1 MEASUREMENTS

1. FUNDAMENTAL AND DERIVED QUANTITIES

	♦	PHYSICAL QUANTITY
	♦	SYSTEM OF UNITS
	♦	RULES OF WRITING UNITS

PHYSICAL QUANTITY

A physical quantity is a quantity that can be measured.

Physical quantity is expressed by stating

(i)Magnitude of the physical quantity.

(ii)The unit employed Therefore, physical quantity = magnitude $\times$ unit.

STANDARD UNIT

In measuring a physical quantity one needs to have an idea of its various units, their inter-relationships and also the various devices used for its measurements.

The unit plays an important role in the description of a physical quantity. But the unit used for a particular physical quantity is person dependent. Hence, they need to be specified and standardized to maintain uniformity. Under this treaty, an International Bureau of weights and measures was established. This Bureau situated at Sevres in Paris has specified standard units, measured more accurately with advanced techniques of science.

CHARACTERISTICS OF STANDARD UNIT

1.It should be of convenient size.

2.It should not change with respect to space and time.

3.It should be easy to define, without any doubt or ambiguity.

4.It should not be perishable.

5.It can be easily reproduced.

TYPES OF PHYSICAL QUANTITIES:

(a) Fundamental quantities:

These quantities do not depend on other physical quantities.

Ex: Length, mass and time are fundamental quantities.

(b) Derived quantities:

These quantities are defined in terms of fundamental quantities.

Ex: Area, density, volume are derived quantities.

TYPES OF UNITS:

Fundamental units

The units of fundamental quantities are called fundamental units. Metre, kilogram, second etc. are fundamental units.

Derived units

The units of derived quantities are called derived units. Newton, cubic metre, joule etc. are derived units.

OBTAINING UNITS OF DERIVED QUANTITIES:

The unit of physical quantity can be obtained with the help of its formula or expression.

How to obtain derived unit of a physical quantity

Step-1: Write the measuring formula of the physical quantity.

Step-2: Check the terms present in the measuring formula.

Step-3: Substitute the units of the terms identified.

Ex.: Find the derived unit for force.

Sol: Area = Length × breadth

Unit of area = m × m = m^2 or sq.m.

SOME DERIVED UNITS ARE GIVEN IN THE TABLE BELOW:

Derived quantity	How it is derived from base units	Symbol	Special name
Area	Length × width	m^2	
Volume	Length × width × height	m^3	
Density	mass ÷ volume	kgm^{-3}	
Speed	distance ÷ time	m/s	
Acceleration	change in veolocity ÷ time	ms^{-2}	
Force	mass × acceleration	$kgms^{-2}$	newton
Pressure	force ÷ area	$kgm^{-1}s^{-2}$	pascal
Work	force × displacement	kgm^2s^{-2}	joule
Power	work done ÷ time taken	kgm^2s^{-3}	watt

SYSTEM OF UNITS

The fundamental units of length, mass and time taken together form a system of units. For measuring various physical quantities following systems are commonly adopted.

Name of the system	Unit		
	Length	**Mass**	**Time**
1. FPS	Foot	Pound	Second
2. CGS	Centimeter	Gram	Second
3. MKS	Metre	Kilogram	Second

S I SYSTEM:

In 1960, the General Conference of Weights and Measures introduced a new system of units known as SI units.

The following table shows the fundamental quantities and their units in SI system:

Name of the system		Unit	Symbol
1	Length	metre	m
2	Mass	kilogram	kg
3	Time	second	s
4	Temperature	kelvin	K
5	Luminous intensity	candela	Cd
6	Electric current	ampere	A
7	Amount of substance	mole	mol
Supplementary Quantities		**Unit**	**Symbol**
1	Plane angle	radian	rad
2	Solid angle	steradian	sr

Some prefixes for SI system:

Positive multiples of 10	Prefix	Symbol	Negative multiples of 10	Prefix	Symbol
10^{1}	Deca	da	10^{-1}	Deci	d
10^{2}	Hecto	h	10^{-2}	Centi	c
10^{3}	Kilo	k	10^{-3}	Milli	m
10^{4}	Mega	M	10^{-4}	Micro	μ
10^{5}	Giga	G	10^{-5}	Nano	n
10^{6}	Tera	T	10^{-6}	Pico	p
10^{7}	Peta	P	10^{-7}	Femto	f
10^{8}	Exa	E	10^{-8}	atto	α

RULES OF WRITING UNITS

- Symbol of a unit named after a scientist starts with capital letter.
  Ex:
  The SI unit of force is newton, named after the scientist Issac Newton. Therefore the symbol for newton is N.
  The SI unit of energy is joule, named after the scientist Joule. Therefore the symbol for joule is J.
- Full names of all units, even if they are named after a scientist should not start with a capital letter.
  Ex: newton, joule, watt, ampere, etc.
  The SI unit of force should be expressed as newton but not Newton.
- The first letter of the unit is used as a symbol for some units.
  Ex: 'm' for metre, 's' for second etc.
- The units may be written in full or using agreed symbols, but not in abbreviated form.
  Ex: metre or 'm', second or 's', kilogram or 'kg'
- Symbols for units don't take plural form.
  Ex:
  If the mass of a stone is 50 kilogram, it should be expressed as 50 kg but should not be expressed as 50 kgs.
  If the length of a stick is 10 metre, then it should be expressed as 10 m but should not be expressed as 10 ms or 10 mts.
- No full stop or other punctuation marks should be used within or at the end of symbols for units.
  Ex:
  (a)Mass of a body 50 kg but should not be expressed as 50 kgs or 50 kg.

1. FUNDAMENTAL AND DERIVED QUANTITIES

WORK SHEET LEVEL–I MAINS CORNER

SINGLE CORRECT ANSWER TYPE QUESTIONS

PHYSICAL QUANTITY

1. The physical quantity which cannot be related to another physical quantity is called:
   1) standard quantity 2) physical quantity
   3) derived quantity 4) fundamental quantity
2. A unit which cannot be related or changed to any other unit is called:
   1) standard unit 2) physical unit 3) fundamental unit 4) derived unit
3. Any quantity which can be measured is known as:
   1) physical quantity 2) fundamental quantity
   3) derived quantity 4) none of the above
4. A constant quantity used for comparison during the measurement of unknown quantity is called:
   1) fundamental quantity 2) standard quantity
   3) physical quantity 4) derived quantity
5. Which one is not a physical quantity?
   1) Force 2) Length 3) Pain 4) Volume
6. Which one is not a derived quantity?
   1) Mole 2) Newton 3) cm^3 4) pascal

SYSTEM OF UNITS

7. Which of the following physical quantities are measured in M.K.S. system?
   1) Length 2) Mass 3) Time 4) All of these
8. Which physical quantity unit is same in all the four systems?
   1) Length 2) Mass 3) Time 4) Temperature
9. In S.I system the unit of solid angle is
   1) Radian 2) Steradian 3) Ampere 4) Second
10. In F.P.S. system the unit of mass is
   1) foot 2) pound 3) second 4) none of these
11. In F.P.S. system the unit of time is
   1) foot 2) pound 3) second 4) minute

RULES OF WRITING UNITS

12. Which of the following system of units is known as rationalized MKS system?
   1) The FPS system 2) The CGS system
   3)The MKS system 4) The SI system

LEVEL–II

PHYSICAL QUANTITY

13. The M.K.S unit of force is_______
 1) joule 2) newton 3) kgm/s 4) dyne
14. The unit of power is
 1) Joule 2) Joule per second/day
 3) Joule per second and watt 4) Watt/sec
15. Light year is a unit of
 1) Time 2) Mass 3) Distance 4) Energy
16. The symbol of unit of plane angle
 1) θ 2) λ 3) rad 4) No units

SYSTEM OF UNITS

17. The unit of speed is a
 1) Fundamental unit 2) Derived unit
 3) Neither of above 4) Cannot say
18. Which among the following is the international system of units?
 1) M.K.S 2) C.G.S 3) F.P.S 4) S.I
19. In C.G.S system the unit of area is
 1) m^2 2) cm^2 3) kg^2 4) s^2
20. In F.P.S. system the unit of length is
 1) pound 2)foot 3) second 4) none of these
21. In C.G.S system the unit of acceleration is
 1) m/s^2 2) cm/s^2 3) m/s 4) cm/s

LEVEL-III ADVANCED CORNER

SINGLE CORRECT ANSWER TYPE QUESTIONS

22. There are _____ supplementary units in the SI system of units
 1) 2 2) 4 3) 6 4) 18
23. Measurement information that is used to describe a quantity is called
 1) Referents 2) Properties
 3) Data 4) A scientific investigation
24. India adopted metric system of unit in
 1) 1947 2) 1950 3) 1956 4) 2000
25. Which of the following unit is different from others?
 1) Mass 2) Length 3) Time 4) Density

LEVEL–IV

STATEMENT TYPE QUESTIONS

26. Statement I: The process of measurement of physical quantities is basically a comparison process.
Statement II: Fundamental quantities are always measured by direct comparison with the standard
1) Both statements are true
2) Both statements are false
3) Statement I is true. Statement II is false
4) Statement I is false. Statement II is true

INTEGER TYPE QUESTIONS

27. The number of fundamental quantity is_____

MULTI CORRECT ANSWER TYPE QUESTIONS

28. Which of the following are fundamental quantities?
1) Luminous intensity 2) Velocity
3) Pressure 4) Electric current

29. Which of the following sets cannot be included in the list of fundamental quantities in any system of units?
1) Length, mass and velocity 2) Length, time and velocity
3) Mass, time and velocity 4) length, time and mass

LEVEL–V

COMPREHENSION TYPE QUESTIONS

PASSAGE:

All derived quantities are derived from fundamental physical quantities.

30. Acceleration is derived from
1) Velocity 2) length 3) time 4) Both (1) and (3)

31. Force is derived from
1) Acceleration 2) velocity
3) mass, length and time 4) none of these

32. Energy has the units as that of
1) force 2) work
3) mass, length and time 4) power

MATRIX MATCH TYPE QUESTIONS

33.

