TRIUMPH
PHYSICS
BASED ON STD. XI CURRICULUM MAHARASHTRA BOARD
MULTIPLE CHOICE QUESTIONS
FOR ALL MEDICAL AND ENGINEERING ENTRANCE EXAMINATIONS
ALBERT EINSTEIN

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Target Publications Pvt. Ltd.
STD. XI Sci.
Triumph Physics
Based on Maharashtra Board Syllabus

Salient Features
- Exhaustive subtopic wise coverage of MCQs
- Important formulae provided in each chapter
- Hints included for relevant questions
- Various competitive exam questions updated till the latest year
- Includes solved MCQs from JEE (Main), AIPMT, NEET P-I, K CET 2015 and 2016
- Includes solved MCQs uptill MH CET 2014
- Evaluation test provided at the end of each chapter

Solutions/hints to Evaluation Test available in downloadable PDF format at www.targetpublications.org/tp10142

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Preface

“Std. XI: Sci. Triumph Physics” is a complete and thorough guide to prepare students for a competitive level examination. The book will not only assist students with MCQs of Std. XI but will also help them to prepare for JEE, AIPMT, CET and various other competitive examinations.

The content of this book is based on the Maharashtra State Board Syllabus. Formulae that form a vital part of MCQ solving are provided in each chapter. Notes provide important information about the topic. Shortcuts provide easy and less tedious solving methods. Mindbenders have been introduced to bridge the gap between a text book topic and the student’s understanding of the same. A quick reference to the notes, shortcuts and mindbenders has been provided wherever possible.

MCQs in each chapter are divided into three sections:

- Classical Thinking: consists of straight forward questions including knowledge based questions.
- Critical Thinking: consists of questions that require some understanding of the concept.
- Competitive Thinking: consists of questions from various competitive examinations like JEE, AIPMT, MH CET, K CET, CPMT, GUJ CET, AP EAMCET (Engineering, Medical), TS EAMCET (Engineering, Medical), Assam CEE, BCECE etc.

Hints have been provided to the MCQs which are broken down to the simplest form possible.

An Evaluation Test has been provided at the end of each chapter to assess the level of preparation of the student on a competitive level.

An additional feature of pictorial representation of a topic is added to give the student a glimpse of various interesting physics concept.

The journey to create a complete book is strewn with triumphs, failures and near misses. If you think we’ve nearly missed something or want to applaud us for our triumphs, we’d love to hear from you.

Please write to us on : mail@targetpublications.org

Best of luck to all the aspirants!

Yours faithfully
Authors

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Chapter 01: Measurements

Subtopics

1.0 Introduction
1.1 Need for measurements
1.2 Units of measurements
1.3 System of units
1.4 S.I Units
1.5 Fundamental and derived units
1.6 Dimensional analysis
1.7 Order of magnitude and significant figures
1.8 Accuracy and errors in measurements

Eratosthenes was first to measure the radius of the Earth using the difference in angle of shadows cast at the same time in two different cities Syene (now Aswan) and Alexandria. Using simple geometry, he determined the degrees of arc between them to be 7°.
1. Measure of physical quantity (M): 
   Numerical value × size of unit. i.e., M = nu

2. For definite amount of physical quantity: 
   \[ n \propto \frac{1}{u} \]
   i.e., magnitude of physical quantity \( \propto \frac{1}{\text{units}} \)

3. Conversion factor of a unit in two system of units: 
   \[ n = \left[ \frac{L_1}{L_2} \right]^a \left[ \frac{M_1}{M_2} \right]^b \left[ \frac{T_1}{T_2} \right]^c \]

4. Average value or mean value: 
   \[ a_m = \frac{a_1 + a_2 + a_3 + \ldots + a_n}{n} = \frac{1}{n} \sum_{i=1}^{n} a_i \]

5. If \( x = x_1 \pm x_2 \), then maximum error in \( x \): 
   \( \Delta x = \Delta x_1 + \Delta x_2 \)

6. If \( x = x_1^n \times x_2^m \), then error in measurement: 
   \[ \frac{\Delta x}{x} = \frac{m \Delta x_1}{x_1} + \frac{n \Delta x_2}{x_2} \]

7. Absolute error: 
   \[ |\Delta a_n| = |a_m - a_n| \]

8. Mean absolute error: 
   \[ |\Delta a_m| = \frac{|\Delta a_1| + |\Delta a_2| + \ldots + |\Delta a_n|}{n} = \frac{1}{n} \sum_{i=1}^{n} |\Delta a_i| \]

9. Relative (fractional) error: 
   \[ \left| \frac{\Delta a_m}{a_m} \right| = \frac{|\Delta a_m|}{a_m} \]

10. Percentage error: 
    Relative error \( \times 100 = \left| \frac{\Delta a_m}{a_m} \right| \times 100 \% \)

Some practical units in term of S.I. unit

<table>
<thead>
<tr>
<th>Practical units</th>
<th>Abbreviation</th>
<th>S.I. unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Angstrom</td>
<td>Å</td>
<td>( 10^{-10} ) m</td>
</tr>
<tr>
<td>1 Micron</td>
<td>( \mu m/\mu )</td>
<td>( 10^{-6} ) m</td>
</tr>
<tr>
<td>1 Nanometer</td>
<td>nm</td>
<td>( 10^{-9} ) m</td>
</tr>
<tr>
<td>1 Light year</td>
<td>ly</td>
<td>( 9.46 \times 10^{15} ) m</td>
</tr>
<tr>
<td>1 Astronomical unit</td>
<td>AU</td>
<td>( 1.496 \times 10^{11} ) m</td>
</tr>
<tr>
<td>1 Atomic mass unit</td>
<td>a.m.u./u</td>
<td>( 1.66 \times 10^{-27} ) kg</td>
</tr>
<tr>
<td>1 Torr</td>
<td>T</td>
<td>1 mm of Hg</td>
</tr>
</tbody>
</table>

Notes

1. Units are classified mainly into two groups.
   i. Fundamental units: These are independent of other units. The seven fundamental quantities and their units are given below.

<table>
<thead>
<tr>
<th>Fundamental Quantity</th>
<th>S.I Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>metre (m)</td>
</tr>
<tr>
<td>Mass</td>
<td>kilogram (kg)</td>
</tr>
<tr>
<td>Time</td>
<td>second (s)</td>
</tr>
<tr>
<td>Temperature</td>
<td>kelvin (K)</td>
</tr>
<tr>
<td>Electric current</td>
<td>ampere (A)</td>
</tr>
<tr>
<td>Luminous intensity</td>
<td>candela (cd)</td>
</tr>
<tr>
<td>Amount of substance</td>
<td>mole (mol)</td>
</tr>
</tbody>
</table>

   ii. Derived units: These units depend upon the fundamental units to give units of a physical quantity.

   For example: speed = \( \frac{\text{Distance}}{\text{Time}} \)

   Thus its unit is m/s. It means that unit of speed depends upon the fundamental unit of length and time.

2. The parallax method is used
   i. to measure separation between two sources (i.e., two planets), if distance (b) between them is very large.

   \[ s = \frac{\text{Basis}}{\text{Parallactic angle}} = \frac{b}{\theta} \]
ii. to find the size of an astronomical object.

![Diagram](image)

**Linear diameter** = distance \times \text{angular diameter}

\[ D = s \times \theta \]

3. To determine dimensions of a physical quantity, the unit of fundamental quantities are represented by ‘L’ for length, ‘M’ for mass, ‘T’ for time, ‘K’ for temperature, ‘I’ or ‘A’ for current, ‘C’ for luminous intensity and ‘mol’ for amount of substance.

4. Percentage error in different cases:
   i. If the error in ‘a’ is \( \Delta a \), then the percentage error in \( a \) is \( \frac{\Delta a}{a} \times 100 \)
   ii. If the error in ‘a’ is \( \Delta a \), then the percentage error in \( a^n \) is \( \pm n \left( \frac{\Delta a}{a} \right) \times 100 \)
   iii. If the error in measurement of \( a \) is \( \Delta a \) and the error in measurement of ‘b’ is \( \Delta b \) then, the percentage error in ‘ab’ is \( \pm \left( \frac{\Delta a}{a} + \frac{\Delta b}{b} \right) \times 100 \)

### Mindbenders

1. The dimensions of a physical quantity are independent of the system of units.
2. A physical quantity that does not have any unit is always dimensionless.
3. Angle is a special physical quantity which is a ratio of two similar physical quantities i.e., arc/radius and requires a unit.
4. In the formula, \([M^x L^y T^z] \); if \( x = y = z = 0 \), then the quantity is a dimensionless quantity.

Examples of dimensionless quantities: Strain, specific gravity, relative density, angle, solid angle, poisson’s ratio, relative permittivity, Reynold’s number, all the trigonometric ratios, refractive index, dielectric constant, magnetic susceptibility etc.

A dimensionless quantity has the same numeric value in all the system of units.

