Exercise-1(A)

1. What is meant by measurement?

Solution:

It is the comparison of the specified physical quantity with the known standard quality of the equivalent nature.

2. What do you understand by the term unit?

Solution:

Unit is the quantity of a constant magnitude which is used to measure the magnitudes of other quantities of the same nature.

3. What are the three requirements for selecting a unit of a physical quantity?

Solution:

The three requirements for selecting a unit of a physical quantity are:

- It should be reproducible
- Is required to be of convenient size
- No ambiguity while defining the unit
- The value of unit should not change with space and time.

4. Name the three fundamental quantities.

Solution:

The three fundamental quantities are:

- Length
- Mass
- Time

5. Name the three systems of unit and state the various fundamental units in them.

Solution:

The three systems of unit and the corresponding fundamental units are:

System of Unit	Fundamental units
CGS system	Centimeter (cm) Gram(g) Second(s)
F.P.S system	Foot(ft) Pound(lb) Second(s)
M.K.S system	Metre(m) Kilogramme(kg) Second(s)

6. Define a fundamental unit.

Solution:

It is that unit which is independent of any other unit or which can neither be changed nor can be related to any other basic unit. Example – Units of mass, length, time etc.

7. What are the fundamental units in S.I. system? Name them along with their symbols.

Solution:

The fundamental units in S.I. system along with their symbols are:

Quantity	Symbol
Length	m
Mass	kg
Time	s
Temperature	K
Luminous intensity	cd
Electric current	A
Amount of substance	mol
Angle	rd
Solid angle	st-rd

8. Explain the meaning of derived unit with the help of one example.

Solution:

Derived units are those which depend on the fundamental units or which can be expressed in relation with the fundamental units.

Example – to measure area, we need to measure length and breadth in the unit of length and then express area in a unit which is length x length or $(\text{length})^2$

9. Define standard metre.

Solution:

The standard meter is the length of the path travelled by light in vaccum during a time interval of 1/299 792 458 of a second.

10. Name two units of length which are bigger than a metre. How are they related to the metre?

Solution:

The two units of length that are bigger than a metre are:

- Astronomical unit (A.U)
- Kilometre (km)

Relation between metre (m) and astronomical unit (A.U):

1 A.U = 1.496×10^{11} m

Relation between metre (m) and kilometer (km):

1 km = 1000m

11. Write the name of two units of length smaller than a metre. How are they related to the metre?

Solution:

The two units of length smaller than a metre are:

- Angstrom(Å)
- Fermi (f)

Relation between metre (m) and Angstrom (Å) is:
1 Angstrom (Å) = 10^{-10} metre

Relation between metre (m) and Fermi is:
1 fermi (f) = 10^{-15}m

12. How is nanometer related to Angstrom?

Solution:

Relation between nanometer (nm) and Angstrom (Å):
1 nanometer = 10 Å

13. Name the three convenient units used to measure length ranging from very short to very long value. How are they related to the S.I. unit?

Solution:

The 3 convenient units used to measure length ranging from very short to very long value are:

- Centimeter (cm)
- Metre (m)
- Kilometer (km)

Relation between meter (m) and the units are:
1 m = 100cm
1 km = 1000m

14. Name the S.I unit of mass and define it.

Solution:

The S.I. unit of mass is Kilogram (Kg)
One kilogram was defined as the mass of a cylindrical piece if platinum-iridium alloy kept at International Bureau of Weights and Measures at Serves near Paris.

15. Complete the following:

(a) 1 light year = ________ m
(b) 1 m = ________ Å
(c) 1 m = ________ μ
(d) 1 micron = ________ Å
(e) 1 fermi = ________ m

Solution:

(a) 1 light year = 9.46×10^{15} m
(b) 1 m = 10^{10} Å
(c) 1 m = 10^{6} μ
(d) 1 micron = 10^{4} Å
(e) 1 fermi = 10^{-15} m

16. State two units of mass smaller than a kilogram. How are they related to kilogram?

Solution:

The two units of mass smaller than a kilogram (kg) are:

- gram(g)
  1 g = 10^{-3}kg
- milligram(mg)
  1 mg = 10^{-6}kg

17. State two units of mass bigger than a kilogram. Give their relationship with the kilogram.

Solution:

The two units of mass bigger than a kilogram (kg) are:

- Quintal
  1 quintal = 100kg
- Metric tonne
  1 metric tonne = 1000kg

18. Complete the following:

(a) 1g = ______kg
(b) 1mg = ________kg
(c) 1 quintal = ________kg
(d) 1 a.m.u (or u) = ________kg

Solution:

(a) 1g = 10^{-3}kg
(b) 1mg = 10^{-6} kg
(c) 1 quintal = 100 kg
(d) 1 a.m.u (or u) = 1.66 x 10^{-27} kg

19. Name the S.I. unit of time and define it.

Solution:

The S.I. unit of time is second(s).
A second can be defined as 1/86400th part of a mean solar day, i.e.,
1s = 1/86400 x one mean solar day

20. Name two units of time bigger than a second. How are they related to second?

Solution:

The two units of time bigger than a second (s) are:

- Minute (min)
  1 min = 60s
- Hour (h)
  1 h = 3600s

21. What is a leap year?

Solution:

A leap year is the year in which the month of February is of 29 days, i.e.,
1 Leap year = 366 days

22. 'The year 2020 will have February of 29 days'. Is this statement true?

Solution:

Yes, the year 2020 shall be a leap year.

23. What is a lunar month?

Solution:

It is a month measured between successive new moons.

24. Complete the following:

(a) 1 nano second = ________s
(b) 1 µs = _______s
(c) 1 mean solar day = ________s
(d) 1 year = ________s

Solution:

(a) 1 nano second = 10^{-9} s
(b) 1 µs = 10^{-6} s
(c) 1 mean solar day = 86400s
(d) 1 year = 3.15×10^{7}s

25. Name the physical quantities which are measured in the following units:

(a) u
(b) ly
(c) ns
(d) nm

Solution:

Unit	Physical quantity measured
u	Mass
ly	Length
ns	Time
nm	Length

26. Write the derived units of the following:

(a) Speed
(b) Force
(c) Work
(d) Pressure

Solution:

The derived units of the following are as follows:

(a) Speed = ms^{-1}

(b) Force = kg m s^{-2}

(c) Work = kg m^2 s^{-2}
(d) Pressure = kg m^{-1} s^{-2}

27. How are the following derived units related to the fundamental units?

(a) Newton
(b) Watt
(c) Joule
(d) Pascal

Solution:

(a) Newton – kg m s^{-2}
(b) Watt - kg m^2 s^{-3}
(c) Joule - kg m^2 s^{-2}
(d) Pascal - kg m^{-1} s^{-2}

28. Name the physical quantities related to the following units:

(a) km^2
(b) newton
(c) joule
(d) pascal
(e) watt

Solution:

The physical quantities related to the following units are:

(a) km^2 - area
(b) newton – force
(c) joule – energy
(d) pascal – pressure
(e) watt – power

Multiple Choice Type

1. **The fundamental unit is:**
   (a) newton
   (b) pascal
   (c) hertz
   (d) second
   Solution:
   (d) second
   Second is a fundamental unit. Some other fundamental units are meter (m), kilogram(kg).

