Be hungry (பசித்திரு) *Be conscious (விழித்திரு)* *Be individual (தனித்திரு)*

HIGHER SECONDARY FIRST YEAR-PHYSICS

NATURE OF PHYSICAL WORLD AND MEASUREMENT

UNIT - 1

COMPLETE GUIDE AND MODEL QUESION PAPER

NAME :

STANDARD : 11 SECTION :

SCHOOL :

EXAM NO :

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PART - I MULTIPLE CHOICE QUESTIONS & ANSWERS WITH SOLUTIONS

1. One of the combinations from the fundamental physical constants is hc/G. The unit of this expression is

(a) kg^2 **(b) m^3**
(c) s^{-1} **(d) m**

Soultion :

- Unit of $\frac{h\,C}{G} = \frac{(J\,s)(m\,s^{-1})}{N\,m^2\,kg^{-2}} = \frac{(N\,m\,s)(m\,s^{-1})}{N\,m^2\,kg^{-2}} = kg^2$

Answer	(a)	kg^2

2. If the error in the measurement of radius is 2%, then the error in the determination of volume of the sphere will be

(a) 8% **(b) 2%**
(c) 4% **(d) 6%**

Soultion :

- Volume of the sphere ; $V = \frac{4}{3}\pi r^3$
- So error in the measurement ;

$$\frac{\Delta V}{V} = 3\left(\frac{\Delta r}{r}\right) = 3\,(2\%) = 6\%$$

Answer	(d)	6%

3. If the length and time period of an oscillating pendulum have errors of 1% and 3% respectively then the error in measurement of acceleration due to gravity is

(a) 4% **(b) 5%**
(c) 6% **(d) 7%**

Soultion :

- Time period is given by ; $T = 2\pi\sqrt{\frac{l}{g}}$ (or) $T^2 = 4\pi^2\frac{l}{g}$
- Hence acceleration due to gravity ; $g = 4\pi^2\frac{l}{T^2}$
- So error in the measurement ;

$$\frac{\Delta g}{g} = \frac{\Delta l}{l} + 2\,\frac{\Delta T}{T} = 1\% + 2(3\%) = 7\%$$

Answer	(d)	7%

4. The length of a body is measured as 3.51 m, if the accuracy is 0.01m, then the percentage error in the measurement is

(a) 351% **(b) 1%**
(c) 0.28% **(d) 0.035%**

Soultion :

- Error in the measurement;

$$\frac{\Delta l}{l} X 100\% = \frac{0.01}{3.51} X 100\% = 0.0028\,X\,100\% = 0.28\%$$

Answer	(c)	0.28 %

5. Which of the following has the highest number of significant figures?

(a) 0.007 m^2 **(b) $2.64x10^{24}$ kg**
(c) 0.0006032 m^2 **(d) 6.3200 J**

Soultion :

- All zeros to the right of a decimal point and to the right of a non-zero digit are significant. Hence
  (a) Significant figure of 0.007 is = 1
  (b) Significant figure of $2.64x10^{24}$ is = 3
  (c) Significant figure of 0.0006032 is = 4
  (d) Significant figure of 6.3200 is = 5

Answer	(d)	6.3200 J

6. If π = 3.14, then the value of π^2 is

(a) 9.8596 **(b) 9.860**
(c) 9.86 **(d) 9.9**

Soultion :

- $\pi^2 = 3.14\,X\,3.14 = 9.8596$
- As the input data (3.14) has 3 significant figure, the answer should be restricted to 3 significant figure by rounding off as ; $\pi^2 = 9.86$

Answer	(c)	9.86

7. Which of the following pairs of physical quantities have same dimension?

(a) force and power **(b) torque and energy**
(c) torque and power **(d) force and torque**

Soultion :

- Dimensional formula for,
  (a) Force $(F = ma) \Longrightarrow [MLT^{-2}]$; Power$(P = \frac{W}{t}) \Longrightarrow [ML^2T^{-3}]$
  (b)Torque $(\tau = F\,r) \Longrightarrow [ML^2T^{-2}]$; Energy$(E = W) \Longrightarrow [ML^2T^{-2}]$
  (c) Torque $(\tau = F\,r) \Longrightarrow [ML^2T^{-2}]$; Power$(P = \frac{W}{t}) \Longrightarrow [ML^2T^{-3}]$
  (d) Force $(F = ma) \Longrightarrow [MLT^{-2}]$; Torque $(\tau = F\,r) \Longrightarrow [ML^2T^{-2}]$

Answer	(b)	torque and energy

8. The dimensional formula of Planck's constant h is

(a) $[ML^2T^{-1}]$ **(b) $[ML^2T^{-3}]$**
(c) $[MLT^{-1}]$ **(d) $[ML^3T^{-3}]$**

Soultion :

- Energy of photon ; $E = h\,\nu$ (here h →Plank's constant)
- Hence dimension of $h = \frac{E}{\nu} = \frac{[M\,L^2\,T^{-2}]}{[T^{-1}]} = [M\,L^2T^{-1}]$

Answer	(a)	$[M\,L^2T^{-1}]$

9. The velocity of a particle v at an instant t is given by v = at + bt^2. The dimensions of b is

(a) [L] **(b) $[LT^{-1}]$**
(c) $[LT^{-2}]$ **(d) $[LT^{-3}]$**

Soultion :

- By the principle of homogeneity,
  Dimension of 'v' = Dimension of 'at' = Dimension of 'bt²'
  (i.e.) Dimension of 'bt²' $= [\,L\,T^{-1}]$
- So the dimension of 'b' $= \frac{[\,L\,T^{-1}]}{t^2} = \frac{[\,L\,T^{-1}]}{[T^2]} = [\,L\,T^{-3}]$

Answer	**(d)**	$[L\,T^{-3}]$

10. The dimensional formula for gravitational constant *G* is

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

Soultion :

- From Newton's law of gravitation ; $F = G\,\frac{M\,m}{r^2}$
- Hence, gravitational constant ; $G = \frac{F\,r^2}{Mm} = \frac{[M\,L\,T^{-2}]\,[L^2]}{[M][M]} = [M^{-1}L^3\,T^{-2}]$

Answer	**(b)**	$[M^{-1}L^3\,T^{-2}]$

11. The density of a material in CGS system of units is 4 g cm⁻³ . In a system of units in which unit of length is 10 cm and unit of mass is 100 g, then the value of density of material will be

(a) 0.04 (b) 0.4 (c) 40 (d) 400

Soultion :

- Dimension of density $= [M\,L^{-3}]$
- We have ; $n_1[M_1L_1^{-3}] = n_2\,[M_2L_2^{-3}]$ (or) $n_2 = n_1\left[\frac{M_1}{M_2}\right]\left[\frac{L_1}{L_2}\right]^{-3}$

$$\therefore \quad n_2 = 4\left[\frac{1\,g}{100\,g}\right]\left[\frac{1cm}{10cm}\right]^{-3} = 4\,X\left[\frac{1}{100}\right]X\left[\frac{1000}{1}\right] = 40\ units$$

Answer	**(c)**	**40**

12. If the force is proportional to square of velocity, then the dimension of proportionality constant is

(a) $[MLT^0]$ (b) $[MLT^{-1}]$ (c) $[ML^{-2}T]$ (d) $[ML^{-1}T^0]$

Soultion :

- Given that, $F \propto v^2$ (or) $F = k\,v^2$ (where $k \to constant$)
- Thus dimension of constant $k = \frac{F}{v^2} = \frac{[M\,L\,T^{-2}]}{[L\,T^{-1}]^2} = \frac{[M\,L\,T^{-2}]}{[L^2\,T^{-2}]} = [M\,L^{-1}]$

Answer	**(d)**	$[M\,L^{-1}\,T^0]$

13. The dimension of $(\mu_o\varepsilon_o)^{-\frac{1}{2}}$ is]

(a) length (b) time (c) velo city (d) force

Soultion :

- Dimension of $\mu_o = M^{-1}L^{-3}T^4A^2$
- Dimension of $\varepsilon_o = M\,L\,T^{-2}A^{-2}$
- Therefore,

$$\text{Dimension of } (\mu_o\varepsilon_o)^{-\frac{1}{2}} = \{[M^{-1}L^{-3}T^4A^2]\,[M\,L\,T^{-2}A^{-2}]\}^{-\frac{1}{2}}$$
$$= \{[L^{-2}T^2]\}^{-\frac{1}{2}} = [L\,T^{-1}] = Dimension\ of\ velocity$$

Answer	**(c)**	*velocity*

14. Planck's constant (h), speed of light in vacuum (c) and Newton's gravitational constant (G) are taken as three fundamental constants. Which of the following combinations of these has the dimension of length?

