Measurements and Experimentation

Unit 1
Exercise 1

(A) Objective Questions

I. Multiple choice Questions.
Select the correct option:

1. Which of the following is not a fundamental unit?
(a) Second
(b) Ampere
(c) Candela
(d) Newton
Ans. (d) Newton
Explanation : Second, Ampere and Candela are the fundamental units while Newton is a derived unit.

2. Which of the following is a fundamental unit?
(a) m/s^2
(b) Joule
(c) Newton
(d) metre
Ans. (d) metre
Explanation : m/s^2, Joule and Newton are derived units while metre is a fundamental unit.

3. Which is not a unit of distance?
(a) metre
(b) millimetre
(c) Leap year
(d) kilometre
Ans. (c) Leap year
Explanation : Leap year is a unit of time while the metre, millimetre and kilometre are the units of distance.

II Fill in the blanks

1. The unit is which we measure the quantity is called **constant quantity.**
2. One light year is equal to **9.46×10^{15} m.**

3. One mean solar day = **86400** sec
4. One year = **3.1536×10^7** sec
5. One micrometre = **10^{-6}** m.

(B) Subjective Questions

Question 1.
What do you understand by the term measurement?
Answer:
"Measurement implies comparison of a physical quantity with a standard unit to find out how many times the given standard is contained in the physical quantity."
Physics, like other branches of science requires experimental study which involves measurement.

Question 2.
What do you understand by the terms

1. unit
2. magnitude, as applied to a physical quantity?

Answer:
(i) Unit : Unit "is a standard quantity of the same kind with which a physical quantity is compared for measuring it. " In order to measure a physical quantity, a standard is needed (which is acceptable internationally). The standard should be some convenient, definite and easily reproducible quantity of the same kind in terms of which the physical quantity as a whole is expressed. This standard is called a unit
(ii) Magnitude of a physical quantity : The number of times a standard quantity is present in a given physical quantity is called magnitude of physical quantity.
Physical quantity = Magnitude × Unit

Question 3.
A body measures 25 m. State the unit and the magnitude of unit in the statement.
Answer:
Here S.I. unit of length i.e. metre (m) has been used. Magnitude of the given quantity = 25
Metre : It is defined as 1,650,763,73 times the wavelength of specified orange red spectral line a emission spectrum of Krypton-86 or 1,553,164.1 times the wavelength of the red line in emission spectrum of cadmium.
or one metre is defined as the distance travelled by the light in 1/299,792,458 of a second in air/vacuum.

Question 4.
State four characteristics of a standard unit.

Answer:
Characteristics of standard unit :

1. It should be of convenient size.
2. It should not change with respect to place and time.
3. It should be well defined.
4. It should be easily reproduced.

Question 5.
Define the term fundamental unit. Name fundamental units of mass; length; time; current and temperature.
Answer:
Fundamental unit : A fundamental or basic unit is that which is independent of any other unit or which can neither be changed nor can be related to any other fundamental unit. e.g. units of mass, length, time and temperature.

S. No.	Physical quantity	Name	Symbol
1.	Mass	kilogramme	kg
2.	Length	metre	m
3.	Time	second	s
4.	current	ampere	A
5.	Temperature	kelvin	K

Question 6.
What do you understand by the term derived unit? Give three examples.
Answer:
Derived units. "Derived units are those which can be expressed in terms of fundamental units."
Example.
1. Force = mass × acceleration

$$= \text{mass} \times \frac{\text{velocity}}{\text{time}}$$

$$= \text{mass} \times \frac{\frac{\text{distance}}{\text{time}}}{\text{time}} = \frac{\text{mass} \times \text{distance}}{(\text{time})^2}$$

$$\therefore \text{ Force} = \frac{\text{mass} \times \text{length}}{(\text{time})^2}$$

2. S.I. unit of area i.e. m^2 is a derived unit.
Area = length × breadth

Now metre is unit of length and breadth, so S.I. unit of area is obtained by multiplying the fundamental unit 'm' with itself. So, m^2 is the derived unit of area.
3. Density = Mass/volume
S.I. unit of density i.e. kg/m^3 is the derived unit of density because it can be obtained by combining two fundamental units kilogram and metre.

Question 7.

(a) Define metre according to old definition.
(b) Define metre in terms of wavelength of light.
(c) Why is the metre length in terms of wavelength of light considered more accurate?

Answer:
(a) Metre : One metre is defined as the one ten millionth part of distance from the pole to the equator.
(b) Metre : One metre is defined as 1,650, 763.73 times the wavelength of specified orange red spectral line in emission spectrum of Krypton = 86.
OR
One metre is defined as 1,553,164.1 times the wavelength of the red line in emission spectrum of cadmium.
(c) Metre length in terms of wavelength of light is considered more accurate because

1. The wavelength of light does not change with time, temperature, pressure etc.
2. It can be reproduced anywhere at any time because Krypton is available every where.

Question 8.
Name the convenient unit you will use to measure :

(a) length of a hall
(b) width of a book
(c) diameter of hair
(d) distance between two cities.

Answer:

(a) Foot (Ft)
(b) Centimetre (cm)
(c) Micrometre (μm)
(d) Kilometre (km)

Question 9.
(a) Define mass.
(b) State the units in which mass is measured in (1) C.GS. system (2) S.I. system.
(c) Name the most convenient unit of mass you will use to measure :

1. Mass of small amount of a medicine.
2. The grain output of a state
3. The bag of sugar
4. Mass of a cricket ball.

Answer:
(a) Mass: The quantity of matter contained in a body is known as its mass.
(b) In C.GS. system, mass is measured in gram. In S.I. system, mass is measured in Kilogram.
(c) (*i*) Microgram (μg). (*ii*) Tonne (*t*)
(*iii*) Quintal (μt) (*iv*) Gram (g)
Note : 1 microgram = 10^{-6} g = 10^{-9} kg
1 Tonne = 1000 kg ; 1 Quintal = 100 kg

Question 10.
(a) Define time.
(b) State or define the following terms :

1. Solar day
2. Mean solar day
3. An hour
4. Minute
5. Second
6. Year.

Answer:
(a) Time : It is defined as the time interval between two events
(b)
(i) Solar day : The time taken by the earth to complete one rotation about its own axis is called solar day.
(ii) Mean solar day : The average of the varying solar days, when the earth completes one revolution around the sun, is called mean solar day.
(iii) An hour : It is defined as the 1/24 th part of the mean solar day.
(iv) Minute : It is defined as the 1/1440 part of the mean solar day.
(v) Second : "A second is defined as 1/86400 th part of a mean solar day."
OR
Second may also be defined "as to be equal to the duration of9,192,631,770 vibrations

corresponding to the transition between two hyperfme levels of caesium – 133 atom in the ground state."

(vi) Year : One year is defined as the time in which earth completes one complete revolution around the sun.

Unit II

Practice Problems 1

Question 1.
A student calculates experimentally the value of density of iron as 7.4 gem^{-3}. If the actual density of iron is 7.6 gcm^{-3}, calculate the percentage error in experiment.

Answer:
Experimental value of density of iron = ρ_1 = 7.4 g cm^{-3}
Actual value of density of iron = ρ_2 = 7.6 g cm^{-3}
Absolute error = $\rho_2 - \rho_1$ = 7.6 – 7.4 = 0.2 g cm^3

$$\text{Percentage error} = \frac{\text{Absolute error}}{\text{Actual value}} \times 100$$

$$= \frac{0.2}{7.6} \times 100 = \frac{100}{38} = 2.63\%$$

Question 2.
A student finds that boiling point of water in a particular experiment is 97.8°C. If the actual boiling point of water is 99.4°C, calculate the percentage error.

Answer:
Experimental value of boiling point of water = $B.P_1$ = 97.8°C
Actual value of boiling point of water = $B.P_2$ = 99.4°C
Absolute error = $B.P._2 - B.P_1$ = 99.4 – 97.8 = 1.6°C

$$\text{Percentage error} = \frac{\text{Absolute error}}{\text{Actual value}} \times 100$$

$$= \frac{1.6}{99.4} \times 100 = 1.60\%$$

Question 3.
A pupil determines velocity of sound as 320 ms^{-1}. If actual velocity of sound is 332 ms^{-1}, calculate the percentage error.