2. **Which of the following unit is not a fundamental unit:**
   (a) metre
   (b) litre
   (c) second
   (d) kilogram
   Solution:
   (b) litre
   Litre is a unit of volume, which is a derived physical quantity.

3. **The unit of time is:**
   (a) light year
   (b) parsec
   (c) leap year
   (d) angstrom
   Solution:
   (c) leap year
   A leap year is the year in which the month of February is of 29 days.

4. **1 Å is equal to:**
   (a) 0.1 nm
   (b) 10^{-10}cm
   (c) 10^{-8}m
   (d) 10^{4}µ
   Solution:
   (a) 0.1 nm
   1 m= 10^{10} Å

5. **ly is the unit of:**
   (a) time
   (b) length
   (c) mass
   (d) none of these
   Solution:
   (b) length
   ly is the short for light year, which is a unit of distance or length.

Numericals

1. **The wavelength of light of a particular colour is 5800 Å. Express it in (a) nanometer and (b) metre**
   Solution:
   The wavelength of light of a particular colour is 5800 Å.
   (a) 1nm = 10 Å
   5800 Å = 5800/10 = 580 nm
   (b) 1 m= 10^{10} Å
   5800 Å = 5800 / 10^{10} = 5.8 x 10^{-7}m

2. **The size of a bacteria is 1 µ. Find the number of bacteria in 1m length.**
   Solution:
   Size of bacteria is 1 µ
   1 µ = 10^{-6}m
   Number of bacteria in 1m = 1/10^{-6}
   Number of bacteria in 1m length = 10^{6} bacteria

3. The distance of a galaxy from the earth is 5.6 x 10^{25}m. Assuming the speed of light to be 3 x 10^8 ms^{-1} find the time taken by light to travel this distance.

[Hint: Time taken = $\frac{\text{distance travelled}}{\text{speed}}$]

Solution:

Given:

distance = 5.6 x 10^{25}m

speed = 3 x 10^8 ms^{-1}

Time = ?

Time taken = $\frac{\text{distance travelled}}{\text{speed}}$

$= \frac{5.6 \text{ x } 10^{25}}{3 \text{ x } 10^8}$

= 1.867 x 10^{17}s

4. The wavelength of light is 589nm. What is its wavelength in Å?

Solution:

Given:

The wavelength of light is 589nm.

1 nm = 10 Å

∴ 589nm = 5890 Å

5. The mass of an oxygen atom is 16.00 u. Find its mass in kg.

Solution:

Given:

Mass of oxygen atom = 16u

1 u = 1.66 x 10^{-27} kg

Mass of 16 u = 16 x 1.66 x 10^{-27}

= 2.656 x 10^{-26} kg

6. It takes time 8 min for light to reach from the sun to the earth surface. If speed of light is taken to be 3 x 10^8 ms^{-1}, find the distance from the sun to the earth in km.

Solution:

Given:

Time = 8 min

Speed = 3 x 10^8 ms^{-1}

Distance = ?

Time is not given in the standard form, i.e., in seconds. So first convert to seconds;

1 min = 60s

8 min = 8 x 60s = 480s

Distance = s x t

= 3 x 10^8 x 480 = 1.44 x 10^8 km

7. 'The distance of a star from the earth is 8.33 light minutes'. What do you mean by this statement? Express the distance in metre.

Solution:

Given:

The distance of a star from the earth is 8.33 light minutes means that it takes 8.33 minutes for light to reach the earth from the ultimate source of light – the Sun. The distance is large, hence light year is used.

Speed of light = 3×10^8 ms^{-1}

Time = 8.33 min = 499.8s

Distance = speed x time

= $3 \times 10^8 \times 499.8$

= 1.5×10^{11} m

Exercise-1(B) Page: 20

1. **Explain the meaning of the term 'least count of an instrument' by taking a suitable example.**

Solution:
The least count of an instrument is the smallest measurement which can be accurately taken from that particular instrument.
Example – if there are 10 divisions between 0 and 5s mark of a stop watch, the least count of that stop watch is 0.5s.

2. **A boy makes a ruler with graduation in cm on it (i.e., 100 divisions in 1m). To what accuracy this ruler can measure? How can this accuracy be increased?**

Solution:
Given: ruler has 100 divisions – centimeter scaling system
100 cm = 1m
Hence the accuracy the ruler can measure up to is the centimeter division.
∴ the ruler can be used to measure the length up to the accuracy of centimeter

In order to increase the accuracy, the scale must further be able to measure the next unit in-line, i.e., the millimeter division. By doing so the accuracy of the ruler can increase from centimeter to millimeter.
Hence,
1m=100cm = 10mm
1 m = 1000 mm

3. **A boy measures the length of a pencil and expresses it to be 2.6cm. What is the accuracy of his measurement? Can he write it as 2.60cm?**

Solution:
Given: The length of the pencil is 2.6cm.
We know that length can be expressed in different units such as metre, centimeter, millimeter etc.
Hence we can say that the measurement may be accurate but not precise enough.

The boy can write 2.6cm or can express it as 2.60cm, both are the same as the value of zero here is not significant.

4. **Define least count of a venier calipers. How do you determine it?**

Solution:
The least count of a vernier caliper can be defined as the difference between the values of one main scale division and one vernier scale division. It is also referred to as vernier constant.
It can be determined using the formula:

$$\text{Least count (L.C.)} = \frac{\text{Value of one main scale division}}{\text{total number of divisions on vernier}}$$

5. Define the term 'Vernier constant'.

Solution:

Vernier constant can be defined as the difference between the values of one main scale division and one vernier scale division.

6. When is a vernier calipers said to be free from zero error?

Solution:

When the zero mark of the vernier scale coincides with the zero mark of the main scale, the tenth division of the vernier calipers coincides with the ninth division of the main scale. In this condition, the vernier is said to be free from zero error.

7. What is meant by zero error of a vernier calipers? How is it determined? Draw neat diagrams to explain it. How is it taken in account to get the correct measurement?

Solution:

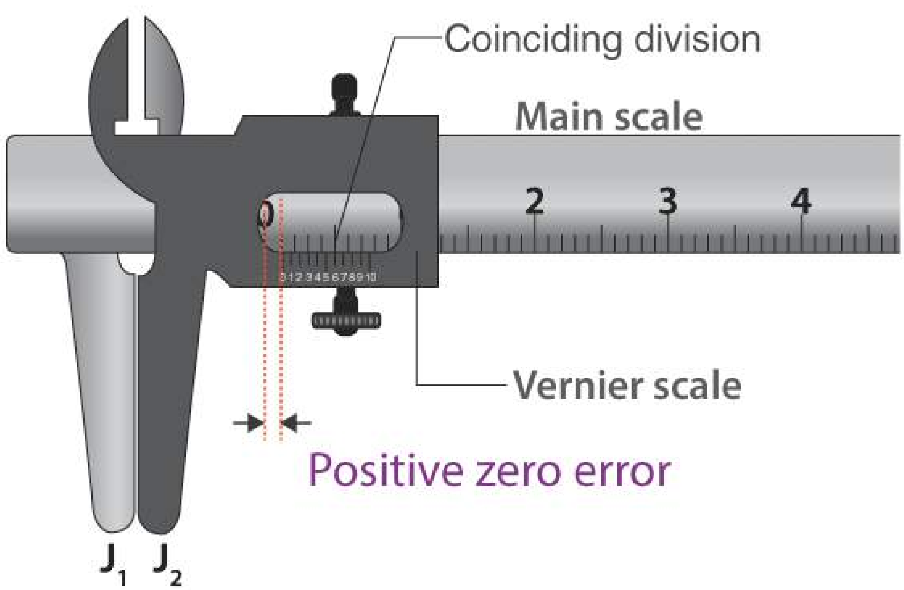
Sometimes due to mechanical errors, the zero mark of the vernier scale does not coincide with the zero mark on the main scale, in this condition, the vernier callipers is said to have a zero error.

