2026
EXAMINATION

CBSE

QUESTION & CONCEPT BANK

Chapter-wise & Topic-wise

CLASS 11

Chapter-wise
CONCEPT MAPS

Important terms, Formulae & Myth Buster
SMART SNAPS

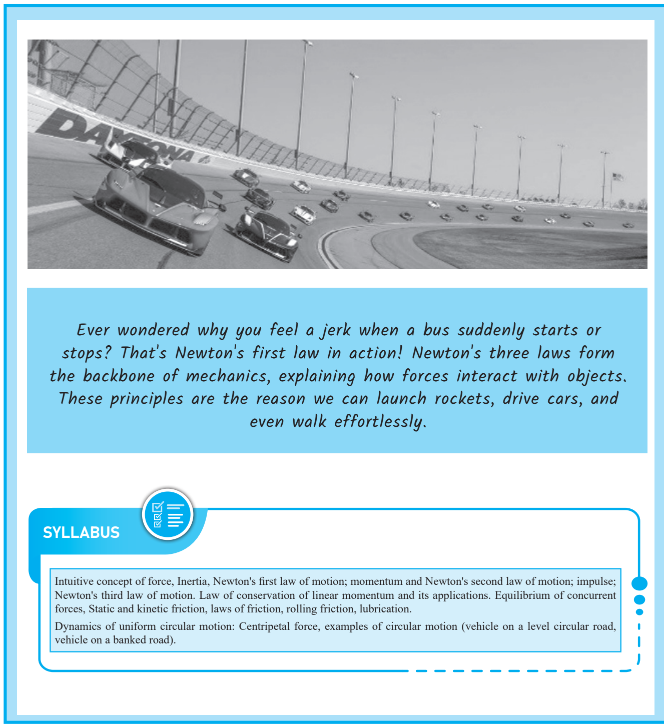
Revision Blue Print & Solved Questions
COMPETENCY FOCUSED

Important Questions with Detailed Explanations
POWER PRACTICE

PHYSICS

HOW TO USE THIS BOOK

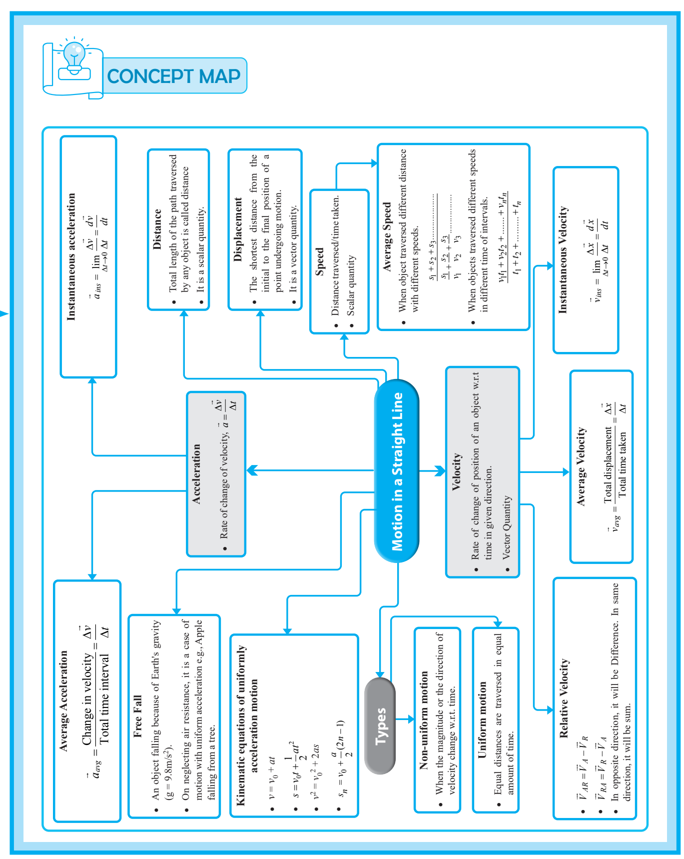
This book is structured to support your learning journey of preparing for your board exams through a variety of engaging and informative elements. Here's how to make the most of it:



Preview

At the start of every chapter, you'll find a thoughtfully chosen image and a quote that captures the main idea and motivation of the topic. This approach aims to get your interest and give you a glimpse of the theme ahead.

Before diving into the details, we outline the syllabus. This helps you prioritize your study focus based on the significance of each section.



Concept Map

The concept map appears to be a comprehensive study aid that outlines key concepts in a structured format, featuring definitions, diagrams, and processes. For a student, it would serve as a visual summary, making complex ideas more accessible and aiding in revision and understanding of concept for their curriculum.

1 VECTORS AND EQUATIONS OF MOTION IN 2D

NCERT Definitions *(Commonly asked in 1 mark)*

- **Scalars:** A scalar quantity is a quantity with magnitude only. It is specified completely by a single number, along with the proper unit. Examples: distance, mass, temperature, and time.
- **Vectors:** A vector quantity is a quantity that has both a magnitude and a direction and obeys the triangle law of addition or the parallelogram law of addition. Examples: displacement, velocity, acceleration, and force.
- **Position Vector:** The position vector of an object in a plane is a vector that extends from the origin of a chosen coordinate system to the object's location.
- **Displacement Vector:** The displacement vector is the straight line joining the initial and final positions of an object, independent of the path taken.
- **Equality of Vectors:** Two vectors are equal if and only if they have the same magnitude and direction.
- **Multiplication of Vectors by a Real Number:** Multiplying a vector by a positive number changes its magnitude but not its direction, while multiplication by a negative number reverses its direction.
- **Vector Addition (Triangle Method):** If two vectors are placed head to tail, the resultant vector is the vector drawn from the tail of the first to the head of the second.
- **Vector Addition (Parallelogram Method):** If two vectors originate from a common point, the diagonal of the parallelogram formed represents their sum.
- **Unit Vector:** A unit vector is a vector with a magnitude of one, indicating direction only. Unit vectors along the x-, y- and z-axes are denoted by $\hat{i}, \hat{j}, \hat{k}$, respectively.

Important Facts

01 Scalars can be derived from Vectors

02 Vectors are represented as arrows, where the length of the arrow represents the magnitude, and the arrowhead shows the direction.

03 Vectors are represented as bold letters (***A***) or with an arrow on top ($\vec{A}$).

04 A vector with zero magnitude has no specific direction.

05 Birds and planes use vectors naturally! A bird flying against the wind adjusts its direction and speed using the principles of **vector addition**.

06 Animation, 3D modeling, and virtual reality (VR) rely on **vector transformations** to create realistic movements.

NCERT Definitions: *It simplifies complex topics into brief, easy-to-understand explanations.*

Important Facts: *Quick, bullet point facts that are crucial for exams.*

Classification

Classification of Heat capacities

Category	Definition	Formula
Heat Capacity	The amount of heat required to raise the temperature of a body by 1 K.	$C = Q/\Delta T$
Specific Heat Capacity	The amount of heat required to raise the temperature of 1 kg of a substance by 1 K.	$S = Q/(m\Delta T)$
Molar Specific Heat Capacity	The amount of heat required to raise the temperature of 1 mole of a substance by 1 K.	$c_m = Q/(\mu\Delta T)$
Latent Heat	The heat required to change the phase of a substance without changing its temperature.	$Q = mL$

Important Formulae

1. **Dot product:**

   The dot product of two vectors $\vec{a}$ and $\vec{b}$ is given by $\vec{a}.\vec{b} = |a||b| \cos\theta$

   Dot product of unit vectors

   $\hat{i}.\hat{i} = \hat{j}.\hat{j} = \hat{k}.\hat{k} = 1$

   $\hat{i}.\hat{j} = \hat{j}.\hat{k} = \hat{k}.\hat{i} = 0$

   If $\vec{A} = A_1\hat{i} + A_2\hat{j} + A_3\hat{j}$ and $\vec{B} = B_1\hat{i} + B_2\hat{j} + B_3\hat{j}$

   Then $\vec{A}.\vec{B} = A_1B_1 + A_2B_2 + A_3B_3$

2. **Work done by a Constant Force**

   (i) If force displaces the particle from its initial position $\vec{r}_i$, to final position $\vec{r}_f$, then displacement vector $\vec{s} = \vec{r}_f - \vec{r}_i$

   $\therefore$ Work done, $W = \vec{F}.\vec{s}$

   or $W = \vec{F}.(\vec{r}_f - \vec{r}_i)$

   (ii) In terms of rectangular components, the force and displacement vectors can be written as.

   $\vec{F} = F_x\hat{i} + F_y\hat{j} + F_z\hat{k}$

   and $\vec{s} = x\hat{i} + y\hat{j} + z\hat{k}$

   $\therefore$ Work done, $W = \vec{F}.\vec{s}$

   $= (F_x\hat{i} + F_y\hat{j} + F_z\hat{k}).(x\hat{i} + y\hat{j} + z\hat{k})$

   or $W = F_x x + F_y y + F_z z$

3. **Work done by a Variable Force**

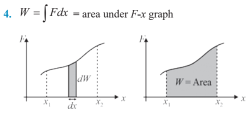
   Work done in a small displacement from x to $x + dx$ will be

   $$dW = F.dx$$

   Now, the total work can be obtained by integration of the above elemental work from x_1 to x_2

   or $W = \int_{x_1}^{x_2} dW = \int_{x_1}^{x_2} F \cdot dx$

4. $W = \int F dx$ = area under F-x graph



Classification: *It organizes complex information into clear categories, making it easier for students to grasp differences, recognize patterns, and predict properties or behaviors in their learning.*

Important Formulas:
Introducing important formulas upfront brings clarity to the chapter's objectives, guiding students' focus towards essential mathematical principles that will be explored further.