(a) $\frac{\sqrt{h\,G}}{c^{3/2}}$ (b) $\frac{\sqrt{h\,G}}{c^{5/2}}$ (c) $\sqrt{\frac{hc}{G}}$ (d) $\sqrt{\frac{G\,c}{h^{3/2}}}$

Soultion :

- Given that , $l \propto h^xc^yG^z$
- By substituting their dimensions,

$$[L] = [M\,L^2T^{-1}]^x\ [L\,T^{-1}]^y\ [M^{-1}L^3\,T^{-2}]^z$$
$$[M^0L^1T^0] = [M^{x-z}\,L^{2x+y+3z}\,T^{-x-y-2z}]$$

- Comparing the powers on both sides, we get

$$x - z = 0 \quad ------ \quad (1)$$
$$2x + y + 3z = 1 \quad ------ \quad (2)$$
$$-x - y - 2z = 0 \quad ------ \quad (3)$$

- By Solving we get, $\boldsymbol{x} = \frac{1}{2}$; $y = -\frac{3}{2}$; $\boldsymbol{z} = \frac{1}{2}$
- Hence, , $\boldsymbol{l} \propto \boldsymbol{h}^{\frac{1}{2}}\,\boldsymbol{c}^{-\frac{3}{2}}\,\boldsymbol{G}^{\frac{1}{2}}$ (or) $\boldsymbol{l} \propto \frac{\sqrt{h\,G}}{c^{3/2}}$

Answer	**(a)**	$\frac{\sqrt{h\,G}}{c^{3/2}}$

15. A length-scale (*l*) depends on the permittivity (ε) of a dielectric material, Boltzmann constant (k_B), the absolute temperature (*T*), the number per unit volume (*n*) of certain charged particles, and the charge (*q*) carried by each of the particles. Which of the following expression for *l* is dimensionally correct?.

(a) $l = \sqrt{\frac{n\,q^2}{\varepsilon\,k_B\,T}}$ (b) $l = \sqrt{\frac{\varepsilon\,k_B\,T}{n\,q^2}}$

(c) $l = \sqrt{\frac{q^2}{\varepsilon\,n^{2/3}k_B\,T}}$ (d) $l = \sqrt{\frac{q^2}{\varepsilon\,n\,k_B\,T}}$

Soultion :

- We know, $F = \frac{1}{4\pi\epsilon}\frac{q^2}{r^2}$ (or) $\frac{q^2}{\varepsilon} = 4\pi\,F\,r^2 \implies [M\,L^3\,T^{-2}]$
- And, $k_B \implies [M\,L^2\,T^{-2}\,K^{-1}]$; $T \implies [K]$; $n \implies [L^{-3}]$

(a) $\sqrt{\frac{n\,q^2}{\varepsilon\,k_B\,T}} \implies \sqrt{\frac{[L^{-3}]\,[M\,L^3\,T^{-2}]}{[M\,L^2\,T^{-2}\,K^{-1}][K]}} = \sqrt{[L^{-2}]} = [L^{-1}] \neq l$

(b) $\sqrt{\frac{\varepsilon\,k_B\,T}{n\,q^2}} \implies \sqrt{\frac{[M\,L^2\,T^{-2}\,K^{-1}][K]}{[L^{-3}]\,[M\,L^3\,T^{-2}]}} = \sqrt{[L^2]} = [L^1] = l$

(c) $\sqrt{\frac{q^2}{\varepsilon\,n^{2/3}k_B\,T}} \implies \sqrt{\frac{[M\,L^3\,T^{-2}]}{[L^{-3}]^{\frac{2}{3}}[M\,L^2\,T^{-2}\,K^{-1}][K]}} == \sqrt{[L^3]} = \left[L^{\frac{3}{2}}\right] \neq l$

(d) $\sqrt{\frac{q^2}{\varepsilon\,n\,k_B\,T}} \implies \sqrt{\frac{[M\,L^3\,T^{-2}]}{[L^{-3}][M\,L^2\,T^{-2}\,K^{-1}][K]}} = \sqrt{[L^4]} = [L^2] \neq l$

Answer	**(b)**	$l = \sqrt{\frac{\varepsilon\,k_B\,T}{n\,q^2}}$

PART - II & III 2 & 3 MARK SHORT ANSWER QUESTIONS & ANSWERS

1. What is mean by science?

- The word '***science***' has its root in the Latin verb scientia. meaning "***to know***"
- In Tamil language, it is "**அறிவியல்**" meaning '***knowing the truth'***
- Science is the systematic organization of knowledge gained through observation, experimentation and logical reasoning.
- The knowledge of science dealing with non -living things is ***physical science*** (physics and chemistry) and that dealing with living things is ***biological science*** (zoology and botany)

2. What is called scientific method and what are the features involved in this method?

- The scientific method is a step-by-step approach in studying natural phenomena and establishing laws which govern these phenomena.
- Any scientific method involves the following general features.

(i) Systematic observation
(ii) Controlled experimentation
(iii) Qualitative and quantitative reasoning
(iv) Mathematical modeling
(v) Prediction and verification or falsification of theories

3. What do you mean by physics?

- The name Physics was introduced by ***Aristotle*** in the year 350 BC
- The word '**Physics**' is derived from the Greek word ***"Fusis",*** meaning nature.
- The study of ***nature and natural phenomena*** is dealt within physics. Hence physics is considered as the most basic of all sciences.
- ***Unification*** and ***Reductionism*** are the two approaches in studying physics.

4. Briefly explain the role of physics in technology and society.

- Technology is the application of the principles of physics for practical purposes.
- Physics and technology can both together impact our society directly or indirectly. For example,

(i) Basic laws of electricity and magnetism led to the discovery of wireless communication technology which has shrunk the world with effective communication over large distances.
(ii) The launching of satellite into space has revolutionized the concept of communication.
(iii) Microelectronics, lasers, computers, superconductivity and nuclear energy have comprehensively changed the thinking and living style of human beings.

5. Whtat is called measurement?

- The comparison of any physical quantity with its standard unit is known as measurement. Measurement is the basis of all scientific studies and experimentation.

6. Define physical quantity.

- Quantities that can be measured, and in terms of which, laws of physics are described are called physical quantities.
  Examples - length, mass, time, force, energy, etc
- Physical quantities are classified into two types. They are ***fundamental*** and ***derived*** quantities.

7. Briefly explain the types of the physical quantities .

Fundamental quantity	Derived quantity
Quantities which cannot be expressed in terms of any other physical quantities are called Fundamental or base quantities	Quantities that can be expressed in terms of fundamental quantities are called derived quantities.
Examples - Length, mass, time, electric current, temperature, luminous intensity and amount of substance	Examples - Area, volume, velocity, acceleration, force, etc.

8. Define units. What are its types?

- An arbitrarily chosen standard of measurement of a quantity, which is accepted internationally is called unit of the quantity.
- Basically there are two types of units. They are fundamental units and derived units.

9. Distinguish between fundamental units and derived units

fundamental units	derived units
The units in which the fundamental quantities are measured are called fundamental or base units	The units in which all the physical quantities which can be obtained by a suitable multiplication or division of power on fundamental units are called derived units
Examples- m, s, kg, A, mol	Examples- m/s, kg/m^3,

10. Define f.p.s system of units.

- It is the British Engineering system of units, which uses ***foot, pound*** and ***second*** as the basic units for measuring length, mass and time respectively

11. Define c.g.s system of units.

- It is the Gaussian system of units, which uses ***centimeter, gram*** and ***second*** as the basic units for measuring length, mass and time respectively

12. Define m.k.s system of units.

- It is the Metric system of units, which uses ***metre, kilogram*** and ***second*** as the basic units for measuring length, mass and time respectively

13. Write a note on SI system?

- The SI unit system (Système International) with a standard scheme of symbols, units and abbreviations were developed and recommended by the General Conference on Weights and Measures in 1971 for international usage in scientific, technical, industrial and commercial work.

14. What are advantages of S.I system?

- It is a rational system (i.e) only one unit for one physical quantity
- It is a coherent system (i.e)all derived units are easily obtained from basic and supplementary units
- It is a metric system (i.e) multiples and submultiples can be expressed as powers of 10

15. Define one metre (S.I standard for length)

- The S.I unit of length is metre (m)
- It is defined as length of the path travelled by light in vacuum in $\frac{1}{29,97,92,458}$ of a second

16. Define one kilogram (S.I standard for mass)

- The S.I unit of mass is kilogram (k*g*)
- It is the mass of platinum-iridium cylinder whose height is equal to its diameter preserved at the International Bureau of Weights and Measures at Serves near Paris.