Determination of zero error: Measure the length between the zero mark of the main scale and the zero mark of the vernier scale.

Zero errors are of two kinds, they are:

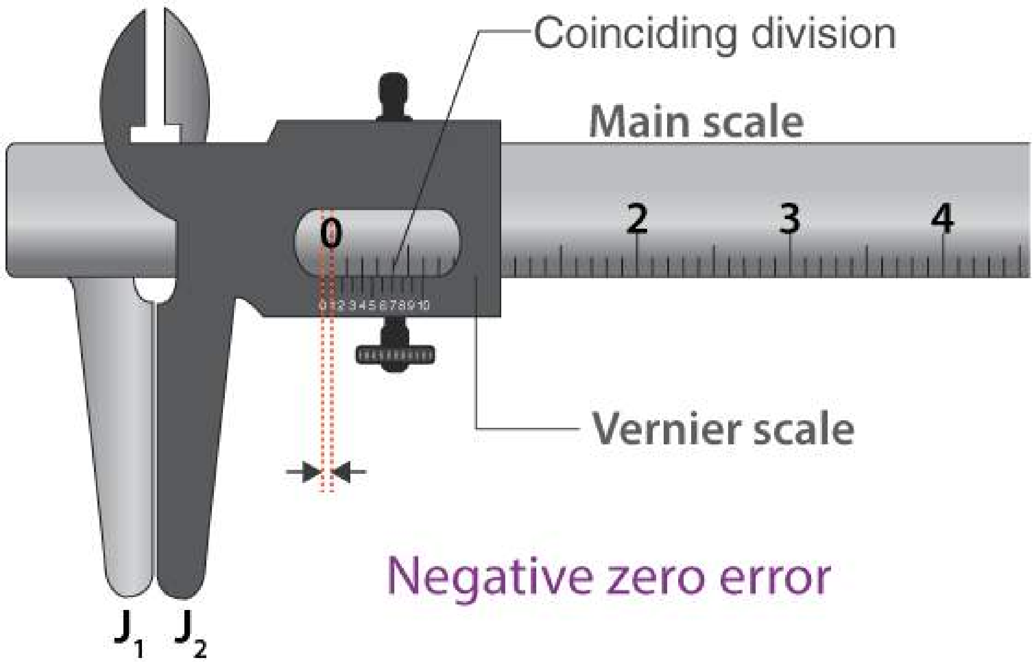
- Positive zero error
- Negative zero error

Positive zero error: if the zero mark of the vernier scale is on the right part of the zero mark of the main scale on brining the two jaws together, it is a positive zero error.



To find positive zero error, division of the vernier scale should be noted that coincides with any division of the main scale. Zero error is obtained when this number of the vernier division is multiplied by the least count of the vernier calipers.
Here, in the example (scale), the L.C = 0.01cm. It is also observed that the 6th division of the vernier scale coincides with main scale division.
∴ zero error = 6 x L.C = 6 x 0.01cm = 0.06cm.

Negative zero error: if the zero mark of the vernier scale is on the left part of the zero mark of the main scale upon bringing the two jaws together, it is a negative zero error.



To find negative zero error, the division of the vernier scale that coincides with any division of the main scale should be observed and noted. The number appearing at this vernier division is subtracted from the total number of divisions on the vernier scale and then the difference is multiplied by the least count.

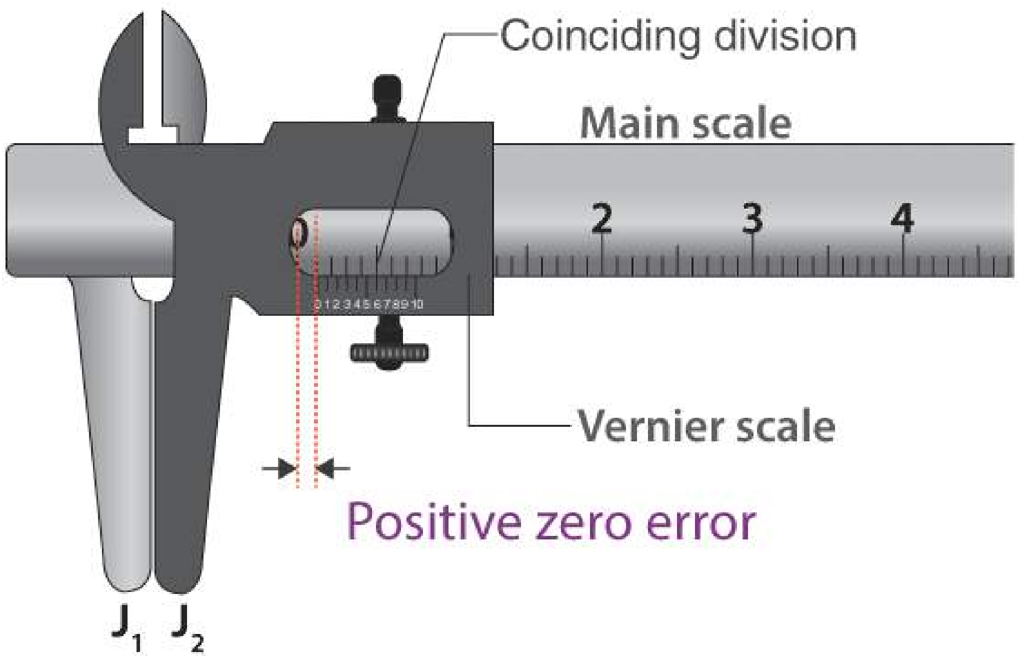
The total number of division on the callipers is 10. Here, in the example (scale), the L.C = 0.01cm, the 6th division of the vernier scale coincides with a particular division of the main scale.
∴ zero error = - (10 – 6) x L.C = -4 x 0.01cm = -0.04cm

In order to correct the measurement of the vernier callipers with zero error, the zero error with proper sign is subtracted always from the observed reading.