- **Dimensions, units, formulae of some quantities:**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Formula</th>
<th>Unit</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed</td>
<td>Distance / Time</td>
<td>m s(^{-1})</td>
<td>[M(^0)L(^1)T(^{-1})]</td>
</tr>
<tr>
<td>Acceleration</td>
<td>Change in velocity / Time</td>
<td>m s(^{-2})</td>
<td>[M(^0)L(^1)T(^{-2})]</td>
</tr>
<tr>
<td>Force</td>
<td>Mass \times Acceleration</td>
<td>N (newton)</td>
<td>[M(^1)L(^1)T(^{-2})]</td>
</tr>
<tr>
<td>Pressure</td>
<td>Force / Area</td>
<td>N m(^{-2})</td>
<td>[M(^1)L(^{-1})T(^{-2})]</td>
</tr>
<tr>
<td>Density</td>
<td>Mass / Volume</td>
<td>kg m(^{-3})</td>
<td>[M(^1)L(^{-3})T(^0)]</td>
</tr>
<tr>
<td>Work</td>
<td>Force \times distance</td>
<td>joule</td>
<td>[M(^1)L(^1)T(^{-2})] [L] = [M(^1)L(^2)T(^{-2})]</td>
</tr>
<tr>
<td></td>
<td>Formula</td>
<td>Unit</td>
<td>Dimension</td>
</tr>
<tr>
<td>------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-------------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>Energy</td>
<td>Force x distance</td>
<td>joule</td>
<td>$[M^1L^1T^{-2}]$</td>
</tr>
<tr>
<td>Power</td>
<td>Work/Time</td>
<td>watt</td>
<td>$[M^1L^2T^{-3}]$</td>
</tr>
<tr>
<td>Momentum</td>
<td>Mass x Velocity</td>
<td>kg m s$^{-1}$</td>
<td>$[M^1L^1T^{-1}]$</td>
</tr>
<tr>
<td>Impulse</td>
<td>Force x Time</td>
<td>N s</td>
<td>$[M^1L^2T^{-1}]$</td>
</tr>
<tr>
<td>Torque</td>
<td>$\tau = r \times F$</td>
<td>N m</td>
<td>$[M^1L^2T^{-2}] [L] = [M^1L^2T^{-2}]$</td>
</tr>
<tr>
<td>Temperature (T)</td>
<td>--</td>
<td>kelvin</td>
<td>$[M^0L^0T^0\theta^1]$</td>
</tr>
<tr>
<td>Heat (Q)</td>
<td>Energy</td>
<td>joule</td>
<td>$[M^1L^2T^{-2}]$</td>
</tr>
<tr>
<td>Specific heat (c)</td>
<td>$\frac{Q}{m\theta}$</td>
<td>joule/kg K</td>
<td>$[M^0L^2T^{-2}\theta^{-1}]$</td>
</tr>
<tr>
<td>Thermal capacity</td>
<td>--</td>
<td>joule/K</td>
<td>$[M^1L^2T^{-2}\theta^{-1}]$</td>
</tr>
<tr>
<td>Latent heat (L)</td>
<td>$\frac{\text{heat} (\theta)}{\text{mass} (m)}$</td>
<td>joule/kg</td>
<td>$[M^0L^2T^{-2}]$</td>
</tr>
<tr>
<td>Gas constant (R)</td>
<td>$\frac{PV}{T}$</td>
<td>joule/mol K</td>
<td>$[M^1L^2T^{-2}\theta^{-1}]$</td>
</tr>
<tr>
<td>Boltzmann constant (k)</td>
<td>$\frac{R}{N^{'}}$, $N$ = Avogadro number</td>
<td>joule/K</td>
<td>$[M^1L^2T^{-2}\theta^{-1}]$</td>
</tr>
<tr>
<td>Coefficient of thermal conductivity (K)</td>
<td>From $\frac{\Delta Q}{\Delta t} = KA\left(\frac{\Delta T}{\Delta x}\right)$</td>
<td>joule/m s K</td>
<td>$[M^1L^1T^{-3}\theta^{-1}]$</td>
</tr>
<tr>
<td>Stefan's constant ($\sigma$)</td>
<td>$\sigma = \frac{E}{T^4}$</td>
<td>watt/m$^2$ K$^4$</td>
<td>$[M^0L^1T^0\theta^{-4}]$</td>
</tr>
<tr>
<td>Wien's constant (b)</td>
<td>$b = N_m \times T$</td>
<td>m K</td>
<td>$[M^0L^1T^0\theta^1]$</td>
</tr>
<tr>
<td>Planck's constant (h)</td>
<td>$\frac{\text{Energy} (E)}{\text{Frequency} (F)}$</td>
<td>joule s</td>
<td>$[M^1L^2T^{-1}]$</td>
</tr>
<tr>
<td>Coefficient of linear Expansion ($\alpha$)</td>
<td>-- $\frac{\Delta L}{L} = \alpha \Delta T$</td>
<td>kelvin$^{-1}$</td>
<td>$[M^0L^0T^0\theta^1]$</td>
</tr>
<tr>
<td>Mechanical equivalent of Heat(J)</td>
<td>-- $\frac{\text{Work}}{\text{Charge}}$</td>
<td>joule/calorie</td>
<td>$[M^0L^0T^0]$</td>
</tr>
<tr>
<td>Electric charge (q)</td>
<td>Current x Time</td>
<td>coulomb</td>
<td>$[M^0L^1T^0A^1]$</td>
</tr>
<tr>
<td>Surface charge density($\sigma$)</td>
<td>$\sigma = \frac{\text{charge}}{\text{area}}$</td>
<td>coulomb metre$^{-2}$</td>
<td>$[M^0L^{-2}T^1A^1]$</td>
</tr>
<tr>
<td>Electric current (I)</td>
<td>--</td>
<td>ampere</td>
<td>$[M^0L^0T^0A^1]$</td>
</tr>
<tr>
<td>Current density (J)</td>
<td>Current per unit area</td>
<td>ampere/m$^2$</td>
<td>$[M^0L^{-2}T^0A^1]$</td>
</tr>
<tr>
<td>Electric potential (V)</td>
<td>$\frac{\text{Work}}{\text{Charge}}$</td>
<td>joule/ coulomb</td>
<td>$[M^1L^2T^{-3}A^{-1}]$</td>
</tr>
<tr>
<td>Intensity of electric field (E)</td>
<td>$\frac{\text{Force}}{\text{Charge}}$</td>
<td>volt/metre, newton/coulomb</td>
<td>$[M^1L^1T^{-3}A^{-1}]$</td>
</tr>
<tr>
<td>Property</td>
<td>P.D.</td>
<td>Unit</td>
<td>Dimension</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>--------------------------</td>
<td>-----------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Resistance (R)</td>
<td>P.D. Current</td>
<td>volt/ampere or ohm</td>
<td>[M$^1$L$^2$T$^{-3}$ A$^{-2}$]</td>
</tr>
<tr>
<td>Conductance</td>
<td>$\frac{1}{R}$</td>
<td>ohm$^{-1}$</td>
<td>[M$^{-1}$L$^{-2}$T$^3$A$^2$]</td>
</tr>
<tr>
<td>Resistivity or Specific resistance ($\rho$)</td>
<td>$\frac{R}{I}$</td>
<td>ohm metre</td>
<td>[M$^1$L$^3$T$^{-3}$ A$^{-2}$]</td>
</tr>
<tr>
<td>Conductivity ($\sigma$)</td>
<td>$\frac{1}{\rho}$</td>
<td>ohm$^{-1}$ metre$^{-1}$</td>
<td>[M$^{-1}$L$^{-3}$T$^3$A$^2$]</td>
</tr>
<tr>
<td>Electric dipole moment (p)</td>
<td>q(2a)</td>
<td>coulomb metre</td>
<td>[M$^0$L$^1$T$^1$A$^1$]</td>
</tr>
<tr>
<td>Permittivity of free space ($\varepsilon_0$)</td>
<td>$\varepsilon_0 = \frac{q_1 q_2}{4\pi F r^2}$</td>
<td>coulomb$^2$ newton metre$^2$</td>
<td>[M$^{-1}$L$^3$T$^4$A$^2$]</td>
</tr>
<tr>
<td>Dielectric constant (K)</td>
<td>$K = \frac{\varepsilon}{\varepsilon_0}$</td>
<td>Unitless</td>
<td>[M$^0$L$^0$T$^0$]</td>
</tr>
<tr>
<td>Capacitance (C)</td>
<td>Charge / P.D.</td>
<td>coulomb/ volt or farad</td>
<td>[M$^{-1}$L$^2$T$^4$A$^2$]</td>
</tr>
<tr>
<td>Coefficient of self induction (L)</td>
<td>$L = \frac{(w / q)dt}{dI}$</td>
<td>volt – second / ampere or henry or ohm-second</td>
<td>[M$^1$L$^2$T$^2$ A$^{-2}$]</td>
</tr>
<tr>
<td>Coefficient of mutual inductance (M)</td>
<td>$\frac{edt}{dI}$</td>
<td>henry</td>
<td>[M$^1$L$^2$T$^2$A$^{-2}$]</td>
</tr>
<tr>
<td>Magnetic flux (\phi)</td>
<td>$d\phi = \frac{wdt}{q}$</td>
<td>volt-second or weber</td>
<td>[M$^1$L$^2$T$^2$ A$^{-1}$]</td>
</tr>
<tr>
<td>Magnetic induction (B)</td>
<td>$B = \frac{F}{qv}$</td>
<td>newton / ampere metre or joule / ampere metre$^2$ or volt second / metre$^2$ or tesla</td>
<td>[M$^1$L$^0$T$^2$ A$^{-1}$]</td>
</tr>
<tr>
<td>Magnetic intensity (H)</td>
<td>$H = \frac{Id}{r^2}$</td>
<td>ampere/ metre</td>
<td>[M$^0$L$^{-1}$T$^0$ A$^1$]</td>
</tr>
<tr>
<td>Magnetic dipole moment (M)</td>
<td>M = IA</td>
<td>ampere metre$^2$</td>
<td>[M$^0$L$^2$T$^0$A$^1$]</td>
</tr>
<tr>
<td>Permeability of free space ($\mu_0$)</td>
<td>$\mu_0 = \frac{4\pi Fr^2}{m_1m_2}$</td>
<td>newton / ampere$^2$ or joule / ampere$^2$ metre or volt second / ampere metre or ohm second / metre or henry / metre</td>
<td>[M$^1$L$^1$T$^2$ A$^{-2}$]</td>
</tr>
<tr>
<td>Rydberg constant (R)</td>
<td>$\frac{2\pi^2 mk^2 e^4}{ch^3}$</td>
<td>m$^{-1}$</td>
<td>[M$^0$L$^{-1}$T$^0$]</td>
</tr>
</tbody>
</table>
- **Quantities having same dimensions:**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>([M^0L^0T^{-1}])</td>
<td>Frequency, angular frequency, angular velocity, velocity gradient and decay constant</td>
</tr>
<tr>
<td>([M^1L^2T^{-2}])</td>
<td>Work, internal energy, potential energy, kinetic energy, torque, moment of force</td>
</tr>
<tr>
<td>([M^1L^{-1}T^{-2}])</td>
<td>Pressure, stress, Young’s modulus, bulk modulus, modulus of rigidity, energy density</td>
</tr>
<tr>
<td>([M^1L^1T^{-2}])</td>
<td>Momentum, impulse</td>
</tr>
<tr>
<td>([M^1L^{-2}T^{-1}])</td>
<td>Acceleration due to gravity, gravitational field intensity</td>
</tr>
<tr>
<td>([M^1L^2T^{-1}])</td>
<td>Thrust, force, weight, energy gradient</td>
</tr>
<tr>
<td>([M^1L^3T^{-2}])</td>
<td>Angular momentum and Planck’s constant</td>
</tr>
<tr>
<td>([M^1L^0T^{-2}])</td>
<td>Surface tension, Surface energy (energy per unit area), spring constant</td>
</tr>
<tr>
<td>([M^0L^0T^{0}])</td>
<td>Strain, refractive index, relative density, angle, solid angle, distance gradient, relative permittivity (dielectric constant), relative permeability etc.</td>
</tr>
<tr>
<td>([M^1L^2T^{-2}])</td>
<td>Latent heat and gravitational potential</td>
</tr>
<tr>
<td>([ML^2T^{-2}0^{-1}])</td>
<td>Thermal capacity, gas constant, Boltzmann constant and entropy</td>
</tr>
<tr>
<td>([M^0L^0T^{1}])</td>
<td>[\sqrt{l} / g, \sqrt{m/k}, \sqrt{R/g}], where (l) = length, (g) = acceleration due to gravity, (m) = mass, (k) = spring constant, (R) = Radius of earth</td>
</tr>
<tr>
<td>([M^1L^0T^{1}])</td>
<td>(L/R, \sqrt{LC}, RC) where (L) = inductance, (R) = resistance, (C) = capacitance</td>
</tr>
<tr>
<td>([ML^2T^{-2}])</td>
<td>(I^2Rt, \frac{V^2}{R}, t, Vt, qV, L^2, \frac{q^2}{C}, CV^2) () where (I) = current, (t) = time, (q) = charge, (L) = inductance, (C) = capacitance, (R) = resistance</td>
</tr>
</tbody>
</table>

- **A few quick conversions:**
  i. Pressure:
     1 N/m\(^2\) = 10 dyne/cm\(^2\) or 1 dyne/cm\(^2\) = 0.1 N/m\(^2\).
  ii. Density:
     1 kg/m\(^3\) = 10\(^{-3}\) g/cm\(^3\) or 1 g/cm\(^3\) = 10\(^3\) kg/m\(^3\).
  iii. Coefficient of viscosity:
     SI units is decapoise (N s/m\(^2\)) and CGS unit is poise.
     1 poise = 10\(^{-1}\) decapoise or 1 decapoise = 10 poise.
  iv. Magnetic induction:
     SI unit is tesla (Wb/m\(^2\)) and CGS unit is Gauss.
     1 gauss = 10\(^{-4}\) tesla or 1 tesla = 10\(^4\) gauss.
  v. Magnetic flux:
     SI unit is weber and CGS unit is maxwell.
     1 Wb = 10\(^8\) maxwell or 1 maxwell = 10\(^{-8}\) Wb.

- **To express large or small magnitudes following prefixes are used:**

<table>
<thead>
<tr>
<th>Power of 10</th>
<th>Prefix</th>
<th>Symbol</th>
</tr>
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<tbody>
<tr>
<td>10(^{18})</td>
<td>exa</td>
<td>E</td>
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<tr>
<td>10(^{15})</td>
<td>peta</td>
<td>P</td>
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<td>10(^{12})</td>
<td>tera</td>
<td>T</td>
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<tr>
<td>10(^9)</td>
<td>giga</td>
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<td>10(^6)</td>
<td>mega</td>
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<td>10(^3)</td>
<td>kilo</td>
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<td>10(^2)</td>
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<td>10(^{-1})</td>
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<td>10(^{-3})</td>
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<td>10(^{-6})</td>
<td>micro</td>
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<td>10(^{-9})</td>
<td>nano</td>
<td>n</td>
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<td>10(^{-12})</td>
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<td>10(^{-15})</td>
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<tr>
<td>10(^{-18})</td>
<td>atto</td>
<td>a</td>
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</tbody>
</table>
1. The atomic, molecular and nuclear phenomena are the parts of _______ domain.
   (A) macroscopic (B) microscopic (C) megascopic (D) electroscopic

2. Nano size of gold has _______ colour.
   (A) yellow (B) red (C) pink (D) orange

3. Maxwell’s equations relate to _______.
   (A) law of gravitation (B) basic laws of electromagnetism (C) laws of electrostatics (D) nuclear model of an atom

4. _______ is needed for the experimental verification of various theories.
   (A) Unit (B) Symbol (C) Instrument (D) Measurement

5. The reference standard used for the measurement of a physical quantity is called _______.
   (A) standard quantity (B) dimension (C) constant (D) unit

6. Which of the following is NOT a characteristic of a good unit?
   (A) It is invariable. (B) It is reproducible. (C) It is perishable. (D) It is easily available.

7. Units are classified into _______ groups.
   (A) 2 (B) 4 (C) 5 (D) 6

8. A set of fundamental and derived units is known as _______.
   (A) supplementary units (B) system of units (C) complementary units (D) metric units

9. The physical quantity having the same unit in all the systems of unit is _______.
   (A) length (B) time (C) mass (D) foot

10. S.I. system of unit contains _______ supplementary unit.
    (A) 7 (B) 2 (C) many (D) 4

11. In which of following system, scientific data can be exchanged between different parts of the world?
    (A) M.K.S. (B) C.G.S. (C) F.P.S. (D) S.I.

12. Out of the following units, which is NOT a fundamental unit?
    (A) newton (B) second (C) pound (D) kg

13. Temperature can be expressed as a derived quantity in terms of _______.
    (A) length and mass (B) mass and time (C) length, mass and time (D) none of these

14. Which of the following is NOT a derived unit?
    (A) joule (B) erg (C) dyne (D) mole

15. Which of the following is the CORRECT way of writing units?
    (A) 25 ms length (B) 30 Kg (C) 5 Newton (D) 10 N

16. To measure the distance of a planet from the earth _______ method is used.
    (A) echo (B) direct (C) parallax (D) paradox

17. The mass of the body depends only on _______.
    (A) temperature. (B) pressure. (C) quantity of matter contained in the body. (D) location of the body from the observer.

18. Which of the following represents a unified atomic mass unit (1u)?
    (A) $8.333 \times 10^{-1}$ of the mass of an atom of $^{12}$C in kg
    (B) $0.8333 \times 10^{-1}$ of the mass of an atom of $^{12}$C in g
    (C) $8.333 \times 10^{-1}$ of the mass of an atom of $^{12}$C in g
    (D) $0.8333 \times 10^{-1}$ of the mass of an atom of $^{12}$C in kg
19. In cesium atomic clock ______ is used.
   (A) cesium-122 atom  (B) cesium-132 atom
   (C) cesium-133 atom  (D) cesium-134 atom

20. A ______ is the interval from one noon to the
    next noon.
   (A) mean solar day  (B) solar day
   (C) lunar day       (D) day

21. Light year is a unit for the measurement of
    ______.
   (A) distance  (B) time
   (C) temperature (D) luminous intensity

22. Which of the following quantity is expressed
    as force per unit area?
   (A) work  (B) pressure
   (C) volume (D) density

23. The physical quantity having the unit dyne g⁻¹
    is _______.
   (A) velocity  (B) mass
   (C) force     (D) acceleration

24. The SI unit of luminous intensity is _______.
    (A) watt  (B) lux
    (C) lumen (D) candela

25. Which of the following is a supplementary unit?
    (A) steradian (B) candela
    (C) kelvin   (D) pascal

26. The pressure of 10³ dyne/cm² is equivalent to
    (A) 10 N/m²  (B) 10² N/m²
    (C) 10⁻² N/m² (D) 10⁻¹ N/m²

**1.6 Dimensional analysis**

27. [M¹L⁻¹T⁻²] is the dimensional formula for
    _______.
    (A) joule constant  (B) gravitational constant
    (C) pressure        (D) force

28. Checking the correctness of physical equations using the method of dimensions is based on
    (A) equality of inertial frame of reference.
    (B) the type of system of units.
    (C) the method of measurement.
    (D) principle of homogeneity of dimensions.

29. A unitless quantity
    (A) always has a non-zero dimension.
    (B) may have a non-zero dimension.
    (C) never has a zero dimension.
    (D) has no dimensions.

30. Which of the following is NOT a dimensionless quantity?
    (A) angle  (B) strain
    (C) specific gravity  (D) density

31. The unit of plane angle is radian, hence its dimensions are
    (A) [M⁰L⁰T⁰]  (B) [M¹L⁻¹T⁰]
    (C) [M⁰L¹T⁻¹]  (D) [M¹L⁰T⁻¹]

32. Dimensional equation CANNOT be used
    (A) to check the correctness of a physical quantity.
    (B) to derive the relation between different physical quantities.
    (C) to find out constant of proportionality which may be pure number.
    (D) to change from one system of units to another system.