17. Define one second (S.I standard for time)

- The S.I unit of time is second (s)
- It is the duration of 9,192,631,770 periods of radiation corresponding to the transition between the two hyperfine levels of the ground state of Cesium-133 atom

18. Define one ampere (S.I standard for current)

- The S.I unit of current is ampere (A)
- It is a constant current which when maintained in each of the two straight parallel thin conductors of infinite length held one metre apart in vacuum shall produce a force per unit length of $2 \text{ X } 10^{-7}$ N/m between them

19. Define one kelvin (S.I standard for temperature)

- The S.I unit of temperature is kelvin (K)
- It is the fraction of $\frac{1}{273.16}$ of the thermodynamic temperature of the triple point of the water.

20. Define one mole (S.I standard for amount of substance)

- The S.I unit of amount of substance is mole (mol)
- It is the amount of substance which contains as man elementary entities as there are atoms in 0.012 kg of pure carbon - 12

21. Define one candela (S.I standard for Luminous intensity)

- The S.I unit of luminous intensity is candela (cd)
- It is the luminous intensity in a given direction of a source that emits monochromatic radiation of frequency $5.40 \text{ X } 10^{14}$ Hz and that has a radiant intensity of $\frac{1}{683}$ watt/steradian in that direction.

22. Define one radian (S.I standard for plane angle)

- The S.I unit of plane angle is radian (rad). It is the angle subtended at the centre of a circle by an arc equal in length to the radius of the circle.

$$1\,rad = \frac{180°}{\pi} = 57.27\,°$$

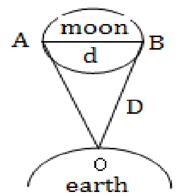
23. Define one steradian (S.I standard for solid angle)

- The S.I unit of soid angle is steradian (sr)
- It is the solid angle subtended at the centre of a sphere, by that surface of the sphere, which is equal in area to the square of radius of the sphere.

24. Write a note on parallax method.

- Parallax is the name given to the object with respect to the background, when the object is seen from two different positions.
- The distance between the two positions is called basis (b)
- This method is used for measuring very large distance such as distance of a planet or star

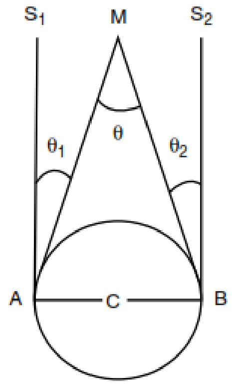
25. How will you measure the diameter of the Moon using Parallax method?



- Diameter of Moon ; AB = d
  Parallax angle ; ∠AOB = θ
  Distance of Moon from Earth ; OA = OB = D
- Hence,

$$\theta = \frac{AB}{OA} = \frac{d}{D}$$
$$d = D\,\theta$$

26. Explain the determination of distance of Moon from Earth using Parallax method.



- Diameter of Earth = AB
  Centre of Earth = C
  Stars = S_1 and S_2
  Moon = M
  Distance of Moon from Earth= MC
  Parallax angles between Stars and Moon = θ_1 and θ_2
  Total Parallax of the Moon subtended on Earth = ∠AMB = θ = $\theta_1 + \theta_2$
- Hence,

$$\theta = \frac{AB}{AM} = \frac{AB}{MC} \qquad [\because\ AB \approx MC]$$
$$\boldsymbol{MC} = \frac{\boldsymbol{AB}}{\boldsymbol{\theta}}$$
$$v = \frac{2\,D}{t}$$

27. One Light Year.

- It is the distance travelled by the light in vacuum in one year.
- 1 Light Year = $9.467 \text{ X } 10^{15}$ m

28. Define one astronomical unit (AU).

- It is the mean distance of the Earth from the Sun.
- 1 A.U = $1.496 \text{ X } 10^{11}$ m

29. Define one parsec (parallactic second)

- It is the distance at which an arc of length 1 A.U subtends an angle of 1 second of arc.
- 1 parsec = $3.08 \text{ X } 10^{16}$ m = 3.26 light years

30. Define Chandrasekar Limit (CSL)

- The Largest practical unit of mass is called Chandrasekar limit.
- 1 CSL = 1.4 times the mass of the Sun

31. Define Shake.

- The smallest practical unit of time is Shake.
- 1 Shake = 10^{-8} s

32. Define accuracy and precision with numerical example.

- Accuracy refers to how far we are from the true value
- Precision refers to how well we measure.

__Numerical example__ :

- Let the real temperature inside the refrigerator is 9°C
- Let first thermometer measures 10°C, 8°C, 12°C, 11°C, 7°C.
  Second thermometer measures 10.4°C, 10.3°C, 10.2°C, 10.2°C, 10.1°C
  Third thermometer measures 9.1°C, 9.2°C, 8.9°C, 9.1°C, 9.1°C
- First thermometer measurement is not accurate and not precise
  Second thermometer measurement is not accurate but precise
  Third thermometer measurement is accurate and precise

33. Write a note on absolute errors.

- The difference between the true value and the measured value of a quantity is called absolute error.
- If a_1, a_2, a_3, ……….a_n are the *measured values* of any quantity '*a*' in an experiment performed *n* times, then the arithmetic mean of these values is called the true value (a_m) of the quantity.

$$(i.e) \qquad true\ value \ ; \ a_m = \frac{a_1 + a_2 + a_3 + \cdots + a_n}{n} = \frac{1}{n}\sum_{i=1}^{n} a_i$$

- Then *the **absolute error*** in measured values is given by,

$$|\Delta a_1| = |a_m - a_1|$$
$$|\Delta a_2| = |a_m - a_2|$$
$$\ldots\ldots\ldots\ldots\ldots$$
$$\ldots\ldots\ldots\ldots\ldots$$
$$|\Delta a_n| = |a_m - a_n|$$

34. Define mean absolute error.

- The arithmetic mean of the magnitude of absolute errors in all the measurements is called the mean absolute error. (i.e.)

$$\boldsymbol{mean\ absolute\ error} \ ; \ \Delta a_m = \frac{|\Delta a_1| + |\Delta a_2| + |\Delta a_3| + \cdots + |\Delta a_n|}{n} = \frac{1}{n}\sum_{i=1}^{n}|\Delta a_i|$$

35. Define relative error.

- The ratio of the mean absolute error to the mean value (true value) is called relative error (or) fractional error.

$$\boldsymbol{Relative\ error} = \frac{Mean\ absolute\ error}{Mean\ value\ (true\ value)} = \frac{\Delta a_m}{a_m}$$

36. Define percentage error.

- The relative error expressed as a percentage is called percentage error.

$$\boldsymbol{percentage\ error} = \frac{\Delta a_m}{a_m}\ X\ 100\ \%$$

37. Define dimensional variables.

- Physical quantities which possess dimensions and have variable values are called dimensional variables.
  (e.g) length, velocity, acceleration etc.,

38. Define dimensionless variables

- Physical quantities which have no dimensions but have variable values are called dimensionless variables.
  (e.g) strain, specific gravity, refractive index etc

39. Define dimensional constants.

- Physical quantities which possess dimensions and have constant values are called dimensional constants.
  (e.g) Gravitational constant, Plank's constant etc.

40. Define dimensionless constants

- Physical quantities which have no dimensions but have constant values are called dimensionless constant.
  (e.g) numbers, π, e, etc.,

41. Explain the principle of homogeneity of dimensions.

- It states that the dimensions of all the terms in a physical expression should be the same.
- For example, consider the following expression $v^2 = u^2 + 2\,a\,S$
- By substituting the dimensions,

$$[\mathrm{L\,T^{-1}}]^2 = [\mathrm{L\,T^{-1}}]^2 + [\mathrm{L\,T^{-2}}][\mathrm{L}]$$
$$[\mathbf{L^2T^{-2}}] = [\mathbf{L^2T^{-2}}] + [\mathbf{L^2T^{-2}}]$$

- Thus the dimensions of terms in both LHS and RHS are same and equal. This is called principle of homogeneity of dimensions,

42. Give the applications of the method of dimensional analysis.

- To convert a physical quantity from one system of units to another.
- To check the dimensional correctness of a given physical equation.
- To establish the relation among various physical quantities.

43. Give the limitations of dimensional analysis.

- This method gives no information about the dimensional constants in the formula like numbers, π, e, etc
- This method cannot decide, whether the given quantity is a vector or scalar.
- This method is not suitable to derive relations involving trigonometric, exponential, logarithmic functions.

PART - IV 5 MARK LONG ANSWER QUESTIONS & ANSWERS

1. Discuss how physics being a fundamental science has played a vital role in the development of all other sciences?

(i) <u>Physics in relation to Chemistry</u> :
- In physics we study the structure of atom, radioactivity, X-ray diffraction etc.
- Such studies have enabled researchers in chemistry to ***arrange elements in the periodic table*** on the basis of their atomic numbers.
- This has further helped to know the nature of valency, chemical bonding and to understand the complex chemical structures.