Difference Between *(Commonly asked in 2-3 marks)*

Conservative and Non-Conservative Forces

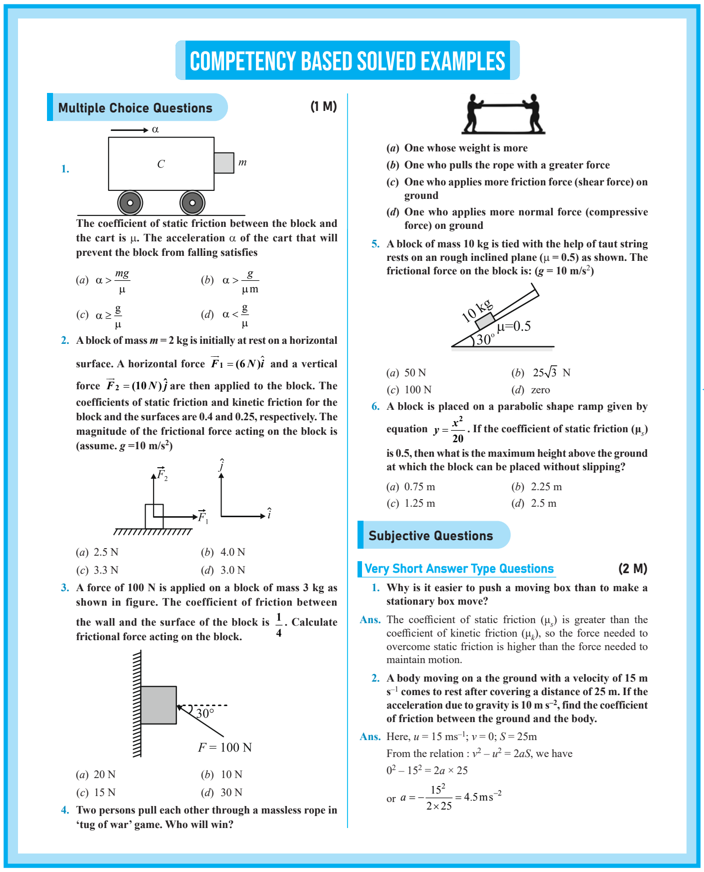
Feature	Conservative Forces	Non-Conservative Forces
Definition	Forces for which the work done is **independent of the path** and depends only on the initial and final positions.	Forces for which the work done **depends on the path taken** by the object.
Work Done in a Closed Path	**Zero**-Work done by a conservative force in a closed loop is zero.	**Non-zero** - Work done is positive or negative over a closed path.
Energy Conservation	**Mechanical energy is conserved** in a system influenced by only conservative forces.	**Mechanical energy is not conserved** because energy is lost as heat, sound, or deformation.
Dependence on Path	Work done depends **only on initial and final positions,** not on the path taken.	Work done **depends on the actual path taken** between initial and final positions.
Sign of Work Done	Work can be **positive or negative,** but it is **reversible**.	Work is mostly **negative** and **not reversible** because energy is lost.
Examples	**Gravitational force**, electrostatic force, spring force	Friction, viscous force

Myth Buster

- **Myth:** Work done by friction is always negative.
  Fact: Friction can do positive work.
- **Myth:** Work done can be path dependent or Independent
  Fact: Conservative forces (like gravity) make work path-independent, while non-conservative forces (like friction) make it path-dependent.
- **Myth:** Work done in a closed path is always zero.
  Fact: For conservative forces, work in a closed path is zero. For non-conservative forces, it is nonzero due to energy dissipation.

Difference Between: *Side-by-side comparisons to help distinguish similar concepts.*

Myth Buster: *Clear up common misconceptions to ensure your understanding is accurate.*



COMPETENCY BASED SOLVED EXAMPLES

Multiple Choice Questions (1 M)

1. The coefficient of static friction between the block and the cart is μ. The acceleration α of the cart that will prevent the block from falling satisfies

(a) $\alpha > \frac{mg}{\mu}$ (b) $\alpha > \frac{g}{\mu m}$

(c) $\alpha \geq \frac{g}{\mu}$ (d) $\alpha < \frac{g}{\mu}$

2. A block of mass $m = 2$ kg is initially at rest on a horizontal surface. A horizontal force $\vec{F}_1 = (6\,N)\hat{i}$ and a vertical force $\vec{F}_2 = (10\,N)\hat{j}$ are then applied to the block. The coefficients of static friction and kinetic friction for the block and the surfaces are 0.4 and 0.25, respectively. The magnitude of the frictional force acting on the block is (assume. $g = 10$ m/s^2)

(a) 2.5 N (b) 4.0 N

(c) 3.3 N (d) 3.0 N

3. A force of 100 N is applied on a block of mass 3 kg as shown in figure. The coefficient of friction between the wall and the surface of the block is $\frac{1}{4}$. Calculate frictional force acting on the block.

(a) 20 N (b) 10 N

(c) 15 N (d) 30 N

4. Two persons pull each other through a massless rope in 'tug of war' game. Who will win?

(a) One whose weight is more

(b) One who pulls the rope with a greater force

(c) One who applies more friction force (shear force) on ground

(d) One who applies more normal force (compressive force) on ground

5. A block of mass 10 kg is tied with the help of taut string rests on an rough inclined plane (μ = 0.5) as shown. The frictional force on the block is: ($g = 10$ m/s^2)

(a) 50 N (b) $25\sqrt{3}$ N

(c) 100 N (d) zero

6. A block is placed on a parabolic shape ramp given by equation $y = \frac{x^2}{20}$. If the coefficient of static friction (μ_s) is 0.5, then what is the maximum height above the ground at which the block can be placed without slipping?

(a) 0.75 m (b) 2.25 m

(c) 1.25 m (d) 2.5 m

Subjective Questions

Very Short Answer Type Questions (2 M)

1. Why is it easier to push a moving box than to make a stationary box move?

Ans. The coefficient of static friction (μ_s) is greater than the coefficient of kinetic friction (μ_k), so the force needed to overcome static friction is higher than the force needed to maintain motion.

2. A body moving on a the ground with a velocity of 15 m s^{-1} comes to rest after covering a distance of 25 m. If the acceleration due to gravity is 10 m s^{-2}, find the coefficient of friction between the ground and the body.

Ans. Here, $u = 15$ ms^{-1}; $v = 0$; $S = 25$m

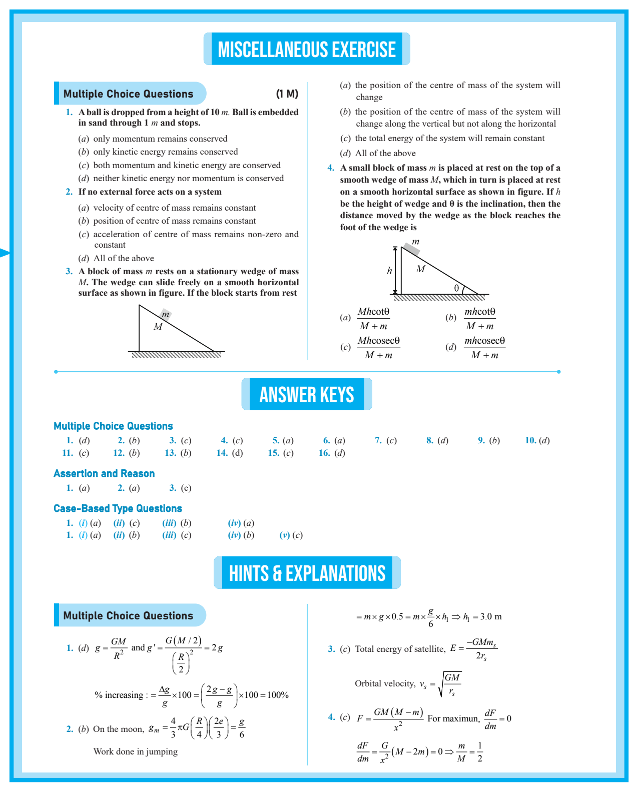
From the relation : $v^2 - u^2 = 2aS$, we have

$0^2 - 15^2 = 2a \times 25$

or $a = -\frac{15^2}{2 \times 25} = 4.5\,\text{ms}^{-2}$

Solved Examples

For each topic solved examples are provided that exemplify how to approach and solve questions. This section is designed to reinforce your learning and improve problemsolving skills.



