UNIT – 01 NATURE OF PHYSICAL WORLD AND MEASUREMENT

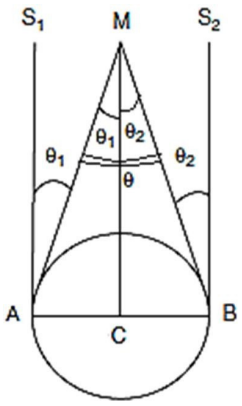
TWO MARKS AND THREE MARKS:

01. Briefly explain the types of physical quantities.

1. Physical quantities are classified into two types. They are fundamental and derived quantities.
2. Fundamental or base quantities are quantities which cannot be expressed in terms of any other physical quantities. These are length, mass, time, electric current, temperature, luminous intensity and amount of substance.
3. Quantities that can be expressed in terms of fundamental quantities are called derived quantities. For example, area, volume, velocity, acceleration, force.

02. How will you measure the diameter of the Moon using parallax method?

i) C is the centre of the Earth. A and B are two diametrically opposite places on the surface of the Earth. From A and B, the parallaxes θ_1 and θ_2 respectively of Moon M with respect to some distant star are determined with the help of an astronomical telescope. Thus, the total parallax of the Moon subtended on Earth $\angle AMB = \theta_1 + \theta_2 = \theta$.



ii) If θ is measured in radians,

then $\theta = \frac{AB}{AM}$; AM≈MC

$\theta = \frac{AB}{MC} \Longrightarrow MC = \frac{AB}{\theta}$

Knowing the values of AB and θ, we can calculate the distance MC of Moon from the Earth.

03. Write the rules for determining significant figures.

i) All non-zero digits are significant. Ex.1342 has **four** significant figures

ii) All zeros between two non zero digits are significant.
Ex. 2008 has **four** significant figures

iii) All zeros to the right of a non-zero digit but to the left of a decimal point are significant. Ex. 30700. has **five** significant figures

iv) The number without a decimal point, the terminal or trailing zero(s) are not significant. Ex. 30700 has **three** significant figures
All zeros are significant if they come from a measurement
Ex. 30700 m has **five** significant figures

v) If the number is less than 1, the zero (s) on the right of the decimal point but to left of the first non zero digit are not significant. Ex. 0.00345 has **three** significant figures

vi) All zeros to the right of a decimal point and to the right of non-zero digit are significant. Ex. 40.00 has **four** significant figures and 0.030400 has **five** significant figures

vii) The number of significant figures does not depend on the system of units used
1.53 cm, 0.0153 m, 0.0000153 km, all have **three** significant figures

04. What are the limitations of dimensional analysis?

1. This method gives no information about the dimensionless constants in the formula like 1, 2, ……..π,e, etc.
2. This method cannot decide whether the given quantity is a vector or a scalar.
3. This method is not suitable to derive relations involving trigonometric, exponential and logarithmic functions.
4. It cannot be applied to an equation involving more than three physical quantities.
5. It can only check on whether a physical relation is dimensionally correct but not the correctness of the relation. For example using dimensional analysis, $s = ut + \frac{1}{3}at^2$ is dimensionally correct whereas the correct relation is $s = ut + \frac{1}{2}at^2$

05. Define precision and accuracy. Explain with one example.

Precision: The closeness of two or more measurements to each other.

Accuracy: The closeness of a measure value to the actual value of the object being measured is called accuracy.

Ex. : The true value of a certain length is near 5.678 cm. In one experiment, using a measuring instrument of resolution 0.1 cm, the measured value is found to be 5.5 cm. In another experiment using a measuring instrument of greater resolution, say 0.01 cm, the length is found to be 5.38 cm. We find that the first measurement is more accurate as it is closer to the true value, but it has lesser precision. On the contrary, the second measurement is less accurate, but it is more precise.

06. Define the terms i) Unification ii) Reductionism

i) Attempting to explain diverse physical phenomena with a few concepts and laws is unification.

ii) An attempt to explain a macroscopic system in terms of its microscopic constituents is **reductionism**.

