According to the Latest Syllabus

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Physics

Class-11 (Part-I)

For the Students of Rajasthan Board of Secondary Education

By

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❖ *Your suggestions shall be taken care of in our next edition.*

Preface

We are extremely pleased to present this book according to latest syllabus of NCERT. The book has been written in easy and simple language so that students may assimilate the subject easily. We hope that students will get benefitted from it and teachers will appreciate our efforts. In comparison to other books available in market, this book has many such features which make it a unique book :

1. Theoretical subject-material is given in adequate and accurate description along with pictures.
2. The latest syllabus of NCERT is followed thoroughly.
3. Complete solutions of all the questions given at the end of the chapter in the textbook are given in easy language.
4. Topic wise summary is also given in each chapter for the revision of the chapter.
5. In every chapter, all types of questions that can be asked in the exam (Objective, Fill in the blanks, Very short, Short, Numerical and Long answer type questions) are given.
6. At the end of every chapter, multiple choice questions asked in various competitive exams are also given with solutions.

Valuable suggestions received from subject experts, teachers and students have also been given appropriate place in the book.

We wholeheartedly bow to the Almighty God, whose continuous inspiration and blessings have made the writing of this book possible.

We express our heartfelt gratitude to the publisher – Mr. Pradeep Mittal and Manoj Mittal of Sanjiv Prakashan, all their staff, laser type center and printer for publishing this book in an attractive format on time and making it reach the hands of the students.

Although utmost care has been taken in publishing the book, human errors are still possible, hence, valuable suggestions are always welcome to make the book more useful.

In anticipation of cooperation!

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CHAPTER 1

UNITS AND MEASUREMENTS

Chapter Overview

1.1 Introduction

The study and analysis of nature and nautral phenomena is called physics. Various events in nature occur according to some fundamental rules. The study of expressing these laws from observed phenomena is called physics.

To measure any physical quantity, a fixed and definite value (standard) of that quantity is compared. **The value considered as a fixed and definite reference standard of a physical quantity is called a unit.** The magnitude of a physical quantity is displayed in the form of units and numerical values of that quantity. Here the physical quantity is measured by units whereas the numerical value tells the magnitude of that quantity. Although the number of physical quantities that we measure is very large, we still need only a limited number of units to express all these physical quantities; because these physical quantities are interrelated to each other. The units of fundamental physical quantities are called basic or **fundamental units**. Those units which are completely independent and which cannot be derived or can be related to any other units, are called **basic or fundamental units**. These units are not dependent on any other unit. All the physical quantities used in Mechanics are expresses in terms of units of length, mass and time. Hence these quantities are called as the **basic or fundamental quantities** and their corresponding units—meter, kilogram and second respectively are called fundamental units. Apart from these, the units of all other physical quantities can be expressed by combination of the fundamental units. The units thus obtained from the derived quantities are termed as **derived units**.

1.2 Physical Quantities

Those quantities which can be measured or weighed are called physical quantities. Such as mass, time, length, temperature, force, velocity, work, momentum etc.

There are two types of physical quantities :

(i) Fundamental Quantities : These are physical quantities that do not depend on any physical quantity. In mechanics, there are seven fundamental quantities – mass, length, time, temperature, electric current, light intensity and amount of substance.

(ii) Derived Quantities : Those physical quantities which are derived from the fundamental quantities and depend on these quantities are called derived quantities. Like momentum, force, work etc.

Example : Momentum = Mass × velocity = Mass × distance/time

1.3 Units

The value assigned to measure a physical quantity is called unit.

(a) Fundamental Units : The units of measurement of length, mass and time are, therefore, called fundamental units or base units, in mechanics.

(b) Derived Units : The units of measurement of all other physical quantities, which can be obtained by suitable multiplication or division of powers of fundamental units are called **derived units**. **Example :** Mass, work, speed etc.

Standard Unit : To express any physical quantity, its numerical value and unit value are required. If there is a physical quantity Q and its numerical value is n and the unit is u, then their product remains constant *i.e.* $Q = nu$ = constant *i.e.* the numerical value of any physical quantity is inversely proportional to its unit. Hence it is clear that, "*The smallar the unit of a physical quantity, the greater will be the numerical value of measurement of a certain quantity.* "

If the units of the same physical quantity are u_1, u_2, u_3 ... and the numerical values of a certain quantity are n_1, n_2, n_3 ... respectively, then the relation between unit and numerical values is

$$Q = n_1u_1 = n_2u_2 = n_3u_3 = ... = \text{constant.}$$

While selecting the unit of any physical quantity, the following things should be kept in mind :

(i) The selected unit must not be affected by changes in temperature, pressure and time.

