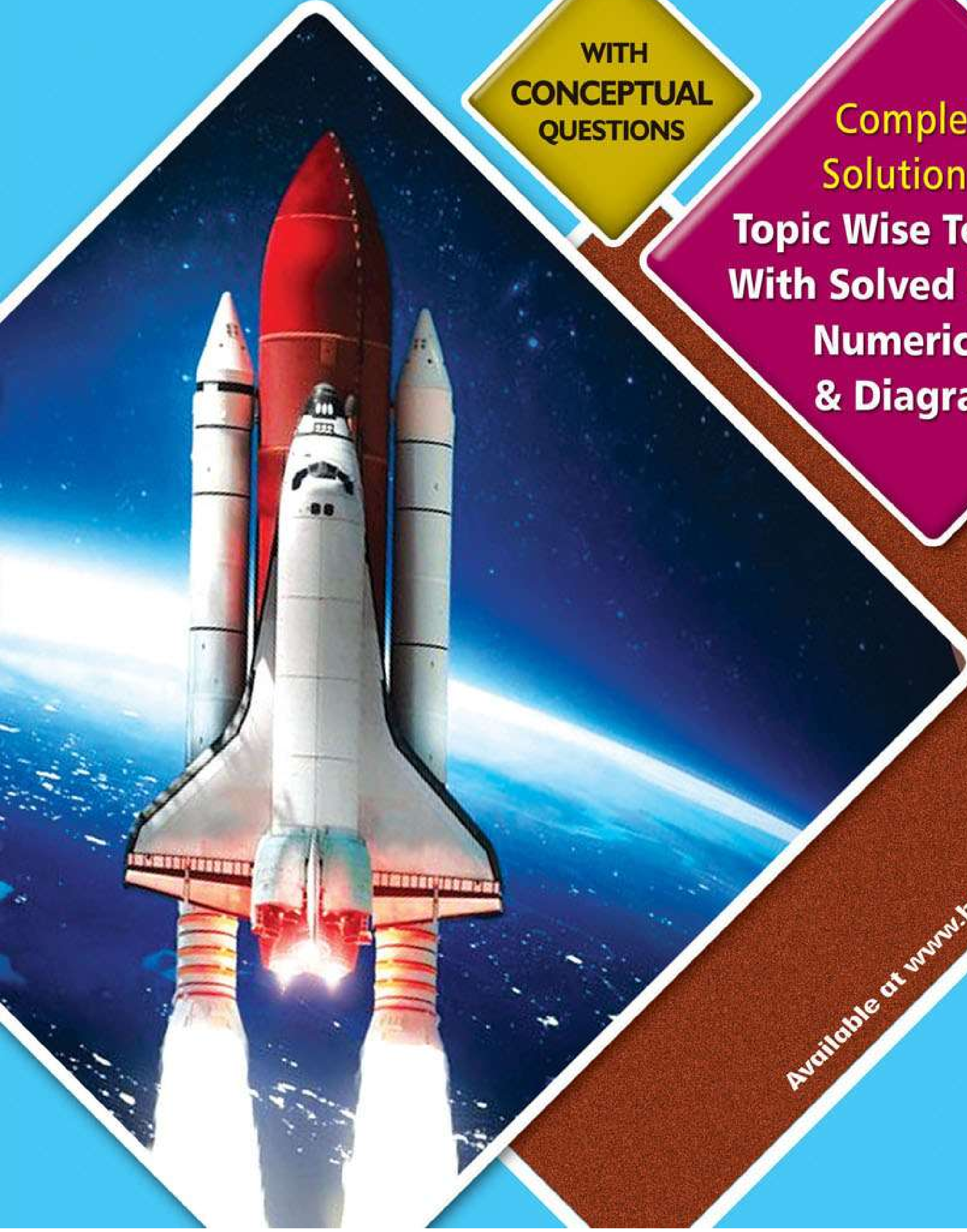
BRAIN SOLUTION

PHYSICS 9

WITH QUESTION BANK AND TUTOR

WITH CONCEPTUAL QUESTIONS

Complete Solution of
Topic Wise Textbook With Solved Exercise Numericals & Diagrams



Available at www.brainbooks.pk

BRAIN BOOKS

BRAIN SOLUTION

WITH TUTOR

PHYSICS

with CONCEPTUAL Questions (CQs)

9

Written by

Muhammad Shoaib Ghani
Ph.D Scholar

Rao Shahid Khalil
Controller Examination
SST (Science) Central Model School
Lower Mall, Lahore

Ali Raza Siddiqui
SST (Science) M.Sc Physics, M.Ed
Govt Comprehensive H/S/S
Bosan Road Multan

Reviewed by

Farrukh Ali
M.Sc Computational Physics
(University of the Punjab Lahore)

Rs. 450

BRAIN BOOKS

1st Floor, Zeeshan Plaza, Ahata Shahdarian, Urdu Bazar, Lahore.

0322-4223373 Ph: 042-37113344 : brainsms.pk : brainbooks.pk

CONTENTS

Unit - 1 Physical Quantities and Measurements

Q.1 What is science? Write its role in daily life.

Ans: Science:

The field of **observation** and **experimentation** to understand about the world around us is known as science.

Role of Science in daily ife:

We are living in a physical world where we observe many natural phenomena and objects around us such as Sun, stars, moon, oceans, plants, winds, rains, etc. People have always been curious to know the reality of such happenings. This has led certain people to investigate the **facts** and **laws** working in this world. Everything in our lives is closely linked to science and the discoveries made by the scientists. In order to obtain reliable results from experiments, the primary thing is to make accurate measurements.

TUTOR

A **Fact** is an observation that has been repeatedly confirmed and is accepted as true.
A **Law** is a description of how something in nature happens. Scientific laws are known as natural laws.

Physical quantities and their measurements have always been the matter of interest for the scientists. They have been investigating to improve the methods and instruments for accurate measurements of the physical quantities.

1.1 Physical and Non-Physical Quantities

Q.2 Differentiate between physical and non-physical quantites.

Ans: Physical quantites:

All measurable characteristics of objects are called physical quantities.

Examples:

There are various natural phenomenon such as length, volume, density, time, temperature, etc. These can be measured directly and indirectly using some tools and instruments such as:

i) Length of an object using a ruler
ii) Time duration of an event using a clock
iii) Temperature (the degree of hotness) of somebody using a thermometer.

Explanation:

Physical quantities and their measurements have always been the matter of interest for the scientists. They have been investigating to improve the methods and instruments for accurate measurements of the physical quantities.

Quick Quiz

Is a non-physical quantity has dimensions?
Ans: No, non-physical quantity has no dimesions. It can be explained by either described, qualitatively or compared using some perdetermined criteria, indices or through survey techniques.

Characteristics of Physical Quantities:

The foundation of physics rests upon physical quantities through which the laws and principles of physics are expressed.

Non-physical quantites:

Characteristics of objects which cannot be measured are called physical quantities.

Examples:

Love, affection, fear, wisdom, beauty cannot be measured by using tools and instruments.

Explanation:

There are various natural phenomenon such as events and human behaviour using some of their features and terms such as love and affection. These features cannot be measured using tools and instruments. They often pertain to the perception or interpretation of the observer. They can be described or qualitatively or compared using some perdetermined criteria, indices or through survey techniques.

Characteristics of Non-physical quantities:

Non-physical quantities mostly help to understand and to analyse human behaviour, emotions and social interactions.

Table 1.1

Quick Quiz: Complete the following

Feature	Physical quantity	Non-Physical quantity
1. Measurement	Yes	No
2. Instrument used	Yes	No
3. Numerical value and unit	Yes	No
4. Examples	1. Length, 2. Time	1. Love, 2. Wisdom

1.2 Base and Derived Physical Quantities

Q.3(a) Define Physics. How it related to physical qantities?

(b) What is meant by base and derived quantities? **Ex Q.1.1(a)**

(c) What is measurement process of physical quantity?

(a) Define Physics. How it related to physical qantities?

Ans: Physics:

Physics is a science of **physical world** where we interact with many different types of **material objects**.

Relation of Physics with Physical quantities:

In physical world, there are some objects which are exposed in terms of their measurable features known as physical quantities.

TUTOR

Q. Why do we study physics?
Ans: We study physics because the laws and priciples of physics help us to understand nature.

Examples of Physical Quantites:

Length, breadth, thickness, mass, volume, density, time, temperature, etc.

Out of these, the scientists have selected arbitrarily some quantities to play a key role. They are called base quantities.

(b) What is meant by base and derived quantities? **Ex Q.1.1(a)**

Ans: Base Quantites:

Quantities which can be expressed independently without the reference of any other quantity are called base quantites.

Examples:

Length, mass, time, temperature, electric current, intensity of light and amount of substance are base quantities.

Derived Quantites:

All the quantities which can be described in terms of one or more base quantities are called derived physical quantities.

Examples:

Area, Volume, Speed, Force, Pressure, Electric charge and plane angle are examples of derived quantites.

Explanation:

Speed is a derived quantity which depends on distance and time which are base quantities whereas density of a material is described in terms of mass and volume.

(c) What is measurement process of physical quantity?

Ans: Measurement of a Physical Quantity:

A measurement is a process of comparison of an unknown quantity with a widely accepted standard quantity.

Activity 1.1

The teacher should facilitate this activity and initiate discussion as perdirection.
One student should measure the length of a writing board with his hand. The same should be repeated by four or five students. Are all the measurements same? If they differ, then why? What is the solution to avoid confusion?

Ans: All the measurements are different, because size of hand of each each student is different.
Solution to avoid confusion is use any measuring instrument just like metre rod, measuring tape etc, so that, measuring by any student may result the same.

Q.4(a) What is a unit? Why scientists need standard units for a quantity?

(b) Write the parts of a measurement. Give an example.

(a) What is a unit? Why scientists need standard units for a quantity?

Ans: Unit:

Scientist describe a standard for measurement of a quantity by any person may result. This standard of measurement is known as a unit.

Measurement of quantity in past:

In the early days, people used to measure length using hand or arm, foot or steps. This measurement may result in confusion as the measurement of different people may differ from each other because of different sizes of their hands, arms or steps.

However, problems were faced when people of different countries exchanged scientific information or traded with other countries using different units. Not very far in the past, every country in the world had its own units of measurements.

The International Prototype kilogram

Standard Solution of Measuring a Mesurement:

To avoid confusions of a measurement in different parameters, scientist describe a standard so that measurement by any person may result the same. **This standard of measurement is known as a unit.**

Eventually, people got the idea of standardizing the units of measurements which could be used by all countries for efficient working and growth of mutual trade, business and share scientific information.

(b) Write the parts of a measurement. Give an example.

Ans: Parts of a measurement:

A measurement consists of two parts, **a number** and **a unit**. A measurement without unit is meaningless.

Example:

If we measure mass of apples then we say as "it is 2 kg". Here "2" is a number and "kg" is the unit of mass.

1.3 International System of Units

Q.5 Write a note on International System of Units.

Ans: International System of Units:

The international committee on weights and measures in 1961 recommended the use of a system consisted of seven base units known as international system of units, abbreviated as SI. This system is in use all over the world.

Role of SI Units in Measurement:

Use of SI measurements helps all scientists to share and compare their observations and results easily.

Q.6(a) Define base units. Describe the name and symbol of base units. Ex Q.1.1(b)

(b) Define derived units. Give the names and symbols of some derived units.

(a) Define base units. Describe the name and symbol of base units. Ex Q.1.1(b)

Ans: Base units:

SI units of seven base quantities are called base units.

Explanation:

Base units cannot be derived from one another and neither can they be resolved into anything more basic.

Seven Base Units:

The seven base units are given in table 1.2. Their values are fixed reference to international standards.

Table 1.2: Names and Symbols of SI base Units

Sr.#	Physical Base quantity	Base Unit	Symbol
1.	Length	metre	m
2.	Mass	kilogram	kg
3.	Time	second	s
4.	Temperature	kelvin	K
5.	Electric current	ampere	A
6.	Intensity of light	candela	cd
7.	Amount of substance	mole	mol

TUTOR

The **SI** (System International) Unit of a base quantity is known as **base unit**.

(b) Define derived units. Give the names and symbols of some derived units.

Ans: Derived Units:

The units which can be expressed in terms of base units are called derived units.

Explanation:

While the units of derived quantities such as speed, area, volume, force, pressure and electric charge can be derived using the base units. These units are called derived units.

Examples of derived units:

(i) Area = length × breadth = metre × metre = square metre
= $metre^2$ or m^2

(ii) Speed = Distance/Time = metre/second = ms^{-1}

A few derived units with specific names and symbols are given in table 1.3.

Table 1.3: Names and Symbols of derived units

Sr. No.	Derived Physical quantity	Derived Unit	Symbol
1.	Area	square metre	m^2
2.	Volume	cubic metre	m^3
3.	Speed	metre per second	ms^{-1}
4.	Force	newton	N
5.	Pressure	pascal	Pa
6.	Electric charge	coulomb	C
7.	Plane angle	radian	Rad

Quick Quiz

(a) Write the unit of charge in terms of base unit ampere and second.

Ans: The unit of charge in terms of base unit ampere and second As^{-1} known as coulomb

Explanation:

Electric charge = Current / Time
= Ampere / second = As^{-1}
= Coulomb = C

(b) Express the unit of pressure "pascal" in some other units.

Ans: The unit of pressure "pascal" is equal to Nm^{-2}. In SI unit, it is equal to $kgm^{-1}s^{-2}$.

Q.7 Define SI prefixes. Explain it with suitable examples.

Ans: SI Prefix:

The words or symbols added before SI unit such as milli, centi, kilo, mega, giga are called prefix.

Examples:

The SI is a decimal system. Prefixes are used to change units by powers of 10. The big quantities like 50000000 m and small quantities like 0.00004 m are not convenient to write down. The use of prefixes makes them simple.

i) The quantity 50000000 m can be written as $5×10^7$ m.

ii) The quantity 0.00004 m can be written as $4×10^{-5}$ m.

Explanation:

The prefixes should be known for use of SI units effectively (Table1.4). For example, one thousandth (1/1000) of a metre is millimetre.

The thickness of a thin wire can be expressed conveniently in millimetres whereas a long distance is expressed in kilometres which is 1000 metres.

Table 1.4
Prefixes used with SI units

Prefix	Symbol	Power of Ten
atto	a	10^{-18}
femto	f	10^{-15}
pico	p	10^{-12}
nano	n	10^{-9}
micro	μ	10^{-6}
milli	m	10^{-3}
centi	c	10^{-2}
deci	d	10^{-1}
kilo	k	10^{3}
mega	M	10^{6}
giga	G	10^{9}
tera	T	10^{12}
peta	P	10^{15}
exa	e	10^{18}

Multiples and sub-multiples:

Multiples and sub-multiples of mass measurement and length are given in Table 1.5 and Table 1.6.

Examples:

(i) $5000\,mm = \frac{5000}{1000}m = 5\,m$

(ii) $50000\,cm = \frac{5000}{100}m = 500\,m$

(iii) $3000\,g = \frac{3000}{1000}kg = 3\,kg$

(iv) $2000\,\mu s = 2000 \times 10^{-6} s$

$= 2 \times 10^{-3} s = 2\,ms$

Table 1.5

100 kg	1 quintal
1000 quintal or 100 kg	1 tonne

Table 1.6

1 m	100 cm
1 cm	10 mm
1 km	1000 m
1 mm	10^{-3} m
1 cm	10^{-2} m
1 km	10^{3} m

Do You Know?

The kilogram is the only base unit has prefix

For Your Information

The negative exponents have values less than one. For example, $1\times10^{-2}=0.01$

Quick Quiz

100 m is equal to:

(a) 1000 µm (b) 1000 cm

(c) 100,000 mm (d) 1 km

Ans: (c) 100,000 mm

TUTOR

As, 1 m = 100 cm

1 cm = 10 mm

1 m = (100 × 10) mm

1 m = 1000 mm

So, 100 m = 100,000 mm

1.4 Scientific Notation

Q.8(a) Define scientific notation. Explain with examples.

(b) Write rules to write a number in scientific notation.

(a) Define scientific notation. Explain with examples.

Ans: Scientific Notation:

The number written as power of ten or prefix in which there is only one non-zero number before decimal is known as scientific notation.

Explanation:

Scientific notation is short way of representing very large or very small numbers. Writing otherwise, the values of these quantities, take up much space.

They are difficult to read, their relative sizes are difficult to visualize and they are awkward to use in calculations. Their decimal places are more conveniently expressed as powers of 10.

Examples:

i) The average distance from the Sun to the Earth is 138,000,000 km. In scientific notation, this distance would be written as 1.38×10^{8} km. The number of places, decimal moved to the left is expressed as a positive exponent of 10.

For Your Information

Addition and subtraction of numbers is only possible if they have same exponents. If they do not have the same exponents, make them equal by the displacement of the position of the decimal point.

ii) Diameter of hydrogen atom is about 0.000,000,000,052 m. To write number in scientific notation, the decimal point is moved 11 places. As a result, the diameter is written as 5.2×10^{-11} m. The number of places moved by the decimal to the right is expressed as a negative exponent of 10.

(b) Write rules to write a number in scientific notation.

Ans: Rules to write a number in scientific notation:

i) The numerical part of the quantity is written as a number from 1 to 9 multiplied by whole number powers of 10.

ii) To write numbers using scientific notation, move the decimal point until only one non-zero digit remains on the left.

iii) Count the number of places through which the decimal point is moved and use this number as the power or exponents of 10.

iv) The number of places, decimal moved to the left is expressed a positive exponent of 10.

v) The number of places moved to the right is expressed a negative exponent of 10.

For Your Information

Q. Write about use of SI units required special care, in writing prefixes.

Ans: Use of SI units required special care, particularly, in writing prefixes.

- Each unit is represented by a symbol not by an abbreviation.
  For example, for SI not S.I, for second "s" not "sec", for ampere "A" not "amp", for gram "g" not "gm".
- Symbols do not take plural form. For example, 10 mN, 100 N, 5 kg, 60 s.
- Full name of the unit does not begin with capital letter. For example metre, second, newton expect Celcius.
- Symbols appear in lower case, m for metre, s for second, expection is only L for litre.
- Symbols named after scientist's name have initial letters capital. For example, N for newton, K for kelvin and Pa for pascal.
- Prefix is written before and close to SI unit. Examples: ms, mm, mN, not m s, m m, m N.
- Units are written one space apart. For example, N m, N s.
- Compound prefixes are not allowed. For example,

(i) 7 μμs should be written as 7 ps.

(ii) 5×10^4 cm should be written as 5×10^2 m.

Quick Quiz

Q. Express the following into scientific notation.

(a) 0.00534 m (b) 2574.32 kg (c) 0.45 m (d) 0.004 kg (e) 186000 s

Ans:

(a) 0.00534 m

For writing 0.00534 m, shift the decimal point to first non-zero number that is 5 in it. As we shift decimal point 3 steps forward, then it will be written as –3 in the power of ten. As, $0.00534 \text{ m} = 5.34\times10^{-3}$ m

(b) 2574.32 kg

For writing 2574.32 kg, shift the decimal point to first non-zero number that is 2 in it. As we shift decimal point 3 steps back, then it will be written as +3 in the power of ten. As, $2574.32 \text{ kg} = 2.57432 \times 10^3$ cm

(c) 0.45 m

For writing 0.45 m, shift the decimal point to first non-zero number that is 4 in it. As we shift decimal point 1 step farword, then it will be written as –1 in the power of ten. As, $0.45\ m = 4.5 \times 10^{-1}\ m$

(d) 0.004 kg

For writing **0.004 kg**, shift the decimal point to first non-zero number that is 4 in it. As we shift decimal point 3 steps farword, then it will be written as –3 in the power of ten. As, $0.004\ km = 4 \times 10^{-3}\ km$

(e) 186000 s

For writing 186000 s, shift the decimal point to first non-zero number that is 1 in it. As we shift decimal point 5 steps back, then it will be written as +5 in the power of ten. As, $186000\ s = 1.86 \times 10^{5}\ cm$

1.5 Length Measuring Instruments

Q.9 Define and explain least count with the example of metre rule. Also write its error.

Ans: Least Count:

Least count is the smallest measurement that can be taken accurately with an instrument.

Metre Rule: Length is generally measured using a metre rule in the laboratory. The smallest division on a metre scale is 1 mm.

Least count of Metre rule:

The smallest measurement that can be taken with a metre rule is 1 mm. One millimetre is known as least count of the metre rule.

Method of Measurement:

To measure the length of an object, the metre ruler is placed in such a way that its zero coincides one edge of the object and then the reading in front of the other edge is the length of the object.

Source of Error:

One common source of error comes from the angle at which an instrument is read. Metre ruler should either be tipped on its edge or read when the person's eye is directly above the ruler at point B (Fig. 1.1).

Parallax error:

If the metre ruler is read from an angle, such as from point A or C, the object will appear to be of different length. This is known as parallax error.

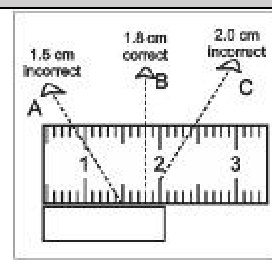
For Your Information!

Parallax error is due to incorrect position of eye when taking measurements. It can be avoided by keeping eye perpendicular to the scale reading.

TUTOR

Digital Vernier Callipers has greater precision than mechanical vernier calipers. Least count of digital vernier calipers is 0.01 mm.

Measuring Tape: It can measure 1 mm to several metres. Its least count is 1 mm. It is used to measure longer distances.



Fig; 1.1

Q.10(a) What is Vernier Callipers? Describe its structure and importance.
(b) Describe the procedure of taking reading from Vernier Callipers.

(a) What is Vernier Callipers? Describe its structure and importance.

Ans: Vernier Callipers:

Vernier callipers is an instrument used to measure small lengths down to 1/10th of a millimetre.

Use of Vernier callipers:

Vernier callipers can be used to measure the thickness, diameter, width or depth of an object.

Do you Know?

Some Secific lengths in (m)	
Football ground	9.1×10^{1}
Man	1.8×10^{0}
Thickness of book page	1.0×10^{-4}
Diameter of pencil	7.0×10^{-3}

Scales of Vernier Callipers:

The two scales on it are:

(a) A main scale which has marking of 1 mm each.

(b) A Vernier (sliding) scale of length 9 mm and it is divided into 10 equal parts.

Do You Know?

Vernier Callipers was invented by a French Scientist Pierre Vernier in 1631.

Least Count of Vernier Callipers:

Least count of a Vernier Callipers is the difference between one main scale division (M.S) and one Vernier scale (V.S) division.

Mathematically:

Least count = 1 M.S div – 1 V.S div = 1 mm – 0.9 mm = 0.1 mm

Usually, the least count is found by dividing the length of one small division on main scale by the total number of divisions on the Vernier scale which is again 1 mm/10 = 0.1 mm.

Structures of Vernier Callipers:

The parts of the Vernier Callipers are shown in Fig. 1.2.

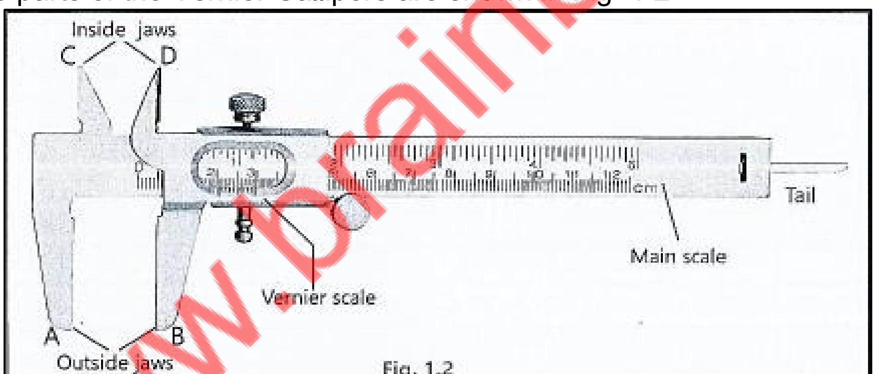


Fig. 1.2

There are two Jaws A and B to measure external dimension of an object whereas jaws C and D are used to measure internal dimension of an object. A narrow strip that projects from behind the main scale known as tail or depth gauge is used to measure the depths of a hollow object.

Importance of Vernier Callipers:

Vernier Callipers are important because they allow for highly precise measurements of both internal and external dimensions of objects, including length, diameter and depth.

(b) Describe the procedure of taking reading from Vernier Callipers.

Ans: Measurement Using Vernier Callipers

Suppose, an object is placed between the two jaws, the position of the Vernier scale on the main scale is shown in the Fig. 1.3.

