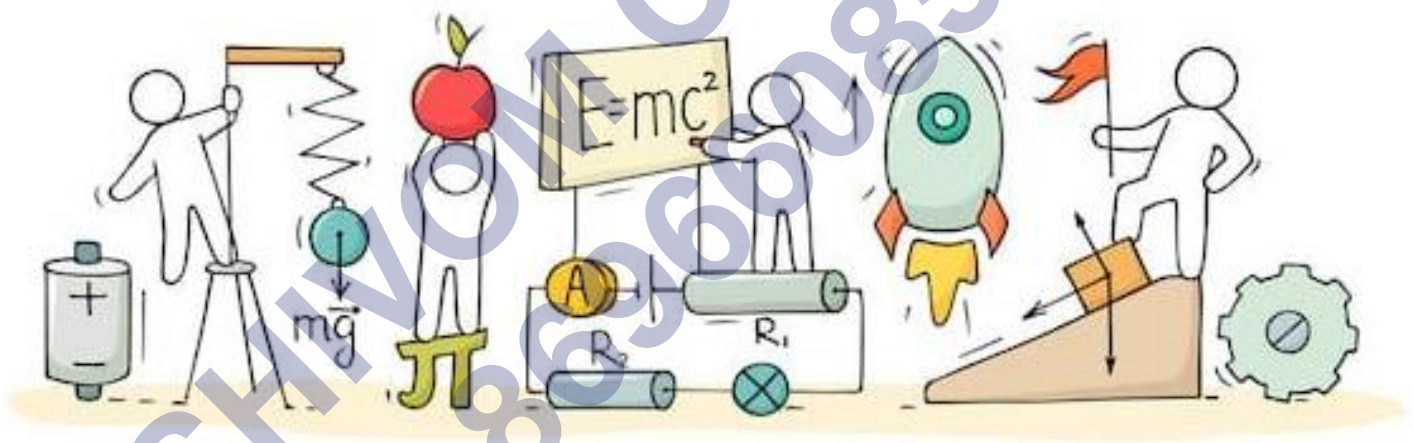


# PHYSICS

## Chapter 2: Units and Measurements



## Units and Measurements

### Units

A unit is an internationally accepted standard for measurements of quantities.

Measurement consists of a numeric quantity along with a relevant unit.

Units for Fundamental or base quantities (like length, time etc.) are called Fundamental units.

Units which are combination of fundamental units are called Derived units.

Fundamental and Derived units together form a System of Units.

Internationally accepted system of units is *Système Internationale d' Unites* (French for International system of Units) or SI. It was developed and recommended by General Conference on Weights and Measures in 1971.

SI lists 7 base units as in the table below. Along with it, there are two units - radian or rad (unit for plane angle) and steradian or sr (unit for solid angle). They both are dimensionless.

Base Quantity	Name	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric Current	ampere	A
Thermo dynamic Temperature	kelvin	K
Amount of Substance	mole	mol

Luminous intensity	candela	cd
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Base Quantity	Name	Symbol
Length	metre	m
Mass	kilogram	kg
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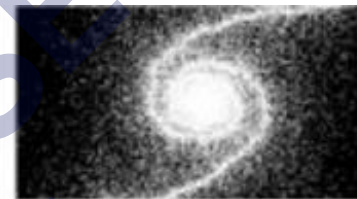
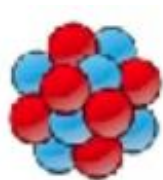
## Measurement of Length

Length can be measured using metre scale ( $10^{-3}\text{m}$  to  $10^2\text{m}$ ), vernier callipers ( $10^{-4}\text{m}$ ) and screw gauge and spherometer ( $10^{-5}\text{m}$ ).

## Range of Length

Size of object or distance	Length (m)
Size of proton	$10^{-15}$
Size of atomic nucleus	$10^{-14}$
Length of typical virus	$10^{-8}$
Wavelength of light	$10^{-7}$
Thickness of paper	$10^{-4}$
Height of Mount Everest above sea level	$10^4$
Radius of earth	$10^7$
Distance of moon from earth	$10^8$
Distance of sun from earth	$10^{11}$
Distance of pluto from sun	$10^{13}$

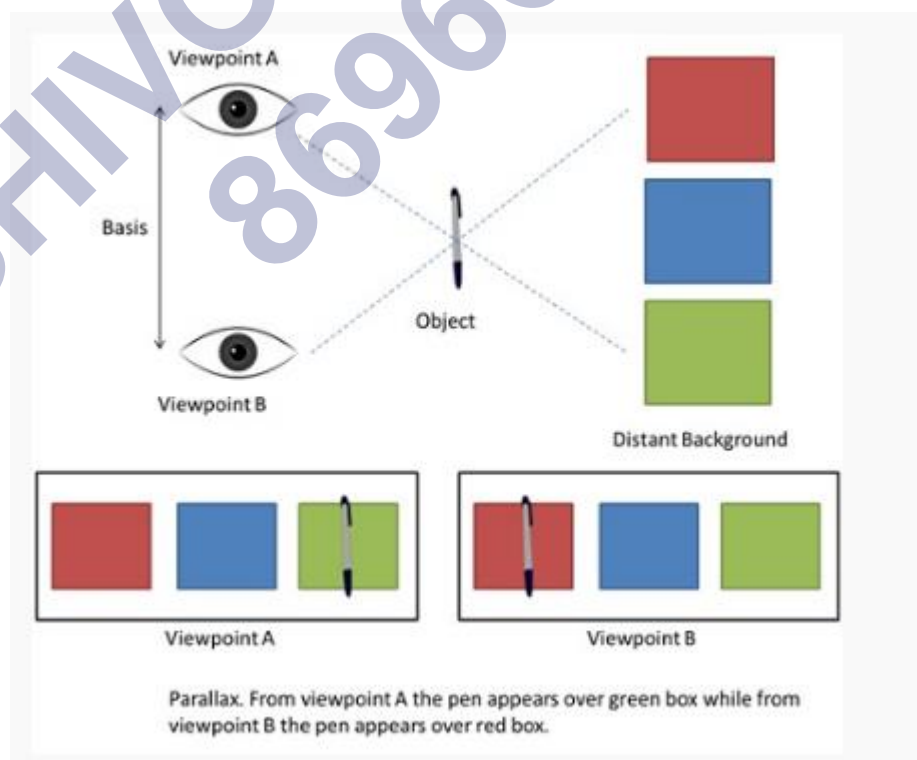
Size of our galaxy	$10^{21}$
Distance to Andromeda Galaxy	$10^{22}$
Distance to observable universe boundaries	$10^{26}$