Answer:

Velocity of sound determined by pupil = V_1 = 320 ms^{-1}
Actual value of velocity of sound = V_2 = 332 ms^{-1}
Absolute error = $V_2 - V_1$ = 332 – 320 = 12 ms^{-1}

$$\text{Percentage error} = \frac{\text{Absolute error}}{\text{Actual value}} \times 100$$

$$= \frac{12}{332} \times 100 = 3.61\%$$

Exercise 2

Question 1.
(a) What do you understand by the term order of magnitude of a quantity?
(b) Why are physical quantities expressed in the order of magnitude? Support your answer by an example.
Answer:
(a) Order of a magnitude of a quantity : The exponent part of a particular measurement is called order of magnitude of a quantity.
OR
The order of magnitude of a given numerical quantity is the nearest power of ten to which its value can be written, (b) Measurement of certain physical quantities are either too large or too small that these cannot be expressed conveniently. It is difficult to write or remember them. So such quantities can be expressed in the order of magnitude.
For example : The diameter of the sun is 1,390,000,000 m. It is difficult to write or remember such a measurement. So it is expressed as 1.39 × 109 m.
Here power of ten i.e. 9 (i.e. exponent part of the measurement) gives the order of magnitude of the given quantity.
So order of magnitude of diameter of the sun is 10^9 m.

Question 2.
Express the order of magnitude of the following quantities :

1. 12578935 m
2. 222444888 kg
3. 0.000,000,127 s
4. 0.000,000,000,00027 m

Answer:

(*i*) $12578935 \text{ m} = 1.2578935 \times 10^7 \text{ m}$

So order of magnitude $= 10^7$ m

(*ii*) $222444888 \text{ kg} = 2.22444888 \times 10^8 \text{ kg}$

Order of magnitude $= 10^8$ kg

(*iii*) $0.000,000,127 \text{ s} = 1.27 \times 10^{-7} \text{ s}$

Order of magnitude $= 10^{-7}$ s

(*iv*) $0.000,000,000,00027 \text{ m} = 2.7 \times 10^{-13} \text{ m}$

Order of magnitude $= 10^{-13}$

Question 3.

(a) What do you understand by the term degree of accuracy?
(b) Amongst the various physical measurements recorded in an experiment, which physical measurement determines the degree of accuracy?

Answer:

(a) Degree of accuracy : It means that we can measure a quantity, without any error of estimation.
In any experiment, all observations should be taken with same degree of accuracy.
(b) Amongst the various physical measurements recorded in an experiment, least accurate observation determines the degree of accuracy.

Question 4.

(a) State the formula for calculating percentage error
(b) Is it possible to increase the degree of accuracy by mathematical manipulations? Support your answer by an example.

Answer:
(a) The percentage error can be calculated by the formula :

$$\text{Percentage error} = \frac{\text{Absolute error}}{\text{Actual value}} \times 100$$

(b) It is not possible to increase the degree of accuracy by mathematical manipulations.
For examples : When a number of values are added or subtracted, the result cannot be more accurate than the least accurate value.

If we add: 5.283

$+72.5$

2.0014

We get, 79.78314

In the above addition 72.5 has least accuracy. When we . say 72.5, it implies that value lies between 72.45 and 72.55 and 72.5 is the most probable value. Thus the error in 72.5 is +0.05. As the final result cannot be more accurate than least accurate observation, so the correct and most reliable answer in the above addition is 72.9.

Question 5.
State the factors which determine number of significant figures for the calculation of final result of an experiment.
Answer:
Factors which determine number of significant figures for the calculation of final result of an experiment are :

1. The nature of experiment.
2. The accuracy with which various measurements are made.

Question 6.
The final result of calculations in an experiment is 125,347,200. Express the number in terms of significant places when

1. accuracy is between 1 and 10
2. accuracy is between 1 and 100
3. accuracy is between 1 and 1000

Answer:
Final result of calculations in an experiment = 125,347,200

1. When accuracy lies between 1 and 10, then final result may be written as 1.2×10^8.
2. When accuracy lies between 1 and 100, then final result may be written as 1.25×10^8.
3. When accuracy lies between 1 and 1000 than final result may be written as 1.253×10^8.

Unit 3

Practice Problems 1

Question 1.
The main scale of vernier callipers has 10 divisions in a centimetre and 10 vernier scale divisions coincide with 9 main scale divisions. Calculate

1. pitch
2. L.C. of vernier callipers.

Answer:
Main scale divisions of vernier callipers in one centimetre = 10

$$\text{Pitch} = \frac{\text{Unit of main scale}}{\text{Number of divisions in the unit}}$$

$$= \frac{1}{10} \text{ cm} = 0.1 \text{ cm}$$

$$\text{Least count} = \frac{\text{Pitch}}{\text{No. of vernier scale divisions}}$$

$$= \frac{0.1}{10} \text{ cm} = 0.01 \text{ cm}$$

Question 2.
In a vernier callipers 19 main scale divisions coincide with 20 vernier scale divisions. If the main scale has 20 divisions in a centimetre, calculate

1. pitch
2. L.C. of vernier callipers.

Answer:
Main scale divisions of vernier callipers in one centimetre = 20 Unit

$$\text{Pitch} = \frac{\text{Unit of main scale}}{\text{Number of divisions in the unit}}$$

$$= \frac{1}{20} \text{ cm} = 0.05 \text{ cm}$$

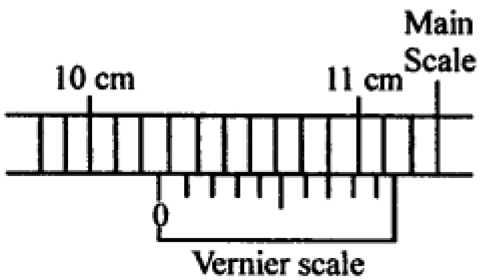
$$\text{Least count} = \frac{\text{Pitch}}{\text{No. of vernier scale divisions}}$$

$$= \frac{0.05}{20} = 0.0025 \text{ cm}$$

Practice Problems 2

Question 1.
Figure shows the position of vernier scale, while measuring the external length of a wooden cylinder.

1. What is the length recorded by main scale?



2. Which reading of vernier scale coincides with main scale?
3. Calculate the length.

Answer:
Main scale divisions of vernier callipers in one centimetre = 10

$$\text{Pitch} = \frac{\text{Unit of main scale}}{\text{Number of divisions in the unit}}$$

$$= \frac{1}{10} \text{ cm} = 0.1 \text{ cm}$$

$$\text{Least count} = \frac{\text{Pitch}}{\text{No. of divisions on the vernier scale}}$$

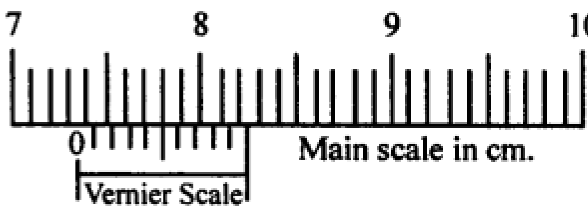
$$\text{L.C.} = \frac{0.1}{10} \text{ cm} = 0.01 \text{ cm}$$

(*i*) Length recorded by main scale = 10.2 cm
$\Rightarrow$ Main scale reading is 10.2 cm

(*ii*) Reading of vernier scale coinciding with main scale = 7th
$\Rightarrow$ Vernier scale division (V.S.D.) is 7th

(*ii*) Length recorded by vernier callipers
= Main scale reading + L.C. × V.S.D.
= 10.2 + 0.01 × 7 = 10.2 + 0.07 = 10.27 cm

Question 2.
In figure for vernier callipers, calculate the length recorded.



Answer:
Main scale divisions of vernier callipers in one centimetre = 10

$$\text{Pitch} = \frac{\text{Unit of main scale}}{\text{Number of divisions in the unit}}$$

$$= \frac{1}{10} \text{ cm} = 0.1 \text{ cm}$$

$$\text{Least count (L.C.)} = \frac{\text{Pitch}}{\text{No. of divisions on the vernier scale}}$$

$$\text{L.C.} = \frac{0.1}{10} \text{ cm} = 0.01 \text{ cm}$$

Here main scale reading = 7.3 cm
Vernier scale reading (V.S.D.) coinciding with main scale = 5th
Length recorded = Main scale reading + L.C. × V.S.D.
$= 7.3 + 0.01 \times 5 = 7.3 + 0.05 = 7.35$ cm

Practice Problems 3

Question 1.
(a) A vernier scale has 10 divisions. It slides over a main scale, whose pitch is 1.0 mm. If the number of divisions on the left hand of zero of the vernier scale on the main scale is 56 and the 8th vernier scale division coincides with the main scale, calculate the length in centimetres.
(b) If the above instrument has a negative error of 0.07 cm, calculate corrected length.

Answer:
No. of divisions on vernier scale = 10
Pitch = 1.0 mm

$$\text{Pitch} = \frac{\text{Pitch}}{\text{No. of divisions on the vernier scale}}$$

$$\text{L.C.} = \frac{1.0}{10}\text{ mm}$$

L.C. = 0.1 mm

L.C. = 0.01 cm

There are 56 number of main scale division on the left hand of zero of the vernier scale.