COLUMN I	COLUMN II
a)Amount of substance	p) candela
b) Luminous intensity	q) hectare
c) Measure of electric current	r) mole
d) Area	s) ampere

2. MULTIPLE AND SUBMULTIPLES OF FACTORS

	♦	MULTIPLES OF METRE, SUB MULTIPLES OF METRE
	♦	MULTIPLES OF KILOGRAM, SUB MULTIPLES OF KILOGRAM
	♦	PRACTICAL UNITS OF TIME

METRE

In 1791, the Paris Academy of Sciences defined metre as under:

One millionth part of distance from the pole to the equator is called metre.

This distance is marked between two parallel lines drawn on a platinum-iridium bar. This bar is kept at a constant temperature in the International Bureau of Weights and Measures at Sevres in Paris.

All replicas of metre are compared with the standard metre described above.

The General Conference of Weights and Measures changed standard metre length to atomic constant, which does not change with time.

One metreis defined as the length of path travelled by light in vacuum in $\frac{1}{299,792,458}$ of a second.

MULTIPLES OF METRE

1. Decametre (dam) = 10^1 m = 10 m.
2. Hectometre (hm) = 10^2 m = 100 m.
3. Kilometre (km) = 10^3 m = 1000 m.

SUB-MULTI PIES OF METRE

1.Decimetre (dm) = 10^{-1} m = 10 cm

2. Centimetre (cm)= 10^{-2} m = 1 cm.

3.Millimetre (mm)=10^{-3} m =0.1 cm

4.Micrometre (pm)=10^{-6} m = 10^{-4} cm

5.Nanometre (nm) = 10^{-9} m = 10^{-7} cm.

6.Pico-metre (pm) = 10^{-12} m = 10^{-10} cm.

KILOGRAM

The standard kilogram is the mass of a cylinder, made from platinum-iridium alloy, kept at Sevres, in International Bureau of Weights and Measures in Paris.

KILOGRAM CAN BE DEFINED AS UNDER:

When a force of one newton produces an acceleration of 1.00 ms^{-2} in a body, then the mass of body is said to be one kilogram.

For practical purposes, the accurate copies of mass are prepared by comparing it with standard kilogram in Sevres.

MULTIPLES OF KILOGRAM

1.Quintal = 10^2 kg =100 kg.

2.Tonne (t) = 10^3 kg = 1000 kg.

SUB-MULTIPLES OF KILOGRAM

1.Hectogram (hg) = 10^{-1} kg = 100 g.

2.Decagram (dag) = 10^{-2} kg = 10 g.

3.Gram (g) = 10^{-3} kg =1 g.

4. Milligram (mg) = 10^{-6} kg = 10^{-3} g.

5.Microgram (g) = 10^{-9} kg = 10^{-6} g.

TIME

Generally, the interval between two events is called time.

The unit of time is second.

Definition: It is the duration of 9,192,631,770 periods of a radiation corresponding to transition between two hyper fine levels of ground state of caesium-133 atom.

The above unit was adopted in 1967. Its multiples are stated as under:

MULTIPLES OF TIME

1. Minute (min) = 60 s

2.Hour (h) = 60 min = 3600 s

3. Day (d) = 24 (h) = 24 × 60 min

= 24 × 60 × 60 s = 86400 s

SUB-MULTIPLES OF TIME

1.Decisecond = 10^{-1} s =0.1 s

2.Centisecond = 10^{-2} s = 0.01 s

3. Millisecond = 10^{-3}s = 0.001 s

4.Microsecond = 10^{-6} s = 0.000001 s

5.1 shake = 10^{-8}s

1 Mean Solar Day = 24 hours

= 24 × 60 minutes

= 1440 minutes

= 1440 × 60 seconds

= 86400 seconds

1 second = $\frac{1}{86400}$ of mean solar day.

ESTIMATION BY THE ORDERS OF MAGNITUDE

LARGE AND SMALL

We encounter objects of widely differing sizes in day-to-day life. Some of the objects may be as large as a mountain and others as small as a speck of dust. When we go beyond these limits, either in the direction of large objects or in the direction of smaller ones, it becomes difficult to grasp the actual size. There are objects which are much larger than mountains such as the Moon, the Sun, the Galaxy, etc.

These bigger objects constitute, what is commonly known as Macrocosm (Greek for "large world").

Conversely, very-very small objects, such as bacteria, atoms, electrons belong to Microcosm (Greek for "small world").

If we use the standard scientific unit metre (abbreviated "m") for measuring length of an object belonging to macrocosm, such as diameter of the Sun, it will be described by a very large number 1,390,000,000 m. Conversely, the diameter of hydrogen atom in microcosm is 0.000,000,000,106 m.

The above numbers are exceptionally big and are difficult to write or remember. Scientists have found an easy and compact way of writing such numbers.

Any number can be written as the product of number between one and ten and a number which is a power of ten.

The diameter of Sun, 1,390,000,000 m= 1.39×10^9 m

Similarly, diameter of hydrogen

$$0.000,000,000,106\ \text{m} = 1.06 \times \frac{1}{10,000,000,000}\ \text{m} = 1.06 \times 10^{-10}\ \text{m}.$$

When we say that the diameter of Sun is 1.39×10^9 m, 1.39 is the numeral value between 1 and 10, and 10^9 is the exponential part.

The exponential part of a particular measurement is called order of magnitude of a quantity. For example, order of magnitude of diameter of the Sun is 10^9 m. Similarly, order of magnitude of diameter of hydrogen atom is 10^{-10} m.

The order of the magnitude of any quantity is given a specific prefix and a symbol as illustrated in the following table.

TABLE: PREFIXES AND SYMBOLS OF ORDERS OF MAGNITUDE

Order	Prefi	Symbol
10^{24}	yotta	Y
10^{21}	zetta	Z
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G

10^6	mega	M
10^3	kilo	k
10^2	hecto	h
10^1	deca	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	It
10^{-9}	nano	n
10^{-12}	pico	P
10^{-15}	femto	f
10^{-18}	atto	a
10^{-21}	zepto	z
10^{-24}	yocto	y

PREFIXES AND SYMBOLS OF ORDER OF MAGNITUDE

STANDARD PREFIXES: To express the physical quantities in SI units having very large or very small numerical values some standard prefixes are used. We use these prefixes together with units to make the numerical values of quantities more "manageable".

Ex:

i)Radius of earth 64, 00, 000 m = 6400 km.

Here the prefix 'k' stands for 10^3.

ii)Mass of an ant 22/1000g = 22 mg.

Here the prefix "m" stands for 10^{-3}.

Prefixes used here are just numbers.

Commonly used prefixes with SI units are given below

SUB- MULTIPLES &MULTIPLES:

Sub Multiples					
d	Deci	10^{-1}	⟷	Deca	da
c	Centi	10^{-2}	⟷	Hector	h
m	Milli	10^{-3}	⟷	Kilo	k
μ	Micro	10^{-6}	⟷	Mega	M
n	Nano	10^{-9}	⟷	Giga	G
p	Pico	10^{-12}	⟷	Tera	T
f	Femto	10^{-15}	⟷	Peta	p
a	Atto	10^{-18}	⟷	Exa	E

NON- SI UNITS:

Length - inch = 2.54 cm; foot = 12 inches;
yard = 3ft; mile = 1760yards = 1.61km;
Astronomical unit (A.U) = 1.496 10^{13}
(It is mean distance of the earth from the sun)
Light year(ly) = 9.46 × 10^{15}m
(The distance travelled by the light in 1 year)
Parsec = 3.26ly
(It is the biggest unit of distance)
Area - 1 hectare = 1 hm
hm = 10^2m × 10^2m=10^4 m^2
Mass -1 Quintal = 100kg
1 Metric tonne = 1000kg = 10 quintals
Atomic mass unit (a.m.u) = 1.66 × 10^{-17}kg
Energy -1 Calorie = 4.186J.

POWERS OF EXPONENTS:

1)	a x a x a x ……………………(m times)=a^m
2)	a^0=1
3)	a^1=a
4)	a^{-m}=1/a^m[a^{-1}=1/a]
5)	a^m x a^n=a^{m+n}
6)	a^m/a^n=a^{m-n}
7)	$(a^m)^n$=a^{mn}
8)	$(ab)^m$=a^m x b^m
9)	$[a/b]^m$= a^m/b^m
10)	$[a/b]^{-1}$=b/a

SOLVED EXAMPLES

1. 1 litre = _______

Sol. 1 litre = 1000cc

1 milliliter $= \frac{1}{1000}$ litre=1cc

$\therefore$ 1 litre = 1000milliliter

1 litre = 1000cc

2. $1km^2$ = _______

Sol. $1km^2 = 1km \times 1km = 1000m \times 1000m = 1000000m^2 = 100 \times 10000m^2$

$\Rightarrow 1km^2 = 100 \times 1$ hectare = 100hectares

3. How many centimeters make 1 nano meter?

Sol. $1nm=10^{-9}m$; $1m=10^{2}$ cm;

Therefore $1nm=10^{-9}m = 10^{-9}\times 10^{2}cm=10^{-7}cm$.