Objects in the increasing order of their lengths

### Measuring large Distances – Parallax Method

Parallax is a displacement or difference in the apparent position of an object viewed along two different lines of sight, and is measured by the angle or semi-angle of inclination between those two lines. Distance between the two viewpoints is called Basis.



Measuring distance of a planet using parallax method:

Similarly,  $\alpha = d/D$

Where  $\alpha$  = **angular size** of the planet (angle subtended by  $d$  at earth) and  $d$  is the **diameter** of the planet.  $\alpha$  is angle between the direction of the telescope when two diametrically opposite points of the planet are viewed.

## What is Speed?

Speed is defined as

The rate of change of position of an object in any direction.

Speed is measured as the ratio of distance to the time in which the distance was covered. Speed is a scalar quantity as it has only direction and no magnitude.

## Speed Formula

The formula of speed is given in the table below:

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

Where,

- $s$  is the speed in  $m.s^{-1}$
- $d$  is the distance traveled in  $m$
- $t$  is the time taken in  $s$

## Speed Unit

Following are the units of speed are:

CGS system	$cm.s^{-1}$
SI system	$ms^{-1}$

Finding the Dimensional Formula of Speed.

The mathematical representation of speed is:

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

Dimensional formula of Distance =  $M^0L^1T^0$

Dimensional formula of time =  $M^0L^0T^1$

Dividing the dimensional formula of distance by the dimensional formula of time, we get:

$$\frac{M^0L^1T^0}{M^0L^0T^1} = M^0L^1T^{-1}$$

## Types of Speed

There are four types of speed and they are:

- Uniform speed
- Variable speed
- Average speed
- Instantaneous speed

**Uniform speed:** A object is said to be in uniform speed when the object covers equal distance in equal time intervals.

**Variable speed:** A object is said to be in variable speed when the object covers a different distance at equal intervals of times.

**Average speed:** Average speed is defined as the uniform speed which is given by the ratio of total distance travelled by an object to the total time taken by the object.

**Instantaneous speed:** When an object is moving with variable speed, then the speed of that object at any instant of time is known as instantaneous speed.

## Measurement of Speed

For the measurement of speed in vehicles, speedometers are used. To measure the distance covered odometers are used. Speed can also be calculated with the help of a graph. The Distance-time graph helps in understanding the speed of an object.

## Measurement Mass Weight

Mass is a basic characteristic property of matter. It exists self-sufficiently and is independent of all other parameters such as the temperature, pressure, and the location of the object in space. Atomic mass is the mass of an atom expressed in atomic mass units. The matter has mass and occupies space. These two things are taught to us as soon as we can grasp these concepts. A matter is anything you can touch physically, so everything you see and interact with around you has a mass. Mass is often confused with another parameter. This confusion occurs due to the fact that this parameter is mistakenly used around the globe instead of mass due to its convenience and also due to the fact that we weigh things to find out their mass. This parameter is called weight. Let's explore both of these essential parameters thoroughly.

## What is Mass?

Mass by definition refers to the amount of matter in a particular object. This value of the amount of matter i.e. mass of an object is an intrinsic value of that body and it can help us find out various other parameters that are dependent on the mass. Mass determines the strength of its mutual gravitational attraction to other bodies, its resistance to acceleration due to a force, Inertia, and mass can also be used to derive the energy

content of a sample through the theory of Relativity using Albert Einstein's  $E = mc^2$ .

## Atomic Mass Unit

For tiny and larger objects we use other units;

- Tonne(Metric Ton) is equal to 1000kg
- The Atomic Mass Unit is used while dealing with atoms and molecules whose masses are so small that the kilogram becomes inconvenient. One atomic mass unit is defined as 1/12th the mass of a Carbon-12 atom. The value of 1 atomic mass unit is obtained as  $1.66 \times 10^{-27}$

## Measurement of mass

Measurement of mass is most commonly done by a Balance. The unknown mass of a body is compared with a known value of mass. We obtain the value of an unknown mass in terms of a known value of mass. A balance works in space and in places of no gravity as well since changes in gravity affect both the masses on the balance equally.