MISCELLANEOUS EXERCISE

Multiple Choice Questions (1 M)

1. A ball is dropped from a height of 10 m. Ball is embedded in sand through 1 m and stops.

(a) only momentum remains conserved

(b) only kinetic energy remains conserved

(c) both momentum and kinetic energy are conserved

(d) neither kinetic energy nor momentum is conserved

2. If no external force acts on a system

(a) velocity of centre of mass remains constant

(b) position of centre of mass remains constant

(c) acceleration of centre of mass remains non-zero and constant

(d) All of the above

3. A block of mass m rests on a stationary wedge of mass M. The wedge can slide freely on a smooth horizontal surface as shown in figure. If the block starts from rest

(a) the position of the centre of mass of the system will change

(b) the position of the centre of mass of the system will change along the vertical but not along the horizontal

(c) the total energy of the system will remain constant

(d) All of the above

4. A small block of mass m is placed at rest on the top of a smooth wedge of mass M, which in turn is placed at rest on a smooth horizontal surface as shown in figure. If h be the height of wedge and θ is the inclination, then the distance moved by the wedge as the block reaches the foot of the wedge is

(a) $\frac{Mh\cot\theta}{M+m}$ (b) $\frac{mh\cot\theta}{M+m}$

(c) $\frac{Mh\text{cosec}\theta}{M+m}$ (d) $\frac{mh\text{cosec}\theta}{M+m}$

ANSWER KEYS

Multiple Choice Questions

1. (d) 2. (b) 3. (c) 4. (c) 5. (a) 6. (a) 7. (c) 8. (d) 9. (b) 10. (d)
11. (c) 12. (b) 13. (b) 14. (d) 15. (c) 16. (d)

Assertion and Reason

1. (a) 2. (a) 3. (c)

Case-Based Type Questions

1. (i) (a) (ii) (c) (iii) (b) (iv) (a)
1. (i) (a) (ii) (b) (iii) (c) (iv) (b) (v) (c)

HINTS & EXPLANATIONS

Multiple Choice Questions

1. (d) $g = \frac{GM}{R^2}$ and $g' = \frac{G(M/2)}{\left(\frac{R}{2}\right)^2} = 2g$

% increasing : $= \frac{\Delta g}{g} \times 100 = \left(\frac{2g - g}{g}\right) \times 100 = 100\%$

2. (b) On the moon, $g_m = \frac{4}{3}\pi G\left(\frac{R}{4}\right)\left(\frac{2e}{3}\right) = \frac{g}{6}$

Work done in jumping

$= m \times g \times 0.5 = m \times \frac{g}{6} \times h_1 \Rightarrow h_1 = 3.0$ m

3. (c) Total energy of satellite, $E = \frac{-GMm_s}{2r_s}$

Orbital velocity, $v_s = \sqrt{\frac{GM}{r_s}}$

4. (c) $F = \frac{GM(M-m)}{x^2}$ For maximun, $\frac{dF}{dm} = 0$

$\frac{dF}{dm} = \frac{G}{x^2}(M - 2m) = 0 \Rightarrow \frac{m}{M} = \frac{1}{2}$

Answer Key

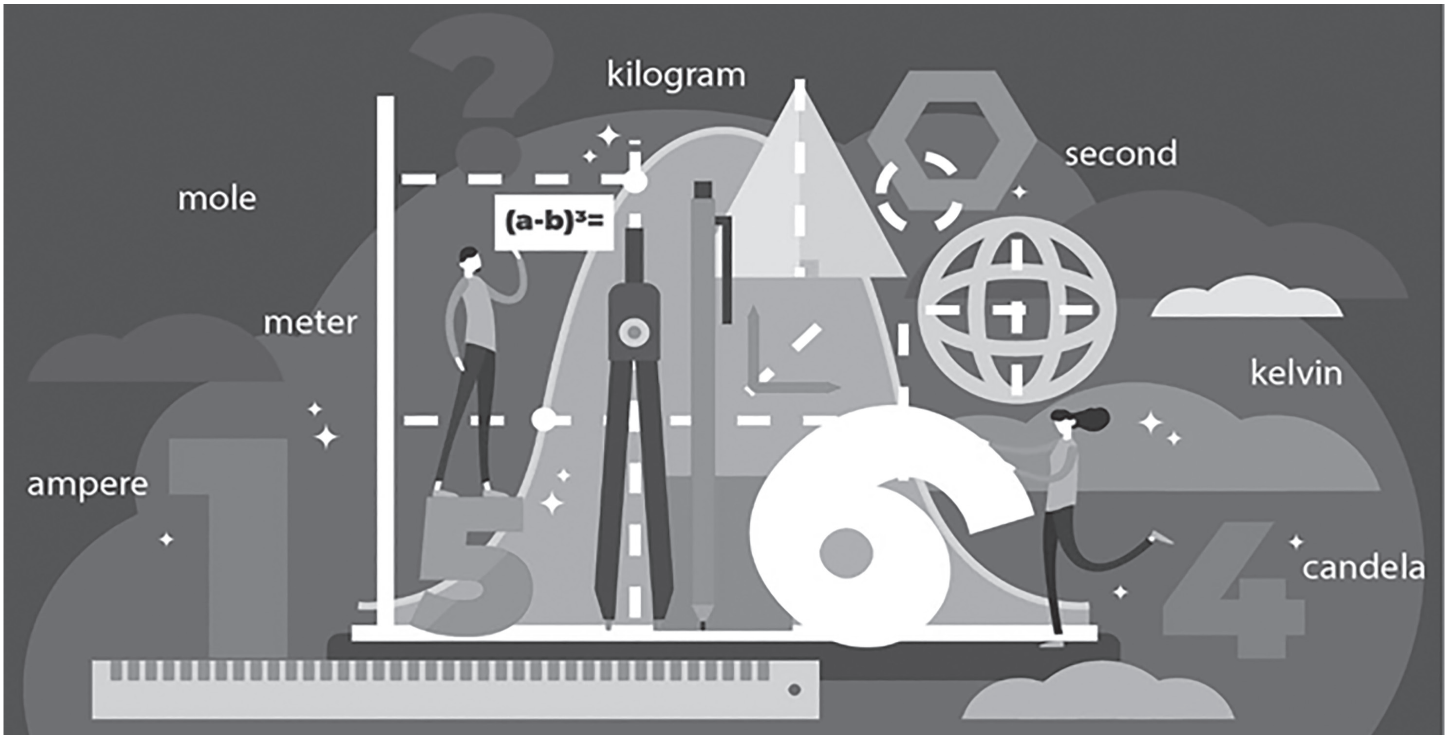
At the end of each chapter, you'll find additional exercises intended to test your grasp of the material. These are great for revision and to prepare for exams.

Answer Key and Explanations helping you to know how to write the ideal answer.

CONTENTS

UNITS AND MEASUREMENT

1



Did you know that the meter was once defined as one ten- millionth of the distance from the equator to the North Pole? Over time, scientists refined measurements, leading to today's precise SI units. Precision in measurement has driven technological advancements, from GPS to space missions.

SYLLABUS

Units of measurement; systems of units; SI units, fundamental and derived units, significant figures. Dimensions of physical quantities, dimensional analysis and its applications.

CONCEPT MAP

Units and Measurements

Unit
- Standard Reference for comparison when measuring other quantitites. Ex- meter is a physical unit for measuring length.

Fundamental Units
- Mass, Length, time, temperature, electric current, luminous intensity and amount of substance have fundamental units kilogram, metre, second, Kelvin, ampere, candela and mol respectively.

Derived Units
- The units which are derived from fundamental units are called derived units.
- Physical quantitites like speed, acceleration have derived units like m/s, m/s^2 respectively.

Supplementary Units
- Units that are used with base units to form derived units.
- Radian ⇒ Plane angle
- Steradian ⇒ Solid Angle

Properties
- Universal acceptance
- Non-perishable
- Well defined
- Does not change with time

System of units
- Set of fundamental and derived units
- CGS – Centimeter, Gram, Second
- MKS - Metre, Kilogram, Second
- S.I - Système International (Internationally accepted)

Dimension of Physical Quantities
- Expression which shows how and which of the base quantities represents the dimension of a physical quantity is called dimension formula. **e.g.** Force = $[MLT^{-2}]$

Measurements
- Assigning a numerical value to a physical quantity by comparing it to a known standard unit.

Significant figures
- All non-zero digits
- All zero between two non-zero digits
- If the number is less than 1, the zero (s) on the right of decimal point but to the left of the non-zero digit are not significant.
- Terminal or trailing zero (s) in a number without a decimal point are not significant

  e.g. → In 020342.010

  Here 20342.01.are significant

Precision
- Limit of resolution of quantity measured.

Accuracy
- Closeness of the measured value to the true value

2 MEASUREMENTS

NCERT Definitions *(Commonly asked in 1 mark)*

- **Measurement:** The process of comparing a physical quantity with a standard unit.
- **Order of Magnitude:** The power of 10 closest to a given quantity, representing its approximate size.
- **Significant figures:** are those digits in a measurement that are known reliably plus the first digit that is uncertain.
- **Accuracy:** The degree to which a measured value matches the true or accepted value of quantity. It indicates how correct a measurement is.
- **Precision:** The degree to which repeated measurements give the same result, regardless of their correctness. It indicates how consistent a measurement is.

Important Facts

01 Scientific notation eliminates ambiguity - Writing 4.20×10^3 makes it clear that the number has three significant figures.

02 More significant figures do not mean more accuracy - A faulty instrument can still give precise but incorrect measurements!

03 Exact numbers have infinite significant figures - If you have 12 apples, the number 12 is exact and has infinite precision

04 Rounding can introduce small errors - If multiple steps involve rounding, the final result may drift slightly from the actual value.