2. MULTIPLE AND SUB MULTIPLES OF FACTORS

WORK SHEET **LEVEL–I** **MAINS CORNER**

SINGLE CORRECT ANSWER TYPE QUESTIONS

MULTIPLES OF METRE, SUB MULTIPLES OF METRE

1. The submultiples of metre are
   1) Milligrams and decameters 2) Millimetre and milligrams
   3) Hectrometre and gram 4) Centimetre and millimeter
2. 1 light year = ________km.
   1) 3.26×10^{15} 2) 3.26×10^{12} 3) 9.46×10^{12} 4) 2.16×10^{13}
3. 1nm = _________
   1) 10^{9}m 2) 10^{-7}m 3) 10^{-7}cm 4) 10^{-9}cm

MULTIPLES OF KILOGRAM, SUB MULTIPLES OF KILOGRAM

4. 600 g=________ kg.
   1) 6 2) 0.006 3) 0.06 4) 0.6
5. The submultiple of kilogram is
   1) Hectogram 2) Centimetre 3) Millimetre 4) Decametre
6. 1 gram=_________kg.
   1) 10^{-2} 2) 10^{-4} 3) 10^{-3} 4) 10^{-6}
7. 1 kilogram is equal to
   1) 1000 gram 2) 100 gram 3) 1000 milligram 4) 100 milligram

PRACTICAL UNITS OF TIME

8. 1 second =_______ of mean solar day
   1) 1/3600 2) 1/86400 3) 1/6300 4) 1/68400
9. 1 mean solar day is equal to how many second?
   1) 86400s 2) 84600 s 3) 68400 s 4) 48600 s
10. Which of the following is used to measure the time?
    1) Table clock 2) Simple balance
    3) Physical balance 4) Measuring tape
11. 1 hour =
    1) 24 s 2) 60 s 3) 100 s 4) 3600 s
12. The smallest measurement that can be measured by using a wall clock is
    1) 2 second 2) 1 minute 3) 1 hour 4) 1 second

LEVEL–II

MULTIPLES OF METRE, SUB MULTIPLES OF METRE

13. One cubic metre is equal to
    1) 10^{6}cc 2) 10^{5}cc 3) 10^{3}cc 4) 10^{8}cc

14. 1pm = 10^X mm, x =?
1) –10 2) –9 3) –12 4) –8

15. 1 km^2 = ____________ hectares
1) 10000 2) 1000 3) 100 4) 10

16. 1 centimetre =____________kilometre
1) 10 2) 100 3) $\frac{1}{10}$ 4) $\frac{1}{100000}$

MULTIPLES OF KILOGRAM, SUB MULTIPLES OF KILOGRAM

17. One metric tone = ___________ quintal
1) 100 2) 10 3) 1000 4) 10,000

18. 1 Quintal(qt) = _________kg
1) 1000 2) 1000 kg 3) 100 kg 4) 1000 kg

19. 1 micro gram(μg) = _________g
1) 10^{-9} 2) 10^{-6} 3) 10^{-8} 4) 10^{-6}

20. Convert 1 metric ton into micro grams(μg)
1) $10^{12}\mu g$ 2) $10^{10}\mu g$ 3) $10^{14}\mu g$ 4) $10^{8}\mu g$

21. How many Kilo ergs make 1 Hecta erg?
1) 10^{-2} 2) 10^{-3} 3) 10^{-5} 4) 10^{-1}

PRACTICAL UNITS OF TIME

22. 1 day = _____ sec
1) 36,400 2) 43,400 3) 86,400 4) 56,230

23. 40 mins is equal to ____ μs .
1) 24×10^8 2) 64×10^5 3) 40×10^3 4) 10×10^2

LEVEL-III ADVANCED CORNER

SINGLE CORRECT ANSWER TYPE QUESTIONS

24. The distance between Radha's home and her school is 3250 m. Express the distance in km.
1) 3.250 km 2) 32.50 km 3) 325.0 km 4) 0.3250 km

25. Light year is
1) Light emitted by sun in one year
2) Time taken by the light to travel from sun to earth
3) The distance travelled by light in free space in one year
4) Time taken by earth to go once around the sun

26. Which of the following is not a unit of time?
1) Solar year 2) Tropical year 3) Leap year 4) Light year

27. One millennium is equal to how many decades?
1) 100 2) 10 3) 1000 4) 10,000

28. Express a speed of 18/5 km/hr in m/s

1) 1 m/s 2) 2 m/s 3) 3 m/s 4) 4 m/s

29. Fermi is equal to how many centimeter

1) 10^{-15} cm 2) 10^{-12} cm 3) 10^{-10} cm 4) 10^{-13} cm

LEVEL–IV

STATEMENT TYPE QUESTIONS

30. Statement I: Negative powers are used for compound units obtained by dividing one unit with another

Statement II: A unit in short form is never written in plural.

1) Both Statements are true
2) Both Statements are false
3) Statement I is true. Statement II is false
4) Statement Iis false. Statement II is true

INTEGER TYPE QUESTIONS

31. If $m^2 = 10^x cm^2$; then, $2x + 1 =$ ________

MULTI CORRECT ANSWER TYPE QUESTIONS

32. $20mm^2 =$ ____________

1) $20\times10^{-5}m^2$ 2) $2\times10^{-1}cm^2$ 3) $2\times10^{-5}m^2$ 4) $2\times10^{-11}m^2$

33. 1 par sec = ___________

1) 3.26m 2) 3.26ly

3) $3.26\times10^{18}m$ 4) $3.26\times9.46\times10^{15}m$

LEVEL–V

COMPREHENSION TYPE QUESTIONS

PASSAGE:

To convert a unit from one system to another, the steps to be followed are

a.First convert the given unit into S.I unit

b. Then, convert it into the desired system of unit

34. 1 km^2 = __________

1) 10 hectare 2) 100 hectare 3) 1000 hectare 4) 1 hectare

35. 1 cm^2 =

1) 10^{-10} km^2 2) 10^{-8} hectares 3)10^{-4} m^2 4) all of these

36. 1 litre = __________

1) 1000 ml 2) 1000 cc 3) Both 1 and 2 4) None of these

MATRIX MATCH TYPE QUESTIONS

37.

Column-I	Column-II
a) 12 inches	p) 1 pole
b) 3 feet	q) 1 foot
c) 5 1/2 yards	r) 1 rod
d) 4 pole	s) 1 yard
	t) 1 chain

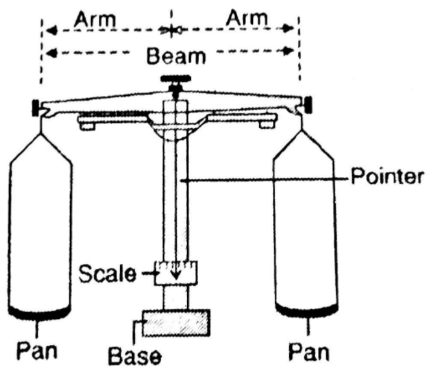
3. MEASUREMENT OF MASS AND DENSITY

	♦	MASS
	♦	DENSITY
	♦	RELATIVE DENSITY

INTRODUCTION TO MASS

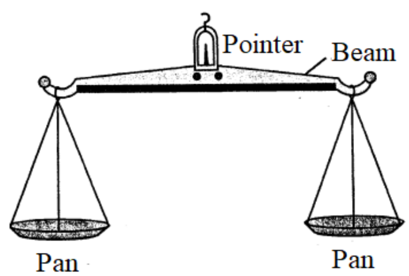
Mass is the amount of matter contained in a substance.

For measuring mass of costly substances such as gold, silver, diamonds we use beam balance. This is shown below.



Beam balance

For finding the mass of substances in general, just as at grocer's shop a simplified form of physical balance is used. This is shown below.



Physical balance

Standard International (S.I.) unit of mass is kilogram. In short form it is written as kg.

Quintal and metric tonne are the multiples of kilogram.

1000 kilogram (kg) = 1 metric tone

1000 kilogram (kg) = 10 quintals

100 kilogram (kg) = 1 quintal

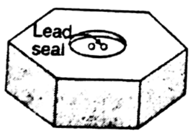
Gram and milligram are the sub-multiples of kilogram.

1000 milligrams (mg) = 1 gram (g)

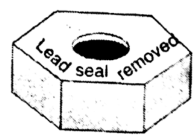
1000 grams (g) = 1 kilogram (kg)

The beam of the balance remains horizontal when equal masses are attached at equal distances from the point of suspension. This is the principle of a common balance.

- The body whose mass is to be determined is placed in the left hand pan and standard masses (usually called weights) are added to the right hand pan of the balance until the pointer attached to its horizontal beam remains at the centre.
- Now a days electronic balances are being used, which automatically measure and display the mass of the body accurately up to one milligram.
- In everyday language we refer to mass as weight For example, we normally say, this bag of vegetables weighs 4 kg or my weight is 35 kg, etc. However, this is scientifically wrong. When I say my weight is 35 kg, actually what I mean is my mass is 35 kg.
- Standard weight is generally made of iron and is hexagonal in shape. At its bottom is a lead seal fixed by the government department of standard weights and measures. Some dishonest shopkeepers remove this lead seal and thus short weigh the goods they sell.



Correct weight

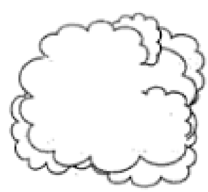


Incorrect (false) weight

INTRODUCTION TO DENSITY

Consider two substances, say iron and cotton each having the same mass, say 1 kg. They will occupy different volumes. Iron will occupy less volume as compared to cotton having same mass. This is because substances differ from one another in their densities. Density of iron is more than that of cotton.

1 kg Iron



1 kg cotton

THE DENSITY OF A SUBSTANCE IS AFFECTED BY THE FOLLOWING FACTORS:

The space between the particles: Larger the space between the particles, lesser is the density of the substance.

Mass of each particle: Larger the mass of each particle, more is the density of the substance.

The property of matter that describes the relationship between mass and volume is called density. The density of a substance is defined as the mass per unit volume of the substance.

Density of a substance (d) $= \frac{\text{Mass of the substance (M)}}{\text{Volume of the substance}}$ or $d = \frac{M}{V}$

UNIT OF DENSITY:

The S.I. unit of density $= kg/m^3 = kg\,m^{-3}$

The C.GS unit of density $= g/cm^3 = g\,cm^{-3}$

RELATIONSHIP BETWEEN THE S.I, AND C.G.S UNITS:

$$1kg/m^3 = \frac{1kg}{1m^3} = \frac{1kg}{1m \times 1m \times 1m} = \frac{1000g}{100cm \times 100cm \times 100cm} = \frac{1g}{1000cm^3}$$

∴ Density of a substance in S.I. system = 1000 × density of the substance in C.GS system.