07. What are the features involved in the scientific methods?

i) Systematic observation ii) Controlled experimentation
iii) Qualitative and quantitative reasoning
iv) Mathematical modeling v) Prediction and verification

08. How can we relate physics with chemistry?

Physics in relation to Chemistry:

1) 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.
2) Physics helped to know the nature of valence and chemical bonding and to understand the complex chemical structures.
3) Inter-disciplinary branches like Physical chemistry and Quantum chemistry play important role.

09. What is the necessity of relating physics with biology?

Physics in relation to biology:

1) A microscope designed using physics principles. The invention of the electron microscope has made it possible to see even the structure of a cell.
2) X-ray and neutron diffraction techniques have helped us to understand the structure of nucleic acids, which help to control vital life processes.
3) X-rays are used for diagnostic purposes. Radio-isotopes are used in radiotherapy for the cure of cancer and other diseases.

10. What is the necessity of relating physics with oceanography?

1) Oceanographers seek to understand the physical and chemical processes of the oceans.
2) They measure parameters such as temperature, salinity, current speed, gas fluxes, chemical components.

11. Define Physical quantity. Write its example.

Quantities that can be measured, and in terms of which, laws of physics are described are called physical quantities. Examples are length, mass, time, force, energy, etc.

12. Define unit. What are its types?

An arbitrarily chosen standard of measurement of a quantity, which is accepted internationally is called unit of the quantity. 1) Fundamental unit 2) Derived unit

13. What are the advantages of SI system?

1) SI system makes use of only one unit for one physical quantity, which means a rational system of units
2) SI system, all the derived units can be easily obtained from basic and supplementary units, which means it is a coherent system of units.
3) It is a metric system which means that multiples and submultiples can be expressed as powers of 10.

14. Define SI standard for length

One metre is the length of the path travelled by light in vacuum in 1/299,792,458 of a Second.

15. Define SI standard for mass

One kilogram is the mass of the prototype cylinder of platinum iridium alloy (whose height is equal to its diameter), preserved at the International Bureau of Weights and Measures at Serves, near Paris, France.

16. Define SI standard for time

One second 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.

17. Define one radian

One radian is the angle subtended at the centre of a circle by an arc equal in length to the radius of the circle.

18. Define steradian

One steradian 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.

19. What is the principle of screw gauge? Write its least count.

The principle of the instrument is the magnification of linear motion using the circular motion of a screw. The least count of the screw gauge is 0.01 mm

20. What is parallax?

Parallax is the name given to the apparent change in the position of an object with respect to the background, when the object is seen from two different positions.

21. What is parsec? Write the value of parsec.

1 parsec (Parallactic second) (Distance at which an arc of length 1 AU subtends an angle of 1 second of arc) 1 parsec = 3.08×10^{16} m =3.26 light year.

22. Define light year

Light year (Distance travelled by light in vacuum in one year)
1 Light Year = 9.467×10^{15} m

23. Define astronomical unit

Astronomical unit (the mean distance of the Earth from the Sun) 1 AU = 1.496×10^{11} m

24. What are 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.

25. How to minimize the systematic error?

Systematic errors are difficult to detect and cannot be analyzed statistically, because all of the data is in the same direction.

26. What is personal error?

These errors are due to individuals performing the experiment, may be due to incorrect initial setting up of the experiment or carelessness of the individual making the observation due to improper precautions.

27. What are least count errors? How is it minimized?

Least count is the smallest value that can be measured by the measuring instrument, and the error due to this measurement is least count error. The instrument's resolution hence is the cause of this error. Least count error can be reduced by using a high precision instrument for the measurement

28. What are Random errors? How is it minimized?

Random errors may arise due to random and unpredictable variations in experimental conditions like pressure, temperature, voltage supply

Random errors can be evaluated through statistical analysis and can be reduced by averaging over a large number of observations.

29. What are Gross errors? How is it minimized?

Reading an instrument without setting it properly. It can be minimized only when an observer is careful and mentally alert.