∴ Correct reading = observed reading – zero error (with sign)

8. A vernier callipers has a zero error +0.06cm. Draw a neat labelled diagram to represent it.

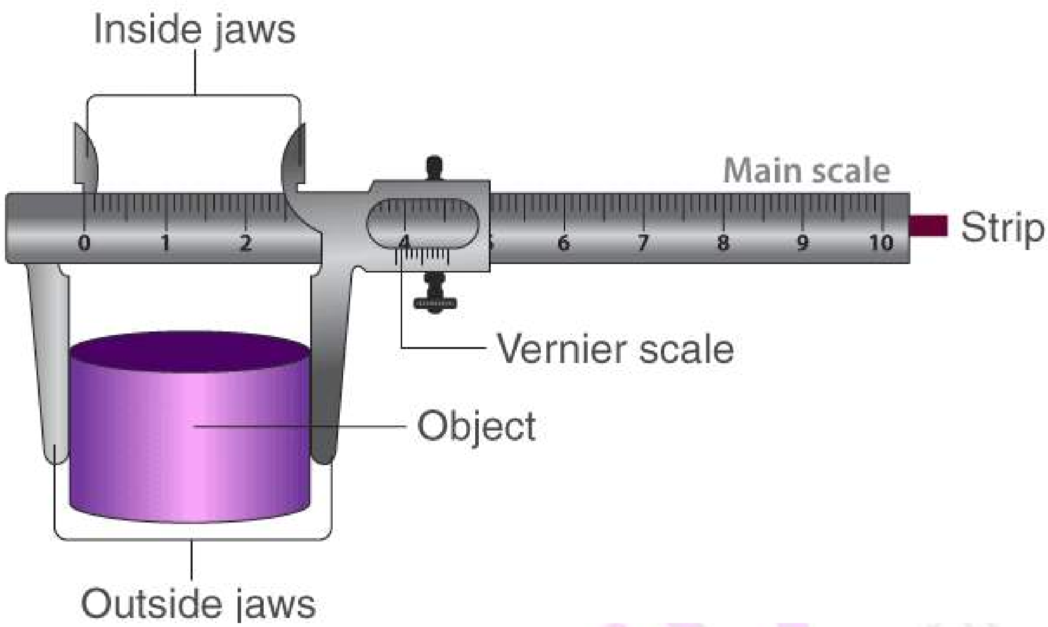
Solution:



Given: L.C. = 0.01cm
As per the scale readings, main scale reading = 3.3mm
The 6th vernier division coincides with a main scale division
Vernier scale reading = 6 x 0.01 cm = 0.06cm
Total reading = m.s.r + v.s.r = 3.3 + 0.06 = 3.36cm

9. Draw a neat labelled diagram of a vernier callipers. Name its main parts and state their functions.

Solution:



The various parts ant their functions are:

Parts	Functions
Main scale	To measure length correct upto 1mm
Vernier scale	To measure length correct upto 0.1mm
Outside jaws	To measure length of rod, external diameter of a hollow cylinder, diameter of a sphere
Inside jaws	Measure the internal diameter of a pipe or hollow cylinder
Strip	Measure the depth of a bottle/beaker

10. State three uses of a vernier calipers.

Solution:

The three uses of vernier calipers are:

- It can be used to measure the length of an object
- It can be used to measure the diameter of a hollow cylinder
- It can be used measure the depth of a beaker

11. Name the two scales of a vernier callipers and explain, how it is used to measure a length correct up to 0.01cm.

Solution:

Two scales of a vernier callipers are:

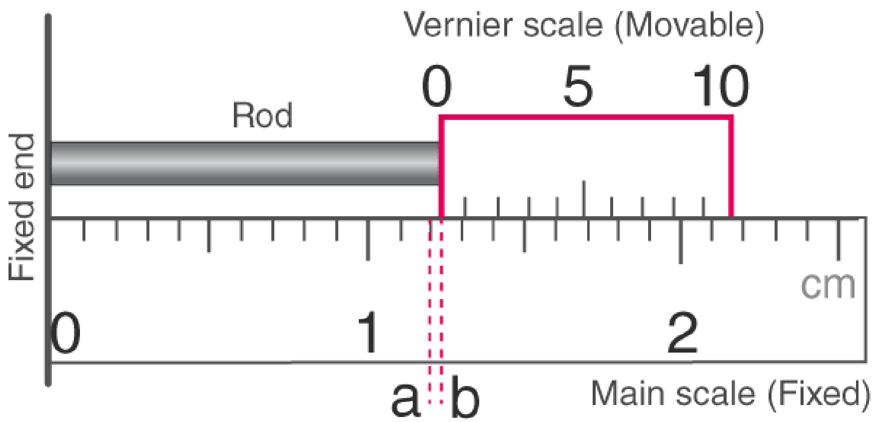
- Main scale - can read up till 1mm
- Vernier scale – length of 10 divisions is equal to length of 9 divisions on the main scale

The value of one division on the main scale is 1mm

Total number of divisions on the vernier scale is 10
∴ Least count = 1mm/10 = 0.1mm = 0.01cm
Consequently, a vernier calipers can be used to measure a length accurately up to 0.01cm.

12. Describe in steps, how would you use a vernier calipers to measure the length of a small rod?

Solution:



Using vernier calipers to measure the length of a small rod:

- The rod is placed between the fixed end and the vernier scale as observed in the figure
- The zero mark of the vernier scale here is ahead of the 1.2cm mark on the main scale. Hence the actual rod length is the total of 1.2cm and the length between the 1.2cm marking on the main scale and 0 mark on the vernier scale (length 'ab' as seen in the figure)
- In order to know the length of 'ab', the pth division of the vernier scale is noted that coincides with ant division of the main scale.
- Length of p division on main scale = ab + length of p division on vernier scale
  Length of p divisions on the main scale – length of p division on the verier scale = ab
  = Length of 1 division of main scale – length of 1 division on vernier scale (p)
  = p x Least Count
  ∴ Final reading = main scale reading + vernier scale reading
  = 1.2cm + (p x L.C)
  This gives the length of the small rod.

13. Name the part of the vernier calipers which is used to measure the following:
(a) External diameter of a tube
(b) Internal diameter of a mug
(c) Depth of a small bottle
(d) Thickness of a pencil

Solution:

(a) External diameter of a tube – outside jaws
(b) Internal diameter of a mug – Inside jaws
(c) Depth of a small bottle - Strip

(d) Thickness of a pencil – Outer jaws

14. Explain the terms (i) pitch, and (ii) least count of a screw gauge. How are they determined?

Solution:

(i) Pitch of a screw gauge – it is the distance moved by the screw through its axis along one complete rotation.

(ii) Least count of a screw gauge – It is the distance moved by it in rotating the circular scale by one division.

Pitch & L.C of the screw gauge can be determined by:

L.C = Pitch of the screw gauge ÷ total number of divisions on its circular scale

For example, if a screw moved by 1mm through 1 rotation and if the circular scale has 100 divisions, then the pitch of the screw = 1mm.