Ex: The density of iron is $7.86\,g/cm^3$ in C.GS system. The density of iron in S.I. system will be 1000×7.86 i.e., $7860\,kg/m^3$.

Density of a substance in C.G.S system $= \frac{\text{density of the substance in S.I. system}}{1000}$

For example, the density of brass in SI system is $8400\,kg/m^3$. So, density of brass in CGS system $= \frac{8400}{1000} = 8.4\,g/cm^3$.

Note: Density depends upon the nature of the material of the substance. If the material is same then density is same.

Substance	Density in CGS System	Density in SI system
Solids		
Ice	0.92 g/cm^3	920. Kg/m^3
Sand (dry)	1.6 g/cm^3	1600 Kg/m^3
Aluminium	2.7 g/cm^3	2700 Kg/m^3
Steel	7.8 g/cm^3	7800 Kg/m^3
Iron	7.86 g/cm^3	7860 Kg/m^3
Copper	8.9 g/cm^3	8900 Kg/m^3
Gold	19.3 g/cm^3	19300 Kg/m^3
Liquids		
Water	1.0 g/cm^3	1000 Kg/m^3
Alcohol	0.8 g/cm^3	800 Kg/m^3
Paraffin oil	0.82 g/cm^3	820 Kg/m^3

Glycerin	1.26 g/cm^3	1260 kg/m^3
Gases (at standard temperature and pressure of 0°C and 1 atm)		
Air	0.0013 g/cm^3	1.3 kg/m^3
Hydrogen	0.00009 g/cm^3	0.09 kg/m^3
Oxygen	0.00143 g/cm^3	1.43 kg/m^3

DETERMINATION OF DENSITY OF A SOLID BY USING A MEASURING CYLINDER:

In order to determine the density of a solid we must know the mass and volume of the solid.

The mass of the solid is determined by a physical balance very accurately. Let it be M grams.

In order to find the volume, take a measuring cylinder and pour in it some water. Record the volume of water from the graduations marked on measuring cylinder. Let it be $50\,cm^3$.

Now tie the given solid to a fine thread and lower it gently in the measuring cylinder, **such that it is** completely immersed in water.

Record the new level of water. Let it be $75\,cm^3$.

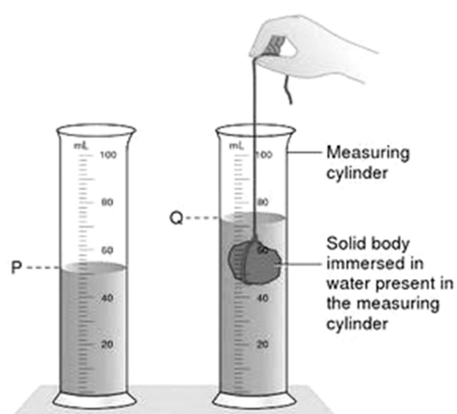
Therefore, volume of the solid $=(75-50)cm^3$

$=25\,cm^3$

$=V\,cm^3$ (Suppose).

Knowing the mass and the volume of the solid, the density can be calculated by the formula:

$$\text{Density}=\frac{\text{mass}}{\text{volume}}=\frac{M}{V}g/cm^3.$$



INTRODUCTION OF RELATIVE DENSITY

Most of the substances expand on heating and contract on cooling (mass remaining constant). Therefore the density of most of the substances decreases with the increase in temperature and increases with the decrease in temperature but water (like other substance) contracts when cooled upto 4^0C but expands (unlike other substances) when cooled further below 4^0C. Thus the density of water is maximum at 4^0C. It is $1 g/cm^3$ or $1000 kg/m^3$ at 4^0C.

RELATIVE DENSITY: It is the ratio of the density of the substance to the density of water at 4^0C. Thus,

$$\text{Relative density}(R.D) = \frac{\text{density of the substance}}{\text{density of water at } 4^0C}$$

$$= \frac{\text{Mass of the substance}}{\text{Volume of the substance}} \div \frac{\text{Mass of water at } 4^0C}{\text{Volume of water at } 4^0C} \qquad \left[\because D = \frac{M}{V}\right]$$

$$R.D = \frac{\text{Mass of the substance}}{\text{Volume of the substance}} \times \frac{\text{Volume of water at } 4^0C}{\text{Mass of water at } 4^0C}$$

If volume of substance = Volume of water at 4^0C

$$\text{Then } R.D = \frac{\text{Mass of the substance}}{\text{Mass of an equal volume of water at } 4^0C}$$

Thus, relative density of a substance is the ratio of the mass of the substance to the mass of an equal volume of water at 4^0C

Note: Relative density is sometimes called specific gravity, i.e., it tells how much a given substance is heavier or lighter as compared to the water at 4^0C.

UNITS OF RELATIVE DENSITY: As the relative density is the ratio between the densities or mass of the substances and the water at 4°C, therefore it has no. units, and is a pure number.

NUMERICAL VALUE OF DENSITY AND RELATIVE DENSITY IN C.GS SYSTEM:

Let there be a substance of R.D. 7.6. We know,

$$R.D = \frac{\text{Density of the substance (in C.G.S. system)}}{\text{density of water (in C.G.S. system)}}$$

$$7.6 = \frac{\text{Density of the substance (in C.G.S. system)}}{1 gm\,cm^{-3}}$$

$\therefore$ Density of substance in C.G.S system $= 7.6 gm\,cm^{-3}$.

Thus, numerical value of density and R.D. is same in C.GS system i.e. 7.6

Numerical value of density and relative density in S.I. system.

Let there be a substance of R.D. 7.6. We know.

$$R.D = \frac{\text{Density of the substance (in S.I system)}}{\text{density of water (in S.I system)}}$$

$$\therefore 7.6 = \frac{\text{Density of the substance (in S.I system)}}{1000\,kgm^{-3}}$$

$\therefore$ Density of substance (in S.I. system) $= 7.6 \times 1000\,kg/m^3 = 7600\,kgm^{-3}$

Thus, numerical value of density in S.I. system is 7600 where is that of R.D. is 7.6.

RELATIONSHIP BETWEEN DENSITY AND RELATIVE DENSITY:

Density of a solid = R.D. of the solid $\times$Density of water (in S.I. Unit)

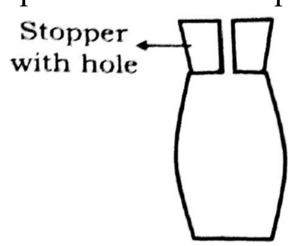
$= \text{R.D. of the solid} t 1000\,kg/m^3$

Density of a solid =R.D. of the solid $\times$Density of water (in C.G.S Unit)

$= \text{R.D. of the solid} \times 1\,g/cm^3$

DETERMINING THE RELATIVE DENSITY OF A LIQUID BY RELATIVE DENSITY BOTTLE:

The relative density of a liquid is determined by using a relative density bottle. It is a small glass bottle. St has a stopper with a fine hole. This bottle is used for finding the mass of equal volumes of liquids.



Relative density bottle

Experiment:

AIM: To find the relative density of kerosene

AIDS: i) R.D. bottle ii) physical balance iii) water iv) kerosene

METHOD: Take a clean and dry relative density bottle and weigh it accurately along with the stopper on a physical balance. Record the mass of the empty bottle. Let it be M_1 grams. Now fill the relative density bottle with water and insert the stopper. The water fills the hole in the stopper and some of if overflows. Wipe off the extra water and weigh the bottle. Let the mass of the bottle filled with water be M_2 grams. Empty the R.D. bottle and dry it with hot air. Refill the bottle with kerosene and insert the stopper. The kerosene fills the hole in the stopper and some of it overflows. Wipe off the extra liquid and weigh the bottle. Let its mass filled with kerosene be M_3 grams.

OBSERVATION:

Mass of empty R.D. bottle= M_1

Mass of R.D. bottle + water= M_2

Mass of R.D. bottle + kerosene= M_3

CALCULATION:

Mass of water $= M_2 - M_1$

Mass of kerosene $= M_3 - M_1$

So, relative density of kerosene $= \frac{M_3 - M_1}{M_2 - M_1}$

Using the relative density, one can also find out the density of a liquid.

$$R.D = \frac{\text{density of the liquid}}{\text{density of water}}$$

Therefore,

Density of the liquid = R.D. $\times$ density of water

To obtain the density of a liquid in g/cm^3, the relative density is multiplied by unity as density of water is 1 g/cm^3. Multiplying relative density by 1000, we get density of the liquid in kg m^3.

DENSITY AND R.D OF SOME COMMON SUBSTANCES:

Substances	Density		Relative density
	$kg\,m^{-3}$	$g\,cm^{-3}$	
Cork	240	0.24	0.24
Wood (Pine)	500	0.50	0.50
Petrol	800	0.80	0.80
Turpentine	870	0.87	0.87
Ice	920	0.92	0.92
Olive oil	920	0.92	0.92
Pure water $(At\,4^0C)$	1000	1.00	1.00
Sea water	1025	1.02	1.02
Glycerin	1260	1.26	1.26
Glass	2500	2.5	2.5
Aluminium	2700	2.70	2.70
Iron	7860	7.86	7.86

Copper	8920	8.92	8.92
Silver	10500	10.50	10.50
Mercury	13600	13.60	13.60
Gold	19300	19.3	19.3
Platinum	21500	21.50	21.50

SOLVED PROBLEMS

1. A piece of iron has dimensions 3 cm $\times$ 1.5 cm $\times$ 6 cm. If its mass is 205.2 g calculate:
i) Volume of iron ii) Density in C.G.S system
iii) Density in S.I. system iv) R.D. of iron

Sol. i) Volume of iron = 3 cm x 1.5 cm $\times$ 6 cm = 27 cm^3

ii) Density in C.G.S system = $\frac{M}{V} = \frac{205.2\ g}{27\ cm} = 7.6\ gcm^{-3}$

iii) Density in S.I system = Density in C.G.S system $\times$ 1000 kgm^{-3}
= 7.6 x 1000 kgm^{-3} = 7600 kgm^{-3}

iv) R.D. of iron = Density of iron = 7.6 g cm^{-3} = 7.6

2. The mass of rectangular block of iron is 23.6g and its dimensions are 2.1cm $\times$ 1.2cm $\times$ 1.1cm. The density of iron in kgm^{-3} is

Sol. Volume of rectangular block
= 2.1cm $\times$ 1.2cm $\times$ 1.1cm = 2.77cm^3

$$density = \frac{Mass}{Volume} = \frac{23.69}{2.77cm^3} = 8.51 gcm^{-3}$$

$$= 8.51 \times 1000 = 8510 kgm^{-3}$$

3. A bottle weights 30g when empty 53.5g when filled with a liquid and 48g when filled with water. The relative density of the liquid is _____.

