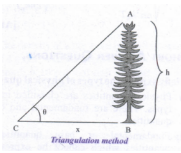
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Answers Key:

5 Marks

1. **Use of screw gauge in measuring radius of a thin wire in the range of 10^{-5} m**
The wire whose diameter is to be determined should be clamped between the jaws of the screw gauge. The reading on pitch scale (P.S.R) is noted. Then the reading of the reading of the head scale coinciding with the pitch scale is noted (A.S.C.) The zero correction is applied to head scale incidence. (C.H.S.S.). The total reading is given by
T.R = P.S.R + (C.H.S.C. X L.C)
The procedure is repeated for at least six different positions of the wire. The mean of the reading taken gives the diameter of the wire. Half of this gives radius of the wire 'r' in the range of 10^{-5} m.
Use of vernier caliper in measuring smaller distances in the range of 10^{-4} m
The sphere is kept between the two jaws. The main scale reading (MSR) is noted (i.e), the main scale division immediately before the zero of the vernier scale. Then the vernier scale division which coincides with some main scale division (VSD) is noted. Zero correction made with this VSD gives VSR. Multiply this VSR by least count and add with MSR. This will give the diameter of the sphere. Observations for different positions of the sphere is hence forth recorded. The mean of the readings taken gives the diameter of the sphere. Half of this gives the diameter of the sphere. Half of this gives radius in the range of 10^{-4} am
(ii) Write a note on triangulation method and radar method to measure larger distances.
Triangulation method for the height of an accessible object
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



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From right angled triangle ABC,
$\tan\theta = \frac{AB}{BC} = \frac{h}{x}$
(or) height h = x tan θ
Knowing the distance x, the height h can be determined.
Radar Method: In Radar method radio waves are sent from transmitters which, after reflection from the planet, are detected by the receiver. By measuring, the time interval (r) between the instants the radio waves are sent and received, the distance of the planet can be determined as 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.
$Speed = \frac{\text{Distance travelled}}{\text{Time taken}}$ (Speed is explained in unit 2)
Distance (d)= Speed of radio waves x Time taken
$d = \frac{v \times t}{2}$
where v is the speed of the radio wave. As the time taken (r) 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.

2. **i) 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
1) Instrumental errors
When an instrument is not calibrated properly at the time of manufacture, instrumental errors may arise. If a measurement is made with a meter scale whose end is worn out, the result obtained will have errors. These errors can be corrected by choosing the instrument carefully.
2) Imperfections in experimental technique or procedure
These errors arise due to the limitations in the experimental arrangement. As an example, while performing experiments with a calorimeter, if there is no proper insulation, there will be radiation losses. This results in errors and to overcome these, necessary correction has to be applied.
3) Personal errors
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.
4) Errors due to external causes
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.
5) Least count error
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.
ii) 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". When different landings are obtained by a person every time he occurs. For example, consider the case of the thickness of a wire measured using a screw gauge. The readings taken may be different for different trials. In this case, a large number of measurements are made and then the arithmetic mean is taken.

If n number of trial readings are taken in an experiment, and the readings are a_1, a_2, a_3,.....a_n. The arithmetic mean is

$a_m = \frac{a_1+a_2+a_3+\ldots\ldots\ldots\ldots\ldots a_n}{n}$ or

$a_m = \frac{1}{n}\sum_{i=1}^{t=n} a_i$

Usually this arithmetic mean is taken as the best possible true value of the quantity.

Certain procedures to be followed to minimize experimental errors, along with examples are shown in Table.

Type of error Example How to minimize it Random error Suppose you measure the mass of a ring three times using the same balance and get slightly different values. 15.46 g, 15.42 g, 15.44 g Take more data. Random errors can be evaluated through statistical analysis and can be reduced by averaging over a large number of observations. Systematic error Suppose the cloth tape measure that you use to measure the length of an object has been stretched out from years of use. (As a result all of the length measurements are not correct). 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) **iii) Gross Error**

The error caused due to the sheer carelessness of an observer is called gross error.

For example

(i) Reading an instrument without setting it properly.

(ii) Taking observations in a wrong manner without bothering about the sources of errors and the precautions.

(iii) Recording wrong observations.

(iv) Using wrong values of the observations in calculations.

These errors can be minimized only when an observer is careful and mentally alert.