30. What is relative error or fractional error?

The ratio of the mean absolute error to the mean value. Relative error = $\frac{\Delta a_m}{a_m}$

31. What is percentage error?

The relative error expressed as a percentage . Percentage error = $\frac{\Delta a_m}{a_m}$ x 100%

32. Define significant figure or digits.

The digits that are known reliably plus the first uncertain digit are known as significant figures or significant digits.

33. Define dimensions.

The dimensions of a physical quantity are the powers to which the units of base quantities are raised to represent a derived unit of that quantity.

Velocity = Displacement / Time = [L] / [L] = M^0LT^{-1}

34. Define Dimensional formula and dimensional equation.

Dimensional formula is an expression which shows how and which of the fundamental units are required to represent the unit of a physical quantity. For example, $[M^0LT^{-2}]$ is the dimensional formula of acceleration.

When the dimensional formula of a physical quantity is expressed in the form of an equation, such an equation is known as the dimensional equation.

Example, acceleration = $[M^0LT^{-2}]$.

35. Define dimensional constant and dimensionless constant

Dimensional Constant

Physical quantities which possess dimensions and have constant values are called dimensional constants. Examples are Gravitational constant, Planck's constant etc.

Dimensionless Constant

Quantities which have constant values and also have no dimensions are called dimensionless constants. Examples are π, e, numbers etc.

35. Define dimensional variable and dimensionless variable

Dimensional variables

Physical quantities, which possess dimensions and have variable values are called dimensional variables. Examples are length, velocity, and acceleration etc.

Dimensionless variables

Physical quantities which have no dimensions, but have variable values are called dimensionless variables. Examples are specific gravity, strain, refractive index etc.

36. Name the SI unit for electric current and give a definition for it.

One ampere is the constant current, which when maintained in each of the two straight parallel conductors of infinite length and negligible cross section, held one metre apart in vacuum shall produce a force per unit length of 2×10^{-7} N/m between them.

37. What is the SI unit of temperature and define it.

One kelvin is the fraction of $\left(\frac{1}{273.16}\right)$of the thermodynamic temperature of the triple point of the water.

38. What is mean absolute error?

The magnitude of difference between the true value and the measured value of a quantity.

39. What are the uses of dimensional analysis?

(i) Convert a physical quantity from one system of units to another.
(ii) Check the dimensional correctness of a given physical equation.
(iii) Establish relations among various physical quantities.

40. Write principle of homogeneity of dimensions.

The principle of homogeneity of dimensions states that the dimensions of all the terms in a physical expression should be the same. For example, in the physical expression $v^2 = u^2 + 2as$, the dimensions of v^2, u^2 and 2 as are the same and equal to $[L^2T^{-2}]$.

CONCEPTUAL QUESTIONS

01. Why is it convenient to express the distance of stars in terms of light year (or) parsec rather than in km?

i) Starts are very far away. So, it will be hard to measure in km. The large distances cannot be expressed in km.
ii) Ex. If we express the distance of the our next nearest big galaxy Andromeda in terms of km we get, 24,030,255,3795,53,923,000km but in light years we get 2.5 mly million light years). This shows the light year representations is more convenient that the others.

02. If humans were to settle on other planets which of the fundamental quantities will be in trouble? Why?

All units in atomic standard are more useful because the units does not charge with time. This unit is very accurate one.

03. Having all units in atomic standards is more useful. Explain.

The time will be trouble for humans to settle on other plants. Because each and every planet has its own year length. So, day and night changes. Some of the planets moves very slow.

04. Why dimensional methods are applicable only up to three quantities?

i) If a quantity depends on more than three factors, having dimensions, the formula cannot be derived.
ii) This is because, equating the powers of M, L and T on either side of the dimensional equation, then we can obtain three equations from which we can compute three unknown dimensions.

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"A paper flying in air is due to its luck but a bird is flying due to its effort.
So if luck is not with you, efforts are always there to support you".

FIVE MARKS QUESTIONS

01. i) Explain the use of screw gauge and vernier caliper in measuring smaller distances.
ii) Write a note on triangulation method and radar method to measure larger distances.