Sol. Mass of liquid (53.5 – 30)g = 23.5g
Mass of an equal volume of water = (48 – 30)g = 18g
Knowing 1g of water occupies a volume 1cm^3
Volume of water = Volume of liquid = 18cm^3
Density of liquid in C.G.S system

$$= \frac{M}{V} = \frac{23.5g}{18cm^3} = 1.30 g/cm^3$$

Density of water in C.G.S system = 1g/cm^3

$$\therefore \text{ Relative density of liquid } = \frac{1.50 g/cm^3}{kg/cm^3} = 1.30$$

3. MEASURING OF MASS AND DENSITY

WORK SHEET LEVEL–I MAINS CORNER

SINGLE CORRECT ANSWER TYPE QUESTIONS

MASS

1. The quantity of matter contained in a body is known as
   1) Weight 2) Mass 3) Length 4) Time
2. For measuring mass of costly substances such as gold, silver, diamonds we use ________
   1) Physical balance 2) Beam balance
   3) Only Physical balance 4) None of these
3. Which of these are correct?
   1) $70\,g = 70\,kilograms$ 2) $70\,kgs = 70\,milligrams$
   3) $70\,kg = 70\,kilograms$ 4) $70\,KG = 70\,kilograms$

DENSITY

4. Density of a substance is equal to
   1) $mass \times volume$ 2) $mass \times area$
   3) $mass \div volume$ 4) $mass \div area$
5. The mass of a body of density $0.5\,gcm^{-3}$ and occupying a volume $2m^3$ is:
   1) 10 Kg 2) 1quintal 3) 10quintal 4) 1Kg
6. The density of water is maximum at
   1) 0^0C 2) 100^0C 3) 4^0C 4) 50^0C

RELATIVE DENSITY

7. Relative density of a substance is equal to
   1) $\frac{density\ of\ substance}{density\ of\ water}$ 2) $\frac{density\ of\ water}{density\ of\ substance}$
   3) Both (1) and (2) 4) none of these
8. The relative density of liquid is determined by using
   1) hydrometer 2) barometer
   3) thermometer 4) relative density bottle
9. A wooden block of dimensions 10cm×20cm×50cm weighs 6.5kg. The relative density is:
   1) 65×10^{-5} 2) 63×10^{-2} 3) 63×10^{-5} 4) 65×10^{-2}

LEVEL–II

DENSITY

10. 1 g/cm^3 is equivalent to this value in S.I. system
    1) $10\,kg/m^3$ 2) $1000\,kg/m^3$ 3) $10,000\,kg/m^3$ 4) $100\,kg/m^3$

11. If the mass of $2m^3$ of steel is 156000 kg, then what is the density of steel in S.I. system?
1) $70800\,kg/m^3$ 2) $78000\,kg/m^3$ 3) $87000\,kg/m^3$ 4) $70080\,kg/m^3$

12. If density of wood is $500\,kg/m^3$, then what will be the value in g/cm^3?
1) $0.5\,g/cm^3$ 2) $0.6\,g/cm^3$ 3) $5\,g/cm^3$ 4) $4\,g/cm^3$

13. What is the volume of wood of mass 6000 kg, when the density of wood is $0.8\,g/cm^3$?
1) $7.5\,m^3$ 2) $7.2\,m^3$ 3) $7.0\,m^3$ 4) $7.6\,m^3$

RELATIVE DENSITY

14. The density of mercury is 13.6×10^3 kg/m^3. What is its relative density?
1) 13.6 2) 13.1 3) 13.8 4) 12.1

15. The density of water is $1000\,kgm^{-3}$. If relative density of iron is 7.844, then what will be the density of iron?
1) $7974\,kgm^{-3}$ 2) $7874\,kgm^{-3}$ 3) $8874\,kgm^{-3}$ 4) $7877\,kgm^{-3}$

16. The relative density of silver is 1.5. If the density of water is $1000\,kgm^{-3}$, then density of silver will be
1) $10.5\,kgm^{-3}$ 2) $105\,kgm^{-3}$ 3) $10500\,kgm^{-3}$ 4) $1050\,kgm^{-3}$

17. The relative density of copper is 8.9. What is its density
i) in C.G.S and (ii) in S.I. unit
1) $8.9\,g/cm^3, 8.9\times10^3\,kg/m^3$ 2) $8.9\,g/cm^3, 89\times10^3\,kg/m^3$
3) $89.9\times10^3\,kg/m^3, 8.9\,g/cm^3$ 4) $890\times10^3\,kg/m^3, 8.9\,g/cm^3$

LEVEL-III ADVANCED CORNER

SINGLE CORRECT ANSWER TYPE QUESTIONS

18. Mass of a wooden piece of length 20 cm breadth 10 cm and thickness 0.5 cm is 50g. What is the density of wood?
1) $0.1\,g/cm^3$ 2) $5.0\,g/cm^3$ 3) $0.5\,g/cm^3$ 4) $5.1\,g/cm^3$

19. Find the mass of 555 cm^3 of iron in kg when density of iron is $7.6\,g/cm^3$
1) 4.218 kg 2) 4.120 kg 3) 41.20 kg 4) None

20. 5 litres of alcohol has a mass of 4 kg. Calculate the density of alcohol in kg/m^3
1) 800 kg/m^3 2) 8000 kg/m^3 3) 8200 kg/m^3 4) None of the these

21. The mass of empty bottle is 20g when filled with water, its mass is 48 g and when filled with some other liquid, its mass is 42.4 g. The density of the liquid is
1) 800 g/cm^3 2) 800 kg/m^3 3) 0.9 kg/m^3 4) 0.9 g/cm^3

22. If the mass of $4m^3$ of steel is 156000 kg, then what is the density of steel in S.I. system ____ kg/m^3

1) $39000 kg/m^3$ 2) $77000 kg/m^3$ 3) $68000 kg/m^3$ 4) $67000 kg/m^3$

LEVEL–IV

STATEMENT TYPE QUESTIONS

23. Statement-I: The distance between two points is called 'Length'.
Statement-II: Simple balance is used to measure the thickness of wire.
1) Both Statements are true
2) Both Statements are false
3) Statement I is true. Statement II is false
4) Statement I is false. Statement II is true

INTEGER TYPE QUESTIONS

24. The density of a liquid of mass 20g and occupies 10ml is ________g/cc

MULTI CORRECT ANSWER TYPE QUESTIONS

25. Which of the following is(are) about the density of a substance?
1) The density of a substance can be measured if the mass of the substance for a certain volume is known
2) Density is a derived quantity
3) The unit of density in S.I system is kilogram per cubic meter
4) $1 kg/m^3 = \frac{1}{1000} g/cm^3$

26. An empty bottle weighs 26.5g. When filled with water, it weighs 52.5g. When filled with liquid, it weighs 54g. The density of liquid is:

1) $1.057 kg/cm^3$ 2) $1057 kg/m^3$ 3) $1057 g/cm^3$ 4) $1.057 g/cm^3$

LEVEL–V

COMPREHENSION TYPE QUESTIONS

PASSAGE:

Mass per unit volume of a substance is called density.

27. A piece of lead weight 232 g and has a volume of 20 cm^3, then the density of lead

1) 11.6 g/cm^3 2) 21.6 g/cm^3 3) 31.6 g/cm^3 4) 41.6 g/cm^3

28. 5 litre of alcohol has a mass of 4 kg, then the density of alcohol in g/cm^3
1) 0.6 g/cm^3 2) 0.10 g/cm^3 3) 0.8 g/cm^3 4) 0.18 g/cm^3

29. Find the mass of 55 cm^3 of iron in kg when density of iron is 7.6 g/cm^3
1) 2.218 kg 2) 0.418 kg 3) 6.218 kg 4) 8.218 kg

MATRIX MATCH TYPE QUESTIONS

30.

COLUMN- I	COLUMN- II
a) Weight of the body of mass 1 Kg	p) Gravitational SI unit of weight
b) Gravitational C.G.S unit of weight	q) 10^6 dyne (if $g=10 m/s^2$)
c) 1 Kgwt	r) 10^{-3} Kgwt
d) Weight of the body of mass 1 kg	s) 980 dyne (if $g=9.8 m/s^2$)
	t) 1gwt

4. VERNIER CALLIPERS

VERNIER CALLIPERS

A vernier calipers is also called slide calipers. Vernier calipers was invented by Pierre vernier.

Vernier calipers is an instrument by which we can measure the smallest length upto $\frac{1}{10}$th of a mm = 0.1 mm = 0.01 cm.

PRINCIPLE OF VERNIER:

n V.S.D = (n – 1) M.S.D

Note: Generally 10 V.S.D = 9 M.S.D.

$1\text{ V.S.D} = \frac{9}{10}\text{ M.S.D} = \frac{9}{10}\text{ mm [1 M.S.D =1mm]} = 0.9\text{ mm.}$

Thus, the difference between one main scale division and one vernier scale division is (1 mm – 0.9 mm) = 0.1 mm. Thus we can measure length accurately upto 0.1 mm.