⇒ Main scale reading = 56 mm = 5.6 cm

Vernier scale reading coinciding with main scale = 8th

(a) Length recorded = Main scale reading + L.C. × V.S.D.

$= 5.6 + 0.01 \times 8 = 5.6 + 0.08 = 5.68$ cm

(b) Negative error = −0.07 cm

⇒ Correction = −(−0.07) = +0.07 cm

∴ Corrected length = Observed reading + Correction

$= 5.68 + (+0.07) = 5.68 + 0.07 = 5.75$ cm

Question 2.

(a) A vernier scale has 20 divisions. It slides over a main scale, whose pitch is 0.5 mm. If the number of divisions on the left hand of the zero of vernier on the main scale is 38 and the 18th vernier scale division coincides with main scale, calculate the diameter of the sphere, held in the jaws of vernier callipers.

(b) If the vernier has a negative error of 0.04 cm, calculate the corrected radius of sphere.

Answer:

No. of divisions on vernier scale = 20

Pitch 0.5 mm

$$\text{Least count} = \frac{\text{Pitch}}{\text{No. of divisions on the vernier scale}}$$

$$\text{L.C.} = \frac{0.5}{20} \text{ mm}$$

L.C. = 0.025 mm

L.C. = 0.0025 cm

(a) There are 38 number of main scale divisions on the left of the zero of vernier scale.

$\Rightarrow$ **Main scale reading = $\frac{38}{2}$ mm = 1.9 cm**

Vernier scale division coinciding with main scale = 18th

Diameter of sphere = Main scale reading + L.C. × V.S.D.

= 1.9 + 0.0025 × 18

= 1.9 + 0.0450 = 1.945 cm

(b) Negative error = –0.04 cm

$\Rightarrow$ **Correction = –(–0.04) = +0.04 cm**

Corrected diameter of sphere = Observed reading + Correction

= 1.945 + (+0.04) = 1.945 + 0.04 = 1.985 cm

Practice Problems 4

Question 1.

The least count of a vernier callipers is 0.0025 cm and it has an error of + 0.0125 cm. While measuring the length of a cylinder, the reading on main scale is 7.55 cm, and 12th vernier scale division coincides with main scale. Calculate the corrected length.

Answer:

Least count (L.C.) = 0.0025 cm
Error = +0.0125 cm
Correction = – (Error) = – (+0.0125) = – 0.0125 cm
Main scale reading = 7.55 cm
Vernier scale division (V.S.D.) coinciding with main scale = 12th
Length recorded = Main scale reading + L.C. × V.S.D.
= 7.55 + 0.0025 × 12
= 7.55+ 0.0300 = 7.58 cm
Correct length = Length recorded + Correction

= 7.58+ (-0.0125)
= 7.58 – 0.0125 = 7.5675 cm = 7.567 cm

Question 2.
The least count of a vernier callipers is 0.01 cm and it has an error of + 0.07 cm. While measuring the radius of a sphere, the main scale reading is 2.90 cm and the 5th vernier scale division coincides with main scale. Calculate the correct radius.

Answer:
Least count (L.C.) = 0.01 cm
Error = + 0.07 cm
Correction = (Error) = – (+ 0.07) = – 0.07 cm
Main scale reading = 2.90 cm
Vernier scale division (V.S.D.) coinciding with main scale = 5th Observed diameter of sphere = Main scale reading + L.C. × V.S.D.
= 2.90 + 0.01 x 5 = 2.90 + 0.0 = 2.95 cm
Corrected diameter = Observed diameter + Correction
= 2.95 + (-0.07) = 2.95 – 0.07 = 2.88 cm
∴ Corrected radius = 2.88/2 = 1.44 cm

Exercise 3

Question 1.
Who invented vernier callipers?

Answer:
Vernier callipers was invented by Pierre Vernier.

Question 2.
What is the need for measuring length with vernier callipers?

Answer:
For measuring the exact length with greater accuracy, especially when we are measuring a very small length, we use an appliance vernier calliper. A vernier calliper can measure accurately upto 1/100 th part of a centimetre.

Question 3.
Up to how many decimal places can a common vernier callipers measure the length in cm?

Answer:
A common vernier calliper can measure the length accurately upto two places of decimal when length is measured in centimetre
i.e. upto 1/100 th part of a centimetre.

Question 4.
Define the terms :

1. pitch
2. least count as applied to a vernier callipers.

Answer:

1. **Pitch :** "The pitch of a screw is the distance moved by the screw in one complete rotation of its head."
   OR
   Pitch may also be defined as "the distance between two consecutive threads of screw measured along the axis of screw."
   $$\text{Pitch} = \frac{\text{Distance moved by thimble on M.S.}}{\text{Number of rotations of thimble}}$$
2. **Least Count of Vernier Calliper :** Least count of a vernier callipers is the difference between one main scale division (M.S.D.) and one vernier scale division (V.S.D.)

Question 5.
State the formula for determining :

1. pitch
2. least count for a vernier callipers.

Answer:

(i) $\text{Pitch} = \dfrac{\text{Unit of main scale}}{\text{No. of divisions in the unit}}$

For example : If one centimetre length has ten divisions then

$$\text{Pitch} = \frac{1\text{ cm}}{10} = 0.1\text{ cm}$$

(ii) $\text{Least count (L.C.)} = \dfrac{\text{Pitch}}{\text{No. of vernier scale division}}$

For example : If pitch is 0.1 cm and there are ten vernier scale divisions.

$$\text{Then L.C.} = \frac{0.1}{10} = 0.01\text{ cm}$$

Question 6.
State the formula for calculating length if :

1. Number of vernier scale division coinciding with main scale and number of division of main scale on left hand side of zero of vernier scale are known.
2. The reading of main scale is known and the number of vernier scale divisions coinciding with main scale are known.

Answer:

1. If we know the number of vernier scale divisions (V.S.D.) coinciding with main scale and number of main scale divisions (M.S.D.) on left hand side of zero of vernier scale then Length recorded = Main scale reading + L.C. × V.S.D.
2. Same as in part (i).

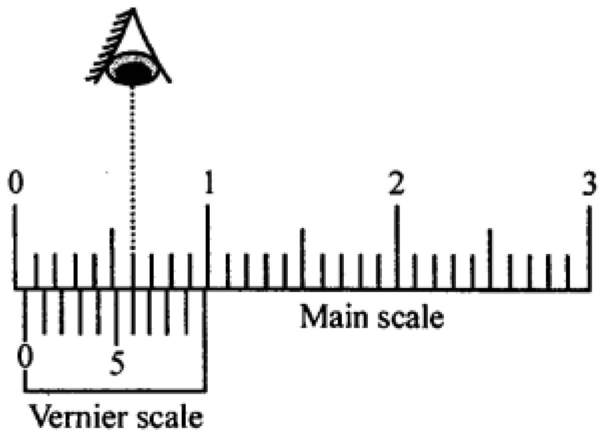
Question 7.
(a) What do you understand by the term zero error?
(b) When does a vernier callipers has

1. positive error
2. negative error?

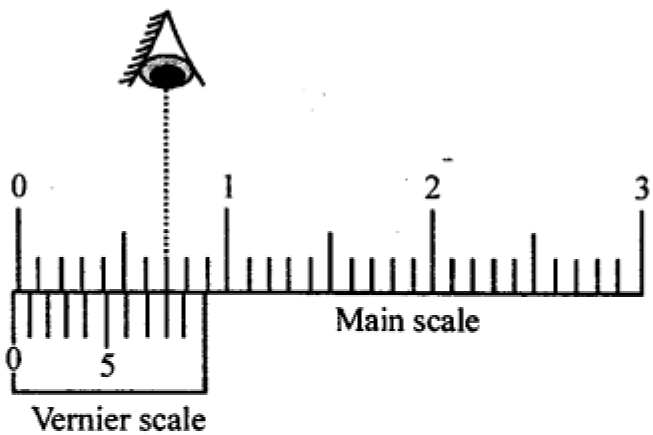
(c) State the correction if

1. positive error is 7 divisions
2. negative error is 7 divisions, when the least count is 0.01 cm.

Answer:
(a) Zero Error : A vernier callipers is said to have a zero error when zero of the main scale does not coincide with zero of vernier scale.
(b) Positive Error : If the zero of the vernier scale is on right hand side of zero of the main scale, then error is said to be positive and correction is said to be negative.



Negative Error : If the zero of the vernier scale is on the left hand side of zero of the main scale, the error is said be negative and the correction is said to be positive.