The L.C = 1mm/100 = 0.01mm = 0.001cm

15. How can the least count of a screw gauge be decreased?

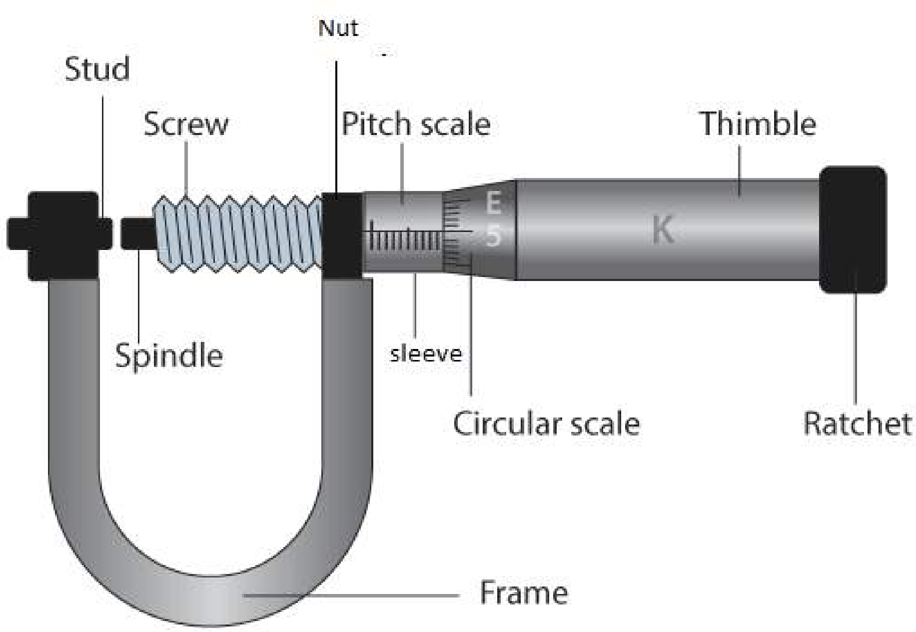
Solution:

The least count can be decreased by

- Increasing the total number of divisions on the circular scale
- Reducing the pitch

16. Draw a neat labelled diagram of a screw gauge. Name its main parts and state their functions.

Solution:



The main parts and their functions are:

1. Ratchet – advances the screw by turning it till the object to be measured in held gently in between the spindle of the screw and the stud.
2. Sleeve – it notes the base line and the base line
3. Thimble – circular scale is marked by the thimble
4. Circular scale – reads length correctly to 0.01mm
5. Main scale – reads length to 1mm

17. State one use of a screw gauge.

Solution:

Use of screw gauge:

- It can be used to measure the diameter of a wire
- It can be used to measure thickness of a paper

18. State the purpose of ratchet in a screw gauge.

Solution:

The purpose of a ratchet in a screw gauge is that it is used to advance the screw by turning it till the object is gently held between the stud and the spindle of the screw.

19. What do you mean by zero error of a screw gauge? How is it accounted for?

Solution:

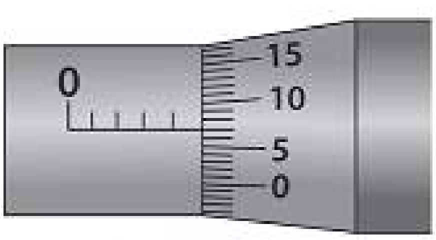
Several times, because of mechanical errors, the anvil and spindle end come in contact wherein the zero mark of the circular scale does not coincide with the main scale's base line, as it is either below or above the base line of the main scale. In this condition, the screw gauge is referred to have zero error which can be both negative and positive.

The zero error can be accounted by subtracting the zero error (with sign) from the reading observed to obtain the actual reading.

Correct reading = Observed reading – zero error (with sign)

20. A screw gauge has a least count 0.001cm and zero error + 0.007cm. Draw a neat diagram to represent it.

Solution:



Positive zero error

21. What is backlash error? Why is it caused? How is it avoided?

Solution:

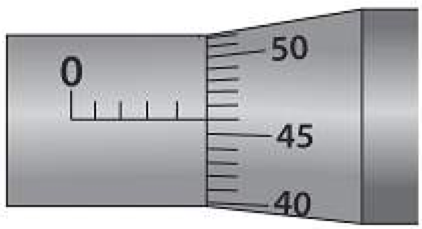
A backlash error is an error in the observation caused due to wear and tear of threads of the screw observed while reversing the direction of rotation of the thimble where the tip of the screw does not start moving in the opposite direction at once, but remains stationary for a part of rotation.

Avoid backlash error:

- While taking measurements, screw should be rotated in one direction only.

22. Describe the procedure to measure the diameter of a wire with the help of a screw gauge.

Solution:



Procedure to measure the diameter of a wire with the help of a screw gauge is as follows:

- Find the least count and the zero error of the screw gauge
- Turn the ratchet anticlockwise so as to obtain a gap between the stud A and the flat end B. Place the wire in the gap between the stud A and the flat end B. Then turn the The ratchet clockwise so as to hold the given wire gently between the stud A and the flat end B of the screw.
- Make note of the main scale reading
- Make note of the division of p on the circular scale that coincides with the base line of the main scale. This circular scale division p when multiplied by the least count, gives the circular scale reading i.e., Circular scale reading = p x L.C.
- Add the circular scale reading to the main scale reading to obtain the total reading (i.e., the observed diameter of the wire).
- Repeat it by keeping the wire in perpendicular direction. Take two more observations at different places of the wire and record them in the table below.

23. Name the instrument which can measure accurately the following:
(a) The diameter of a needle
(b) The thickness of a paper
(c) The internal diameter of the neck of a water bottle
(d) The diameter of a pencil

Solution:

(a) The diameter of a needle – screw gauge
(b) The thickness of a paper – screw gauge
(c) The internal diameter of the neck of a water bottle – vernier callipers
(d) The diameter of a pencil – screw gauge

24. Which of the following measures a small length to a high accuracy: metre rule, vernier calipers, screw gauge?

Solution:

The screw gauge measures a small length to a high accuracy.

25. Name the instrument which has the least count:

(a) 0.1mm
(b) 1mm
(c) 0.01mm

Solution:

(a) 0.1mm – vernier callipers
(b) 1mm – metre rule
(c) 0.01mm – screw gauge

Multiple Choice Type

1. **The least count of a vernier calipers is:**
   (a) 1cm
   (b) 0.001cm
   (c) 0.1cm
   (d) 0.01cm
   Solution:
   (c) 0.01cm
   Least count is the smallest measurement that can be accurately taken with the instrument

2. **A microscope has its main scale with 20 divisions in 1cm and vernier scale with 25 divisions, the length of which is equal to the length of 24 divisions of main scale. The least count of microscope is:**
   (a) 0.002cm
   (b) 0.001cm
   (c) 0.02cm
   (d) 0.01cm
   Solution:
   (a) 0.002cm
   The least count of any instrument is the smallest measurement that can be taken accurately

3. **The diameter of a thin wire can be measured by:**
   (a) A vernier calipers
   (b) A metre rule
   (c) A screw gauge
   (d) None of these
   Solution:
   (c) A screw gauge

Numericals:

1. **A stop watch has 10 divisions graduated between the 0 and 5s marks. What is its least count?**
   Solution:
   Least count is the smallest value that can be measured by an instrument.
   L.C = (5-0)/10 = 0.5s
2. **A vernier has 10 divisions and they are equal to 9 divisions of main scale in length. If the main scale is calibrated in mm, what is its least count?**
   Solution:
   Value of the main scale division = 1/10
   $\therefore$ L.C=$\frac{\text{Value of one main scale division}}{\text{total number of divisions on vernier}} = 1\text{mm}/10 = 0.1\text{mm} = 0.01\text{cm}$

3. **A microscope is provided with a main scale graduated with 20 divisions in 1cm and a vernier scale with 50 divisions on it of length same as of 49 divisions of main scale. Find the least count of the microscope.**
   Solution:
   Given: 1 main scale division = 1/20cm
   50 divisions of vernier scale = 49 divisions of main scale
   1 division of vernier scale = 49 ÷ 50 main scale divisions
   = 0.98 main scale division

   Vernier calipers:
   L.C = 1 main scale division – 1 vernier scale division
   = 1 main scale division – 0.98 main scale division
   = 0.02 main scale division

   Microscope:
   1 main scale division = 1/20cm
   L.C = 0.02 x 1/20 = 0.001cm

   $\therefore$ Least count of the microscope is 0.001cm

4. **A boy uses a vernier calipers to measure the thickness of his pencil. He measures it to be 1.4mm. If the zero error of vernier calipers is +0.02cm, what is the correct thickness of pencil?**
   Solution:
   Given: Thickness of the pencil = 1.4mm
   Zero error = +0.02cm
   Actual thickness =?

