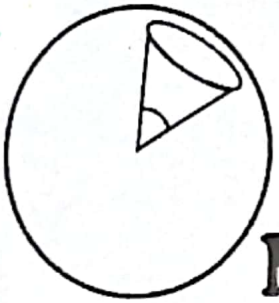


Chapter 1

MEASUREMENTS

KEY POINTS

Physics:

"Physics is an experimental science that deals with the study of matter, energy and their mutual relationship".

The study of science can be classified as

- Biological science: dealing with living things.
- Physical science: concerned with Non living things.

Frontiers of fundamental sciences:

There are three main frontiers of fundamental sciences

- 1st frontier: world of extremely large things. Such as universe.
- 2nd frontier: world of complex matter or middle sized things. Such as molecules.
- 3rd frontier: world of extremely small things. Such as electrons, protons etc.

S.I System:

The internationally adopted system of units used by all the scientists and almost all the countries of the world is international system (SI units). It consists of seven base units, two supplementary units and a number of derived units.

Physical quantities:

A property of the matter associated with measurement is called physical quantity.

There are two types of physical quantities

- Base quantities: those quantities which are predefined e.g mass, length, time, temperature etc.
- Derived quantities: which can be expressed in terms of standard combination of the base quantities e.g velocity acceleration, force etc.
- Base units: the units of base quantities.

Physical Quantity	SI Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Intensity of light	candela	cd
Amount of substance	mole	mol

- **Supplementary units:**

Physical Quantity	SI Unit	Symbol
Plane angle	radian	rad
Solid angle	steradian	sr

- **Derived units: the units of derived quantities**

Physical Quantity	Unit	Symbol	In terms of base units
Force	newton	N	$Kg\ m\ s^{-2}$
Work	joule	J	$N\ m = kg\ m^2\ s^{-2}$
Power	watt	W	$J\ s^{-1} = kg\ m^2\ s^{-3}$
Pressure	pascal	Pa	$N\ m^{-2} = kg\ m^{-1}\ s^{-2}$
Electric charge	coulomb	C	A s

Scientific Notation:

The standard to express the number in term of power of ten is called scientific notation.

Factor	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{-1}	deci	d
10^{1}	deca	da
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E

Error:

The difference between standard and experimental values is called error.

- **Occurrence:**
  1. Negligence or inexperience of a person.
  2. The faulty apparatus.
  3. Inappropriate method or technique.

Types of Error:

- **Systematic error:** it may occur due to error in instruments, poor calibration of instruments or incorrect markings etc.
- **Removal:** These errors can be reduced by comparing the instrument with another which is known to be more accurate. Thus for systematic error, a correction factor can be applied.
- **Random error:** random error is said to occur when repeated measurements of the quantity, gives different values under the same condition of environment.
- **Removal:** Such errors can be removed by repeating the measurements several times and taking an average can reduce the effect of random errors

Significant Figures:

In any measurement, accurately known digits and the first doubtful digit are called significant figures.

Rules for Rounding off data:

- All non-zero digits from 1 to 9 are significant e.g in a measurement 87234 the number of significant figures are five. In case of zeros the following rules may be adopted:
- A zero between two significant figures is itself significant. e.g 24064 the number of significant figures in the measurement are five.
- Zero to the left of significant figures are not significant. e.g 0.00467 and 02.594 contains three and four significant figures respectively.
- Zeros to the right of significant figures may or may not be significant.
- In decimal fraction zeros to the right of significant figure are also significant. e.g 2.500 contains four significant figures.
- In integers the significant of a zero is determined by the L.C of the measuring tool. e.g. If 2500cm length is measured by a meter rod of L.C 1cm then significant figures are four, but if recorded by a measuring instrument of L.C 10cm then it contains three significant figures.

Precision:

A precise measurement is the one which has less absolute uncertainty.

Accuracy:

An accurate measurement is the one which has less fractional or percentage uncertainty or error.