(c) When positive error is 7 divisions and L.C. is 0.01 cm
Then correction = – (+ 7 × L.C.)
= -7 × 0.01 cm = – 0.07 cm
When negative error is 7 divisions and count (L.C.) is 0.01 cm
Then correction = – (- 7 × L.C.)
= – (– 7 × 0.01) cm = + 0.07 cm

Question 8.
Which part of vernier callipers is used to measure

(a) external diameter of a cylinder
(b) internal diameter of a hollow cylinder
(c) internal length of a hollow cylinder?

Answer:

(a) External Jaws of a vernier callipers are used to measure the external diameter of cylinder.
(b) Internal Jaws are used to measure internal diameter of a hollow cylinder.
(c) Tail of vernier callipers is used to measure the internal length of a hollow cylinder.

Unit 4

Practice Problems 1

Question 1.
The circular scale of a screw gauge has 50 divisions. Its spindle moves by 2 mm on sleeve, when given four complete rotations calculate

1. pitch
2. least count.

Answer:
Number of circular scale divisions (C.S.D.) = 50
Distance moved by screw (spindle) on sleeve = 2 mm
Number of complete rotations given = 4

$$(i) \quad \text{Pitch} = \frac{\text{Distance moved by screw on sleeve}}{\text{No. of complete rotations}}$$

$$= \frac{2 \text{ mm}}{4} = 0.5 \text{ mm}$$

$$(ii) \quad \text{Pitch} = 0.05 \text{ cm}$$

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

$$= \frac{0.05}{50} \text{ cm} = 0.001 \text{ cm}$$

Question 2.
The circular scale of a screw gauge has 100 divisions. Its spindle moves forward by 2.5 mm when given five complete turns. Calculate

1. pitch
2. least count of the screw gauge.

Answer:
Number of circular scale divisions = 100
Distance moved by spindle (screw) = 2.5 mm
No. of complete rotations given = 5

$$(i) \quad \text{Pitch} = \frac{\text{Distance moved by screw on sleeve}}{\text{No. of complete rotations}}$$

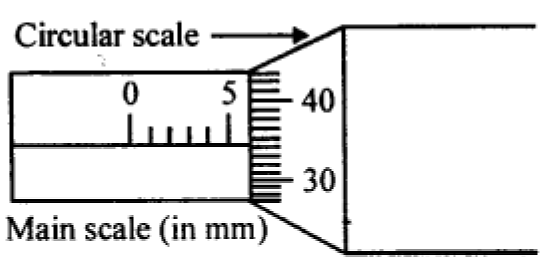
$$= \frac{2.5}{5} = 0.5 \text{ mm} = 0.05 \text{ cm}$$

$$(ii) \quad \text{Least count} = \frac{\text{Pitch}}{\text{No. of circular scale divisions}}$$

$$= \frac{0.05}{100} \text{ cm} = 0.0005 \text{ cm}$$

Practice Problems 2

Question 1.
Figure shows a screw gauge in which circular scale has 200 divisions. Calculate the least count and radius of wire.



Answer:
No. of circular scale divisions = 200
Pitch = 1 mm

$$\text{Least count (L.C.)} = \frac{\text{Pitch}}{\text{No. of circular divisions}}$$

$$= \frac{1 \text{ mm}}{200} = 0.005 \text{ mm}$$

L.C. = 0.0005 cm

Main scale reading = 5 mm = 0.5 cm

(C.S.D.) circular scale reading = 34 divisions

Observed diameter of wire = Main scale reading + L.C. × C.S.D.

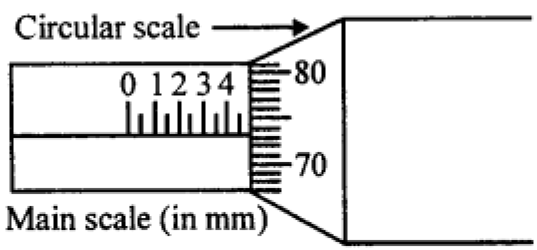
$$= 0.5 + 0.0005 \times 34$$

$$= 0.5 + 0.0170 = 0.5170 \text{ cm}$$

$$\text{Radius of wire} = \frac{\text{diameter}}{2} = \frac{0.5170}{2} = 0.2585 \text{ cm}$$

Question 2.

Figure shows a screw gauge in which circular scale has 100 divisions. Calculate the least count and the diameter of a wire.



Answer:

No. of circular scale division = 100

Pitch =0.5 mm

$$= \frac{0.5 \text{ mm}}{100} = 0.005 \text{ mm}$$

L.C. = 0.005 mm = 0.0005 cm

Main scale reading = 4.5 mm = 0.45 cm

(C.S.D.) circular scale reading = 73 division

Observed diameter of wire = Main scale reading + L.C. × C.S.D.

$$= 0.45 + 0.0005 \times 73$$

$$= 0.45 + 0.0365 = 0.4865 \text{ cm}$$

Practice Problems 3

Question 1.
A micrometre screw gauge having a positive zero error of 5 divisions is used to measure diameter of wire, when reading on main scale is 3rd division and 48th circular scale division coincides with base line. If the micrometer has 10 divisions to a centimetre on main scale and 100 divisions on circular scale, calculate

1. Pitch of screw
2. Least count of screw
3. Observed diameter
4. Corrected diameter.

Answer:
(*i*) Micrometre has 10 divisions in one centimetre on main scale.

$$\therefore \text{Pitch} = \frac{\text{Unit}}{\text{No. of divisions in unit}}$$

$$\text{Pitch} = \frac{1 \text{ cm}}{10} = 0.1 \text{ cm}$$

(*ii*) No. of circular scale divisions = 100

$$\therefore \text{Least count (L.C.)} = \frac{\text{Pitch}}{\text{No. of circular divisions}}$$

$$= \frac{0.1 \text{ cm}}{100} = 0.001 \text{ cm}$$

(*iii*) Reading on main scale is 3rd division.
$\Rightarrow$ Main scale reading = 3 mm = 0.3 cm.
Circular scale reading = 48 div.
Observed diameter = M.S. reading + L.C. × C.S. reading
$= 0.3 + 0.001 \times 48 = 0.3 + 0.048$
$= 0.348$ cm

(*iv*) Positive zero error = +5 divisions
$\therefore$ Correction = −(Error × L.C.)
$= -(5 \times 0.001) = -0.005$ cm
$\therefore$ Corrected diameter = Observed diameter + Correction
$= 0.348 - 0.005$
$= 0.343$ cm

Question 2.
A micrometre screw gauge has a positive zero error of 7 divisions, such that its main scale is marked in 1/2 mm and the circular scale has 100 divisions. The spindle of the screw advances by 1 division complete rotation.
If this screw gauge reading is 9 divisions on main scale and 67 divisions on circular scale for the diameter of a thin wire, calculate

1. Pitch
2. L.C.
3. Observed diameter
4. Corrected diameter.

Answer:

(*i*) Pitch $= \frac{1}{2}$ mm = 0.5 mm = 0.05 cm

(*ii*) No. of circular scale divisions = 100

$$\therefore \text{ Least count (L.C.)} = \frac{\text{Pitch}}{\text{No. of circular scale divisions}}$$

$$\text{L.C.} = \frac{0.05 \text{ cm}}{100} = 0.0005 \text{ cm}$$

(*iii*) Main scale reading = 9 divisions $= 9 \times \frac{1}{2}$ mm.

= 4.5 mm = 0.45 cm

Circular scale reading = 67 div.

∴ Observed diameter = M.S. reading + L.C. × C.S. reading

= 0.45 + 0.0005 × 67 = 0.45 + 0.0335

= 0.4835 cm

(*iv*) Positive zero error = 7 divisions

Correction = –(Error × L.C.)

= –(7 × 0.0005) cm = –0.0035 cm

∴ Corrected diameter = Observed diameter + Correction

= 0.4835 + (–0.0035)

= 0.4835 – 0.0035

= 0.4800 cm

Question 3.
The thimble of a screw gauge has 50 divisions for one rotation. The spindle advances 1 mm when the screw is turned through two rotations.

1. What is the pitch of screw?
2. What is the least count of screw gauge?
3. When the screw gauge is used to measure the diameter of wire the reading on sleeve is found to be 0.5 mm and reading on thimble is found 27 divisions. What is the diameter of wire in centimetres?

Answer:
Pitch of screw gauge is the distance moved by spindle in one revolution = 1/2 = 0 – 5 mm

(i) $\therefore$ Pitch = 0·5 mm ***OR*** 0·05 cm

(ii) The thimble of a screw gauge has 50 divisions for one rotation.
$\Rightarrow$ No. of circular scale divisions = 50

$$\text{Least count (L.C.)} = \frac{\text{Pitch}}{\text{No. of circular scale divisions}}$$

$$= \frac{0.05}{50}\text{ cm} = 0.001\text{ cm}$$

(iii) Main scale reading = 0.5 mm = 0.05 cm
Circular scale reading = 27 div.
Diameter of wire = M.S. reading + L.C. × C.S. reading
$= 0.05 + 0.001 \times 27 = 0.05 + 0.027$
Diameter of wire = 0.077 cm

Practice Problems 4

Question 1.
A micrometre screw gauge has a negative zero error of 8 divisions. While measuring the diameter of a wire the reading on main scale is 3 divisions and 24th circular scale division coincides with base line.
If the number of divisions on the main scale are 20 to a centimetre and circular scale has 50 divisions, calculate

1. pitch
2. observed diameter.