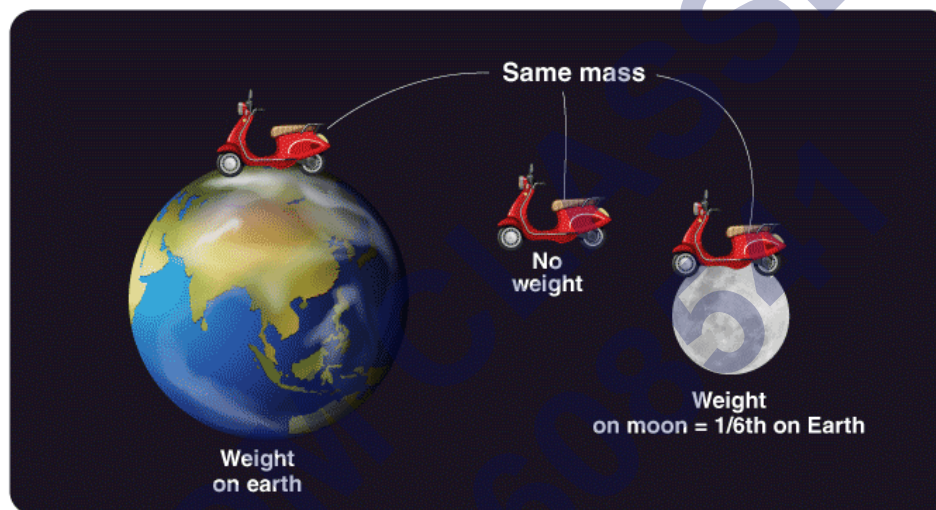
## What is Weight?

Mass is not the same as weight. While mass is the intrinsic property of the body, weight is the measure of the force exerted on the mass of the body due to gravity. Mass refers to a universal value of the object whereas weight is a localized interpretation of the mass of the object. Weight is the effect of gravity and therefore we describe weight with the formula;



$$W = mg$$

Where  $m$  is the mass and  $g$  is the acceleration due to gravity at that particular location. The unit of measurement of weight is Force, the SI Unit of which is Newton. For example, an object that has a mass of 50 kg experiences a gravitational force i.e. weight which is equal to  $50 \times 9.8 = 490$  Newton. So when you tell your friends you weight 50kg you are telling them about your mass and not your weight. The same object albeit with the same mass of 50 kg will weigh 1/6th on the moon what it did on Earth. Weight and mass mean the same thing on Earth since the effects of gravity are fairly constant throughout the Earth. It was upon our venture into space that it became necessary to create a distinction between mass and weight.



Here is a problem based on the weighing machine, the problem deals with an advanced question on how normal reaction and tension act in an accelerated pulley system when the support is provided by the man which is being measured.

## Length

Historically, the human body was used to provide the basis for units of length

- **Inch:** Inch is the measure of the thumb, which was used to measure the length of items small, for example, the seam of a cloth, length of paper, etc.
- **Foot:** Foot is the measure of length typically defined as 15.3 % of the height of a human body with an average height of 160 cm. This unit differed from place to place and trade to trade. This unit was preferred by Roman and Greeks and was typically used to calculate the size of a piece of cloth, the height of human beings and cattle, the size of a building, etc.
- **Cubit:** Cubit is the unit of measurement of length based on the length of the forearm, typically the tip of the middle finger to the elbow bottom. This unit of measurement was preferred by Egyptians and Mesopotamians. Cubit rods have been discovered in the remains of the ancient Egyptian civilization. These rods are

usually 20 inches in length, and are divided into seven palms; each palm is further divided into four fingers which are further subdivided.



- **Yard:** Yard is the unit of distance typically based on human paces. A yard is typically equivalent to two cubits or three feet, which is approximately 36 inches.



- **Miles:** A mile is equivalent to a thousand paces, where the pace is equal to two steps, such that the walker is back to the same foot.

A foot comprises 12 inches and three feet comprise a yard. With measurements such as these, it was easy to explain how far the next village was and to find out whether an object will get through a doorway.

These measurements also helped the people exchange clothes and wood in a barter system.

## Weight

- The grains of wheat were used as a measure of weight due to their approximate standard size. The number of grains of wheat was taken as a standard, which even now is used by some jewellers. One grain is equal to 64.79891 milligrams.



- A measured length of metal used to be kept in the town centre or the temples and copies of the same were distributed among the people of that community. This metal lump was considered as a standard of weight.



## Time

- **Sundial:** The movement of the sun in the sky was one of the measures to estimate time, which was done on the basis of length and position of the shadow cast by a vertical stick. Later, the marks were made where the sun's shadow fell, which gave an approximate measure of time of the day consistently. The device came on to be called as a sundial.



- **Water Clock:** The water clock was used to measure time on the basis of the amount of water dripping from a tank. This method was not considered reliable because the flow of water is difficult to be controlled. The device was termed as Clepsydra.



- **Hour Glass:** The hourglass works on the same principle as a water clock, using sand instead of water. It is still found in some places, in a reduced form.



### Dimensional formula:

Dimensions of a physical quantity are the powers (or exponents) to which the base quantities are raised to represent that quantity.