(ii) <u>Physics in relation to biology</u>:
- Biological studies are impossible without a microscope designed using physics principles.
- The invention of the electron microscope has made it possible to see even the structure of a cell.
- X-ray and neutron diffraction techniques have helped us to understand the structure of nucleic acids, which help to control vital life processes.
- X-rays are used for diagnostic purposes. Radio-isotopes are used in radiotherapy for the cure of cancer and other diseases.
- In recent years, biological processes are being studied from the physics point of view.

(iii) <u>Physics in relation to mathematics</u>:
- Physics is a quantitative science. It is most closely related to mathematics as a tool for its development.

(iv) <u>Physics in relation to astronomy</u>:
- Astronomical telescopes are used to study the motion of planets and other heavenly bodies in the sky.
- Radio telescopes have enabled the astronomers to observe distant points of the universe. Studies of the universe are done using physical principles.

(v) <u>Physics in relation to geology</u>:
- Diffraction techniques help to study the crystal structure of various rocks.
- Radioactivity is used to estimate the age of rocks, fossils and the age of the Earth.

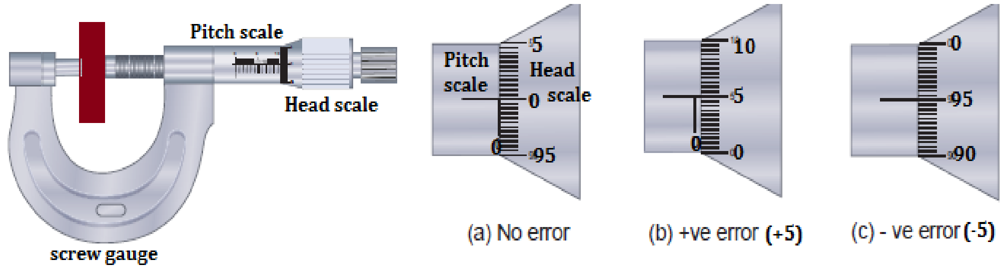
(vi) <u>Physics in relation to oceanography</u>:
- Oceanographers seek to understand the physical and chemical processes of the oceans. They measure parameters such as temperature, salinity, current speed, gas fluxes, chemical components.

(vii) <u>Physics in relation to psychology</u>:
- All psychological interactions can be derived from a physical process.
- The movements of neurotransmitters are governed by the physical properties of diffusion and molecular motion.
- The functioning of our brain is related to our underlying wave-particle dualism.

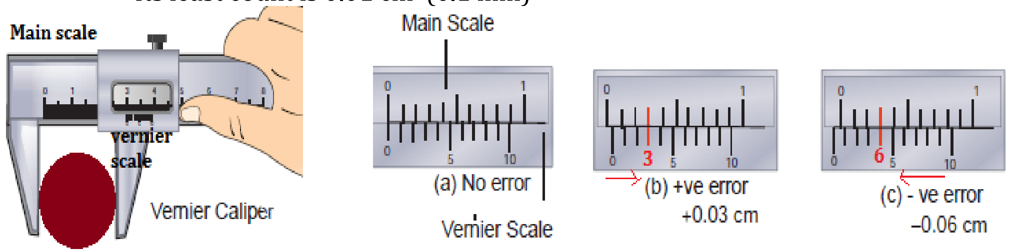
2. Explain the use of screw gauge and vernier caliper in measuring smaller distances.

<u>Measurement of small distances</u> :

(i) <u>Screw gauge</u> :
- It is an instrument used for measuring accurately the dimensions of objects up to a maximum of about 50 mm
- Magnification of linear motion using circular motion of a screw is the principle involved in this instrument.
- Its least count is 0.01 mm



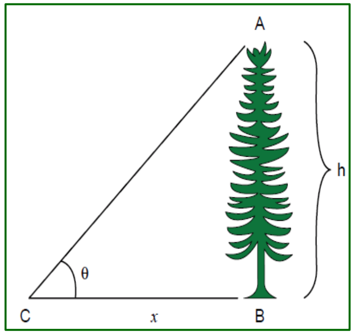
(ii) <u>Vernier caliper</u> :
- It is a versatile instrument used to measuring dimensions such that diameter of a hole or depth of a hole.
- Its least count is 0.01 cm (0.1 mm)



3. Write a note on triangulation method and radar method to measure larger distances.

<u>Measuring larger distances</u> :

(i) **<u>Triangulation method</u>** :



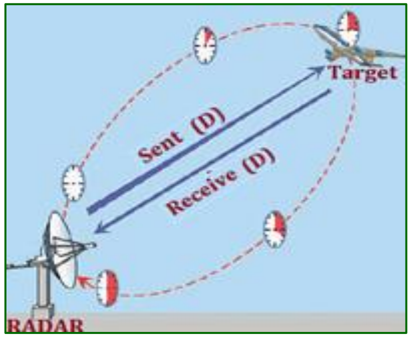
- Point of observation of tree = C
- Height of tree or tower = AB = h
  Distance of tree from C = BC = x
  Angle of elevation of tree = $\angle ACB = \theta$
- In ΔABC,

$$\tan\theta = \frac{AB}{BC} = \frac{h}{x}$$

$$(or) \quad \boldsymbol{h = x \tan\theta}$$

- Knowing the distane 'x', the height (h) of the tree or tower can be determined.

(ii) **Radar method** :



- The word RADAR stands for RAdio Detection And Ranging.
- In this method, radio waves are sent from transmitters which reflected by distant object (planets) are detected by receiver.
- By measuring the time interval (t) between sent and received instants the distance of the planet is determined. Here,

  Speed of radio waves = Distance travelled/ time interval

$$v = \frac{2D}{t}$$

- Thus, the distance of the object (target)

$$D = \frac{v \times t}{2}$$

where, $v = 3 \times 10^8\ \mathrm{m\,s^{-1}} \rightarrow$ *Speed of the radio waves*

$t \rightarrow$ *time taken* by the radiowaves to covering the distance during the forward and backward path

4. Explain in detail the various types of errors.

Errors :

- The uncertainty in a measurement is called an error.
- Random error, systematic error and gross error are the three possible errors.

1. **Systematic errors :**
   - Systematic errors are reproducible inaccuracies that are consistently in the same direction.
   - These occur often due to a problem that persists throughout the experiment.

     Systematic errors can be classified as follows

     (a) Instrumental errors
     (b) Imperfections in experimental technique or procedure
     (c) Personal errors
     (d) Errors due to external causes
     (f) Least count errors
   - Systematic errors are difficult to detect and cannot be analysed statistically, because all of the data is in the same direction. (Either too high or too low)
2. **Random errors :**
   - Random errors may arise due to random and unpredictable variations in experimental conditions like pressure, temperature, voltage supply etc.
   - Errors may also be due to personal errors by the observer who performs the experiment.
   - Random errors are sometimes called **"chance error"**.
   - Random errors can be evaluated through statistical analysis and can be reduced by averaging over a large number of observations.
3. **Gross Error :**
   - Gross error is caused due to the shear carelessness of an observer. (i.e.)
     (a) Reading an instrument without setting it properly.
     (b) Taking observations in a wrong manner without bothering about the sources of errors and the precautions.
     (c) Recording wrong observations.
     (d) Using wrong values of the observations in calculations.
   - These errors can be minimized only when an observer is careful and mentally alert.

5. What do you mean by propagation of errors? Explain the propagation of errors in (i)addition, (ii) subtraction, (iii) multiplication, (iv) division and (v) power.

Propagation of errors:

- The method of transferring errors from individual observation in to final result through series of calculations is called propagation of errors.
- The error in the final result depends on

  (1) The errors in the individual measurements
  (2) On the nature of mathematical operations performed to get the final result.

Propagation of errors in addition (Errors in the sum of two quantities) :

- Absolute Error in quantity A = ΔA

  Absolute Error in quantity B = ΔB
- Measured value of A = $A \pm \Delta A$

  Measured value of B = $B \pm \Delta B$
- Consider the sum ; $Z = A + B$
- Let ΔZ be the error in Z, then

$$Z \pm \Delta Z = (A \pm \Delta A) + (B \pm \Delta B)$$
$$= (A + B) \pm (\Delta A + \Delta B)$$
$$Z \pm \Delta Z = Z \pm (\Delta A + \Delta B)$$

(or) $\quad \mathbf{\Delta Z = \Delta A + \Delta B}$

- *The maximum possible error in the sum of two quantities is equal to the sum of the absolute errors in the individual quantities*.

Propagation of errors in subtraction (Errors in the difference of two quantities):

- Absolute Error in quantity A = ΔA

  Absolute Error in quantity B = ΔB
- Measured value of A = $A \pm \Delta A$

  Measured value of B = $B \pm \Delta B$
- Consider the difference ; $Z = A - B$
- Let ΔZ be the error in Z, then

$$Z \pm \Delta Z = (A \pm \Delta A) - (B \pm \Delta B)$$
$$= (A - B) \pm (\Delta A + \Delta B)$$
$$Z \pm \Delta Z = Z \pm (\Delta A + \Delta B)$$

(or) $\quad \mathbf{\Delta Z = \Delta A + \Delta B}$

- *The maximum possible error in the sum of two quantities is equal to the sum of the absolute errors in the individual quantities*.