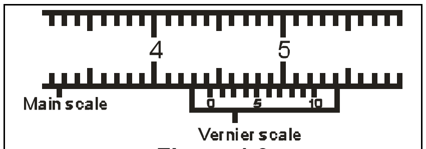
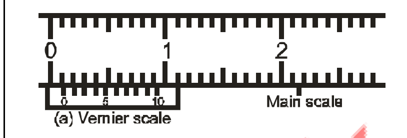


Figure 1.3

1. Read the main scale marking just infront of zero of the Vernier scale. It shows 4.3 cm.
2. Find the Vernier scale marking or division which is in line with any of the main scale marking. This shows:

   Length of object = Main scale reading + (Least count × Vernier scale reading)

   = 4.3 + 0.01 × 4 = 4.3 + 0.04 = 4.34 cm



Q.11 What is zero error of Vernier Callipers? Also describe important points before checking zero error.

Ans: Checking for zero error. Following are some important points to keep in mind before checking zero error.

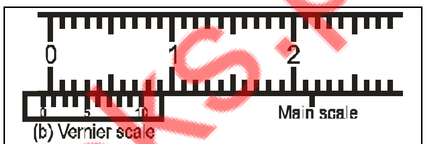


Fig. 1.4

(a) Zero Error of Vernier Callipers: If on joining the jaws A and B, the zeros of the main scale and Vernier scale do not exactly coincide with each other then there is an error in the instrument called zero error.

(b) Positive Zero Error:

If the zero of the Vernier scale is on the right side of the zero of the main scale (Fig. 1.4 a) then this instrument will show slightly more than the actual length. This is known as **positive zero error**.

Zero Correction:

When zero error is positive, then zero errors are subtracted from the observed measurement for **accurate reading**.

Explanation:

To find the zero error, note the number of the division of the Vernier scale which is exactly in front of any division of the main scale. Multiply this number with the least count. The resultant number is the zero error of this instrument. The observed reading is corrected by subtracting the zero error from it.

Negative Zero Error:

(c) If the zero of the Vernier scale is on the left side of the zero of the main scale (Fig. 1.4b), then instrument will show slightly less than the actual length.

Zero Correction:

The zero error is added in the observed measurement.

Laboratory Safety Rules

Q. Write rules of laboratory safety.

Ans: Rules of Laboratory Safety:

- Handle all apparatus and chemicals carefully and correctly. Always check the label on the container before using the substance it contains.
- Do not taste any chemical unless otherwise instructed by the teacher.
- Do not eat, drink or play in the laboratory.
- Do not tamper with the electrical mains and other fittings in the laboratory. Never work with electricity near water.
- Don't place flammable substance near naked flames.
- Wash your hands after all laboratory work.

Example:

If 3 is the number of divisions coinciding with any main scale division then 3 is subtracted from 10 and the result is then multiplied with the least count. Therefore, the zero error in this case will be 0.7 mm. For correction, it is added in the observed reading.

Activity 1.2

The teacher should facilitate to perform this activity by making groups. Each group should place ten coins one above the other. Record their total height using a metre rule. Divide by 10.

Q. What is the thickness of one coin?

Ans: Suppose thicknes of 10 coins with metre rule is 3.2 cm. Then

Thickness of one coin $= \frac{3.2\,cm}{10} = 0.32\,cm$

Q. Find the thickness of one coin using Vernier Callipers.

Ans: Thickness of one coin by using Vernier Callipers is 0.25 cm.

Q. What is the result?

Each group should comment on the measurement using the two instruments.

Ans: **Result:** Mesurement taking from vernier callipers is more precise and accurate as compare to measurement taken from metre rule.

Q.12(a)Define Micrometer Screw Gauge. Describe its structure and importance.

(b) Write about zero error and zero correction of Micrometer Screw Gauge. Describe measurement of Micrometer Screw Gauge.

(a) Define Micrometer Screw Gauge. Describe its structure and importance.

Ans: Micrometer Screw Gauge

Micrometer Screw Gauge is used to measure very small lengths such as diameter of a wire or thickness of a metal sheet.

Scales of Micrometer Screw Gauge:

Micrometer Screw Gauge has two scales:

(a) The main scale on the sleeve which has marking of 0.5 mm each.

(b) The circular scale on the thimble which has 50 divisions. Some instruments may have main scale marking of 1 mm and 100 divisions on the thimble.

Pitch of Micrometer Screw Gauge:

When the thimble makes one complete turn, the spindle moves 0.5 mm (1 scale division) on the main scale which is called pitch of the screw gauge.

Formula of Least Count of Micrometer Screw Gauge:

The formula of Least Count of Micrometer Screw Gauge

$$Least\ count = \frac{Pitch\ of\ the\ screw\ gauge}{No.of\ division\ on\ the\ circular\ scale} = \frac{0.5\,mm}{50} = 0.01\,mm$$

Parts of Micrometer Screw Gauge:

The parts of the screw gauge are shown in Fig. 1.5.

The object that is to be measured is placed between the anvil and the spindle.

Figure 1.5

Limitations of measuring Instruments		
Instrument	**Range**	**Leastcount**
Measuring Tape	1 cm to several metres	1 mm
Metre rule	1 mm to 1 m	1 mm
Vernier Callipers	0.1 mm to 15 cm	0.1 mm
Micrometer Screw gauge	0.01 mm to 2.5 cm	0.01 mm

Importance of Micrometer Screw Gauge:

A micrometer screw gauge is crucial because it allows for extremely precise measurements of small dimensions, making an essential in engineering and manufacturing. Ther micrometer screrw gauge is used to measure even smaller dimensions than the vernier callipers.

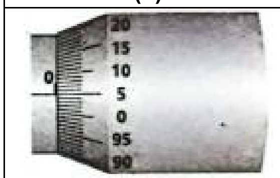
(b) Write about zero error and zero correction of Micrometer Screw Gauge. Describe measurement of Micrometer Screw Gauge.

Ans: If the zero of the circular scale coincides with horizontal line, there is no zero error (Fig. 1.6-a).

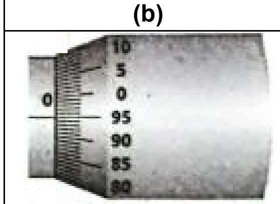
Checking for Zero Error:

If the zero of the circular scale is not exactly in front of the horizontal line of the main scale on joining the anvil and spindle then there is a zero error in the screw gauge (Fig. 1.6-b).

(a)



(b)



(c)

Figure 1.6

Zero Error and their Correction:

(i) If zero of the circular scale is below the horizontal line then it will measure slightly more than the actual thickness and hence, zero error will be subtracted from the observed measurement.

(ii) If the zero of the circular scale is above the horizontal line (Fig. 1.6-c), then it will show slightly less than the actual thickness and hence, the zero error will be added to the observed measurement.

Measurement Using Screw Gauge:

Suppose when a steel sheet is placed in between the anvil and spindle, the position of circular scale (Fig. 1.7).

(a) Read the marking on the sleeve just before the thimble. It shows 6.5 mm.

(b) Read the circular scale marking which is in line with the main scale. This shows 25. Hence,

Thickness

= main scale reading + (circular scale reading×L.C.)

= 6.5 mm + 25 × 0.01 mm

= 6.5 mm + 0.25 mm = 6.75 mm

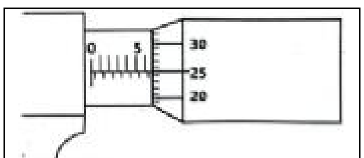


Figure 1.7

1.6 Mass Measuring Instruments

Q.13(a) Write a note on physical balance.
(b) Write measuring procedure of physical balance.

(a) Write a note on physical balance.
Ans: Physical Balance:

A physical balance is a measuring instrument that determines the mass of an object.

Explanation:

There are many kinds of balances used for measuring mass of an object. In our daily life, we use the term weight instead of mass. In Physics, they have different meanings. Mass is the measure of quantity of matter in a body whereas the weight is the force by which the body is attracted towards the Earth. Weight can be measured using spring balance (Fig. 1.8).

TUTOR

Physical Balance is a modified type of beam balance used to measure small masses by comparison wirth greater accuracy.

TUTOR

A **beam balance** is a devicve that measures the mass or weight of an object by comparing to be known as mass.

TUTOR

Spring balance is a mechanical deives that measures the weight of an object by measuring the amount of a spring stretches when the object is attached to it.

Weighing:

The mass of an object is found by comparing it with known standard masses. This process is called weighing.

(b) Write measuring procedure of physical balance.
Ans: Measuring Procedure of Physical Balance:

In laboratories, we use physical balance (Fig. 1.9) which is based on the **principle of levers**. The process of measurement is given below:

1. Level base of the balance using levelling screws until the plumb line is exactly above the pointed mark.
2. Turn the knob so that the pans of the balance are raised up. Is the beam horizontal and pointer at the centre of the scale? If not, turn the balancing screws on the beam so that it becomes horizontal.
3. Place the object to be weighed on the left pan.
4. Place the known weight from the weight box in the right pan using forceps.
5. Adjust the weight so that pointer remains on zero or oscillates equally on both sides of the zero of the scale.

Figure: 1.8

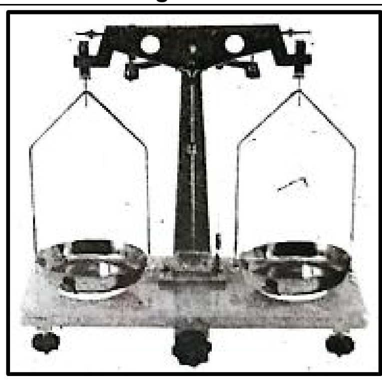


Figure 1.9

6. The total of standard masses (weights) is a measure of the mass of the object in the left pan.

TUTOR

The **principle of a lever** is that the product of the force and the distance from the fulcrum is the same for both the load and the effort.

For Your Information

The most precise balance is the digital electronic balance. It can measure mass of the order of 0.1 mg

1.7 Time Measuring Instruments

Q.14 Write a note on stopwatch and digital stopwatch.

Ans: Stopwatch:

A device by which the duration of time of an event is measured is called a stopwatch.

Parts of Mechanical Stopwatch:

A stopwatch contains two needles, one for seconds and other for minutes. The duration of time of an event is measured by a stopwatch (Fig. 1.10).

Leastcount of Mechanical Stopwatch:

The dial is divided usually into 30 big divisions each being further divided into 10 small divisions.

Each small division represents one tenth (1/10) of a second. Thus, one tenth of a second is the least count of this stopwatch.

Working of Mechanical Stopwatch:

While using, a knob present on the top of the device is pressed. This results in the starting of the watch. The same knob is again pushed to stop it. After noting the reading, the same knob is again pressed to bring back the needles to the zero position.

Digital Stopwatch:

Now-a-days, electronic/digital watches (Fig 1.11) are also available which can measure one hundredth part of a second.

Explanation:

The digital stopwatch is an electronic timepiece for tracking time. Especially, suitable for use in school science experiments, this stopwatch has a lartge 7-digit LCD display, easy operation with stop/start and split/reset buttons.

Fig: 1.10 Mechanical Stopwatch

Fig: 1.11 Digital Stopwatch

1.8 Volume Measuring Instruments

Q.15 Explain briefly Measurig Cylinder.

Ans: Measuring Cylinder:

Measurig Cylinder is a cylinder made of glass or **transparent** plastic with a scale divided in cubic centimetres (cm^3 or cc) or millilitres (mL) marked on it.

Uses of Measurig Cylinder:

Measurig cylinder is used to find the volume of liquids and non-dissolvable solids.

Caution: While taking a reading, keep your eye in front and in line with the lower meniscus of the water.

Do You Know?

Q. How Ancient Chinese estimate volume of grains?

Ans: Ancient Chinese used to estimate the volume of grains by sounding their containing vessels.

Q.16 How a displacement can method is used to measure the volume of a solid?

Ans: Displacement Can Method:

If the body does not fit into the measuring cylinder, then an overflow can or displacement can of wide opening is used (Fig. 1.13). Place the displacement can on the horizontal table. Pour water in it until it starts overflowing through its opening. Now, tie a piece of thread to the solid body and lower it gently into the displacement can.

TUTOR

A **displacement can** method also known as Archimedes priniciple, is a technique for measuring the amount of a fluid it displaces. A displacement can is tool used to perform this method.

The body displaces water which overflows through the side opening. The water or liquid is collected in a beaker and its volume is measured by the measuring cylinder. This is equal to the volume of solid body.

Do You Know?

Despite the use of SI in most countries, the old measure is still in use, such as printers type is measured in point. One point is 1/72 of an inch equivalent to 0.35 mm.

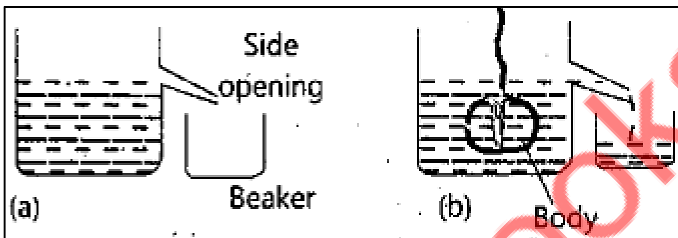
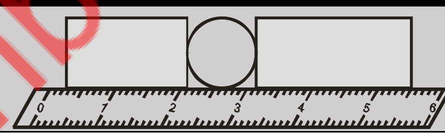


Fig: 1.13 Displacement can or Overflow can

Do You Know?

Despite the use of SI in most countries, the old measure is still in use, such as printers type is measured in point. One point is 1/72 of an inch equivalent to 0.35 mm.

Do You Know?



1.9 Errors in Measurement

Q.17 Identity and explain the reasons for human errors, random errors and systematic errors in experiments. **Ex Q.1.3**

Ans: Mesurements using tools and instruments are never perfect. They inherit some errors and differ from their true values. The best we shall do is to ensure that the errors are as small as reasonably possible. A scientific measurement should indicate the estimated error in the measured values.

TUTOR

A erro may be defined as the difference between the measured and ther actual values.

Types of Errors:

Usually, there are three types of experimental errors affecting the measurements.

For Your Information

The symbol of the base units are universal independent of the language used in the written text.

(i) Human Errors (ii) Systematic Errors (iii) Random Errors

(i) Human Errors

Human Errors occur due to personal performance.

Limitations of Human Errors:

The limitations of the human perception are:

1. The inability to perfectly estimate the position of the pointer on a scale.
2. Personal errors can also arise due to faulty procedure to read the scale.
3. The correct measurement needs to line up your eye right in front of the level.
4. In timing experiments, the reaction time of an individual to start or stop clock also affects the measured value.

Way to reduce Human Errors:

Human error can be reduced by ensuring proper training, techniques and procedure to handle the instruments and avoiding environmental distraction or disturbance for proper focusing.

Best Way to reduce Human Errors:

The best way is to use automated or digital instruments to reduce the impact of human errors.

(ii) Systematic Errors

Systematic Errors refer to an effect that influences all measurements of particular measurements equally. It produces a consistence difference in reading.

Occurance of Systematic Errors:

Systematic Errors occur due to some definite rule. It may occur due to **zero error of instrument**, **poor calibration of instrument** or **incorrect marking**.

Way to reduce Systematic Errors:

The effect of systematic errors can be reduced by comparing the instrument with another which is known to be more accurate. Thus, a correction factor can be applied.

(iii) Random Errors

Random Errors are said to occur when repeated measurements of a quantity give different values under the same conditions.

Occurance of Random Errors:

Random Errors are due to some unknown causes which are unpredictable.

The experimenter have a little or no control over it. Random error arise due to sudden **fluctuation** or **variation** in the environmental conditions.

Environmental condition:

Changes in temperature, pressure, humidity, voltage, etc.

Way to reduce Random Errors:

The effect of random errors can be reduced by using several or multiple readings and then taking their average or mean value.

Example:

For the measuring time period of oscillating pendulum, the time of several oscillations, say 30 oscillations is noted and then mean or average value of one oscillation is determined.

Quick Quiz

Identify Personal, Systematic and Random errors:

1. **Your eye level may move a bit while reading the meniscus.**

Ans: Personal error

2. **Air current may cause the balance to fluctuate.**

Ans: Systematic error

3. **The balance may not be properly calibrated.**

Ans: Systematic error

4. **Some of the liquid may have evaporated while it is being measured.**

Ans: Random error

1.10 Uncertainty in a Measurement

Q.18 Explain uncertainty in a measurement.

Ans: Uncertainty in a Measurement:

There is no such thing as a perfect measurement. Whenever a physical quantity is measured except counting, there is inevitably some uncertainty about its determined value due to some instrument.

Reason of uncertainty:

Uncertainty in a measurement may be due to use of a number of reasons. One reason is the type of instrument being used.

As every measuring instrument is calibrated to a certain smallest division and this fact puts a limit to the degree of accuracy which can be achieved while measuring with it.

> **Uncertainty in Digital Instruments**
> Some modern measuring instruments have a digital scale. We usually estimate one digit beyond what is certain. With digital scale, this is reflected in fluctuation of the last digit.

Value of Uncertainty in a Measurement:

The value of uncertainty in a measurement is equal to the least count of that instrument.

Examples:

- Suppose that we want to measure the length of a straight line with the help of a metre rule calibrated in millimetres. Let the end point of the line lies between 10.3 cm and 10.4 cm marks. By convention, if the end of the line does not touch or cross the midpoint of the smallest division, the reading is confined to the previous division. In case the end of the line seems to be touching or have crossed the midpoint, the reading is extended to the next division. Thus, in this example, the maximum uncertainty is ± 0.05 cm. It is, infact, equivalent to an uncertainty of 0.1 cm equal to the least count of the instrument divided into two parts, half above and half below the recorded reading.
- The uncertainty in small length such as diamerter of a wire and short interval of time can be reduced to further by takin multiple readings and then finding average values.

For example, the average time of of one oscialltion of a sinople pendulum is usually found by measuring the time of one oscillation of a simple pendulum is usually found by measuring the time for thirty oscillations.

Uncertainty in a Value in Terms of Significant Figures:

The uncertainty or accuracy in the value of a measured quantity can be indicated conveniently by using significant figures.

1.11 Significant Figures

Q.19(a) Explain significant figures with suitable example.

(b) Write rules of significant figures in any data.

(a) Explain significant figures with suitable example.

Ans: Significant Figures:

In any measurement, the accurately known digits and the first doubtful digit are known as significant figures.

The significant figures or digits are the digits of a measurement which are reliably known.

Example:

Figure 1.14 shows a rod whose length is measured with a ruler. The measurement shows the length in between 4.6 cm and 4.7 cm. Since the length of the rod is slightly more than 4.6 cm but less than 4.7 cm, so the first student estimates it to be 4.6 cm whereas the second student takes it as 4.7 cm. So, the first student thinks that the edge is nearer to 6 mm mark whereas the second student considers the edge of the rod nearer to 7 mm mark. It is difficult to decide what is the true length.

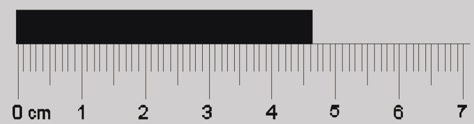


Figure 1.14

Explanation:

Both students agree on digit 4 but the next digit is doubtful which has been determined by estimation only and has a probability of error. Therefore, it is known as a doubtful digit.

We can count the number of candies in a jar and know it exactly by counting but we cannot measure the height of the jar exactly. All measurements include uncertainties depending upon the refinement of the instrument which is used for measurement.

It is important to reflect the degree of uncertainty in a measurement by recording the observation in significant figures.

Quick Quiz

Name some repetitive processes occuring in nature which could serve as reasonable time standard.

Ans:

1. Earth's Rotation 2. Earth's Revolution around the Sun
3. Lunar Phases 4. Tidal Cycles 5. Seasonal Cycles
6. Atomic Vibrations 7. Heart Beat 8. Eclipses
9. Planetary Alignments 10. Star Movements

(b) Write rules of significant figures in any data.

Ans: The following points are to be kept in mind while determining the number of significant figures in any data. All digits from 1 to 9 are significant. However, zeros may or may not be significant. In case of zeros, the following rules apply:

(a) A zero between two digits is considered significant. For example in 5.06 m, the number of significant figures are 3.

(b) Zeros on the left side of the measured value are not significant. For example, in 0.0034m, the number of significant figures are 2.

(c) Zeros on the right side of a decimal are considered significant. For example, in 2.40 mm the number of significant figures are 3.

(d) If numbers are recorded in scientific notation, then all the digits before the exponent are significant. For example, in 3.50×10^4m, the number of significant figures are 3.

Quick Quiz

How many significant figures are there in each of the following?

(a) 1.25×10^2 m (b) 12.5 cm (c) 0.125 m (d) 0.000125 km

Ans:

Figure	No. of Significant Figures	Reason
(a) 1.25×10^2 m	3	1,2 are accurately known and 5 Is first doubtful digit
(b) 12.5 cm	3	1,2 are accurately known and 5 Is first doubtful digit
(c) 0.125 m	3	0 before non-zero digit is not significant. 1,2 are accurately known and 5 Is first doubtful digit
(d) 0.000125 km	3	0's before non-zero digit are not significant. 1,2 are accurately known and 5 Is first doubtful digit

1.12 Precision and Accuracy

Q.19 Differentiate between Precision and Accuracy? Illustrate with examples. **Ex Q.1.5**

Ans: Precision:

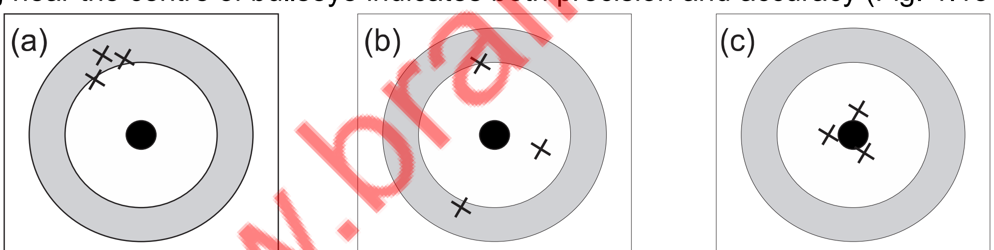
Precision of a measurement refers to how close together a group of measurements actually are to each other.

Accuracy:

Accuracy of a measurement refers how close the measured value is to some accepted or true value.

Illustrated Concept of Precision and Accuracy:

A classic illustration is helpful to distinguish the two concepts. Consider a target or bullseye hit by arrows in Fig 1.15. To be precise, arrows must hit near each other (Fig 1.15a) and to be accurate, arrows must hit near the bullseye(Fig. 1.15 b). Consistently hitting near the centre of bullseye indicates both precision and accuracy (Fig. 1.15 c).



Precise not accurate — Accurate not precise — Accurate and precise

Fig. 1.165

Explanation:

When these concepts are applied to measurements, the precision is determined by the instrument being used for measurement. The smaller the least count, the more precise is the measurement. A measurement is accurate if it correctly reflects the size of the object being measured. Accuracy depends on fractional uncertainty in the measurement.

> **TUTOR**
> **More Precise instrument**
> Micrometre screw gauge is more precise instrument as compare to vernier calipers because least count of micrometer screw gauge is 0.01 mm whereas least count vernier calipers is 0.1 mm.

Infact, it is relative measurement which is important. The smaller the size of physical quantity, the more precise instrument is needed to be used. The accuracy of measurement is reflected by the number of significant figures, the larger is the number of significant figures, the higher is the accuracy.

Q.20 Write uses and accuracy of different types of clocks/watches.

Ans:

Table 1.7 Some Timing Devices

Type of clock/watch	**Use and accuracy**
Atomic clock	Measures very short time intervals of about 10^{-10} seconds.
Digital stopwatch	Measures short time intervals (in minutes and seconds) to an accuracy to ±0.01 s.
Analogue stopwatch	Measures short time intervals (in minutes and seconds) to an accuracy to ±0.1 s.
Ticker-tape timer	Measures short time intervals of 0.02 s.
Watch/Clock	Measures longer time intervals in hours, minutes and seconds.
Pendulum clock	Measures longer time intervals in hours, minutes and seconds.
Radioactive decay clock	Measures (in years) the age of remains from thousands of years ago.

1.13 Rounded off the digits

Q.21 Write rules of rounding off the digits.

Ans: Rules of Rounding Off the Digits.

1. When rounding off numbers to a certain number of significant figures, do so to the nearest value. If the last digit is more than 5, the retained digit is increased by one and if it is less than 5, it is retained.

TUTOR

Rounding digits

Rounding means making a number simpler but keeping its value close to what it was?

Examples:

(i) Round to 2 significant figures: 2.512×10^3 m then result is 2.5×10^3 m.