Assessment of Total Uncertainty in the Final Result:

- For addition and subtraction the absolute uncertainties in each measurement are added.
- In multiplication and division the percentage uncertainties are added.
- For power factor the power is multiplied with the percentage uncertainty.
- For average value of many measurements, the mean deviation from the average value is the uncertainty in the average value.
- For time measurement, uncertainty is obtained by dividing the least count of the timing device with the number of vibrations.

Dimensions:

Each base quantity is considered as dimension denoted by a specific symbol written within square brackets. It stands for the qualitative nature of the physical quantity.

Dimensions use to:

- Checking the homogeneity of physical equation
- Deriving a possible formula

TOPICAL MULTIPLE CHOICE QUESTIONS

Topic 1.1:

Introduction to Physics

(1) **Science and technology are _____ for change in outlook of mankind.**
(a) potent force (b) nuclear force
(c) atomic force (d) electric force

(2) **Astrophysics included in**
(a) disciplinary area of physics (b) inter disciplinary areas of physics
(c) both (d) none of these

(3) **The discipline of physics dealing with the central part of atom is called**
(a) atomic physics (b) nuclear physics
(c) astrophysics (d) quantum physics

(4) **The branch of physics which deals with the velocities approaching that of light is called**
(a) quantum physics (b) relativistic mechanics
(c) thermodynamics (d) plasma physics

(5) **Silicon is a**
(a) conductor (b) semi-conductor
(c) insulator (d) all of these

(6) **The study of physics deals with**
(a) the laws of motion
(b) the structure of space and time
(c) interaction of electromagnetic radiation with matter
(d) all of these

(7) **Radio telescope had received the firelight of big bang which suppose to be started.**
(a) 20 billion years ago (b) 10 billion years ago
(c) 20 million years ago (d) 5 million years ago

(8) **In the beginning the man's attempt resulted in the birth of single discipline of science called**
(a) natural psychology (b) natural history
(c) natural philosophy (d) natural physics

(9) **At the present time the main frontiers of fundamental sciences are**
(a) 3 (b) 4
(c) 5 (d) 2

(10) **The second frontier of science is**
(a) world of "middle sized" things (b) fire light
(c) the world extremely small (d) the world of complex matter

(11) **Physics is a quantitative science based on primarily on**
(a) fundamental quantities (b) definition
(c) experiment and measurement (d) description of facts

(12) **The branch of physics which deals with the structure and properties of solid is called**
(a) solid state physics (b) quantum physics
(c) particle physics (d) atomic physics

(13) **Silicon is obtained from**
(a) space (b) sand
(c) moon (d) air

(14) **Chips are made from**
(a) silicon (b) carbon
(c) iron (d) copper

(15) **The overlapping of physics and other fields gave birth to**
(a) area of physics (b) interdisciplinary areas of physics
(c) both (a) and (b) (d) disciplinary area of physics

(16) **Which of the following does not lie in the interdisciplinary area of physics**
(a) astrophysics (b) geophysics
(c) atomic physics (d) biophysics

(17) **The diameter of the nucleus is**
(a) 10^{-12} m (b) 10^{10}m
(c) 10^{-15} m (d) 10^{-20} m

Topic 1.2:

Physical quantities

(18) **The number of physical quantities in S.I are**
(a) 7 (b) 2
(c) 3 (d) innumerable

(19) **The types of physical quantities in S.I are**
(a) 7 (b) 3
(c) 2 (d) innumerable

(20) **The diameter of milky way galaxy is**
(a) 10^{0}m (b) 10^{30}m
(c) 10^{10}m (d) 10^{20}m

(21) **The measurement of a base quantity involves**
(a) 3 steps (b) 2 steps
(c) 4 steps (d) 5 steps

(22) **Characteristics for an ideal standard are**
(a) variable and non-accessible (b) variable and accessible
(c) invariable and accessible (d) invariable and non – accessible