05 Precision is independent of accuracy - A broken clock that always shows 10:00 AM is precise but highly inaccurate!.

Difference Between

Accuracy vs. Precision

Aspect	Accuracy	Precision
Definition	How close a measured value is to the true or accepted value.	How closely repeated measurements agree with each other.
Focus	Measures correctness.	Measures consistency.
Affected by	Systematic errors.	Random errors.
Example	If the true weight of an object is 50.0 kg and a balance reads 49.9 kg, it is accurate.	If multiple measurements are taken as 49.8 kg, 49.9 kg, and 50.0 kg, it is precise.
Ideal Case	A measurement should be both accurate and precise.	Precision without accuracy means repeated errors.

Differences Between Rounding-Off and Significant Figures

Aspect	Rounding-off	Significant figures
Definition	The process of reducing the number of digits in a value while maintaining its approximate accuracy.	The number of meaningful digits in a value that indicate its precision and accuracy.
Purpose	To simplify calculations and make numbers easier to interpret.	To indicate the precision of a measured or calculated value.
Application	Used in intermediate steps of calculations to avoid excessive digits.	Used to express the accuracy of measured values in scientific work.
Rules	Follows standard rules based on the digit following the last retained digit (e.g., if it's >5, increase the last digit by 1).	Includes all non-zero digits, zeros between non-zero digits, and trailing zeros after a decimal.
Effect on Accuracy	May lose some precision	Preserves all meaningful digits, ensuring precise representation of data.
Example	**12.467 → 12.47 (rounded to 2 decimal places)**	**0.00450 has 3 significant figures (4, 5, and trailing 0)**
Usage	Used in everyday arithmetic, estimations, and final reported values in calculations.	Used in scientific measurements, lab experiments, and engineering applications.

Myth Buster

- **Myth: Rounding a number always makes it less accurate.**
  Fact: Rounding simplifies a number, but it does not reduce accuracy if done correctly using significant figures.
- **Myth: Rounding-off is always done after every calculation step.**
  Fact: To minimize errors, rounding should be done only at the final step of calculations.
- **Myth: If the digit to be dropped is 5, always round up.**
  Fact: Rounding a 5 depends on the preceding digit: If it's even, keep it the same; if it's odd, round up (banker's rounding rule).
- **Myth: More significant figures always mean higher accuracy.**
  Fact: More significant figures indicate higher precision, but accuracy depends on the instrument and method used.
- **Myth: Trailing zeros never count as significant figures.**
  Fact: Trailing zeros are significant only if there is a decimal point (e.g., 50.00 has 4 significant figures, but 500 has only 1).
- **Myth: Scientific notation eliminates the need for significant figures.**
  Fact: Scientific notation clarifies significant figures but does not replace their importance in calculations.
- **Myth: Zeros in a number are always insignificant.**
  Fact: Zeros between non-zero digits (e.g., 2004) and zeros after a decimal point (e.g., 3.50) are significant.
- **Myth: A highly accurate measurement means it is also precise.**
  Fact: Accuracy refers to correctness, while precision refers to consistency. A value can be accurate but not precise, or precise but not accurate.
- **Myth: If a measurement is close to the expected value once, it is always accurate.**
  Fact: A single measurement may be accidentally close to the true value, but accuracy requires consistent correctness across multiple measurements
- **Myth: Increasing the number of measurements automatically improves accuracy.**
  Fact: More measurements increase precision, but accuracy improves only if systematic errors are corrected.

COMPETENCY BASED SOLVED EXAMPLES

Multiple Choice Questions (1 M)

1. **Each side a cube is measured to be 7.203 m. The volume of the cube up to appropriate significant figures is**

   (*a*) 373.714 (*b*) 373.71
   (*c*) 373.7 (*d*) 373

2. **The number of significant figures in 0.007 m^2 is**

   (*a*) 1 (*b*) 2
   (*c*) 3 (*d*) 4

3. **The mass of a box is 2.3 kg. Two marbles of masses 2.15 g and 12.39 g are added to it. The total mass of the box to the correct number of significant figures is**

   (*a*) 2.340 kg (*b*) 2.3145 kg
   (*c*) 2.3 kg (*d*) 2.31 kg

4. **The length of a rectangular sheet is 1.5 cm and breadth is 1.203 cm. The area of the face of rectangular sheet to the correct no. of significant figures is :**

   (*a*) 1.8045 cm^2 (*b*) 1.804cm^2
   (*c*) 1.805 cm^2 (*d*) 1.8 cm^2

5. **Each side of a cube is measured to be 5.402 cm. The total surface area and the volume of the cube in appropriate significant figures are :**

   (*a*) 175.1 cm^2, 157 cm^3
   (*b*) 175.1 cm^2, 157.6 cm^3
   (*c*) 175 cm^2, 157 cm^3
   (*d*) 175.08 cm^2, 157.639 cm^3

6. **The value of the multiplication 3.124 × 4.576 correct to three significant figures is**

   (*a*) 14.295 (*b*) 14.3
   (*c*) 14.295424 (*d*) 14.305

7. **The number of the significant figures in 11.118 × 10^{-6} V is**

   (*a*) 3 (*b*) 4
   (*c*) 5 (*d*) 6

8. **The number of significant figures in a pure number 410 is**

   (*a*) two (*b*) three
   (*c*) one (*d*) infinite

Assertion and Reason (1 M)

Direction: **In the following questions a statement of assertion (A) is followed by a statement of Reason (R). Choose the correct answer out of the following choices**

(*a*) Both Assertion (A) and Reason (R) are correct and Reason (R) is correct explanation of Assertion (A).
(*b*) Both Assertion (A) and Reason (R) are correct but Reason (R) is not the correct explanation of Assertion (A).
(*c*) Assertion (A) is correct, but Reason (R) is false.
(*d*) Both Assertion (A) and Reason (R) are incorrect.

1. **Assertion (A):** Two students measure the length of a stick as 1.3 m and 1.30m. Both the measurements are equally accurate.

   Reason (R): The zero at the end of a number is always meaningless.

2. **Assertion (A):** The number of significant figures in 0.001 is 1.

   Reason (R): All zeros to the right of a decimal point and to the left of a non-zero digit are never significant.

3. **Assertion (A):** The number of significant figures in 0.100 is 1.

   Reason (R): The zeros at the end of a number are always meaningless.

Subjective Questions

Very Short Answer Type Questions (2 M)

1. **Round off to 3 significant figures:**

   (i) 20.96 metre
   (ii) 0.0003125 kg

Ans. (i) 20.96 metre has four significant figures. The fourth significant figure is more than 5 and hence on rounding off to three significant figures, the given measurement will become 20.9 + 0.1 i.e. 21.0 metre.

(ii) 0.0003125 kg has four significant figures. The fourth significant figure is 5 and hence on rounding off to three significant figures, the given measurement will become 0.000313 or 3.13 × 10^{-6} kg.

2. **A jeweller puts a diamond in a box weighing 1.2 kg. Find the total weight of the box and the diamond with due regard to significant figures, if the weight of diamond is 5.42 g.**

Ans. Weight of box, a = 1.2 kg

Weight of diamond, b = 5.42 g = 0.00542 kg

$\therefore a + b = 1.2 + 0.00542 = 1.20542$ kg

Of all the weight measurements, weight of the box (1.2 kg) has the least number of decimal places i.e. one. Therefore, rounding off the above result to the first decimal place,

we have the total weight of the box, $a + b = 1.2$ kg

3. **The length, breadth and thickness of a rectangular sheet of metal are 4.234 m, 1.005 m and 2.01 cm respectively. Find the area and volume of the sheet to correct significant figures.**

Ans. $A = L \times B = 4.25517 \text{ m}^2$

Expressing to four significant figures,

$A = 4.255 \text{ m}^2$

Volume = area × thickness = 0.0855m^3 (Three significant figures)

4. **5.74 g of a substance occupies1.2 cm³. Express its density keeping significant figures in view.**

Ans. Density = mass/volume = 5.74/1.2 = 4.7833 = 4.8 gm/cc

5. **Mass of a proton is 1.6×10^{-27} kg. Calculate the number of protons, whose net mass is one gram. Express in the order of magnitude.**

Ans. Here, mass of a proton, $m_p = 1.6 \times 10^{-27}$ kg

Net mass of the protons, m = 1 g = 10^{-3} kg

Therefore, number of protons in 1 g,

$$n = \frac{m}{m_p} = \frac{10^{-3}}{1.6 \times 10^{-27}}$$

Therefore, order of magnitude of the number of protons in 1 g is 10^{24}.

Short Answer Type Questions (3 M)

1. **Write down rules for 'Rounding off ' with suitable examples.**

Ans. Rounding off a value means adjusting a number to a simpler or more convenient form while keeping it close to the original value. It is done to reduce the number of digits while maintaining accuracy as much as needed.

Rules for Rounding-OFF:

Rule-I: If the digit to be dropped is smaller than 5, then the preceding digit should be left unchanged.

Example: (i) 7.34 is rounded off to 7.3.

(ii) 7.93 is rounded off to 7.9.

Rule-II: If the digit to be dropped is greater than 5, then the preceding digit should be raised by 1.

Example: (i) 17.26 is rounded off to 17.3.

(ii) 11.89 is rounded off to 11.9.

Rule-III: If the digit to be dropped is 5 followed by digits other than zero, then the preceding digit should be raised by 1.

Example: (i) 7.351, on being rounded off to first decimal becomes 7.4.

(ii) 18.159, on being rounded off to first decimal becomes 18.2

Rule-IV: If the digit to be dropped is 5 or 5 followed by zeros, then the preceding digit is not changed if it is even.

Example: (i) 3.45, on being rounded off, becomes 3.4.