(ii) Round to 3 significant figures: $3.4\,5\,67 \times 10^4$ kg then result is 3.46×10^4 kg.

2. For the integer 5, there is an arbitrary rule:

- If the number before the 5 is odd, one is added to the last digit retained.
- If the number before the 5 is even, it remains the same:

The justification for this is that in the course of a senses of many calculations, any rounding error will be averaged out.

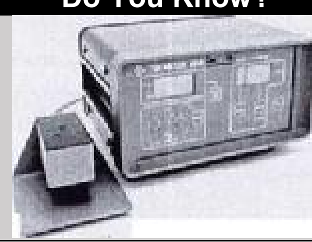
Examples:

(i) Round to 2 significant figures: 4.45×10^2 m then result is 4.4×10^2 m.

(ii) Round to 2 significant figures: 4.55×10^2 m then result is 4.6×10^2 m .

3. Sometimes, logic is applied to decide the fate of a digit. If we round to 2 significant figures

Do You Know?



4.452×10^2 m, the answer should be 4.5×10^2 m since 4.452×10^2 m is more closer to 4.5×10^2 m than 4.4×10^2 m.

An Electronic timer can measure time intervals as short as one-ten thousands (1/10,000) of a second.

KEY POINTS

- A **physical quantity** can be measured directly or indirectly using some instruments.
- **Non-physical** quantity is not measurable using an instrument. It qualitatively depends on the perception of the observer and estimated only.
- **Base quantities** are length, mass, time, temperature, electric current, etc.
- **Derived quantities** are all those quantities which can be defined with reference to base quantities. For example, speed, area, volume, etc.
- **Standard unit** does not vary from person to person and understood by all the scientists.
- **Base units** of system international are: metre, kilogram, second, ampere, candela, kelvin and mole.
- The units which can be expressed in terms of base units are called **derived units**.
- **Scientific notation** is an internationally accepted way of writing numbers in which numbers are recorded using the powers of ten or prefixes and there is only one non-zero digit before the decimal.
- **Least count** is the least measurement recorded by an instrument.
- **Vernier Callipers** is an instrument which can measure length correct upto 0.1 mm.
- **Screw guage** is an instrument which can measure length correct upto 0.01 mm.
- Measurements using instruments are not perfect. There are inevitable errors in the measured values, may be due to **human errors**, **systematic errors** and **random errors**.
- Measurements using instruments errors are uncertain to some extent depending upon the limitations or refinement of the instrument.
- **Significant figures** are the accurately known digits and first doubtful digit in any measurement.
- The **precision** is detemined by the instrument being used for measurement whereas the **accuracy** depends on relative measurement reflected by the number of significant figures.

IMPORTANT FORMULAE

Instrument	Range	Least count
Measuring Tape	1 cm to several metres	1 mm
Metre rule	1 mm to 1 m	1 mm
Vernier Callipers	0.1 mm to 15 cm	0.1 mm
Micrometer Screw Gauge	0.01 mm to 2.5 cm	0.01 mm

Formula to find the Lesastconut (L.C)

Least count of Vernier Callipers	= 1 M.S div – 1 V.S div
Least count of Micrometer Screw Gauge	$= \frac{\textit{Pitch of the screw gauge}}{\textit{No. of division on the circular scale}}$

SOLVED EXAMPLES

Example 1.1

Solve the following:

(a) **5.123×10^4 m + 3.28×10^5 m** **(b)** **2.57×10^{-2} mm - 3.43×10^{-3} mm** **(1.4)**

Solution:

(a) 5.123×10^4 m + 3.28×10^5 m = 5.123×10^4 m + 32.8×10^4 m
= $(5.123 + 32.8) \times 10^4$ m = 37.923×10^4 m = 3.7923×10^5 m

(b) 2.57×10^{-2} mm – 3.43×10^{-3} mm = 2.57×10^{-2} mm – 0.343×10^{-2} mm
= $(2.57 - 0.343) \times 10^{-2}$ mm = 2.227×10^{-2} mm
= $2.227 \times 10^{-2} \times 10^{-3}$ m = 2.227×10^{-5} m

Example 1.2

Find the value of each of the following quantities: **(1.4)**

(a) **$(4\times10^3$ kg$)(6\times10^6$ m$)$** **(b)** $\dfrac{6\times10^6 m^3}{2\times10^{-2} m^2}$

Solution:

(a) $(4\times10^3$ kg$)(6\times10^6$ m$)$ = $(4\times6)\times10^{3+6}$ kg m
= 24×10^9 kg m = 2.4×10^{10} kg m

(b) $$\frac{6\times10^6 m^3}{2\times10^{-2} m^2} = \frac{6}{2}\times10^{6-(-2)} m^{3-2} = 3\times10^8 m$$

EXERCISE

A Multiple Choice Questions

1. Tick (✓) the correct answer.

1.1 The instrument that is most suitable for measuring the thickness of a few sheets of cardboard is a: **(1.5)**

(a) metre rule (b) measuring tape
(c) Vernier Callipers (d) micrometer screw gauge ✓

1.2 One femtometre is equal to: **(1.3)**

(a) 10^{-9} m (b) 10^{-15} m ✓ (c) 10^9 m (d) 10^{15} m

1.3 A light year is a unit of: **(1.2)**

(a) light (b) time (c) distance ✓ (d) speed

1.4 Which one is a non-physical quantity? **(1.1)**

(a) distance (b) density (c) colour ✓ (d) temperature

1.5 When using a measuring cylinder, one precaution to take is to: **(1.8)**

(a) check for the zero error
(b) look at the meniscus from below the level of the water surface ✓
(c) take several readings by looking from more than one direction
(d) position the eye in line with the bottom of the meniscus

1.6 Volume of water consumed by you per day is estimated in: **(1.8)**

(a) millilitre (b) litre✓ (c) kilogram (d) cubic metre

1.7 A displacement can is used to measure: (1.8)

(a) mass of a liquid (b) mass of a solid
(c) volume of a liquid (d) volume of a solid ✓

1.8 Two rods with lengths 12.321 cm and 10.3 cm are placed side by side, the difference in their lengths is: (1.11)

(a) 2.02 cm (b) 2.0 cm ✓ (c) 2 cm (d) 2.021 cm

1.9 Four students measure the diameter of a cylinder with Vernier Callipers. Which of the following readings is correct? (1.5)

(a) 3.4 cm (b) 3.475 cm (c) 3.47 cm✓ (d) 3.5 cm

1.10 Which of the following measures are likely to represent the thickness of a sheet of this book? (1.5)

(a) 6×10^{-25} m (b) 1×10^{-4} m✓ (c) 1.2×10^{-15} m (d) 4×10^{-2} m

1.11 In a Vernier Callipers ten smallest divisions of the Vernier scale are equal to nine smallest divisions of the main scale. If the smallest division of the main scale is half millimetre, the Vernier constant is equal to: (1.5)

(a) 0.5 mm ✓ (b) 0.1 mm (c) 0.05 mm (d) 0.001 mm

B Short Answer Questions

1.1. Can a non-physical quantity be measured? If yes, then how? (1.1)

Ans: No,a non-physical quantity can be measurement but can described by other ways. **Explanation:** A non-physical quanitity cannot be measured using tools and instruments. They often pertain to the perception or interpretation of the observer. They can be described or qualitatively or compared using some perdetermined criteria, indices or through survey techniques.

1.2. What is measurement? Name its two parts. (1.2)

Ans: **Measurement:** A mesurement is a physical quantity having number and a unit.

Parts of a measurement: A measurement consists of two parts, **a number** and **a unit**. A measurement without unit is meaningless.

1.3. Why do we need a standard unit for measurements? (1.3)

Ans: We need a standard unit for measurements because:

i) In the early days, people used to measure length using hand or arm, foot or steps. This measurement may result in confusion as the measurement of different people may differ from each other because of different sizes of their hands, arms or steps.

ii) For scientist, problems were faced when people of different countries exchanged scientific information or traded with other countries using different units. Not very far in the past, every country in the world had its own units of measurements.

1.4. Write the name of 3 base quantities and 3 derived quantities. (1.2)

Ans: **Base Quantites:**

i) Length ii) Mass iii) Time iv) Temperature

Derived Quantities:

i) Area ii) Volume iii) Speed iv) Force

1.5. Which SI unit will you use to express the height of your desk? (1.3)

Ans: In SI unit, we will use to express the height of our desk is metre (m).

1.6. Write the name and symbols of all SI base units. (1.3)

Ans:

Sr.#	Physical Base quantity	Base Unit	Symbol
1.	Length	metre	m
2.	Mass	kilogram	kg
3.	Time	second	s
4.	Temperature	kelvin	k
5.	Electric current	ampere	a
6.	Intensity of light	candela	cd
7.	Amount of substance	mole	mol

1.7. Why prefix is used? Name three sub-multiples and three multiple prefixes with their symbols. (1.3)

Ans: Prefixes are used to change units by powers of 10.

Sub-Multiples of Length			Multiples of Mass		
1 milli metre	1 mm	10^{-3} m	1 kilogram	1 kg	10^{3} m
1 centi metre	1 cm	10^{-2} m	1 mega gram	1 Mg	10^{6} m
1 micro metre	1 μm	10^{3} m	1 Giga gram	1 Gg	10^{9} m

1.8. What is meant by?

(a) 5 pm (b) 15 ns (c) 6 μm (d) 5 fs (1.3)

Ans: **(a) 5 pm:** 5 pm means 5 pico metre, it is length i.e., 5×10^{-12} m.

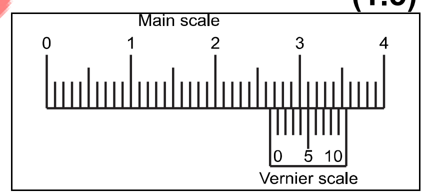
(b) 15 ns: 15 ns means 15 nano seconds, it is time i.e., 15×10^{-9} s.

(c) 6 μm: 6 μm means 6 micro metre, it is length i.e., 6×10^{-6} m.

(d) 5 fs: 5 fs means 5 femto seconds, it is time i.e., 5×10^{-15} s.

1.9(a) For what purpose a Vernier Callipers is used? (1.5)

Ans: Vernier Callipers is an instrument used to measure small lengths down to 1/10th of a millimetre. It can be used to measure the thickness, diameter, width or depth of an object.



(b) Name its two main parts.

Ans: Vernier Callipers has two parts:

(i) Main scale (ii) Vernier scale

(c) How is least count found?

Ans: The least count is found by dividing the length of one small division on main scale by the total number of divisions on the Vernier scale. Mathematically,

Least Count of Verniers Callipers $= \dfrac{smallest\ reding\ on\ main\ scale}{no. of\ divisions\ on\ vernier\ scale}$

$$= \frac{1\,mm}{10\,divisions} = 0.1\,mm = 0.01\,cm$$

Least count of a Vernier Callipers is the difference between one main scale division (M.S) and one Vernier scale (V.S) division.

Least count = 1 M.S div – 1 V.S div = 1 mm – 0.9 mm = 0.1 mm

So, the least count of vernier callipers is 0.1 mm or 0.01 cm.

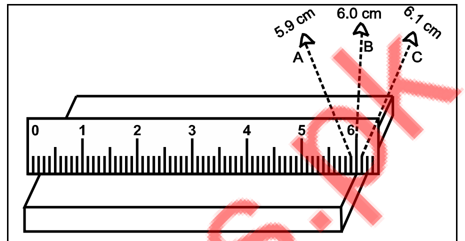
(d) What is meant by zero error?

Ans: Zero Error: Zerro error is a type of error in which an instrument gives a reading when the true reading at that time is zero.

Definition: Any error in the measuring instrument that can effect the reading is called zero error.

Explanation: If on joining the jaws A and B, the zeros of the main scale and Vernier scale do not exactly coincide with each other then there is an error in the instrument called zero error.

1.10. State least count and Vernier scale reading as shown in the figure and hence, find the length. (1.5)



Ans: Least Count of Vernier Callipers:

Least count of a Vernier Callipers is the difference between one main scale division (M.S) and one Vernier scale (V.S) division.

Hence,

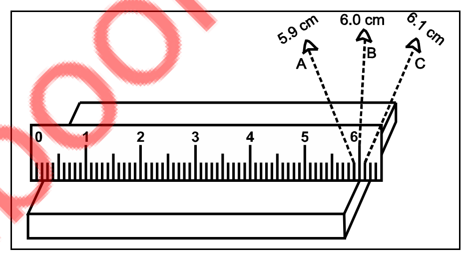
Least count = 1 M.S div − 1 V.S div

= 1 mm − 0.9 mm = 0.1 mm

Vernier scale reading:

The correct vernier scale reading of given figure is 6.0 cm.

1.11. Which reading out of A, B and C shows the correct length and why? (1.5)



Ans: In the figure, three readings are taken which of them, reading B (6.0 cm) is correct length because eye shall be kept in level vernier scale and zero error is zero.

C Constructed Response Questions

1.1. In what unit will you express each of the following? (1.3)

(a) Thickness of a five-rupee coin:
(b) Length of a book:
(c) Length of football field:
(d) The distance between two cities:
(e) Mass of five-rupee coin:
(f) Mass of your school bag:
(g) Duration of your class period:
(h) Volume of petrol filled in the tank of a car:
(i) Time to boil one litre milk:

Ans:

(a)	**Thickness of a five-rupee coin:**	millimetre (mm)
(b)	**Length of a book:**	inches (inch)
(c)	**Length of football field:**	metre (m)
(d)	**The distance between two cities:**	kilometre (km)
(e)	**Mass of five-rupee coin:**	gram (g)

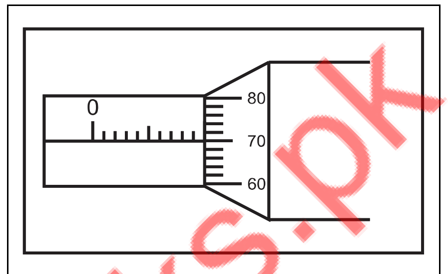
(f)	**Mass of your school bag:**	kiogram (kg)
(g)	**Duration of your class period:**	minutes (min)
(h)	**Volume of petrol filled in the tank of a car:**	litre (L)
(i)	**Time to boil one litre milk:**	minutes (min)

1.2. Why might a standard system of measurement be helpful to a tailor? (1.3)

Ans: A standard system of measurement can be helpful to a tailor because it can improve **efficiency** and **reduce errors** in garment sizes.

Explantion: Tailoring requires precise measurements to ensure a good fit. A standard system allows tailors to accurately measure body dimensions, reducing errors and the need for extensive alteration.

1.3. The minimum main scale reading of a micrometer screw gauge is 1 mm and there are 100 divisions on the circular scale. When thimble is rotated once, 1 mm is its measurement on the main scale. What is the least count of the instrument? The reading for thickness of a steel rod as shown in the figure. What is the thickness of the rod?



(1.5)

Ans:

a) The least count of given micrometer screw gauge is 1 mm.

b) Reading on main scale is 9 mm.
Reading on circular scale is 70.
Therefore, the thickness of the rod given in figure is:

Thickness of the rod $= 9mm + \frac{70}{100}mm = 9 + 0.70\,mm = 9.70\,mm$

1.4. You are provided a metre scale and a bundle of pencils; how can the diameter of a pencil be measured using the metre scale with the same precision as that of Vernier Callipers? Describe briefly. (1.5)

Ans: To measure the diameter of a pencil using a metre scale with the same precision as Vernier Callipers.

(i) Arrange Multiple Pencils: Line up several identical pencils tightly in a row.

(ii) Measure Total Length: Use the metre scale to measure the total length L of all pencils.

(iii) Count the Pencils: Note the total number of pencils n

(iv) Calculate Diameter: Divide the total length L by the number of pencils n.

Distance $= \frac{L}{n}$

This method averages out errors, improving precision.

1.5. The end of a metre scale is worn out. Where will you place a pencil to find the length? (1.5)

Ans: If the end of a metre scale is worn out, you should avoid using it as a reference point. Instead:

(i) **Place the Pencil at a Mark:** Align one end of the pencil with a clear marking, such as the 1 cm or 10 cm mark on the scale.

(ii) **Measure the Other End:** Note the reading at the other end of the pencil.

(iii) **Subtract:** Subtract the starting mark from the final reading to find the length of the pencil.

Length of the pencil = Final reading − Starting reading

Example: If one end of the pencil is at the 10 cm mark and the other end is at the 18 cm mark, the length of thhe pencil would be 18 cm – 10 cm = 8 cm.

This method avoids errors caused by the worn-out end.

1.6. Why is it better to place the object close to the metre scale? (1.5)

Ans: It is better to place the object close to the metre scale for the following reasons:

(i) Minimizing Parallax Error (ii) More Accurate Measurement
(iii) Using the Unworn Sections (iv) Improved Precision

1.7. Why a standard unit is needed to measure a quantity correctly? (1.3)

Ans: A standard unit is needed to measure quantities accurately because it ensures consistency, avoids ambiguity, allows for comparability, and enables clear communication. It provides a reliable reference for precise measurements, essential for science, technology, and everyday use.

1.8. Suggests some natural phenomena that could serve as a reasonably accurate time standard. (1.11)

Ans: Natural phenomena that can serve as accurate time standards include:

i) Earth's Rotation (Day): The 24-hour cycle of Earth's rotation.

ii) Earth's Orbit (Year): The 365.25-day orbit around the Sun.

iii) Pendulum Oscillation: The consistent swinging of a pendulum.

iv) Atomic Transitions: The vibrations of atoms like cesium for precise time keeping.

v) Moon's Phases: The 29.5 day lunar cycle.

These provide reliable and repeatable time intervals.

1.9. It is difficult to locate the meniscus in a wider vessel. Why? (1.8)

Ans: In wider vessels, the meniscus is harder to locate due to the reduced curvature of the liquid's surface, making it flatter. This reduces the noticeable effect of surface tension, and the wider surface increases the risk of parallax errors.

1.10. Which instrument can be used to measure: (1.5)

(i) Internal diameter of a test tube. (ii) Depth of a beaker.

Ans:

(i) A Vernier Callipers can be used to measure the internal diameter of a test tube because it has a **vernier scale**.

(ii) Vernier Callipers can be used to measure the depth of a beaker because it has a **vernier scale**.

D Comprehensive Questions

1.1. What is meant by base and derived quantities? Give the names and symbols of SI base units. (1.3)

Ans: For Answer, See Question # 3(b) and 6(a)

1.2. Give three examples of derived unit in SI. How are they derived from base units? Describe briefly. (1.3)

Ans: Derived Units:

The units which can be expressed in terms of base units are called derived units.

Examples of derived units:

(i) Area = length × breadth
= metre × metre = square metre = metre^2 or m^2

(ii) Speed = Distance/Time = metre/second = ms^{-1}

(iii) Electric charge = Current / Time
= Ampere / second = As^{-1} = Coulomb = C

1.3. State the similarities and differences between Vernier Callipers and Micrometer Screw Gauge. (1.5)

Ans: Similarities between Vernier Callipers and Micrometer Screw Gauge:

i) Both Vernier Callipers and micrometer screw gauge measure the length measuring instruments.

ii) Both Vernier Callipers and micrometer screw gauge are used for small objects.

iii) Both Vernier Callipers and micrometer screw gauge are used for linear measurements such as the length, width, or thickness of small objects.

Difference between Vernier Callipers and micrometre screw gauge:

i) The least count of a Verniers Callipers is 0.1 mm while least count of a Micrometer Screw Gauge is 0.01 mm.

ii) Vernier Callipers consists of a main scale and vernier scale while Micrometer Screw Gauge consists of circular scale, spindle, anvil and screw.

iii) Measuring range of Vernier Callipers is 0.1 mm to 15 mm, while measuring range of micrometer screw gauge is 0.01 mm to 2.5 cm.

1.4. Identity and explain the reasons for human errors, random errors and systematic errors in experiments. (1.9)

Ans: For Answer, See Question # 17

1.5. Differentiate between precision and accuracy of a measurement with examples. (1.12)

Ans: For Answer, See Question # 19

E Numerical Problems

1.1 Calculate the number of seconds in a (a) day (b) week (c) month and state your answers using SI prefixes. (86.4 ks, 604.8 ks, 2.592 Ms) (1.3)

Solution: Calculations:

a) Number of seconds in a day:

As, we know that

1 day = 24 hours

1 hour = 60 min

1 min = 60 sec

= 7 × 24 × 60 × 60s = 60,4800 s

In terms of Prefixes:

= 604.8 × 10^3 s

= 604.8 ks $\left(\because 1k = 10^3\right)$

So, number of seconds in a day

$= 24 \times 60 \times 60$ s = 86,400 s

In terms of Prefixes:

$= 86.4 \times 10^3$ s

$= 86.4$ ks $\quad (\because 1\text{k} = 10^3)$

b) Number of seconds in a week:

Since, 1 week = 7 days

So, Number of seconds in a week

c) Number of seconds in a month:

Since, 1 month = 30 days

So, Number of seconds in a month

$= 30 \times 24 \times 60 \times 60$ s

= 2,592,000 s

In terms of Prefixes:

$= 2.592 \times 10^6$ s

$= 2.592$ Ms $\quad (\because 1\text{M} = 10^6)$

1.2 State the answers of problem 1.1 in scientific notation. (1.4)

(8.64×10^4 s, 6.048×10^5 s, 2.592×10^6 s)

Solution: Calculations:

a) Number of seconds in a day:

As, we know that

1 day = 24 hours

1 hour = 60 min

1 min = 60 sec

Number of seconds in a day

$= 24 \times 60 \times 60$ s = 86,400 s

In terms of Scientific Notation:

$= 8.64 \times 10^4$ s

b) Number of seconds in a week

$= 7 \times 24 \times 60 \times 60$ s = 60,4800 s

In terms of Scientific Notation:

$= 6.048 \times 10^5$ s

c) Number of seconds in a year

Since, 1 month = 30 days

So, Number of seconds in a month

$= 30 \times 24 \times 60 \times 60$ s

$= 30 \times 24 \times 60 \times 60$ s

= 2,592,000 s

In terms of Scientific Notation:

$= 2.592 \times 10^6$ s

1.3 Solve the following addition or subtraction. State your answers in scientific notation. (1.4)

(a) 4×10^{-4} kg + 3×10^{-5} kg (b) 5.4×10^{-6} m – 3.2×10^{-5} m

[(a)4.3×10^{-4} kg (b) – 2.66×10^{-5} m]

Solution: Calculations:

(a) 4×10^{-4} kg + 3×10^{-5} kg:

To add the term, both term should be in same power of 10, i.e., greater power from the given terms

4×10^{-4} kg + 3×10^{-5} kg

$= 4\times10^{-4}$ kg + 0.3×10^{-4} kg

$= (4+0.3)\times10^{-4}$ kg = 4.3×10^{-4} kg

(b) 5.4×10^{-6} m – 3.2×10^{-5} m:

To add the term, both term should be in same power of 10, i.e., greater power from the given terms

5.4×10^{-6} m – 3.2×10^{-5} m

$= 0.54\times10^{-5}$ m – 3.2×10^{-5} m

$= (0.54–3.2)\times10^{-5}$ m=$–2.66\times10^{-5}$ m

1.4 Solve the following multiplication or division. State your answers in scientific notation. (1.4)

(a) (5×10^4 m) × (3×10^{-2} m) (b) $\dfrac{6\times10^8\,kg}{3\times10^4\,m^3}$

[(a) 1.5×10^3 m^2 (b) 2.0×10^4 kg m^{-3}]

Solution: Calculations:

(a) (5×10^4 m) × (3×10^{-2} m):

$= (5\times3) \times (10^4\text{ m}\times10^{-2}\text{ m})$

$= 15 \times 10^{4-2}\text{ m}^2 = 15 \times 10^2\text{ m}^2$

(b) $\dfrac{6\times10^8\,kg}{3\times10^4\,m^3}$:

$= 1.5 \times 10^1 \times 10^2\ m^2$
$= 1.5 \times 10^{1+2}\ m^2$
$= 1.5 \times 10^3\ m^2$

$$\frac{6\times10^8 kg}{3\times10^4 m^3} = \frac{6}{3}\times10^8\times10^{-4} kgm^{-3}$$
$= 2\times10^{8-4}\ kgm^{-3} = 2\times10^4\ kgm^{-3}$

1.5 Calculate the following and state your answer in scientific notation. (1.4)

$$\frac{(3\times10^2 kg)(4.0 km)}{5\times10^2 s^2}$$

(2.4×10^3 kg m s^{-2})

Solution: Calculations:

$$\frac{(3\times10^2 kg)(4.0 km)}{5\times10^2 s^2} = \frac{(3\times10^2 kg)(4.0\times10^3 m)}{5\times10^2 s^2} \qquad (\because\ 1k = 10^3)$$
$$= \frac{3\times4.0\times10^3 kgm\times10^2}{5 s^2} = \frac{12.0\times10^3}{5} kgms^{-2}$$
$$= 2.4\times10^3 kgms^{-2}$$

1.6 State the number of significant digits in each measurement. (1.11)

(a) 0.0045 m (b) 2.047 m (c) 3.40 m (d) 3.420×10^4 m

[(a) 2 (b) 4 (c) 3 (d) 4]

Solution: Calculations:

(a) 0.0045 m:

In 0.0045 m, zero before first non-zero digits are not significant. Therefore, there are only two (2) significant digits "4" and "5".