   Correct reading = observed reading – zero error
   = 1.4mm – 0.02cm
   = 1.4mm – 0.2mm

= 1.2mm

5. **A vernier calipers has its main scale graduated in mm and 10 divisions on its vernier scale are equal in length to 9mm. When the two jaws are in contact, the zero of vernier scale is ahead of zero of main scale and 3rd division of vernier scale coincides with a main scale division. Find: (i) the least count and (ii) the zero error of the vernier calipers.**

Solution:

Main scale reading = 9mm

Vernier scale reading = 10

Coinciding division = 3

$\therefore$ L.C= $\frac{\text{Value of one main scale division}}{\text{total number of divisions on vernier}}$ = 1mm/10 = 0.1mm

Least count = 0.1mm = 0.01cm

Positive zero error = L.C x Coinciding division

= + (0.1mm x 3)

= + 0.3mm or +0.03cm

6. **The main scale of a vernier calipers is calibrated in mm and 19 divisions of main scale are equal in length to 20 divisions of vernier scale. In measuring the diameter of a cylinder by this instrument, the main scale reads 35 divisions and 4th division of vernier scale coincides with a main scale division. Find: (i) least count and (ii) radius of cylinder.**

Solution:

(i) To find the least count

Given:

20 divisions of vernier scale = 19 divisions of main scale

Least count of the vernier scale = 1/20 mm = 0.05mm or 0.005cm

(ii) To find the zero error of the vernier caliper

Vernier scale reading = 4 x 0.005cm = 0.02cm

Total reading = main scale reading + vernier scale reading

= 3.5cm + 0.02cm

= 3.52cm

Diameter = 3.52cm

Radius = ½ x diameter = ½ x 3.52cm = 1.76cm or 17.6mm

7. **In a vernier calipers, there are 10 divisions on the vernier scale and 1cm on the main scale is divided in 10 parts. While measuring a length, the zero of the vernier lies just ahead of 1.8cm mark and 4th division of vernier coincides with a main scale division.**

(a) Find the length

(b) If zero of vernier calipers is -0.02cm, what is the correct length?

Solution:

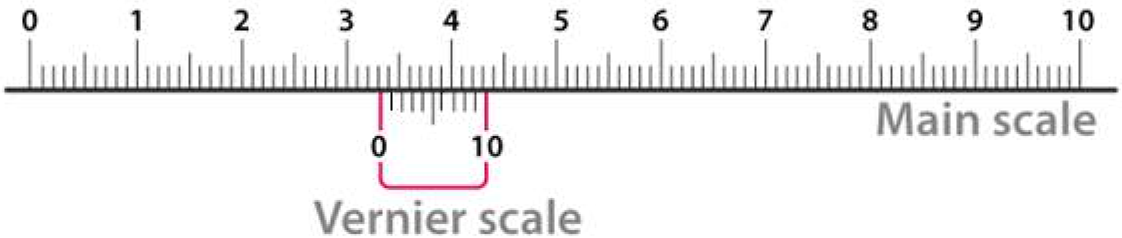
(a) L.C = 0.01cm

Main scale reading of vernier calipers = 1.8cm

Coinciding division = 4th
Vernier scale reading = vernier scale division x L.C
= 4 x 0.01 = 0.04cm
Total reading = main scale reading + vernier scale reading
= 1.8cm + 0.04cm = 1.84cm

(b) If zero error is -0.02cm, the correct length is
Correct reading = observed reading – zero error
= 1.84cm – (-0.02cm)
= 1.86cm

8. While measuring the length of a rod with a vernier calipers, Figure below shows the position of its scales. What is the length of the rod?



Solution:
The least count of vernier calipers = 0.01cm
Main scale reading = 3.3cm
6th division of vernier scale coincides with a division on main scale i.e., p=6
∴ vernier scale reading = 6 x 0.01 = 0.06cm

Observed reading = main scale reading + vernier scale reading
= 3.3cm + 0.06cm
=3.36cm
If the vernier calipers is free from zero error, then the true length of the rod is 3.36cm

9. The pitch of a screw gauge is 0.5mm and the head scale is divided in 100 parts. What is the least count of screw gauge?

Solution:
Given : Pitch = 0.5mm
Number of divisions on circular head = 100

Least count = $\frac{\text{Pitch}}{\text{total number of divisions on circular head}}$ = 0.5mm/100

= 0.005mm or 0.0005cm

10. The thimble of a screw gauge has 50 divisions. The spindle advances 1mm when the screw is turned through two revolutions.
(i) What is the pitch of screw gauge?
(ii) What is the least count of the screw gauge?

Solution:

Given: Number of circular divisions = 50

Distance covered in two rotations = 1mm

(i) Pitch = ½ x distance covered in two rotations

= ½ x 1mm = 0.5mm

(ii) Least count = $\frac{\text{Pitch}}{\text{total number of divisions on circular head}}$ = 0.5mm/50 = 0.01mm

11. The pitch of a screw gauge is 1mm and its circular scale has 100 divisions. In measurement of the diameter of a wire, the main scale reads 2mm and 45th mark on circular scale coincides with the base line. Find:

(i) The least count, and

(ii) The diameter of the wire

Solution:

(i) Least count = $\frac{\text{Pitch}}{\text{total number of divisions on circular head}}$

= 1mm/100

=0.01 mm or 0.001cm

(ii) Diameter of the wire = main scale reading + circular scale reading

= 2mm + (45 x 0.01mm)

= 2 + 0.45

= 2.45mm or 0.245cm

12. When a screw gauge of least count 0.01mm is used to measure the diameter of a wire, the reading on the sleeve is found to be 1mm and the reading on the thimble is found to be 27 divisions. (i) what is the diameter of the wire in cm? (ii) if the zero error is +0.005cm, what is the correct diameter?

Solution:

Reading on the sleeve = 1mm

Reading on the thimble = 27 x least count = 27 x 0.01mm = 0.27mm

Total reading = reading on the sleeve + reading on the thimble

= 1mm + 0.27mm = 1.27mm or 0.127cm

Zero error = + 0.005mm

Correct reading = observed reading – zero error

= 1.27mm – 0.005mm = 1.265mm

13. A screw gauge has 50 divisions on its circular scale and its screw moves by 1mm on turning it by two rotations. When the flat end of the screw is in contact with the stud, the zero of circular scale lies below the base line and 4th division of circular scale is in line with the base line. Find: (i) the pitch, (ii) the least count and (iii) the zero error, of the screw gauge.