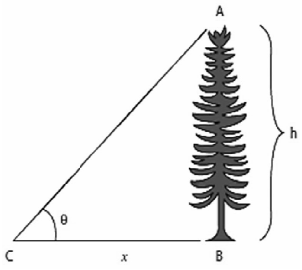
Measurement of small distances

1) Screw gauge: The screw gauge is an instrument used for measuring accurately the dimensions of objects up to a maximum of about 50 mm. The principle of the instrument is the magnification of linear motion using the circular motion of a screw. The least count of the screw gauge is 0.01 mm
2) Vernier caliper: A vernier caliper is a versatile instrument for measuring the dimensions of an object namely diameter of a hole, or a depth of a hole.

Measurement of large distances

3) For measuring larger distances such as the height of a tree, distance of the Moon or a planet from the Earth, some special methods are adopted. Triangulation method, parallax method and radar method are used to determine very large distances.

Triangulation method for the height of an accessible object



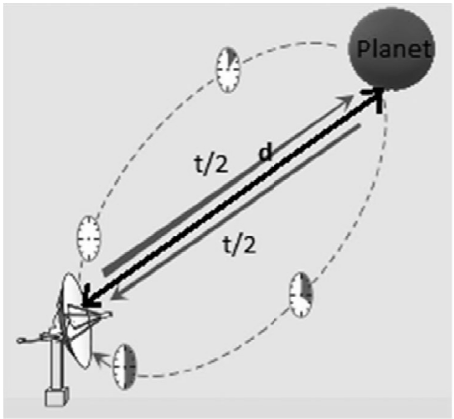
i) Let AB = h be the height of the tree or tower to be measured. Let C be the point of observation at distance *x* from B. Place a range finder at C and measure the angle of elevation, ∠ACB = θ as shown in Figure. From right angled triangle ABC,

$$\tan\theta = \frac{AB}{BC} = \frac{h}{x} \text{ (or) height } h = x \tan\theta$$

Knowing the distance *x*, the height h can be determined.

RADAR method

i) The word RADAR stands for radio detection and ranging. Radar can be used to measure accurately the distance of a nearby planet such as Mars. In this method, radio waves are sent from transmitters which, after reflection from the planet, are detected by the receiver.



ii) By measuring, the time interval (t) between the instants the radio waves are sent and received, the distance of the planet can be determined as $d = \frac{v \times t}{2}$ where v is the speed of the radio wave. As the time taken (t) is for the distance covered during the forward and backward path of the radio waves, it is divided by 2 to get the actual distance of the object. This method can also be used to determine the height, at which an aeroplane flies from the ground.

02. Explain in detail the various types of errors.

Random error, systematic error and gross error are the three possible errors

Systematic errors:

Systematic errors are reproducible inaccuracies that are consistently in the same direction.

Instrumental errors

1) When an instrument is not calibrated properly at the time of manufacture, These errors can be corrected by choosing the instrument carefully.

Imperfections in experimental technique or procedure

2) These errors arise due to the limitations in the experimental arrangement. To overcome these, necessary correction has to be applied.

Personal errors

3) These errors are due to individuals performing the experiment, may be due to incorrect initial setting up of the experiment or carelessness of the individual making the observation due to improper precautions

Errors due to external causes

4) The change in the external conditions during an experiment can cause error in measurement. For example, changes in temperature, humidity, or pressure during measurements may affect the result of the measurement.

Least count error

5) Least count is the smallest value that can be measured by the measuring instrument, and the error due to this measurement is least count error.

Random errors

6) Random errors may arise due to random and unpredictable variations in experimental conditions like pressure, temperature, voltage supply etc.
7) Errors may also be due to personal errors by the observer who performs the experiment. Random errors are sometimes called **"chance error"**
8) It can be minimized by repeating the observations a large number of measurements are made and then the arithmetic mean is taken.

Gross Error

9) The error caused due to the shear carelessness of an observer is called gross error. These errors can be minimized only when an observer is careful and mentally alert.