33. If the dimensional formula for the physical quantity is [M¹L²T⁻²] then the physical quantity is _______.
    (A) torque  (B) impulse
    (C) force   (D) force per unit area

34. If the dimensions of a physical quantity are given by [LᵃMᵇTᶜ], then the physical quantity will be
    (A) force, if a = -1, b = 0, c = -2
    (B) pressure, if a = -1, b = 1, c = -2
    (C) velocity, if a = 1, b = 0, c = 1
    (D) acceleration, if a = 1, b = 1, c = -2

**1.7 Order of magnitude and significant figures**

35. The value of the magnitude rounded off to the nearest integral power of 10 is called _______.
    (A) significant figure  (B) uncertain number
    (C) significant number  (D) order of magnitude

36. Order of magnitude of (10⁶ + 10³) is
    (A) 10¹⁸  (B) 10⁹
    (C) 10⁶   (D) 10³

37. The length of a rod is 0.5 x 10² m, the order of magnitude of the length of the rod is
    (A) 10² m  (B) 10³ m
    (C) 10¹ m  (D) 10⁻¹ m
38. The charge on the electron is \(1.6 \times 10^{-19}\) C. The order of magnitude is
(A) \(10^{19}\) C  (B) \(10^{18}\) C
(C) \(10^{-18}\) C  (D) \(10^{-19}\) C

39. Significant figures depends upon the _____ of the measuring instrument.
(A) length  (B) readings
(C) number  (D) accuracy

40. The number of significant figures in 0.0009 is
(A) 4  (B) 3
(C) 2  (D) 1

41. The number of significant figures in 0.400 is
(A) 1  (B) 2
(C) 3  (D) 4

42. The number of significant figures in 0.0500 is
(A) 4  (B) 3
(C) 2  (D) 1

43. State the number of significant figures in 6.032 J
(A) 4  (B) 3
(C) 2  (D) 1

1.8 Accuracy and errors in measurements

44. The difference between the true value and measured value is called _______.
(A) mistake  (B) error
(C) significant figures  (D) fault

45. If the pointer of the voltmeter is not exactly at the zero of the scale then the error is called _______.
(A) instrumental error  (B) systematic error
(C) personal error  (D) random error

46. Zero error of an instrument introduces
(A) systematic error  (B) random error
(C) instrumental error  (D) none of these

47. Accidental error can be minimised by
(A) taking only one reading.
(B) taking small magnitude of the quantity.
(C) selecting instrument with greater least count.
(D) selecting instrument with small least count.

48. Constant error can be caused due to
(A) faulty construction of instrument.
(B) wrong setting of instrument.
(C) lack of concentration of observer.
(D) wrong procedure of handling the instrument.

49. Error due to non-removal of parallax between pointer and its image in case of magnetic compass needle causes _______.
(A) instrumental error  (B) persistant error
(C) personal error  (D) random error

50. Instrumental error can be minimised by
(A) taking large number of readings.
(B) using different accurate instrument for the same reading.
(C) adjusting zero of the instrument.
(D) maintaining the temperature of the surrounding.

51. The magnitude of the difference between mean value and each individual value is called _______.
(A) absolute error  (B) error in reading
(C) most probable error  (D) true error

52. The formula for percentage error is
(A) \(\text{Percentage error} = \frac{|\Delta a_m|}{a_m} \times 100\%\)
(B) \(\text{Percentage error} = \frac{1}{\sum_{i=1}^{n}}|\Delta a_i| \times 100\%\)
(C) \(\text{Percentage error} = \frac{a_m}{|\Delta a_m|} \times 100\%\)
(D) \(\text{Percentage error} = \frac{1}{\sum_{i=1}^{n}} \times 100\%\)

53. If \(x = \frac{a}{b}\), then maximum relative error in the measurement is
(A) \(\frac{\Delta a}{a} / \frac{\Delta b}{b}\)
(B) \(\frac{\Delta a}{a} + \frac{\Delta b}{b}\)
(C) \(\frac{\Delta a}{a} - \frac{\Delta b}{b}\)
(D) \(\frac{\Delta b}{b} / |\Delta a/a|\)

54. Given: \(l_1 = 44.2 \pm 0.1\) and \(l_2 = 23.1 \pm 0.1\), the uncertainty in \(l_1 + l_2\) is
(A) 0  (B) 0.1
(C) 0.2  (D) 0.4

55. Two resistances \(R_1 = 50 \pm 2\) ohm and \(R_2 = 60 \pm 3\) ohm are connected in series, the equivalent resistance of the series combination is
(A) \((110 \pm 4)\) ohm  (B) \((110 \pm 2)\) ohm
(C) \((110 \pm 5)\) ohm  (D) \((110 \pm 6)\) ohm
56. If \( x = a^n \) then relative error is (where \( n \) is power of \( a \))
   (A) \( \frac{\Delta a}{a} + n \)  
   (B) \( n \frac{\Delta a}{a} \)  
   (C) \( \frac{\Delta a}{a} - n \)  
   (D) \( \frac{\Delta a}{na} \)

57. Thickness of the paper measured by micrometer screw gauge of least count 0.01 mm is 1.03 mm, the percentage error in the measurement of thickness of paper is
   (A) 1.1%  
   (B) 1%  
   (C) 0.97%  
   (D) 0.8%

Miscellaneous

58. One micron is related to centimetre as
   (A) 1 micron = \( 10^{-8} \) cm  
   (B) 1 micron = \( 10^{-6} \) cm  
   (C) 1 micron = \( 10^{-5} \) cm  
   (D) 1 micron = \( 10^{-4} \) cm
9. To determine the Young’s modulus of a wire, the formula is \( Y = \frac{FL}{A\Delta L} \); where \( L \) = length, \( A \) = area of cross-section of the wire, \( \Delta L \) = change in length of the wire when stretched with a force \( F \). The conversion factor to change it from CGS to MKS system is

(A) 1  (B) 10  
(C) 0.1  (D) 0.01

10. The moon subtends an angle of 57 minute at the base-line equal to the radius of the earth. What is the distance of the moon from the earth? [Radius of the earth = \( 6.4 \times 10^6 \) m]

(A) \( 11.22 \times 10^8 \) m  (B) \( 3.86 \times 10^8 \) m  
(C) \( 3.68 \times 10^{-3} \) cm  (D) \( 3.68 \times 10^8 \) cm

11. The angular diameter of the sun is 1920” . If the distance of the sun from the earth is \( 1.5 \times 10^{11} \) m, then the linear diameter of the sun is

(A) \( 2.6 \times 10^9 \) m  (B) \( 0.7 \times 10^9 \) m  
(C) \( 5.2 \times 10^9 \) m  (D) \( 1.4 \times 10^9 \) m

1.6 Dimensional analysis

12. The fundamental physical quantities that have same dimensions in the dimensional formulae of torque and angular momentum are

(A) mass, time  (B) time, length  
(C) mass, length  (D) time, mole

13. Which of the following represents correct dimensions of the coefficient of viscosity?

(A) \( [M^1L^{-1}T^{-2}] \)  (B) \( [M^1L^{-1}T^{-1}] \)  
(C) \( [M^1L^1T^{-1}] \)  (D) \( [M^1L^{-2}T^{-2}] \)

14. The dimensional equation for the electrical resistance of a conductor is

(A) \( [M^1L^2T^{-1}I^{-1}] \)  (B) \( [M^1L^2T^{-2}I^{-2}] \)  
(C) \( [M^1L^1T^{-3}I^{-2}] \)  (D) \( [M^1L^2T^{-3}I^{-2}] \)

15. Dimensions of length in electric dipole moment, electric flux and electric field are respectively

(A) \( L, L^2, L^3 \)  (B) \( L^3, L^2, L \)  
(C) \( L^{-1}, L^3, L^3 \)  (D) \( L, L^3, L \)

16. If \( L \) denotes the inductance of an inductor through which a current \( i \) is flowing, the dimensions of \( Li^2 \) are

(A) \( [L^2M^1T^{-2}] \)  (B) Not expressible in LMT  
(C) \( [L^1M^1T^{-2}] \)  (D) \( [L^2M^2T^{-2}] \)

17. If the magnitude of length is halved and that of mass is doubled then dimension of force is

(A) \( [M^2L^{-2}T^{-2}] \)  (B) \( [M^4L^{-1/2}T^{-2}] \)  
(C) \( [M^2L^{1/2}T^{-2}] \)  (D) \( [M^1L^1T^{-2}] \)

18. Out of the following pairs, which one does NOT have identical dimensions?

(A) Energy and moment of force  (B) Work and torque  
(C) Density and surface energy  (D) Pressure and stress

19. Which of the following equations is dimensionally correct?

(A) pressure = Energy per unit volume  (B) pressure = Energy per unit area  
(C) pressure = Momentum \( \times \) volume \( \times \) time  (D) pressure = Force \( \times \) area

20. The dimensional formula for impulse is the same as dimensional formula for _____.

(A) acceleration  (B) force  
(C) momentum  (D) rate of change in momentum

21. The dimensions of \( \frac{1}{\sqrt{e_0\varepsilon_0}} \) is that of

(A) Velocity  (B) Time  
(C) Capacitance  (D) Distance

22. Which of the following pair has same dimensions?

(A) Energy and moment of force  (B) Work and torque  
(C) Density and surface energy  (D) Pressure and stress

23. The terminal velocity \( v \) of a small steel ball of radius \( r \) falling under gravity through a column of viscous liquid coefficient of viscosity \( \eta \) depends on mass of the ball \( m \), acceleration due to gravity \( g \). Which of the following relation is dimensionally correct?

(A) \( v \propto \frac{mg}{\eta r} \)  (B) \( v \propto \frac{mg}{\eta} \)  
(C) \( v \propto \frac{mg}{\eta r} \)  (D) \( v \propto \frac{\eta mg}{r} \)

24. A force \( F \) is given by \( F = at + bt^2 \), where ‘t’ is time. What are the dimensions of a and b?

(A) \( [M^1L^1T^{-1}] \) and \( [M^1L^0T^0] \)  (B) \( [M^1L^1T^{-1}] \) and \( [M^1L^1T^{-1}] \)  
(C) \( [M^1L^1T^{-1}] \) and \( [M^1L^1T^1] \)  (D) \( [M^1L^{-3}T^{-1}] \) and \( [M^1L^1T^{-1}] \)
25. The force \( F \) is expressed in terms of distance \( x \) and time \( t \) as \( F = ax + bt^2 \). The dimensions of \( a/b \) is
   (A) \([M^0L^0T^{-2}]\)  (B) \([M^1L^0T^{-2}]\)
   (C) \([M^0L^{-1/2}T^2]\)  (D) \([M^0L^{-1/2}T^{-2}]\)

26. For the equation \( F \propto A^a v^b d^c \), where \( F \) is the force, \( A \) is the area, \( v \) is the velocity and \( d \) is the density, the values of \( a \), \( b \) and \( c \) are respectively
   (A) 1, 2, 1  (B) 2, 1, 1
   (C) 1, 1, 2  (D) 0, 1, 1

27. Using the principle of homogeneity of dimensions, find which of the following relation is correct? [\( T \) is the time period, \( a \) is the radius of the orbit and \( M \) is the mass of the sun.]
   (A) \( T^2 = \frac{4\pi^2a^3}{GM} \)  (B) \( T^2 = \frac{2\pi a}{GM} \)
   (C) \( T^2 = 4\pi^2a^3 \)  (D) \( T^2 = \frac{2\pi a^3}{GM^2} \)

28. The period of a body under SHM is represented by \( T = \sqrt{\frac{P D^a S^b}{G}} \); where \( P \) is pressure, \( D \) is density and \( S \) is surface tension. The value of \( a \), \( b \) and \( c \) are
   (A) \( -\frac{3}{2}, \frac{1}{2}, 1 \)  (B) \(-1, -2, 3 \)
   (C) \( \frac{1}{2}, -\frac{3}{2}, \frac{1}{2} \)  (D) \( 1, 2, \frac{1}{3} \)

29. The equation of a wave is given by
   \[ Y = A \sin \left( \frac{x}{v} \right) \]
   where \( \omega \) is the angular velocity and \( v \) is the linear velocity. The dimension of \( k \) is
   (A) \( LT \)  (B) \( T \)
   (C) \( T^{-1} \)  (D) \( T^2 \)

30. Find the dimensions of \( (a/b) \) in the equation:
   \[ P = \frac{a - t^2}{bx} \]
   Where \( P \) is pressure, \( x \) is distance and \( t \) is time.
   (A) \([M^1L^1T^{-2}]\)  (B) \([M^1L^0T^{-2}]\)
   (C) \([M^{-1}L^{-2}T^2] \)  (D) \([M^2L^{-2}T^2] \)

31. The equation of state of some gases can be expressed as
   \[ P + \frac{a}{V^2} (V - b) = RT \]. Here \( P \) is the pressure, \( V \) is the volume, \( T \) is the absolute temperature and \( a \), \( b \), \( R \) are constants. The dimensions of \( \frac{a}{b} \) are
   (A) \([M^2L^2T^{-2}]\)  (B) \([ML^{-1}T^{-2}]\)
   (C) \([M^0L^3T^0] \)  (D) \([M^1L^0T^0] \)

32. If the speed of light \( c \), acceleration due to gravity \( g \) and pressure \( p \) are taken as the fundamental quantities, then the dimension of gravitational constant is
   (A) \([c^2g^0p^{-1}] \)  (B) \([c^0g^2p^{-1}] \)
   (C) \([cg^0p^{-2}] \)  (D) \([c^{-1}g^0p^{-1}] \)

33. The value of acceleration due to gravity is 980 cm s\(^{-2}\). If the unit of length is kilometre and that of time is minute then value of acceleration due to gravity is
   (A) 980 km min\(^{-2}\)  (B) 98 km min\(^{-2}\)
   (C) 35.28 km min\(^{-2}\)  (D) 28.35 km min\(^{-2}\)

1.7 Order of magnitude and significant figures

34. The magnitude of any physical quantity can be expressed as \( A \times 10^n \) where \( n \) is a number called order of magnitude and \( A \) is
   (A) \( 0.1 \leq A < 1 \)  (B) \( 0.5 \leq A < 5 \)
   (C) \( 5 \leq A < 9 \)  (D) \( 1 \leq A > 9 \)

35. The radius of the earth is 6400 km, the order of magnitude is
   (A) \( 10^7 \) m  (B) \( 10^4 \) m
   (C) \( 10^3 \) m  (D) \( 10^2 \) m

36. The order of magnitude of 49 and the order of magnitude of 51
   (A) is same.  (B) differs by 1.
   (C) is 1.  (D) is 2.