(ii) 3.450, on being rounded off, becomes 3.4

Rule-V: If the digit to be dropped is 5 or 5 followed by zeros, then the preceding digit is raised by 1 if it is odd.

Examples: (i) 3.35, on being rounded off, becomes 3.4

(ii) 3.350, on being rounded off, becomes 3.4

Note: Rules IV and V are based on the convection that the number is to be rounded off to the nearest even number.

2. **"A more precise measurement does not necessarily imply greater accuracy." Comment on this statement.**

Ans. A more precise measurement does not necessarily imply greater accuracy. Precision reflects the consistency of measurements, while accuracy reflects how close a measurement is to the true value. Precision and accuracy are independent, and achieving one does not guarantee the other.

Consider measuring the length of a table that is exactly 2.00 meters using two different instruments:

I. Instrument A: A faulty steel tape measure that is stretched and always underestimates by 0.05 meters.

- **Measurements:** 1.95, 1.95, 1.95, 1.95 meters.
- **Precision:** High (all measurements are consistent).
- **Accuracy:** Low (all measurements deviate by 0.05 meters from the true value).

II. Instrument B: A rough wooden scale with worn-out markings.

- **Measurements:** 1.96, 2.02, 2.04, 1.98 meters.
- **Precision:** Low (measurements vary significantly).
- **Accuracy:** Moderate (average is closer to the true value).

3. **The length, breadth and thickness of a metal sheet are 4.234 m, 1.005 m and 2.01 cm respectively. Give the area and volume of the sheet to correct significant figures.**

Ans. Here, length = 4.234 m; breadth = 1.005 m and thickness = 2.01 cm = 2.01×10^{-2} m

Therefore, area of the metal sheet = 4.234 × 1.005 = 4.25517 m^2

Since both length and breadth measurements have four significant figures, the area of the metal sheet after rounding off to four significant figures is given by

area = 4.255 m^2

Now, volume of the metal sheet

$= 4.234 \times 1.005 \times 2.01 \times 10^{-2} = 8.55289 \times 10^{-2} \text{ m}^{-3}$

Since thickness is measured upto only three significant figures, the volume of the metal sheet after rounding off to three significant figures is given by

volume = $8.55 \times 10^{-2} \text{ m}^3$ or 0.0855 m^3

4. **The mass of a box measured by a grocer's balance is 2.3 kg. Two gold pieces of masses 20.15 g and 20.17 g are added to the box. What is (a) the total mass of the box, (b) the difference in the masses of the pieces to correct significant figures?**

Ans. Here, mass of the box, $M = 2.3$ kg;

mass of the gold piece, $m_1 = 20.15$ g = 0.02015 kg and mass of the other gold piece,

$m_2 = 20.17$ g = 0.02017 kg

(a) Total mass of the box,

$M + m_1 + m_2 = 2.3 \text{ kg} + 0.02015 \text{ kg} + 0.02017 \text{ kg}$

$= 2.34032 \text{ kg}$

As the mass of the box has least number of decimal places i.e. one, retaining the result up to first decimal place, we have

total mass of the box = 2.3 kg

(b) Difference in masses of the two gold pieces,

$m_2 - m_1 = 20.17 \text{ g} - 20.15 \text{ g} = 0.02 \text{ g}$

Since the mass of each of the two gold pieces is measured upto two decimal places, the result has to be expressed likewise. Therefore, difference in masses of the two gold pieces,

$m_2 - m_1 = 0.02 \text{ g}$

Long Answer Type Questions (5 M)

1. What are significant figures in measurement, and what are the rules for determining them?

Ans. Significant Figures

- The digits which tell us the number of units we are reasonably sure of having counted in making a measurement are called significant figures.
- Significant figures are those digits in a measurement that are known reliably plus the first digit that is uncertain.

Rules:

(i) All the non-zero digits are significant.

Example: 132.73 contains five significant figures.

(ii) All the zeros between the non-zero digits are significant.

Example: 207.009 contains six significant figures.

(iii) (a) All zeros to the left of an understood decimal point but to the right of a non-zero digits are not significant.

Example: 307000 contains only three significant figures

(b) All zero to the left of an understood decimal point but to the right of a non-zero digits are significant if they come from a measurement.

If there is no decimal point, all zeros to the right of the right-most non-zero digit are significant if they come from a measurement.

As example, consider a distance of 400 m. This distance is measured to the nearest metre. Both the zeros in this value are significant.

(iv) All zeros to the left of an expressed decimal point but to the right of a non-zero digit are significant. As an example, 307000.0 contains seven significant figures.

(v) All zeros to the right of a decimal point but to the left of non-zero digit are not significant provided there is only a zero to the left of the decimal point.

(vi) All zeros to the right of a decimal point and to the right of a non-zero digit are significant.

Example, 0.03040 and 40.00 m each contain four significant figures.

(vii) The number of significant figures does not vary with the choice of different units.

2. State and explain the rules of finding the significant digits in the sum, difference, product and quotient of two numbers.

Ans. Significant figures in addition and subtraction

Rule: Do not retain a greater number of decimal places in a result computed from addition and/or subtraction than in the observation, which has the fewest decimal places.

Illustration: Add and subtraction 428.5 and 17.23

To add or subtract in such a situation, there are two methods:

(i) By rounding off the answer. The data 428.5 is the weakest link as its value is known upto first decimal only. Therefore, the answer should also be retained only up to first decimal place i.e.

428.5	428.5
17.23	17.23
Sum = 445.73	Difference = 411.27

In case the second decimal is occupied by 5 or more than 5, the number in first decimal is increased by 1. On the other hand, if the second decimal is occupied by a number less than 5, it is ignored.

Rounding off the results of the above sum and difference to the first decimal, we have correct sum = 445.7 and correct difference = 411.3

(ii) By rounding off the other data. The result can also be obtained by rounding off the other data in accordance with the data, which is the weakest link. The data 17.23 should be rounded off to 17.2 (3 in second decimal place is ignored) and then added to or subtracted from 428 5. Thus, we have

428.5	428.5
17.2	17.2
Sum = 445.7	Difference = 411.3

Significant figures in Multiplication and Division

Rule: Do not retain a greater number of significant figures in a result computed from multiplication and/or division than the least number of significant figures in the data from which the result is computed.

Illustration. Multiply 312.65 and 26.4 with due regards to significant figures.

We have,

312.65
26.4
125060
187590×
62530××
8253.960

But as the weakest link i.e. the data 26.4 has only three significant figures, the correct result of multiplication will be 8250. This is because in 8250, there are three significant figures. Hence,

$312.65 \times 26.4 = 8250$

Illustration. Divide 2.5×10^5 by 4.75×10^3 with due regards to significant figures.

We have, $\dfrac{2.5\times10^5}{4.75\times10^3}=52.6316$

Since the weakest link 2.5×10^5 has only two significant figures, the correct result of the division will be 53. Hence,

$$\frac{2.5\times10^5}{4.75\times10^3}=53$$

Hints & Explanations

Multiple Choice Questions

1. (*c*) Volume = $a^3 = (7.023)^3 = 373.715\ m^3$

   In significant figures volume of cube will be 373.7 m^3 because its side has four significant figures.
2. (*a*) Leading zeros or the zeros placed to the left of the number are never significant.
3. (*c*) Total mass = 2.3 + 0.00215 + 0.01239 = 2.31 kg

   Total mass in appropriate significant figure be 2.3 kg.
4. (*d*) Area =1.5 × 1.203 = 1.8045 cm^2 = 1.8 cm^2 (Upto correct number of significant figure).
5. (*b*) Total surface area = 6 × $(5.402)^2$ = 175.09 cm^2 = 175.1 cm^2 (Upto correct number of significant figure)

   Total volume = $(5.402)^3$ = 175.64 cm^3 = 175.6 cm^3 (Upto correct number of significant figure).
6. (*b*) $3.124\times4.576=14.295=14.3$ (Correct to three significant figures).
7. (*c*) The number of significant figure is 5 as 10^{-6} does not affect this number.
8. (*d*) A pure number has infinite number of significant figures.

Assertion and Reason

1. (*d*) A measurement made to the second decimal place is more accurate.

   All zeros to the right of the last non-zero digit after the decimal point are significant.

   Thus, both Assertion and Reason are false.

   Hence, the option (4) is correct.
2. (*a*) Zeros at the beginning of a number are not significant. They merely locate the decimal point. Therefore, the number of significant figures in 0.001 is 1. Thus, both Assertion and Reason are true.

   Hence, the option (a) is correct.
3. (*d*) All zeros to the right of the last non-zero digit after the decimal point are significant. Therefore, the number of significant figures in 0.100 is 3.

   Thus, both Assertion and Reason are false.

   Hence, the option (d) is correct.