03. What do you mean by propagation of errors? Explain the propagation of errors in addition and multiplication.

1) A number of measured quantities may be involved in the final calculation of an experiment. Different types of instruments might have been used for taking readings. Then we may have to look at the errors in measuring various quantities, collectively. The error in the final result depends on
2) The errors in the individual measurements ii) On the nature of mathematical operations performed to get the final result. So we should know the rules to combine the errors. The various possibilities of the propagation or combination of errors in different mathematical operations are discussed below:

(i) Error in the sum of two quantities

Let ΔA and ΔB be the absolute errors in the two quantities A and B respectively.

Then, Measured value of A = A ± ΔA

Measured value of B = B ± ΔB

Consider the sum, Z = A + B

The error ΔZ in Z is then given by

$$Z \pm \Delta Z = (A \pm \Delta A) + (B \pm \Delta B)$$
$$= (A + B) \pm (\Delta A + \Delta B)$$
$$= Z \pm (\Delta A + \Delta B)$$
$$\text{(or) } \Delta Z = \Delta A + \Delta B$$

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

(ii) Error in the difference of two quantities

Let ΔA and ΔB be the absolute errors in the two quantities, A and B, respectively. Then,

Measured value of A = A ± ΔA

Measured value of B = B ± ΔB

Consider the difference, Z = A – B

The error ΔZ in Z is then given by

$$Z \pm \Delta Z = (A \pm \Delta A) - (B \pm \Delta B)$$
$$= (A - B) \pm \Delta A \pm \Delta B$$
$$= Z \pm \Delta A \pm \Delta B$$
$$\text{(or) } \Delta Z = \Delta A + \Delta B$$

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

(iii) Error in the product of two quantities

Let ΔA and ΔB be the absolute errors in the two quantities A, and B, respectively. Consider the product Z = AB

The error ΔZ in Z is given by $Z \pm \Delta Z = (A \pm \Delta A)(B \pm \Delta B)$

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

Dividing L.H.S by Z and R.H.S by AB, we get,

$$1 \pm \frac{\Delta Z}{Z} = 1 \pm \frac{\Delta B}{B} \pm \frac{\Delta A}{A} \pm \frac{\Delta A}{A} \cdot \frac{\Delta B}{B}$$

As ΔA /A, ΔB / B are both small quantities,

their product term $\frac{\Delta A}{A} \cdot \frac{\Delta B}{B}$ can be neglected.

The maximum fractional error in Z is $\frac{\Delta Z}{Z} = \pm \left(\frac{\Delta A}{A} + \frac{\Delta B}{B}\right)$

04. Write short notes on the following.

a) Unit b) Rounding – off c) Dimensionless quantities

a) Unit

1) The digits that are known reliably plus the first uncertain digit are known as Significant figures or significant digits. The units in which the fundamental quantities are measured are called fundamental or base units and the units of measurement of all other physical quantities, which can be obtained by a suitable multiplication or division of powers of fundamental units, are called derived units.

b) Rounding – off

1) 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 should be rounded off.

c) Dimensionless quantities

i) Physical quantities which have no dimensions, but have variable values are called dimensionless variables. Examples are specific gravity, strain, refractive index etc

ii) Quantities which have constant values and also have no dimensions are called dimensionless constants. Examples are π, e, numbers etc.

05. Write the rules for rounding off.

i) If the digit to be dropped is smaller than 5, then the preceding digit should be left unchanged.

Ex. i) 7.32 is rounded off to 7.3 ii) 8.94 is rounded off to 8.9

ii) If the digit to be dropped is greater than 5, then the preceding digit should be increased by 1

Ex. i) 17.26 is rounded off to 17.3 ii) 11.89 is rounded off to 11.9

iii) If the digit to be dropped is 5 followed by digits other than zero, then the preceding digit should be raised by 1

Ex. i) 7.352, on being rounded off to first decimal becomes 7.4
ii) 18.159 on being rounded off to first decimal, become 18.2

iv) If the digit to be dropped is 5 or 5 followed by zeros, then the preceding digit is not changed if it is even

Ex. i) 3.45 is rounded off to 3.4 ii) 8.250 is rounded off to 8.2

v) 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

Ex. i) 3.35 is rounded off to 3.4 ii) 8.350 is rounded off to 8.4

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