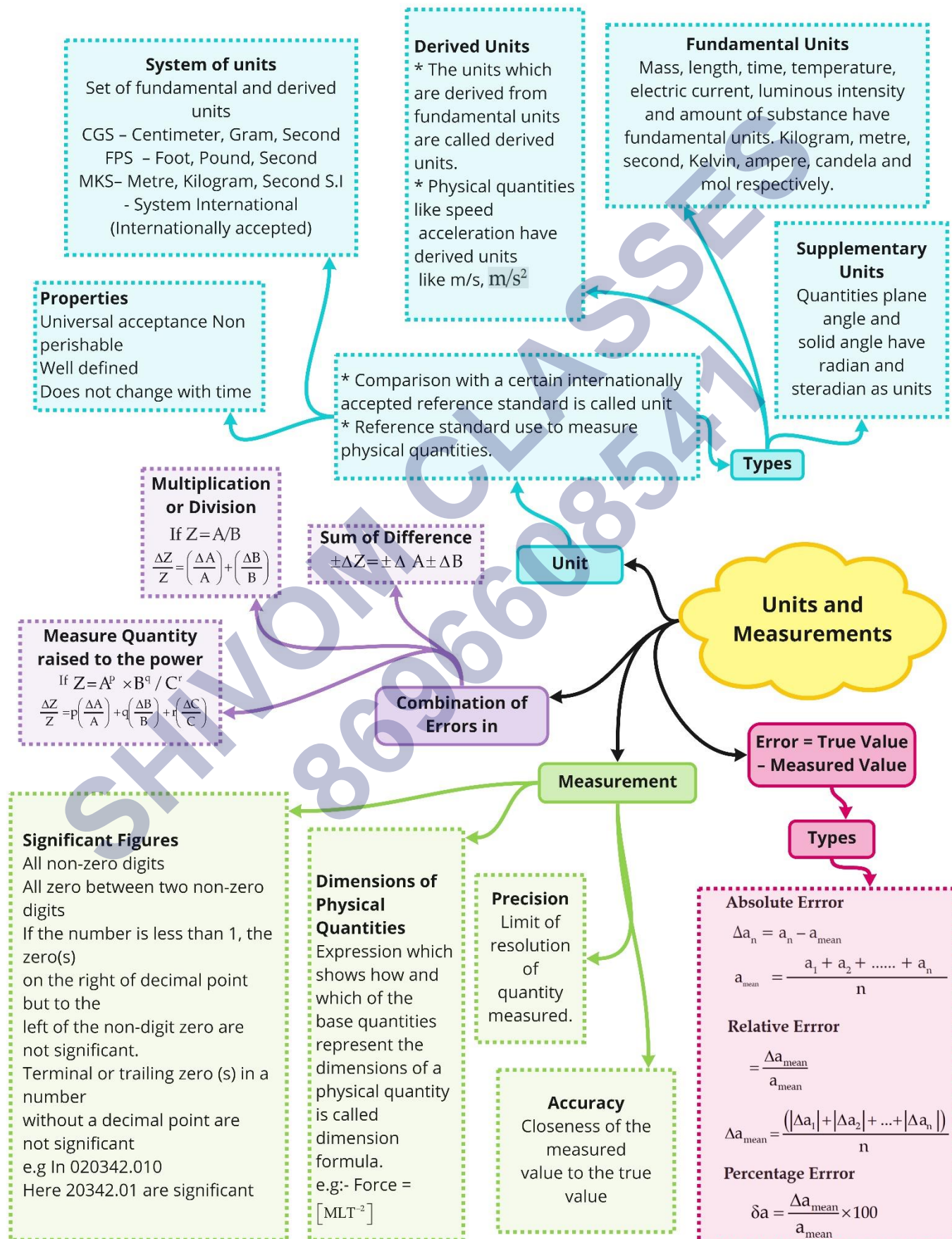
**Dimensional formula:** The expression which shows how and which of the base quantities represent the dimensions of a physical quantity.

Dimensional Formula		
Physical quantity	Expression	Dimensional formula
Area	length $\times$ breadth	$[L^2]$
Volume	Area $\times$ height	$[L^3]$
Density	mass / volume	$[ML^{-3}]$
Velocity	displacement/time	$[LT^{-1}]$
Acceleration	velocity / time	$[LT^{-2}]$
Momentum	mass $\times$ velocity	$[MLT^{-1}]$
Force	mass $\times$ acceleration	$[MLT^{-2}]$
Work	force $\times$ distance	$[ML^2T^{-2}]$
Power	work / time	$[ML^2T^{-3}]$
Energy	Work	$[ML^2T^{-2}]$
Impulse	force $\times$ time	$[MLT^{-1}]$
Radius of gyration	Distance	$[L]$
Pressure (or) stress	force / area	$[ML^{-1}T^{-2}]$
Surface tension	force / length	$[MT^{-2}]$
Frequency	1 / time period	$[T^{-1}]$
Moment of Inertia	mass $\times$ (distance) <sup>2</sup>	$[ML^2]$
Moment of force (or torque)	force $\times$ distance	$[ML^2T^{-2}]$
Angular velocity	angular displacement / time	$[T^{-1}]$
Angular acceleration	angular velocity / time	$[T^{-2}]$
Angular momentum	linear momentum $\times$ distance	$[ML^2T^{-1}]$
Co-efficient of Elasticity	stress/strain	$[ML^{-1}T^{-2}]$
Co-efficient of viscosity	(force $\times$ distance) / (area $\times$ velocity)	$[ML^{-1}T^{-1}]$
Surface energy	work / area	$[MT^{-2}]$
Heat capacity	heat energy / temperature	$[ML^2T^{-2}K^{-1}]$
Charge	current $\times$ time	$[AT]$
Magnetic induction	force / (current $\times$ length)	$[MT^{-2}A^{-1}]$
Force constant	force / displacement	$[MT^{-2}]$
Gravitational constant	[force $\times$ (distance) <sup>2</sup> ] / (mass) <sup>2</sup>	$[M^{-1}L^3T^{-2}]$
Planck's constant	energy / frequency	$[ML^2T^{-1}]$
Faraday constant	avogadro constant $\times$ elementary charge	$[AT \text{ mol}^{-1}]$
Boltzmann constant	energy / temperature	$[ML^2T^{-2}K^{-1}]$

- Applications of dimensional analysis:
  - i. To derive a physical equation.
  - ii. To verify if the given equation is dimensionally correct.
  - iii. To find the dimensions of an unknown parameter in the equation.