37. Calculate the number of seconds in a day and express it in the order of magnitude.
   (A) \( 8.64 \times 10^4 \) s, \( 10^5 \) s  (B) \( 6.84 \times 10^4 \) s, \( 10^4 \) s
   (C) \( 8.64 \times 10^5 \) s, \( 10^5 \) s  (D) \( 6.85 \times 10^4 \) s, \( 10^5 \) s

38. Figure which is of some significance but it does not necessarily denote certainty is defined as _______.
   (A) special figures  (B) characteristic figures
   (C) unknown figures  (D) significant figures

39. The number of significant figures in all the given numbers 25.12, 2009, 4.156 and \( 1.217 \times 10^{-4} \) is
   (A) 1  (B) 2
   (C) 3  (D) 4

40. The answer of \( (9.15 + 3.8) \) with due regards to significant figure is
   (A) 13.000  (B) 13.00
   (C) 13.0  (D) 13
41. In the reading 2.614 cm of measurement with a vernier calliper, only uncertain figure is
(A) 1  (B) 2
(C) 4  (D) 6

42. The sides of a rectangle are 6.01 m and 12 m. Taking the significant figures into account, the area of the rectangle is
(A) 72.00 cm²  (B) 72.1 cm²
(C) 72 m²  (D) 72.12 cm²

1.8 Accuracy and errors in measurements

43. Estimate the mean absolute error from the following data.
20.17, 21.23, 20.79, 22.07, 21.78
(A) 0.85  (B) 0.58
(C) 0.03  (D) 0.01

44. In the expression \( A = \frac{xy^3}{z^2} \), the percentage error is given by
(A) \( \frac{\Delta x}{x} + 3\frac{\Delta y}{y} - 2\frac{\Delta z}{z} \) \times 100%
(B) \( \frac{\Delta x}{x} + 3\frac{\Delta y}{y} + 2\frac{\Delta z}{z} \) \times 100%
(C) \( \frac{\Delta x}{x} - 3\frac{\Delta y}{y} - 2\frac{\Delta z}{z} \) \times 100%
(D) \( \frac{\Delta x}{x} - 3\frac{\Delta y}{y} + 2\frac{\Delta z}{z} \) \times 100%

45. The least count of a screw gauge is 0.005 cm. The diameter of a wire is 0.020 cm as measured by it. The percentage error in measurement is
(A) 25%  (B) 20%
(C) 15%  (D) 5%

46. The percentage error in the measurement of radius \( r \) of a sphere is 0.1% then the percentage error introduced in the measurement of volume is
(A) 0.1%  (B) 0.2%
(C) 0.25%  (D) 0.3%

47. The pressure on a square plate is measured by measuring the force on the plate and the length of the sides of the plate. If the maximum error in the measurement of force and length are respectively 4% and 2%, The maximum error in the measurement of pressure is
(A) 1%  (B) 2%
(C) 6%  (D) 8%

48. The percentage error in the measurement of mass of a body is 0.75% and the percentage error in the measurement of its speed is 1.85%. Then the percentage error in the measurement of its kinetic energy is
(A) 7.05%  (B) 4.45%
(C) 2.6%  (D) 1.1%

49. The error in the measurement of length (\( L \)) of the simple pendulum is 0.1% and the error in time period (\( T \)) is 3%. The maximum possible error in the measurement of \( \frac{L}{T^2} \) is
(A) 2.9%  (B) 3.1%
(C) 5.9%  (D) 6.1%

50. The period of oscillation of a simple pendulum is given by \( T = 2\pi \sqrt{\frac{L}{g}} \) where \( l \) is about 100 cm and is known to have 1 mm accuracy. The period is about 2 s. The time of 100 oscillations is measured by a stop watch of least count 0.1 s. The percentage error in \( g \) is
(A) 0.1%  (B) 1%
(C) 0.3%  (D) 0.8%

51. The length, breadth and height of a rectangular block of wood were measured to be
\( l = 13.12 \pm 0.02 \) cm, \( b = 7.18 \pm 0.01 \) cm, \( h = 4.16 \pm 0.02 \) cm.
The percentage error in the volume of the block will be
(A) 7%  (B) 0.77%
(C) 0.72%  (D) 0.27%

52. The heat dissipated in a resistance can be determined from the relation: \( H = \frac{I^2Rt}{4.2} \) cal
If the maximum errors in the measurement of current, resistance and time are 2%, 1% and 1% respectively, what would be the maximum error in the dissipated heat?
(A) 5%  (B) 4%
(C) 6%  (D) 0.5%

Miscellaneous

53. If momentum (\( P \)), area (\( A \)) and time (\( T \)) are assumed to be fundamental quantities, then energy has dimensional formula
(A) \([P^1A^{-1/2}T^{-1}]\)  (B) \([P^1A^{1/2}T^{-1}]\)
(C) \([P^2A^{-1}T^{-1}]\)  (D) \([P^1A^{-1}T^{-1}]\)
54. **Assertion:** Avogadro number is the number of atoms in one gram mole.

**Reason:** Avogadro number is a dimensionless constant.

(A) Assertion is True, Reason is True; Reason is a correct explanation for Assertion

(B) Assertion is True, Reason is True; Reason is not a correct explanation for Assertion

(C) Assertion is True, Reason is False

(D) Assertion is False, Reason is False.

55. **Assertion:** The graph between P and Q is straight line, when P/Q is constant.

**Reason:** The straight line graph means that P is proportional to Q or P is equal to constant multiplied by Q.

(A) Assertion is True, Reason is True; Reason is a correct explanation for Assertion

(B) Assertion is True, Reason is True; Reason is not a correct explanation for Assertion

(C) Assertion is True, Reason is False

(D) Assertion is False, Reason is False.

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**Competitive Thinking**

1.5 **Fundamental and derived units**

1. Correct unit of surface tension is

   (A) \( \frac{N}{m^2} \) (B) \( \frac{J}{m} \)

   (C) \( J - m \) (D) \( \frac{J}{m^2} \)

2. Which of the following is not the unit of energy?

   (A) watt-hour (B) electron volt

   (C) \( N \) (D) \( kg \) \( m^2 \) \( s^{-2} \)

3. Units of ‘a’ in Van der Waals equation of state is

   (A) \( Nm^4/\text{mole} \) (B) \( Nm^3/\text{mole} \)

   (C) \( N^2m/\text{mole} \) (D) none of these.

4. Unit of constant b in Van der Waal’s equation is

   (A) \( m^3/\text{mole} \) (B) \( m^3/\text{mole} \)

   (C) \( m/\text{mole} \) (D) \( m^3 \)

5. The S.I. units of the constant in Wein’s displacement law are

   (A) \( cm \) \( K^{-1} \) (B) mK

   (C) \( cm^2K^{-1} \) (D) cm \( K^{-2} \)

6. S.I unit of principle specific heat is

   (A) kcal/gm K (B) cal/gm K

   (C) J/kg K (D) erg/kg K

7. \( \tau \) is unit of

   (A) capacitance. (B) charge.

   (C) energy. (D) power.

8. S.I. unit of specific resistance is

   (A) \( \Omega cm \) (B) \( \Omega m \)

   (C) \( \Omega/cm \) (D) mho-cm

9. The unit of permeability of vacuum (\( \mu_0 \)) is

   (A) \( \frac{N}{A} \) (B) \( \frac{N}{A^2} \)

   (C) NA (D) \( \frac{J}{A^2} \)

10. 1 Tesla =

    (A) \( 1 \) Wb/m (B) \( 1 \) J/Am

     (C) \( 1 \) N/Am (D) \( 1 \) Am/N
11. Unit of ‘λ’ in radioactivity is [MH CET 2002]
   (A) \( m \) (B) (unit of half life)\(^{-1} \)
   (C) (year)\(^{-1} \) (D) sec

12. If the unit of length and force be increased four times, then the unit of energy is [Kerala PMT 2005]
   (A) increased 4 times.
   (B) increased 8 times.
   (C) increased 16 times.
   (D) decreased 16 times.

13. The surface tension of a liquid is \( 10^8 \) dyne/cm. It is equivalent to [MH CET 1999]
   (A) \( 10^7 \) N/m (B) \( 10^6 \) N/m
   (C) \( 10^5 \) N/m (D) \( 10^4 \) N/m

1.6 Dimensional analysis

14. The quantities RC and \( \frac{L}{R} \) (where R, L and C stand for resistance, inductance and capacitance respectively) have the dimensions of [Kerala PET 2010]
   (A) force (B) linear momentum
   (C) linear acceleration (D) time

15. R, L and C represent the physical quantities resistance, inductance and capacitance respectively. Which one of the following combination has dimensions of frequency? [IIT JEE 1986]
   (A) \( \frac{R}{\sqrt{RC}} \) (B) \( \frac{R}{L} \)
   (C) \( \frac{1}{LC} \) (D) \( \frac{C}{L} \)

16. The quantity \( X=\frac{\varepsilon_0 LV}{t} \) : \( \varepsilon_0 \) is the permittivity of free space, L is length, V is potential difference and t is time. The dimensions of X are same as that of [IIT JEE 2001; AMU (Engg.) 2009]
   (A) Resistance (B) Charge
   (C) Voltage (D) Current

17. Planck’s constant has same dimensions as [MH CET 2004]
   (A) energy. (B) angular momentum.
   (C) mass. (D) force.

18. Dimension’s of Planck’s constant are same as the dimensions of the product of [MH CET 2010]
   (A) Force and time
   (B) Force, displacement and time.
   (C) Force and velocity
   (D) Force and displacement

19. Which of the following set have different dimensions? [IIT 2005]
   (A) Pressure, Young’s modulus, stress
   (B) e.m.f, potential difference, electric potential
   (C) Heat, work done, energy
   (D) dipole moment, electric flux, electric field

20. The dimensions of G, the gravitational constant, are [AIIMS 2000; MH CET 2006; Orissa JEE 2010; BCECE 2015]
   (A) \([MLT^{-2}]\) (B) \([ML^3T^{-2}]\)
   (C) \([M^{-1}L^3T^{-2}]\) (D) \([M^{-1}LT^{-2}]\)

21. Dimension of angular momentum is [MH CET 2004]
   (A) \([M^1L^2T^{-2}]\) (B) \([M^1L^{-2}T^{-1}]\)
   (C) \([M^1L^2T^{-2}]\) (D) \([M^1L^0T^{-1}]\)

22. Dimension of surface tension is [MH CET 2002]
   (A) \([M^1L^2T^{-2}]\) (B) \([M^1L^0T^{-2}]\)
   (C) \([M^1L^2T^{-2}]\) (D) \([M^1L^2T^{-2}]\)

23. Dimension of force constant is given by, [MH CET 2003]
   (A) \([M^1L^2T^{-2}]\) (B) \([M^0L^1T^{-1}]\)
   (C) \([M^1L^2T^{-2}]\) (D) \([M^0L^0T^{-2}]\)

24. The dimensions of K in the equation
   \[ W = \frac{1}{2} K x^2 \] is [Orissa JEE 2003]
   (A) \([M^1L^0T^{-2}]\) (B) \([M^0L^1T^{-1}]\)
   (C) \([M^1L^2T^{-2}]\) (D) \([M^0L^0T^{-1}]\)

25. An object is moving through the liquid. The viscous damping force acting on it is proportional to the velocity. Then dimension of constant of proportionality is [Orissa JEE 2002]
   (A) \([M^1L^{-1}T^{-1}]\) (B) \([M^1L^1T^{-1}]\)
   (C) \([M^1L^{-1}T^{-1}]\) (D) \([M^1L^0T^{-1}]\)

26. The dimensional formula for Reynold’s number is [MH CET 2014]
   (A) \([L^0M^0T^0]\) (B) \([L^1M^1T^1]\)
   (C) \([L^{-1}M^1T^1]\) (D) \([L^1M^1T^{-1}]\)
27. The dimensions of universal gas constant is
   \[ \text{[Pb PET 2003; AIIMS 2010]} \]
   (A) \[ \text{[ML}^2\text{T}^{-2}\theta^{-1}] \]  (B) \[ \text{[M}^2\text{L}^2\text{T}^2\theta^{-2}] \]
   (C) \[ \text{[ML}^2\text{T}^{-3}\theta^{-1}] \]  (D) None of these

28. The relation between force ‘F’ and density ‘d’ is
   \[ F = \frac{x}{\sqrt{d}} \text{.} \] The dimensions of x are
   \[ \text{[MH CET 2014]} \]
   (A) \[ \text{[L}^{-\frac{1}{2}}\text{M}^\frac{1}{2}\text{T}^{-\frac{1}{2}}] \]  (B) \[ \text{[L}^{-\frac{1}{2}}\text{M}^\frac{1}{2}\text{T}^{-\frac{1}{2}}] \]
   (C) \[ \text{[L}^{-1}\text{M}^\frac{1}{2}\text{T}^{-\frac{1}{2}}] \]  (D) \[ \text{[L}^{-1}\text{M}^\frac{1}{2}\text{T}^{-\frac{1}{2}}] \]

29. Force F is given by the equation
   \[ F = \frac{X}{\text{Linear density}} \text{.} \] Then dimensions of X are
   \[ \text{[TS EAMCET (Engg.) 2015]} \]
   (A) \[ \text{[M}^\frac{1}{2}\text{L}^\frac{3}{2}\text{T}^{-1}] \]  (B) \[ \text{[M}^\frac{1}{2}\text{L}^\frac{3}{2}\text{T}^{-1}] \]
   (C) \[ \text{[L}^2\text{T}^{-2}] \]  (D) \[ \text{[M}^\frac{1}{2}\text{L}^\frac{3}{2}\text{T}^{-2}] \]

30. What is dimension of a in Van der Waal’s equation?
   \[ \text{[MH CET 2005]} \]
   (A) \[ \text{[M}^{-\frac{1}{2}}\text{L}^{\frac{3}{2}}\text{T}^{-\frac{1}{2}}\text{mol}^{-\frac{3}{2}}] \]  (B) \[ \text{[M}^{\frac{1}{2}}\text{L}^{\frac{3}{2}}\text{T}^{-\frac{1}{2}}\text{mol}^{-\frac{3}{2}}] \]
   (C) \[ \text{[M}^\frac{1}{2}\text{L}^\frac{3}{2}\text{T}^{-\frac{1}{2}}\text{mol}^{-\frac{3}{2}}] \]  (D) \[ \text{[M}^\frac{1}{2}\text{L}^\frac{3}{2}\text{T}^{-\frac{1}{2}}\text{mol}^{-\frac{3}{2}}] \]

31. Let \( \varepsilon_0 \) denote the dimensional formula of the permittivity of vacuum. If M = mass, L = length, T = time and A = electric current, then
   \[ \text{[JEE (Main) 2013]} \]
   (A) \[ \text{[M}^{-1}\text{L}^{-3}\text{T}^{-2}\text{A}] \]  (B) \[ \text{[M}^{0}\text{L}^{0}\text{T}^{-4}\text{A}^{-1}] \]
   (C) \[ \text{[M}^{-1}\text{L}^{-2}\text{T}^{-1}\text{A}^{2}] \]  (D) \[ \text{[M}^{0}\text{L}^{0}\text{T}^{-2}\text{A}] \]

32. Dimensional formula for electrical field is
   \[ \text{[GUJ CET 2014]} \]
   (A) \[ \text{[M}^1\text{L}^2\text{T}^{-3}\text{A}^{2}] \]  (B) \[ \text{[M}^1\text{L}^2\text{T}^{-3}\text{A}^{2}] \]
   (C) \[ \text{[M}^1\text{L}^1\text{T}^{-3}\text{A}^{1}] \]  (D) \[ \text{[M}^0\text{L}^{0}\text{T}^{4}\text{A}^{4}] \]

33. The dimension of \( \frac{1}{2} \varepsilon_0 E^2 \), where \( \varepsilon_0 \) is permittivity of free space and E is electric field, is
   \[ \text{[AIPMT 2010]} \]
   (A) \[ \text{[L}^{-2}\text{M}^1\text{T}^{-2}] \]  (B) \[ \text{[L}^1\text{M}^1\text{T}^{-2}] \]
   (C) \[ \text{[L}^2\text{M}^1\text{T}^2] \]  (D) \[ \text{[L}^1\text{M}^1\text{T}^1] \]