3. **Propagation of errors**

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

(i) 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 A△ and △B be the absolute errors in the two quantities A and B respectively. Then,

Measured value of A = A ±△ A

Measured value of B = B ±△ B

Consider the sum, Z = A + B

The error △ Z in Z is the given by

Z ±△ Z = (A ±△A) + (B ±△ B)

= (A + B) ± (△A+ △ B)

= Z ± (△ A + △ B)

(or) △Z = △ A+ △ B

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

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

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

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

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

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

As △A/A, △B/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

$\frac{\Delta Z}{Z} = \pm\left(\frac{\Delta A}{A} + \frac{\Delta B}{B}\right)$

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 division or quotient of two quantities

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

Consider the quotient, $Z = \frac{A}{B}$

The error △Z in Z is given by

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

$= \frac{A}{B}\left(1 \pm \frac{\Delta A}{A}\right)\left(1 \pm \frac{\Delta B}{B}\right)^{-1}$

or $Z \pm \Delta Z = Z\left(1 \pm \frac{\Delta A}{A}\right)\left(1 \pm \frac{\Delta B}{B}\right)$

[using (1+x) n ≈ 1+n x, when x<1]

Dividing both sides by Z, we get,

$1 \pm \frac{\Delta Z}{Z} = \left(1 \pm \frac{\Delta A}{A}\right)\left(1 \pm \frac{\Delta B}{B}\right)$

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

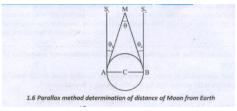
As the terms △A /A and △B/ B are small, their product term can be neglected. The maximum fractional error in Z is given by

$\frac{\Delta Z}{Z} = \left(\frac{\Delta A}{A} + \frac{\Delta B}{B}\right)$

The maximum fractional error in the quotient of two quantities is equal to the sum of their individual fractional errors.

4. 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 ∠AMB = $\theta_1 + \theta_2 = \theta$



If θ is measured in radians, then$\theta = \frac{AB}{MC}; AM \approx MC$

$\theta = \frac{AB}{MC} or M.C = \frac{AB}{\theta}$

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

5. 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 $[L^2T^{-2}]$.

This method is used to

(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.

(i) **To convert a physical quantity from one system of units to another:** This is based on the fact that the product of the numerical values (n) and its corresponding unit (u) is a constant. i.e, $n_1[u_1]$ = constant (or) $n, n_1[u_1] = n_2[u_2]$.

Consider a physical quantity which has dimension 'a' in mass, 'b' in length and 'c' in time.

If the fundamental units in one system are M_1, L_1 and T_1 and the other system are M_2, L_2, and T_2 respectively, then we can write, $n_1 [M_1^a L_1^b T_1^c] = n_2 [M_2^a L_2^b T_2^c]$

We have thus converted the numerical value of physical quantity from one system of units into the other system.

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

Solution: In cgs system 76 cm of mercury pressure $=76 \times 13.6 \times 980$ dyne cm^{-2}

The dimensional formula of pressure P is $[ML^{-1}T^{-2}]$

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

We have

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

$M_1 = 1 \text{ g}, M_2 = 1 \text{ kg}$

$L_1 = 1 \text{ cm}, \ L_2 = 1 \text{ m}$

$T_1 = 1 \text{ s}, T_2 = 1 \text{ s}$

So a=1, b=1 and c=-2

Then

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

$= 76 \times 13.6 \times 980 \left[\frac{10^{-3} kg}{1 kg}\right]^1 \left[\frac{10^{-2} m}{1 m}\right]^{-1} \left[\frac{1 s}{1 s}\right]^{-2}$

$= 76 \times 13.6 \times 980 \times \left[10^{-3}\right] \times 10^2$

$P_2 = 1.01 \times 10^5 Nm^{-2}$

(ii) To check the dimensional correctness of a given physical equation:

Example: The equation $\frac{1}{2}$ mv^2 = mgh can be checked by using this method as follows.

Solution: Dimensional formula for

$\boxed{\frac{1}{2}mv^2 = [M][LT^{-1}]^2 = [ML^2T^{-2}]}$

Dimensional formula for

$\boxed{mgh = [M][LT^{-2}][L] = [ML^2T^{-2}][ML^2T^2] = [ML^2T^{-2}]}$

Both sides are dimensionally the same, hence the equations $\frac{1}{2}$ mv^2 = mgh is dimensionally correct.