(ii) The units selected should be universally accepted, of appropriate size and quantity.

(iii) The selected units can be easily defined and their models can be easily made at every place.

1.4 Systems of Units

Following are the main unit systems used in measurement of basic units of physical quantities. In these the basic units of length, mass and time are expressed respectively.

(i) C.G.S. (centimeter-gram-second) method or Gaussian method.

(ii) M.K.S. (meter-kilogram-second) method or Giorgi method.

(iii) F.P.S. (foot-pound-second) method.

(iv) International system of units (S.I.).

C.G.S. method or Gaussian method : In this method mass, length, time are measured in grams, centimeters, and seconds respectively.

M.K.S. method : In this method mass, length, time are measured in kilograms, meters, and seconds respectively.

F.P.S. method or British method : In this method mass, length, time are measured in pounds, feet, and seconds respectively.

1.5 International System of Units

It is the modified form of M.K.S. system. The member countries of the world had approved it in the international conference on weights and measures in 1960. In this system, standard units of seven basic quantities and two supplementary quantities have been defined.

(A) Basic Units :

S.No.	Name of physical quantity	Unit	Symbol
1.	Mass	Kilogram	kg
2.	Length	Meter	m
3.	Time	Second	s
4.	Temperature	Kelvin	K
5.	Electric Current	Ampere	A
6.	Luminous Intensity	Candela	cd
7.	Quantity of Matter	Mole	mol

(B) Supplementary Units :

S.No.	Name of physical quantity	Unit	Symbol
1.	Plane angle (Planar angle)	Radian	rad
2.	Solid angle or cubic angle	Steradian	sr

Merits of S.I. System :

(1) It is metric or decimal system.

(2) In this method, units are based on constant and available standards.

(3) All these units are well defined and restorable.

(4) S.I. methodology can be used in all branches of science. But M.K.S. system can be used only in mechanics.

(5) In this method, derivatives of all physical quantities can be obtained only by multiplying and dividing the basic units.

(6) In this method, only one unit is used for one physical quantity.

1.6 International Definitions of Fundamental Units

(1) Meter : One meter is the distance in which 1,650,763,73 waves of orange-red light emitted from Kr^{86} located in vacuum and in other work 1 meter is the distance that light travels in vacuum in $\frac{1}{299,792,458}$ seconds.

(2) Kilogram : One kilogram is equal to the mass of a special cylinder of platinum-iridium kept in the International Institute of Weights and Measures, Paris. This is the mass of one liter of water at 4ºC. One kilogram volume is equal to the mass of 5×10^{25} atoms of C^{12}.

(3) Second : This is time in which Cesium-133 (Cs^{133}) vibrates 9,192,631,770 times in the atomic clock. Atomic clocks are based on this definition, they measure time accurately and can have an error of only one second in every 5000 years.

(4) Ampere : It is the unit of electric current. One ampere is that constant electric current which, when flowing in two straight parallel wires of infinite length and negligible radius, placed at a distance of one meter in vacuum, produces a force of 2×10^{-7} N/m per unit length between them.

(5) Kelvin : One hundredth part of the difference between the boiling point of water and melting point of ice at normal atmospheric pressure is called 1 kelvin temperature. At triple point temperature of water (273.16K), $\frac{1}{273.16}$ th part of the thermodynamic temperature is called 1 kelvin. Its symbol is K. Degrees are not written in expressing temperature in kelvin. For example, the temperature of the room is 304K, it is wrong to write it as 304ºK.

(6) Candela : It is the unit of illumination intensity. A candela is the amount of luminous intensity that is emitted vertically from a black body with an area of $\frac{1}{6,00,000}$ square meter, when the pressure of the black body is 101,325 N/m^2 and temperature is equal to the melting point of platinum (2046 K).

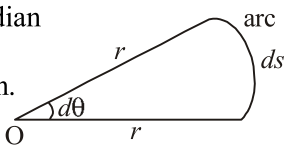
(7) Mole : 1 mole is that amount (mass) of substance in which the number of basic elements is equal to the number of carbon atoms in 0.012 kg of ${}_6C^{12}$. This number is called Avogadro's Number N_A. $N_A = 6.02 \times 10^{23}$ moles per gram.