34. The dimensional formula of magnetic flux is
   \[ \text{[MH CET 2001, GUJ CET 2014]} \]
   (A) \[ \text{[M}^1\text{L}^2\text{T}^{-3}\text{A}^{-1}] \]  (B) \[ \text{[M}^1\text{L}^2\text{T}^{-3}\text{A}^{-1}] \]
   (C) \[ \text{[M}^{-1}\text{L}^2\text{T}^2\text{A}^{1}] \]  (D) \[ \text{[M}^1\text{L}^2\text{T}^2\text{A}^{-3}] \]

35. The dimensions of solar constant are
   \[ \text{[BCECE 2015]} \]
   (A) \[ \text{[M}^{0}\text{L}^{0}\text{T}^{0}] \]  (B) \[ \text{[M}^{0}\text{L}^{0}\text{T}^{0}] \]
   (C) \[ \text{[M}^{0}\text{L}^{0}\text{T}^{0}] \]  (D) \[ \text{[M}^{0}\text{L}^{0}\text{T}^{0}] \]

36. The velocity v of a particle at time t is given by
   \[ v = at + \frac{b}{t+c} \text{, where a, b and c are constants.} \] The dimensions of a, b and c are respectively
   \[ \text{[AIPMT 2006]} \]
   (A) \[ \text{L, LT and T} \]  (B) \[ \text{L, LT and T} \]
   (C) \[ \text{L, LT and T} \]  (D) \[ \text{L, LT and T} \]

37. If E, M, J and G respectively denote energy, mass, angular momentum and gravitational constant, then
   \[ \frac{EJ^2}{M^2G^2} \] has the dimensions of
   \[ \text{[AIIMS 1985; IIT 1990]} \]
   (A) \[ \text{length} \]  (B) \[ \text{angle} \]
   (C) \[ \text{mass} \]  (D) \[ \text{time} \]

38. If X = 3YZ^2 then the dimension of Y in MKS system, if X and Z are the dimension of capacity and magnetic field respectively is
   \[ \text{[MP PMT 2003]} \]
   (A) \[ \text{[M}^{-3}\text{L}^{-2}\text{T}^{-4}\text{A}^{-1}] \]  (B) \[ \text{[M}^1\text{L}^{-2}] \]
   (C) \[ \text{[M}^{-3}\text{L}^{-2}\text{T}^{-4}\text{A}^{-1}] \]  (D) \[ \text{[M}^{-3}\text{L}^{-2}\text{T}^{-8}\text{A}^{-4}] \]

39. If the time period (T) of vibration of a liquid drop depends on surface tension (S), radius (r) of the drop and density (\( \rho \)) of the liquid, then the expression of T is
   \[ \text{[AMU (Med.) 2000]} \]
   (A) \[ T = k\sqrt{r^3 / S} \]  (B) \[ T = k\sqrt{r^{3/2} / S} \]
   (C) \[ T = k\sqrt{r^3 / S^{1/2}} \]  (D) \[ T = \text{None of these} \]
40. In the relation \( P = \frac{\alpha}{\beta} e^{\frac{-aZ}{k\theta}} \) P is pressure, Z is the distance, k is Boltzmann’s constant and \( \theta \) is the temperature. The dimensional formula of \( \beta \) will be \[ \text{IIT (Screening) 2004} \]

(A) \([M^0L^2T^{-1}]\)
(B) \([M^1L^1T^{-1}]\)
(C) \([M^1L^0T^{-1}]\)
(D) \([M^0L^2T^{-2}]\)

41. Match the following two columns.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Electrical resistance</td>
<td>(p) ([ML^3T^{-3}A^{-2}])</td>
</tr>
<tr>
<td>(b) Electrical potential</td>
<td>(q) ([ML^2T^{-3}A^{-2}])</td>
</tr>
<tr>
<td>(c) Specific resistance</td>
<td>(r) ([ML^2T^{-2}A^{-1}])</td>
</tr>
<tr>
<td>(d) Specific conductance</td>
<td>(s) None of these</td>
</tr>
</tbody>
</table>

\[ \text{GUJ CET 2015} \]

(A) a – q, b – s, c – r, d – p
(B) a – q, b – r, c – p, d – s
(C) a – p, b – q, c – s, d – r
(D) a – p, b – r, c – q, d – s

42. Match the list-I with list-II

<table>
<thead>
<tr>
<th>List-I</th>
<th>List-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>P Boltzmann constant</td>
<td>(I) ([ML^0T^0])</td>
</tr>
<tr>
<td>Q Coefficient of viscosity</td>
<td>(II) ([ML^{-1}T^{-1}])</td>
</tr>
<tr>
<td>R Water equivalent</td>
<td>(III) ([MLT^{-3}K^{-1}])</td>
</tr>
<tr>
<td>S Coefficient of thermal conductivity</td>
<td>(IV) ([ML^2T^{-2}K^{-1}])</td>
</tr>
</tbody>
</table>

\[ \text{AP EAMCET (Engg.) 2016} \]

(A) P – III, Q – I, R – II, S – IV
(B) P – III, Q – II, R – I, S – IV
(C) P – IV, Q – II, R – I, S – III
(D) P – IV, Q – I, R – II, S – III

43. The number of significant figures in 0.002305 is \[ \text{Kerala PET 2010} \]

(A) 6
(B) 4
(C) 7
(D) 2

44. The respective number of significant figures for the numbers 23.023, 0.0003 and 2.1 \( \times \) \( 10^{-3} \) are \[ \text{AIEEE 2010} \]

(A) 4, 4, 2
(B) 5, 1, 2
(C) 5, 1, 5
(D) 5, 5, 2

45. In an experiment the angles are required to be measured using an instrument. 29 divisions of the main scale exactly coincide with the 30 divisions of the vernier scale. If the smallest division of the main scale is half-a-degree (\( \pm 0.5^\circ \)) then the least count of the instrument is \[ \text{AIEEE 2009} \]

(A) one minute
(B) half minute
(C) one degree
(D) half degree

46. A vernier callipers has 1 mm marks on the main scale. It has 20 equal divisions on the Vernier scale which match with 16 main scale divisions. For this Vernier callipers, the least count is \[ \text{IIT JEE 2010} \]

(A) 0.02 m
(B) 0.05 mm
(C) 0.1 mm
(D) 0.2 mm

47. The diameter of a cylinder is measured using a Vernier callipers with no zero error. It is found that the zero of the Vernier scale lies between 5.10 cm and 5.15 cm of the main scale. The Vernier scale has 50 divisions equivalent to 2.45 cm. The 24th division of the Vernier scale exactly coincides with one of the main scale divisions. The diameter of the cylinder is \[ \text{JEE (Advanced) 2013} \]

(A) 5.112 cm
(B) 5.124 cm
(C) 5.136 cm
(D) 5.148 cm

48. A student measured the length of a rod and wrote it as 3.50 cm. Which instrument did he use to measure it? \[ \text{JEE (Main) 2014} \]

(A) A metre scale
(B) A vernier calliper where the 10 divisions in vernier scale matches with 9 division in main scale and main scale has 10 divisions in 1 cm
(C) A screw gauge having 100 divisions in the circular scale and pitch as 1 mm
(D) A screw guage having 50 divisions in the circular scale and pitch as 1 mm

49. In a vernier callipers, one main scale division is \( x \) cm and \( n \) divisions of the vernier scale coincide with \( (n – 1) \) divisions of the main scale. The least count (in cm) of the callipers is \[ \text{AMU PMT 2009} \]

(A) \( \frac{n-1}{n} \)
(B) \( \frac{nx}{n-1} \)
(C) \( \frac{x}{n} \)
(D) \( \frac{x}{n-1} \)
50. A screw guage gives the following reading when used to measure the diameter of a wire.
Main scale reading : 0 mm
Circular scale reading : 52 divisions
The diameter of wire from the above data is

\[\text{AIEEE 2011}\]

(A) 0.52 cm  (B) 0.052 cm
(C) 0.026 cm  (D) 0.005 cm

51. A spectrometer gives the following reading when used to measure the angle of a prism.
Main scale reading : 58.5 degree
Vernier scale reading : 09 divisions
Given that 1 division on main scale corresponds to 0.5 degree. Total divisions on the vernier scale is 30 and match with 29 divisions of the main scale. The angle of the prism from the above data

\[\text{AIEEE 2012}\]

(A) 58.59 degree  (B) 58.77 degree
(C) 58.65 degree  (D) 59 degree

52. Choose the INCORRECT statement out of the following.

\[\text{AMU 2010}\]

(A) Every measurement by any measuring instrument has some error.
(B) Every calculated physical quantity that is based on measured values has some error.
(C) A measurement can have more accuracy but less precision and vice versa.
(D) The percentage error is different from relative error.

53. **Assertion:** The error in the measurement of radius of the sphere is 0.3%. The permissible error in its surface area is 0.6%.

**Reason:** The permissible error is calculated by the formula \(\frac{\Delta A}{A} = \frac{4\Delta r}{r}\)  

\[\text{AIIMS 2008}\]

(A) Assertion is True, Reason is True; Reason is a correct explanation for Assertion
(B) Assertion is True, Reason is True; Reason is not a correct explanation for Assertion
(C) Assertion is True, Reason is False
(D) Assertion is False, Reason is False.

54. If \(x = (a - b)\), the maximum percentage error in the measurement of \(x\) will be

\[\text{BCECE 2015}\]

(A) \(\frac{\Delta a}{a - b} - \frac{\Delta b}{a - b}\) \times 100
(B) \(\frac{\Delta a}{a - b} + \frac{\Delta b}{a - b}\) \times 100
(C) \(\frac{\Delta a}{a} + \frac{\Delta b}{b}\) \times 100
(D) \(\frac{\Delta a}{a} - \frac{\Delta b}{b}\) \times 100

55. If radius of the sphere is \((5.3 \pm 0.1)\) cm. Then percentage error in its volume will be

\[\text{Pb PET 2000}\]

(A) \(\frac{1003 + 6.01 \times 5.3}{5.3}\)
(B) \(\frac{1100 \times 0.01 \times 35.3}{5.3}\)
(C) \(3 \times 0.1 \times 100\frac{5.3}{5.3}\)
(D) \(0.1 \times 100\frac{5.3}{5.3}\)

56. Resistance of a given wire is obtained by measuring the current flowing in it and the voltage difference applied across it. If the percentage errors in the measurement of the current and the voltage difference are 3% each, then error in the value of resistance of the wire is

\[\text{AIEEE 2012}\]

(A) 6%  (B) Zero
(C) 1%  (D) 3%

57. In an experiment four quantities \(a, b, c\) and \(d\) are measured with percentage error 1%, 2%, 3% and 4% respectively. Quantity \(P\) is calculated as follows:

\[\text{NEET UG 2013}\]

\(P = \frac{a^3 b^2}{c d}\) \% error in \(P\) is

(A) 14%  (B) 10%
(C) 7%  (D) 4%
58. Two full turns of the circular scale of a screw gauge cover a distance of 1 mm on its main scale. The total number of divisions on the circular scale is 50. Further, it is found that the screw gauge has a zero error of – 0.03 mm. While measuring the diameter of a thin wire, a student notes the main scale reading of 3 mm and the number of circular scale divisions in line with the main scale as 35. The diameter of the wire is

\[ AIEEE\ 2008 \]
(A) 3.73 mm (B) 3.67 mm
(C) 3.38 mm (D) 3.32 mm

59. The circular divisions of shown screw gauge are 50. It moves 0.5 mm on main scale in one rotation. The diameter of the ball is

\[ IIT\ JEE\ 2006 \]
(A) 2.25 mm (B) 2.20 mm
(C) 1.20 mm (D) 1.25 mm

60. A screw gauge with a pitch of 0.5 mm and a circular scale with 50 divisions is used to measure the thickness of a thin sheet of aluminium. Before starting the measurement, it is found that when the two jaws of the screw gauge are brought in contact, the 45th division coincides with the main scale line and that the zero of the main scale is barely visible. What is the thickness of the sheet if the main scale reading is 0.5 mm and the 25th division coincides with the main scale line?

\[ JEE\ (Main)\ 2016 \]
(A) 0.80 mm (B) 0.70 mm
(C) 0.50 mm (D) 0.75 mm

61. The density of a solid ball is to be determined in an experiment. The diameter of the ball is measured with a screw gauge, whose pitch is 0.5 mm and there are 50 divisions on the circular scale. The reading on the main scale is 2.5 mm and that on the circular scale is 20 divisions. If the measured mass of the ball has a relative error of 2%, the relative percentage error in the density is

\[ IIT\ JEE\ 2011 \]
(A) 0.9% (B) 2.4%
(C) 3.1% (D) 4.2%

62. In the determination of Young’s modulus \( Y = \frac{4MLg}{\pi d^4} \) by using Searle’s method, a wire of length \( L = 2 \) m and diameter \( d = 0.5 \) mm is used. For a load \( M = 2.5 \) Kg, an extension \( l = 0.25 \) mm in the length of the wire is observed. Quantities \( d \) and \( l \) are measured using a screw gauge and a micrometer, respectively. They have the same pitch of \( 0.5 \) mm. The number of divisions on their circular scale is 100. The contributions to the maximum probable error of the \( Y \) measurement are

\[ IIT\ JEE\ 2012 \]
(A) due to the errors in the measurements of \( d \) and \( l \) are the same.
(B) due to the error in the measurement of \( d \) is twice that due to the error in the measurement of \( l \).
(C) due to the error in the measurement of \( l \) is twice that due to the error in the measurement of \( d \).
(D) due to the error in the measurement of \( d \) is four times that due to the error in the measurement of \( l \).

63. If the time period of a simple pendulum is \( T = \frac{2}{g} \sqrt{\frac{L}{g}} \), then the fractional error in acceleration due to gravity is

\[ Assam\ CEE\ 2015 \]
(A) \( \frac{4\pi^2 \Delta l}{\Delta T^2} \) (B) \( \frac{\Delta l}{l} - 2 \frac{\Delta T}{T} \)
(C) \( \frac{\Delta l}{l} + 2 \frac{\Delta T}{T} \) (D) None of these

64. A student measures the value of \( g \) with the help of a simple pendulum using the formula \( g = \frac{4\pi^2 L}{T^2} \). He measures length \( L \) with a metre scale having least count 1 mm and finds it 98.0 cm. The time period is measured with the help of a watch of least count 0.1 s. The time of 20 oscillations is found to be 40.0 s. The error \( \Delta g \) in the measurement of \( g \) is (in m/s^2).

\[ BCECE\ 2014 \]
(A) \( 9.68 \left[ \frac{0.1}{98} + 0.1 \right] \) (B) \( 9.68 \left[ \frac{1}{98} + 0.1 \right] \)
(C) \( 9.68 \left[ \frac{0.1}{98} + \frac{0.1}{20} \right] \) (D) \( 9.68 \left[ \frac{1}{98} + \frac{1}{20} \right] \)
65. The period of oscillation of a simple pendulum is \( T = \frac{2\pi}{\sqrt{\frac{L}{g}}} \). Measured value of \( L \) is 20.0 cm known to 1 mm accuracy and time for 100 oscillations of the pendulum is found to be 90 s using a wrist watch of 1 s resolution. The accuracy in the determination of \( g \) is [JEE (Main) 2015]
(A) 2\%  
(B) 3\%  
(C) 1\%  
(D) 5\%

66. Students I, II and III perform an experiment for measuring the acceleration due to gravity \((g)\) using a simple pendulum. They use different lengths of the pendulum and/or record time for different number of oscillations. The observations are shown in the table.