(b) 2.047 m:

In 2.047 m, all digits are significant. As, zero between two non-zero digits is sigficant. Therefore, there are 4 significant digits.

(c) 3.40 m:

In 3.40 m, all digits are significant. It is before "3" and "4" are known digits whereas "0" is first doubtful digit. Therefore, there are 3 significant digits.

(d) 3.420×10^4 m:

In 3.420×10^4 m, all digits are significant. It is before "3" , "4" and "2" are known digits whereas "0" is first doubtful digit. Therefore, there are 4 significant digits.

1.7 Write in scientific notation: (1.4)

(a) 0.0035 m (b) 206.4×10^2 m [(a) 3.5×10^{-3} m, (b) 2.064×10^4 m)]

Solution: Calculations:

(a) 0.0035 m:

To write a measurement in significant notation, shift the decimal place to first non-zero digit.

$0.0035\ m = 3.5 \times 10^{-3}\ m$

(b) 206.4×10^2 m

To write a measurement in significant notation, shift the decimal place to first non-zero digit.

$206.4\times10^2\ m = 2.064\times10^2\times10^2\ m$
$= 2.064\times10^{2+2}\ m = 2.064\times10^4\ m$

1.8 Write using correct prefixes: (1.3)

(a) 5.0×10^4 cm (b) 580×10^2 g (c) 45×10^{-4} s

[(0.5 km, 58 kg, 4.5 ms)]

Solution: Calculations:

(a) 5.0×10^4 cm:

5.0×10^4 cm

$= 5.0\times10^4\times10^{-2}$m $\left(\because 1cm = 10^{-2}m\right)$

$= 5.0\times10^{4-2}$ m $= 5.0\times10^2$ m

The nearest prefix is 10^3 = 1 k

$= 5\times10^{-1}\times10^2\times10^1$ m

$= 5\times10^{-1}\times10^{2+1}$ m

$= 0.5\times10^3$m = 0.5 km

(b) 580×10^2 g:

580×10^2 g $= 5.80\times10^2\times10^2$ g

$= 5.80\times10^{2+2}$ g $= 5.80\times10^4$ g

The nearest prefix is 10^3 = 1 k

$= 5.80\times10^1\times10^3$ g

= 58 kg

(c) 45×10^{-4} s:

45×10^{-4} s $= 45\times10^{-1}\times10^{-3}$ s

$= 4.5\times10^{-3}$ s

The nearest prefix is 10^{-3} s = 1 ms

= 4.5 ms

1.9 Light year is a unit of distance used in Astronomy. It is the distance covered by light in one year. Taking the speed of light as 3.0×10^8 ms^{-1}, calculate the distance. (1.3)

(9.46×10^{15} m)

Solution: Given Data:

Time = t = 1 year

$= 365\times24\times60\times60$ s

= 31,536,000 s

$= 3.1536\times10^7$ s

Speed = v = 3.0×10^8 ms^{-1}

To Find:

Distance = S = ?

Calculations:

As, we know that

$S = v\times t = (3.0\times10^8 \text{ ms}^{-1})\times(3.1536\times10^7 \text{ s})$

$= (3.0\times3.1536)\times10^{8+7}$ s

$= 9.4608\times10^{15}$ m

$S = 9.46\times10^{15}$ m

1.10 Express the density of mercury given as 13.6 g cm^{-3} in kg m^{-3}. (1.4)

(1.36×10^4 kg m^{-3})

Solution: Given Data:

Density = 13.6 gcm^{-3}

To Find:

Density in kgm^{-3}

Calculations:

Density = 13.6 gcm^{-3}

= 13.6 (g)(cm)$^{-3}$

Put g = 10^{-3} kg, 1 cm = 10^{-2} m

$= 13.6\ (10^{-3}\text{ kg})(10^{-2}\text{ m})^{-3}$

$= 13.6\ (10^{-3}\text{ kg})(10^{6}\text{ m}^{-3})$

$= 13.6\times10^{6-3}$ kgm^{-3}

$= 13.6\times10^3$ kgm^{-3}

$= 1.36\times10^1\times10^3$ kgm^{-3}

$= 1.36\times10^{1+3}$ kgm^{-3}

$= 1.36\times10^4$ kgm^{-3}

QUESTION BANK

General MCQs with Conceptual Questions (CQs)

1.1 Physical and Non-Physical Quantities

1. **Which of the following quantities is not physical quantity?** **(CQs)**
   (A) Temperature (B) Wisdom ✓ (C) Length (D) Time
2. **Quantites which can measured directly and indirectly are called:** **(CQs)**
   (A) Physical quantites ✓ (B) Non-physical quantity
   (C) Bsae quantities (D) Derived quantites
3. **Love is a quantity:**
   (A) Physical quantity ✓ (B) Base quantity
   (C) Non-physical quantity (D) Derived quantites
4. **Which of the following quantity is not non-physical quantity?** **(CQs)**
   (A) Affection (B) Fear (C) Beauty (D) Volume ✓
5. **Density is a quantity.**
   (A) Physical quantity (B) Base quantity
   (C) Non-phyiscal quantity ✓ (D) Non-measured quantity

1.2 Base and Derived Physical Quantities

6. **Which of the following quantities is base quantity?** **(CQs)**
   (A) Length ✓ (B) Speed (C) Density (D) Volume
7. **Which is the following quantity is not base quantity?** **(CQs)**
   (A) Mass (B) Temperature (C) Speed ✓ (D) Time
8. **A measurement consist of _____ parts.**
   (A) One (B) Two ✓ (C) Three (D) Four
9. **Which of the following quantity is not derived quantity?**
   (A) Speed (B) Volume (C) Temperature ✓ (D) Force
10. **All the quantities which can be described in terms of one or more base quantites are called:**
    (A) Non-physical quantites (B) Derived quantites ✓
    (C) Base physical quantities (D) Standard physical quantities
11. **Identify the derived physical quantity:**
    (A) Electric current (B) Intensity of light
    (C) Amount of substance (D) Electric charge ✓
12. **Identify the base physical quantity:**
    (A) Area (B) Pressure (C) Mass ✓ (D) Force
13. **How many base quantities are in SI?**
    (A) Three (B) Five (C) Seven ✓ (D) Nine

1.3 International System of Units

14. **Number of base units in SI are:**
    (A) Nine (B) Seven ✓ (C) Five (D) Three
15. **Which is not a base unit in SI units?** **(CQs)**
    (A) Kilogram (B) Ampere (C) Kelvin (D) Joule ✓

16. Pascal is SI unit of:
(A) Force (B) Tension (C) Pressure ✓ (D) Speed

17. Kilogram is:
(A) Basic unit ✓ (B) Basic quantity
(C) Derived unit (D) Derived quantity

18. One metre is equal to:
(A) 10 cm (B) 100 cm ✓ (C) 1000 cm (D) 100 mm

19. One litre is equal to ______ mililiter.
(A) 10^2 (B) 10^3 ✓ (C) 10^4 (D) 10^5

20. 5 liter is equal to:
(A) 5×10^{-3} m^3 (B) 5×10^3 m^3 (C) 5×10^3 cm^{-3} (D) 5×10^3 cm^3 ✓

21. SI unit of electric current is:
(A) Second (B) Ampere ✓ (C) Mole (D) Meter

22. The unit of volume is:
(A) Meter (B) Force (C) Cubic meter ✓ (D) Second

23. The derived unit is:
(A) Ampere (B) Pascal ✓ (C) Candela (D) Kelvin

24. One giga is equal to:
(A) 10^3 (B) 10^6 (C) 10^9 (D) 10^{12} ✓

25. One pico metre is equal to:
(A) 10^{12} m (B) 10^{-12} m ✓ (C) 10^6 m (D) 10^{-6} m

26. One femto is equal to:
(A) 10^{-12} (B) 10^{12} (C) 10^{-15} ✓ (D) 10^{15}

27. One tera is equal to:
(A) 10^{-12} (B) 10^{-18} (C) 10^{12} ✓ (D) 10^{18}

28. 3.3 GHz is equal to:
(A) 3300×10^6 Hz ✓ (B) 3.300×10^6 Hz
(C) 3300×10^9 Hz (D) 3.300×10^{15} Hz

29. 0.00002 g is equal to how many micrograms? (CQs)
(A) 2.0 µg (B) 0.2 µg (C) 20 µg ✓ (D) 200 µg

30. One megameter is equal to:
(A) 10^6 m ✓ (B) 10^3 m (C) 10^9 m (D) 10^{12}

31. One peta is equal to:
(A) 10^{16} (B) 10^{15} ✓ (C) 10^{12} (D) 10^9

32. Which of the following is least multiple? (CQs)
(A) Pico (B) Femto (C) Nano (D) Atto ✓

33. How many nanometers in a meter?
(A) 10^{12} (B) 10^9 ✓ (C) 10^6 (D) 10^3

1.4 Scientific Notation

34. Scientific notation of 0.00534 m is:
(A) 5.34×10^3 m (B) 5.34×10^3 m (C) 5.34×10^{-3} m ✓ (D) 5.34×10^{-3} m

35. Scientific notation of 0.000,000,000,052 is:
(A) 5.2×10^{-11} m ✓ (B) 5.2×10^{11} m (C) 5.2×10^{-10} m (D) 5.2×10^{10} m

36. Scientific notation of 138,000,000 km is:
(A) 138×10^{6} km (B) 138×10^{-6} km (C) 1.38×10^{8} km ✓ (D) 1.38×10^{-8} km

37. Which of the following base unit has a prefix? (CQs)
(A) Meter (B) Second (C) Ampere (D) Kilogram ✓

38. What is the diameter of hydrogen atom?
(A) 5.2×10^{-11} m ✓ (B) 5.2×10^{-12} m (C) 5.2×10^{-13} m (D) 5.2×10^{-14} m

39. Average distance from the Sun to the Earth is:
(A) 1.38×10^{-8} km (B) 1.38×10^{8} km ✓ (C) 1.38×10^{-8} m (D) 1.38×10^{8} m

40. Scientific notation of 0.004 kg is:
(A) 4.0×10^{3} kg (B) 4.0×10^{5} kg (C) 4.0×10^{-3} kg ✓ (D) 4.0×10^{-5} kg

1.5 Length Measuring Instruments

41. Least count of meter rod is:
(A) 1 mm ✓ (B) 0.1 mm (C) 0.01 mm (D) 1 cm

42. What is the diameter of pencil? (CQs)
(A) 1.0×10^{-4} m (B) 1.8×10^{0} m (C) 9.1×10^{1} m (D) 7.0×10^{-3} m ✓

43. Length of the man in meter is:
(A) 9.1×10^{1} m (B) 1.0×10^{-4} m (C) 1.8×10^{0} m ✓ (D) 1.8×10^{1} m

44. The least count of Vernier Callipers is:
(A) 0.01 m (B) 0.01 mm (C) 0.001 cm (D) 0.01 cm ✓

45. How many divisions are in vernier scale of Vernier Callipers? (CQs)
(A) 10 ✓ (B) 20 (C) 40 (D) 50

46. The least count of digital Vernier Callipers is:
(A) 0.1 mm (B) 0.01 mm (C) 0.001 mm (D) 0.0001 mm ✓

47. Vernier calipers was invented by a _____ scientist.
(A) Arabic (B) English (C) French ✓ (D) Pakistani

48. Vernier calipers was invented in _____ year.
(A) 1631 ✓ (B) 1731 (C) 1831 (D) 1931

49. Vernier callipers was inverted by:
(A) Pierre screw (B) Pierre Vernier ✓ (C) Paul Vernier (D) Carl Vernier

50. Least count of screw guage is:
(A) 1 cm (B) 0.001 m (C) 0.01 mm ✓ (D) 1 mm

51. What is the range of Vernier Callipers? (CQs)
(A) 0.01 mm to 15 cm (B) 0.1 mm to 15 cm ✓
(C) 1 mm to 19 cm (D) 1 mm to 25 cm

52. Range of micrometer screw gauge is:
(A) 0.01 mm to 2.5 cm (B) 0.1 mm to 15 cm ✓
(C) 0.01 mm to 2.5 cm (D) 0.1 mm to 2.5 cm

53. Which of the following is the range of metre rule?
(A) 1 cm to 1 m (B) 1 mm to 1 m ✓
(C) 0.01 cm to 1 m (D) 0.1 mm to 1 m

1.6 Mass Measuring Instruments

54. Weight of a body can be measured by:
(A) Spring balance ✓ (B) Beam balance
(C) Lever balance (D) Physical balance

55. The most sensitive balance for measuring mass of lighter object is:
(A) Beam balance (B) Lever balance
(C) Electronic balance ✓ (D) Beam balance

56. Which balance is used for measuring mass in laboratories? (CQs)
(A) Electronic balance (B) Beam balance
(C) Spring balance (D) Physical balance ✓

1.7 Time Measuring Instruments

57. Least count of mechanical stopwatch is:
(A) $\frac{1}{10}$ sec ✓ (B) $\frac{1}{100}$ sec (C) $\frac{1}{1000}$ sec (D) 1 sec

58. Least count of digital stopwatch is:
(A) 1 sec (B) $\frac{1}{1000}$ sec (C) $\frac{1}{100}$ sec ✓ (D) $\frac{1}{10}$ sec

59. How many types of stopwatch are?
(A) One (B) Two ✓ (C) Three (D) Four

60. Dial of mechanical stopwatch is usually divides into _____ big divisions.
(A) 10 (B) 20 (C) 30 ✓ (D) 50

1.8 Measuring Cylinder

61. A measuring cylinder is used to measure:
(A) Mass (B) Area (C) Volume ✓ (D) Level of liquid

62. A scale of measuring cylinder is:
(A) cm^3 (B) cc (C) mL (D) All of these ✓

1.9 Errors in Measurement

63. Zero error belongs to:
(A) Personal error (B) Random error
(C) Collective error (D) Systemetic error ✓

64. How many types of error in measurement? (CQs)
(A) One (B) Two (C) Three ✓ (D) Four

65. If change in temperature occurs during experiment which error may be occur? (CQs)
(A) Human error (B) Sysmetic error (C) Random error ✓ (D) Collective error

1.10 Uncertainty in a Measurement

66. How reduce uncertainty in small measurement?
(A) Taking small multiple reading ✓ (B) Taking one reading
(C) Taking multipole instruments (D) All of these

1.11 Significant Figures

67. Significant figures in 0.0010 are:
(A) 1 (B) 2 ✓ (C) 3 (D) 4

68. Significant figures in 0.00567 are:
(A) 2 (B) 3 ✓ (C) 4 (D) 5

69. Significant figures in 0.04060 are:
(A) 2 (B) 4 ✓ (C) 5 (D) 6

70. Significant figures in 0.0004813 are:
(A) 8 (B) 7 (C) 4 ✓ (D) 3

71. Significant figures in 0.0045 are:
(A) 1 (B) 2 ✓ (C) 3 (D) 4

72. The numbers of significant figures in 0.00232 are:
(A) 6 (B) 5 (C) 3 ✓ (D) 4

73. The numbers of significant figures in 0.00407 are:
(A) 6 (B) 5 (C) 3 ✓ (D) 4

74. The quantity of 0.00467 has significant figures:
(A) 3 ✓ (B) 4 (C) 5 (D) 6

75. If least count is 10 kg, then 8.00×10^3 kg has significant figures:
(A) 1 (B) 2 (C) 3 ✓ (D) 4

76. The number of significant zeros in the number 0.00904 is/are:
(A) 1 (B) 2 (C) 3 ✓ (D) 4

77. A number such as 5.0×10^4 cm can be expressed in scientific notation as:
(A) 5.0×10^2 m ✓ (B) 5.0×10^6 m (C) 5.0×10^4 m (D) 5.0×10^{-2} m

1.12 Precision and Accuracy

78. A precise measurement is the one which has:
(A) Greater precision (B) Less precision ✓
(C) Medium precision (D) More % error

79. In order to reduce the uncertainty in finding time period of a vibrating body, it is advised to count:
(A) Small number of swings (B) Large number of swings ✓
(C) Infinite number of swings (D) Both A and C

80. Which of the following measurement is more precise? (CQs)
(A) 3127 s (B) 312.7 s (C) 31.27 s (D) 3.127 s ✓

81. The appropriate precision on addition of following masses 0.089, 2.189, 5.32, 11.8 in kg is:
(A) 19.398 kg (B) 19.39 kg (C) 19.4 kg ✓ (D) 19.41 kg

82. The least count of a balance A is 10 kg, of B is 1 kg, of C is 0.1 kg and of D is 0.01 kg, which is most precise:
(A) Balance A (B) Balance B (C) Balance C (D) Balance D ✓

1.13 Rounded off the digits

83. An electronic timer can measure time intervals:

(A) $\frac{1}{100}$ second (B) $\frac{1}{1000}$ second

(C) $\frac{1}{10000}$ second ✓ (D) $\frac{1}{100000}$ second

84. Round to 3 significant figures 3.4567×10^4 kg is:

(A) 3.45×10^4 kg (B) 3.457×10^4 kg

(C) 3.456×10^4 kg (D) 3.46×10^4 kg ✓

85. Round to 2 significant figures 2.512×10^3 m is:

(A) 2.51×10^3 m (B) 2.5×10^3 m ✓ (C) 2.51×10^5 m (D) 2.5×10^3 m

86. Round to 2 significant figures 4.45×10^2 m is:

(A) 4.4×10^2 m ✓ (B) 4.5×10^2 m (C) 4.4×10^{-2} m (D) 4.5×10^{-2} m

General Short Questions with Conceptual Questions (CQs)

1.1 Physical and Non-Physical Quantities

1. Differentiate between physical and non-physical quantities.

Ans:

Physical Quantities	Non-Physical Quantities
Definition: All measurable characteristics of objects are called physical quantities.	**Definition:** Characteristics of objects which cannot be measured are called non-physical quantities.
Examples: Length, volume, density, time, temperature.	**Examples:** Love, affection, fear, wisdom, beauty
Mesurement: Physical quantites can be measured directly and indirectly using some tools and instruments.	**Mesurement:** Non-physical quantities can be described or qualitatively or compared using some perdetermined criteria, indices or through survey techniques.

2. What are the foundations of physics? (CQs)

Ans: Foundation of Physics rest upon physical quantities through which the laws and principle of physics are expressed.

3. Write down characeteristics of non-physical quantities.

Ans: Non-physical quantities help us to understand and to analyse human behaviour, emotions and social interactions.

1.2 Base and Derived Physical Quantities

4. Define Physics. How it related to physical qantities?

Ans: **Physics:** Physics is a science of **physical world** where we interact with many different types of **material objects**.

Relation of Physics with Physical quantities: In physical world, there are some objects which are exposed in terms of their measurable features physical quantities.

5. Differentiate between base and derived quantities.

Ans:

Base Quantities	Derived Quantities
Quantities which can be expressed independently without the reference of any other quantity are called base quantites.	Quantities which can be expressed with the reference to base quantities are called derived quantites.
Examples: Length, mass, time, temperature, electric current, intensity of light and amount of substance are base quantities.	**Examples:** Area, volume, speed, force, pressure, electric charge and plane angle are examples of derived quantites.

6. How a physical quantity is measured? **(CQs)**

Ans: A measurement is a process of comparison of an unknown quantity with a widely accepted standard quantity.

Example: Length of book is measured by metre rule.

7. What is a unit?

Ans: Scientist describe a standard for measurement of a quantity by any person may result. This standard of measurement is known as a unit.

1.3 International System of Units

8. Define derived units with examples.

Ans: **Derived Units:** The units which can be expressed in terms of base units are called derived units.

Examples:

(i) Force:

Force = Mass × Acceleration = kilogram ×metre / $(\text{second})^2$

= kgms^{-2} = N

(ii) Volume:

Volume = Length × breath × width = metre × metre × metre

= cubic metre = $(\text{metre})^3$ or m^3

9. Define base units. Give two examples.

Ans: **Base units:** The units that describe base quantities are called base units.

Examples:

(i) Unit of length is metre. (ii) Unit of mass is kilogram.

10. Pick out the base unit in the following:
mole, ampere, metre, newton, watt, joule, kilogram

Ans: **Base units:** mole, ampere, metre, kilogram

11. Define prefixes. Give its two examples.

Ans: **Prefix:** The words or symbols added before SI unit such as milli, centi, kilo, mega, giga are called prefix.

Examples:

i) The quantity 50000000 m can be written as 5×10^7 m, i.e., $5\times10^1\times10^6$ m = 50 Mm

ii) The quantity 0.00004 m can be written as 4×10^{-5} m, i.e.,

$4\times10^{-5}\text{ m} = 4\times10^1\times10^{-1}\times10^{-5}\text{ m} = 40\times10^{-6}\text{ m} = 40\,\mu\text{m}$

12. Express 4800,000 W in kilo and mega watt by using prefixes. (CQs)

Ans: 4800,000 W $= 4800 \times 10^3$ W = 4800 kW $(\because 10^3 = 1k)$

Now, 4800,000 W $= 4.8 \times 10^6$ W = 4.8 MW $(\because 10^6 = 1M)$

13. Convert 3500000000 Hz into MHz and 0.00003 g into (μg) by using prefixes. (CQ's)

Ans: (a) 3500000000 Hz $= 3500 \times 10^6$ Hz $= 3500\,\text{Mg}$ $(\because 10^6 = 1M)$

(b) 0.00003 g $= 3.0 \times 10^{-5}$ g $= 3.0 \times 10^1 \times 10^{-1} \times 10^{-5}$ g

$= 30 \times 10^{-6} = 30\,\mu g$ $(\because 10^{-6} = 1\mu)$

1.4 Scientific Notation

14. Define scientific notation with example.

Ans: **Scientific Notation:** The number written as power of ten or prefix in which there is only one non-zero number before decimal is known as scientific notation.

Example: In scientific notation, distance from the Sun to the Earth is:

138,000,000 km = 1.38×10^8 km

15. Describe how to write a number in scientific notation? (CQs)

Ans:

i) The numerical part of the quantity is written as a number from 1 to 9 multiplied by whole number powers of 10. i.e 0.00534 m

ii) To write numbers using scientific notation, move the decimal point until only one non-zero digit remains on the left. i.e 5.34

iii) Count the number of places through which the decimal point is moved and use this number as the power or exponents of 10. i.e. 0.00534 m = 5.34×10^{-3} m

16. Write in standard form (a) 384000000 m (b) 0.00045 s

Ans:

(a) 384000000 m

Standard form: 3.84×10^8 m

(b) 0.00045 s

Standard form: 4.5×10^{-4} s

1.5 Length Measuring Instruments

17. Define least count. Write least count of meter rule.

Ans: **Least Count:** Least count is the smallest measurement that can be taken accurately with an instrument.

Least count of Metre Rule: Least count of metre rule is 1 mm.

18. What do you know about measuring tape? (CQs)

Ans: Measuring Tape can measure 1 mm to several metres. Its least count is 1 mm. It is used to measure longer distances.

19. What is micrometer screw guage? (CQs)

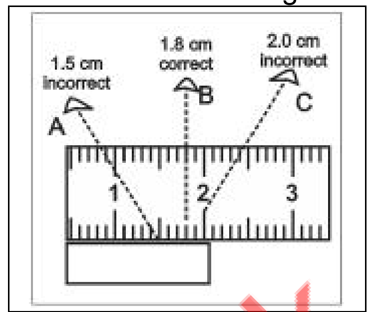
Ans: A micrometer screw guage is an instrument that is used to measure small length with accuracy greater than vernier calipers i.e, correct upto 0.01 mm.

20. Write names of important instruments used in physics laboratory.

Ans: Names of important instruments used in physics laboratory are:

i) Metre rule ii) Vernier Callipers iii) Micrometer Screw Gauge

21. Define Parallax error.



Ans: If the metre rule is read from an angle, such as from point A or C, the object will appear to be of different length. This is known as parallax error.

22. Why does parallax error occur?

Ans: Parallax error is due to incorrect position of eye when taking measurements. It can be avoided by keeping eye perpendicular to the scale reading.