3. least count
4. corrected diameter.

Answer:

(*i*) The number of divisions on the main scale are 20 to a centimetre

$$\Rightarrow \text{Pitch} = \frac{\text{Unit}}{\text{No. of divisions in unit}} = \frac{1 \text{ cm}}{20} = 0.05 \text{ cm}$$

(*ii*) No. of circular scale divisions = 50

$$\therefore \text{Least count (L.C.)} = \frac{\text{Pitch}}{\text{No. of circular scale divisions}}$$

$$= \frac{0.05}{50} \text{ cm}$$

L.C. = 0.001 cm

(*iii*) Main scale reading = 3 division

$\Rightarrow$ Main scale reading = 3 × Pitch = 3 × 0.05 = 0.15 cm

Circular scale reading = 24 division

$\therefore$ Observed diameter = M.S. reading + L.C. × C.S. reading

= 0.15 + 0.001 × 24

= 0.15 + 0.024 = 0.174 cm

(*iv*) Negative zero error = 8 division

Correction = −(−8 × L.C.)

= −(−8 × 0.001) cm = +0.008 cm

Correct diameter = Observed diameter + Correction

= 0.174 + 0.008 = 0.182 cm

Question 2.

A micrometre screw gauge has a negative zero error of 7 divisions. While measuring the diameter of a wire the reading on main scale is 2 divisions and 79th circular scale division coincides with base line.

If the number of divisions on main scale is 10 to a centimetre and circular scale has 100 divisions, calculate

1. pitch
2. observed diameter

3. least count
4. corrected diameter.

Answer:

(*i*) The number of divisions on the main scale are 10 to a centimetre

$$\Rightarrow \text{Pitch} = \frac{\text{Unit}}{\text{No. of divisions in unit}} = \frac{1\text{ cm}}{10} = 0.1\text{ cm}$$

(*ii*) No. of circular scale divisions = 100

$$\therefore \text{Least count (L.C.)} = \frac{\text{Pitch}}{\text{No. of circular scale divisions}}$$

$$= \frac{0.1}{100}\text{ cm} = 0.001\text{ cm}$$

(*iii*) Main scale reading = 2 division

$\Rightarrow$ Main scale reading = 2 × Pitch = 0.2 cm

Circular scale reading = 79 division

$\therefore$ Observed diameter = M.S. reading + L.C. × C.S. reading

$= 0.2 + 0.001 \times 79$

$= 0.2 + 0.079\text{ cm} = 0.279\text{ cm}$

(*iv*) Negative zero error = 7 division

$\therefore$ Correct $= -(-7 \times \text{L.C.})$

$= -(-7 \times 0.001) = +0.007\text{ cm}$

Corrected diameter = Observed diameter + Correction

$= 0.279 + 0.007 = 0.286\text{ cm}$

Exercise 4

Question 1.

For what range of measurement is micrometre screw gauge used?

Answer:

Micrometre screw gauge is used to measure upto the accuracy of 0.001 cm.

Question 2.
What do you understand by the following terms as applied to micrometre screw gauge?

1. Sleeve cylinder
2. Sleeve scale
3. Thimble
4. Thimble scale
5. Base line.

Answer:

1. **Sleeve cylinder :** A hollow cylinder attached to a nut of the screw gauge is known as sleeve cylinder.
   The spindle of the screw passes through sleeve cylinder
2. **Sleeve scale :** It is also known as main scale. A reference line or base line graduated in mm, drawn on the sleeve cylinder, parallel to axis of nut is known as sleeve scale.
3. **Thimble :** A hollow circular cylinder connected to the screw, which rotates along with nut on turning, is called thimble.
4. **Thimble scale :** It is also known as circular scale. A scale marked on tapered end of a hollow cylinder, which can move over the sleeve cylinder, is known as thimble scale.
5. **Base line :** A reference line drawn on the sleeve cylinder parallel to the axis of nut is known as base line.

Question 3.
What is the function of ratchet in screw gauge?

Answer:
When the flattened end of the screw comes in contact with stud, ratchet becomes free and makes a rattling noise. It indicates that screw should not be further pushed towards the stud.

Question 4.
What do you understand by the terms

(a) pitch of screw
(b) least count of screw?

Answer:

(a) Pitch of screw : The pitch of screw is defined as the distance between two consecutive threads he screw, measured along the axis of the screw.
(b) Least count of the screw : Least distance of the screw is defined as the smallest distance moved by its tip when the screw turn through one division marked on it.

Question 5.
State the formula for calculating

1. pitch of screw
2. least count of screw.

Answer:

(*i*) Pitch of screw

$$= \frac{\text{Distance moved by thimble on main scale}}{\text{Number of rotations of thimble}}$$

E.g. If 5 mm is the distance moved by the thimble on the main scale in 5 rotations then,

$$\text{Pitch} = \frac{5 \text{ mm}}{5} = 1 \text{ mm}$$

(*ii*) Least count of screw

$$= \frac{\text{Pitch}}{\text{Number of circular scale divisions}}$$

E.g. If pitch of screw is 1 mm and there are 100 divisions on the circular scalen, then

$$\text{Least count} = \frac{1 \text{ mm}}{100} = 0.01 \text{ mm}$$

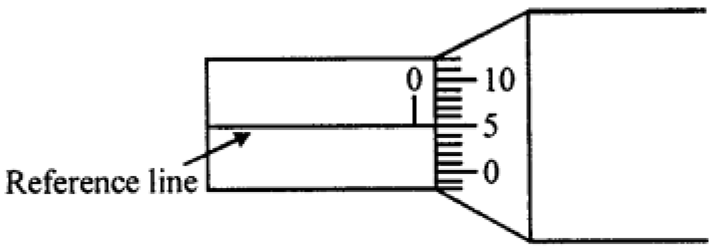
L.C. = 0.01 mm or 0.001 cm

Question 6.
What do you understand by the following terms as applied to screw gauge?

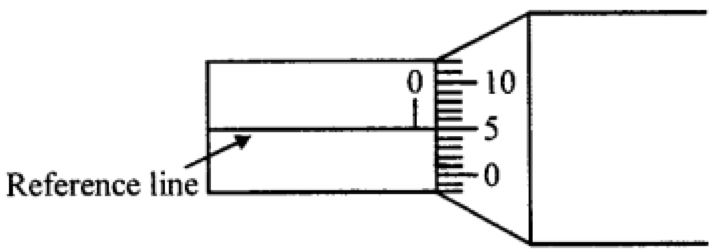
(a) Zero error
(b) Positive zero error
(c) Negative zero error.

Answer:

(a) Zero error : If the zero of the main scale does not coincide with zero of circular scale on bringing the screw end in contact with the stud, the screw gauge is said to have zero error.
(b) Positive zero error : If the zero of the circular scale is below the reference line of the main scale, then screw gauge is said to have positive zero error and the correction is negative.

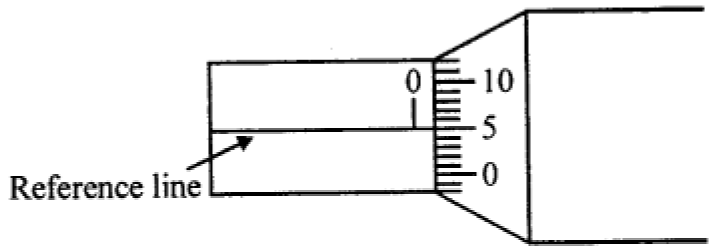


(c) Negative zero error : If the zero of the circular scale is above the reference line of the main scale, then screw gauge is said to have negative zero error and correction is positive.

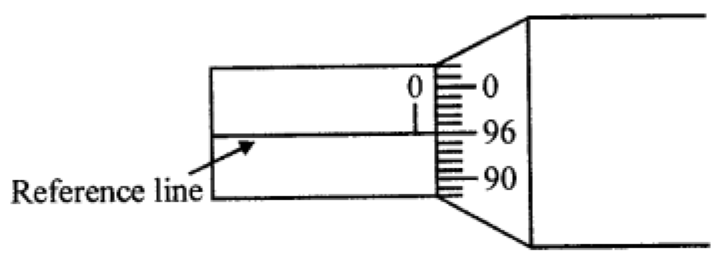


Question 7.
How do you account for **(a)** positive zero error **(b)** negative zero error, for calculating correct diameter of wires?