<table>
<thead>
<tr>
<th>Length of the pendulum (cm)</th>
<th>Number of oscillation (n)</th>
<th>Total time for (n) oscillations (s)</th>
<th>Time period (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I 64.0</td>
<td>8</td>
<td>128.0</td>
<td>16.0</td>
</tr>
<tr>
<td>II 64.0</td>
<td>4</td>
<td>64.0</td>
<td>16.0</td>
</tr>
<tr>
<td>III 20.0</td>
<td>4</td>
<td>36.0</td>
<td>9.0</td>
</tr>
</tbody>
</table>

If \( E_I, E_{II} \) and \( E_{III} \) are the percentage errors in \( g \), i.e., \( \left( \frac{\Delta g}{g} \times 100 \right) \) for students I, II and III, respectively, [IIT JEE 2008]
(A) \( E_I = 0 \)
(B) \( E_I \) is minimum
(C) \( E_I = E_{II} \)
(D) \( E_{II} \) is maximum

69. Which of the following physical quantities represent the dimensions of \( \frac{b}{a} \) in the relation \( P = \frac{x^2 - \frac{b}{a}}{t} \), where \( P \) is power, \( x \) is distance and ‘t’ time? [AP EAMCET (Med.) 2016]
(A) Power  
(B) Surface tension  
(C) Torsional constant  
(D) Force

70. If force \((F)\), velocity \((V)\) and time \((T)\) are taken as fundamental units, then the dimensions of mass are [AIPMT 2014]
(A) \( [F V T^{-1}] \)  
(B) \( [F V T^{-2}] \)  
(C) \( [F V^{-1} T^{-1}] \)  
(D) \( [F V^{-1} T] \)

71. If energy \((E)\), velocity \((V)\) and time \((T)\) are chosen as the fundamental quantities, the dimensional formula of surface tension will be [AIPMT 2015]
(A) \( [E V^{-2} T^{-1}] \)  
(B) \( [E V^{-1} T^{-2}] \)  
(C) \( [E V^{-2} T^{-2}] \)  
(D) \( [E^{-2} V^{-1} T^{-3}] \)

72. If the velocity of surface wave \((v)\) depends upon surface tension \((T)\), coefficient of viscosity \((\eta)\) and density \((\rho)\), then the expression for \( v \) will be [Assam CEE 2015]
(A) \( \frac{T^2}{\rho \eta} \)  
(B) \( \frac{T}{\eta} \)  
(C) \( \frac{\eta \rho}{T^2} \)  
(D) \( \frac{\rho}{\eta} \)

73. The ratio of the dimensions of Planck constant and that of moment of inertia has the dimensions of [K CET 2015]
(A) angular momentum.  
(B) time.  
(C) velocity.  
(D) frequency.
Chapter 01: Measurements

Classical Thinking

1. (B) 2. (C) 3. (B) 4. (D) 5. (D) 6. (C) 7. (A) 8. (B) 9. (B) 10. (B)
11. (D) 12. (A) 13. (D) 14. (D) 15. (D) 16. (C) 17. (C) 18. (D) 19. (C) 20. (B)
21. (A) 22. (B) 23. (D) 24. (D) 25. (A) 26. (B) 27. (C) 28. (D) 29. (D) 30. (D)
31. (A) 32. (C) 33. (A) 34. (B) 35. (D) 36. (C) 37. (B) 38. (D) 39. (D) 40. (D)
41. (C) 42. (B) 43. (A) 44. (B) 45. (B) 46. (A) 47. (D) 48. (A) 49. (C) 50. (B)
51. (A) 52. (A) 53. (B) 54. (C) 55. (C) 56. (B) 57. (C) 58. (D)

Critical Thinking

1. (A) 2. (A) 3. (D) 4. (C) 5. (D) 6. (B) 7. (C) 8. (A) 9. (C) 10. (B)
11. (D) 12. (C) 13. (B) 14. (D) 15. (D) 16. (A) 17. (D) 18. (C) 19. (A) 20. (C)
21. (A) 22. (C) 23. (B) 24. (C) 25. (B) 26. (A) 27. (B) 28. (A) 29. (B) 30. (B)
31. (A) 32. (B) 33. (C) 34. (B) 35. (A) 36. (B) 37. (A) 38. (D) 39. (D) 40. (C)
41. (C) 42. (C) 43. (B) 44. (B) 45. (A) 46. (D) 47. (D) 48. (B) 49. (D) 50. (C)
51. (B) 52. (C) 53. (B) 54. (C) 55. (A)

Competitive Thinking

1. (D) 2. (C) 3. (D) 4. (A) 5. (B) 6. (C) 7. (B) 8. (B) 9. (B) 10. (C)
11. (B) 12. (C) 13. (C) 14. (D) 15. (B) 16. (D) 17. (B) 18. (B) 19. (D) 20. (C)
21. (C) 22. (B) 23. (C) 24. (A) 25. (D) 26. (A) 27. (A) 28. (A) 29. (A) 30. (C)
31. (B) 32. (C) 33. (B) 34. (B) 35. (C) 36. (B) 37. (B) 38. (D) 39. (A) 40. (A)
41. (B) 42. (C) 43. (B) 44. (B) 45. (A) 46. (A) 47. (B) 48. (B) 49. (C) 50. (B)
51. (C) 52 (D) 53. (C) 54. (B) 55. (C) 56. (A) 57. (A) 58. (C) 59. (C) 60. (A)
61. (C) 62. (A) 63. (C) 64. (A) 65. (B) 66. (C) 67. (B) 68. (A) 69. (C) 70. (D)
71. (C) 72. (B) 73. (D)

Hints

Classical Thinking

13. Temperature is a fundamental quantity.

26. \(1\text{ dyne} = 10^{-5}\text{ N}, 1\text{ cm}^2 = 10^{-4}\text{ m}^2\)
\[
10^3\text{ dyne/cm}^2 = 10^3 \times 10^{-5}/10^{-4}\text{ N/m}^2
= 10^2\text{ N/m}^2
\]

Using quick conversion for pressure,

\(1\text{ dyne/cm}^2 = 0.1\text{ N/m}^2\)
\[
10^3\text{ dyne/cm}^2 = 10^3 \times 0.1 = 10^2\text{ N/m}^2
\]

57. Percentage error \(= \left(\frac{\Delta d}{d} \times 100\right)\%\)

\(= \left(\frac{0.01}{1.03} \times 100\right)\%\)

\(= 0.97\%\)

Critical Thinking

1. Physical quantity \((M)\)

\(= \text{Numerical value (n)} \times \text{Unit (u)}\)

If physical quantity remains constant then \(n \propto \frac{1}{u} \therefore n_1u_1 = n_2u_2\).

2. Because in S.I. system, there are seven fundamental quantities.

3. \[
\frac{\text{mass} \times \text{pressure}}{\text{density}} = \frac{m \times (F/A)}{(m/V)} = \frac{F \times V}{A}
= \frac{F \times (A \times s)}{A} = F \times s = \text{work}
\]

6. \(mv = \frac{kg}{sec}\)

7. Curie = disintegration/second
8. Bxt is unitless.
\[\Rightarrow\] Unit of B is \(m^{-1}s^{-1}\).

9. \[Y = \frac{F}{A \Delta L} = \text{dyne/cm}^2 = \frac{10^{-5} \text{N}}{10^{-2} \text{m}^2} = 0.1 \text{N/m}^2\]

10. Parallactic angle, \(\theta = 57'\)
\[= \left(\frac{57}{60}\right) \times \frac{\pi}{180} \text{ rad}\]
\[b = \text{Radius of earth} = 6.4 \times 10^6 \text{ m}\]
Distance of the moon from the earth,
\[s = b \theta = \frac{6.4 \times 10^6 \times 60 \times 180}{57 \times \pi} = 3.86 \times 10^8 \text{ m}\]

11. Distance of sun from earth, \(s = 1.5 \times 10^{11} \text{ m}\)
Angular diameter of sun,
\[\theta = 1920'' = \left(\frac{1920}{60}\right) \times \frac{\pi}{180} \text{ rad}\]
Diameter of sun, \(D = s \times \theta = 1.5 \times 10^{11} \times \frac{1920}{3600} \times \frac{\pi}{180}\)
\[D \approx 1.4 \times 10^9 \text{ m}\]

12. Torque = \([M^1L^3T^{-2}]\),
Angular momentum = \([M^1L^2T^{-1}]\)
So mass and length have the same dimensions.

13. According to Poiseuille’s formula,
\[\eta = \frac{\pi Pr^4}{8((dV/dt)}\]
\[\therefore [\eta] = \frac{[M^1L^{-1}T^{-2}][L^4]}{[L^2][L/T]} = [M^0L^{-3}T^{-1}]\]

15. [Dipole moment] = \([M^0L^1T^1A^{-1}]\)
[Electric flux] = \([M^1L^{-3}T^{-1}A^{-1}]\)
[Electric field] = \([M^1L^{-2}T^{-3}A^{-1}]\)

16. \(\frac{1}{2} Li^2\) = energy stored in an inductor
\[= [M^1L^2T^{-2}]\]

17. The dimension of a quantity is independent of changes in its magnitude.

21. \(\frac{1}{\sqrt{\varepsilon_0\mu_0}} = c = \text{velocity of light}\)

23. \[\frac{mg}{\eta r} = \left[\frac{M^1}{L^2M^{-1}T^{-1}} \right] = [L^1T^{-1}]\]

24. From \(F = at + bt^2\)
\[a = \frac{F}{t} = \left[\frac{M^1L^1T^{-2}}{T^2}\right] = [M^0L^1T^{-3}]\]

b = \(\frac{F}{t^2} = \left[\frac{M^1L^1T^{-2}}{T^2}\right] = [M^0L^1T^{-4}]\)

25. \(F = a\sqrt{x}\)
\[\therefore a = \frac{F}{\sqrt{x}} = \left[\frac{M^1L^1T^{-2}}{L^2}\right] = [M^0L^{-1}T^{-2}]\]
\[bt^2 = F\]
\[\therefore b = \frac{F}{t^2} = \left[\frac{M^1L^1T^{-2}}{T^2}\right] = [M^0L^1T^{-4}]\]
\[a = \left[\frac{M^1L^1T^{-2}}{T^2}\right] = [L^{-1/2} T^{-2}]\]

26. \([M^1L^1T^{-2}] = [L^2][L^1T^{-1}]b = [M^0L^{-3}T^{-1}]b\)
\[= [L^2][L^{b+1}T^{-1}]\]
\[= [M^0 L^{2a+b-3c}T^{-b}]\]
Comparing powers of M, L and T,
\[c = 1, 2a + b - 3c = 1,\]
\[-b = -2\]
\[\therefore b = 2\]
\[2a + 2 - 3(1) = 1\]
\[\therefore 2a = 2\]
\[\therefore a = 1\]

27. \(T^2 = \frac{4\pi^2 a^3}{G^2 M^2}\)
4\(\pi^2\) being pure number is dimensionless.
\[\therefore [M^0L^0T^2] = \left[\frac{M^0L^1T^0}{M^1L^{-1}T^{-1}}\right]^2\]
\[= [L^2]\]
\[\Rightarrow [M^0L^0T^2] = [L^2][M^1L^{-3}T^{-2}]^{-2}[M^1T^{-2}]\]
Comparing powers of M, L and T
\[y - z = 0,\]
\[x - 3y = 0 \text{ and } 2y = 2\]
\[\therefore y = 1\]
Substituting value of y,
\[z = 1, x = 3\]
Thus, \(T^2 = \frac{4\pi^2 a^3}{G M}\)

28. \(T = P^D^b S^c\)
\([M^0L^0T^1] = [M^1L^{-1}T^{-2}]^a [M^1L^{-3}T^0]^b [M^1L^0T^{-2}]^c\)
Comparing powers of M, L, T
\[a + b + c = 0,\]
\[-a - 3b = 0 \text{ and } -2a - 2c = 1\]
Solving, \(a = -\frac{3}{2}, b = \frac{1}{2} \text{ and } c = 1.\)
29. In the given wave equation \( x \) denotes displacement. Thus \( \frac{x}{v} \) has dimensions of \( T \). Hence from the principle of homogeneity \( k \) has dimensions of \( T \).

30. 
\[
P = \frac{a - t^2}{b^x}
\]
\( a = [T^1] = [T^2] \)
\[
P = \frac{T^2}{b^x}
\]
\( b = \frac{T^2}{p_x} = \left[ \frac{T^2}{M^1L^{-1}T^{-2}} \right] = \left[ \frac{T^4}{M^1} \right] \)
\( a = \frac{[T^2]}{[T^4]} = [M^1T^{-2}] \)

31. By principle of dimensional homogeneity
\[
\left[ \frac{a}{V^2} \right] = [P]
\]
\[
[a] = [P] [V^2] = [M^1L^{-1}T^{-2}] \times [L^6]
\]
\[
= [M^1L^5T^{-2}]
\]
Dimensions of \( b \) are same as that of \( V \),
\( [b] = [L^3] \)
\[
\frac{a}{b} = \frac{[M^1L^5T^{-2}]}{[L^3]} = [M^1L^2T^{-2}]
\]

32. Let \( G \propto c^x p^y r^z \)
Substituting dimensions,
\( [M^{-1}L^{-1}T^2] = [M^xL^yT^z] [M^1L^{-1}T^{-2}] \)
Comparing powers of \( M, L, T \)
\(- 1 = z, \)
\( x + y - z = 3 \) and
\( - x - 2y - 2z = -2 \)
Solving, \( x = 0, y = 2 \)

33. Acceleration due to gravity = \( g = \frac{s}{t^2} \)
\( g = [L^1T^{-2}] \)
\( a = 1, b = -2 \)
\( 1^{st} \) system
\( L_1 = 1 \text{ cm} \)
\( = 10^{-5} \text{ km} \)
\( T_1 = 1 \text{ s} = \frac{1}{60} \text{ min} \)
\( n = \frac{[L_1]}{[L_2]} \left[ \frac{T_1}{T_2} \right]^2 = 980 \times \left[ \frac{10^{-5} \text{ km}}{1 \text{ km}} \right] \left[ \frac{1/60 \text{ min}}{1 \text{ min}} \right]^2 \)
\( = 980 \times 10^{-5} \times 3600 \)
\( = 35.28 \text{ km min}^{-2} \)

39. The number of significant figures in all of the given number is 4.

41. A vernier calliper has a least count 0.01 cm. Hence measurement is accurate only upto three significant figures.

42. In multiplication or division, final result should retain the same number of significant figures as there are in the original number with the least significant figures.