SHIVOM CLASSES  
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Class : 11th Physics  
Chapter- 2 : Units and Measurements





## Important Questions

### Multiple Choice questions-

1. Electron volt is a unit of
  - (a) charge
  - (b) potential difference
  - (c) energy
  - (d) magnetic force
2. Light year is a unit of
  - (a) time
  - (b) distance
  - (c) sunlight intensity
  - (d) mass
3. Which of the following pairs has the same dimensions?
  - (a) specific heat and latent heat
  - (b) impulse and momentum
  - (c) surface tension and force
  - (d) moment of inertia and torque
4. Which of the following sets of quantities has the same dimensional formula?
  - (a) Frequency, angular frequency and angular momentum
  - (b) Surface tension, stress and spring constant
  - (c) Acceleration, momentum and retardation
  - (d) Work, energy and torque
5. If C and R denote capacitance and resistance respectively, what will be the dimensions of C x R?
  - (a)  $[M^0L^0TA^0]$
  - (b)  $[ML^0TA^{-2}]$
  - (c)  $[ML^0TA^2]$
  - (d)  $[MLTA^{-2}]$
6. A particle starting from the origin (0, 0) moves in a straight line in the (x, y) plane. Its coordinates at a later time are (The path of the particle makes with the x-axis an angle of

- (a) 300
  - (b) 450
  - (c) 600
  - (d) 0
7. Resolution is
- (a) a measure of the bias in the instrument
  - (b) None of these
  - (c) the smallest amount of input signal change that the instrument can detect reliably
  - (d) a measure of the systematic errors
8. Fundamental or base quantities are arbitrary. In SI system these are
- (a) length, force, time, electric current, thermodynamic temperature, amount of substance, and luminous intensity
  - (b) length, mass, time, electric current, thermodynamic temperature, amount of substance, and luminous intensity
  - (c) as length, mass, time, electric charge, thermodynamic temperature, amount of substance, and luminous intensity
  - (d) length, mass, force, electric current, thermodynamic temperature, amount of substance, and luminous intensity
9. Unit for a fundamental physical quantity is
- (a) defined as best of various reference standards
  - (b) the smallest measurable value of the physical quantity
  - (c) defined as average various reference standards
  - (d) reference standard for the physical quantity
10. The volume of a cube in  $\text{m}^3$  is equal to the surface area of the cube in  $\text{m}^2$ . The volume of the cube is
- (a)  $64 \text{ m}^3$
  - (b)  $216 \text{ m}^3$
  - (c)  $512 \text{ m}^3$
  - (d)  $196 \text{ m}^3$

### Very Short:

1. If the size of the atom were enlarged to the tip of the sharp pin, how large would the height of Mount Everest be?

2. What does the LASER mean?
3. If the Universe were shrunk to the size of the Earth, how large would the Earth be on this scale?
4. A research worker takes 100 careful readings in an experiment. If he repeats the same experiment by taking 400 readings, then by what factor will the probable error be reduced?
5. What is the number of significant figures in 0.06070?
6. The density of a cube is calculated by measuring the length of one side and its mass. If the maximum errors in the measurement of mass and length are 3% and 2% respectively, then what is the maximum possible error in the measurement of density?
7. The mass of a body as measured by two students is given as 1.2 kg and 1.23 kg. Which of the two is more accurate and why?
8. Do the inertial and gravitational masses of ordinary objects differ in magnitude?
9. Are S.I. units Coherent? Why?
10. Do A.U. and Å represent the same magnitudes of distance?

### Short Questions:

1. If the size of a nucleus is scaled up to the tip of a sharp pin, what roughly is the size of an atom?
2. (a) What do you mean by physical quantity?  
(b) What do you understand by:
  - (i) Fundamental physical quantities?
  - (ii) Derived physical quantities?
3. (a) Define the unit of a physical quantity.  
(b) Define
  - (i) Fundamental units.
  - (ii) Derived units.
4. Define one Candela.
5. What is the advantage of choosing wavelength of light radiation as standard of length?
6. Which type of phenomenon can be used as a measure of time? Give two examples of it.

- Find the number of times the heart of a human being beats in 10 years. Assume that the heartbeats once in 0.8s.
- Why it is not possible to establish a physical relation involving more than three variables using the method of dimensions?

### Long Questions:

- State the rules for writing the units of physical quantities in the S.I. system.
- Explain the Triangular method.
- What are the uses of dimensional analysis? Explain each of them.

### Assertion Reason Questions:

- Directions:** Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

- Assertion is correct, reason is correct; reason is a correct explanation for assertion.
- Assertion is correct, reason is correct; reason is not a correct explanation for assertion
- Assertion is correct, reason is incorrect
- Assertion is incorrect, reason is correct

**Assertion:** Dimensional constants are the quantities whose values are constant.

**Reason:** Dimensional constants are dimensionless.

- Directions:** Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

- Assertion is correct, reason is correct; reason is a correct explanation for assertion.
- Assertion is correct, reason is correct; reason is not a correct explanation for assertion
- Assertion is correct, reason is incorrect
- Assertion is incorrect, reason is correct

