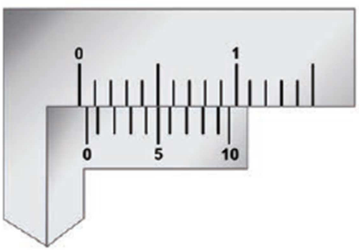


Figure 1.3 Positive zero error

Negative zero error

Now look at the Figure 1.4. You can see that the zero of the vernier scale is shifted to the left of the zero of the main scale. So, the obtained reading will be less than the actual reading. To correct this error we should first find which vernier division is coinciding with any of the main scale divisions, as we found in the previous case. In this case, you can see that sixth line is coinciding. To find the negative error, we can count backward (from 10). Here, the fourth line is coinciding. Therefore,

negative zero error = –4 .

LC = –4 X 0.01 = –0.04 cm.

Then zero correction is positive. Hence, zero correction is +0.04 cm.

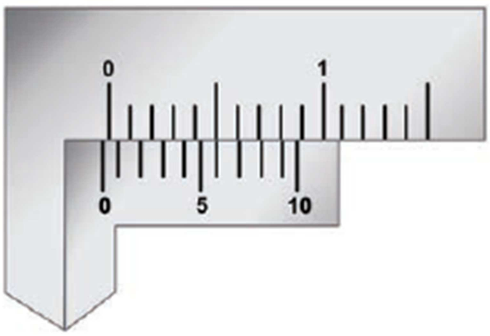


Figure 1.4 Negative zero error

We can use Vernier caliper to find different dimensions of any familiar object. If the length, width and height of the object can be measured, volume can be calculated. For example, if we could measure the inner diameter of a beaker (using appropriate jaws) as well as its depth (using the depth probe) we can calculate its inner volume.

Digital Vernier caliper

We are living in a digital world and the digital version of the vernier callipers are available nowadays. Digital Vernier caliper (Figure 1.5) has a digital display on the slider, which calculates and displays the measured value. The user need not manually calculate the least count, zero error etc.

Figure 1.5 Digital Vernier caliper

Screw Gauge:

- ❖ Screw gauge is an instrument that can measure the dimensions upto 1/100th of a millimetre or 0.01 mm.
- ❖ With the screw gauge it is possible to measure the diameter of a thin wire and thickness of thin metallic plates.

Description of screw gauge:

- ❖ The screw gauge consists of a U shaped metal frame.
- ❖ A hollow cylinder is attached to one end of the frame.
- ❖ Grooves are cut on the inner surface of the cylinder through which a screw passes (Figure 1.6).
- ❖ On the cylinder parallel to the axis of the screw there is a scale which is graduated in millimetre. It is called Pitch Scale (PS).
- ❖ One end of the screw is attached to a sleeve.
- ❖ The head of the sleeve (Thimble) is divided into 100 divisions and it is called the Head scale.

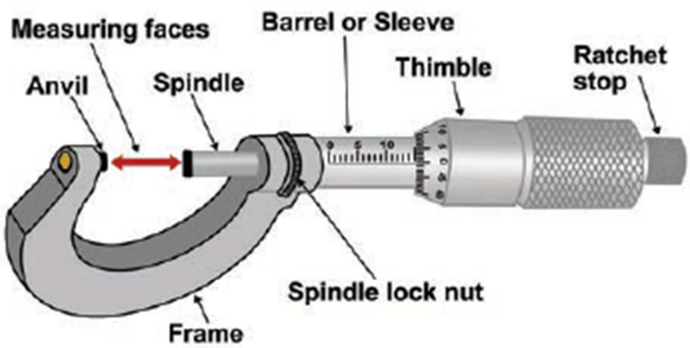


Figure 1.6 Screw gauge

- ❖ The end of the screw has a plane surface (Spindle).
- ❖ A stud (Anvil) is attached to the other end of the frame, just opposite to the tip of the screw.
- ❖ The screw head is provided with a ratchat arrangement (safety device) to prevent the user from exerting undue pressure.

Using the screw gauge:

The screw gauge works on the principal that when a screw rotates in a nut, the distance moved by the tip of the screw is directly proportional to the number of rotations.

a) Pitch of the screw

The pitch of the screw is the distance moved by the tip of the screw for one complete rotation of the head. It is equal to 1 mm in typical screw gauges.

Pitch of the screw = Distance moved by the Pitch / No. of rotations by Head scale

b) Least count of a screw gauge

The distance moved by the tip of the screw for a rotation of one division on the head scale is called the least count of the screw gauge.

$$\text{Least count of the instrument (L.C.)} = \frac{\text{Value of one smallest pitch scale reading}}{\text{Total number of Head scale division}}$$

$$LC = \frac{1}{100} = 0.01 \text{ mm}$$

c) Zero Error of a screw gauge

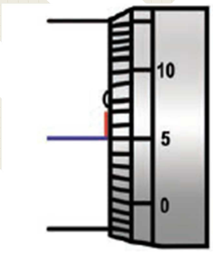
When the movable stud of the screw and the opposite fixed stud on the frame area brought into contact, if the zero of the head scale coincides with the pitch scale axis there is no zero error.