Answer:
(a) Positive zero error : If the zero line, marked on circular scale, is below the reference line of the main scale, then there is a positive zero error and the correction is negative.
In the figure 5th circular scale division is coinciding with reference line.
∴ Correction
= – Coinciding division of C.S. × L.C.
= – 5 × 0.001 cm = -0.005 cm
If the observed diameter is 0.557 cm, then:
Corrected diameter
= Observed diameter + Correction
= 0.557 cm – 0.005 cm = 0.552 cm



(b) Negative zero error : If the zero line marked on circular scale, is above the reference line of the main scale, then there is a negative error and the correction is positive.
In the figure, there is 96th division on the circualr scale which coincides with reference line.
∴ Correction – + [n- coinciding division of C.S. × L.C.]
where n is the total number of circular scale divisions.
∴ Correction = + [100 – 96] × 0.001 cm
= 0.004 cm
If observed diameter is 0.557 cm, then :
Corrected diameter
= Observed diameter + Correction
= 0. 557 cm + 0.004 cm
= 0.561 cm



Unit 5

Exercise 5

Question 1.

(a) What do you understand by the term volume of substance?
(b) State the unit of volume in SI system.

Answer:
(a) Volume : The space occupied a substance (solid, liquid or gas) is called volume.
(b) SI unit of volume is Cubic metre (m^3).
One cubic metre : Is the volume occupied by a cube whose each side is equal to 1 m.

Question 2.
How is SI system of unit of volume is related to 1 litre ? Explain.

Answer:
We know one cubic metre is the SI unit of volume

and $1 \text{ m}^3 = 1 \text{ m} \times 1 \text{ m} \times 1 \text{ m}$

$= 100 \text{ cm} \times 100 \text{ cm} \times 100 \text{ cm}$

$1 \text{ m}^3 = 10^6 \text{ cm}^3$

Also, $1 \text{ litre} = 1000 \text{ mL} = 1000 \text{ cm}^3 = 10^3 \text{ cm}^3$

$[\because 1 \text{ mL} = 1 \text{ cm}^3]$

$1 \text{ litre} = 10^3 \text{ cm}^3$

Multiply both sides by 10^3

$10^3 \text{ litre} = 10^3 \times 10^3 \text{ cm}^3 = 10^6 \text{ cm}^3$

$1000 \text{ litre} = 1 \text{ m}^3$ $\quad [\because 1 \text{ m}^3 = 10^6 \text{ cm}^3]$

So, $1 \text{ m}^3 = 1000 \text{ litre}$

Question 3.
In which unit, volume of liquid is measured? How is this unit is related to S.I. unit of volume?

Answer:
The volume of liquid is measured in litre of its sub-multiple millilitre (mL).

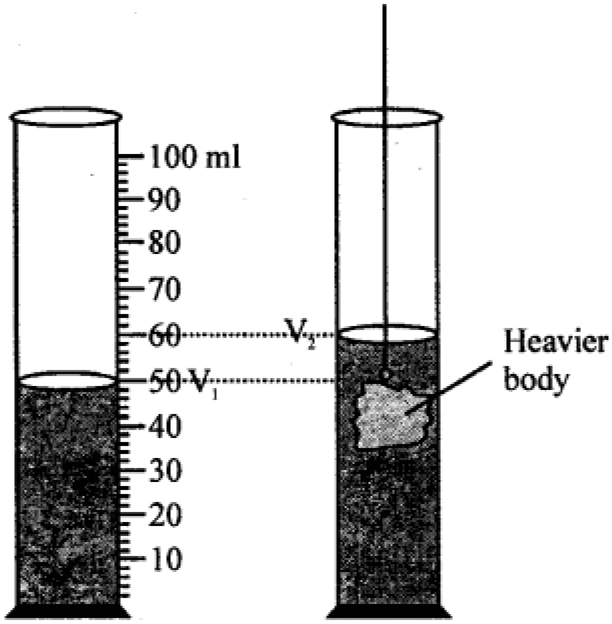
$1 \text{ m}^3 = 1000 \text{ litre}$

and $1 \text{ litre} = 1000 \text{ mL}$

$\Rightarrow \quad 1 \text{ m}^3 = 1000 \text{ litre} = 1000 \times 1000 \text{ mL} = 10^6 \text{ mL}$

Question 4.
Explain the method in steps to find the volume of an irregular solid with the help of measuring cylinder.

Answer:
Volume of an irregular solid



1. Take a measuring cylinder and fill water up to certain level. Note down the level of water in measuring cylinder. Let it be V_1.
2. Tie the irregular solid body with a thin and strong thread and lower the body gently so that the solid body is completely immersed in the water. The level of water rises. Solid body displaces water of its own volume. Note down the new level of water. Let it be V_2.
3. Take the difference of two level of water, i.e., $(V_2 - V_1)$. This will give the volume of irregular solid body.

Question 5.

Amongst the units of volume (i) cm^3 **(ii)** m^3 **(iii)** litre **(iv)** millilitre, which is most suitable for measuring:

(a) Volume of a swimming tank
(b) Volume of a glass filled with milk
(c) Volume of an exercise book
(d) Volume of air in the room.

Answer:

(a) litre
(b) cm^3
(c) millilitre
(d) m^3

Question 6.
Find the volume of a book of length 25 cm, breadth 18 cm and height 2 cm in m^3.

Answer:
Length of book = l = 25 cm
Breadth of book = b = 18 cm
Height of book = h = 2 cm
Volume of biook = $l \times b \times h$
$V = 25 \times 18 \times 2$
$V = 900 \text{ cm}^3$

$$V = \frac{900}{10^6} m^3 \; ; \; V = \frac{9}{10000} m^3$$

$V = 0.0009 \text{ m}^3$

Question 7.
The level of water in a measuring cylinder is 12.5 ml. When a stone is lowered in it, the volume is 21.0 ml. Find the volume of the stone.

Answer:
Level of water in measuring cylinder = V_1 = 12.5 ml
When stone is lowered, then level of water in measuring cylinder
= V_2 = 21.0 ml
Volume of stone = $V_2 - V_1$
$V = 21.0 - 12.5$
$V = 8.5$ ml

Question 8.
A measuring cylinder is filled with water upto a level of 30 ml. A solid body is immersed in it so that the level of water rises to 37 ml. Now solid body is tied with a cork and then immersed in water so that the water level rises to 40 ml. Find the volume of solid body and the cork.

Answer:
Level of water in measuring cylinder = V_1 = 30 ml
Level of water in measuring cylinder when a solid body is immersed in it V_2 = 37 ml
Level of water in measuring cylinder when a cork tied with the solid is immersed in water = V_3 = 40 ml

Volume of solid body = $V_2 - V_1$ = 37 – 30 = 7 ml or 7 cm^3
Volume or cork = $V_3 - V_2$ = 40 – 37
= 3 ml or 3 cm^3 [∵ 1 ml = 1 cm^3]

Unit 6

Practice Problems 1

Question 1.
Calculate the time period of simple pendulum of length 0. 84 m when g = 9.8 ms^{-2}.

Answer:
Length of the pendulum = l = 0.84 m
$g = 9.8\ ms^{-2}$

$$\text{Time period (T)} = 2\pi\sqrt{\frac{l}{g}} = 2 \times \frac{22}{7} \times \sqrt{\frac{0.84}{9.8}}$$

$$= \frac{44}{7} \times 0.2928 = 1.84\ s$$

Question 2.
Calculate the time period of simple pendulum of length 1.44 m on the surface of moon. The acceleration due to gravity on the surface of moon is 1/6 the acceleration due to gravity on earth, [g = 9.8 ms^{-2}]

Answer:
Length of simple pendulum = l = 1.44 m
Time period (T) = ?

Acceleration due to gravity on the surface of moon

$$= g' = \frac{1}{6} \times g$$

$$g = \frac{9.8}{6}$$

$$T = 2\pi\sqrt{\frac{1}{g'}} \; ; T = 2 \times \frac{22}{7} \times \sqrt{\frac{1.44 \times 6}{9.8}}$$

$$T = \frac{14}{7} \times 0.9389 = 5.90 \text{ s}$$

Practice Problems 2

Question 1.
Length of second's pendulum is 100 cm. Find the length of another pendulum whose time period is 2.4 s.

Answer:
We know time period of second's pendulum is 2 s.