23. Write the name of parts of Vernier Callipers.

Ans: There are two parts of Vernier Callipers.

(a) A **main scale** which has marking of 1 mm each.

(b) A **Vernier (sliding) scale** of length 9 mm and it is divided into 10 equal parts.

24. How many divisions are there on vernier scale? (CQs)

Ans: A **Vernier (sliding) scale** of length 9 mm and it is divided into 10 equal parts. Each division is 0.9 mm.

25. Who invented Vernier Callipers?

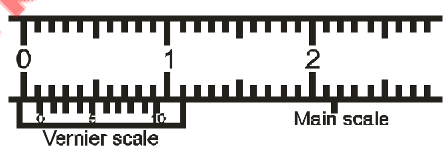
Ans: Vernier Callipers was invented by a French Scientist Pierre Vernier in 1631.

26. For what purpose depth guage of Vernier Callipers is used? (CQs)

Ans: Tail or depth gauge of vernier Callipers is used to measure the depths of a hollow object.

27. When the zero error of Vernier Callipers is positive? (CQs)

Ans: **Positive zero error:** Zero error will be positive if zero line of vernier scale is on right side of the main scale.



Explanation: If the zero of the Vernier scale is on the right side of the zero of the main scale (Figure) then this instrument will show slightly more than the actual length. Hence, these zero errors are subtracted from the observed measurement.

28. Write four rules of laboratory safety.

Ans: **Rules of Laboratory Safety:**

i) Do not taste any chemical unless otherwise instructed by the teacher.

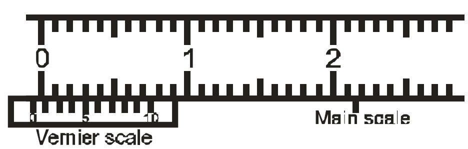
ii) Do not eat, drink or play in the laboratory.

iii) Do not place flammable substance near naked flames.

iv) Wash your hands after all laboratory work.

29. When the zero error of Vernier Callipers is negative? (CQs)

Ans: **Negative zero error:** Zero error will be negative if zero line of vernier scale is on left side of the main scale.



Explanation: If the zero of the Vernier scale is on the left side of the zero of the main scale (Figure), then instrument will show slightly less than the actual length.

30. Define Pitch of a Micrometer Screw Gauge.

Ans: When the thimble makes one complete turn, the spindle moves 0.5 mm (1 scale division) on the main scale which is called pitch of the screw gauge.

31. Write the formula to finding the least count of micrometer screw guage.

Ans: The formula of Least Count of Micrometer Screw Gauge

$$Least\ count = \frac{Pitch\ of\ the\ screw\ gauge}{No.\ of\ division\ on\ the\ circular\ scale} = \frac{0.5\,mm}{50} = 0.01\,mm$$

32. For which purpose Micrometer Screw Gauge is used? (CQs)

Ans: Micrometer Screw Gauge is used to measure very small lengths such as diameter of a wire or thickness of a metal sheet.

33. Write the name of parts of Micrometer Screw Gauge.

Ans: There are two parts of micrometer screw gauge.

(a) The **main scale** on the sleeve which has marking of 0.5 mm each.

(b) The **circular scale** on the thimble which has 50 divisions. Some instruments may have main scale marking of 1 mm and 100 divisions on the thimble.

34. How zero error of micrometer screw gauge is checked? (CQs)

Ans: There are two steps to check the zero error.

i) If the zero of the circular scale coincides with horizontal line, there is no zero error.

ii) If the zero of the circular scale is not exactly in front of the horizontal line of the main scale on joining the anvil and spindle then there is a zero error in the screw gauge.

35. Why a Micrometer Screw Gauge measures more accurately than Vernier Callipers? (CQs)

Ans: Least count of Vernier Callipers is 0.1 mm and leastcount of screw guage is 0.01 mm. Thus, measurements taken by screw guage are more precise than Vernier Callipers.

36. When the zero error of Micrometer Screw Gauge will be negative? (CQs)

Ans: Zero error of a micrometer screw gauge will be negative if zero of circular scale has crossed the index line.

37. Describe the positive zero error of Micrometer Screw Gauge. (CQs)

Ans: Zero error of a micrometer screw gauge is positive if zero of circular scale has not reach zero of the main scale.

1.6 Mass Measuring Instruments

38. Which instrument is most precise for the measurement of mass? What is its least count? (CQs)

Ans: The most precise balance is the digital electronic balance for the measurement of mass. Its least count is 0.1 mg.

39. Define weighing process.

Ans: The mass of an object is found by comparing it with known standard masses. This process is called weighing.

40. What is the use of physical balance? (CQs)

Ans: A physical balance is used in the laboratory to measure the mass of various objects by comparison.

41. What is the function of balancing screw in a physical balance? (CQs)

Ans: The most precise balance is the digital electronic balance for the measurement of mass. Its least count is 0.1 mg.

42. Why digital electronic balance is more accurate than beam balance? (CQs)

Ans: Least count of electronic balance is 0.001 g or 1 mg. Therefore, its measurement should be more precise than a beam balance.

1.7 Time Measuring Instruments

43. What is stopwatch? Write the name of its parts.

Ans: **Stopwatch:** A devices by which the duration of time of an event is measured is called a stopwatch.

Parts of Stopwatch: A stopwatch contains two needles, one for seconds and other for minutes.

44. Which stop watch is better for the measurement of small time interval?

Ans: The least count of mechanical stopwatch is 0.1 second while least count of electronic / digital watch is one hundredth part of a second i.e., 0.01 second. Since, electronic / digital stopwatch has less least count, therefore, electronic / digital stopwatch is better than mechanical stopwatch.

1.8 Measuring Cylinder

45. What is Measurig Cylinder? Write its use.

Ans: **Measurig Cylinder:** Measurig cylinder is a cylinder made of glass or **transparent** plastic with a scale divided in cubic centimetres (cm^3 or cc) or millilitres (mL) marked on it.

Use of Measurig Cylinder: Measurig Cylinder is used to find the volume of liquids and non-dissolvable solids.

46. How Ancient Chinese estimate volume of grains? (CQs)

Ans: Ancient Chinese used to estimate the volume of grains by sounding their containing vessels.

1.9 Errors in Measurement

47. Why errors occurs in measuring instruments? (CQs)

Ans: Errors occurs in measuring instruments because the tools and instruments used for measurements are **never perfect**. They inherit some errors and differ from their true values. However, we can do is to ensure that the errors are as small as reasonably possible.

48. Write the names of types of errors.

Ans: There are three types of experimental errors.

(i) Human Errors (ii) Systematic Errors (iii) Random Errors

49. What are the reasons of human errors?

Ans: **Reasons of Human Errors:** Human Errors occur due to personal performance.The limitations of the human perception are:

i) The inability to perfectly estimate the position of the pointer on a scale.

ii) Personal errors can also arise due to faulty procedure to read the scale.

50. How a person can take precise and accurate measurement? (CQs)

Ans: A person take can a precise and accurate measurement needs to line up your eye right in front of the level. In timing experiments, the reaction time of an individual to start or stop clock also affects the measured value.

51. How human errors can be reduced? (CQs)

Ans: Human error can be reduced by ensuring proper training, techniques and procedure to handle the instruments and avoiding environmental distraction or disturbance for proper focusing.

52. Describe the best way to reduce Human Errors.

Ans: The best way is to use automated or digital instruments to reduce the impact of human errors.

53. What are Systematic Errors? Why this type of error occur?

Ans: **Systematic Error:** Systematic Errors refer to an effect that influences all measurements of particular measurements equally. It produces a consistence difference in reading.

Reasons: Systematic errors occur due to some definite rule. It may occur due to **zero error of instrument**, **poor calibration of instrument** or **incorrect marking**.

54. How systematic error can be reduced?

Ans: The effect of systematic errors can be reduced by comparing the instrument with another which is known to be more accurate. Thus, a correction factor can be applied.

55. Why does random error occur?

Ans: The experimenter have a little or no control over it. Random error arise due to sudden **fluctuation** or **variation** in the environmental conditions.

Example: Changes in temperature, pressure, humidity, voltage, etc.

56. Explain with example how random error can be reduce?

Ans: The effect of random errors can be reduced by using several or multiple readings and then taking their average or mean value.

Example: For the measuring time period of oscillating pendulum, the time of several oscillations, say 30 oscillations is noted and then mean or average value of one oscillation is determined.

1.10 Uncertainty in a Measurement

57. What is the value of uncertainty in a measurement? (CQs)

Ans: The value of uncertainty in a measurement is equal to the least count of that instrument.

1.11 Significant Figures

58. Define significant figures with suitable example.

Ans: **Significant Figures:** In any measurement, the accurately known digits and the first doubtful digit are known as significant figures.

The significant figures or digits are the digits of a measurement which are reliably known.

Example: In 12.5 cm, number of significant figures are 3, i.e., 1,2, are accurately known and 5 is first doubtful digit.

1.12 Precision and Accuracy

59. Define Precision and Accuracy.

Ans: **Precision:** Precision of a measurement refers to how close together a group of measurements actually are to each other.

Accuracy: Accuracy of a measurement refers how close the measured value is to some accepted or true value.

60. Does all physical measurements are accurate or precise? (CQs)

Ans: No, not all the physical measurements are accurate or precise.

61. How is precision related to the significant figures in measured quantity? (CQ's)

Ans: All accurately known digits and the first doubtful digit in an expression is called significant figures. It reflects the precision of a measured value of a physical quantity. More significant figure means greater precision.

62. Write uses and accuracy of digital and analogue stopwatches.

Ans:

Type of clock/watch	Use and accuracy
Atomic clock	Measures very short time intervals of about 10^{-10} seconds.
Digital stopwatch	Measures short time intervals (in minutes and seconds) to an accuracy to ±0.01 s.
Analogue stopwatch	Measures short time intervals (in minutes and seconds) to an accuracy to ±0.1 s.

63. Write uses of Pendulum clock and radioactive decay clock. (CQs)

Ans:

Type of clock/watch	Use
Pendulum clock	Measures longer time intervals in hours, minutes and seconds.
Radioactive decay clock	Measures (in years) the age of remains from thousands of years ago.

1.13 Rounded off the digits

64. Describe the measuring time of an electronic timer.

Ans: An Electronic timer can measure time intervals as short as one-ten thousands (1/10,000) of a second.

65. Round to 2 significant figure. (CQs)

(i) 4.45×10^2 **m** **(ii)** 4.55×10^2 **m**

Ans:

(i) 4.45×10^2 m = 4.4×10^2 m

(ii) 4.55×10^2 m = 4.6×10^2 m

Unit - 2 Kinematics

Q.1(a) Define Mechanics. Describe the branches of Mechanics.
(b) Discuss Mechanics on the basis of everyday life examples.

(a) Define Mechanics. Describe the branches of Mechanics.
Ans: Mechanics:

Mechanics is the branch of physics that deals with the **motion of objects** and the **forces** that change it.

Branches of Mechanics:

Generally, mechanics is divided into two branches:

i) Kinematics:

Kinematics is the study of **motion of objects without referring to forces**.

ii) Dynamics:

Dynamics deals with **forces** and their **effects** on the motion of objects.

(b) Discuss Mechanics on the basis of everyday life examples.
Ans: Example of Mechanics in Everyday Life:

In our everyday life, we observe many objects in motion. For example, cars, buses, bicycles, motorcycles moving on the roads, aeroplanes flying through air, water flowing in canals or some object falling from the table to the ground.

Explanation:

The motion of these objects can be studied with or without considering the force which causes motion in them or changes it.

2.1 Scalars and Vectors

Q.2 Differentiate between scalars and vectors.

Ans:

Scalar	Vectors
Definition: A scalar is that physical quantity which can be described completely by its **magnitude** only.	**Definition:** A vector is that physical quantity which needs **magnitude** as well as **direction** to describe it completely.
Parts of Scalars: Scalars are defined by magnitude includes **a number** and **an appropriate unit**.	**Parts of Vectors:** A vector quantity is completely described with its **magnitude** and **direction**.
Addition of Scalar Quantities: Scalar quantities can be added up like numbers. For example: 5 metres + 3 metres = 8 metres.	**Addition of Vector Quantities:** Vectors cannot be added like scalars. There are specific methods to add up vectors. These methods take their directions also into consideration.
Examples: Distance, length, time, speed, energy and temperature.	**Examples:** Displacement, velocity, acceleration, weight and force.
Explanation:	**Explanation:**

When we ask a shopkeeper to give us 5 kilograms of sugar, he can fully understand how much quantity we want. It is the magnitude of mass of sugar. Mass is a scalar quantity.	The velocity of a car moving at 90 kilometre per hour (25 ms^{-1}) towards north can be represented by a vector. Velocity is a scalar quantity because it has magnitude 25 ms^{-1} and direction (towards north).

Q.3(a) How many ways to representation of vectors? Explain the symbolically representation of vectors.

(b) How a vector can be represented graphically? Explain. **Ex. Q. 2.1**

(a) How many ways to representation of vectors? Explain the symbolically representation of vectors.

Ans: Representation of vectors:

Vectors can be represented by following two ways:

- Symbolically Representation of Vectors • Graphical Representation of Vectors
- **Symbolically Representation of Vectors:**

(i) Symbol used for a vector is a bold face letter such as **A, V, F** and **d** etc.

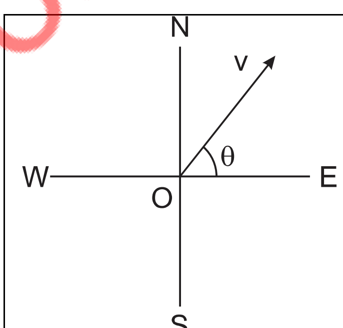
(ii) A vector is written as the letter with a small arrow over it, i.e. $\vec{A}, \vec{v}, \vec{F}, \vec{d}$.

(iii) The magnitude of a vector is given by italic letter without arrow head A, v, F, d.

(b) How a vector can be represented graphically? Explain. **Ex. Q. 2.1**

- **Graphical Representation of Vectors:**

A vector can be represented graphically by drawing a straight line with an arrow head at one end. The length of line represents the magnitude of the vector quantity according to a suitable scale while the direction of arrow indicates the direction of the vector.



A vector **v** making an angle θ towards north from east Fig 2.1 (a)

Representation of Direction by Vector Method:

To represent the direction, two mutually perpendicular lines are required. We can draw one line to represent east-west direction and the other line to represent north-south direction (Fig.2.1-a). The direction of a vector can be given with respect to these lines. Mostly, we use any two lines which are perpendicular to each other.

X-axis:

Horizontal line (XX') in xy-plane is called x-axis.

Y-axis:

Vertical line (YY') in xy-plane is called y-axis.

Origin:

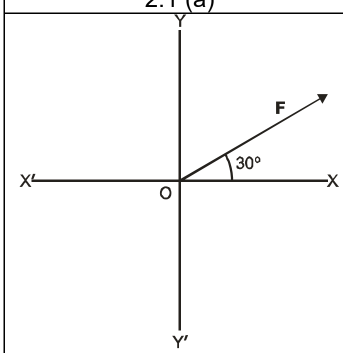
The point where both the axes meet is known as origin. The origin is usually denoted by O (Fig.2.1-b).

Reference axis:

x-axis and y-axis are called reference axis.

Representation of a Vector in xy-Plane:

A vector is drawn starting from the origin of the



A Vector **F** making angle 30° with x-axis Fig 2.1 (b) reference axes towards the given direction. The direction is usually given by an angle θ (theta) with x-axis. The angle with x-axis is always measured from the right side of x-axis in the anti-clockwise direction.

For Your Informtion

For geographical direction, the reference line is north – south system whereas for Cartesian co-ordinate system positive x-axis is the reference.

Q.4(a) Define resultant vector. Explain head to tail rule.
(b) Describe addition of vectors by graphical method.

(a) Define resultant vector. Explain head to tail rule.

Ans: Resultant Vector:

We can add two or more vectors to get a single vector. This is called as resultant vector.

Explanation:

A resultant vector has the same effect as the combined effect of all the vectors to be added. We have to determine both magnitude and direction of the resultant vector, therefore, it is quite different from that of scalar addition.

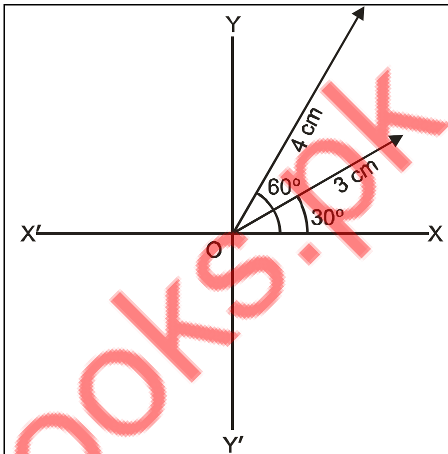


Figure: 2.4 (a)

Head-to-Tail Rule:

To add a number of vectors, redraw their representative lines such that the head of one line coincides with the tail of the other. The resultant vector is given by a single vector which is directed from the tail of the first vector to the head of the last vector.

(b) Describe addition of vectors by graphical method.

Ans: Addition of Vectors by Graphical Method:

Let us add two vectors $\mathbf{v_1}$ and $\mathbf{v_2}$ having magnitudes of 300 N and 400 N acting at angles of 30° and 60° with x-axis. By selecting a suitable scale 100 N = 1cm, we can draw the vectors (Fig. 2.4-a).

By head-to-tail rule, measured length of resultant vector is 6.8 cm (Fig.2.4-b). According to selected scale, magnitude of the resultant vector v is 680 N and direction is angle 49° with x-axis.

We can find the resultant vector of more than two vectors by adding them with the same way applying head-to-tail rule.

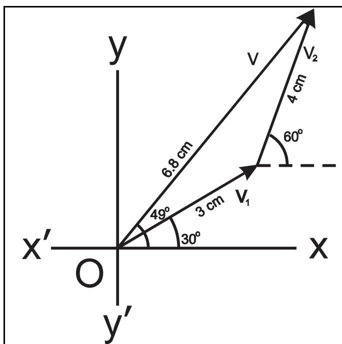


Figure: 2.4 (b)

TUTOR

Resultant vector is a single vector having same effect as all the original vectors taken together.

2.2 Rest and Motion

Q.5(a) Differentiate between rest and motion. **Ex. Q.2.2(i)**
(b) Explain briefly that state of rest and motion is relative.

(a) Differentiate between rest and motion. **Ex. Q.2.2(i)**

Ans: Rest:

If a body does not change its position with respect to its surroundings, it is said to be at rest.

Example:

Suppose a motorcyclist is standing on the road (Fig. 2.5-a). An observer sees that he is not changing his position with respect to his surroundings i.e., a nearby building, tree or a pole.

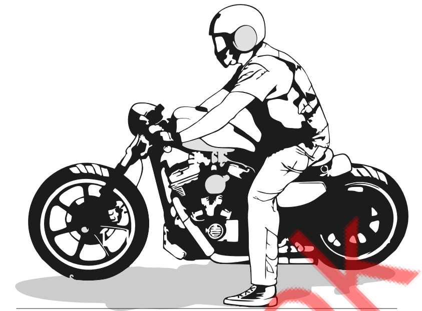


Fig 2.5 (a)

Explanation:

When we look around us, we see many things like buildings, trees, electric poles, etc. which do not change their positions. We say that they are in a state of rest.

Motion:

If a body continuously changes its position with respect to its surroundings, it is said to be in motion.

Example:

When the motorcyclist is driving (Fig. 2.5-b), the observer will notice that he is continuously changing his position with respect to the surroundings. Then the observer will say that the motorcyclist is in motion.

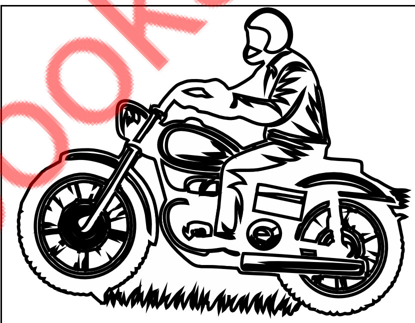


Fig. 2.5 (b)

Explanation:

A moving bus on road or a flying butterfly in the garden is continuously changes its position with respect to its surrounding.

(b) Explain briefly that state of rest and motion is relative.

Ans: The state of rest or motion of a body is always relative.

Explanation:

A person standing in the compartment of a moving train is at rest with respect to the other passengers in the compartment but he is in motion with respect to an observer standing on the platform of a railway station.

2.3 Types of Motion

Q.6 Describe different types of motion. Also give examples. **Ex. Q. 2.3**

Ans: We observe different types of motion in our daily life. A train moves almost along a straight line, the blades of a fan rotate about an axis, a swing vibrates about its mean position.

Types of Motions:

Generally, there are three types of motion of bodies.

- Translatory motion
- Rotatory motion
- Vibratory motion

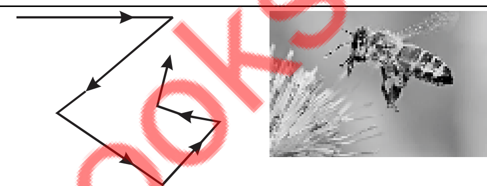
- **Translatory Motion:**
  If the motion of a body is such that every particle of the body **moves uniformly** in the **same direction**, it is called tanslatory motion.
  Example:
  The motion of a train or a car is tanslatory motion (Fig.2.6).
  Types of Translatory Motion:
  Translatory motion can be of three types:

Fig. 2.6 The motion of a train is translatory motion

(i) Linear Motion:
If the body **moves** along a **straight line**, it is called linear motion.
Example:
A freely falling body is the example of linear motion.

(ii) Random Motion:
If the body **moves** along an **irregular path**, the motion is called random motion.

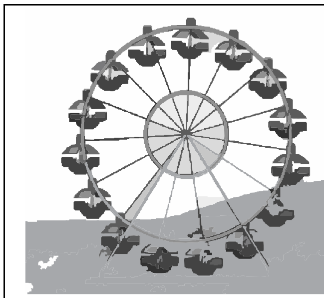
TUTOR
The disorder or irregular motion of an object called **random motion**.



(a) Irregular path
(b) The motion of bee is random motion
Fig. 2.7

Example:
Motion of bee is random motion. (Fig. 2.7)

(iii) Circular Motion:
The motion of a body along a circle is called circular motion.
Examples:
- If a ball tied to one end of a string is whirled, it moves along a circle.
- Motion of a Ferris wheel is circular motion (Fig.2.8).



Circular motion
Fig.2.8

- **Rotatory Motion**
  If each point of a body moves around a fixed point (axis), the motion of this body is called rotatory motion.
  Example:
- The motion of an electric fan and the drum of a washing machine dryer is rotatory motion (Fig.2.9).

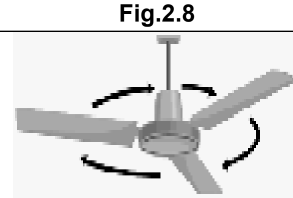


Fig 2.9
Rotatory motion of a fan

- The motion of a top is also rotatory motion.
- **Vibratory Motion**

  When a body repeats its to and fro motion about a fixed position, the motion is called vibratory motion.

  Example:

  The motion of a swing in a children park is vibratory motion (Fig.2.10).

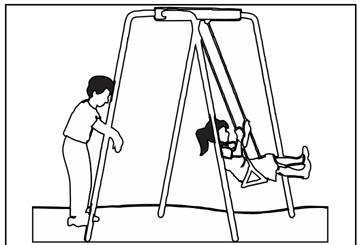
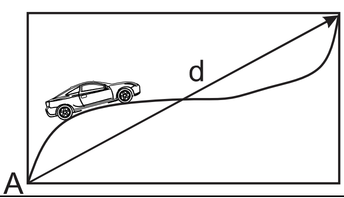


Fig 2.10 Vibratory Motion

2.4 Distance and Displacement

Q.7 Differentiate between distance and displacement. **Ex. Q. 2.4**

Ans:

Distance	Displacement
Definition: The distance is the **length of actual path** of the motion.	**Definition:** The magnitude of displacement is the **shortest distance** between the **initial** and **final positions** of the motion.
Exaplanation: Motion is the action of an object going from one place to another or change of position. The length between the original and final positions is taken as distance.	**Explanation:** Distancement is the change in position. The shortest length between the original and final positions is taken as displacement.
Example: Let a person be travelling from Lahore to Multan in a car. On reaching Multan, he reads the speedometer and notices that he has travelled a distance of 320 km. It is the distance travelled by that person. Obviously, it is not the shortest distance from Lahore to Multan, as the car took many turns in the way. He did not travel along a straight line.	**Example:** Suppose a car travels from a position A to B. The curved line is the actual path followed by the car (Fig. 2.11). The total distance covered by the car will be equal to the length of the curved line AB. The displacement **d** is the straight line AB directed from A to B as indicated by the arrow head. 
Nature of Quantity: Distance is a scalar quantity.	**Nature of Quantity:** Distance is a vector quantity and its direction is from the initial position to the final position.
Formula: Distance can find out by given formula. $S = v \times t$	**Formula:** Displacement can find out by given formula. $\mathbf{d} = \mathbf{v} \times t$

Note:

The SI unit of both distance and displacement is metre (m).