\( \therefore \) Area of rectangle = \( 6 \times 12 = 72 \text{ m}^2 \)

43. \( a_m = 20.17 + 21.23 + 20.79 + 22.07 + 21.78 \)
\( a_m = 105.16 \)
\( \frac{\Delta a_1}{a_m} = \frac{21.21 - 20.17}{105.16} = 0.011 \)
\( \frac{\Delta a_2}{a_m} = \frac{21.21 - 21.23}{105.16} = 0.0002 \)
\( \frac{\Delta a_3}{a_m} = \frac{0.2}{105.16} = 0.0019 \)
\( \frac{\Delta a_4}{a_m} = \frac{0.42}{105.16} = 0.004 \)
\( \frac{\Delta a_5}{a_m} = \frac{0.57}{105.16} = 0.0054 \)
\( \frac{\Delta a_m}{a_m} = \frac{0.005 + 0.002 + 0.004 + 0.001}{5} = 0.002 \)

45. Percentage error = \( \left( \frac{\Delta d}{d} \times 100 \right) \)%
\( = \left( \frac{0.005}{0.020} \times 100 \right) \)% = 25%

46. \( \frac{\Delta r}{r} \times 100 = 0.1 \% \) and \( V = \frac{4}{3} \pi r^3 \)
Percentage error in volume = \( \frac{\Delta V}{V} \)%
\( = 3 \Delta r \)
\( = 0.3 \% \)

47. \( P = \frac{F}{A} = \frac{F}{t^2} \)
so maximum error in pressure (\( P \))
\( \frac{\Delta P}{P_{max}} = \frac{\Delta F}{F} \times 100 + 2 \frac{\Delta t}{t} \times 100 \)
\( = 4 \% + 2 \times 2 \% = 8 \% \)

48. Percentage error in K.E = \( \left( \frac{\Delta m}{m} + 2 \frac{\Delta v}{v} \right) \)%
\( = (0.75 + 2 \times 1.85) \)%
\( = 4.45 \% \)

49. Maximum possible error in measurement of
\( \frac{L}{T^2} = \left( \frac{\Delta L}{L} + 2 \frac{\Delta T}{T} \right) \)%
\( = (0.1 + 2 \times 3) \% = 6.1 \% \)
50. \[ T = 2\pi \sqrt{\frac{l}{g}} \Rightarrow T^2 = 4\pi^2 l/g \Rightarrow g = \frac{4\pi^2 l}{T^2} \]

\[
\text{% error in } l = \frac{1 \text{ mm}}{100 \text{ cm}} \times 100 = 0.1 \times 100 = 0.1\%
\]

and error in \( T = 2 \left[ \frac{0.1}{100} \times 100 \right] = 0.2\% \)

\[
\therefore \text{ % error in } g = \text{ % error in } l + \text{ % error in } T = 0.1 + 0.2 = 0.3\%
\]

51. \[ V = \frac{100 V}{100} \times \frac{b}{h} = \frac{b}{h} \times \frac{100}{100} = 0.1 \times \frac{100}{100} = 0.1\% \]

52. \[ H = \frac{I^2 R t}{4.2} \]

\[
\text{% Error in } H = \frac{\Delta H}{H} \times 100 = \left( \frac{2 \Delta I}{I} + \frac{\Delta R}{R} + \frac{\Delta t}{t} \right) \%
= 2 \times 2 + 1 + 1 = 6\%
\]

53. \[ \text{[Energy]} = [M^1 L^2 T^{-2}]
= [M^1 L^1 T^{-1}] [T^{-1}] = [P^1 A^{1/2} T^{-1}] \]

54. Avogadro number \((N)\) represents the number of atoms in 1 gram mole of an element. i.e., it has the dimensions of mole\(^{-1}\).

55. As the graph is a straight line, \( P \propto Q \), or \( P = \text{Constant} \times Q \) i.e., \( \frac{P}{Q} = \text{constant} \).

**Competitive Thinking**

3. The van der Waals equation for ‘\( n \)’ moles of the gas is,

\[
(P + \frac{n^2 a}{V^2}) \times [V - nb] = nRT
\]

Pressure correction Volume correction

\[
\therefore a = \frac{PV^2}{n^2} = \frac{F \times V^2}{A} = \frac{F}{V} = \frac{F}{t}
\]

Thus, S.I. units of \( a \) is N m\(^4\)/mol\(^2\).

4. From Van der Waals equation, \( nb \) has dimensions of volume.

\[
\therefore b = \frac{V}{n}
\]

Thus, S.I. units of \( b \) is m\(^3\)/mol.

12. Energy = force \times distance, so if both are increased by 4 times then energy will increase by 16 times.

13. 1 dyne = 10\(^{-5}\) N and 1 cm = 10\(^{-2}\) m

\[
\Rightarrow 1 \text{ dyne/cm} = 10^{-3} \text{ N/m}
\]

\[
\therefore 10^8 \text{ dyne/cm} = 10^5 \text{ N/m}
\]

14. RC is the time constant of RC circuit and \( \left( \frac{L}{R} \right) \) is the time constant of LR circuit. Hence, both RC and \( \frac{L}{R} \) have the dimensions of time

**Alternate method:**

\[
RC = \text{ohm} \times \text{farad} = \frac{\text{volt}}{\text{ampere} \times \text{coulomb}} = \frac{\text{coulomb}}{\text{ampere} \times \text{coulomb}} = \text{ohm seconds}
= \text{second}[T]
\]

Now, \( \frac{L}{R} \text{ henry} = \frac{\text{ohm} \times \text{second}}{\text{ohm}} = \text{second}[T] \)

Both RC and \( \frac{L}{R} \) have the dimensions of time.

16. \[ [\varepsilon_0 L] = [C] \]

\[
\therefore X = \frac{\varepsilon_0 LV}{t} = \frac{C \times V}{t} = \frac{Q}{t} = \text{Current}
\]

20. \[ F = \frac{Gm_m}{r^2} \]

\[
\Rightarrow G = \frac{Fr^2}{m_m}
\]

\[
\therefore [G] = \left[ \frac{M^1 L^1 T^{-2}}{L^2} \right] = [M^{-1} L^3 T^{-2}]
\]

24. \[ W = \frac{1}{2} Kx^2 \]

\[
\Rightarrow [K] = \left[ \frac{[W]}{[x^2]} \right] = \left[ \frac{M^1 L^2 T^{-2}}{L^2} \right] = [M^1 T^{-2}]
\]

25. \[ F \propto v \]

\[
F = kv
\]

\[
k = \frac{F}{v} = \left[ \frac{M^1 L^2 T^{-2}}{L T^{-1}} \right] = [M^1 L^0 T^{-3}]
\]
Chapter 01: Measurements

27. \( R = \frac{PV}{T} = \left[ \frac{M^{1}L^{2}T^{-2} \times L^{3}}{\theta} \right] = [M^{1}L^{2}T^{-2}\theta^{-1}] \)

28. \( F = \frac{x}{\sqrt{d}} \)

\[ [x] = [F][d]^{1/2} = \left[ M^{1}L^{2} \right] \times \left[ L^{3} \right]^{1/2} = \left[ M^{1/2}L^{-1/2}T^{-2} \right] \]

29. \( F = \frac{X}{ \text{Linear density} } \)

Linear density is mass per unit length

\[ [x] = [X] \]

\[ [X] = [M^{1/2}L^{0}T^{-2}] \]

30. The van der Waals equation for \( n \) moles of the gas is,

\( P + \frac{n^{2}a}{V^{2}} \times [V - nb] = nRT \)

Pressure correction

\( a = \frac{PV^{2}}{n^{2}} = \frac{F}{A^{n^{2}}} = \frac{F}{n^{2}} \)

Volume correction

\[ [a] = \left[ \frac{F}{n^{2}} \right] = [M^{1/2}L^{-2}T^{-2}mol^{-2}] \]

31. \( \varepsilon_{0} = \frac{q_{1}q_{2}}{4\pi r^{2}} \)

\[ [\varepsilon_{0}] = \frac{A^{2}T^{2}}{(M^{1}L^{2}T^{-2})L^{2}} = [M^{-1}L^{-3}T^{4}A^{2}] \]

32. Electric Field = \( \frac{\text{Force}}{\text{Charge}} = \frac{[M^{1}L^{1}T^{-2}]}{[A^{3}T]} \)

\[ [E] = [M^{1}L^{1}T^{-3}A^{-1}] \]

33. \( [\varepsilon_{0}\varepsilon^{2}] = [\varepsilon_{0}][E]^{2} \)

\[ = [M^{-1}L^{-3}T^{4}A^{-1}]^{2} \]

\[ = [M^{1}L^{1}T^{-2}A^{0}] \]

\[ \frac{1}{2}\varepsilon_{0}E^{2} = u \]

where \( u \) is energy density and has dimensions \([M^{1}L^{0}T^{-3}]\)

34. \( c = [T] \)

\[ a = \frac{v}{t} = \frac{[L^{1}]}{[T^{1}]} = [L^{1}] \]

\[ b = v(t + c) = [L^{1}T^{-1}] \times [L^{1}] \]

35. \( \varepsilon_{0} = \frac{12}{r^{2}} \)

\[ [\varepsilon_{0}] = \frac{A^{2}T^{2}}{(M^{1}L^{2}T^{-2})L^{2}} = [M^{-1}L^{-3}T^{4}A^{2}] \]

36. \( \varepsilon = [M^{1}L^{0}T^{0}] \)

\[ \alpha = \frac{v}{\beta} = \frac{[L^{1}]}{[L^{1}]} = [1] \]

\[ \beta = \frac{[L^{1}]}{[M^{1}]} \]

\[ = [M^{1}T^{0}] \]

And \( P = \frac{\alpha}{\beta} \)

\( \Rightarrow \beta = \left[ \frac{\alpha}{P} \right] = \frac{[M^{1}L^{2}T^{-2}]}{[M^{1}L^{1}T^{-2}]} \)

\( \Rightarrow \beta = [M^{1}L^{0}T^{0}] \)

37. \( \frac{EJ^{2}}{M^{2}G^{2}} = \frac{[M^{1}L^{2}T^{-2}][M^{1}L^{2}T^{-1}]^{2}}{[M^{1}]^{2}[M^{1}L^{2}T^{-2}]} \)

\( = [M^{1}L^{0}T^{0}] \)

The dimensions of angle are \([M^{0}L^{0}T^{0}]\).

38. \( Y = \frac{X}{3Z^{2}} = \frac{[M^{1}L^{2}T^{4}A^{2}]}{[M^{1}L^{2}T^{4}A^{2}]} \)

\( = [M^{3}L^{-2}T^{-8}A^{4}] \)

39. \( T \propto S^{1/2}r^{3/2} \rho^{1/2} \)

\( [M^{0}L^{0}T^{1}] = [M^{0}L^{0}T^{0}]^{y} [M^{1}L^{3}T^{0}]^{z} \)

Comparing powers of \( M, L, T \)

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

Solving, \( x = -\frac{1}{2}, \quad y = \frac{3}{2}, \quad z = \frac{1}{2} \)

Thus, \( T \propto S^{-1/2}r^{3/2} \rho^{1/2} \)

\( T = k (r^{3} \rho / S)^{1/2} = k \sqrt{r^{3} \rho / S} \)

40. In the given equation, \( \frac{\alpha Z}{k0} \) should be dimensionless,

\[ \Rightarrow \alpha = \frac{k0}{Z} \]

\( \Rightarrow \alpha = \frac{[M^{1}L^{2}T^{-2}K^{-1}] \times [K^{1}]}{[L^{1}]} \)

\( = [M^{1}L^{1}T^{-2}] \)

And \( P = \frac{\alpha}{\beta} \)

\[ \Rightarrow \beta = \left[ \frac{\alpha}{P} \right] = \frac{[M^{1}L^{2}T^{-2}]}{[M^{1}L^{1}T^{-2}]} \)

\( \Rightarrow \beta = [M^{1}L^{0}T^{0}] \)

41. \( [R] = [M^{1}L^{2}T^{-3}A^{-2}] \) using \( R = \frac{V}{I} \)

\( [V] = [M^{1}L^{2}T^{-3}A^{-1}] \) using \( V = \frac{U}{q} \)

\( [\rho] = [M^{1}L^{3}T^{-3}A^{-2}] \) using \( \rho = \frac{RA}{l} \)

\( [\sigma] = [M^{1}L^{3}T^{-3}A^{-2}] \) using \( \sigma = \frac{1}{\rho} \)
42. Boltzmann constant \( (k_B) = \frac{PV}{NT} \)
S.I. unit: J K^{-1} = [M^1 L^2 T^{-2} K^{-1}]

Coefficient of viscosity \( (\eta) = \frac{F}{A \left(\frac{dv}{dx}\right)} \)

S.I. unit: N s m^{-1} = [M^1 L^{-1} T^{-1}]

Water equivalent is the mass of water that will absorb or lose same quantity of heat as that of the substance for the same change in temperature.
S.I. unit: kg = [M^1 L^0 T^0]

Coefficient of thermal conductivity \( (K) = \frac{Q}{A \left(\frac{\Delta \theta}{\Delta x}\right)} \)

S.I. unit: J m s K^{-1} = [M^1 L^1 T^{-3} K^{-1}]

45. 30 VSD = 29 MSD
1 VSD = \( \frac{29}{30} \) MSD
L.C. = 1 MSD - 1 VSD
\( = \left(1 - \frac{29}{30}\right)\) MSD
\( = \frac{1}{30} \times 0.5^\circ \)
\( = 1 \) minute

46. 20 VSD = 16 MSD
1 VSD = 0.8 MSD
Least count = MSD - VSD
\( = 1 \) mm - 0.8 mm = 0.2 mm

48. As per the question, the measured value is 3.50 cm. Hence the least count must be 0.01 cm = 0.1 mm

49. One main scale division, 1 M.S.D. = x cm
One vernier scale division,
\( 1 \) V.S.D. = \( \frac{(n-1)x}{n} \)
Least count = 1 M.S.D. - 1 V.S.D.
\( = \frac{nx - nx + x}{n} = \frac{x}{n} \) cm.

50. Least count of screw gauge = \( \frac{1}{100} \) mm
\( = 0.01 \) mm
Diameter = Main scale reading + (Divisions on circular scale \times least count)
\( = 0 + \left(52 \times \frac{1}{100}\right) = 0.52 \) mm
Diameter = 0.052 cm.