$\therefore \; T_1 = 2$ s $\qquad l_2 = 100$ cm

$T_2 = 2.4$ s $\qquad l_2 = ?$

$$\frac{T_1}{T_2} = \sqrt{\frac{l_1}{l_2}}$$

$$\frac{2}{2.4} = \sqrt{\frac{100}{l_2}}$$

$$\frac{1}{1.2} = \sqrt{\frac{100}{l_2}}$$

Squaring both sides,

$$\frac{1}{1.44} = \frac{100}{l_2}$$

$$l_2 = 100 \times 1.44 = 144 \text{ cm}$$

Question 2.
A pendulum of length 36 cm has time period 1.2 s. Find the time period of another pendulum, whose length is 81 cm.

Answer:
$l_1 = 36$ cm $\quad T_1 = 1.2$ s
$l_2 = 81$ cm $\quad T_2 = ?$

$$\frac{T_1}{T_2} = \sqrt{\frac{l_1}{l_2}}$$

$$\frac{1.2}{T_2} = \sqrt{\frac{36}{81}}$$

$$\frac{1.2}{T_2} = \frac{6}{9}$$

$$T_2 = \frac{9 \times 1.2}{6} = 9 \times 0.2 = 1.8 \text{ s}$$

Question 3.
Calculate the length of second's pendulum on the surface of moon when acceleration due to gravity on moon is 1.63 ms^{-2}.

Answer:
Length of second's pendulum = l = ?
Acceleration due to gravity on surface of moon
$= g_m = 1.63 \text{ ms}^{-2}$
Time period = T = 2 s

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

$$2 = 2 \times \frac{22}{7} \times \sqrt{\frac{l}{1.63}}$$

$$\sqrt{\frac{l}{1.63}} = \frac{7}{22}$$

Squaring both sides

$$\frac{l}{1.63} = \frac{49}{484}$$

$$l = \frac{49}{484} \times 1.63$$

$$l = 0.165 \text{ m}$$

Practice Problems 3

Question 1.
The length of two pendulum are 110 cm and 27.5 cm. Calculate the ratio of their time periods.

Answer:
$l_1 = 110$ cm ; $l_2 = 27.5$ cm
Let T_1 and T_2 be the time period of two pendulums.

$$\frac{T_1}{T_2} = \sqrt{\frac{l_1}{l_2}}$$

$$\frac{T_1}{T_2} = \sqrt{\frac{110}{27.5}} = \sqrt{\frac{4}{1}}$$

$$\frac{T_1}{T_2} = \frac{2}{1}$$

Question 2.
A pendulum 100 cm and another pendulum 4 cm long are oscillating at the same time. Calculate the ratio of their time periods.

Answer:

$l_1 = 100$ cm ;

$l_2 = 4$ cm

Let T_1 and T_2 be the time period of two pendulums.

$$\frac{T_1}{T_2} = \sqrt{\frac{l_1}{l_2}}$$

$$\frac{T_1}{T_2} = \sqrt{\frac{100}{4}} = \sqrt{\frac{25}{1}}$$

$$\frac{T_1}{T_2} = \frac{5}{1}$$

Practice Problems 4

Question 1.

The time periods of two pendulums are 1.44 s and 0.36 s respectively. Calculate the ratio of their lengths.

Answer:

$T_1 = 1.44$ s ;

$T_2 = 0.36$ s

Let l_1 and l_2 be the lengths of the two pendulums.

$$\frac{T_1}{T_2} = \sqrt{\frac{l_1}{l_2}}$$

$$\sqrt{\frac{l_1}{l_2}} = \frac{1.44}{0.36} = \frac{144}{36} = \frac{4}{1}$$

Squaring both sides,

$$\left(\sqrt{\frac{l_1}{l_2}}\right)^2 = \left(\frac{4}{1}\right)^2 \Rightarrow \frac{l_1}{l_2} = \frac{16}{1}$$

Question 2.
The time period of two pendulums are 2 s and 3 s respectively. Find the ratio of their lengths.

Answer:
$T_1 = 2$ s ; $T_2 = 3$ s
Let l_1 and l_2 be the length of the two pendulums.

$$\frac{T_1}{T_2} = \sqrt{\frac{l_1}{l_2}}$$

$$\sqrt{\frac{l_1}{l_2}} = \frac{2}{3}$$

Squaring both sides,

$$\left(\sqrt{\frac{l_1}{l_2}}\right)^2 = \left(\frac{2}{3}\right)^2 = \frac{4}{9}$$

$$\sqrt{\frac{l_1}{l_2}} = \frac{4}{9} = 4 : 9$$

Exercise 6

Question 1.

(a) Define simple pendulum.
(b) State two factors which determine time period of a simple pendulum.
(c) Write an expression for the time period of a simple pendulum.

Answer:
(a) Simple Pendulum : A simple pendulum consists of a heavy point mass (called bob) suspended from a rigid support by a massless, inextensible string.
(b) Factors on which time period of a simple pendulum depends :

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

$$T \propto \sqrt{l} \text{ or } T^2 \propto l$$

1. i.e., if length increases, time period increases. That is why in summer pendulum of clock goes slow.
   $$T \propto \frac{1}{\sqrt{g}}.$$
2. That is why when clock is taken to a mountain where 'g' decreases with altitude, time period increases and pendulum takes more time to complete an oscillation and hence the clock goes slow.
3. **Mass or material of bob :** Time period of simple pendulum is independent of mass.
4. **Amplitude :** Time period of simple pendulum is independent of amplitude. So long as swing is not too large.

(c) Expression for time period of a simple pendulum is given as :

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

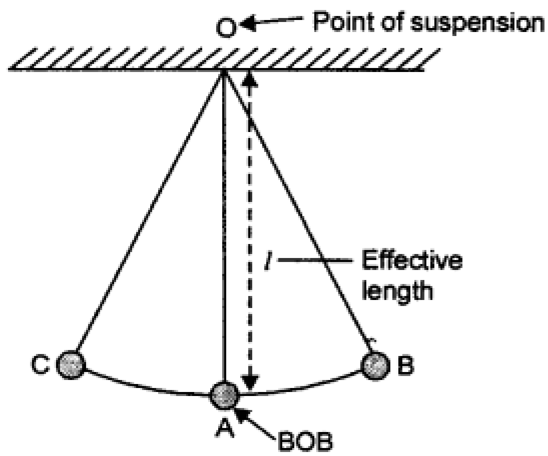
Where l = length of the pendulum

g = acceleration due to gravity.

Question 2.
Define the following in connection with a simple pendulum.

(a) Time period
(b) Oscillation
(c) Amplitude
(d) Effective length.

Answer:
(a) Time period (T) : "is the time taken to complete one oscillation." Its unit is second (s) and time period is denoted by 'T"
(b) Oscillation : "One complete to and fro motion of the pendulum" is called an oscillation.
i.e., motion of bob from B to C and then C to B is one oscillation.



(c) Amplitude : The maximum displacement of bob from mean position on either side is called amplitude
Amplitude = AB or AC. It is denoted by 'a'.
(d) Effective length : The length between the point of suspension and centre of gravity of bob of a pendulum is called effective length.

Question 3.
(a) What is a second's pendulum?
(b) A second's pendulum is taken on the surface of moon where acceleration due to gravity is l/6th of that of earth. Will the time period of pendulum remain same or increase or decrease? Give a reason.

Answer:
(a) Seconds' pendulum : "A pendulum which has time period of two seconds" is called seconds' pendulum.

OR

Seconds' pendulum may also be defined as "a pendulum which completes one oscillation in two seconds."

(b) We know time period of a simple pendulum is inversely proportional to the square root of acceleration due to gravity

i.e. $T \propto \frac{1}{\sqrt{g}}$

As acceleration due to gravity on the surface of the moon decreases as compared to that of the earth

$\because$ $g_{moon} < g_{earth}$ $\therefore T_{moon} > T_{earth}$

$\Rightarrow$ The time period of second's pendulum increases when it is taken to the surface of the moon.

Question 4.
Which of the following do not affect the time period of a simple pendulum?

(a) mass of bob
(b) size of bob
(c) effective length of pendulum
(d) acceleration due to gravity
(e) amplitude.

Answer:
(a) Mass of the bob, and (b) Size of the bob, do not affect the time period of a pendulum. Also time period of pendulum is independent of the amplitude provided this is not too great.

Question 5.
A simple pendulum is hollow from within and its time period is T. How is the time period of pendulum affected when :

(a) 1/4 of bob is filled with mercury
(b) 3/4 of bob is filled with mercury
(c) The bob is completely filled with mercury?

Answer:
We know that time period of a simple pendulum is independent of its mass. So in all the above said cases, time period of simple pendulumn remains same.

Question 6.
Two simple pendulums, A and B have equal lengths but their bobs weigh 50 gf and 100 gf respectively. What would be the ratio of their time periods? What is the reason for your answer?