<u>Propagation errors in multiplication</u> (Errors in the product of two quantities) :

- Error in A = ΔA
  Error in B = ΔB
- Measured value of A = $A \pm \Delta A$
  Measured value of B = $B \pm \Delta B$
- Consider the product ; $Z = AB$
- Let ΔZ be the error in Z, then

$$Z \pm \Delta Z = (A \pm \Delta A)(B \pm \Delta B)$$
$$Z \pm \Delta Z = AB \pm (A\,\Delta B) \pm (B\,\Delta A) \pm (\Delta A\,\Delta B)$$

- Divide by Z (= A B) on both sides,

$$1 \pm \frac{\Delta Z}{Z} = 1 \pm \frac{\Delta B}{B} \pm \frac{\Delta A}{A} \pm \frac{\Delta A}{A}\frac{\Delta B}{B} \qquad \left[\because \frac{\Delta A}{A}\frac{\Delta B}{B} \approx 0\right]$$
$$\therefore \quad 1 \pm \frac{\Delta Z}{Z} = 1 \pm \frac{\Delta B}{B} \pm \frac{\Delta A}{A}$$
$$(or) \qquad \boldsymbol{\frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}}$$

- *The maximum fractional error in the product of two quantities is equal to the sum of the fractional errors in the individual quantities*.

<u>Propagation errors in division or quotient</u> (Errors in the division of two quantities) :

- Error in A = ΔA
  Error in B = ΔB
- Measured value of A = $A \pm \Delta A$
  Measured value of B = $B \pm \Delta B$
- Consider the product ; $Z = \frac{A}{B}$
- Let ΔZ be the error in Z, then

$$Z \pm \Delta Z = \frac{(A \pm \Delta A)}{(B \pm \Delta B)} = \frac{A\left(1 \pm \frac{\Delta A}{A}\right)}{B\left(1 \pm \frac{\Delta B}{B}\right)} = \frac{A}{B}\left(1 \pm \frac{\Delta A}{A}\right)\left(1 \pm \frac{\Delta B}{B}\right)^{-1}$$
$$Z \pm \Delta Z = Z\left(1 \pm \frac{\Delta A}{A}\right)\left(1 \mp \frac{\Delta B}{B}\right) \qquad [\because (1+x)^{-n}] \approx (1-nx)]$$

- Divide by Z on both sides,

$$1 \pm \frac{\Delta Z}{Z} = 1 \pm \frac{\Delta A}{A} \mp \frac{\Delta B}{B} \mp \frac{\Delta A}{A}\frac{\Delta B}{B} \qquad \left[\because \frac{\Delta A}{A}\frac{\Delta B}{B} \approx 0\right]$$
$$\therefore \qquad \boldsymbol{\frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}}$$

- *The maximum fractional error in the division (quotient) of two quantities is equal to the sum of the fractional errors in the individual quantities*.

<u>Propagation of errors in powers</u> (Errors in the power of a quantity) :

- Error in A = ΔA
- Measured value of A = $A \pm \Delta A$
- Consider the power ; $Z = A^n$
- Let ΔZ be the error in Z, then,

$$Z \pm \Delta Z = (A \pm \Delta A)^n = A^n\left(1 \pm \frac{\Delta A}{A}\right)^n$$
$$Z \pm \Delta Z = Z\left(1 \pm n\frac{\Delta A}{A}\right) \qquad [\because (1+x)^n] \approx (1+nx)]$$

- Divide by Z on both sides,

$$1 \pm \frac{\Delta Z}{Z} = 1 \pm n\frac{\Delta A}{A}$$
$$(or) \qquad \boldsymbol{\frac{\Delta Z}{Z} = n\frac{\Delta A}{A}}$$

- *The fractional error in the n^{th} power of a quantity is n times the fractional error in that quantity*.

6. What are the rules for counting significant figures?

<u>Significant figure</u> :

- It is defined as the **number of meaningful digits which contain numbers that are known reliably and first uncertain number**.

<u>Rules for counting significant figures</u> :

- All non zero digits are significant
  (e.g.) 2345 has 4 significant figure
- All zeros between two non zero digits are significant
  (e.g.) 2005 has 4 significant figure
- If the number without a decimal point, the trailing zeros are not significant
  (e.g.) 23400 has 3 significant figure
- If the number with a decimal point, all the zeros to the left of the decimal point are significant
  (e.g.) 23400. has 5 significant figure
- All the zeros are significant if they come from a measurement
  (e.g.) 23400 m has 5 significant figure
- All zeros to the right of the decimal point are also significant
  (e.g.) 23400.00 has 7 significant figure
- If the number less than 1, the zeros between the right of the decimal point and left of the first non zero digit are not significant
  (e.g)0.00023040 has 5 significant figure
- The power of 10 is irrelevant to the determination of significant figure.
  (e.g.) 2.40 m =2.40 X 10^2 cm = 2.40 X 10^3mm all has 3 significant figure

7. What is the need for rounding off a number? What are the rules for rounding off the number?

Rounding - off :

- Calculations are easily done by calculators and the result given by a calculator has too many figures.
- In no case should the result have more significant figures than the figures involved in the data used for calculation.
- The result of calculation with numbers containing more than one uncertain digit must be dropped and this is called rounding off.

Rules for rounding off the number :

- If the digit to be dropped is smaller than 5, then preceding digit left unchanged (e.g.) 2.43 is rounded off to 2.4
- If the digit to be dropped is greater than 5, then preceding digit should be increased by 1 (e.g.) 2.76 is rounded off to 2.8
- If the digit to be dropped is 5, which is followed by non zero digits, then preceding digit should be raised by 1
  (e.g.) 6.352 is rounded off to 6.4 and 6.659 is rounded off to 6.7
- If the digit to be dropped is 5 or 5 followed by zeros, then the preceding digit is not changed if it is even
  (e.g.) 6.45 is rounded off to 6.4 and 6.250 is rounded off to 6.2
- If the digit to be dropped is 5 or 5 followed by zeros, then the preceding digit is raised by 1, if it is odd
  (e.g.) 6.35 is rounded off to 6.4 and 6.750 is rounded off to 6.8

8. Discuss the arithmetical operations with significant figures and give examples.

(i) Addition and subtraction :

- In addition and subtraction, the final result should retain as many decimal places as there are in the number with the smallest number of decimal places.

  Examples :

  1) $3.1 + 1.780 + 2.046 = 6.926 \Longrightarrow 6.9$
  2) $5.67 + 12.498 + 1.2 = 19.368 \Longrightarrow 12.4$
  3) $12.637 - 2.42 = 10.217 \Longrightarrow 10.22$
  4) $15.650 - 12.4 = 3.250 \Longrightarrow 3.2$

(ii) Multiplication and Division :

- In multiplication or division, the final result should retain as many significant figures as there are in the original number with smallest number of significant figures.

  Examples :

  1) $1.21\ X\ 36.72 = 44.4312 \Longrightarrow \mathbf{44.4}$
  2) $3.14\ X\ 3.1 = 9.734 \Longrightarrow \mathbf{9.7}$
  3) $36.72 \div 1.2 = 30.6 \Longrightarrow \mathbf{31}$
  4) $560.6 \div 60.5 = 9.2661157 \Longrightarrow \mathbf{9.27}$

EXAMPLE PROBLEMS WITH SOLUTION

1. **From a point on the ground, the top of a tree is seen to have an angle of elevation 60°. The distance between the tree and a point is 50 m. Calculate the height of the tree?**

Solution : $\theta = 60°$, $x = 50\ m$, $h = ?$

$$h = x \tan\theta = 50 \tan 60° = 50\ X\ \sqrt{3} = 50\ X\ 1.732$$

$$\boldsymbol{h = 86.6\ m}$$

2. **The Moon subtends an angle of 1° 55′ at the base line equal to the diameter of the Earth. What is the distance of the Moon from the Earth? (Radius of the Earth is $6.4 \times 10^6 m$)**

Solution : $\theta = 1°55' = 115' = 115\ X\ 2.91\ X\ 10^{-4}$ rad ;

$$b = 2\,r = 2\ X\ 6.4\ X\ 10^6\ m \quad ; \quad x = ?$$

$$x = \frac{b}{\theta} = \frac{2\ X\ 6.4\ X\ 10^6}{115\ X\ 2.91\ X\ 10^{-4}} = \frac{12.8\ X\ 10^{10}}{334.65}$$

$$x = 3.826\ X\ 10^{-2}\ X\ 10^{10} = \boldsymbol{3.83\ X\ 10^8\ m}$$

no	log
12.8	1.1072
334.6	2.5244
(-)	$\bar{2}.5828$
ALog =	$3.826\ X\ 10^{-2}$

3. **A RADAR signal is beamed towards a planet and its echo is received 7 minutes later. If the distance between the planet and the Earth is 6.3×10^{10} m. Calculate the speed of the signal?**