PITCH:

The smallest value of the length or any other unit which can be read directly from a main scale accurately is called pitch.

Ex: If one centimetre length has ten divisions.

Then pitch is $\frac{1}{10}$ cm = 0.1 cm.

$$\text{Thus pitch} = \frac{1\text{ unit (length)}}{\text{Number of divisions in the unit}}$$

LEAST COUNT:

The magnitude of the smallest measurement which can be measured by an instrument accurately is called its least count. (L.C).

LEAST COUNT OF VERNIER CALLIPERS:

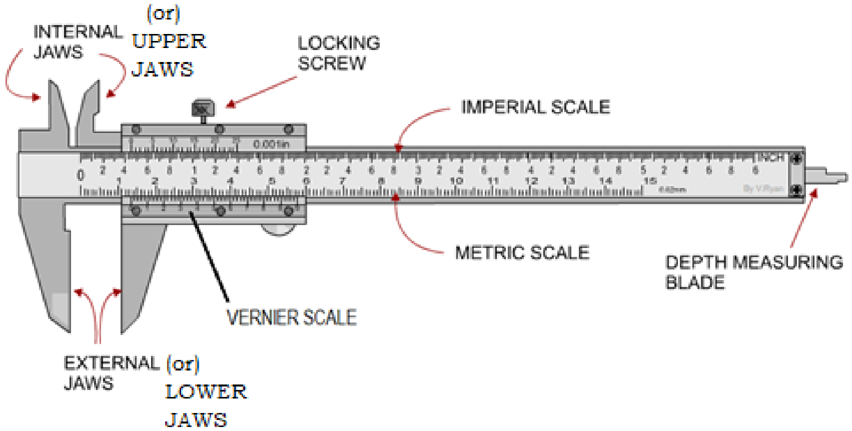
The difference between one M.S.D and one V.S.D is called Least Count (L.C.)

L.C = 1 M.S.D – 1 V.S.D

A vernier calipers consists of the following parts.

1) Main scale
2) Vernier scale

3) Movable jaws 4) Metallic strip



Note: i) 1 M.S.D = 1 mm

ii) 1 V.S.D $= \frac{9}{10}$ mm [n V.S.D=(n – 1) M.S.D]

= 0.9 mm

iii) External jaws are used to measure external dimension of an object, such as external length, external diameter of a cylinder, a sphere etc.

iv) Internal jaws are used to measure internal dimension of an object, such as the internal diameter of a hollow cylinder.

v) Metallic strip is used for measuring the depth of a vessel.

DETERMINATION OF LEAST COUNT OF VERNIER:

We know, least count of a vernier is the difference between one main scale division (M.S.D.) and one vernier scale division (V.S.D.)

∴ L.C.= one M.S.D. – one V.S.D.

$$=1mm-\frac{9}{10}mm=\left(1-\frac{9}{10}\right)mm=\left(\frac{10-9}{10}\right)mm=\frac{1}{10}mm=0.1mm=0.01cm$$

The least count of vernier calipers can also be defined as smallest division on the main scale to the no. of divisions on the vernier scale.

$$L.C=\frac{\text{Smallest value of one M.S.D}}{\text{No. of vernier scale division (V.S.D)}}=\frac{\text{Pitch}}{\text{No.of V.S.D}}$$

$$=\frac{1}{10}\ mm=0.1mm=0.01cm$$

Note:

L.C of ordinary scale = 1 mm L.C of metre scale = 1 mm

L.C of vernier calipers = 0.1 mm = 0.01 cm

HOW TO USE VERNIER CALLIPERS?

- Determine the smallest value of one M.S.D by observing the main scale.

  Note it down as the pitch of the main scale.

  OBSERVATIONS:

  Pitch of the main scale = _______________

  Generally used vernier calipers have a pitch of 1mm.

- Note the number of V.S.D and add it to the observation.

  No. of V.S.D = ______________ generally No. of V.S.D is 10.

  Calculated least count using the following formula

  $$\text{Least count L.C} = \frac{\text{Pitch}}{\text{No.of V.S.D}}$$

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

- Hold the object tightly in the between the Jaws.
- Determine the position of the zero of the vernier scale on the main scale and hence, find the value of length on the main - scale as under.

  From the figure, it is clear that zero of the vernier scale is between 1 and 1.1cm marks. The required length must be somewhere between 1cm and 1.1cm.

  The main scale reading is always the smaller of the two values between which the zero of vernier scale lies.

  Thus, in the above case, main scale reading is 1.0cm. M.S.D = 10

  M.S.R = M.S.D × Pitch; M.S.R = 10 × 0.1cm = 1.0cm

- Now look for the vernier scale division, which coincides with any of the main scale division. In the figure the 5^{th} division of vernier scale coincides with main scale.
- Length of the object is found by the formula.

  Length = Reading on M.S + L.C × V.S.D.or

  Length = Pitch × M.S.D + L.C × V.S.D.

  here,Length = 1.0cm + 0.01cm × 5= 1.0cm + 0.05cm = 1.05cm.

  ZERO ERROR OF VERNIER CALLIPERS

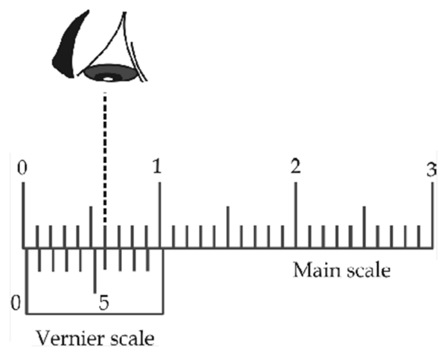
- For a correct measurement, the zero of the main scale must coincide with the zero of the vernier scale, when the movable jaw is in contact with the fixed jaw.
- However, if the zeros of M.S and V.S do not coincide, the vernier is said to have an error.
- These errors are of two types - positive and negative.

POSITIVE ZERO ERROR: If the zero of the vernier is on the right side of zero of main scale, the error is said to be positive.

In the above figure the zero of the vernier is to the right of the zero of the main scale.

Hence its error is positive.

How much is the error? To determine this look for the V.S division which coincides with any of the main scale divisions.



In the above figure, 6th vernier division coincides with main scale division.

The correction is then calculated by the formula.

Correction= – coinciding division of V.S × L.C= – 6 × 0.01cm = –0.06cm.

Suppose the length of a cylinder is determined to be 1.14cm and the vernier has a zero error of +5.

When the correction is applied to it,

we get correct reading=1.14cm–0.05cm= 1.09cm

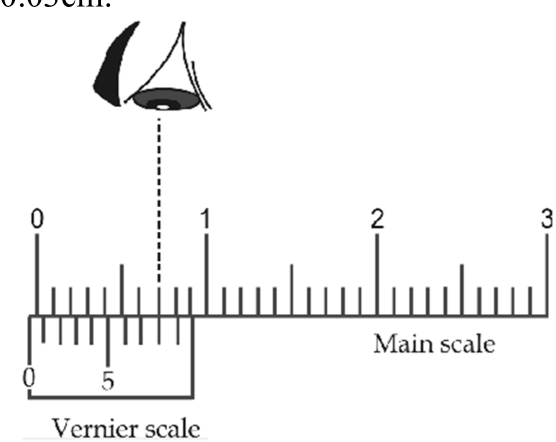
- **NEGATIVE ZERO ERROR:**

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

The figure shows a vernier with a negative zero error.

Correction = (n – coinciding division of V.S) × L.C = (10 – 7)× 0.01cm

= 3 × 0.01cm = 0.03cm.



SOLVED PROBLEMS

1. A vernier caliper has 20 divisions on the vernier scale, which coincide with 19 on the main scale. The lease count of the instrument is 0.1mm. The main scale divisions are of

Sol. $L.C=\frac{1M.S.D}{No.of\ V.S.D}\Rightarrow 0.1mm=\frac{1M.S.D}{20}$

$\therefore$ 1M.S.D=20×0.1mm=2mm

$\frac{0.1}{10}mm=\left(1-\frac{19}{20}\right)M.S.D$ or $\frac{1}{100}=\frac{1}{20}\times 1M.S.D$

$1M.S.D=\frac{1}{5}cm=\frac{1}{5}\times 10mm=2mm$

2. One centimetre on the man scale of vernier calipers is divided into ten equal parts. If 10 divisions of vernier scale coincide with 8 small divisions of the main scale, the L.C. of the calipers is

Sol. $L.C=1M.S.D-1V.S.D=\left(1-\frac{8}{10}\right)M.S.D=\frac{1}{5}M.S.D=\frac{1}{5}\times\frac{1}{10}cm=0.02cm$

3. In an instrument, 25 divisions of vernier scale coincides with 24 divisions of the main scale, one cm on main scale is divided in 20 equal parts, then what will be the least count?

Sol. The value of $1M.S.D=\frac{1}{20}cm$

The number of divisions on vernier scale = 25

$\therefore\ L.C=\frac{\text{Value of 1M.S.D}}{\text{no.of divisions on vernier sclae}}=\frac{\frac{1}{20}cm}{25}=\frac{1}{500}cm=0.002cm$

4. The least count of avernier calipers is 0.0025 cm and it has error of +0.0125cm. While measuring the length of a cylinder the reading on main scale is 7.55cm and 12^{th}vernier scale division coincides with main scale, what will be the correct length?