Answer:
We know that time period of simple pendulum at a place is given by

$$T = 2\pi\sqrt{\frac{l}{g}} \quad ...(i)$$

and this expression does not contain weight of bob i.e. is independent of the weight of bob.
∴ Time period of both pendulums will be same.
∴ Ratio of their time periods =1 : 1

Question 7.
State the numerical value of the frequency of oscillation of a second's pendulum. Does it depend on the amplitude of oscillation?

Answer:

$$\text{Frequency} = \frac{1}{T}$$

and T for seconds' pendulum is 2 seconds

$$\therefore \text{ Frequency} = \frac{1}{2} = 0\cdot5 \ s^{-1}$$

Oscillation of pendulum does not depend on amplitude.

Question 8.
(a) Name the two factors on which time period of a simple pendulum depends.
(b) Name the devices commonly used to measure
(i) mass and
(ii) weight of a body.

Answer:
(a) Factors on which time period of a simple pendulum depends :

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

1. $T \propto \sqrt{l}$ or $T^2 \propto l$ i.e., if length increases, time period increases. That is why in summer pendulum of clock goes slow.
2. That is why when clock is taken to a mountain where 'g' decreases with altitude, time period increases and pendulum takes more time to complete an oscillation

and hence the clock goes slow.

$T \propto \frac{1}{\sqrt{g}}$.

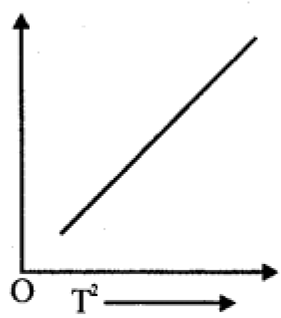
3. **Mass or material of bob :** Time period of simple pendulum is independent of mass.
4. **Amplitude :** Time period of simple pendulum is independent of amplitude. So long as swing is not too large.

(b)

1. Mass of measured by physical balance.
2. Weight of a body is measured by spring balance.

Question 9.
Draw a graph of l, the length of simple pendulum against T^2, the square of its time period.

Answer:
Nature : The graph of length (l) of simple pendulum against square of its time period (T^2) is a straight line inclined to time axis.



Question 10.
What do you understand by (a) amplitude and (b) frequency of oscillations of simple pendulum?

Answer:

(a) Amplitude : The maximum displacement of bob from mean position on either side is called amplitude.
Amplitude = AB or AC. It is denoted by 'a'.
(b) Frequency: "It is the number of vibrations or oscillations made in one second."It is denoted by f or n and its unit is Hertz (Hz) or per second (s-1).

Unit 7

Exercise 7

Question 1.

(a) What do you understand by the term graph?
(b) What do you understand by the terms (i) independent variable, (ii) dependent variable?
(c) Amongst the independent variable and dependent variable, which is plotted on X-axis?

Answer:
(a) Graph : A pictorial representation of two physical variables, recorded by ah experimenter is called graph.
(b)

1. **Independent variable :** A variable whose variation does not depend on that of another is known as independent variable.
2. **ependent variable :** A variable whose variation depends upon another variable is known as dependent variable.

(c) The independent variable is always plotted on x – axis.

Question 2.

(a) State how will you choose a scale for the graph.
(b) State the two ratios of a scale, which are suitable for plotting points.
(c) State the two ratios of a scale, which are not suitable for plotting points.

Answer:
(a) We can choose any convenient scale to represent a given variable on a given axis, such that the whole range of variations are well spread out on the whole graph paper, to give the graph line a suitable size.
For this a round number, nearest to or slightly less than minimum value should be taken as origin and a round number nearest to or slightly more than the maximum value should be taken at the far end of the respective axis for a given variable.
(b) Two ratios of a scale suitable for ploting points are 1 : 2 and 1 : 4.
(c) Two ratios of a scale not suitable for plotting points are 1 : 3 and 1 : 7. Because such scales are impractical and pose difficulty in plotting intermediate points.

Question 3.
State three important precautions which must be followed while plotting points on a graph.

Answer:
Precautions for plotting points on a graph :

1. The points marked on graph paper should be sharp, but not thick.
2. Ordinates of points should be written close to the plotted point.
3. It is not necessary that graph line should pass through all points. A best fit line should be drawn.

Question 4.
State two important precautions for drawing a graph line.

Answer:
Precautions for drawing a graph line :

1. The graph line should be thin, single straight line and sharp.
2. It is not necessary that graph line should pass through all the points. A best fit graph line should be drawn.

Question 5.

(a) What is a best fit line for a graph?
(b) What does best fit line show regarding the variables plotted and the work of experimenter?

Answer:

(a) A best bit line for a graph means a line which either passes through maximum number of points or passes closest to the maximum number of points, which appear on either side of the line.
(b) A best fit line shows that two variable quantities are directly proportional to each other. With its help, experimenter can easily understand nature of proportional relations between two variable quantities.

Question 6.

(a) What do you understand by the term constant of proportionality?
(b) How can proportionality constant be determined from the best fit straight line graph?

Answer:

(a) Constant of proportionality : If a quantity say X is directly proportional to another quantity Y, then X is written as X = KY, where K is called constant of proportionality.
(b) Constant of proportionality : can be determined from the best fit straight line by calculating the slope of graph by using the formula. Slope of graph

$$= \frac{\text{Difference between the co-ordinates on y-axis for any two points on the graph line}}{\text{Difference between the co-ordinates on x-axis for any two points on the graph line}}$$

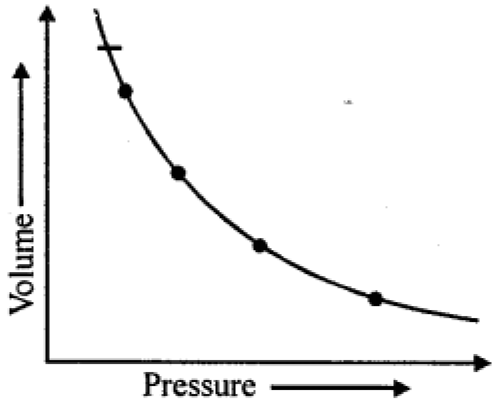
Question 7.
State three uses of graph.

Answer:
Uses of a graph :

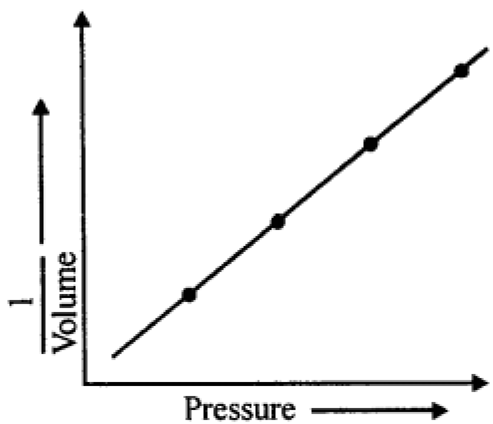
(a) One can determine constant of proportionality by calculating slope of graph.
(b) It can be used to calculate mean average value of large number of observations.
(c) It can be used for verifying already known physical laws.
(d) It can also show the weakness of the experimenter at some particular instant during the course of experiment.

Question 8.
How does a graph help in determining the proportional relationship between two quantities?

Answer:
It has been found that if a graph is plotted between pressure of an enclosed gas at constant temperature, against its volume, the graph line is a smooth curve, which does not meet X-axis or Y- axis on extending as shown in figure.
From the figure, it is clear that pressure of gas is not directly proportional to volume of gas.

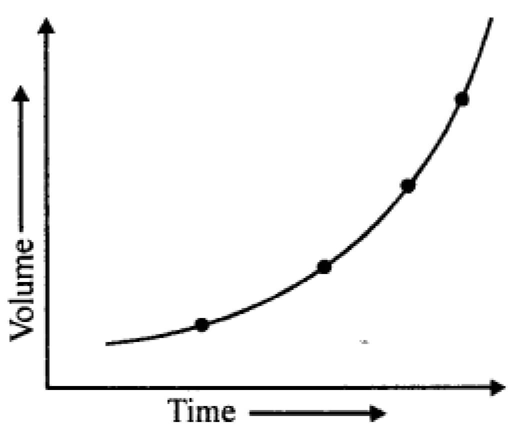


However, if a graph is plotted between pressure and inverse of volume, the graph line is a straight line as illustrated in figure. From the straight line graph we can say:
Pressure is inversely proportional to volume.



Thus, $P \propto \frac{1}{V}$

Similarly, if a graph is plotted between length and time period of a simple pendulum, the graph line is a curve, which has a tendency to meet X-axis or Y-axis when produced towards origin, as shown in the figure.



From the figure, it is clear that length of a simple pendulum is not proportional to its time period.
However, if a graph is plotted between length and $(\text{Time})^2$, the graph line is a straight line. Thus, we can say :
From the above discussion it is very clear that graph line helps to determine the nature of proportional relationship between two variable quantities.