Topic 1.3:

International system of units

(23) **Steradian is the unit of**
(a) plane angle (b) solid angle
(c) time (d) distance

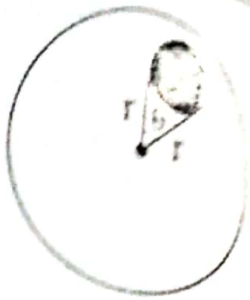
(24) **Light year is a unit of**
(a) time (b) speed
(c) distance (d) light

(25) **In a complete rotation plane angle is equal to**
(a) π rad (b) $\frac{\pi}{2}$ rad
(c) 2π rad (d) 4π rad

(26) **In a complete rotation solid angle is equal to**
(a) 2π rad (b) 2π sr
(c) 4π rad (d) 4π sr

(27) **Solid angle is a**
(a) two dimensional angle (b) three dimensional angle
(c) one dimensional angle (d) dimensionless

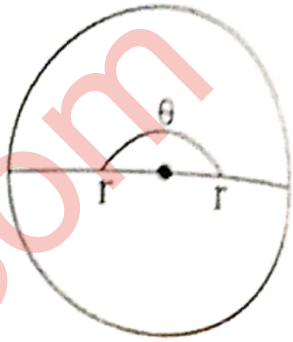
(28) In the figure a sphere of radius 5cm is shown. An area is drawn to it's surface equal to 25 cm^2. What must be the solid angle of the sphere?



(a) 1 sr (b) 2sr
(c) 25 sr (d) 5sr

(29) The unit of thermodynamic temperature is
(a) K (b) °C
(c) F (d) none of these

(30) A circle is shown in the figure whose radius is 2cm. What must be the plane angle if arc length is equal to half of the circumference of circle?



(a) 2 rad (b) $\frac{\pi}{2}$ rad
(c) 2π rad (d) π rad

(31) One pico is
(a) 10^{-18} (b) 10^{-9}
(c) 10^{-15} (d) 10^{-12}

(32) 3μμF can be written as
(a) 3 pF (b) 3nF
(c) 3mF (d) 3cF

(33) Which sub multiple has the least value
(a) pico (b) atto
(c) nano (d) femto

(34) 1 light year =
(a) 9.5×10^{15} m (b) 9.5×10^{7} m
(c) 3.0×10^{6} m (d) 3×10^{-15} m

(35) Micro ÷ milli is equal to
(a) 10^{6} (b) 10^{-3}
(c) 10^{-6} (d) 10^{-9}

(36) Electric charge in terms of base units are
(a) as (b) a
(c) As (d) s

(37) In scientific notation 1000.00 can written as
(a) 10^{4} (b) 10^{-3}
(c) 10^{-2} (d) 10^{3}

(38) Radian is the SI unit for measuring
(a) solid angle (b) plane angle
(c) both a & b (d) none

(39) 1 Pascal =
(a) $kgms^{-2}$ (b) $kgm^{-1}s^{-2}$
(c) $kgm^{-2}s^{-3}$ (d) $kgm^{-2}s^{-3}$

(40) Which of the following is the base quantities
(a) force (b) torque
(c) mass (d) velocity

(41) 1000 kilo gram is equivalent to
(a) 1 Mega gram (b) 1 tera kg
(c) 1 peta kg (d) 1 exa gram

(42) **Which of the following is derived quantities**
(a) mass
(b) force
(c) electric current
(d) luminous intensity

Topic 1.4:

Errors and Uncertainties

(43) **Repeating the measurement several times and taking an average can reduce the effect of**
(a) systematic error
(b) random error
(c) personal error
(d) all of these

(44) **Uncertainty may occur due to**
(a) natural variation of the object being measured
(b) natural imperfection of person's senses
(c) limitation of an instrument
(d) all of these