Sol. L.C = 0.0025cm

Zero error =+0.0125cm

Zero correction =-0.0125cm

M.S.R=7.55cm

V.S.D=12

Corrected length $=(M.S.R+L.C\times V.S.D)-0.0125cm$

$=(7.55cm+0.0025cm\times 12)-0.0125cm$

$=(7.55cm+0.0300cm)-0.0125cm$

$=7.5800cm-0.0125cm=7.5675cm$

4. VERNIER CALLIPERS

WORK SHEET LEVEL–I MAINS CORNER

SINGLE CORRECT ANSWER TYPE QUESTIONS

PRINCIPLE OF VERNIER CALLIPERS

1. Vernier calipers was invented by
   1) Pierre Vernier 2) Newton 3) Kelvin 4) Darwin
2. The least count of vernier calipers is
   1) 1mm 2) 0.2mm 3) 0.01mm 4) 0.01cm
3. The least count of ordinary scale is
   1) 1cm 2) 1mm 3) 0.01cm 4) 0.1mm
4. The principle of vernier is
   1) $n\,M.S.D = (n+1)V.S.D$ 2) $n\,M.S.D = (n-1)V.S.D$
   3) $n\,V.S.D = (n-1)M.S.D$ 4) $n\,V.S.D = (n+1)M.S.D$
5. In a vernier calipers 10 V.S.D is equal to how many M.S.D?
   1) 11 2) 10 3) 9 4) 12
6. In vernier calipers the smallest value of one M.S.D is called
   1) Least count 2) Pitch 3) Both (1) & (2) 4) None of these
7. Which one is the false statement?
   1) $L.C = \frac{\text{Pitch}}{\text{No.of vernier scale division}}$ 2) $L.C = 1M.S.D - 1V.S.D$
   3) $L.C = \frac{1M.S.D}{\text{No.of } V.S.D}$ 4) $L.C = \frac{\text{No.of } V.S.D}{M.S.D}$

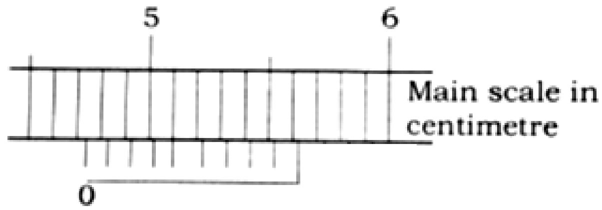
LEVEL–II

PRINCIPLE OF VERNIER CALLIPERS

8. The internal jaws of a vernier are used
   1) To measure internal dimension of an object
   2) To measure external dimension of an object
   3) To measure the depth of an object
   4) None of these
9. If the M.S.D of a reading is 81 and the pitch of the scale is 0.05cm then the main scale reading is
   1) 40.5 cm 2) 4.05cm 3) 4.5cm 4) 0.45cm
10. The zero error of a vernier is +2. Its zero correction is take (L.C = 0.01cm)
    1) 0.2cm 2) -0.2cm 3) -0.02cm 4) +0.02cm

11. A vernier calipers has 20 vernier divisions which coincide with 19 divisions on the main scale. If one main scale division is 1 mm, then what will be least count and vernier constant of the calipers?
1) 0.05 mm, 0.05 mm 2) 0.5 mm, 0.1 mm
3) 0.05 mm, 0.5 mm 4) 0.5 mm, 0.5 mm

12. Study the figure carefully and hence, calculate (i) Pitch (ii) Least count



1) 0.01 cm, 0.01 cm 2) 0.01 cm, 0.1 cm
3) 0.1 cm, 0.1 cm 4) 0.1 cm, 0.01 cm

13. A sphere is held tightly between the external jaws of vernier calipers. The zero of the vernier lies between 0.5 cm and 0.6 cm marks. What is the M.S.D?
1) 0.5 2) 0.6 3) 5 4) 6

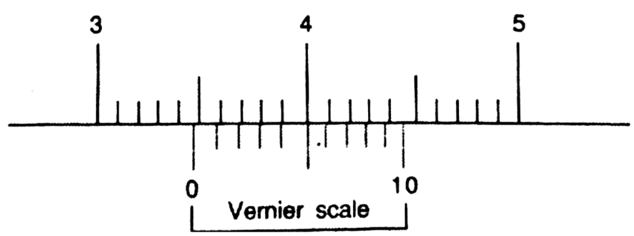
14. If the M.S.D of a reading is 81 and the pitch of the scale is 0.5cm then the main scale reading is
1) 4.05cm 2)40.5cm 3) 4.5cm 4) 0.45cm

LEVEL-III ADVANCED CORNER

SINGLE CORRECT ANSWER TYPE QUESTIONS

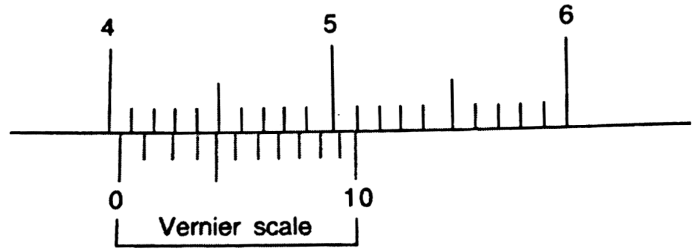
15. A vernier having a positive zero error of +5 is used to measure the side of a 2cm cube. The length as measured by the vernier will be: (use L.C = 0.01cm)
1) 1.95cm 2) 2cm 3) 2.05cm 4) Cannot say

16. Study the figure carefully and calculate reading shown by the vernier calipers (L.C=0.1mm)



1) 3.45cm 2) 4.35cm 3) 5.34cm 4) 3.54cm

17. Study the figure carefully and calculate the reading, (L.C=0.1mm)



1) 4.31cm 2) 4.31mm 3) 4.13mm 4) 4.13cm

18. The main scale of a vernier calipers reads 4.7cm, the 3rd division on the vernier scale coincides with a main scale division. The least count of the calipers 0.1mm. What is the reading of the vernier calipers?

1) 4.73cm 2) 4.73mm 3) 4.37cm 4) 4.37mm

LEVEL–IV

STATEMENT TYPE QUESTIONS

19. Statement-I: L.C. of vernier calipers $= 1\text{M.S.D} - 1\text{V.S.D}$

Statement-II: L.C of vernier calipers $= \dfrac{1\text{M.S.D}}{\text{No.of V.S.D}}$

1) Both Statements are true
2) Both Statements are false
3) Statement I is true. Statement II is false
4) Statement I is false. Statement II is true

INTEGER TYPE QUESTIONS

20. The main scale of vernier calipers has 10 divisions in a centimeter and ten vernier scale divisions coincide with 9 main scale divisions the least count of vernier is __________ $\times 10^{-4}$ m.

MULTI CORRECT ANSWER TYPE QUESTIONS

21. If smallest value of main scale division is 1 mm and number of V.S.D are 10 then L.C. is

1) 1 m 2) 0.01 cm 3) 0.0001 m 4) 0.000001

LEVEL–V

COMPREHENSION TYPE QUESTIONS

PASSAGE:

The smallest division on main scale of a vernier calipers is 1 mm and 10 vernier divisions coincide with 9 main scale divisions. When measuring the length of a line, the zero of the vernier scale lies between 10.2 cm and 10.3 cm and third division of vernier scale coincide with a main scale division.

22. The main scale reading on the left of zero of vernier scale is
    1) 10.2 cm 2) 10.3 cm 3) 20.5 cm 4) 0.01 cm
23. The L.C of the calipers is
    1) 0.01 cm 2) 0.001 cm 3)0.05 cm 4) 0.005 cm
24. The length of the line is
    1) 12.23 cm 2) 11.23 cm 3) 10.23 cm 4) 15.23 cm

MATRIX MATCH TYPE QUESTIONS

25. Match the following

Column-I	Column-II
a) L.C. of ordinary scale	p) 1 second
b) L.C of vernier scale	q) 1 mm
c) L.C. of wristwatch	r) 0.01 cm
d) The principle of vernier is	s) n V.S.D = (n-1) M.S.D
	t) n V.S.D = (n+1) M.S.D

5. SCREW GAUGE

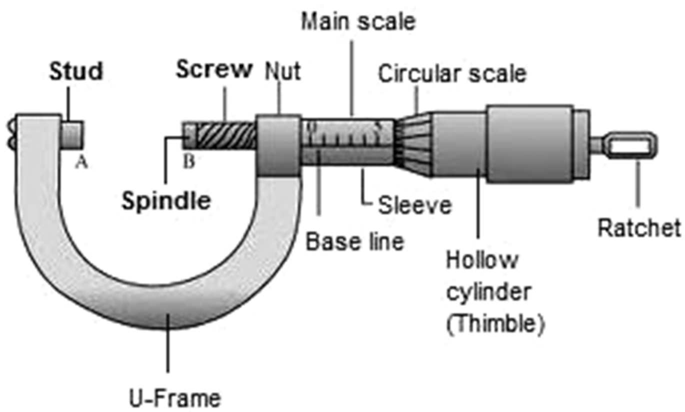
SCREW GAUGE

SCREW GAUGE (MICROMETER SCREW GAUGE): It is an instrument by which we can measured the length about

$\frac{1}{100}$th of a mm = 0.01mm = 0.001cm = 0.00001m = 10^{-5}m = 10^{-2}mm

PRINCIPLE OF SCREW GAUGE: Screw gauge works on the principle of screw in a nut.

CONSTRUCTION OF SCREW GAUGE: Screw gauge consists of the following parts.



U - FRAME: It is a steel frame, shaped in the form of U. On one end of U-frame is fixed a screw permanently. It is commonly called stud and forms the fixed jaw of the screw gauge. On the other end of U - frame is fixed a nut, through which slides a screw. The end B of the screw forms the movable jaw of screw gauge.

NUT AND SCREW: The nut is threaded from inside and the screw from outside. The screw can move in and out of nut by circular motion.

THIMBLE OR CIRCULAR CYLINDER: The screw is connected to a hollow circular cylinder (S), which rotates along with nut on turning.

SLEEVE CYLINDER: To the nut is attached a hollow cylinder, commonly called sleeve cylinder. The spindle of the screw passes through sleeve cylinder.

BASE LINE: A reference line or base line, graduated in mm, is drawn on the sleeve cylinder, parallel to the axis of nut. It is commonly called main scale or sleeve scale or linear scale or pitch scale.