Solution:

Given : 50 divisions on circular scale

(i) One complete rotation, or the distance travelled by the screw is the pitch

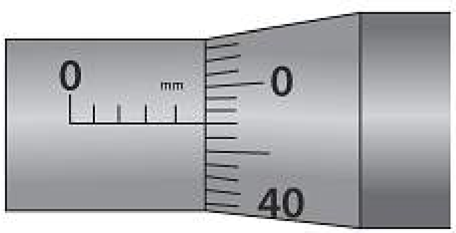
1mm movement has 2 rotations.

∴ pitch = distance / rotation = ½ = 0.5mm

(ii) Least count = $\frac{\text{Pitch}}{\text{total number of divisions on circular head}}$ = 0.5/50 = 0.01mm

(iii) Zero error = coinciding division x least count
= +4 x 0.01mm = + 0.04mm

14. Figure below shows the reading obtained while measuring the diameter of a wire with a screw gauge. The screw advances by 1 division on main scale when circular head is rotated once.
Find: (i) pitch of the screw gauge,
(ii) Least count of the screw gauge, and
(iii) The diameter of the wire.



Solution:

(i) Pitch = distance covered in one revolution = 1mm

(ii) Least count = $\frac{\text{Pitch}}{\text{total number of divisions on circular head}}$ = 1mm/50=0.02mm

(iii) Diameter of the wire = main scale reading + circular scale reading
= 4.94mm

15. A screw has a pitch equal to 0.5mm. What should be the number of division on its head so as to read correct up to 0.001mm with its help?

Solution:

Given: Pitch = 0.5mm

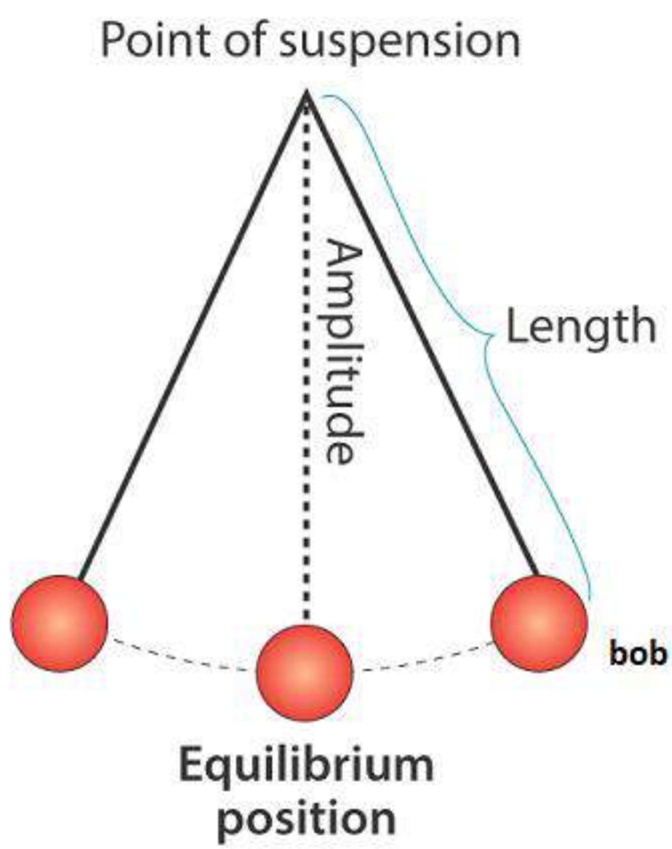
Number of divisions = 0.5mm/0.001mm = 500

Exercise-1(C)

1. **What is a simple pendulum? Is the pendulum used in a pendulum clock simple pendulum? Give reason to your answer.**
   Solution:
   It is a heavy point mass that is suspended from a rigid support by a massless and inextensible string.
   No, the pendulum in the pendulum clock is not a simple pendulum as it is an ideal case. The mass cannot be heavy having the size of point and string having no mass.

2. **Define the terms: (i) oscillation, (ii) amplitude (iii) frequency (iv) time period as related to a simple pendulum**
   Solution:
   (i) **Oscillation –** one complete to and fro motion of the bob of pendulum
   (ii) **Amplitude –** It is the maximum displacement of the bob from its mean position on either side
   (iii) **Frequency –** It is the number of oscillations made in one second
   (iv) **Time period –** It is the time taken to complete one oscillation

3. **Draw a neat diagram of a simple pendulum. Show on it the effective length of the pendulum and its one oscillation.**
   Solution:



4. **Name two factors on which the time period of a simple pendulum depends. Write the relation for the time period in terms of the above named factors.**

Solution:

The two factors on which the time period of a simple pendulum is dependent are:

- Acceleration due to gravity
- Length of the string of the pendulum

Time period in terms of the above named factors are:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Time period is directly dependent on length with square root and inversely proportional to 'g' – acceleration due to gravity with square root.

5. **Name two factors on which the time period of a simple pendulum does not spend.**

Solution:

The time period of a simple pendulum does not spend on the following factors:

- Mass of the bob
- Material of the pendulum

6. **How is the time period of a simple pendulum affected, if at all, in the following situations:**
(a) The length is made four times,
(b) The acceleration due to gravity is reduced to one-fourth.

Solution:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

(a) The length is made four times – 'T' is directly proportional to the square root of the 'l' – length of the string and inversely proportional to the acceleration due to gravity. Hence the length is doubled when the period is increased by two times.

(b) The acceleration due to gravity is reduced to one-fourth – when g - acceleration due to gravity, is reduced by $1/4^{th}$, the period is increased by 2 times.

7. **How are the time period T and frequency f of an oscillation of a simple pendulum related?**

Solution:

The time period and frequency of an oscillation of a simple pendulum are related as stated below:

$$f = \frac{1}{T}$$

8. **How do you measure the time period of a given pendulum? Why do you note the time for more than one oscillation?**

Solution:

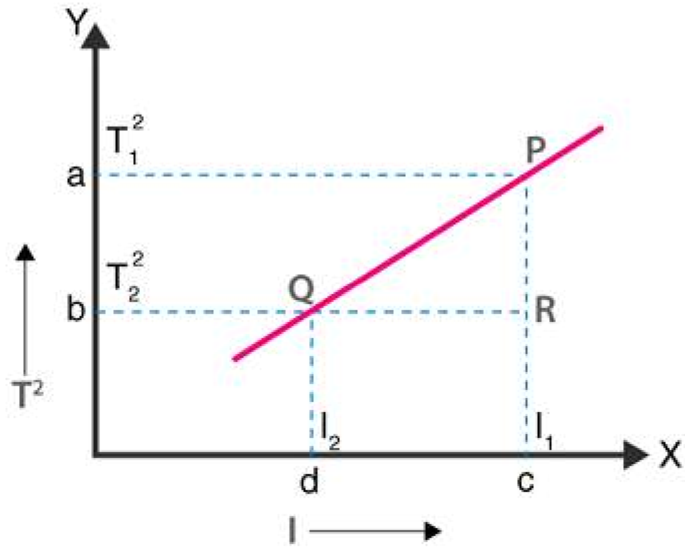
In order to measure the time period of pendulum, total time taken by the pendulum should be divided by the number of oscillations.

9. How does the time period (T) of a simple pendulum depend on its length (l)? Draw a graph showing the variation of T^2 with l. How will you use this graph to determine the value of g (acceleration due to gravity)?