(iii) To establish the relation among various physical quantities:

If the physical quantity Q depends upon the quantities Q_1, Q_2 and Q_3 ie. Q is proportional to Q_1, Q_2 and Q_3.

Then,

$Q \alpha Q_1^a Q_2^b Q_3^c$

$Q = k Q_1^a Q_2^b Q_3^c$

where k is a dimensionless constant. When the dimensional formula of Q_1, Q_2 and Q_3 are substituted, then according to the principle of homogeneity, the powers of M, L, T are made equal on both sides of the equation. From this, we get the values of a, b, c.

Example:

Obtain an expression for the time period T of a simple pendulum. The time period T depend upon (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) i.e

Solution:

$\boxed{T \alpha m^a l^b g^c T = k.m^a l^b g^c}$

Here k is the dimensionless constant. Rewriting the above equation with dimensions.

$\boxed{[T^1] = [M^a][L^b][LT^{-2}]^c[M^o L^o T^1] = [M^a L^{b+c} T^{-2c}]}$

Comparing the powers of M, L and T on both sides, a = 0, b + C = 0, -2c = 1

Solving for a, b and c a = 0, b = 1/2, and c = -1/2

From the above equation

$T = k. m^o l^{1/2} g^{-1/2}$

$T=k\frac{1}{g}^{\frac{1}{2}} = k\sqrt{\frac{1}{g}}$

Experimentally k = 2π , hence $T = 2\pi\sqrt{\frac{l}{g}}$

3 Marks

6. (i) Physical quantities are classified into two types. There are fundamental and derived quantities.

(ii) Fundamental or base quantities are quantities which cannot be expressed in terms of any other physical quantities.

(iii) These are length, mass, time, electric current, temperature, luminous intensity and amount of substance.

(iv) Quantities that can be expressed in terms of fundamental quantities are called derived quantities.

(v) For example, area, volume, velocity, acceleration, force.

7.

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Limitations of Dimensional analysis:

(i) This method gives no information about the dimensionless constants in the formula like 1, 2,..... π, e, etc.

(ii) This method cannot decide whether the given quantity is a vector or a scalar.

(iii) This method is not suitable to derive relations involving trigonometric, exponential and logarithmic functions.

(iv) It cannot be applied to an equation involving more than three physical quantities.

(v) 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 + 1/3 at^2 is dimensionally correct whereas the correct relation is s = ut+1/2 at^2.

8. The speed of sound in water v = 1460 ms^{-1}

Time taken t = 80 s

$= \frac{2d}{t}$

2d = u x t

= 1460 x 80

2d =11680 m

$\therefore$ Distance of enemy submarine $d = \frac{11680}{2}$

= 58.40 km

9. Frequency of a vibrating body $\gamma \alpha \frac{1}{l}\sqrt{\frac{F}{M}}$

a Dimension of frequency $= \mathrm{M^0\ L^0\ T^{-1}}$

Dimension of length $= \mathrm{L = M^0LT^0}$

Dimension of Force $= \mathrm{MLT^{-2}}$

Dimension of Mass $= \mathrm{M^1\ L^0\ T^0}$

Frequency $\gamma = x$

$\gamma = \mathrm{K\,[F^x][M]^y[\,L]^z}$

Using dimensions we get

$\mathrm{M^0\ L^0\ T^{-1} = \left[MLT^{-2}\right]^x[M]^y[\,L]^z}$

$\mathrm{M^0\ L^0\ T^{-1} = M^{x+y}\ L^{x+z}\ T^{-2x}}$

Comparing the powers we get

x + y = 0 z = -x = $\frac{1}{2}$

x + z = 0 y = -x = $\frac{-1}{2}$

-2 x = -1

$\therefore x = \frac{-1}{-2} = \frac{1}{2}$

$\therefore \gamma = 1 \times [\mathrm{F}]^{1/2}[\mathrm{M}]^{-1/2}[\,\mathrm{L}]^{-1/2}$

$\gamma = \frac{1}{l}\sqrt{\frac{F}{m}}$

10. **Gross Error**

(i) The error caused due to the shear carelessness of an observer is called gross error.

For example:

(ii) Reading an instrument without setting it properly.

(iii) Taking observations in a wrong manner without bothering about the sources of errors and the precautions.

(iv) Recording wrong observations. These errors can be minimized only when an observer is careful and mentally alert.

11. Angle θ = 60 °

The distance between the tree and a point

x = 50m

Height of the tree (h)=?