MISCELLANEOUS EXERCISE

Multiple Choice Questions (1 M)

1. The number of significant figures in 3400 is

   (*a*) 3 (*b*) 1 (*c*) 4 (*d*) 2
2. The significant figures in the number 6.0023 are

   (*a*) 2 (*b*) 5 (*c*) 4 (*d*) 3
3. The length and breadth of a metal sheet are 3.124 m and 3.002 m respectively. The area of this sheet upto correct significant figure is

   (*a*) 9.378 m^2 (*b*) 9.37 m^2 (*c*) 9.4 m^2 (*d*) None of these
4. The length, breadth and thickness of a block are given by l = 12 cm, b = 6 cm and t = 2.45 cm. The volume of the block according to the idea of significant figures should be

   (*a*) $1\times10^2\ cm^3$ (*b*) $2\times10^2\ cm^3$ (*c*) $1.763\times10^2\ cm^3$ (*d*) None of these
5. The mass of a ball is 1.76 kg . The mass of 25 such balls is

   (*a*) 0.44×10^3 kg (*b*) 44.0 kg (*c*) 44 kg (*d*) 44.00 kg
6. Dimension of velocity gradient is

   (*a*) $[M^0 L^0 T^{-1}]$ (*b*) $[ML^{-1} T^{-1}]$ (*c*) $[M^0 L T^{-1}]$ (*d*) $[ML^0 T^{-1}]$
7. Which of the following is the dimension of the coefficient of friction?

   (*a*) $[M^2 L^2 T]$ (*b*) $[M^0 L^0 T^0]$ (*c*) $[ML^2 T^{-2}]$ (*d*) $[M^2 L^2 T^{-2}]$
8. Which of the following sets have different dimensions?

   (*a*) Pressure, Young's modulus, Stress

   (*b*) Emf, Potential difference, Electric potential

   (*c*) Heat, Work done, Energy

   (*d*) Dipole moment, Electric flux, Electric field

9. The viscous force F on a sphere of radius a moving in a medium with velocity v is given by $F = 6\pi\eta av$. The dimensions of η are

(*a*) $\left[ML^{-3}\right]$ (*b*) $\left[MLT^{-2}\right]$

(*c*) $\left[MT^{-1}\right]$ (*d*) $\left[ML^{-1}T^{-1}\right]$

10. A force is given by

$F = at + bt^2$

where, t is the time. The dimensions of a and b are

(*a*) $\left[MLT^{-4}\right]$ and $\left[MLT\right]$

(*b*) $\left[MLT^{-1}\right]$ and $\left[MLT^{0}\right]$

(*c*) $\left[MLT^{-3}\right]$ and $\left[MLT^{-4}\right]$

(*d*) $\left[MLT^{-3}\right]$ and $\left[MLT^{0}\right]$

11. The physical quantity having the dimensions $[M^{-1} L^{-3} T^3 A^2]$ is

(*a*) resistance (*b*) resistivity

(*c*) electrical conductivity (*d*) electromotive force

12. The dimensional formula for magnetic flux is

(*a*) $\left[ML^2T^{-2}A^{-1}\right]$ (*b*) $\left[ML^3T^{-2}A^{-2}\right]$

(*c*) $\left[M^0L^{-2}T^{-2}A^{-2}\right]$ (*d*) $\left[ML^2T^{-1}A^2\right]$

13. Choose the wrong statement.

(*a*) All quantities may be represented dimensionally in terms of the base quantities

(*b*) A base quantity cannot be represented dimensionally in terms of the rest of the base quantities

(*c*) The dimension of a base quantity in other base quantities is always zero

(*d*) The dimension of a derived quantity is never zero in any base quantity

14. If unit of length and time is doubled, the numerical value of g (acceleration due to gravity) will be

(*a*) doubled (*b*) halved

(*c*) four times (*d*) same

15. Using mass (M), length (L), time (T) and current (A) as fundamental quantities, the dimension of permeability is

(*a*) $\left[M^{-1}LT^{-2}A\right]$ (*b*) $\left[ML^{-2}T^{-2}A^{-1}\right]$

(*c*) $\left[MLT^{-2}A^{-2}\right]$ (*d*) $\left[MLT^{-1}A^{-1}\right]$

16. The equation of a wave is given by

$$y = a\sin\omega\left(\frac{x}{v} - k\right)$$

where, ω is angular velocity and v is the linear velocity. The dimensions of k will be

(*a*) $\left[T^2\right]$ (*b*) $\left[T^{-1}\right]$

(*c*) $\left[T\right]$ (*d*) $\left[LT\right]$

17. If the energy (E), velocity (v) and force (F) be taken as fundamental quantities, then the dimensions of mass will be

(*a*) $\left[Fv^{-2}\right]$ (*b*) $\left[Fv^{-1}\right]$

(*c*) $\left[Ev^{-2}\right]$ (*d*) $\left[Ev^{2}\right]$

18. If force F, length L and time T are taken as fundamental units, the dimensional formula for mass will be

(*a*) $\left[FL^{-1}T^2\right]$ (*b*) $\left[FLT^{-2}\right]$

(*c*) $\left[FL^{-1}T^{-1}\right]$ (*d*) $\left[FL^5T^2\right]$

Assertion and Reason **(1 M)**

Direction: In the following questions a statement of assertion (A) is followed by a statement of Reason (R). Choose the correct answer out of the following choices

(*a*) Both Assertion (A) and Reason (R) are correct and Reason (R) is correct explanation of Assertion (A).

(*b*) Both Assertion (A) and Reason (R) are correct but Reason (R) is not the correct explanation of Assertion (A).

(*c*) Assertion (A) is correct, but Reason (R) is false.

(*d*) Both Assertion (A) and Reason (R) are incorrect.

1. **Assertion (A):** The dimensional formula for potential difference is $[ML^2T^{-3}A^{-1}]$

Reason (R): Electric potential is work done to carrying the test charge from one point to another.

2. **Assertion (A):** The constant of proportionality in SI system is unity.

Reason (R): SI system is coherent system of units.

3. **Assertion (A):** The equation representing distance traversed in n^{th} second $S_n = u + \frac{1}{2}a(2n-1)$ is numerically and dimensionally correct.

Reason (R): The distance traversed in n^{th} second has the dimensiosns of velocity.

4. **Assertion (A):** Force and pressure can be added.

Reason (R): Force and pressure have same dimensions.

5. **Assertion (A):** The number 1.202 has four significant figures and the number 0.0024 has two significant figures.

Reason (R): All the non zero digits are significant.

6. **Assertion (A):** The given equation $x = x_0 + u_0 t + \frac{1}{2}at^2$ is dimensionally correct, where x is the distance travelled by a particle in time t, initial position x_0 initial velocity u_0 and uniform acceleration a is along the direction of motion.

Reason (R): Dimensional analysis can be used for checking the dimensional consistency or homogeneity of the equation.

Subjective Questions

Very Short Answer Type Questions (2 M)

1. How do we make the choice of a standard unit of measurement?
2. In the formula, $x = 3yz^2$, x and z have dimensions of capacitance and magnetic induction, respectively. Find the dimensions of y in MKS system.
3. The equation of state of real gases can be expressed as $\left(p + \frac{a}{V^2}\right)(V - b) = RT$ where, p is pressure, V is volume and T is absolute temperature. Find dimensional formula of a and b constants.
4. Check the correctness of the relation $v^2 - u^2 = 2as$ by method of dimensions. The symbol have their usual meaning.
5. The speed of sound in a solid is given by the formula $v = \sqrt{\frac{E}{\rho}}$ where, E is coefficient of elasticity and ρ is density of given solid. Check the relation by method of dimensional analysis.
6. If force F, length L and time T are taken as fundamental units, then what will be the dimensions of mass?

Short Answer Type Questions (3 M)

1. The speed of light c, gravitational constant G and Plank's constant are taken as the fundamental units in a system. Find the dimensions of length and time in this new system of unit.
2. In the expression $P = El^2m^{-5}G^{-2}$ where E, m, l and G denote energy, mass, angular momentum and gravitational constant, respectively. Show that P is a dimensionless quantity.
3. A new system of units is proposed in which unit of mass is αkg, unit of length is βm and unit of time is γs. How much will 5 J measure in this new system?
4. An artificial satellite is revolving around a planet of mass M and radius R, in a circular orbit of radius r. From kepler's third law about the period of a satellite around a common central body, square of the period of revolution T is proportional to the cube of the radius of the orbit r. Show using dimensional analysis, that $T = \frac{k}{R}\sqrt{\frac{r^3}{g}}$, where k is a dimensionless constant and g is acceleration due to gravity.
5. The number of particles crossing a unit area perpendicular to x-axis in unit time is given by $n = -D\frac{n_2 - n_1}{x_2 - x_1}$ where n_1 and n_2 are number of particles per unit volume for the values of x meant to x_1 and x_2. Find the dimensions of the diffusion constant D.

Long Answer Type Questions (5 M)

1. If the velocity of light c, Planck's constant h and gravitational constant G are taken as fundamental quantities then express mass, length and time in terms of dimensions of these quantities.

Case Based Questions

1. The dimensional analysis helps us in deducing the relations among different physical quantities and checking the accuracy derivation and dimensional consistency or its homogeneity of various numerical expressions.

   The conversion of one system of units into another is an application of dimension. As we know numerical value is inversely proportional to the size of the unit but the magnitude of the physical quantity remains the same whatever be the system of its measurement.

   i.e. $n_1u_1 = n_2u_2 \Rightarrow n_2 = \frac{n_1u_1}{u_2}$

   Where, u_1 and u_2 are two units of measurement of the quantity and n_1 and n_2 are their respective numerical values. The method of dimensions is used to deduce the relation among the physical quantities. We should know the dependence of the physical quantity on other quantities.

   (i) How the numerical value of a physical quantity is related to its unit.

   (ii) Which method is used to deduce the relation among the physical quantities.

   (iii) Force $= \frac{\alpha}{\text{Density} + \beta^3}$, then what are the dimension of α, β ?