Definitions of Supplementary Units : In the international system, angle and solid or positive angle are considered as supplementary quantities and their units are radian and steradian respectively are considered as supplementary units.

(i) Radian : The angle subtended at the center of the circle by an arc equal to the radius of a cricle is equal to 1 radian.

Plane angle $d\theta = \left(\frac{ds}{r}\right)$ radian

If $ds = r$ then $d\theta = 1$ radian.



$$1 \text{ radian} = \frac{180}{\pi} \text{ degree} = 57.3^o$$

(ii) Steradian : It is the unit of measuring solid angle. Its symbol is sr, the positive angle made at the center of the sphere by a square of area R^2 with side equal to its radius R on the surface of a sphere is called 1 steradian. It is expressed by Ω or ω. The solid angle formed at the central point is 4π.

$$\text{Solid angle } (d\Omega) = \frac{\text{Perpendicular surface area}}{(\text{Radius})^2}$$

$$\text{Solid angle } (d\Omega) = \frac{dA}{R^2} \text{ steradian}$$

If $dA = R^2$ then $d\Omega = 1$ steradian

If there is entire surface area then cube angle subtended by it $(\Omega) = \frac{4\pi r^2}{r^2} = 4\pi$ steradian.

1.7. Other Practical Units of Mass, Length and Time

(1) Units of Mass :

(i) 1 mg = 10^{-6} kg.

(ii) 1 gram = 10^{-3} kg.

(iii) 1 quintal = 100 kg.

(iv) 1 metric ton = 10 quintal = 1000 kg.

(v) 1 grain = 0.000065 kg.

(vi) 1 Ounce = 0.02835 kg.

(vii) 1 Pound = 0.4535 kg.

(viii) 1 Stone = 6.350 kg.

(ix) Atomic mass unit (amu)

1 amu = 1.67×10^{-27} kg.

(The mass of a proton or neutron is of the order of a 1 amu)

(x)1 Chandrasekhar unit = 1.4 times the mass of the sun

= 2.8×10^{30} kg.

It is the largest unit of mass.

(2) Units of Length :

(a) Units of small distances : Small multiples of meter are used to measure very small distances.

(i) 1 cm = 10^{-2} meter

(ii) 1 millimeter = 10^{-3} meter

(iii) 1 micron = 10^{-6} meter

(iv) 1 nanometer = 10^{-9} meter

(v) 1 Angstrom (1Å) = 10^{-10} meter

(vi) 1 Picometer (1 p.m.) = 10^{-12} meter

(vii) 1 x-ray unit = 10^{-13} meter

(viii) 1 Fermi (fm) = 10^{-15} meter

(This distance is used to measure size of the nucleus)

(b) Units of large distances : The following units are commonly used for measurement of large distances :

(i) Astronomical Unit, AU : The average distance between the center of the sun and the center of the earth is called 1 Astronomical unit.

1 AU = 1.496×10^{11} meter

$\approx 1.5 \times 10^{11}$ meter

(ii) Light Year : The distance covered by light in a vacuum in one year is called 1 light year.

1 Light year = Speed of light in vacuum × time (1 year in seconds)

$= 3 \times 10^8 \times 365 \times 24 \times 60 \times 60$

$= 9.467 \times 10^{15}$ meter

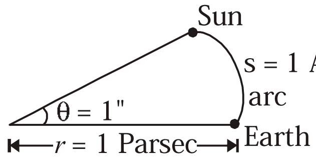
$\cong 10^{16}$ meter.

(iii) Parsec : This is the largest unit of distance. A parsec is the distance obtained by subtending an angle of 1" (one arc second) at any point, taking the astronomical unit distance as an arc.

$\because$ Angle = $\frac{\text{Arc}}{\text{Radius}}$

$\therefore$ 1" = $\frac{1\text{AU}}{1\text{Parsec}}$

or 1 Parsec = $\frac{1\text{AU}}{1"}$



$$= \frac{1.496 \times 10^{11}\text{ m}}{\frac{1}{3600} \times \frac{\pi}{180}\text{ rad}}$$

$$= \frac{1.496 \times 10^{11} \times 3600 \times 180\text{ m}}{3.14}$$

$= 3.084 \times 10^{16}$m $\cong 3.1 \times 10^{16}$ m

Note : $\because 1° = 3600" \therefore 1" = \left(\frac{1}{3600}\right)^\circ$ and to convert in radian multiply by $\left(\frac{\pi}{180}\right)$.