For triangulation method $\tan\theta = \frac{h}{x}$

h= x tan θ = 50$\times$tan 60^0 = 50$\times$1.732

h = 86.6m

The height of the tree is 86.6m.

12. R_1 = 100 ± = 3Ω; R_2 = 150 ± 2Ω

Equivalent resistance R =?

Equivalent resistance R = R_1+ R_2 = (100 ± 3) + (150 ± 2) = (100 + 150) ± (3 + 2)

R = (250 ± 5) Ω

13. Voltage V = (100 ± 5)V

Current I = (10 ± 0.2)A

Resistance R = ?

Then resistance R is given by Ohm's law,

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

$\frac{\triangle R}{R} = (\frac{\triangle V}{V} + \frac{\triangle I}{I})$

$\frac{\triangle R}{R} = (\frac{\triangle V}{V} + \frac{\triangle I}{I})R = (\frac{5}{100} + \frac{0.2}{10})10$

= (0.05 + 0.02)10 = 0.07$\times$10 = 0.7

The resistance R = (10 ± 0.7)Ω

14. T ∝ m^a l^b g^c;

T = k.m^a l^b g^c

Here k is the dimensionless constant. Rewriting the above equation with dimensions

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

$[M^0L^0T^1] = [M^aL^{b+c}T^{-2c}]$

Comparing the powers of M, L and T on both sides, a = 0, b + c = 0, -2c = 1

Solving for a, b and c a = 0, b = 1/2, and c = -1/2

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From the above equation T = k.m^0 $l^{1/2}$ $g^{-1/2}$

T= k$\left(\frac{l}{g}\right)^{1/2} = k\sqrt{\frac{l}{g}}$

Experimentally k = 2π hence

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

15. Let G_{SI} be the gravitational constant in the SI system and G_{cgs} in the cgs system. Then

G_{SI} = 6.6 ×10^{-11} Nm^2 kg^{-2}

G_{cgs} = ?

$n_2 = n_1\left[\frac{M_1}{M_2}\right]^a\left[\frac{L_1}{L_2}\right]^b\left[\frac{T_1}{T_2}\right]^c$

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

M_1 = 1 kg L_1 = 1m T_1 = 1s

M_2 = 1 g L_2 = 1 cm T_2 = 1s

The dimensional formula for G is $M^{-1}L^3T^{-2}$

a = -1 b = 3 and c = -2

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

$= 6.6 \times 10^{-11}\left[\frac{1\text{ kg}}{10^{-3}\text{ kg}}\right]^{-1}\left[\frac{1\text{ m}}{10^{-2}\text{ m}}\right]^3\left[\frac{1\text{ s}}{1\text{ s}}\right]^{-2}$

= 6.6 × 10^{-11} × 10^{-3} x 10^6 × 1

G_{cgs} = 6.6 × 10^{-8} dyne cm^2 g^{-2}

2 Marks

16.

Rule	Example
(i) All non-zero digits are significant	1342 has four significant figures
(ii) All zeros between two non-zero digits are significant	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.	30700 has five significant figures
(iv) a) The number without a decimal point, the terminal or trailing zero(s) are not significant.	30700 has three significant figures
b) All zeros are significant if they come from a measurement	30700 has three significant figures
(v) If the number is less than 1, the zero (s) on the right of the decimal point but to the left of the first non-zero digit are not significant.	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.	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.

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17. Precision refers to the closeness of two or more measurements to each other. Precision is a measure of the detail in which a quantity is expressed.
Precision is independent of accuracy.
Precision is the quantity or state of being precise exactness. It is the degree of refinement with which an operation is performed or a measurement stated.
Precision refers to the resolution or the limit to which the quantity is measured. It is determined by the least count of the measuring instrument.
Example:
(1) If you weigh a given substance five times, and get 2.7 kg each time then your measurement is very precise.
(2) If the temperature outside a building is 40°C as measured by a weather thermometer and if the real outside temperature is 40°C, then the thermometer is accurate. If the thermometer consistently registers this exact temperature in a row the thermometer is precise.
Accuracy of a measurement is a measure of how close the measured value is to the true value of the quantity. A measurement system can be accurate but not precise, precise but not accurate, or neither, or both.
Example:
If an experiment containing a systematic error then increasing the sample size generally increases precision but does not improve accuracy.
If a measurement is precise, that does not necessarily mean that it is accurate. However, if the measurement is consistently accurate, it is also precise.