   (iv) Find the value of 60 J per min on a system that has 100g, 100 cm and 1 min as the base units.

2. Einstein's mass energy relation emerging out of his famous theory of relativity relates mass (m) to energy (E) as $E = mc^2$, where c is speed of light in vacuum. At the nuclear level, the magnitudes of energy are very small. The energy at nuclear level is usually measured in MeV, where 1 MeV = 1.6×10^{-13} J; the masses are measured in unified atomic mass unit (u) where $h_1 = 1.67 \times 10^{-27}$ kg .

   (i) Show that the energy equivalent of 1u is 931.5 Mev.

   (ii) A student writes the relation as 1u = 931.5 MeV. The teacher points out that the relation is dimensionally incorrect. Write the correct relation.

ANSWER KEYS

Multiple Choice Questions

1. (*d*)	**2.** (*b*)	**3.** (*a*)	**4.** (*b*)	**5.** (*b*)	**6.** (*a*)	**7.** (*b*)	**8.** (*d*)	**9.** (*d*)	**10.** (*c*)
11. (*c*)	**12.** (*a*)	**13.** (*d*)	**14.** (*b*)	**15.** (*c*)	**16.** (*c*)	**17.** (*c*)	**18.** (*a*)		

Assertion and Reason

1. (*c*) **2.** (*a*) **3.** (*c*) **4.** (*d*) **5.** (*b*) **6.** (*a*)

Very Short Answer Type Questions

1. Refer to hints and solution
2. Refer to hints and solution
3. Refer to hints and solution
4. Refer to hints and solution
5. Refer to hints and solution
6. Refer to hints and solution

Short Answer Type Questions

1. Refer to hints and solution
2. Refer to hints and solution
3. Refer to hints and solution
4. Refer to hints and solution

Long Answer Type Question

1. Refer to hints and solution

Case Study Based Questions

1. Refer to hints and solution

HINTS & EXPLANATIONS

Multiple Choice Questions

1. (*d*)

2. (*b*)

3. (*a*)

$$A = l \times b = 3.124 \times 3.002$$

$$= 9.378248 \text{ m}^2$$

$$= 9.378 \text{ m}^2$$

(rounding off to four significant digits)

4. (*b*)

$$V = lbt = 12 \times 6 \times 2.45$$

$$= 176.4 \text{ cm}^3 = 2 \times 10^2 \text{ cm}^3$$

(rounding off to one significant digit of breadth)

5. (*b*)

Number 25 has infinite number of significant figures. Therefore we will round off to least number of significant figures or three significant figures in the measurement 1.76 kg.

6. (*a*) Velocity gradient is change in velocity per unit depth.

7. (*b*) Coefficient of friction is unitless and dimensionless.

8. (*d*)

Dipole moment = (charge) × (distance)

Electric flux = (electric field) × (area)

Hence, the correct option is (d).

9. (*d*)

$$[\eta] = \left[\frac{F}{av}\right] = \left[\frac{MLT^{-2}}{LLT^{-1}}\right]$$

10. (*c*)

$$a = \frac{F}{t}$$

$$b = \frac{F}{t^2}$$

11. (*c*)

$$R = \frac{l}{\sigma A} \Rightarrow \sigma = \frac{l}{RA}$$

From $H = I^2 Rt$

we have $R = \frac{H}{I^2 t}$

$$\therefore \quad [\sigma] = \left[\frac{LI^2 t}{HA}\right]$$

$$= \left[\frac{LA^2\ T}{ML^2\ T^{-2}\ L^2} \right]$$

$$= \left[\mathrm{M}^{-1}\ \mathrm{L}^{-3}\ \mathrm{T}^{3}\ \mathrm{A}^{2} \right]$$

12. (*a*)

$$\phi = Bs = \frac{F}{IL} \cdot s = \left[\frac{MLT^{-2}\ L^2}{AL} \right]$$

$$[g] = LT^{-2}]$$

13. (*d*)

14. (*b*) If unit of length and time is double, then value of g will be halved.

15. (*c*)

$$B = \frac{\mu_0}{2\pi}\frac{i}{r}$$

But $B = \frac{F}{il}$

$$\therefore \frac{F}{il} = \frac{\mu_0}{2\pi}\frac{i}{r}$$

$$\therefore [\mu_0] = \left[\frac{F}{i^2} \right]$$

16. (*c*)

$\because$ ωk is dimensionless

$$\therefore \quad [k] = \left[\frac{1}{\omega} \right] = [T]$$

17. (*c*)

Let $E^a v^b F^c = km$

Then, $\left[ML^2\ T^{-2} \right]^a \left[LT^{-1} \right]^b \left[MLT^{-2} \right]^c = [M]$

Equating the powers, we get

$a = 1, b = -2$ and $c = 0$

18. (*a*)

$$[F]^a [L]^b [T]^c = [M]$$

$$\therefore \left[MLT^{-2} \right]^a [L]^b [T]^c = [M]$$

Equating the powers we get,

$a = 1$, $b = -1$

and $c = 2$

Assertion and Reason

1. (*c*)

Electric potential is the work done to carrying positive test charge from infinity to a desired point. So, reason is a wrong statement.

2. (*a*)

3. (*c*)

4. (*d*)

According to principle of homogeneity, the same physical quantity can be added or subtracted. Here, force and pressure have different quantity and dimensions

5. (*b*)

The number of significant figures in 1.202 is four and the number of significant figures in 0.0024 is two. All non zero digits are significant. All zeros occurring between two non zero digits are significant, no matter where the decimal point is. If the number is less than one, the zeros on the right of decimal point and to the left of first non-zero digit are no significant.

6. (*a*)

Given equation:

$x = x_0 + u_0 t + \frac{1}{2}at^2$. The dimensions of each term may be written as

$$[x] = [L]$$

$$[x_0] = [L]$$

$$[u_0 t] = \left[LT^{-1} \right][T] = [L]$$

$$\left[\left(\frac{1}{2} \right) at^2 \right] = \left[LT^{-2} \right]\left[T^2 \right] = [L]$$

As each term on the right hand side of this equation has the same dimensions as left hand side of the equation, hence this equation is dimensionally correct.

Subjective Questions

Very Short Answer Type Questions

1. We make the choice of a standard unit of measurement by keeping in mind the following properties.

(i) The unit should be of convenient size.

(ii) It should be possible to define the unit without ambiguity.

(iii) The unit should be reproducible.

(iv) The value of unit should not change with space and time.

2. Given, $x = 3yz^2$, where x has dimensions of capacitance, i.e., $x = \left[M^{-1}\ L^{-2}\ A^2\ T^4 \right]$ and z has dimensions of magnetic induction, i.e. $z = \left[M^1 A^{-1}\ \mathrm{T}^{-2} \right]$

Let $y = M^{\alpha} L^{\beta} T^{\gamma} A^{\delta}$

Now considering the given expression and substituting the dimensions, we get

$$\left[M^{-1}L^{-2}A^2T^4\right]=\left[M^{\alpha}L^{\beta}T^{\gamma}A^{\delta}\right]\left[M^1L^0A^{-1}T^{-2}\right]^2$$

On comparing and solving further, we get

$\alpha=-3, \beta=-2, \gamma=8, \delta=4$

$$[Y]=\left[M^{-3}\ L^{-2}\ T^8A^4\right]$$

3. By principle of homogeneity, only the quantities having same dimensions can be added. Hence, dimensional formula of $\frac{a}{V^2}$ is same as that of pressure.

$$\left[\frac{a}{V^2}\right]=[p]\Rightarrow[a]=\left[pV^2\right]$$

$$=\left[\frac{MLT^{-2}}{L^2}\times\left(L^3\right)^2\right]$$

$$=\left[\mathrm{ML^5\ T^{-2}}\right]$$

Also, $[b]=$ [volume] $=\left[M^0L^3T^0\right]$

4. The relation is given as $v^2-u^2=2as$

On LHS dimension of $v^2=\left[L^2\ T^{-2}\right]$ and

$$u^2=\left[LT^{-1}\right]^2=\left[L^2\ T^{-2}\right]$$

$$\text{RHS } 2as=\left[LT^{-2}\right][L]=\left[L^2\ T^{-2}\right]$$

As dimensions of both terms on LHS are equal to the dimensions of RHS, the relation is dimensionally correct.

5. In the given relation, dimensions of LHS terms v are $[LT^{-1}]$.

Dimensional formulae for E and ρ are $\left[ML^{-1}\ T^{-2}\right]$ and $[ML^{-3}]$.

Dimensions of RHS

$$=\sqrt{\frac{ML^{-1}\ T^{-2}}{ML^{-3}}}=\sqrt{L^2\ T^{-2}}=\left[LT^{-1}\right]$$

As dimensions of LHS and RHS of the equation are same. Hence, the equation is dimensionally correct.

6. Suppose dimensions of mass M be $\left[F^aL^bT^c\right]$. Then, we have

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

$$=\mathrm{M}^a\ \mathrm{L}^{a+b}\ \mathrm{T}^{-2a+c}$$

$a=1, a+b=0, -2a+c=0$

$b=-a=-1, c=2a=2$

Hence, dimensions of mass M are $\left[F^1L^{-1}T^2\right]$.