Positive zero error

When the movable stud of the screw and the opposite fixed stud on the frame are brought into contact, if the zero of the head scale lies below the pitch scale axis, the zero error is positive (Figure 1.7). Here, the 5th division of the head scale coincides with the pitch scale axis. Then the zero error is positive and is given by,

Z.E = + (n X L. C) where 'n' is the head scale coincidence.

In this case, Zero error = + (5 . 0.01) = 0.05mm. So the zero correction is – 0.05 mm.



;ure 1.7 Positive Zero Error

Negative zero error

When the plane surface of the screw and the opposite plane stud on the frame are brought into contact, if the zero of the head scale lies above the pitch scale axis, the zero error is negative (Figure 1.8). Here, the 95th division coincides with the pitch scale axis. Then the zero error is negative and is given by,

ZE = – (100 – n) X LC

ZE = – (100 – 95) X LC = – 5 X 0.01 = – 0.05 mm

The zero correction is + 0.05mm.

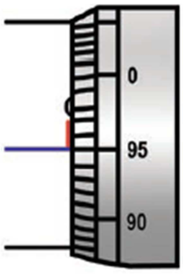


Figure 1.8 Negative Zero Error

Measuring Mass:

- ✓ We commonly use the term 'weight' which is actually the 'mass'. Many things are measured in terms of 'mass' in the commercial world. The SI unit of mass is kilogram (kg).
- ✓ In any case, the units are based on the items purchased. For example, we buy gold in gram or milligram, medicines in milligram, provisions in gram and kilogram and express cargo in tonnes.
- ✓ Can we use the same instrument for measuring the above listed items?
- ✓ Different measuring devices have to be used for items of smaller and larger masses.

In this section we will study about some of the instruments used for measuring mass.

Common (beam) balance

A beam balance compares the sample mass with a standard reference mass (Standard reference masses are 5g, 10g, 20g, 50g, 100g, 200g, 500g, 1kg, 2kg, 5kg). This balance can measure mass accurately up to 5g (Figure 1.9).

Figure 1.9 Common beam balance

Physical balance

This balance is used in labs and is similar to the beam balance but it is a lot more sensitive and can measure mass of an object correct to a milligram (Figure 1.10). The standard reference masses used in this physical balance are 10 mg, 20 mg, 50 mg, 100 mg, 200 mg, 500 mg, 1 g, 2g, 5 g, 10 g, 20 g, 50 g, 100g, and 200 g.

Figure 1.10 Physical balance

Digital balance:

Nowadays, for accurate measurements digital balances are used, which measure mass accurately even up to a few milligrams, the least value being 10 mg (Figure 1.11). This electrical device is easy to handle and commonly used in jewellery shops and labs.

Figure 1.11 Digital balance

Spring balance:

This balance helps us to find the weight of an object. It consists of a spring fixed at one end and a hook attached to a rod at the other end. It works by 'Hooke's law' which states that the addition of weight produces a proportional increase in the length of the spring (Figure 1.12). A pointer isattached to the rod which slides over a graduated scale on the right. The spring extends according to the weight attached to the hook and the pointer reads the weight of the object on the scale.

Figure 1.12 Spring balance

Difference between mass and weight

Mass (m) is the quantity of matter contained in a body. Weight (w) is the normal force (N) exerted by the surface on the body to balance against gravitational pull on the object. In the case of spring scale, the tension in the spring balances the gravitational pull on the object. When a man is standing on the surface of the earth or floor, the surface exerts a normal force on the body which is equivalent to gravitational force. The gravitational force acting on the object is given by 'mg'. Here, m is mass of the object and 'g' is acceleration due to gravity.

The pull of gravity on the Moon is 1/6 times weaker than that on the Earth. This causes the weight of the object on the Moon to be less than that on the Earth by six times. Acceleration due to gravity on the Moon = 1.63 ms^{-2} If the mass of a man is 70 kg then his weight on the Earth is 686 N and on the Moon is 114 N. But his mass is still 70 kg on the Moon.

Mass	Weight
1. It is a fundamental quantity.	It is a derived quantity.
2. It has magnitude alone – scalar quantity.	It has magnitude and direction – vector quantity.
3. It is the amount of matter contained in a body.	It is the normal force exerted by the surface on the object against gravitational pull.
4. Remains the same everywhere.	Varies from place to place.
5. It is measured using physical balance.	It is measured using spring balance.
6. Its unit is kilogram.	Its unit is newton.

Accuracy in Measurements:

When measuring physical quantities, accuracy is important. Accuracy represents how close a measurement comes to a true value. Accuracy in measurement is center in engineering, physics and all branches of science. It is also important in our daily life. You might have seen in jewellery shops how accurately they measure gold. What will happen if little more salt is added to food while cooking?

So, it is important to be accurate when taking measurements. Faulty instruments and human error can lead to inaccurate values. In order to get accurate values of measurement, it is always important to check the correctness of the measuring instruments. Also, repeating the measurement and getting the average value can correct the errors and give us accurate value of the measured quantity.