**Assertion:** Parallax method cannot be used for measuring distances of stars more than 100 light years away.

**Reason:** Because parallax angle reduces so much that it cannot be measured accurately.

### Case Study Questions:

1. Measurement of Physical Quantity All engineering phenomena deal with definite and measured quantities and so depend on the making of the measurement. We must be clear and precise in making these measurements. To make a measurement, magnitude of the physical quantity (unknown) is compared. The record of a measurement consists of three parts, i.e., the dimension of the quantity, the unit which represents a standard quantity and a number which is the ratio of the measured quantity to the standard quantity.
  1. A device which is used for measurement of length to an accuracy of about  $10^{-5}\text{m}$ , is
    - (a) Screw gauge
    - (b) Spherometer
    - (c) Vernier callipers
    - (d) Either (a) or (b)
  2. Which of the technique is not used for measuring time intervals?
    - (a) Electrical oscillator
    - (b) Atomic clock
    - (c) Spring oscillator
    - (d) Decay of elementary particles
  3. The mean length of an object is 5cm. Which of the following measurements is most accurate?
    - (a) 4.9cm
    - (b) 4.805cm
    - (c) 5.25cm
    - (d) 5.4cm
  4. If the length of rectangle  $l = 105.\text{cm}$ , breadth  $b = 21.\text{cm}$  and minimum possible measurement by scale =  $01.\text{cm}$ , then the area is
    - (a)  $22.0\text{cm}^2$
    - (b)  $21.0\text{cm}^2$
    - (c)  $22.5\text{cm}^2$
    - (d)  $21.5\text{cm}^2$
  5. Age of the universe is about  $10^{10}$  yr., whereas the mankind has existed for 106 yr. For how many seconds would the man have existed if age of universe were 1 day?
    - (a) 9.2 s

- (b) 10.2 s
- (c) 8.6 s
- (d) 10.5 s

2. Normally, the reported result of measurement is a number that includes all digits in the number that are known reliably plus first digit that is uncertain. The digits that are known reliably plus the first uncertain digit are known as significant digits or significant

figures.

e.g., When a measured distance is reported to be 374.5m, it has four significant figures 3, 7,

4 and 5. The figures 3, 7, 4 are certain and reliable, while the digit 5 is uncertain. Clearly,

the digits beyond the significant digits reported in any result are superfluous.

i. In 4700m, significant digits are

- (a) 2
- (b) 3
- (c) 4
- (d) 5

ii. To determine the number of significant figures, scientific notation is

- (a)  $a^b$
- (b)  $ab \times 10^b$
- (c)  $a \times 10^2$
- (d)  $a \times 10^4$

iii. 5.74 g of a substance occupies  $1.2\text{cm}^3$  Express its density by keeping the significant figures in view.

- (a)  $4.9\text{ g cm}^{-3}$
- (b)  $5.2\text{ g cm}^{-3}$
- (c)  $4.8\text{ g cm}^{-3}$
- (d)  $4.4\text{ g cm}^{-3}$

iv. Choose the correct option.

- (a) Change in unit does not change the significant figure.
- (b) 4 700. m=4700 mm, here there is a change of significant number from 4 to 2 due to change in unit.

(c)  $4700\ 4\ 700\ 103\ \text{m} = \text{m}$ , here there is change in numbers of significant numbers.

(d) Change in unit changes the number of significant figure.

v. Consider the following rules of significant figures.

I. All the non-zero digits are significant.

II. All the zeroes between two non-zero digits are significant.

III. The terminal or trailing zero(s) in a number without a decimal point are significant.

Which of the above statement(s) is/are? correct?

(a) I and II

(b) II and III

(c) I and III

(d) All of these

✓ Answer Key:

### Multiple Choice Answers-

1. Answer: (c) energy

2. Answer: (b) distance

3. Answer: (b) impulse and momentum

4. Answer: (d) Work, energy, and torque

5. Answer: (a)  $[M^0L^0TA^0]$

6. Answer: (c) 600

7. Answer: (d) a measure of the systematic errors

8. Answer: (b) length, mass, time, electric current, thermodynamic temperature, amount of substance, and luminous intensity

9. Answer: (d) reference standard for the physical quantity

10. Answer: (b)  $216\ \text{m}^3$

### Very Short Answers:

1. Answer:  $10^{10}\ \text{m}$ .

2. Answer: It stands for Light Amplification by Stimulated Emission of Radiation.

3. Answer:  $10^{-11}\ \text{m}$  (size of an atom.).

4. Answer: By a factor of 4.

5. Answer: 4.
6. Answer:  $3\% + 3 \times 2\% = 9\%$ .
7. Answer: The second measurement is more accurate as it has been made to the second decimal point.
8. Answer: No.
9. Answer: Yes, because all the derived units in this system can be obtained by multiplying or dividing a certain set of basic units.
10. Answer: No,  $1 \text{ A.U.} = 1.496 \times 10^{11} \text{ m}$  and  $1 \text{ \AA} = 10^{10} \text{ m}$ .

### Short Questions Answers:

1. Answer: The size of a nucleus is in the range of  $10^{-15} \text{ m}$  to  $10^{-14} \text{ m}$ . The tip of a sharp pin may be taken to be in the range of  $10^{-5} \text{ m}$  to  $10^{-4} \text{ m}$ . Thus, we are scaling up the size of the nucleus by a factor of  $10^{-5}/10^{-15} = 10^{10}$ . An atom roughly of size  $10^{-10} \text{ m}$  will be scaled up to a rough size of  $10^{-10} \times 10^{10} = 1 \text{ m}$ . Thus, nucleus in an atom is as small in size as the tip of a sharp pin placed at the center of a sphere of radius about a meter.
2. Answer: It is defined as a quantity that can be measured, e.g., mass, length, time, etc.
  - (b)
    - (i) They are defined as those quantities which cannot be expressed in terms of other quantities and are independent of each other, e.g., mass, length, time.
    - (ii) They are defined as the quantities which can be expressed in terms of fundamental quantities, e.g., velocity, acceleration, density, pressure, etc.
3. Answer: It is defined as the reference standard used to measure a physical quantity.
  - (b)
    - (i) They are defined as the units of fundamental quantities. They are independent of each other and are expressed by writing the letter of the fundamental quantity in a parenthesis. e.g., Fundamental units of mass, length and time are [M], [L], [T] respectively.
    - (ii) They are defined as those units which can be derived from fundamental units. They are expressed by writing the symbol of a derived quantity in a parenthesis.  
e.g., D.U. of velocity = [u]  
acceleration = [a]



pressure = [P]

work = [W] and so on.