Short Answer Type Questions

1. Dimension of $c=\left[LT^{-1}\right]$ ...(i)

$G=\left[M^{-1}\ L^3\ T^{-2}\right]$ ....(ii)

and $h=\left[ML^2\ T^{-1}\right]$ .....(iii)

From equation (i),

$$c^3=\left[L^3\ T^{-3}\right]$$

And from equations (ii) & (iii), we have

$$Gh=\left[L^5\ T^{-3}\right]$$

$$\therefore\quad \frac{Gh}{c^3}=L^2$$

which gives

$$L=G^{1/2}h^{1/2}c^{-3/2}$$

Again from equation (i),

$$T=\frac{\text{length}}{\text{speed}}$$

$$=\frac{G^{1/2}h^{1/2}c^{-3/2}}{c}$$

$$=G^{1/2}h^{1/2}c^{-5/2}$$

2. $\left[M^0L^0T^0\right]$

The given expression is $P=EL^2\ m^{-5}G^{-2}$

Dimension of $(E)=\left[ML^2\ T^{-2}\right]$

$(L)=\left[ML^2\ T^{-1}\right]$

$(m)=[M]$

$(G)=\left[M^{-1}\ L^3\ T^{-2}\right]$

Substitution dimensions of each term in the given expression,

$(P)=[ML^2T^{-2}]\times[ML^2T^{-1}]^2-[M]^{-5}\times[M^{-1}L^3T^{-2}]^2$

$$=\left[M^{1+2-5+2}\ L^{2+4-6}\ T^{-2-2+4}\right]=\left[M^0\ L^0\ T^0\right]$$

Therefore, P is a dimensionless quantity.

3. Dimensions of energy $=\left[ML^2\ T^{-2}\right]$

Let M_1, L_1, T_1 and M_2, L_2, T_2 are units of mass, length and time in given two systems.

$\therefore \quad m_1 = 1\text{ kg},\ L_1 = 1\text{ m},\ T_1 = 1\text{ s}$

$m_2 = \alpha\text{kg}, L_2 = \beta\text{m}, T_2 = \gamma\text{s}$

Using, $n_2 = n_1 \dfrac{\left[M_1\ L_1^2\ T_1^{-2}\right]}{\left[M_2\ L_2^2\ T_2^{-2}\right]}$

$$= 5\left[\frac{M_1}{M_2}\right] \times \left[\frac{L_1}{L_2}\right]^2 \times \left[\frac{T_1}{T_2}\right]^{-2}$$

$$= 5\left[\frac{1}{\alpha}kg\right] \times \left[\frac{1}{\beta}m\right]^2 \times \left[\frac{1}{\gamma}s\right]^{-2}$$

$$= 5 \times \frac{1}{\alpha} \times \frac{1}{\beta^2} \times \frac{1}{\gamma^{-2}}$$

$n_2 = \dfrac{5\gamma^2}{\alpha\beta^2}$ new unit of energy

4. From Kelper's third law

$T^2 \propto r^3$ or $T \propto r^{3/2}$

and T is a function of R and g

Let $T \propto r^{3/2} R^a g^b$

Or $\mathrm{T} = kr^{3/2} R^{\mathrm{a}} g^{\mathrm{b}}$ ....(i)

where, k is a dimensionless constant of proportionality.

Substituting the dimensions of each term in Eq. (i), we get

$$\left[M^0\ L^0\ T\right] = k[L]^{3/2}[L]^a\left[LT^{-2}\right]^b$$

$$= k\left[\ L^{a+b+3/2}\ \ T^{-2b}\right]$$

On comparing the powers of same terms, we get

$a + b + 3/2 = 0$ ...(ii)

$-2b = 1 \ \Rightarrow\ b = -1/2$

From Eq. (ii), we get

$a - 1/2 + 3/2 = 0 \Rightarrow a = -1$

Substituting the values of a and b in Eq. (i), we get

or $T = kr^{3/2} R^{-1} g^{-1/2}$

$$T = \frac{k}{R}\sqrt{\frac{r^3}{g}}$$

5. Given $n = -D\dfrac{n_2 - n_1}{x_2 - x_1}$

$$\therefore \quad D = -\frac{n\left(x_2 - x_1\right)}{\left(n_2 - n_1\right)}$$

Dimensions of D = $\dfrac{\text{dimensions of } n \times \text{ dimensions of } x}{\text{dimensions of } n_2 \text{ or } n_1}$

$$= \frac{T^{-1}L^{-2} \times L}{L^{-3}} = L^2T^{-1}$$

Long Answer Type Questions

1. Let $m \propto c^x h^y G^z$

$m = Kc^x h^y G^z$ ....(A)

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

$c = [LT^{-1}],$

$G = \left[M^{-1}L^3T^{-2}\right]$ (k = dimensionless)

Or,

$$\left[ML^0T^0\right] = \left[LT^{-1}\right]^x\left[ML^2\ T^{-1}\right]^y\left[M^{-1}\ L^3\ T^{-2}\right]^z$$

$$= \left[M^{y-z}L^{x+2y+3z}T^{x-y-2z}\right]$$

Comparing powers

$y - z = 1$ ...(a)

$x + 2y + 3z = 0$ .....(b)

$-x - y - 2z = 0$ ....(c)

Adding above all three equations-

$2y = 1$

$$\Rightarrow \quad y = \frac{1}{2}$$

$$z = -\frac{1}{2}, x = \frac{1}{2}$$

Putting in eqn (A)

$$m = kc^{\frac{1}{2}}\ h^{\frac{1}{2}}G^{-\frac{1}{2}}$$

$$\Rightarrow\ m = k\sqrt{\frac{ch}{G}}$$

(ii) Let $L \propto c^x h^y G^z$

$L = kc^x h^y G^z$ ....(B)

Substituting in B

$$\left[M^0LT^0\right] = \left[LT^{-1}\right]^x \times \left[ML^2T^{-1}\right]^y \times \left[M^{-1}L^3T^{-2}\right]^z$$

$$= \left[M^{y-z}L^{x+2y+3z}T^{-x-y-2z}\right]$$

Comparing powers-

$y - z = 0$ ...(a)

$x+2y+3z=1$ ...(b)

$-x-y-2z=0$ ....(c)

Adding (a), (b), (c), we get-

$$y=\frac{1}{2}, z=\frac{1}{2}, x=-\frac{3}{2}$$

Putting in (B)

$$L=kc^{-\frac{3}{2}}h^{\frac{1}{2}}G^{\frac{1}{2}}$$

$$L=k\sqrt{\frac{hG}{c^3}}$$

(iii) Let $L \propto c^x h^y G^z$

$$T=kc^x h^y G^z \quad ....(C)$$

$$\left[M^0L^0T\right]=\left[LT^{-1}\right]^x \times \left[ML^2T^{-1}\right]^y \times \left[M^{-1}L^3T^{-2}\right]^z$$

$$=\left[M^{y-z}L^{x+2y+3z}T^{-x-y-2z}\right]$$

Comparing powers

$y-z=0$ ....(a)

$x+2y+3z=0$ ...(b)

$-x-y-2z=1$ ....(c)

Adding (a), (b), (c), we get-

$$y=\frac{1}{2}, z=\frac{1}{2}, x=-\frac{5}{2}$$

Putting in (C)

$$T=kc^{-\frac{5}{2}}h^{\frac{1}{2}}B^{\frac{1}{2}}$$

$$T=k\sqrt{\frac{hG}{c^5}}$$

Case Based Questions

1. (i) The numerical value of a physical quantity is inversely proportional to its unit

i.e. $n \propto \frac{1}{u}$ or $nu =$ constant

(ii) The method of dimensions is used to deduce the relation among the physical quantities.

(iii) Dimension of β^3 = Dimensions of density $=\left[ML^{-3}\right]$

$$\beta=\left[M^{1/3}L^{-1}\right]$$

Also, α = Force × Density $=\left[MLT^{-2}\right]\left[ML^{-3}\right]$

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

(iv) $P=\frac{60\text{ J}}{60}=1$ watt

Dimensional formula of power is $\left[ML^2\ T^{-3}\right]$

$n_1=1$

$M_1=1\text{ kg}=1000\text{ g}$

$L_1=1\text{ m}=100\text{ cm}$

$T_1=1\text{ s}$

$n_2=?$

$M_2=100\text{ g} \Rightarrow L_2=100\text{ cm}$

$T_2=1\text{ min}=60\text{ s}$

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

$$=1\left[\frac{1000}{100}\right]^1\left[\frac{100}{100}\right]^2\left[\frac{1}{60}\right]^{-3}=2.16\times10^6$$

$\therefore$ 60 J $\text{min}^{-1}=2.16\times10^6$ new units of power.

2. (i) We can apply Einstein's mass energy relation in this problem, $E=mc^2$, to calculate the energy equivalent of the given mass.

Here, $1\text{ amu}=1\,u=1.67\times10^{-27}$ kg

Applying $E=mc^2$,

$$E=\left(1.67\times10^{-27}\right)\left(3\times10^{-8}\right)^2\text{ J}$$

$$=1.67\times9\times10^{-11}\text{ J}$$

or $E=\frac{1.67\times9\times10^{-11}}{1.6\times10^{-13}}$ MeV

$=939.3$ MeV

≈ 931.5 MeV

(ii) As $E=mc^2 \Rightarrow m=\frac{E}{c^2}$

According to this $1u=\frac{931.5\ MeV}{c^2}$

Hence, the dimensionally correct relation is

$1\text{ amu}\times c^2=1u\times c^2$

$=931.5$ MeV

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