Solution : : $d = 6.3\ X\ 10^{10} m$, $t = 7min = 7\ X\ 60 = 420\ s$, $v = ?$

$$v = \frac{2\,d}{t} = \frac{2\ X\ 6.3\ X\ 10^{10}}{420} = \frac{12.6\ X\ 10^{10}}{420}$$

$$v = 3\ X\ 10^{-2}\ X\ 10^{10}\ m\ s^{-1}$$

$$\boldsymbol{v = 3\ X\ 10^8\ m\ s^{-1}}$$

no	log
12.6	1.1004
420	2.6232
(-)	$\bar{2}.4772$
ALog =	$3.000\ X\ 10^{-2}$

4. **In a series of successive measurements in an experiment, the readings of the period of oscillation of a simple pendulum were found to be 2.63s, 2.56 s, 2.42s, 2.71s and 2.80s. Calculate (i) the mean value of the period of oscillation (ii) the absolute error in each measurement (iii) the mean absolute error (iv) the relative error (v) the percentage error. Express the result in proper form.**

Solution : $T_1 = 2.63\ s$, $T_2 = 2.56\ s$, $T_3 = 2.42\ s$, $T_4 = 2.71\ s$, $T_5 = 2.80\ s$

(i) The mean value of the period of oscillation),

$$T_m = \frac{T_1 + T_2 + T_3 + T_4 + T_5}{5} = \frac{2.63 + 2.56 + 2.42 + 2.71 + 2.80}{5}$$

$$T_m = \frac{13.12}{5} = 2.624\ s$$

$$\boldsymbol{T_m = 2.62\ s}$$

(ii) The absolute error in each measurement,

$$\Delta T_1 = T_m - T_1 = 2.62 - 2.63 = -0.01\ s$$
$$\Delta T_2 = T_m - T_2 = 2.62 - 2.56 = +0.06\ s$$
$$\Delta T_3 = T_m - T_3 = 2.62 - 2.42 = +0.20\ s$$
$$\Delta T_4 = T_m - T_4 = 2.62 - 2.71 = -0.09\ s$$
$$\Delta T_1 = T_m - T_1 = 2.62 - 2.63 = -0.01\ s$$

(iii) The mean absolute error,

$$\Delta T_m = \frac{1}{n}\sum_{i=1}^{n}|T_i| = \frac{1}{5}\,(0.01 + 0.06 + 0.20 + 0.09 + 0.01) = \frac{0.54}{5}$$

$$\Delta T_m = 0.108\ s$$

$$\boldsymbol{\Delta T_m = 0.11\ s}$$

(iv) The relative error,

$$S_T = \frac{\Delta T_m}{T_m} = \frac{0.11}{2.62} = 4.198\ X\ 10^{-2} = 0.04198$$

$$\boldsymbol{S_T = 0.04}$$

no	log
0.11	$\bar{1}.0414$
2.62	0.4183
(-)	$\bar{2}.6231$
ALog =	$4.198\ X\ 10^{-2}$

(v) The percentage error $= 0.04\ X\ 100\ \% = \mathbf{4}\ \%$

Hence the period of oscillation of simple pendulum : $\boldsymbol{T} = (\mathbf{2.62} \pm \mathbf{4}\ \%)\ \boldsymbol{s}$

5. **Two resistances $R_1 = (100 \pm 3)\ \Omega$ and $R_2 = (150 \pm 2)\ \Omega$ are connected in series. What is their equivalent resistance?**

Solution : In series connection, the equivalent resistance

$$R = R_1 + R_2$$
$$= (100 \pm 3) + (150 \pm 2)$$
$$= (100 + 150) \pm (3 + 2)$$
$$\mathbf{R} = (\mathbf{250 \pm 5})\boldsymbol{\Omega}$$

6. **The temperatures of two bodies measured by a thermometer are $t_1 = (20 + 0.5)°C$, $t_2 = (50 \pm 0.5)°C$. Calculate the temperature difference and the error therein.**

Solution : The temperature difference ,

$$t = t_2 - t_1$$
$$= (50 \pm 0.5) - (20 \pm 0.5)$$
$$= (50 - 20) \pm (0.5 + 0.5)$$
$$\mathbf{t} = (\mathbf{30 \pm 1})\ \mathbf{°C}$$

7. **The length and breadth of a rectangle are (5.7 ± 01.) cm and (3.4 ± 02.) cm respectively. Calculate the area of the rectangle with error limits.**

Solution : $l \pm \Delta l = (5.7 \pm 0.1)$ cm ; $b \pm \Delta b = (3.4 \pm 0.2)$ cm

The area of rectangle : $A = l\ X\ b = 5.7\ X\ 3.4 = 19.38\ cm^2 \approx 19.4\ cm^2$

$$\frac{\Delta A}{A} = \left[\frac{\Delta l}{l} + \frac{\Delta b}{b}\right]$$

$$\Delta A = \left[\frac{\Delta l}{l} + \frac{\Delta b}{b}\right] A$$

$$\Delta A = \left[\frac{0.1}{5.7} + \frac{0.2}{3.4}\right] X\ 19.38 = \left[\frac{0.34 + 1.14}{19.38}\right] X\ 19.38$$

$$\Delta A = 1.48 \approx 1.5$$

Hence area with error limits : $\boldsymbol{A \pm \Delta A} = (\mathbf{19.4 \pm 1.5})\ \boldsymbol{cm^2}$

8. **The voltage across a wire is (100 ± 5)V and the current passing through it is (10±0.2) A. Find the resistance of the wire.**

Solution : $V \pm \Delta V = (100 \pm 5)$ V ; $I \pm \Delta I = (10 \pm 0.2)$ A

By Ohm's law,resistance ;

$$R = \frac{V}{I} = \frac{100}{10} = 10\ \Omega$$

The maximum fractional error is

$$\frac{\Delta R}{R} = \left[\frac{\Delta V}{V} + \frac{\Delta I}{I}\right]$$

$$\Delta R = \left[\frac{\Delta V}{V} + \frac{\Delta I}{I}\right] R = \left[\frac{5}{100} + \frac{0.2}{10}\right] X\, 10 = \left[\frac{50+20}{1000}\right] X\, 10$$

$$\Delta R = \frac{700}{1000} = \frac{7}{10} = 0.7$$

Hence resistance with error limits : $\boldsymbol{R \pm \Delta R = (10 \pm 0.7)\,\Omega}$

9. A physical quantity x *is* given by $x = \frac{a^2 b^3}{c\sqrt{d}}$. If the percentage errors of measurement in a, b, c and d are 4%, 2%, 3% and 1% respectively, then calculate the percentage error in the calculation of *x*.

Solution : The given expression, $\boldsymbol{x = \frac{a^2 b^3}{c\sqrt{d}}}$

Then the percentage error will be,

$$\frac{\Delta x}{x} X100 = \left(2\frac{\Delta a}{a} X100\right) + \left(3\frac{\Delta b}{b}\, X100\right) + \left(\frac{\Delta c}{c} X100\right) + \left(\frac{1}{2}\frac{\Delta d}{d}\, X100\right)$$

$$= (2\, X\, 4\%) + (3\, X\, 2\%) + (1\, X\, 3\%) + \left(\frac{1}{2}\, X\, 1\%\right)$$

$$= 8\% + 6\% + 3\% + 0.5\% = 17.5\,\%$$

Percentage error in the calculation of $x = 17.5$ %

10. State the number of significant figures in the following

(1) 600800 (2) 400 (3)0.007 (4)5213.0
(5) 2.65 X 10^{24} m (6) 0.0006032 (7)40.00 (8) 30700 m

Solution :

(1) 600800 - significant figure **= 4**
(2) 400 - significant figure **= 1**
(3) 0.007 - significant figure **= 1**
(4) 5213.0 - significant figure **= 5**
(5) 2.65 X 10^{24} m - significant figure **= 3**
(6) 0.0006032 - significant figure **= 4**
(7) 40.00 - significant figure **= 4**
(8) 30700 m - significant figure **= 5**

11. Round off the following numbers as indicated

(1) 18.35 up to 3 digits (2) 19.45 up to 3 digits
(3) 101.55X10^6 up to 4 digits (4) 248337 up to 3 digits
(5) 12.653 up to 3 digits

Solution :