2.5 Speed and Velocity

Q.8(a) Define speed. Write its formula and unit. **Ex. Q. 2.2**

(b) Define instantaneous speed and average speed.

(a) Define speed. Write its formula and unit. **Ex. Q. 2.2**

Ans: Speed:

Distance covered by a body in **one second** is called speed.

Explanation:

We are often interested to know how fast a body is moving. For this purpose, we have to find the distance covered in unit time which is known as speed.

Formula:

If a body covers a distance S in time t, its speed v will be written as:

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

$$v = \frac{S}{t} \quad \text{or} \quad S = vt \qquad (2.1)$$

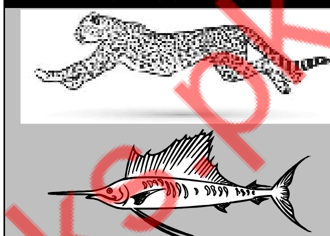
Nature of Quantity:

Speed is a scalar quantity.

SI unit:

The SI unit of speed is ms^{-1} or kmh^{-1}.

Do You Know

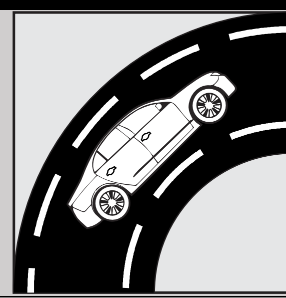


The fastest land mammal (cheeta) and the fastest fish (sailfish) have the same higest recorded speed of 110 kmh^{-1}.

Brain Teaser

Q. The car while moving on a circular road may have constant speed, but its velocity is changing at every instant. Why?

Ans: As a velocity is a vector quantity. Every vector quantity has two parts, magitude and direction. So, when the car is moving with constant speed i.e., magnitude of velocity is constant but in circular path, the direction of car changes at every point. That is why, velolcity of the car is changing at every instant.



(b) Define instantaneous speed and average speed.

Ans: Instantaneous speed:

The speed of a vehicle that is shown by its speedometer at any instant is called **instantaneous speed.**

Average speed:

The ratio between the total distance covered to the total time taken of an event is called average speed.

Formula of Average Speed:

$$Average\ speed = \frac{Total\ distance\ covered}{Total\ Time\ taken}$$

For Your Information!

Mount st. Helen erupted in 1980, causing rock to travel at velocities up to 400 km h^{-1}

or $$v_{av} = \frac{S}{t}$$

Explanation:

It is obvious that speed of a vehicle does not remain constant throughout the journey. If the reading of the speedometer of the vehicle is observed, it is always changing.

Q.9(a) Define velocity. Write its formula and SI unit.

(b) Define uniform and non-uniform velocity with examples.

(a) Define velocity. Write its formula and unit.

Ans: Velocity:

The **net displacement** of a body in **unit time** is called velocity.

Formula of average velocity:

If a body moves from point A to B along a curved path (Fig.2.11), the displacement **d** is the straight line AB, then

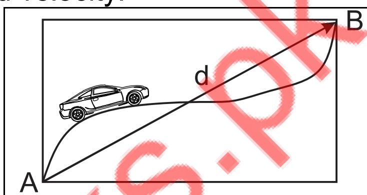


Fig 2.11

$$Average\ velocity = \frac{Displacement}{Time}$$

or $$\boldsymbol{v}_{av} = \frac{\boldsymbol{d}}{t} \qquad (2.2)$$

Nature of Quantity:

Velocity is a vector quantity. The Equation (2.2) shows that the direction of velocity **v** is the same as that of displacement **d.**

SI unit:

The SI unit of velocity is ms^{-1} or kmh^{-1}.

TUTOR

A LIDAR gun is light detection and ranging speed gun. It uses the time taken by lase pulse to make a series of measurements of vehicle's distance from the gun. The data is then used to calculate the vehicle's speed.

Explanation:

The speed of an object does not tell anything about the direction of motion. To take into account the direction, the vector concept is needed. For this, we have to find the displacement **d** between the initial and final positions.

Example:

Consider the example of a car moving towards north at the rate of 70 kmh^{-1}.To differentiate between speed and velocity, we shall say that the speed of car is 70 kmh^{-1} which is a scalar quantity. The velocity of the car is a vector quantity whose magnitude is 70 kmh^{-1} and is directed towards north.

(b) Define uniform and non-uniform velocity with examples.

Ans: Uniform Velocity:

The velocity is said to be uniform if the speed and direction of a moving body does not change.

Example:

A body moving with uniform velocity is the downward motion of a paratrooper.

Explanation:

When a paratrooper jumps from an aeroplane, he falls freely for a few moments.

Then the parachute opens. At this stage the force of gravity acting downwards on the paratrooper is balanced by the resistance of air on the parachute that acts upward. Consequently, the paratrooper moves down with uniform velocity.

Variable Velocity or Non-uniform Velocity:

Velocity is said to be non-uniform if the speed or direction or both of them change, it is known as variable velocity or non-uniform velocity.

Explanation:

Practically, a vehicle does not move in a straight line throughout its journey. It changes its speed or its direction frequently. So, it has a variable velocity.

For Your Information

Time-lapse photo of motorway traffic, the velocity of cars showing straight lines. White lines are the headlights and the red lines are taillights of vehicles moving in opposite directions.

2.6 Acceleration

Q.10(a) Define acceleration. Write its formula and SI unit.
(b) Explain average acceleration.
(c) Define uniform and non-uniform acceleration.
(a) Define acceleration. Write its formula and SI unit.

Ans: Acceleration:

Acceleration is defined as the time rate of change of velocity.

Formula:

$$Acceleration = \frac{Change\ in\ Velocity}{Time} \quad \text{or} \quad \boldsymbol{a} = \frac{\boldsymbol{v}_f - \boldsymbol{v}_i}{t}$$

Nature of Quantity:

Acceleration is a vector quantity like velocity. The direction of acceleration is that of change of velocity.

SI unit:

The SI unit of acceleration is ms^{-2}.

Whenever the velocity of an object is increasing, we say that the object is accelerating.

Example:

When a car overtakes another one, it accelerates to a greater velocity (Fig.2.12). In contrary to that the velocity decreases when brakes are applied to slow down a bicycle or a car. In both the cases, a change in velocity occurs.

The change in velocity can occur in magnitude or direction or both of them.

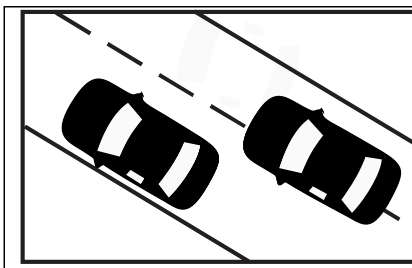


Fig. 2.12: While overtaking a caraccelerates to a greater velocity

Positive Acceleration:

The acceleration is positive if the velocity is increasing.

Negative Acceleration:

The acceleration is negative if the velocity is decreasing. Negative acceleration is also called deceleration or retardation.

(b) Explain average acceleration.

Ans: Average Acceleration:

If a body is moving with an initial velocity v_i and after some time t its velocity changes to v_f, the change in velocity is $\Delta v = v_f - v_i$ that occurs in time t. In this case, rate of change of velocity i.e., acceleration will be average acceleration.

$$\text{Average acceleration} = \frac{\text{Change in velocity}}{\text{Time taken}}$$

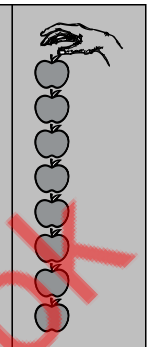
$$a_{av} = \frac{v_f - v_i}{t} \qquad (2.3)$$

Equation (2.3) can be written as: $a_{av} = \frac{\Delta v}{t}$

In case of constant acceleration:

If acceleration a is constant, then Eq 2.3 can be written as: $v_f = v_i + at$

Fascinating Snap:
This is a photograph of a falling apple dropped from some height. The images of apple are captured by the camera at 60 flashes per second. The widening spaces between the images indicate the acceleration of the apple.



(c) Define uniform and non-uniform acceleration.

Ans: Uniform Acceleration:

If time rate of change of velocity is constant, the acceleration is said to be uniform.

Non-uniform Acceleration:

If anyone of the magnitude or direction or both of them changes it is called variable or non-uniform acceleration.

2.7 Graphical Analysis of Motion

Q.11 Define graph. Explain graphical analysis of motion.

Ans: Graph:

A graph is a pictorial diagram in the form of a straight line or a curve which shows the relationship between two physical quantities.

Graphical Analysis of Motion:

For graphical analysis of motion, we draw a graph on a paper on which equally spaced horizontal and vertical lines are drawn. Generally, every 10th line is a thick line on the graph paper. In order to draw a graph, two mutually perpendicular thick lines XOX′ and YOY′ are selected as x and y axes (Fig 2.13).

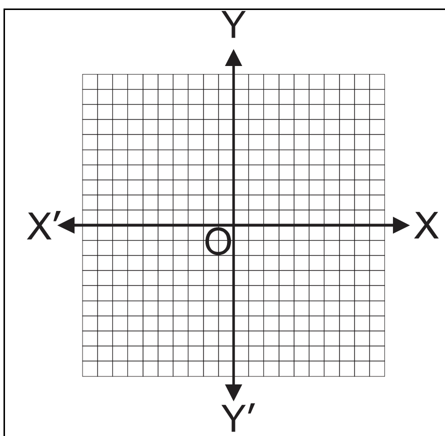


Fig. 2.13

Origin:

The point where the two axes intersect each other is known as origin O.

TUTOR
The quanites between which a grapgh is plotted are called the variable.

Independent Variable:

Positive values along x-axis are taken to the right side of the origin and negative values are taken to the left side. In graph study, the independent quantity is taken along x-axis.

Dependent Variable:

Similarly, positive values along y-axis are taken above the origin whereas negative values are taken below the origin. In graph study, dependent variable quantity along y-axis.

Example:

In distance-time graph, t is independent and S is dependent variable. Therefore, *t* should be along x-axis and S along y-axis.

Selection of Scale for x-axis and y-axis:

To represent a physical quantity along any axis, a suitable scale is chosen by considering the minimum and maximum values of the quantity.

TUTOR

Independent Variable:
Those variables which are used to manipulate, control, or vary in an experimental study to explore its effects.

Dependent Variable:
Those variables which dependence on independent variables are called dependent varibles.

Q.12 Explain briefly distance-time graph with an example.

Ans: Distance-Time Graph:

Distance-time graph shows the relation between distance S and time t taken by a moving body.

Example:

Let a car be moving in a straight line on a motorway. Suppose that we measure its distance from starting point after every one minute, and record it in the table given below:

Time t (min)	0	1	2	3	4	5
Distance S (km)	0	1.2	2.4	3.6	4.8	6.0

Steps of Measuring Distance-Time Graph:

Follow the steps given below to draw a graph on a centimetre graph paper:

i. Take time t along x-axis and distances along y-axis.

ii. Select suitable scales (1 minute = 1 cm) along x-axis and (1.2 km =1 cm) along y-axis. The graph paper shown here is not to the scale.

iii. Mark the values of each big division along x and y axes according to the scale.

iv. Plot all pairs of values of time and distance by marking points on the graph paper.

v. Join all the plotted points to obtain a best straight line (Fig. 2.14). From the table, we can observe that car has covered equal distance in equal intervals of time.

Conclusion:

This shows that the car moves with uniform speed. Therefore, a straight line graph between time and distance represents motion with uniform speed.

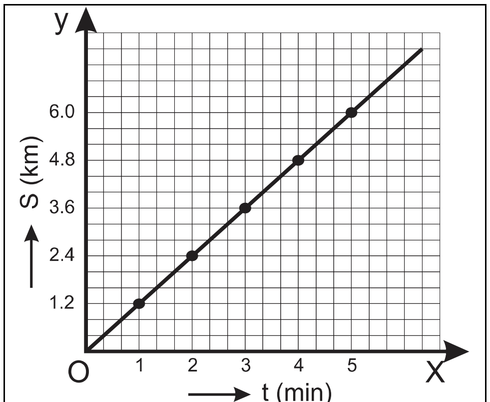


Fig. 2.14

Q.13(a) Describe distance-time graph of increasing speed in equal interval of time.
(b) Describe distance-time graph of decreasing speed in same interval of time.
(c) Describe distance-time graph when body is at rest.

(a) Describe distance-time graph of increasing speed in equal interval of time.

Ans: Consider a journey of the car as recorded in the table given below:

Time *t* (min)	0	1	2	3	4	5
Distance S (km)	0	0.240	0.960	2.160	3.840	6.000

Explanation:

Table shows that speed goes on increasing in equal intervals of time. This is very obvious from the graph (Fig 2.15). The graph line is curved upward. This is the case when the body (car) is moving with certain acceleration.

Graphical Representation of Data:

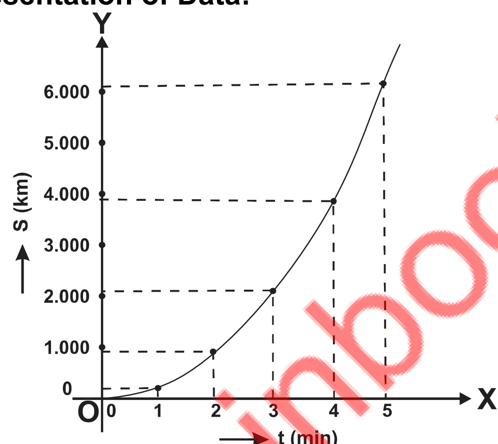


Figure 2.15

(b) Describe distance-time graph of decreasing speed in same interval of time.

Ans: Consider the case when the speed of car is decreasing.

Time *t* (min)	0	1	2	3	4	5
Distance S (km)	0	2.0	3.1	4.0	4.6	5.0

Explanation:

The graph line is curved downwards. This shows that distance travelled in the same interval of time goes on decreasing, so speed is decreasing. This is the case of motion with deceleration or negative acceleration (Fig.2.16).

Graphical Representation of Data:

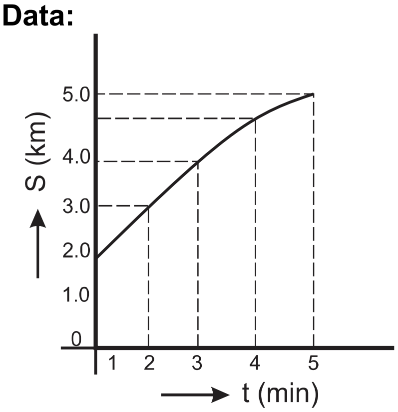


Figure 2.16

(c) Describe distance-time graph when body is at rest.

Ans: Consider the case when the distance discovered by the car does not change eith the change of time.

Time t (min)	0	1	2	3	4	5
Distance S (km)	1.2	1.2	1.2	1.2	1.2	1.2

Graphical Representation of Data:

Graph line is horizontal in this case (Fig 2.17). It shows that the distance covered by the car does not change with change in time. It means that the car is not moving; it is at rest.

Graphical Representation of Data:

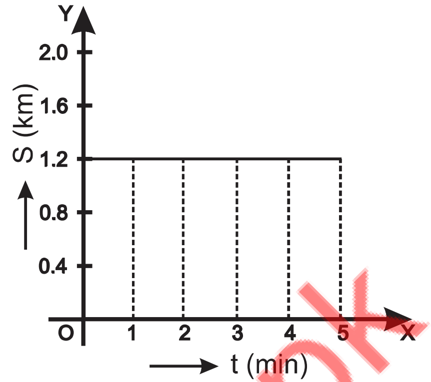


Fig. 2.17

2.8 Gradient of a Distance-Time Graph

Q.14 What do you understand gradient? Explain Gradients of Distance-time Graph by drawing diagram. **Ex. Q.2.5(i)**

Ans: Gradient:

The gradient is the measure of slope of a line.

Gradient of the Distance-time Graph:

Gradient of the distance-graph is equal to the average speed of the body.

Explanation:

Consider the distance-time graph of uniform speed again. Select any two values of time t_1 and t_2. Draw two vertical dotted lines at t_1 and t_2 on x-axis. These lines meet the graph at points P and Q. From these points draw horizontal lines to meet y-axis at S_1 and S_2 respectively (Fig.2.18).

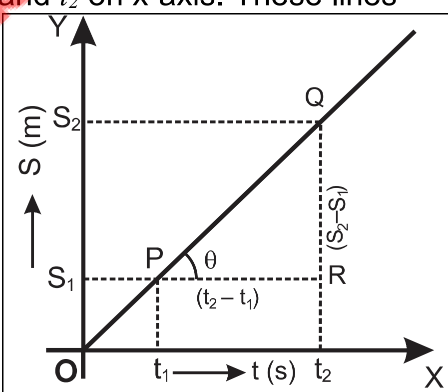


Fig. 2.18

Distance covered in this time interval is:

$$S_2 - S_1 = S$$

Time taken $t_2 - t_1 = t$

Slope or Gradient of graph:

The slope or gradient of the graph is the measure of tangent θ of the triangle RPQ:

$$Slope = \frac{RQ}{PR}$$

$$Slope = \frac{S_2 - S_1}{t_2 - t_1} = \frac{S}{t}$$

From Eq. (2.1), $\frac{S}{t} = v_{av}$, the average speed during the time interval t.

Figure 2.18, show that $\frac{S}{t} = \tan\theta =$ slope of graph line, therefore,

2.9 Speed time graph

Q.15 Explain briefly speed-time graph with suitable examples.

Ans: Speed-Time Graph:

Speed-time graph shows the relation between speed v and time t taken by a moving body.

Examples:

(i) Suppose we can note the speed of the same car after every one second and record it in the table given below, we can draw the graph between speed v versus time t. This is called speed-time graph.

Time *t* (s)	0	1	2	3	4	5
Speed *v* (ms^{-1})	0	8	16	24	32	40

Take time (t) along x-axis and velocity (v) along y-axis.

Selection of Scale for Graph:

Scale can be selected as 1 s = 1 cm (x-axis) and speed 10 ms^{-1} = 1 cm along y-axis.

Graphical Representation of Data:

Shape of the graph is shown in Fig. 2.19. It is a straight line rising upward. This shows that speed increases by the same amount after every one second. This is a motion with uniform acceleration. It is also evident from the table.

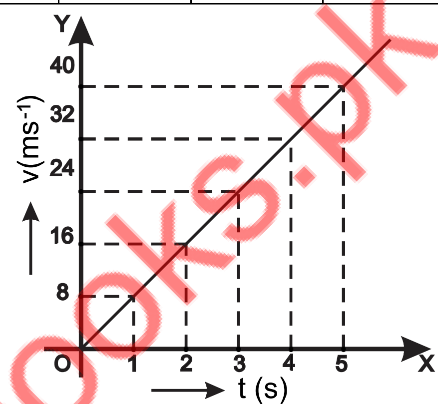


Fig: 2.19

Graph of Constant Speed:

(ii) Consider the observations are recorded in the table given below:

Time *t* (s)	0	1	2	3	4	5
Speed *v* (ms^{-1})	20	20	20	20	20	20

Graphical Representation of Data:

In this case, graph line is horizontal (Fig. 2.20) parallel to time x- axis. It shows that speed does not change with change in time. This is a motion with constant speed.

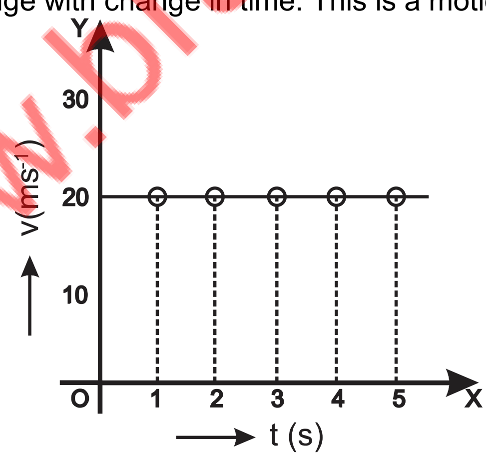


Fig: 2.20

2.10 Gradient of a Speed-Time Graph

Q.16 What do gradients of speed-time graph represent? Explain it by drawing diagrams. **Ex. Q.2.5(ii)**

Ans: Gradient of the speed-graph:

Gradient of the speed-time graph is equal to the average acceleration of the body.

Examples:

(i) Constant Acceleration:

Now consider the speed-time graph (Fig. 2.21). The speeds at times t_1 and t_2 are v_1 and v_2 respectively. The change in speed in a time interval (t_2-t_1) is (v_2-v_1). Therefore,

$$Slope = \frac{Change\ in\ speed}{Total\ time\ taken} \quad \text{or} \quad Slope = \frac{v_2 - v_1}{t_2 - t_1}$$

$$Slope = \frac{\Delta v}{t}$$

But $\frac{\Delta v}{t} = a$, the average acceleration.

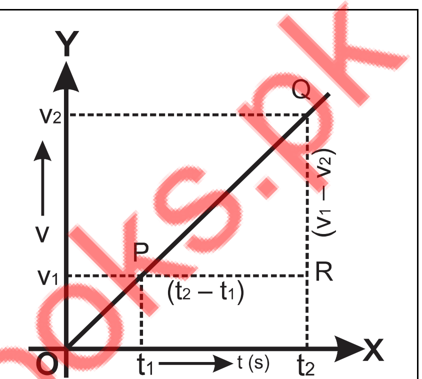


Fig: 2.21

Result:

This shows that when a car moves with constant acceleration, the velocity-time graph is a straight line which rises through same height for equal intervals of time.

(ii) Zero Acceleration (Constant Speed):

The graph (Fig. 2.22) is drawn to find its slope. The speed v_1 at time t_1 is the same as speed v_2 at time t_2, hence, the change in speed is also zero $v_2 - v_1 = 0$.

Thus,

$$Slope = \frac{(v_2 - v_1)}{(t_2 - t_1)} = 0$$

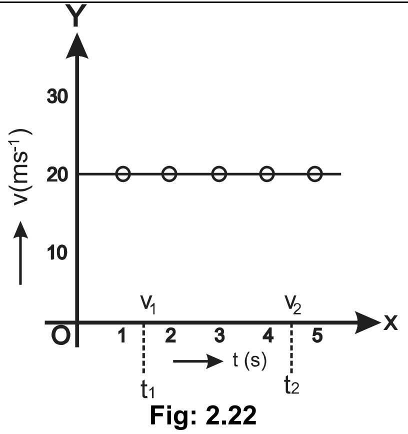


Fig: 2.22

When the speed of the object is constant, the speed-time graph is a horizontal straight line parallel to time axis.

Result:

This shows that the acceleration of this motion is zero. It is the motion without the change in speed.

2.11 Area Under Speed-Time Graph

Q.17 Prove that the area under speed-time graph is equal to the distance covered by an object. **Ex. Q. 2.6**

Ans: The distance moved by an object can also be determined by using its speed-time graph.

Example 1:

Figure 2.23 shows that the object is moving with constant speed v. For a time-interval t, the distance covered by the object as given by Eq.2.1 is $v\times t$.

This distance can also be found by calculating the area under the speed-time graph. The area under the graph for time interval t is the area of rectangle of sides t and v. This area is shown shaded in Fig.2.23 and is equal to $v\times t$. Thus, area under speed-time graph up to the time axis is numerically equal to the distance covered by the object in time t.

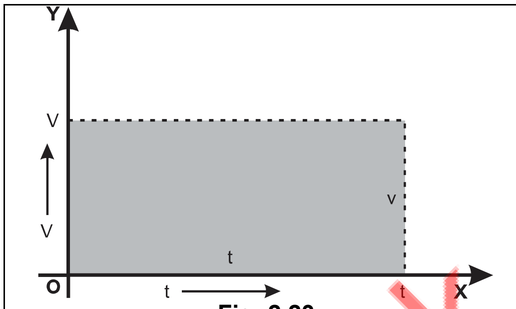


Fig: 2.23

Example 2:

Consider another example shown in Fig. 2.24. Here, the speed of the object increases uniformly from 0 to v in time t. The average speed is given by:

$$v_{av} = \frac{0+v}{2} = \frac{1}{2}v$$

Distance covered = average speed × time

$$= \frac{1}{2}v\times t$$

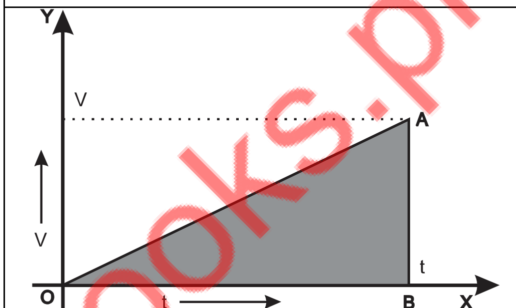


Fig: 2.24

If we calculate the area under speed-time graph, it is equal to the area of the right-angled triangle shown shaded in Fig. 2.24. The base of the triangle is equal to t and the perpendicular is equal to v.