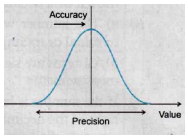


Illustration: Target shooting is an example which explains the difference between accuracy and precision. In Figure, the shots are focused so as to reach the bull's eye (midpoint), but the arrows have reached only around this point. Hence the shots are not accurate and also not precise.
In Figure (b), all the shots are close to each other but not at the central point. Hence the shots are said to be precise but not accurate. In Figure (c), the shots are closer and also at the central point. Hence the shots are both precise and accurate.



18. **(a) Unit:** An arbitrarily chosen standard of measurement of a quantity, which is accepted internationally is called unit of the quantity.
19. Radius of the circle r = 3.12 m
    Area of the circle A = πr^2
    = 3.14×3.12×3.12
    = 30.566016 m^2
    According to the rule of significant
    A = 30.6 m^2
20. "ampere" is the SI unit of electric current. 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.
21. The distance of the planet from the Earth
    d = 6.3×10^{10} m
    Time t = 7 minutes = 7×60 s.
    The speed of signal v = ?
    The speed of signal v = $\frac{2d}{t} = \frac{2\times6.3\times10^8}{7\times60} = 3\times10^8 ms^{-1}$
22. Dimension formula for
    $\frac{1}{2}mv^2 = [M][LT^{-1}]^2 = [ML^2T^{-2}]$
    Dimension formula for
    mgh = $[M][LT^{-2}][L] = [ML^2T^{-2}]$
    $[ML^2T^{-2}] = [ML^2T^{-2}]$
    Both sides are dimensionally the same, hence the equations $\frac{1}{2}mv^2 = mgh$ is dimensionally correct
23. In cgs system 76 cm of mercury pressure = 76×13.6×980 dyne cm^{-2}
    The dimensional formula of pressure P is $[ML^{-1}T^{-2}]$; so $P_1[M_1^a L_1^b T_1^c] = P_2[M_2^a L_2^b T_2^c]$
    We have $P_2 = P_1\left[\frac{M_1}{M_2}\right]^a\left[\frac{L_1}{2}\right]^b\left[\frac{T_1}{T_2}\right]^c$
    M_1 = 1g, M_2 =1kg
    L_1 = 1 cm, L_2 = 1m
    T_1 = 1 s, T_2 = 1s
    So, a = 1, b = -1, and c =-2
    Then, $P_1 = 76\times13.6\times980$
    $\left[\frac{1g}{1kg}\right]^1\left[\frac{1cm}{1m}\right]^{-1}\left[\frac{1s}{1s}\right]^{-1} = 76\times13.6\times980\left[\frac{10^{-3}kg}{1kg}\right]^1\left[\frac{10^{-2}m}{1m}\right]^{-1}\left[\frac{1s}{1s}\right]^{-2}$
    = $76\times13.6\times980\times[10^{-3}]\times10^2$
    $P_2 = 1.01\times10^5$ Nm^{-2}
24. (a) 17.2
    (b) 4.00×10^5
    (c) 3.7×10^{-3}
    (d) 124780
25. **1) Instrumental errors**
    When an instrument is not calibrated properly at the time of manufacture, instrumental errors may arise.
    2) Imperfections in experimental technique or procedure
    These effors arise due to the limitations in the experimental arrangement.
26. **(b) Rounding-off:** 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. By following the rules for rounding off a value, we can get the most accurate value of a measured quantity. This procedure is known as rounding off.
27. **Dimensionless quantities:** Quantities that have constant values and also have no dimensions are called dimension less constants. **Examples are:** π, e, numbers etc.

Multiple Choice Questions

28. Unit of a (Planck's constant) - Js
    Unit of c (Velocity of light) - ms^{-1}
    Unit of G (Gravitational Constant) - $\frac{Nm^2}{Kg^2}$
    $\therefore$ Unit of $\frac{hc}{G}$ is $= \frac{Js\times ms^{-1}}{Nm^2/kg^2}$
    $= \frac{Nms\times ms^{-1}\times kg^2}{Nm^2}[J = Nm] = kg^2$
29. Error in radius $= 2\%$
    $\Delta r = \frac{2}{100} = 0.02$