(45) **The chances of the error in a certain measurement occur due to**
(a) faulty apparatus
(b) negligence of experiment
(c) in-appropriate technique
(d) all of these

(46) **Systematic error can be reduced by**
(a) comparing values
(b) comparing instruments
(c) comparing techniques
(d) taking an average

(47) **Systematic error occurs due to**
(a) poor calibration of instrument
(b) due to zero error in instrument
(c) incorrect marking
(d) all of theses

(48) **The error which occurs due to some definite rule is called**
(a) personal error
(b) random error
(c) systematic error
(d) uncertain error

Topic 1.5:

Significant Figures

(49) **In any measurement, the accurately know digits and the first doubtful digit are called**
(a) accurate figures
(b) doubtful figures
(c) rounded off figures
(d) significant figures

(50) **1 year =**
(a) 1.4×10^{17} sec
(b) 3.2×10^{7} sec
(c) 8.6×10^{4} sec
(d) 5×10^{17} sec

(51) **The number of significant figures in 0.00067**
(a) 2
(b) 3
(c) 4
(d) 5

(52) **1 kg of mass is equivalent to**
(a) 9×10^{14} J
(b) 9×10^{16} J
(c) 9×10^{19} J
(d) 1.9×10^{18} J

(53) **Zero is always significant if it is present**
(a) on left in a number
(b) on right in number
(c) between two significant digits
(d) any where

(54) **The number 733.750 is rounded up to one decimal position is**
(a) 733.8
(b) 733.6
(c) 733.7
(d) 733.65

(55) When the dropped digit is 5 then retained digit increases by 1, if it is
(a) zero (b) odd
(c) even (d) prime

(56) Time taken by light to reach from sun to earth is
(a) 1 min, 20sec (b) 4 min, 20sec
(c) 8 min 20sec (d) 10 min, 20sec

(57) 73. 650 is rounded off as
(a) 73. 7 (b) 73.5
(c) 73. 6 (d) none of these

(58) The number of significant figures depend _____on least count of instrument.
(a) inversely (b) directly
(c) both (d) does not depend

(59) The number of significant figures in 6.60×10^4 kg are
(a) 3 (b) 2
(c) 1 (d) 0

(60) A measurement of 1000 kg was taken using an instrument of least count of 10 kg. The number of significant zero's in above measurement are.
(a) force (b) energy
(c) momentum (d) all of these

(61) The length of a rectangle is 0.233m while its breadth is 0.178. Its area in significant figures is
(a) $0.041m^2$ (b) $0.0415m^2$
(c) $0.041563m^2$ (d) $0.042\ m^2$

(62) In adding or subtracting numbers, the number of decimal places retained in the answers should be equal to
(a) the smallest number of decimal places (b) the largest number of decimal places
(c) both a and b (d) none of these

Topic 1.6:

Precision and Accuracy

(63) A precise measurement is one which has
(a) less precision (b) maximum precision
(c) less absolute uncertainty (d) both 'a' and 'c'

(64) In printing we use colours which are in number
(a) 1 (b) 2
(c) 3 (d) 4

(65) The least count of meter rod is
(a) 0. 1 cm (b) 0.01 cm
(c) cannot be zero (d) can be zero

(66) The absolute uncertainty of screw gauge is
(a) 0.01 cm (b) 0.01 mm
(c) 0.001 mm (d) 0.1 cm

(67) Any measurement taken from an instrument will be more precise, if instrument has
(a) large absolute uncertainty (b) small least count
(c) both a and b (d) none of these

Topic 1.7:

Assessment of Total Uncertainty in the Final Result

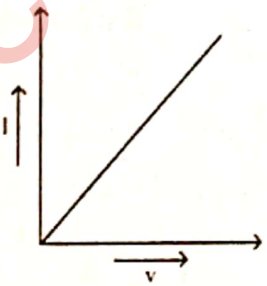
(68) **To reduce the uncertainty in finding time period of a vibrating body, it is advised that count**
(a) large number of swings
(b) medium number of swings
(c) small number of swings
(d) both a and b