Area of a triangle = 1/2 (perpendicular × base)$=\frac{1}{2}(v\times t)$

We see that this area is numerically equal to the distance covered by the object during the time interval t.

Result:

From example 1 and 2, it is proved that:

"The area under the speed-time graph up to the time axis is numerically equal to the distance covered by the object."

Mini Exercise

The distance-time graph shows the motion of three cyclist.

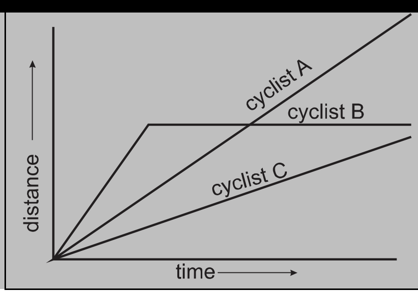
(a) What does each line on the graph represent?

Ans: Each line of graph represent the speed of cyclist A, B and C.

(b) Which cyclist travelled at the most distance?

Ans: In graph, cyclist B travelled at the most distance.

(c) Which cyclist travelled at the greatest speed? the lowest speed? at constant speed?



Ans: In graph;
Cyclist B travelled at the greatest speed because they give almost horinzontal slope.
Cyclist A travelled at the lowest speed.
Cyclist A and C travelled at the constant speed because they give straight slope.

2.12 Solving Problems for Motion Under Gravity

Q.18 Write three equations of motion. Also write assumption made for them.

Ans: Three equations of motion are used to solve problems for motion of bodies. If v_i is the initial velocity of the body, v_f is the final velocity, t is the time taken, S is the distance covered and a is the acceleration, then:

First equation of Motion: $v_f = v_i + at$

Second equation of Motion: $S = v_i t + \frac{1}{2}at^2$

Third equation of Motion: $2aS = v_f^2 - v_i^2$

Assumptions made for Equation of Motion:

While applying these equations, the following assumptions are made:

(i) Motion is always considered along a straight line
(ii) Only the magnitudes of vector quantities are used.
(iii) Acceleration is assumed to be uniform.
(iv) The direction of initial velocity is taken as positive. Other quantities in the direction opposite to the initial velocity are taken as negative.

2.13 Free Fall Acceleration

Q.19(a) How equations of motion can be applied to the bodies moving under the action of gravity? **Ex. Q.2.7**

(b) Write assumptions made for equation of motion under gravity.

(a) How equations of motion can be applied to the bodies moving under the action of gravity? **Ex. Q.2.7**

Ans: Gravitational Acceleration:

When a body is falling freely under the action of gravity of the Earth, the acceleration acting on it is the gravitational acceleration and is denoted by g.

Direction of Gravitational Acceleration:

The direction of gravitational acceleration g is always downwards.

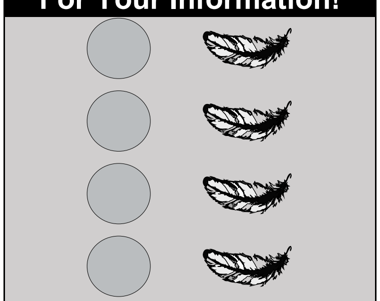
Value of Gravitational Acceleration:

Gravitational acceleration value is 9.8 ms^{-2}, but for convenience we shall use the value of g as 10 ms^{-2}.

Equation of Motion under the Action of Gravity:

Since the freely falling bodies move vertically downwards in a straight line with uniform acceleration *g,* so the three equations of motion can be applied to the motion of such bodies. While applying equations of motion, the acceleration a is replaced by *g.* Thus, equations of motion for freely falling bodies can be written as:

For Your Information!



Light and heavier objects when fall through vacuum, move side by side.

First equation of Motion under Gravity: $v_f = v_i + gt$

Second equation of Motion under Gravity: $S = v_i t + \frac{1}{2} g t^2$

Third equation of Motion under Gravity: $2gS = v_f^2 - v_i^2$

(b) Write assumptions made for equation of motion under gravity.

Ans: Assumptions made for Equation of Motion under Gravity:

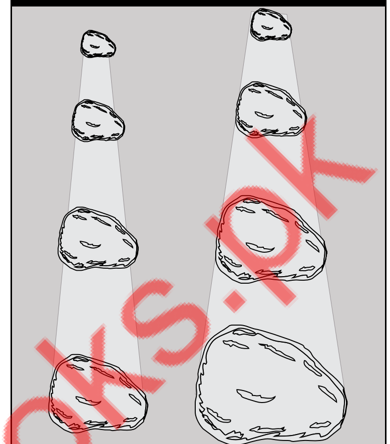
Assumptions made for equation of motion under gravity are:

(i) If a body is **released** from some height to fall freely, its initial velocity v_i will be taken as **zero**.

(ii) The gravitational acceleration g will be taken as **positive** in the **downward direction**. All other quantities will also be taken as positive in the **downward direction**. The quantities in the **direction opposite** to the acceleration will be taken as **negative**.

(iii) If a body is thrown **vertically upward**, the value of g will be **negative** and the **final velocity** will be **zero** at the highest point.

For Your Information!



Acceleration of free fall *g* is 10 ms^{-2} for all objects.

Q.20 Describe the speed of light according to Eienstein's theory of special relativity.

Ans: In 1905, famous scientist Albert Einstein proposed his revolutionary theory of special relativity which modified many of the basic concepts of physics.

Universal Constant:

According to his theory of special relativity, speed of light is a universal constant.

Value of Speed of Light:

Value of speed of light is approximately 3×10^8 ms^{-1}.

Universal Speed Limit:

Speed of light remains the same for all motions. Any object with mass cannot achieve speeds equal to or greater than that of light. This is known as universal speed limit.

KEY POINTS

- A **scalar** is that physical quantity which can be described completely by its magnitude only.
- A **vector** is that physical quantity which needs magnitude as well as direction to describe it completely.
- To add a number of vectors, redraw their representative lines such that the head of one line coincides with the tail of the other. The **resultant vector** is given by a single vector which is directed from the tail of the first vector to the head of the last vector.

- Translatory motion, rotatory motion and vibratory motions are **different types of motion**.
- **Position** of any object is its distance and direction from a fixed point.
- The shortest distance between the initial and final positions of a body is called its **displacement**.
- Distance covered by a body in a unit time is called its **speed**.
- Time rate of displacement of a body is called its **velocity**.
- The velocity is said to be uniform if the speed and direction of a moving body does not change, otherwise it is **non-uniform velocity**.
- Rate of change of velocity of a body is called its **acceleration**.
- If change of velocity with time is constant, the acceleration is said to be **uniform**, otherwise it is **non-uniform**.
- A graph that shows the relation between distance and time taken by a moving body is called a **distance-time graph**.
- A graph that shows the relation between the speed and time taken by a moving body is called a **speed-time graph**.
- **Gradient or slope** of the distance-time graph is equal to the average speed of the body. Slope of the speed-time graph is equal to the acceleration of the body.
- The **area under speed-time graph** is numerically equal to the distance covered by the object.
- Following are **three equations** of motion:

$$v_f = v_i + at$$

$$S = v_i t + \frac{1}{2}at^2$$

$$2aS = v_f^2 - v_i^2$$

- **Gravitational acceleration** g acts downward on bodies falling freely. The magnitude of g is 10 ms^{-2}.

IMPORTANT FORMULAE

Speed: $v = \frac{S}{t}$

Gravitational acceleration: g = 10 ms^{-2}

Average speed: $\vec{v}_{av} = \frac{\vec{d}}{t}$

$$Average\,Velocity = \frac{Total\ Distance\ Covered}{Total\ Time\ Taken}$$ or $$v_{av} = \frac{S}{t}$$

Slope of the Graph line: $\tan\theta = \frac{S}{t}$

Average aceleration: $a = \frac{v_f - v_i}{t}$

First equation of Motion: $v_f = v_i + at$

Second equation of Motion: $S = v_i t + \frac{1}{2}at^2$

Third equation of Motion: $2aS = v_f^2 - v_i^2$

First equation of Motion under Gravity: $v_f = v_i + gt$

Second equation of Motion under Gravity: $S = v_i t + \frac{1}{2}gt^2$

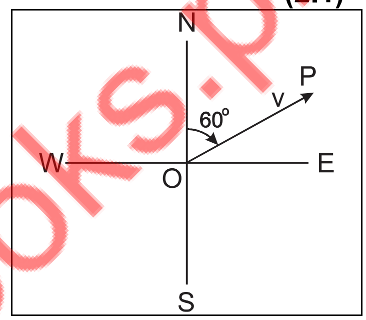
Third equation of Motion under Gravity: $2gS = v_f^2 - v_i^2$

SOLVED EXAMPLES

Example 2.1

Draw the velocity vector *v*, a velocity of 300 ms^{-1} at an angle of 60° to the east of north. (2.1)

Solution:



i. Draw two mutually perpendicular lines indicating N, S, E & W.

ii. Select a suitable scale. If 100 ms^{-1} = 1 cm, then 300 ms^{-1} are represented by 3 cm line.

iii. Draw 3 cm line OP at an Angle of 60° starting from N towards E.

iv. Make an arrow head at the end of line OP. The OP is the vector **S**.

Example 2.2

Draw a force vector F having magnitude of 350 N and acting at an angle of 60° with x-axis. (2.1)

Solution:

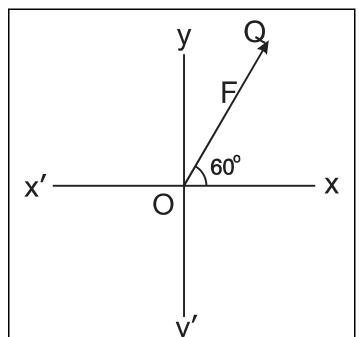


Fig 2.3

(i) Draw horizontal and vertical lines to represent x-axis and y-axis (Fig. 2.3).

(ii) Scale: If 100 N = 1 cm, then 350 N = 3.5 cm.

(iii) Draw 3.5 cm line OQ at an angle of 60° with x-axis.

(iv) Make an arrow head at the end of the line OQ. The OQ is the vector **F.**

Example 2.3

An eagle dives to the ground along a 300 m path with an average speed of 60 ms^{-1}. How long does it take to cover this distance? (2.5)

Solution: Given Data:

Total distance covered = S = 300 m

Average speed = v_{av} = 60 m s^{-1}

$$v_{av} = \frac{S}{t}$$

To Find:

Total time taken = t = ?

Calculations:

Using the equation

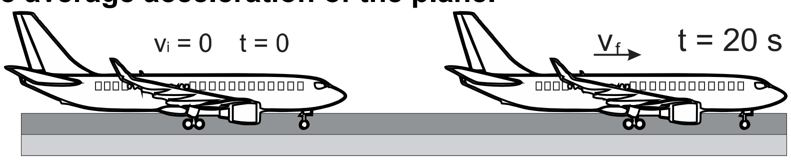
or $t = \dfrac{S}{v_{av}}$

By putting these values

$$t = \frac{300\,m}{60\,ms^{-1}} = 5\,s$$

Example 2.4

A plane starts running from rest on a run-way as shown in the figure below. It accelerates down the run-way and after 20 seconds attains a velocity of 252 kmh^{-1}. Determine the average acceleration of the plane. (2.6)



Solution: Given Data:

Initial velocity = v_i=0 ms^{-1}

Final velocity = v_f = 252 kmhr^{-1}

$$= \frac{252\times10^3\,m}{60\times60\,s} = 70\,ms^{-1}$$

Time taken = t =20 s

To Find:

Average acceleration $= a_{av} = ?$

Calculations:

Using formula

$$a_{av} = \frac{v_f - v_i}{t}$$

Putting the values

$$a_{av} = \frac{v_f - v_i}{t}$$

$$a_{av} = \frac{70\,ms^{-1} - 0\,ms^{-1}}{20\,s}$$

$$a_{av} = 3.5\,ms^{-2}$$

Example 2.5

An iron bob is dropped from the top of a tower. It reaches the ground in 4 seconds. Find: (a) the height of the tower (b) the velocity of the ball as it strikes the ground. (2.13)

Ans: Given Data:

For freely falling body:

Initial velocity $= v_i = 0\,ms^{-1}$

Acceleration $= g = 10\,ms^{-2}$

Time $= t = 4\,s$

To Find:

Height (distance) $= S = h = ?$

Final velocity $= v_f = ?$

Calculations:

(a) According to second equation of motion under gravity

$$S = v_i t + \frac{1}{2}gt^2$$

Putting the values,

$$h = 0\times4\,s + \frac{1}{2}\times10\,ms^{-2}\times(4\,s)^2$$

$$h = 80\,m$$

(b) From the first equation of motion under gravity, we have

$$v_f = v_i + gt$$

Putting the values

$$v_f = 0 + 10\,ms^{-2}\times4\,s = 40\,ms^{-1}$$

Example 2.6

An arrow is thrown vertically upward with the help of a bow. The velocity of the arrow when it leaves the bow is 30 ms^{-1}. Determine time to reach the highest point? Also, find the maximum height attained by the arrow. (2.13)

Ans: Given Data:

Initial velocity $= v_i = 30\,ms^{-1}$

Final velocity $= v_f = 0\,ms^{-1}$

Here, acceleration will be taken as negative, for the arrow is thrown vertically upward.

Acceleration $= g = -10\,ms^{-2}$

To Find:

a) Time $= t = ?$

b) Height (distance) $= S = h = ?$

Calculations:

a) From first equation of motion under gravity

$$v_f = v_i + gt$$

$$t = \frac{v_f - v_i}{g}$$

Putting the values

$$t = \frac{0 - 30\,ms^{-1}}{-10\,ms^{-2}} = 3\,s$$

b) Now, from the third equation of motion under gravity

$$2gS = v_f^2 - v_i^2$$

$$S = \frac{v_f^2 - v_i^2}{2g}$$

Putting the values,

$$S = \frac{0 - (30\,ms^{-1})^2}{2 \times (-10\,ms^{-2})} = \frac{-900\,m^2s^{-2}}{-20\,ms^{-2}}$$

$$S = 45\,m$$

EXERCISE

A Multiple Choice Questions

1. Tick (✓) the correct answer.

2.1 The numerical ratio of displacement to distance is: (2.4)

(a) always less than one ✓ (b) always equal to one
(c) always greater than one (d) equal to or less than one

2.2 If a body does not change its position with respect to some fixed point, then it will be in a state of: (2.1)

(a) rest ✓ (b) motion (c) uniform motion (d) variable motion

2.3 A ball is dropped from the top of a tower, the distance covered by it in the first second is: (2.13)

(a) 5 m ✓ (b) 10 m (c) 50 m (d) 100 m

2.4 A body accelerates from rest to a velocity of 144 kmh^{-1} in 20 seconds. Then the distance covered by it is: (2.12)

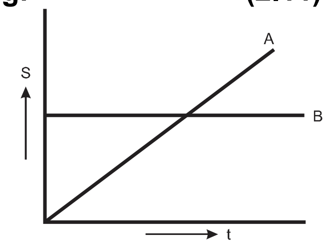
(a) 100 m (b) 400 m ✓ (c) 1400 m (d) 1440 m

2.5 A body is moving with constant acceleration starting from rest. It covers a distance S in 4 seconds. How much time does it take to cover one-fourth of this distance? (2.12)

(a) 1 s ✓ (b) 2 s (c) 4s (d) 16 s

2.6 The displacement time graphs of two objects A and B are shown in the figure. Point out the true statement from the following: (2.11)

(a) The velocity of A is greater than B
(b) The velocity of A is less than B
(c) The velocity of A is equal to that of B
(d) The graph gives no information in this regard ✓



2.7 The area under the speed-time graph is numerically equal to: (2.11)

(a) velocity (b) uniform velocity (c) acceleration (d) distance covered ✓

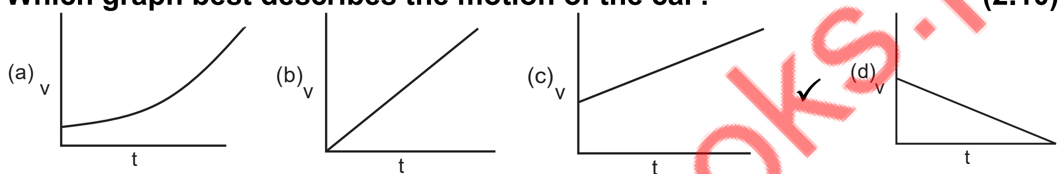
2.8 Gradient of the speed-time graph is equal to: (2.10)

(a) speed (b) velocity (c) acceleration ✓ (d) distance covered

2.9 Gradient of the distance-time graph is equal to the: (2.8)

(a) speed ✓ (b) velocity (c) distance covered (d) acceleration

2.10 A car accelerates uniformly from 80.5 kmh^{-1} at t = 0 to 113 kmh^{-1} at t = 9 s. Which graph best describes the motion of the car? (2.10)



B Short Answer Questions

2.1 Define scalar and vector quantities. (2.1)

Ans: Scalar Quantity: A scalar is that physical quantity which can be described completely by its **magnitude** only.

Examples: Distance, length, time, speed, energy and temperature are scalars.

Vector Quantities: A vector is that physical quantity which needs **magnitude** as well as **direction** to describe it completely.

Examples: Displacement, velocity, acceleration, weight and force etc are vectors.

2.2 Give 5 examples each for scalar and vector quantities. (2.1)

Ans: Scalar Quantity:

Distance, length, time, speed, energy and temperature are scalars.

Vector Quantities:

Displacement, velocity, acceleration, weight and force are vectors.

2.3 State head-to-tail rule for addition of vectors. (2.1)

Ans: To add a number of vectors, redraw their representative lines such that the head of one line coincides with the tail of the other. The resultant vector is given by a single vector which is directed from the tail of the first vector to the head of the last vector.

2.4 What are distance - time graph and speed-time graph? (2.7+2.9)

Ans: Distance-Time Graph: Distance-time graph shows the relation between distance S and time t taken by a moving body.

Speed-Time Graph: Speed-time graph shows the relation between speed v and time t taken by a moving body.

2.5 Falling objects near the Earth have the same constant acceleration. Does this imply that a heavier object will fall faster than a lighter object? (2.13)

Ans: No, a heavier object will not fall faster than a lighter object if they are dropped from the same height and air resistance is negligible. This is because the acceleration due to gravity is constant for all objects, regardless of their mass.

2.6 The vector quantities are sometimes written in scalar notation (not bold face). How is the direction indicated? (2.11)

Ans: Sometimes vector quantities are written in scalar notation, then their direction is indicated by the sign with the number. If there is a **plus sign** then vector points **right or up**, and if there is a **minus sign** then vector points **left or down**.

2.7 A body is moving with uniform speed. Will its velocity be uniform? Give reason. (2.5)

Ans: A body is moving with uniform speed. There are two situtations. If:

a) Motion of the body is linear (one direction), then velocity will also be uniform.

b) Motion of the body is non-linear (random or circular motion), then velocity will not be uniform. It is because the body is changing its direction during motion.

2.8 Is it possible for a body to have acceleration? When moving with:

(i) constant velocity (ii) constant speed (2.6)

Ans:

(i) **Constant Velocity:** A body moving with constant velocity has zero acceleration. This is because the **magnitude** and **direction** of the velocity vector remain **constant**, Therefore, it is not possible for a body to have acceleration.

(ii) **Constant Speed:** As, constant speed is equal to the magnitude of the velocity (vector quantity). It does not discuss the direction of body. Therefore, it is **possible** for a body to have **acceleration**.

Example: In uniform circular motion, a body moves at a **constant speed** but **have acceleration** due to the **change in direction**.

C Constructed Response Questions

2.1 Distance and displacement may or may not be equal in magnitude. Explain this statement. (2.4)

Ans: **Distance:** The distance is the length of actual path of the motion.

Displacement: The magnitude of displacement is the shortest distance between the initial and final positions of the motion.

Explanation: Distance and displacement may be equal in magnitude if in **one direction**. In other word, if distance is the **shortest path** between two points, then it is same as displacement.

If path between two point is **not a straight path** then distance and displacement are not equal in magnitude.

2.2 When a bullet is fired, its velocity with which it leaves the barrel is called the muzzle velocity of the gun. The muzzle velocity of one gun with a longer barrel is lesser than that of another gun with a shorter barrel. In which gun is the acceleration of the bullet larger? Explain your answer. (2.6)

Ans: The gun with the shorter barrel has a larger acceeratiion of the bullet.

Explanation: The muzzle velocity of the bullet depends on both the acceleration imparted to the bullet and the time the force is applied (which depends on the length of barrel).

In the gun with the longer barrel, the force acts over a long time, allowing the bullet to reach a given velocity more gradually. Conversely, in the gun with the shorter barrel, the force acts for a shorter time requiring a large acceleration to achieve a higher muzzle velocity in that shorter duration.

2.3 For a complete trip, average velocity was calculated. Its value came out to be positive. Is it possible that its instantaneous velocity at any time during the trip had the negative value? Give justification of your answer. (2.5)

Ans: Yes, it is possible for the instantaneous velocity at same point during the trip to have a negative value, even if the average velocity for the entire trip is positive.

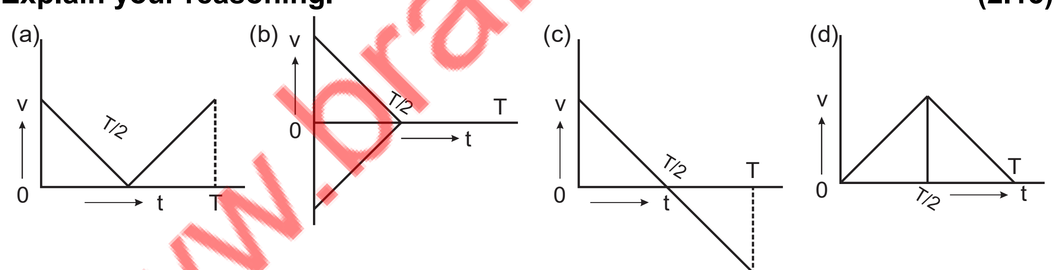
Justification: The average velocity is calculated as:

$$Average\ Velocity = \frac{Net\ Displacement}{Total\ Time\ Taken}$$

If the average velocity is positive, it means that the net displacement over the entire trip is in the positive direction. However, it does not guarantee that the instantaneous velocity is always positive through out trip.

Example: In cases like a pendulum or a car on winding road, the instantaneous velocity can change direction. But as long as the net displacement over the total time is poisitive, the average velocity will also be positive.

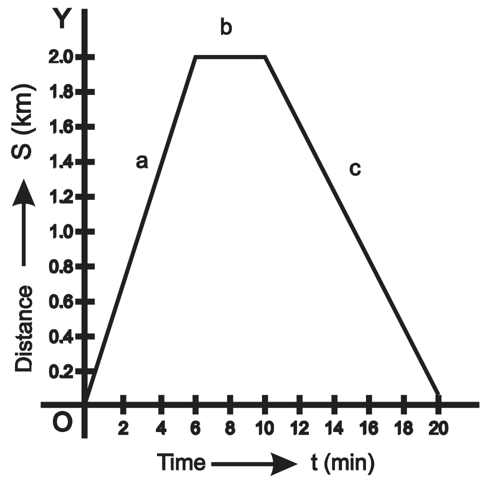
2.4 A ball is thrown vertically upward with velocity v. It returns to the ground in time T. Which of the following graphs correctly represents the motion? Explain your reasoning. (2.13)



Ans: Graph "d" correctly represents the motion.

Reason: When a ball is thrown vertically upward with velocity v, its motion is subject to gravity, which causes it to decelerate as it moves upwrd, momentarily stop at the highest point, and accelerates back downward.

2.5 Figure given below shows the distance - time graph for the travel of a cyclist. Find the velocities for the segments a, b and c. (2.5)



Ans: From the given figure, velocity of a cyclist along point "a"" is increasing, while moving along point "b" velocity of the cyclist is constant and velocity of the cyclist along point C is decreasing.

2.6 Is it possible that the velocity of an object is zero at an instant of time, but its acceleration is not zero? If yes, give an example of such a case. (2.6)

Ans: Yes, it is possible for the velocity of an object to be zero at an instant of time while its acceleration is not zero.