4. Answer: It is defined as the luminous intensity in a perpendicular direction of a surface of  $\frac{1}{600,000}$  square meter area of a black body at a temperature of freezing platinum ( $1773^{\circ}\text{C}$ ) under a pressure of  $101,325 \text{ N/m}^2$ .
5. Answer:
- It can be easily made available in any standard laboratory as Krypton is available everywhere.
  - It is well defined and does not change with temperature, time, place or pressure, etc.
  - It is invariable.
  - It increases the accuracy of the measurement of length (1 part in  $10^9$ ).
6. Answer: Any phenomenon that repeats itself regularly at equal intervals of time can be used to measure time.

The examples are:

- Rotation of earth – the time interval for one complete rotation is called a day.
  - Oscillations of a pendulum.
7. Answer: In 0.8 s, the human heart makes one beat.

$\therefore$  In 1 s, the human heart makes  $= \frac{1}{0.8} = \frac{10}{8}$  beats.

$\therefore$  In 10 years, the human heart makes

$= \frac{10}{8} \times 365 \times 24 \times 60 \times 60$  beats.

$= 3.942 \times 10^8$  beats.

8. Answer: The dimensional analysis fails to derive a relation involving more than three unknown variables. The reason is that there will be more than three unknown factors in that case whose values cannot be determined from the three relations which we get by comparing the powers of M, L, and T.

### Long Questions Answers:

1. Answer: While writing the units of physical quantities following rules are followed with S.L units:

(1) The S.I. units are written in the form of symbols after the number i.e., number of time, the unit is contained in the physical quantity so that physical quantity = nu

With symbols, certain rules are laid down:

- Units in symbols are never written in plural i.e., meters is only m and not ms, years is y.
- The units based on the name of the scientists are written beginning with small letters and with capital letters in symbolic form viz, weber (Wb), newton (N), etc.
- No full stop is used at the end of the symbol.
- Symbols of units not based on the name of scientists are written as small letters viz. kilogram (kg), second (s), etc.

(2) Bigger and smaller number of units are represented with symbols corresponding to the power of 10 viz.  $10^6$  is mega (M),  $10^{12}$  is Tera (T),  $10^{-3}$  is milli (m),  $10^{-9}$  is nano (n), etc.

(3) All units are written in numerator viz.  $\text{kg/m}^3$  is kg m,  $\text{Nm}^2\text{c}^2$ .

(4) The units are written within parenthesis in graphs below the corresponding axes viz.  $(\text{ms}^{-1})$  and (s) in the velocity-time graph.

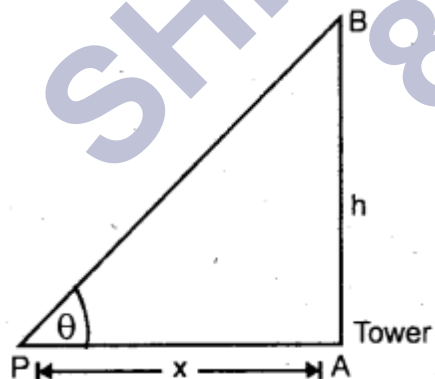
(5) Units of a similar physical quantity can be added or subtracted.

2. Answer: It is used to measure the distance of an accessible or inaccessible hill or a tower by measuring the angle which the object makes at point P (say)

Let x = distance y of point P from the foot of tower = PA .

$$\therefore h = x \tan \theta$$

It is also used to measure the distance of an inaccessible object eg. a tree on the other bank of a river.



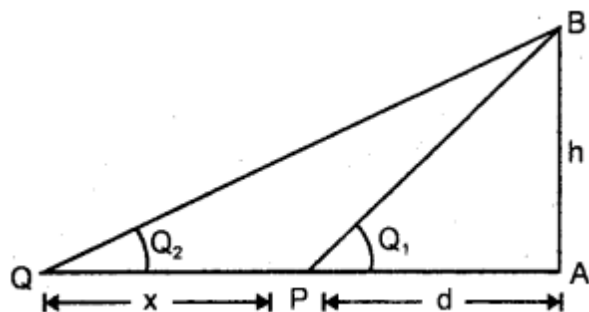
Let h = height of the inaccessible object.

Let  $\theta_1, \theta_2$  = be the angle made at P and Q by the object.

Let PA = d, PQ = x.

$\therefore$  In  $\triangle PAB$  and  $\triangle QAB$ ,

$$\begin{aligned}
 & \text{and} & d &= h \cot \theta_1 & \dots (i) \\
 & (ii) \text{ and } (i) \text{ gives,} & d + x &= h \cot \theta_2 & \dots (ii) \\
 & \therefore & x &= h (\cot \theta_2 - \cot \theta_1) \\
 & & h &= x / (\cot \theta_2 - \cot \theta_1).
 \end{aligned}$$



3. Answer:

Dimensional analysis is used for:

(a) checking the dimensional correctness of the given physical equation or relation.