CIRCULAR SCALE OR THIMBLE SCALE: The hollow cylinder moving over the sleeve cylinder is tapered from one end. On the tapered end are made graduations, which are either 50 or 100 in number. The scale marked on sleeve is called circular scale or thimble scale or head scale.

RATCHET: The ratchet is attached to screw by means of a spring. When the flattened end B of the screw comes in contact with stud A, the ratchet becomes free and makes a rattling noise. Thus, end B of the screw is not further pushed towards the stud A.

PITCH OF THE SCREW: It is the distance advanced by the screw for one complete rotations of the screw head.

Or

It is the distance between two consecutive threads of a screw.

$$\text{Pitch of the screw (P)} = \frac{\text{Distance travelled by the screw}}{\text{No.of complete rotations made}}$$

Let x be the distance travelled by the tip of the screw through a nut when n complete revolutions of the head are made. Then,

$$\text{Pitch of the screw (P)} = \frac{x}{n}$$

Ex: If 5mm is the distance moved by the screw on the main scale for 5 rotations then

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

LEAST COUNT: Least count of the screw is the smallest distance moved by its tip when the screw turns through 1 division marked on it.

The L.C is determined by the formula given below

$$\text{L.C} = \frac{\text{Pitch of the screw}}{\text{No. of head scale divisions}} = \frac{P}{N}$$

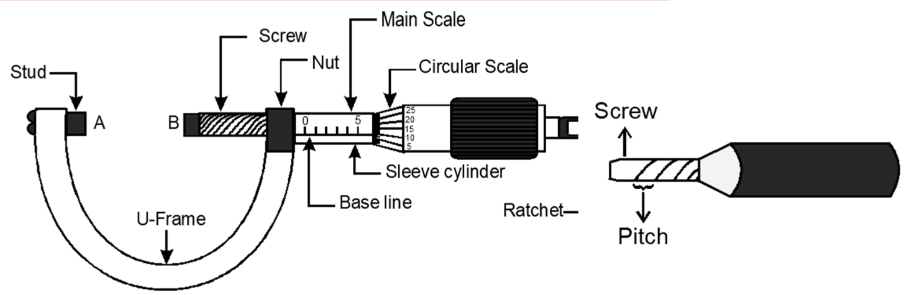
Ex: Let us assume that the number of divisions on the head scale is 100 and pitch of the screw 1mm. Then, the

$$L.C = \frac{1mm}{100} = 0.01mm = 0.001cm$$

Notes:

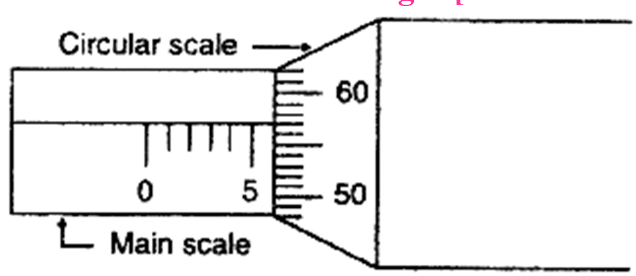
1. L.C of ordinary scale is = 1mm = 0.1cm
2. L.C of vernier calipers = 0.1mm = 0.01cm
3. L.C of screw gauge = 0.01mm = 0.001cm = 0.00001m = 10mm Since least count of a screw gauge of the order of 10mm. So, the screw gauge is called a micrometre screw.

TO MEASURE OF DIAMETER OF A WIRE BY SCREW GAUGE:



i)Calculate the least count of screw gauge.
ii)Calculate the zero error, if any.
iii)Place the given wire, in between stud A and movable screw B and turn the ratchet in clockwise direction, till the ratchet becomes free.
iv)Note the main scale reading from the left of the zero of circular scale.
v) Note the circular scale reading, by finding the number of divisions on circular scale, which coincide with the base line.
vi)Multiply the circular scale reading with the least count.
vii) Add circular scale reading to the main scale, so as to obtain observed reading.
viii) To the observed reading add or subtract zero error, so as to correct the measurement of diameter.

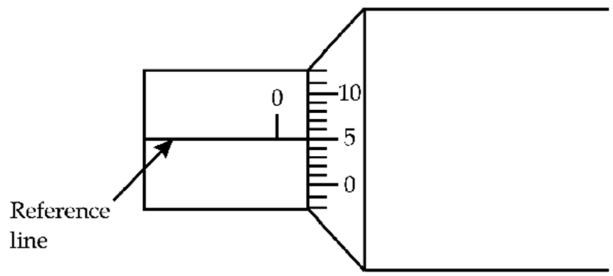
Observed diameter = Main scale reading + [Circular scale reading × L.C.]



In figure the main scale reading is 5mm and 57th the circular scale reading coincides with base line.

$\therefore$ Observed diameter=5 mm + 57 × 0.001 cm= 0.5 cm + 0.057 cm=0.557 cm

= 0.557 cm – 0.005 cm. = 0.552 cm.



USES OF SCREW GAUGE:

It is used to

1. Measure the thickness of the glass plate.
2. Measure the diameter of the thin wire.
3. Measure the diameter of small lead spheres.

5. SCREW GAUGE

WORK SHEET LEVEL–I MAINS CORNER

SINGLE CORRECT ANSWER TYPE QUESTIONS

SCREW GAUGE

1. The pitch of a screw gauge is distance between
   1) Two consecutive threads of screw, at right angles to the axis of screw
   2) Two consecutive threads of screw, along the axis of screw
   3) The smallest division on the main scale
   4) None of the above
2. A hollow nut through which a spindle of the screw passes is called:
   1) Sleeve cylinder 2) Circular cylinder
   3) Thimble 4) Both (b) and (c)
3. The least count of a micrometre screw gauge is:
   1) 10^{-4}m 2) 10^{-6}m 3) 10^{-3}m 4) 10^{-5}m
4. The least possible value which can be measured accurately using an instrument is called:
   1) Absolute count 2) Minimum count
   3) Least count 4) Smallest count
5. An instrument which uses nut and screw for accurate measurements is called:
   1) Vernier calipers 2) Physical balance
   3) Hydrometer 4) screw gauge

LEVEL–II

SCREW GAUGE

6. In a screw gauge (when the studs are in contact), if the zero of circular scale is above the base line, the screw gauge has
   1) Zero error 2) Negative zero error
   3) Positive zero error 4) No error
7. In a screw gauge (when the studs are in contact), if the zero of the thimble is below the base line, the screw gauge has:
   1) Zero error 2) Negative zero error
   3) Positive zero error 4) No error
8. Which of the following measures the length most accurately
   1) A screw gauge of L.C. 0.001 km 2) A screw gauge of L.C. 0.001 cm
   3) A screw gauge of L.C. 0.0025 cm 4) A screw gauge of L.C. 0.05 mm
9. A screw gauge is used to measure the diameter of a wire usually upto an accuracy up to
   1) 0.01 cm 2) 0.001 cm 3) 0.1 cm 4) 0.00001 cm
10. Least count of screw gauge is =
    1) 0.1mm 2) 0.001 cm 3) 0.01 cm 4) 1 m

LEVEL-III ADVANCED CORNER

SINGLE CORRECT ANSWER TYPE QUESTIONS

11. If 5 mm is the distance moved by the main scale for 5 rotations then pitch is equal to
1) 1 mm 2) 2 mm 3) 5 mm 4) 4 mm
12. If pitch of screw is 1 mm and number of divisions marked on the thimble are 100, then least count equal to
1) 0.1 cm 2) 0.001 cm 3) 0.2 cm 4) 0.002 cm
13. A screw gauge has 100 parts circular scale and on rotation of a full circular scale, the screw advances a distance of 1 mm. The least count of screw gauge is
1) 0.1 cm 2) 0.01 cm 3) 0.001 cm 4) 0.02 cm
14. The pitch of the screw gauge is 1 mm there are 100 divisions on the circular scale. In measuring the diameter of a sphere there are six divisions on the linear scale and 40th division on the circular scale coincides with reference line then the diameter of the sphere is
1) 6.4 mm 2) 5.6 mm 3) 3.6 mm 4) 4 mm

LEVEL–IV

STATEMENT TYPE QUESTIONS

15. Statement-I: The pitch of a screw gauge is 0.1 cm and number of circular scale divisions are 100. The L.C. of the screw is 0.01 cm.

Statement-II: $L.C = \frac{\text{Pitch}}{\text{No.of circular scale divisions}} = \frac{0.1\text{cm}}{100} = 0.001\text{cm}$.

1) Both Statements are true
2) Both Statements are false
3) Statement I is true. Statement II is false
4) Statement I is false. Statement II is true

MULTI CORRECT ANSWER TYPE QUESTIONS

16. If a screw moves by 1mm in two rotations and the head scale has 50 divisions then
1) L.C of the screw is 0.001 mm 2) L.C of the screw is 1 micrometre
3) Pitch of the screw is half mm 4) Pitch of the screw is 0.0001 mm

LEVEL–V

COMPREHENSION TYPE QUESTIONS

PASSAGE:

When the jaws of micrometre screw gauge are fully closed, the 94th circular scale division coincide with the base line. The circular scale of this instrument has 100 divisions and main scale has 10 divisions to a centimetre. While measuring the diameter of a wire the reading on main scale is 5 mm and 35th circular scale division coincides the main scale, base line.

17. Error is
    1) –5 divisions 2) –6 divisions 3) –4 divisions 4) –7 divisions
18. Observed diameter is
    1) 0.053 cm 2) 0.535 cm 3) 0.355 cm 4) 0.325 cm
19. Corrected diameter is
    1) 0.053 cm 2) 0.535 cm 3) 0.541 cm 4) 0.325 cm

MATRIX MATCH TYPE QUESTIONS

20. Match the following

No.	Column-I	No.	Column-II
a)	A device used for finding diametre of thin wires.	p)	pitch
b)	The smallest value of length which can be read from the main scale.	q)	least count
c)	The correction for negative zero error.	r)	screw gauge
d)	The correction for positive zero error.	s)	negative correction
		t)	positive correction