Solution:

In a simple pendulum, Time period is dependent on the length directly. Time period is directly proportional to the square root of its effective length.

i.e., $T \propto \sqrt{l}$



The acceleration due to gravity (g) can be calculated from the above mentioned graph:

To find the slope of the straight line, two points P and Q can be taken on the straight line. Draw two normals from these mentioned points on the X and Y axis respectively. Value of T2 can be noted at a and b. To note the value at 'l', consider the points c and d.

Slope = $\frac{PR}{QR} = \frac{ab}{cd} = \frac{T_1^2 - T_2^2}{l_1 - l_2}$

The slope is observed to be constant at a point which is equal to $\frac{4\pi^2}{g}$, g=acceleration due to gravity at that place. Hence 'g' can be determined at a place with the help of these measurements with the help of this relation:

$$g = \frac{4\pi^2}{\text{Slope of } T^2 \text{vs l graph}}$$

10. Two simple pendulum A and B have equal lengths, but heir bobs weigh 50 gf and 100 gf respectively. What would be the ratio of their time periods? Give reason for your answer.

Solution:

The ratio of the time periods to the two pendulums A and B are 1:1 as the time period is a factor that is independent of the mass of the bob.

11. Two simple pendulums A and B have lengths 1.0m and 4.0m respectively at a certain place. Which pendulum will make more oscillations in 1 minute? Explain your answer.

Solution:

Pendulum A will take more time, twice to be precise in the given period of time as the time period (T) is directly proportional to the square root of the length, i.e., $T \propto \sqrt{l}$. Consequently, A will make more oscillations in a given period of time than B, as B has lesser oscillations.

12. State how does the time period of a simple pendulum depend on (a) length of pendulum, (b) mass of bob, (c) amplitude of oscillation and (d) acceleration due to gravity.

Solution:

Time period varies in the following ways with the listed below factors:

(a) length of pendulum – Time period is directly proportional to the square root of the length of the pendulum
(b) mass of bob – Time period does not depend on the mass of the bob
(c) amplitude of oscillation - Time period does not depend on the amplitude of oscillation
(d) acceleration due to gravity – Time period inversely varies with the square root of 'g' – acceleration due to gravity.

13. What is a seconds' pendulum?

Solution:

Seconds' pendulum is a pendulum with the time period of oscillation equal to two seconds.

14. State the numerical value of the frequency of oscillation of a seconds' pendulum. Does it depend on the amplitude of oscillation?

Solution:

The numerical value of the frequency of oscillation of a seconds' pendulum is 0.5 s^{-1}. No, it does not depend on the amplitude of oscillation.

Multiple Choice Type:

1. The length of a simple pendulum is made one-fourth. Its time period becomes:
(a) Four times
(b) One-fourth
(c) Double
(d) Half

Solution:

(d) Half

Time period is directly proportional to the square root of the length of the pendulum.

2. The time period of a pendulum clock is:
(a) 1s
(b) 2s
(c) 1 min
(d) 12h

Solution:
(b) 2s
Time period is found using the number of oscillations more than once as least count of stop watch is either 1s or 0.5s.

3. **The length of a seconds' pendulum is nearly:**
(a) 0.5m
(b) 9.8m
(c) 1.0m
(d) 2.0m
Solution:
(c) 1.0m
The effective length of a pendulum is the distance of the point of oscillation from the point of suspension

Numericals:

1. **A simple pendulum completes 40 oscillations in one minute. Find its (a) frequency, (b) time period.**
Solution:
Given: oscillations = 40
Time taken = 1 minute or 60s
(a) In one second the frequency is 40/60 = 0.67hertz

(b) Frequency = 1/time period
∴ time period = 1/frequency
= 1/0.67
=1.5s

2. **The time period of a simple pendulum is 2s. What is its frequency? What name is given to such a pendulum?**
Solution:
Given:
Time period = 2s
Frequency =?

Frequency = 1/time period
= ½ = 0.5 s^{-1}
The name given to such a pendulum is seconds' pendulum.

3. **A seconds' pendulum is taken to a place where acceleration due to gravity falls to one-forth. How is the time period of the pendulum affected, if at all? Give reason. What will be its new time period?**

Solution:

The time period is affected by acceleration due to gravity. The relation given below clearly states that:

$T \propto \sqrt{\frac{1}{g}}$. Time period is inversely proportional to the square root of acceleration due to gravity. Hence, when 'g' falls one-fourth, time period increases, it doubles.

Hence the new time period is 2 x 2 = 4s.

4. Find the length of a seconds' pendulum at a place where $g=10ms^{-2}$ (Take π =3.14).

Solution:

For seconds' pendulum T=2s, $g=10ms^{-2}$

We know, $T = 2\pi\sqrt{\frac{l}{g}}$

∴ Length of pendulum, $l = \frac{gT^2}{4\pi^2}$

$$l = \frac{10 \times 2^2}{4 \times 3.14^2}$$

$$= \frac{10 \times 4}{4 \times 3.14^2}$$

$$= \frac{10}{9.8956} = 1.0142m$$

5. Compare the time periods of two pendulums of length 1m and 9m.

Solution:

We know that time period of pendulum is:

$T = 2\pi\sqrt{\frac{l}{g}}$

'l' = length of the pendulum

'g' = acceleration due to gravity

As per the above relation, time period is proportional to the square root of the length.

Let T(1) and T(2) be the time period and L(1) and L(2) be the length of the pendulum respectively, accordingly;

$$T(1) : T(2) = \sqrt{L(1)} : \sqrt{L(2)}$$
$$= \sqrt{1} : \sqrt{9}$$
$$= 1:3$$

6. A Pendulum completes 2 oscillations in 5s. (a) What is its time period? (b) If $g=9.8\ ms^{-2}$, find its length.

Solution:

Given: oscillations = 2

(a) Time period = 1/oscillations per second

$$= \frac{1}{2 \div 5} = \frac{5}{2} = 2.5\text{s}$$

(b)

We know, $T = 2\pi\sqrt{\frac{l}{g}}$

∴ Length of pendulum, $l = \frac{gT^2}{4\pi^2}$

$$= \frac{9.8 \times (2.5)^2}{4 \times (3.14)^2}$$

= 1.55m

7. The time periods of two simple pendulums at a place are in the ratio 2:1. What will be the ratio of their lengths?

Solution:

We know that time period of pendulum is:

$T = 2\pi\sqrt{\frac{l}{g}}$

As per the above relation, time period is proportional to the square root of the length.
Let T(1) and T(2) be the time period and L(1) and L(2) be the length of the pendulum respectively, accordingly;

$T(1) : T(2) = \sqrt{L(1)} : \sqrt{L(2)}$

Or

$L1 : L2 = (T1)^2 : (T2)^2$
$L1 : L2 = (2)^2 : (1)^2$
$= 4:1$

8. It takes 0.2s for a pendulum bob to move from mean position to one end. What is the time period of pendulum?

Solution:

Time taken to complete one oscillation is the time period
= (4 x 0.2)s
= 0.8s

9. How much time does the bob of a seconds' pendulum take to move from one extreme of its oscillation to the other extreme?

Solution:

We know that the time period of a seconds' pendulum is 2seconds
∴ The time taken for a seconds' pendulum to make half oscillation is ½ x 2 seconds = 1 second.