51. 30 VSD = 29 MSD
1 VSD = \( \frac{29}{30} \) MSD
Least count = 1 M.S.D. - 1 V.S.D.
\( = 0.5^\circ - \left(\frac{29}{30} \times 0.5^\circ\right) = 0.5^\circ - \frac{30}{30} \)
Reading of vernier = M.S. reading + V.S. reading \times L.C.
\( = 58.5^\circ + 9 \times 0.5^\circ = 58.65^\circ \)

53. \( A = 4\pi r^2 \)
\( \therefore \) Fractional error \( \frac{\Delta A}{A} = \frac{2\Delta r}{r} \)
\( \frac{\Delta A}{A} \times 100 = 2 \times 0.3\% = 0.6\% \)

55. Volume of sphere \( (V) = \frac{4}{3} \pi r^3 \)
% error in volume = \( 3 \times \frac{\Delta r}{r} \times 100 \)
\( = \left(3 \times \frac{0.1}{5.3}\right) \times 100 \)

56. \( R = \frac{V}{I} \Rightarrow \pm \frac{\Delta R}{R} = \pm \frac{\Delta V}{V} \pm \frac{\Delta I}{I} \)
\( = 3 + 3 = 6\% \)
57. Given that: \( P = \frac{a^3 b^2}{cd} \)

error contributed by \( a = 3 \times \left( \frac{\Delta a}{a} \times 100 \right) \)

\( = 3 \times 1\% = 3\% \)

error contributed by \( b = 2 \times \left( \frac{\Delta b}{b} \times 100 \right) \)

\( = 2 \times 2\% = 4\% \)

error contributed by \( c = \left( \frac{\Delta c}{c} \times 100 \right) \)

\( = 3\% \)

error contributed by \( d = \left( \frac{\Delta d}{d} \times 100 \right) \)

\( = 4\% \)

\[ \therefore \text{Percentage error in } P \text{ is given as}, \]

\[ \frac{\Delta P}{P} \times 100 = (\text{error contributed by } a) + (\text{error contributed by } b) + (\text{error contributed by } c) + (\text{error contributed by } d) \]

\[ = 3\% + 4\% + 3\% + 4\% \]

\[ = 14\% \]

58. Least count = \( \frac{\text{Pitch}}{\text{No. of div. in circular scale}} \)

\[ = \frac{0.5}{50} = 0.01 \text{ mm} \]

Actual reading = 0.01 \times 35 + 3 = 3.35 mm

Taking error into consideration

\[ = 3.35 + 0.03 \]

\[ = 3.38 \text{ mm}. \]

59. Zero error = \( 5 \times \frac{0.5}{50} = 0.05 \text{ mm} \)

Actual measurement

\[ = 2 \times 0.5 \text{ mm} + 25 \times \frac{0.5}{50} - 0.05 \text{ mm} \]

\[ = 1 \text{ mm} + 0.25 \text{ mm} - 0.05 \text{ mm} \]

\[ = 1.20 \text{ mm} \]

60. Main Scale Reading (MSR) = 0.5 mm

Circular Scale Division (CSD) = 25\text{\textdegree}

Number of divisions on circular scale = 50

Pitch of screw = 0.5 mm

\[ \therefore \text{LC of screw gauge} = \frac{0.5}{50} = 0.01 \text{ mm} \]

\[ \therefore \text{zero error} = -5 \times \text{LC} = -0.05 \text{ mm} \]

\[ \therefore \text{zero correction} = +0.05 \text{ mm} \]

Observed reading = 0.5 mm + (25 \times 0.01) mm

\[ = 0.75 \text{ mm} \]

Corrected reading = 0.75 mm + 0.05 mm

\[ = 0.80 \text{ mm} \]

61. Least count = \( \frac{0.5}{50} = 0.01 \text{ mm} \)

Diameter of ball \( D = 2.5 \text{ mm} + \left( \frac{D}{100} \right) (0.01) \)

\[ \Rightarrow D = 2.7 \text{ mm} \]

\[ \rho = \frac{M}{V} = \frac{M}{\frac{4}{3}\pi \left( \frac{D}{2} \right)^3} \]

\[ \Rightarrow \left( \frac{\Delta \rho}{\rho} \right)_{\text{max}} = \left( \frac{\Delta M}{M} + 3 \frac{\Delta D}{D} \right) \]

\[ \Rightarrow \left( \frac{\Delta \rho}{\rho} \right)_{\text{max}} = 2\% + \left[ 3 \left( \frac{0.01}{2.7} \right) \times 100\% \right] \]

\[ \Rightarrow \frac{\Delta \rho}{\rho} = 3.1\% \]

62. Least count of both instrument

\[ \Delta a = \Delta l = \frac{0.5}{100} \text{ mm} = 5 \times 10^{-3} \text{ mm} \]

\[ \text{Y} = \frac{4MLg}{\pi d^2} \]

\[ \left( \frac{\Delta Y}{\text{Y}} \right)_{\text{max}} = \frac{\Delta l}{l} + 2 \frac{\Delta d}{d} \]

Error due to \( l \) measurement \( \frac{\Delta l}{l} \)

\[ = \frac{0.5}{100} \text{ mm} = 2\% \]

Error due to \( d \) measurement,

\[ 2 \frac{\Delta d}{d} = \frac{2 \times \frac{0.5}{100}}{0.5 \text{ mm}} = \frac{0.5}{0.25} = 2\% \]

63. We have;

\[ T = 2\pi \sqrt{\frac{l}{g}} \]

Squaring

\[ T^2 = 4\pi^2 \left( \frac{l}{g} \right) \]

\[ \therefore \text{g} = 4\pi^2 \frac{l}{T^2} \]

Fractional error in \( g \) is

\[ \frac{\Delta g}{g} = \frac{\Delta l}{l} + 2 \frac{\Delta T}{T} \]

64. \[ \frac{\Delta g}{g} = \frac{\Delta L}{L} + 2 \left( \frac{\Delta T}{T} \right) \]

\[ \therefore \Delta g = g \left[ \frac{\Delta L}{L} + 2 \left( \frac{\Delta T}{T} \right) \right] \]
Time for 20 oscillations = 40 s
\[\therefore\] Time for 1 oscillation = \(\frac{40}{20}\)
\[\therefore\] \(T = 2\, s\)

\[g = \frac{4\pi^2L}{T^2} = \frac{4(3.14)^2 \times 0.98}{(2)^2} = 9.68\, \text{m/s}^2\]

\[\therefore\] \(\Delta g = 9.68 \left[ \frac{0.1}{98} + 0.1 \right]\)

\[\therefore\] \(\Delta g = 9.68 \left[ \frac{0.1}{98} + 0.1 \right]\)

65. Given: \(T = 2\pi\sqrt{\frac{L}{g}}\)
\[\Rightarrow\] \(g = 4\pi^2 \cdot \frac{L}{T^2}\)

% Accuracy in determination of \(g\),
\[\frac{\Delta g}{g} \times 100 = \frac{\Delta L}{L} \times 100 + 2 \frac{\Delta T}{T} \times 100\]
\[= \frac{\Delta L}{L} \times 100 + 2 \frac{\Delta T}{t} \times 100\]
\[= \frac{0.1}{20} \times 100 + 2 \times \frac{1}{90} \times 100\]
\[= \frac{100}{200} + \frac{200}{90}
\[= 0.5 + 2.22\]
\[= 2.72 \approx 3\%\]

66. \(g = \frac{4\pi^2l}{T^2}\)
\[\therefore\] % error in \(g = \frac{\Delta g}{g} \times 100\]
\[= \left( \frac{\Delta l}{l} \right) \times 100 + 2 \left( \frac{\Delta T}{T} \right) \times 100\]
\(E_1 = \frac{0.1}{64} \times 100 + 2 \left( \frac{0.1}{16} \right) \times 100 = 1.406\%\)
\(E_2 = \frac{0.1}{64} \times 100 + 2 \left( \frac{0.1}{16} \right) \times 100 = 1.406\%\)
\(E_3 = \frac{0.1}{20} \times 100 + 2 \left( \frac{0.1}{9} \right) \times 100 = 2.72\%\)

68. \[\frac{ML^2}{Q^2} = \left[ \frac{ML^2}{A'T^2} \right] \]
These are the dimensions of unit Henry.

69. Given: \(P = \frac{x^2 - b}{at}\)
From principle of homogeneity, 'b' will have the dimensions of \(x^2'\)
Chapter 01: Measurements

Evaluation Test

1. When dimensions of a given physical quantity are given, the physical quantity is unique.
   (A) The statement and its converse both are true.
   (B) The statement and its converse both are false.
   (C) The statement is false but its converse is true.
   (D) The statement is true but its converse is false.

2. Two quantities A and B are related by the relation \( \frac{A}{B} = m \), where m is linear mass density and A is force. The dimensions of B will be same as that of
   (A) latent heat (B) pressure (C) work (D) momentum

3. The readings of a constant potential difference are noted four times by a student. The student averages these readings but does not take into account the zero error of the voltmeter. The average measurement of the potential difference is

| Reading 1 | 1.176 V |
| Reading 2 | 1.178 V |
| Reading 3 | 1.177 V |
| Reading 4 | 1.176 V |

   (A) precise and accurate. (B) precise but not accurate. (C) accurate but not precise. (D) not accurate and not precise.

4. The ‘rad’ is the correct unit used to report the measurement of
   (A) the rate of decay of radioactive source. (B) the ability of a beam of gamma ray photons to produce ions in a target. (C) the energy delivered by radiation to a target. (D) the biological effect of radiation.

5. The dimensions of capacitance in M, L, T and C (Coulomb) is given as
   (A) \([M^1L^2T^{-2}C^{-2}]\) (B) \([L^{-2}T^2C^2]\) (C) \([M^{-1}L^2T^2C^2]\) (D) \([M^1L^{-2}T^2C^2]\)

6. Two full turns of the circular scale of a screw gauge cover a distance of 1 mm on its main scale. The total number of divisions on the circular scale is 50. Further, it is found that the screw gauge has a zero error of \(-0.02\) mm. While measuring the diameter of a thin wire, a student notes the main scale reading of 4 mm and the number of circular scale divisions in line with the main scale as 37. The diameter of the wire is
   (A) 4.37 mm (B) 4.39 mm (C) 4.74 mm (D) 4.76 mm

7. The potential energy U of a particle varies with distance x from a fixed origin as
   \( U = \frac{A\sqrt{x}}{x^2 + B} \), where A and B are dimensional constants. The dimensional formula for AB is
   (A) \([M^1L^{7/2}T^{-2}]\) (B) \([M^1L^{11/2}T^{-2}]\) (C) \([M^1L^{5/2}T^{-2}]\) (D) \([M^1L^{9/2}T^{-2}]\)

8. **Assertion:** The number 37800 has three significant digits.
   **Reason:** All non-zero digits are significant.
   (A) Assertion is True, Reason is True; Reason is a correct explanation for Assertion.
   (B) Assertion is True, Reason is True; Reason is not a correct explanation for Assertion.
   (C) Assertion is True, Reason is False.
   (D) Assertion is False but, Reason is False.

9. If \( A = B + \frac{C}{D+E} \), the dimensions of B and C are \([M^0L^0T^{-1}]\) and \([M^0L^0T^0]\), respectively. Find the dimensions of A, D and E.
   (A) \( A = [M^0L^0T^{-1}], D = [T], E = [LT] \)
   (B) \( A = [MLT^0], D = [T^2], E = [T^2] \)
   (C) \( A = [M^0LT^{-1}], D = [MT], E = [MT] \)
   (D) \( A = [M^0LT^{-1}], D = [T], E = [T] \)

10. In the measurement of a physical quantity
    \( X = \frac{A^2B}{C^0D^3} \). The percentage errors introduced in the measurements of the quantities A, B, C and D are 1%, 3%, 4% and 5% respectively. Then the minimum amount of percentage of error in the measurement of X is contributed by
    (A) A (B) B (C) C (D) D
11. If \( E = \text{energy}, G = \text{gravitational constant}, \ I = \text{impulse} \) and \( M = \text{mass} \), the dimension \( \frac{G I^2 M}{E^2} \) is same as that of
(A) spring constant
(B) wavelength
(C) energy gradient
(D) Rydberg constant

12. Choose the incorrect statement:
(A) A dimensionally correct equation may be correct.
(B) A dimensionally correct equation may be incorrect.
(C) A dimensionally incorrect equation must be incorrect.
(D) A dimensionally incorrect equation may be correct.

13. The radius of a ball is \((6.2 \pm 0.4) \text{ cm}\). The percentage error in the volume of the ball is
(A) 11%  (B) 4%
(C) 19%  (D) 9%

14. The number of particles crossing the unit area perpendicular to the z-axis per unit time is given by \( N = -D \left( \frac{n_2 - n_1}{z_2 - z_1} \right) \) where \( n_1 \) and \( n_2 \) are the numbers of particles per unit volume at \( z_1 \) and \( z_2 \) respectively along z-axis. What is the dimensional formula for the diffusion constant \( D \)?
(A) \([M^0L^1T^2]\]
(B) \([M^0L^2T^4]\]
(C) \([M^0L^1T^{-3}]\]
(D) \([M^0L^2T^{-1}]\]

15. When a screw gauge is completely closed, zero of circular scale is 4 divisions above the reference line of graduation. If L.C. of screw gauge is \(10^{-3} \text{ cm}\), the zero error is
(A) \(-4 \times 10^{-3} \text{ cm}\)
(B) \(+4 \times 10^{-3} \text{ cm}\)
(C) \(-0.004 \text{ mm}\)
(D) \(+0.004 \text{ mm}\)

16. Which of the following is not dimensionless?
(A) Relative refractive index
(B) Relative permittivity
(C) Relative density
(D) Relative velocity

17. The jaws of a vernier callipers touch the inner wall of calorimeter without any undue pressure. The position of zero of vernier scale on the main scale reads 3.48. The 6th of vernier scale division is coinciding with any main scale division. Vernier constant of callipers is 0.01 cm. Find actual internal diameter of calorimeter, when it is observed that the vernier scale has a zero error of \(-0.03 \text{ cm}\).
(A) 3.37 cm  (B) 3.57 cm
(C) 3.42 cm  (D) 3.54 cm

18. The thin metallic strip of vernier callipers move downward from top to bottom in such a way that it just touches the surface of beaker. Main scale reading of calliper is 6.4 cm whereas its vernier constant is 0.1 mm. The 4th of vernier scale division is coinciding with main scale division. The actual depth of beaker in mm is (when zero of vernier coincides with zero of main scale)
(A) 6.64 cm  (B) 6.42 cm
(C) 6.44 cm  (D) 6.13 cm

Answers to Evaluation Test

1.  (C)  2.  (A)  3.  (B)  4.  (D)
5.  (C)  6.  (B)  7.  (B)  8.  (B)
9.  (D)  10. (C) 11. (B) 12. (D)
13. (C)  14. (D) 15. (A) 16. (D)
17. (B)  18. (C)