Relationship between light year and parsec :

$$\frac{1\text{ Parsec}}{1\text{ Light year}} = \frac{3.1 \times 10^{16}}{9.467 \times 10^{15}}$$

$\therefore$ **1 Parsec = 3.28 Light year**

Relationship between parsec and astronomical units :

1 Parsec = 3.1×10^{16} m

1 AU = 1.496×10^{11} m

$$\therefore \frac{1\text{ Parsec}}{1\text{AU}} = \frac{3.1 \times 10^{16}}{1.496 \times 10^{11}} = 2.072 \times 10^5$$

$\therefore$ **1 Parsec = 2.07×10^5 AU**

Other F.P.S. units :

1 Foot = 12 inches = 0.3048 meter

1 yard = 3 feet

1 mile = 1.609×10^3m $\approx$ 1.6 km

1 mile = 1760 yard = 1.609×10^3 m

(c) Units of time :

1 milli second = 10^{-3} second

1 micro second (μs) = 10^{-6} s

1 nano second (ns) = 10^{-9} s

1 hour = 60 minutes = 60 × 60
= 3600 seconds

1 day = 24 hours
= 24 × 60 × 60 seconds
= 86400 seconds

1 year = 365 days
= 365 × 24 × 60 × 60
= 3.156×10^7 seconds

1 shake = 10^{-8} seconds

Note : This is practical unit of time but it is not used at present.

Lunar month : The time taken by the moon to complete one cycle in its orbit around the earth is 1 Lunar month.

1 Lunar month = 27.3 days

Metric Prefixes for Powers of 10 : Prefixes are used to increase and decrease the units.

Prefix	Power	Symbol
deca	10^1	da
hecto	10^2	h
kilo	10^3	k
mega	10^6	M
giga	10^9	G
tera	10^{12}	T
peta	10^{15}	P
exa	10^{18}	E
zetta	10^{21}	Z
yotta	10^{24}	Y
deci	10^{-1}	d
centi	10^{-2}	c
milli	10^{-3}	m
micro	10^{-6}	μ
nano	10^{-9}	n
pico	10^{-12}	P
femto	10^{-15}	f
atto	10^{-18}	a
zepto	10^{-21}	z
yocto	10^{-24}	y

1.8 Significant Figures

The digits that express a physical quantity in pure form are called significant figures and in other words the number of digits required to explain the measurement of a certain physical quantity is called significant figures. The number of digits obtained by removing the decimal sign from a number and leaving out the left most zero (if any) is called significant digits.

This will become clear from the following examples :

(1) 123.64 has 5 significant figures, 203.004 has 6 significant figures.

(2) 2000 has 4 significant figures, 0.00031 has 2 significant figures.

(3) 1.00031 has 6 significant figures, 20.00 has 4 significant figures.

(4) 0.04050 has 4 significant figures.

Rules for finding the number of significant figures in an expression are following :

First rule : All non-zero digits are significant digits. *e.g.*, the amount of $x = 8696$ has four significant figures and the amount $x = 636$ has three significant figures.

Second rule : All zeros falling between two non-zero digits are taken into account in the calculation of significant digits. *e.g.*, the number of significant figures in the quantity $x = 2003$ is four and the number of significant figures in the quantity $x = 2.02304$ is 6.

Third rule : If the numerical value of the number is less than 1 then the zeros on the right side of the decimal and on the left side of the non-zero digit are not significant digits. *e.g.*, The number of significant figures in the quantity $x = 0.00046$ is two and the number of significant figures in the quantity $x = 1.00046$ (from Rule 2) is 6.

Fourth rule : All the zero digits coming to the right after the last non-zero digit of the decimal point are taken into account in calculating the significant digit. *e.g.*, the number of significant figures in quantity $x = 0.000600$ is three. The number of significant figures in the quantity $x = 0.0060$ is two.

Fifth rule : All zeros situated to the right of a zero digit are not significant digits. *e.g.*, the number of significant figures in the amount $x = 20000$ is 1 and in quantity $x = 4650000$, it is 3.

Sixth rule : All zero significant figures coming to the right of the last non-zero quantity are taken if they have been obtained by measurement. *e.g.*, if the distance between two