(69) **In addition and subtraction resultant uncertainty is obtained by**
(a) adding absolute uncertainties
(b) subtraction of absolute uncertainties
(c) addition of % uncertainties
(d) multiplication of % uncertainties

(70) **Velocity of object has 2% uncertainty and mass has 1% uncertainty. Total % uncertainty in K.E is**
(a) 3%
(b) 4%
(c) 5%
(d) 6%

(71) **The earliest known exquisite and sensitive thermometer have built by**
(a) Colarado university
(b) Accademia del Cimento
(c) ASCII
(d) none of these

(72) **A graph is plotted between voltage and current as shown in the figure. What will be the uncertainty in power if voltage has an error of 2% add current has 5%?**



(a) 10%
(b) 5%
(c) 2%
(d) 7%

Topic 1.8:

Dimensions of Physical Quantities

(73) **Which of the following statements is true?**
(a) different physical quantities can have same dimensions.
(b) a dimensionally consistent statement may be mathematically in consistent.
(c) a dimensionally inconsistent statement is always inconsistent.
(d) all of these

(74) **Dimensions stands for _____ of physical quantities.**
(a) numerical nature
(b) qualitative nature
(c) both a & b
(d) none of these

(75) **Dimension of radian is**
(a) no dimension
(b) $[T^{-1}]$
(c) $[L^{-1}]$
(d) $[M^{-1}]$

(76) **Dimension of frequency is same that of**
(a) time period
(b) angular velocity
(c) angular acceleration
(d) mass

(77) **Linear momentum and impulse has same**
(a) dimension
(b) unit
(c) both a & b
(d) physical significance

(78) $[ML^2T^{-2}]$ **is the dimensions of**
(a) work
(b) torque
(c) energy
(d) all of these

(79) **Pressure has dimension**
(a) $[ML^2T^{-2}]$
(b) $[ML^{-2}T^{-2}]$
(c) $[ML^{-1}T^{-2}]$
(d) $[ML^2T^2]$

MULTIPLE CHOICE QUESTIONS

(From Past Papers 2012-2017)

(Federal Board)

(1) **The dimension of gravitational constant "G" is _____.** (FDR 2012)

(a) $M^1L^1T^{-3}$
(b) $M^{-1}L^3T^{-2}$
(c) $M^2L^3T^{-3}$
(d) $M^2L^{-3}T^{-1}$

(2) **The S.I unit of time is _____.** (FDR 2012)

(a) 60 min
(b) Cesium Sec
(c) Krypton -86
(d) 60 Sec

(3) **Light year is the unit of _____** (FDR 2014,2015)

(a) Time
(b) Distance
(c) Light intensity

(4) **Which of the following is the dimensions of angular momentum?** (FDR 2016)

(a) $\left[ML^2T^{-1}\right]$
(b) $\left[ML^2T^{-2}\right]$
(c) $\left[MLT^{-1}\right]$
(d) $\left[MLT^{-2}\right]$

(5) **The dimensions of Power are:** (FDR 2017)

(a) $[M\ L\ T^{-2}]$
(b) $[M\ L\ T^{-3}]$
(c) $[M^2\ L^2\ T^{-2}]$
(d) $[M\ L^2\ T^{-3}]$

(6) **The significant figures in 34.678 are:** (FDR 2017)

(a) 4
(b) 3
(c) 5
(d) 2

SHORT QUESTIONS

(From Textbook Exercise)

1. Name several repetitive phenomenons occurring in nature which could serve as reasonable time standards?

Ans: Any natural phenomenon that repeats itself after certain intervals of time can be used as time standard or measure of time e.g.

(a) The moon is reasonable time standard, because it gives the information of time.

(b) Sun is also a reasonable time standard because sunset and sunrise gives the information of time.