(1) 18.35 up to 3 digits **– 18.4**
(2) 19.45 up to 3 digits **– 19.4**
(3) 101.55 X10^6 up to 4 digits **– 101.6 X10^6**
(4) 248337 up to 3 digits **– 248000**
(5) 12.653 up to 3 digits **– 12.7**

12. Convert 76 cm of mercury pressure into Nm^{-2} using the method of dimensions.

Solution : In CGS system, 76 cm of mercury pressure

$$P_1 = h\,\rho\, g = 76\, X\, 13.6\, X\, 980\; dynes\; cm^{-1}$$

In S I system, $P_2 = ?$

The dimensional formula of pressure ; $[M^a L^b L^c] = [ML^{-1}T^{-2}]$

Hence, $a = 1, \quad b = -1, \quad c = -2$

$$We\ have, \quad P_1[M_1^a\, L_1^b\, T_1^c] = P_2\,[M_2^a\, L_2^b\, T_2^c]$$

$$P_2 = P_1 \left[\frac{M_1}{M_2}\right]^a \left[\frac{L_1}{L_2}\right]^b \left[\frac{T_1}{T_2}\right]^c$$

$$P_2 = 76\, X\, 13.6\, X\, 980\, X \left[\frac{1\, g}{1\, kg}\right]^1 \left[\frac{1\, cm}{1\, m}\right]^{-1} \left[\frac{1\, s}{1\, s}\right]^{-2}$$

$$= 1.013\, X\, 10^6 \left[\frac{1\, g}{1000\, g}\right]^1 \left[\frac{1\, cm}{100\, cm}\right]^{-1} [1]^{-2}$$

$$= 1.013\, X\, 10^6\, X\, [10^{-3}]^1\, [10^{-2}]^{-1}$$

$$= 1.013\, X\, 10^6 X\, 10^{-3}\, X\, 10^2$$

$$\boldsymbol{P_2 = 1.013\, X\, 10^5\; N\, m^{-2}}$$

13. If the value of universal gravitational constant in SI is 6.6x10^{-11} Nm2 kg^{-2}, then find its value in CGS System?

Solution : In S I system, G_{SI} = 6.6 X 10^{-11} N m^2 kg^{-2} ; In CGS system, G_{CGS} = ?

Dimensional formula of gravitational constant ; $[M^a L^b L^c] = [M^{-1} L^3\, T^{-2}]$

Hence, $a = -1, \; b = 3, \; c = -2$

$$we\ have, \quad G_{SI}[M_1^a\, L_1^b\, T_1^c] = G_{CGS}\,[M_2^a\, L_2^b\, T_2^c]$$

$$G_{CGS} = G_{SI} \left[\frac{M_1}{M_2}\right]^a \left[\frac{L_1}{L_2}\right]^b \left[\frac{T_1}{T_2}\right]^c$$

$$G_{CGS} = 6.6\, X\, 10^{-11} X \left[\frac{1\, kg}{1\, g}\right]^{-1} \left[\frac{1\, m}{1\, cm}\right]^3 \left[\frac{1\, s}{1\, s}\right]^{-2}$$

$$= 6.6\, X\, 10^{-11} X \left[\frac{1000\, g}{1\, g}\right]^{-1} \left[\frac{100\, cm}{1\, cm}\right]^3 [1]^{-2}$$

$$= 6.6\, X\, 10^{-11} X\; [10^3]^{-1}\, [10^2]^3$$

$$= 6.6\, X\, 10^{-11} X\, 10^{-3}\, X\, 10^6$$

$$\boldsymbol{G_{CGS} = 6.6\, X\, 10^{-8}\; dyne\; cm^2\; g^{-2}}$$

14. Check the correctness of the equation $\boldsymbol{\frac{1}{2} m\, v^2 = m\, g\, h}$ using dimensional analysis method.

Solution :

$Dimension\ for\ m = [M]$; $Dimension\ for\ v = [L\, T^{-1}]$
$Dimension\ for\ g = [L\, T^{-2}]$; $Dimension\ for\ h = [L]$

Put these dimensional formula in the given equation,

$$\frac{1}{2} m\, v^2 = m\, g\, h$$

$$[M]\,[L\,T^{-1}]^2 = [M]\,[L\,T^{-2}]\,[L]$$

$$[M\,L^2\,T^{-2}] = [M\,L^2\,T^{-2}]$$

Both sides are dimensionally the same, hence the given equation is dimensionally correct.

15. Obtain an expression for the time period T of a simple pendulum. The time period T depends on (i) mass '*m*' of the bob (ii) length '*l*' of the pendulum and (iii) acceleration due to gravity *g* at the place where the pendulum is suspended. (Constant k = 2π)

Solution :

$$T \propto m^a\, l^b\, g^c$$

$$T = K\ m^a\, l^b\, g^c \quad - - - - - - - - (1)$$

$Dimension\ of\ T = [T]$

$Dimension\ of\ m = [M]$

$Dimension\ of\ l = [L]$

$Dimension\ of\ g = [L\,T^{-2}]$

Put these dimensional formula in equation (1)

$$[T] = K\,[M]^a\,[L]^b\,[L\,T^{-2}]^c$$

$$[M^0\,L^0\,T^1] = K\,[M^a\,L^{b+c}\,T^{-2c}]$$

Compare the powers of M, L and T on both sides,we get,

a = 0 ; b + c = 0 ; -2 c = 1

b = - c ; $c = -\frac{1}{2}$

$b = \frac{1}{2}$

Pput the values of a, b and c in equation (1)

$$T = K\ m^0\, l^{\frac{1}{2}}\, g^{-\frac{1}{2}}$$

$$T = K\,\frac{l^{\frac{1}{2}}}{g^{\frac{1}{2}}} = K\left[\frac{l}{g}\right]^{\frac{1}{2}} = K\sqrt{\frac{l}{g}}$$

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

EXERCISE PROBLEMS WITH SOLUTION

1. In a submarine equipped with sonar, the time delay between the generation of a pulse and its echo after reflection from an enemy submarine is observed to be 80 s. If the speed of sound in water is 1460 ms^{-1}. What is the distance of enemy submarine?

Solution : t = 80 s ; $v = 1460\ m\,s^{-1}$; D = ?

$$D = \frac{v\,t}{2} = \frac{1460\ X\ 80}{2} = 1460\ X\ 40$$

$$\boldsymbol{D = 58400\ m = 58.4\ km}$$

2. The radius of the circle is 3.12 m. Calculate the area of the circle with regard to significant figures.

Solution : r = 3.12 m ; A = ?

$$A = \pi\, r^2 = 3.14\ X\ 3.12\ X\ 3.12$$

A = 30.57 m^2

A = 30.6 m^2 (rounding off with significant figure 3)

no	log
3.14	0.4969
3.12	0.4942
3.12	0.4942
(+)	1. 48 53
ALog	3.057 X 10^1

3. Assuming that the frequency v of a vibrating string may depend upon i) applied force (F) ii) length (l) iii) mass per unit length (m), prove that $\boldsymbol{v \propto \frac{1}{l}\sqrt{\frac{F}{m}}}$ using dimensional analysis.

Solution : Given that

$$v \propto l^a\, F^b\, m^c \quad - - - - - - - - (1)$$

$Dimension\ of\ v = [T - 1]$; $Dimension\ of\ l = [L]$

$Dimension\ of\ F = [M\,L\,T^{-2}]$; $Dimension\ of\ m = [M\,L^{-1}]$

Put these dimensional formula in equation (1)

$$[T^{-1}] \propto [L]^a\,[M\,L\,T^{-2}]^b\,[M\,L^{-1}]^c$$

$$[M^0\,L^0\,T^{-1}] \propto [M^{b+c}\,L^{a+b-c}\,T^{-2b}]$$

Compare the powers of M ,L and T on both sides,we get,

b + c = 0 ; a + b -c = 0 ; - 2 b = -1

c = -b ; a +b +b= 0 ; $b = \frac{1}{2}$

$c = -\frac{1}{2}$; $a + 2\left[\frac{1}{2}\right] = 0$

a = -1

Put the values of a, b and c in equation (1)

$$v \propto l^{-1}\, F^{\frac{1}{2}}\, m^{-\frac{1}{2}}$$

$$v \propto \frac{F^{\frac{1}{2}}}{l\, m^{\frac{1}{2}}} = \frac{1}{l}\left[\frac{F}{m}\right]^{\frac{1}{2}}$$

$$\boldsymbol{v \propto \frac{1}{l}\sqrt{\frac{F}{m}}}$$

4. Jupiter is at a distance of 824.7 million km from the Earth. Its angular diameter is measured to be 35.72″. Calculate the diameter of Jupiter.