(b) converting one system of units to another system.

(c) deriving the relationship between various physical quantities.

(a) checking of the dimensional correctness of a physical relationship is done by using the principle of homogeneity of dimensions. If the dimensions of M, L, T of each term on R.H.S. are equal to the dimensions of M, L, T of each term on L.H.S., then the given- physical relation is dimensionally correct, otherwise wrong.

(b) conversion: It is based on the fact that the magnitude of a physical quantity remains the same whatever may be the system of units, i.e.,  $n_1 u_1 = n_2 u_2$ .

$$\begin{aligned}
 \text{or} & \quad n_2 = n_1 \frac{u_1}{u_2} \\
 \text{where} & \quad u_1 = M^a L^b T^c \\
 \text{and} & \quad u_2 = M^a L^b T^c
 \end{aligned}$$

are the units of M, L, T in the first and second system of units of a physical quantity having dimensions of M, L, T, and a, b, c respectively.

$$\therefore n_2 = n_1 \left[ \frac{M_1}{M_2} \right]^a \left[ \frac{L_1}{L_2} \right]^b \left[ \frac{T_1}{T_2} \right]^c \quad \dots(1)$$

Thus, if fundamental units of both systems, dimensions of the quantity, and its numerical value  $n_1$  in one system, are known then we can easily calculate  $n_2$  in another system.

(c) Derivation of a relationship between various physical quantities is based on the principle of homogeneity of dimensions.

Following are the steps used:

- We must know the physical quantities (say  $p, q, r$ ) upon which a physical quantity say  $x$  depends.
- We must know the dimensions of  $p, q, r$  say  $a, b, c$  respectively.
- Then we write  $x = k p^a q^b r^c$
- Now, write the dimensions of each physical quantity on both sides of the equation
- and compare the powers of  $M, L, T$  to find  $a, b, c$ . Putting values of  $a, b, c$  in the equation
- we get the required relation.

### Assertion Reason Answer:

1. (c) Assertion is correct, reason is incorrect

**Explanation:**

Dimensional constants are not dimensionless.

2. (a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

**Explanation:**

As the distance of star increases, the parallax angle decreases, and great degree of accuracy is required for its measurement. Keeping in view the practical limitation in measuring the parallax angle, the maximum distance of a star we can measure is limited to 100 light years.

### Case Study Answer:

1. i (d) Either (a) or (b)

**Explanation:**

A screw gauge and a spherometer can be used to measure length accurately as less as

$10\text{m}^{-5}$

- ii (c) Spring oscillator

**Explanation:**

Spring oscillator cannot be used to measure time intervals.

- iii (a) 4.9 cm

**Explanation:**

Given, length,  $l = 5\text{cm}$  Now, checking the errors with each options one-by-one, we get

$$\Delta l_1 = 5 - 4.9 = 0.1 \text{ cm}$$

$$\Delta l_2 = 5 - 4.805 = 0.195 \text{ cm}$$

$$\Delta l_3 = 5.25 - 5 = 0.25 \text{ cm}$$

$$\Delta l_4 = 5.4 - 5 = 0.4 \text{ cm}$$

Error  $\Delta l_1$  is least.

Hence, 4.9cm is most precise or accurate.

iv (a)  $22.0\text{cm}^2$

**Explanation:**

Area of rectangle,  $A = \text{Length} \times \text{Breadth}$

$$\text{So, } A \text{ lb} = 10. \times 5 = 22.05\text{cm}^2$$

Minimum possible measurement of

scale = 0.1 cm.

So, area measured by scale = 22.0 cm<sup>2</sup>

v (c) 8.6 s

**Explanation:**

$$\text{Magnification in time} = \frac{\text{Age of mankind}}{\text{Age of universe}}$$

$$= \frac{10^6}{10^{10}} = 10^{-4}$$

$$\begin{aligned} \text{Apparent age of mankind} &= 10^{-4} \times 1 \text{ day} \\ &= 10^{-4} \times 86400 \text{ s} \\ &= 8.64 \text{ s} \approx 8.6 \text{ s} \end{aligned}$$

2. i (a) 2

**Explanation:**

As, we know that the terminal or trailing zero(s) in a number without a decimal point are not significant. So, 4700m has two significant figures.

ii (b)  $ab \times 10^b$

**Explanation:**

Every number is expressed as  $a \times 10^b$ , where  $a$  is a number between 1 & 10 and  $b$  is any

positive or negative exponent (or power) of 10.

iii (c)  $4.8 \text{ g cm}^{-3}$

**Explanation:**

There are 3 significant figures in the measured mass whereas there are only 2 significant figures in the measured volume. Hence, the density should be expressed to only 2 significant figures.

$$\text{Density} = \frac{5.74}{1.2} = 4.8 \text{ g cm}^{-3}$$

iv (a) Change in unit does not change the significant figure.

**Explanation:**

There is no change in number of significant figures on changing the units. For it, the convention is that we write,

$$4700 \text{ m} = 4700 \times 10^3 \text{ m}$$

This convention ensures no change in number of significant numbers.

v (a) I and II

**Explanation:**

Following rules of significant figures are

I. All the non-zero digits are significant.

II. All the zeroes between two non-zero digits are significant, no matter where the decimal point is, if at all.

III. The terminal or trailing zero(s) in a number without a decimal point are not significant. Thus,  $123 \text{ m} = 12300 \text{ cm} = 123000 \text{ mm}$  has three significant figures, the trailing zero(s) being not significant.