Some of other phenomenons are

(i) Changing of weather

(ii) Hearts beat

1.2. Give the drawbacks to use the period of a pendulum as a time standard.

Ans: As the time period of a simple pendulum depends upon length and the value of g

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

From the above relation it is clear that

(a) As the value of g different at different places. So, the time period of simple pendulum of fixed length may have different values.

(b) The time period can also be effected by air resistance.

(c) The time period of simple pendulum can also be effected by change in temperature i.e; In winters length of simple pendulum slightly decreases and in summer it slightly increases.

1.3. Why do we find it useful to have two units for the amount of substance, the kilogram and the mole?

Ans: If we want to consider the specific amount of mass without considering number of microscopic atoms present in it, it is useful to use kilogram.

Mole: If we want to consider a fixed number of atoms present in it, it is useful to use mole, it is more sensitive unit than kg.

1.4. Three students measured the length of a needle with scale on which minimum division is 1mm and recorded as (i) 0.2145m (ii) 0.21 m (iii) 0.214 m. Which record is correct and why?

Ans: In these records (iii) 0.214 m is more correct because the least count of scale is 1mm which can be written as 0.001m. So we can measure the length upto their decimal places.

1.5. An old saying is that "A chain is only as strong as its weakest link". What analogous statement can you make regarding experimental data used in a computation?

Ans: The analogous statement regarding experimental data in computation is as follow "A precise measurement is the one which has less precision."

1.6. The period of simple pendulum is measured by a stop watch. What types of errors are possible in the time period?

Ans: When a stop watch is used (to measure time period of a vibration). There are two types of possible errors.

(1) Zero error in the stopwatch, which is a systematic error.

(2) The timing to start and to stop the watch, which is personal error.

1.7. Does a dimensional analysis give any information on constant of proportionally that may appear in algebraic expression? Explain.

Ans: Dimensional analysis does not give any information about the constant of proportionality k. This constant k can be determined experimentally.

Example

The relation for the time period of a simple pendulum is given as

$$T = \text{cosntant}\sqrt{\frac{l}{g}}$$

The numerical value of constant in the above relation cannot be measured by dimensional analysis, however, it can be found by experiments.

1.8. Write the dimensions of (i) Pressure (ii) Density

Ans: (i) Pressure (ii) Density

$$P = \frac{F}{A}$$

(a)

$$\therefore [P] = \frac{[F]}{[A]}$$

$$But\,[F] = [MLT^{-2}]\,and\,[A] = [L^2]$$

$$\therefore [P] = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$$

As

$$\rho = m/V$$

(b)

$$[\rho] = \frac{[m]}{[V]}$$

$$But, [m] = [M],\ and [V] = [L^3]$$

$$\therefore \quad [\rho] = \frac{[M]}{[L^3]} = [ML^{-3}]$$

1.9. The wavelength λ of a wave depends on the speed v of the wave and its frequency f knowing that

$$[\lambda] = [L],\ [V] = [LT^{-1}]\,and\,[f] = [T^{-1}]$$

Decides which of the following is correct. $f = v\lambda$ or $f = \frac{v}{\lambda}$

Ans: (i) $f = v\lambda$

$$[f] = [V][\lambda]$$

Dimension of L.H.S= [f] = [T^{-1}]

Dimension of R.H.S = $[V][\lambda] = [LT^{-1}][L] = [L^2T^{-1}]$

Dimension of L.H.S ≠ Dimension of R.H.S

Thus equation is dimensionally incorrect

(ii) $$f = \frac{V}{\lambda}$$

$$[f] = \frac{[V]}{[\lambda]}$$

Dimension of L.H.S $= [f] = [T^{-1}]$

Dimension of R.H.S $= \frac{[V]}{[\lambda]} = \frac{[LT^{-1}]}{[L]} = [T^{-1}]$

Dimension of L.H.S = Dimension of R.H.S

Thus equation is dimensionally correct.