Solution : x = 824.7 million km = 824.7 X 10^6 X 10^3 m ;

θ = 35.72″ = 35.72 X 4.85 X 10^{-6} rad; b = ?

$$x = \frac{b}{\theta}$$

$$(or) \quad b = x\,\theta$$

$$= 824.7\ X\ 10^9\ X\ 35.72\ X\ 4.85\ X\ 10^{-6}$$

$$= 1.428\ X\ 10^5\ X\ 10^3\ m$$

$$\boldsymbol{b = 1.428\ X\ 10^5\ km}$$

no	log
824.7	2.9163
35.72	1.5529
4.85	0.6857
(+)	5.1549
ALog	1.428 X 10^5

5. The measurement value of length of a simple pendulum is 20 cm known with 2 mm accuracy. The time for 50 oscillations was measured to be 40 s within 1 s resolution. Calculate the percentage accuracy in the determination of acceleration due to gravity 'g' from the above measurement.

Solution: : $l = 20\ cm = 200\ mm; \quad \Delta l = 2\ mm$

$$50\,T = 40\ s \quad (or)\ T = \frac{40}{50} = 0.8\ s;$$

$$50\,\Delta T = 1\ s\ \ (or)\ \Delta T = \frac{1}{50} = 0.02\ s$$

$$T = 2\,\pi\sqrt{\frac{l}{g}} \quad (or)\ T^2 = 4\,\pi^2\,\frac{l}{g}$$

$$\therefore \quad g = 4\,\pi^2\,\frac{l}{T^2} \quad (or) \quad g \propto \frac{l}{T^2}$$

- Hence thr percentage accuracy ,

$$\frac{\Delta g}{g} X100\% = \left[\frac{\Delta l}{l} + 2\,\frac{\Delta T}{T}\right] X100\ \%$$

$$= \left[\frac{2}{200} + 2\,X\,\frac{0.02}{0.8}\right] X\ 100\ \%$$

$$= \left[\frac{1}{100} + \frac{2}{40}\right] X\ 100\ \%$$

$$\boldsymbol{\frac{\Delta g}{g} X100\%} = \boldsymbol{\frac{240}{4000}\ X\ 100}\ \% = \boldsymbol{6}\ \%$$

Exam No | | | | | | | |

UNIT - 1 NATURE OF PHYSICAL WORLD AND MEASUREMENT

Time - 2 : 30 hours Total - 60 marks

PART - I

15 X 1 = 15

Note : (i) Answer all the questions

(ii) Choose the best answer and write the option code andcorresponding answer

1. One of the combinations from the fundamental physical constants is hc/G. The unit of this expression is

(a) kg^2 (b) m^3

(c) s^{-1} (d) m

2. If the error in the measurement of radius is 2%, then the error in the determination of volume of the sphere will be

(a) 8% (b) 2%

(c) 4% (d) 6%

3. If the length and time period of an oscillating pendulum have errors of 1% and 3% respectively then the error in measurement of acceleration due to gravity is

(a) 4% (b) 5%

(c) 6% (d) 7%

4. The length of a body is measured as 3.51 m, if the accuracy is 0.01m, then the percentage error in the measurement is

(a) 351% (b) 1%

(c) 0.28% (d) 0.035%

5. Which of the following has the highest number of significant figures?

(a) 0.007 m^2 (b) 2.64×10^{24} kg

(c) 0.0006032 m^2 (d) 6.3200 J

6. If π = 3.14, then the value of π^2 is

(a) 9.8596 (b) 9.860

(c) 9.86 (d) 9.9

7. Which of the following pairs of physical quantities have same dimension?

(a) force and power (b) torque and energy

(c) torque and power (d) force and torque

8. The dimensional formula of Planck's constant h is

(a) $[ML^2T^{-1}]$ (b) $[ML^2T^{-3}]$

(c) $[MLT^{-1}]$ (d) $[ML^3T^{-3}]$

9. The velocity of a particle v at an instant t is given by $v = at + bt^2$. The dimensions of b is

(a) [L] (b) $[LT^{-1}]$

(c) $[LT^{-2}]$ (d) $[LT^{-3}]$

10. The dimensional formula for gravitational constant G is

(a) $[ML^3T^{-2}]$ (b) $[M^{-1}L^3T^{-2}]$

(c) $[M^{-1}L^{-3}T^{-2}]$ (d) $[ML^{-3}T^2]$

11. The density of a material in CGS system of units is 4 g cm^{-3}. In a system of units in which unit of length is 10 cm and unit of mass is 100 g, then the value of density of material will be

(a) 0.04 (b) 0.4

(c) 40 (d) 400

12. If the force is proportional to square of velocity, then the dimension of proportionality constant is

(a) $[MLT^0]$ (b) $[MLT^{-1}]$

(c) $[ML^{-2}T]$ (d) $[ML^{-1}T^0]$

13. The dimension of $(\mu_o\varepsilon_o)^{-\frac{1}{2}}$ is

(a) length (b) time

(c) velocity (d) force

14. Planck's constant (h), speed of light in vacuum (c) and Newton's gravitational constant (G) are taken as three fundamental constants. Which of the following combinations of these has the dimension of length?

(a) $\frac{\sqrt{h\,G}}{c^{3/2}}$ (b) $\frac{\sqrt{h\,G}}{c^{5/2}}$

(c) $\sqrt{\frac{hc}{G}}$ (d) $\sqrt{\frac{G\,c}{h^{3/2}}}$

15. A length-scale (l) depends on the permittivity (ε) of a dielectric material, Boltzmann constant (k_B), the absolute temperature (T), the number per unit volume (n) of certain charged particles, and the charge (q) carried by each of the particles. Which of the following expression for l is dimensionally correct?.

(a) $l = \sqrt{\frac{n\,q^2}{\varepsilon\,k_B\,T}}$ (b) $l = \sqrt{\frac{\varepsilon\,k_B\,T}{n\,q^2}}$

(c) $l = \sqrt{\frac{q^2}{\varepsilon\,n^{2/3}k_B\,T}}$ (d) $l = \sqrt{\frac{q^2}{\varepsilon\,n\,k_B\,T}}$

PART - II

6 X 2 = 12

Note : (i) Answer any 6 of the following questions .

(ii) Question No. 23 is compulsory

16. Briefly explain the types of the physical quantities.

17. Define S.I standard for length (i.e.) metre

18. Define one radian.

19. Define one light year.

20. Define relative error (or) fractional error.

21. Define dimensionless variable and give examples.

22. Check the correctness of the equation $\frac{1}{2}m\,v^2 = m\,g\,h$ using dimensional analysis method.

23. The radius of the circle is 3.12 m. Calculate the area of the circle with regard to significant figures.

PART - III

6 X 3 = 18

Note : (i) Answer any 6 of the following questions .
(ii) Question No. 24 is compulsory

24. Define three types of measurement systems. Also Give the advantages of S.I system.

25. Write a note on parallax method. Explain the determination of distance of Moon from Earth using Parallax method.

26. Explain accuracy and precision with numerical example.

27. Explain the principle of homogeneity of dimensions with example.

28. Give the applications and limitations of the method of dimensional analysis.

29. A physical quantity *x is* given by $x = \frac{a^2b^3}{c\sqrt{d}}$. If the percentage errors of measurement in a, b, c and d are 4%, 2%, 3% and 1% respectively, then calculate the percentage error in the calculation of *x.*

30. Convert 76 cm of mercury pressure into Nm^{-2} using the method of dimensions.

PART - IV

3 X 5 = 15

Note : (i) Answer all the questions

31. Write a note on triangulation method and radar method to measure larger distances.

(or)

Obtain an expression for the time period T of a simple pendulum. The time period T depends on

(i) mass '*m*' of the bob
(ii) length '*l*' of the pendulum and
(iii) acceleration due to gravity *g* at the place where the pendulum is suspended. (Constant k = 2π)

32. What are called errors? Explain in detail the various types of errors.

(or)

What do you mean by propagation of errors? Explain the propagation of errors in (i) addition and (ii) multiplication of two physical quantities.

33. Define significant figure. What are the rules for counting significant figures?

(or)

(i) Define astronomical unit.
(ii) Jupiter is at a distance of 824.7 million km from the Earth. Its angular diameter is measured to be 35.72″. Calculate the diameter of Jupiter.

வெற்றிவேற்கை (நறுந்தொகை)

கற்கை நன்றே கற்கை நன்றே
பிச்சை புகினும் கற்கை நன்றே
பிச்சை எடுத்தாவது கல்வி கற்பதே நல்லது

எக்குடி பிறப்பினும் யாவரே ஆயினும்
அக்குடியில் கற்றோரை வருக என்பர்
கற்றவர்கள் எந்த குடியில் பிறந்தவராக இருந்தாலும்,
அவர்களை மற்ற கற்றவர்கள் மேலே வரவேற்று
ஏற்றுக்கொள்வார்

\- அதிவீர ராமபாண்டியர்