Volume of the sphere $= \frac{4}{3}\pi r^3$

$V = \frac{4}{3}\pi r^3$

$\frac{dV}{V} = \frac{4}{3}\pi \times 3r^2 dr$

$= 3dr = 3(2\%) = 6\%$

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

$g = 4\pi^2 l/T^2$

$\frac{dg}{g} = \frac{dl}{l} - \frac{2dT}{T}$

$\frac{dg}{g}\% = \left(\frac{dl}{l}\right)\% - 2\left(\frac{dT}{T}\right)\%$

$= 1\% - 2 \times (-3\%)$

$= 1 + 6 = 7\%$

31. $\Delta l = 0.01$

$l = 3.51$

$\%$ error $= \frac{\Delta l}{l} \times 100 = \frac{0.01}{3.51} \times 100$

$= 0.00284 \times 100$

$= 0.284 = 0.28\%$

32. The number of significant figures of 6.3200 J is 5

33. $\pi = 3.14$

$\pi^2 = 3.14 \times 3.14$

$= 9.8596 = 9.86$

34. Torque = Force $\times$ r

Dimension of torque

$= \left[\mathrm{MLT^{-2}}\right][\mathrm{L}] = \left[\mathrm{ML^2\,T^{-2}}\right]$

Energy = Force $\times$ displacement

Dimension of Energy

$= \left[\mathrm{MLT^{-2}}\right][\mathrm{L}] = \left[\mathrm{ML^2\,T^{-2}}\right]$

35. Dimensional formula of Planck's constant $= \frac{\text{Energy}}{\text{Frequency}} = \frac{\mathrm{ML^2\,T^{-2}}}{\mathrm{T^{-1}}}$

$= ML^2T^{-2+1} = ML^2T^{-1}$

36. $v = at + bt^2$

Dimensional equation is $\mathrm{LT^{-1}}$

$= aT = bT^2$

$\therefore$ The dimension of $b = \frac{\mathrm{LT^{-1}}}{\mathrm{T^2}} = \mathrm{LT^{-3}}$

37. Gravitational constant $G = \frac{Fr^2}{m_1 m_2}$

Dimensional formula of G $= \frac{[\mathrm{MLT^{-2}}][\mathrm{L^2}]}{[\mathrm{M}][\mathrm{M}]}$

$= \frac{\mathrm{ML^3\,T^{-2}}}{\mathrm{M^2}} = \mathrm{M^{-1}\,L^3\,T^{-2}}$

38. (c) 40

39. $F = kv^2$

Dimensional of k

$= \frac{\text{Dimension of F}}{\text{Dimension of } (v)^2}$

$= \frac{\mathrm{MLT^{-2}}}{\left(\mathrm{LT^{-1}}\right)^2} = \frac{\mathrm{MLT^{-2}}}{\mathrm{L^2\,T^{-2}}}$

$= \left[\mathrm{ML^{-1-2}\,T^{-2+2}}\right]$

Dimension of proportionality constant $= \left[\mathrm{ML^{-1}\,T^0}\right]$

40. Velocity of light $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

$c = (\mu_0 \varepsilon_0)^{-\frac{1}{2}}$

Hence dimension $(\mu_0 \varepsilon_0)^{-\frac{1}{2}}$ is that of velocity.

41. Dimension of Planck's constant is $\left[\mathrm{ML^2\,T^{-1}}\right]$

Dimension of Gravitational constant is $\left[\mathrm{M^{-1}\,L^{+3}\,T^{-1}}\right]$

Dimension of Velocity constant is $\mathrm{LT^{-1}}$

Dimension of Length is L

$\therefore$ Dimension of $\frac{\sqrt{hG}}{C^{\frac{3}{2}}}$

$= \frac{\sqrt{\left(\mathrm{ML^2\,T^{-1}}\right)\left(\mathrm{M^{-1}\,L^3\,T^{-2}}\right)}}{\left(\mathrm{LT^{-1}}\right)^{3/2}}$

$= \frac{\sqrt{\mathrm{L^5\,T^{-3}}}}{\mathrm{L^{3/2}\,T^{-3/2}}}$

$= \frac{\mathrm{L^{5/2}\,T^{-3/2}}}{\mathrm{L^{3/2}\,T^{-3/2}}}$

$= \mathrm{L^{5/2-3/2}\,T^{3/2+3/2}} = \mathrm{L^1\,T^0} = \mathrm{L}$

Dimension of length = L

42. (b) 20.0

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