Example:

In SHM (simple harmonic motion), at the exterem points, the ball stay a while i.e., velocity at that point is zero but acceleration is not zero (maximum).

D Comprehensive Questions

2.1 How a vector can be represented graphically? Explain. (2.1)

Ans: For answer, See Question # 3(b)

2.2(i) Differentiate between rest and motion. (2.2)

Ans: For answer, See Question # 5(a)

2.2(ii) Differentiate between speed and velocity. (2.5)

Ans: For answer, See Question # 8(a) and 9(a)

2.3 Describe different types of motion. Also give examples. (2.3)

Ans: For answer, See Question # 6(a)

2.4 Explain the difference between distance and displacement. (2.4)

Ans: For answer, See Question # 7

2.5 What do gradients of distance-time graph and speed-time graph represent? Explain it by drawing diagrams. (2.8+2.10)

Ans: For answer, See Question # 14 and 16

2.6 Prove that the area under speed-time graph is equal to the distance covered by an object. (2.11)

Ans: For answer, See Question # 17

2.7 How equations of motion can be applied to the bodies moving under the action of gravity? (2.13)

Ans: For answer, See Question # 19(a)

E Numerical Problems

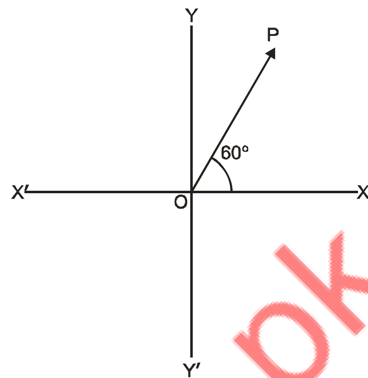
2.1 Draw the representative lines of the following vectors: (2.1)

(a) A velocity of 400 ms^{-1} making an angle of 60° with x-axis.

(b) A force of 50 N making an angle of 120° with x-axis.

Solution: Calculations:

(a) A velocity of 400 ms^{-1} making an angle of 60° with x-axis.



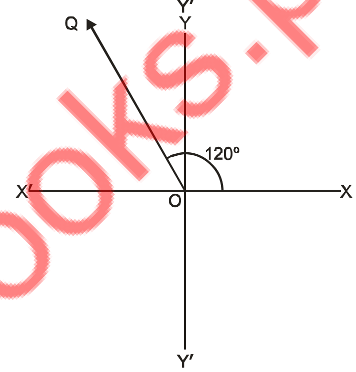
i) Draw horizontal and vertical lines to represent x-axis and y-axis.

ii) **Scale:** If 100 ms^{-1} = 1 cm, then 400 ms^{-1} = 4 cm.

iii) Draw 4 cm line OP at an angle of 60° with x-axis.

iv) Make an arrow head at the end of the line OP. The OP is the velocity.

(b) A force of 50 N making an angle of 120° with x-axis.



i) Draw horizontal and vertical lines to represent x-axis and y-axis.

ii) **Scale:** If 10 N = 1 cm, then 50 N = 5 cm.

iii) Draw 5 cm line OQ at an angle of 120° with x-axis.

iv) Make an arrow head at the end of the line OQ. The OQ is the vector force.

2.2 A car is moving with an average speed of 72 kmh^{-1}. How much time will it take to cover a distance of 360 km? (2.5)

(5 h)

Solution: Given Data:

Average speed $= v_{av} = 72\,kmh^{-1}$

Distance $= d = 360\,km$

To Find:

Time $= t = ?$

Calculations:

As, we know that

$$v_{av} = \frac{d}{t}$$

then

$$t = \frac{d}{v_{av}}$$

Putting the values

$$= \frac{360\,km}{72\,kmh^{-1}}$$

$$t = 5\,h$$

2.3 A truck starts from rest. It reaches a velocity of 90 kmh^{-1} in 50 seconds. Find its average acceleration. (2.6)

(0.5 ms^{-2})

Solution: Given Data:

Initial velocity $= v_i = 0\,ms^{-1}$

(Truck starts from rest)

Final velocity $= v_f = 90\,kmh^{-1}$

$= \dfrac{90 \times 1000\,m}{60 \times 60 s}$

$= \dfrac{900000\,m}{3600\,s} = 25\,ms^{-1}$

Time $= t = 50\,s$

To Find:

Average acceleration $= a = ?$

Calculations:

By definition of acceleration

$$a = \frac{v_f - v_i}{t}$$

Putting the values,

$$a = \frac{25\,ms^{-1} - 0\,ms^{-1}}{50\,s} = \frac{25\,ms^{-1}}{50\,s}$$

$$a = 0.5\,ms^{-2}$$

2.4 A car passes a green traffic signal while moving with a velocity of 5 ms^{-1}. It then accelerates to 1.5 ms^{-2}. What is the velocity of car after 5 seconds? (2.12)

(12.5 ms^{-1})

Solution: Given Data:

Initial velocity $= v_i = 5\,ms^{-1}$

Acceleration $= a = 1.5\,ms^{-2}$

Time $= t = 5\,s$

To Find:

Final velocity $= v_f = ?$

Calculations:

By Newton's first equation of motion

$$v_f = v_i + at$$

Putting the values,

$$v_f = 5\,ms^{-1} + \left(1.5\,ms^{-2}\right)\left(5\,s\right)$$

$$v_f = 5\,ms^{-1} + 7.5\,ms^{-1} = 12.5\,ms^{-1}$$

2.5 A motorcycle initially travelling at 18 kmh^{-1} accelerates at constant rate of 2 ms^{-2}. How far will the motorcycle go in 10 seconds? (2.12)

(150 m)

Solution: Given Data:

Initial velocity $= v_i = 18\,kmh^{-1}$

$v_i = \dfrac{18 \times 1000}{60 \times 60} ms^{-1}$

$v_i = \dfrac{18000}{3600} ms^{-1} = 5\,ms^{-1}$

Acceleration $= a = 2\,ms^{-2}$

Time $= t = 10\,s$

To Find:

Distance covered $= S = ?$

Calculations:

By Newton's Second equation of motion

$$S = v_i t + \frac{1}{2} a t^2$$

Putting the values,

$$S = 5\,ms^{-1} \times 10\,s + \frac{1}{2}\left(2\,ms^{-2}\right)\left(10\,s\right)^2$$

$$= 50\,m + 100\,m$$

$$S = 150\,m$$

2.6 A wagon is moving on the road with a velocity of 54 kmh^{-1}. Brakes are applied suddenly. The wagon covers a distance of 25 m before stopping. Determine the acceleration of the wagon. (2.12)

(–4.5 ms^{-2})

Solution: Given Data:

Initial velocity $= v_i = 54\,kmh^{-1}$

$$v_i = \frac{54\times 1000}{60\times 60}ms^{-1}$$

$$v_i = \frac{54000}{3600}ms^{-1} = 15\,ms^{-1}$$

Final velocity $= v_f = 0\,ms^{-1}$ (at rest)

Distance covered $= S = 25\,m$

To Find:

Acceleration $= a = ?$

Calculations:

By Newton's third equation of motion

$$2aS = v_f^2 - v_i^2$$

$$a = \frac{v_f^2 - v_i^2}{2S}$$

Putting the values

$$= \frac{\left(0\,ms^{-1}\right)^2 - \left(15\,ms^{-1}\right)^2}{2\left(25\,m\right)}$$

$$a = \frac{0\,m^2s^{-2} - 225\,m^2s^{-2}}{50\,m} = \frac{-225\,m^2s^{-2}}{50\,m}$$

$$a = -4.5\,ms^{-2}$$

Negative sign indicates that the velocity is decreasing.

2.7 A stone is dropped from a height of 45 m. How long will it take to reach the ground? What will be its velocity just before hitting the ground? (2.12)

(3 s, 30 ms^{-1})

Solution: Given Data:

Height $= S = h = 45\,m$

Initial velocity $= v_i = 0\,ms^{-1}$ (at rest)

Acceleration $= a = g = 10\,ms^{-2}$

To Find:

a) Time $= t = ?$

b) Final velocity $= v_f = ?$

Calculations:

a) By Newton's second equation of motion freely falling:

$$S = v_i t + \frac{1}{2}gt^2$$

Putting the values

$$45\,m = (0)(t) + \frac{1}{2}\left(10\,ms^{-2}\right)t^2$$

$$45\,m = 0 + \left(5\,ms^{-2}\right)t^2$$

$$t^2 = \frac{45\,m}{5\,ms^{-2}} = 9\,s^2$$

$$t = \pm 3\,s$$

Since, time is always taken positive.

$$t = 3\,s$$

b) Now, By Newton's first equation of motion under gravity

$$v_f = v_i + gt$$

Putting the values,

$$v_f = 0 + \left(10\,ms^{-2}\right)\left(3\,s\right)$$

$$v_f = 30\,ms^{-1}$$

2.8 A car travels 10 km with an average velocity of 20 m s^{-1}. Then it travels in the same direction through a diversion at an average velocity of 4 ms^{-1} for the next 0.8 km. Determine the average velocity of the car for the total journey. (2.5)

(15.4 ms^{-1})

Solution: Given Data:

Distance travelled in first spell

$= S_1 = 10\,km = 10 \times 1000\,m$

$= 10,000\,m$

Average velocity in first spell

$= v_1 = 20\,ms^{-1}$

Distance travelled in second spell

$= S_2 = 0.8\,km = 0.8 \times 1000\,m$

$= 800\,m$

Average velocity in second spell

$= v_2 = 4\,ms^{-1}$

To Find:

Average velocity during total journey

$= v_{av} = ?$

Calculations:

Time Interval for First Spell of Travelling:

As, $v = \frac{S}{t}$

$\Rightarrow \quad S_1 = v_1 \times t_1$

$$10,000\,m = \left(20\,ms^{-1}\right) \times t_1$$

$$t_1 = \frac{10,000\,m}{20\,ms^{-1}} = 50\,s$$

Time Interval for Second Spell of Travelling:

$$S_2 = v_2 \times t_2$$

$$800\,m = \left(4\,ms^{-1}\right) \times t_2$$

$$t_2 = \frac{800\,m}{4\,ms^{-1}} = 20\,s$$

Now, average velocity for total distance

$$Average\,Velocity = \frac{Total\,Distance\,Covered}{Total\,Time\,Taken}$$

$$v_{av} = \frac{S_1 + S_2}{t_1 + t_2}$$

$$= \frac{10,000\,m + 800\,m}{50\,s + 20\,s} = \frac{10,800\,m}{70\,s}$$

$$v_{av} = 15.4\,ms^{-1}$$

2.9 A ball is dropped from the top of a tower. The ball reaches the ground in 5 seconds. Find the height of the tower and the velocity of the ball with which it strikes the ground. (2.13)

(125 m, 50 ms^{-1})

Solution: Given Data:

Initial velocity $= v_i = 0\,ms^{-1}$ (ball at rest)

Time taken $= t = 5\,s$

Gravitional acceleration $= g = 10\,ms^{-2}$

To Find:

a) Height of tower $= h = ?$

b) Final velocity $= v_f = ?$

Calculations:

a) By Newton's second equation of motion under gravity

$$h = v_i t + \frac{1}{2} g t^2$$

Putting the values

$$h = \left(0\,ms^{-1}\right)t + \frac{1}{2}\left(10\,ms^{-2}\right)\left(5\,s\right)^2$$

$$h = 0 + \left(5\,ms^{-2}\right)\left(25\,s^2\right)$$

$$h = 125\,m$$

b) By Newton's first equation of motion under gravity

$$v_f = v_i + gt$$

Putting the values,

$$v_i = \left(0\,ms^{-1}\right) + \left(10\,ms^{-2}\right)\left(5\,s\right)$$

$$v_f = 50\,ms^{-1}$$

2.10 A cricket ball is hit so that it travels straight up in the air. An observer notes that it took 3 seconds to reach the highest point. What was the initial velocity of the ball? If the ball was hit 1 m above the ground, how high did it rise from the around? (2.13)

(30 ms^{-1}, 46 m)

Solution: Given Data:

Time taken $= t = 3s$

Gravitational acceleration

$= g = -10ms^{-2}$ (Upward motion)

Height from the ground to the point from bat from maximum height

$= h_1 = 1m$

Final velocity $= v_f = 0ms^{-1}$

(at maximum height the ball stopping while a moment)

To Find:

a) Initial velocity $= v_i = ?$

b) Total height of the ball from ground $= H = ?$

Calculations:

a) By Newton's first equation of motion under gravity

$$v_f = v_i + gt$$

$$\Rightarrow v_i = v_f - gt$$

Putting the values

$$v_i = (0ms^{-1}) - (-10ms^{-2})(3s)$$

$$v_i = 30ms^{-1}$$

b) Find the height of ball to hit the ball after hitting the bat

By Newton's second equation of motion under gravity

$$h = v_i t + \frac{1}{2}gt^2$$

For this $v_i = 0ms^{-1}$

(at this point ball stop while a moment or starting its downward motion at maximuim height ball stopping while a moment)

Putting the values

$$h = (0ms^{-1})t + \frac{1}{2}(10ms^{-2})(3s)^2$$

$$h = 0 + (5ms^{-2})(9s^2)$$

$$h = 45m$$

Now, total height from the ground to the maximum height is equal to the sum of height of bat from ground and the ball hitting from bat to the maximum height.

$$H = h_1 + h = 1m + 45m$$

$$H = 46m$$

General MCQs with Conceptual Questions (CQs)

2.0 Introduction

1. Mechanics is divided into _____ branches.

(A) Two ✓ (B) Three (C) Four (D) Five

2. _____ is the study of motion of objects without referring to forces.

(A) Dynamics (B) Mechanics (C) Kinematics ✓ (D) Astronomy

2.1 Scalars and Vectors

3. Which of the following is a vector quantity? (CQs)

(A) Mass (B) Weight ✓ (C) Speed (D) Work

4. Which is not example of scalar quantity? (CQs)

(A) Force ✓ (B) Mass (C) Work (D) Density

5. **Distance is a quantity.** **(CQs)**

(A) Vedctor (B) Vector and scalar (C) Scalar ✓ (D) Base

6. **Which is a scalar quantity?**

(A) Acceleration (B) Energy ✓ (C) Velocity (D) Weight

7. **How many methods are to represent a vector?**

(A) One (B) Two ✓ (C) Three (D) Four

8. **The number of vectors that can be added by head to tail rule is:**

(A) 2 (B) 3 (C) 5 (D) Any number ✓

9. **Which quantity is an example of scalar quantity?** **(CQs)**

(A) Length ✓ (B) Veloctiy (C) Torque (D) Displacement

10. **A single vector having same effect as all the original vector taken together is:**

(A) Unit vector (B) Resultant vector ✓
(C) Position vector (D) Equal vector

2.2 Rest and Motion

11. **If a body does not change its position with respect to its surroundings, it is said to be at:**

(A) Translatory motion (B) Rotatory motion
(C) Rest ✓ (D) Motion

2.3 Types of Motion

12. **The motion of body in straight line is:**

(A) Random motion (B) Circular motion
(C) Linear motion ✓ (D) Translatory motion

13. **The motion of steering wheel is:** **(CQs)**

(A) Random (B) Rotatory ✓ (C) Vibratory (D) Linear

14. **See - saw game is example of ____ motion.** **(CQs)**

(A) Rotatory (B) Circular (C) Random (D) Vibratory ✓

15. **The motion of the pendulum of a clock is:**

(A) Rotatory (B) Vibratory ✓ (C) Linear (D) Random

17. **A body has translatory motion if it moves along a:**

(A) straight line (B) circle
(C) line without rotation (D) all are right ✓

18. **The motion of a body about an axis is called:**

(A) circular motion (B) rotatory motion ✓
(C) vibratory motion (D) random motion

19. **How many types of translatory motion?** **(CQs)**

(A) One (B) Two (C) Three ✓ (D) Four

20. **Motion of a fan is:**

(A) Circular motion (B) Linear motion
(C) Vibratory motion (D) Rotatory motion ✓

21. **Motion of swing is:**

(A) Rotatory motion (B) Circular motion
(C) Vibratory motiion ✓ (D) Translatory motion

22. Motion of top is:
(A) Circular motion (B) Rotatory motion ✓
(C) Vibratory motion (D) Linear motion

23. Motion of Ferris wheel is:
(A) Circular motion ✓ (B) Random motion
(C) Rotatory motion (D) Vibratory motion

24. Which of the following is example of vibratory motion? (CQs)
(A) Motion of fan (B) Motion of Ferris wheel
(C) Motion of swing ✓ (D) Motion of train

25. Example of circular motion is:
(A) Motion of swing (B) Motion of Ferris wheel ✓
(C) Motion of fan (D) Motion of train

2.4 Distance and Displacement

26. The product of velocity and time is equal to:
(A) Mass (B) Force (C) Acceleration (D) Distance ✓

27. Length of actual path of the motion is called:
(A) Distance ✓ (B) Displacement (C) Speed (D) Velocity

28. Shortest distance between two points is called:
(A) Acceleration (B) Displacement ✓ (C) Distance (D) Speed

29. SI unit of displacement is:
(A) m/s (B) m/s^2 (C) m ✓ (D) m^2

30. SI unit of distance is same as:
(A) Velocity (B) Acceleration (C) Speed (D) Displacement ✓

2.5 Speed and Velocity

31. One meter per second is equal to:
(A) 3.6 km/h ✓ (B) $\frac{1}{3.6} km/h$ (C) 6.3 km/h (D) $\frac{1}{6.3} km/h$

32. A sprinter completes its 100 metre race in 12s its average speed will be: (CQs)
(A) $100\ ms^{-1}$ (B) $12\ ms^{-1}$ (C) $8\ ms^{-1}$ (D) $8.33\ ms^{-1}$ ✓

33. In SI unit, units of speed is:
(A) kmh^{-1} (B) kmh (C) ms^2 (D) ms^{-1} ✓

34. Unit of velocity is:
(A) meter (B) second
(C) Meter per second ✓ (D) Meter per second square

35. Cheeta can run at a speed of:
(A) $200\ kmh^{-1}$ (B) $110\ kmh^{-1}$ ✓ (C) $100\ kmh^{-1}$ (D) $120\ kmh^{-1}$

36. A train is moving at a speed of $72\ kmh^{-1}$. Its speed expressed in ms^{-1} is:
(A) $25\ ms^{-1}$ (B) $20\ ms^{-1}$ ✓ (C) $10\ ms^{-1}$ (D) $5\ ms^{-1}$

37. The formula of velocity is:

(A) $\mathbf{v} = \frac{t}{\mathbf{d}}$ (B) $\mathbf{v} = \frac{\mathbf{d}}{t}$ ✓ (C) $\mathbf{v} = \mathbf{d} + t$ (D) $\mathbf{v} = h + t$

38. The fastest land mammal is:
(A) Horse (B) Dog (C) Cheetah ✓ (D) Bear

39. Which fish is fastest?
(A) Dolpin (B) Sailfish ✓ (C) Starfish (D) Tuna fish

40. Speed of cheetah is same as speed of:
(A) Dog (B) Starfish (C) Sailfish ✓ (D) Deer

41. Formula for average speed is:
(A) $v_{av} = \frac{S}{t}$ ✓ (B) $v_{av} \times S = t$ (C) $v_{av} = \frac{t}{S}$ (D) $v_{av} = S \times t$

42. Speed has same SI unit as:
(A) Acceleration (B) Displacement (C) Distance (D) Velocity ✓

43. The net displacement of a body in unit time is called:
(A) Speed (B) Velocity ✓
(C) Acceleration (D) Uniform acceleration

2.6 Acceleration

43. The unit of acceleration is:
(A) Nm (B) ms^{-2} ✓ (C) ms^{-1} (D) kgm^{-1}

45. $\frac{v_f - v_i}{t}$ is equal to:
(A) a ✓ (B) S (C) h (D) 2aS

46. The velocity of a body changes with constant rate, then acceleration is:
(A) Negative (B) Positive (C) Zero (D) Constant ✓

47. A body is moving with uniform velocity, its acceleration will be:
(A) Variable (B) Zero ✓ (C) Uniform (D) Positive

48. An acceleration of 1.5 ms^{-2} expressed in kmh^{-2} is:
(A) 324 kmh^{-2} (B) 19440 kmh^{-2} ✓ (C) 5400 kmh^{-2} (D) 414 kmh^{-2}

2.7 Graphical Analysis of Motion

49. The point where the two axes intersect each other is known as:
(A) Origin ✓ (B) Negative (C) Positive axes (D) y-axis

50. The slope of distance time graph shows:
(A) Velocity (B) Speed ✓ (C) Acceleration (D) Momentum

2.8 Gradient of a Distance-Time Graph

51. The gradient is the measure of slope of a:
(A) Curve (B) Graph (C) Line ✓ (D) Axes

52. Gradient of the distance-time graph is equal to the average _____ of the body.
(A) Velocity (B) Acceleration (C) Displacement (D) Speed ✓

2.9 Speed time graph

53. The slope of speed-time graph shows:

(A) Total distance covered (B) Average acceleration
(C) Intantaneous acceleration ✓ (D) Variable acceleration

2.10 Gradient of a Speed-Time Graph

54. When the body moves with onstant acceleration, the speed-time graph is:

(A) Parabola (B) Hyperbola (C) Curve (D) Straight line ✓

55. The area under speed-time graph is equal to:

(A) Distance ✓ (B) Power (C) Force (D) Work

56. If speed-time graph is parallel to time axis, the acceleration of moving body will be:

(A) Maximum (B) Positive (C) Negative (D) Zero ✓

57. Gradient of the speed-time graph is equal to the average _____ of the body.

(A) Velocity (B) Displacement (C) Acceleration ✓ (D) Speed

2.11 Area Under Speed-Time Graph

58. Area of a triangle is equal to:

(A) Perpendicular × base (B) Perpendicular + base
(C) $\frac{1}{2}$ (Perpendicular × base) ✓ (D) $\frac{1}{2}$ (Perpendicular + base)

59. Area of rectangle is equal to:

(A) Length + width (B) Length × width ✓
(C) $\frac{1}{2}$ (Length + width) (D) $\frac{1}{2}$ (Length × width)

2.12 Solving Problems for Motion Under Gravity

60. 3rd equation of motion is:

(A) $S = vt$ (B) $v_f = v_i + at$ (C) $2aS = v_f^2 - v_i^2$ ✓ (D) $F = ma$

61. The correct equation of motion will be:

(A) $v_f{}^2 + v_i{}^2 = a^2t^2$ (B) $v_f{}^2 - v_i{}^2 = a^2t^2$ (C) $v_f - v_i = at$ ✓ (D) $v_f + v_i = at$

62. In first equation of motion $v_f - v_i =$ _____ :

(A) S (B) $2aS$ (C) at ✓ (D) t

63. In third equation of motion $2aS + v_i^2 =$ _____ :

(A) v_f^2 ✓ (B) v_f (C) t^2 (D) t

2.13 Free Fall Acceleration

64. The acceleration of an object falling freely is:

(A) 9.8 ms^{-2} ✓ (B) 0 ms^{-2} (C) -9.8 ms^{-2} (D) 98 ms^{-2}

65. Distance travelled by free faling object in first second is: (CQs)

(A) 4.9 m ✓ (B) 9.8 m ✓ (C) 19.6 m ✓ (D) 10 m

66. Velocity of an object dropped from a building at any instant time "t" is

given by:

(A) $\frac{1}{2}gt^2$ (B) $v_i t+\frac{1}{2}gt^2$ (C) at (D) gt ✓

67. A mass of 1 kg is freely falling. The force of gravity is:

(A) 1 N (B) 9.8 N ✓ (C) 0.5 N (D) 0 N

68. Which of the given variable is present in all three equations of motion? (CQs)

(A) Acceleration ✓ (B) Distance (C) Time (D) Torque

69. The distance covered by free falling body in 2 seconds is: (CQs)

(A) 9.8 m (B) 19.6 m ✓ (C) 4.9 m (D) 49 m

70. Albert Einstein proposed his revolutionary theory of special relativity in year:

(A) 1605 (B) 1705 (C) 1805 (D) 1905 ✓

71. Speed of light is:

(A) 3×10^{-8} ms^{-1} (B) 3×10^{8} ms^{-1} ✓ (C) 3×10^{-8} ms^{-2} (D) 3×10^{8} ms^{-2}

General Short Questions with Conceptual Questions (CQs)

2.0 Introduction

1. Define Mechanics. Write the name of its branches.

Ans: Mechanics: Mechanics is the branch of physics that deals with the **motion of objects** and the **forces** that change it.

Branches of Mechanics: Generally, mechanics is divided into two branches:

i) Kinematics ii) Dynamics

2. Define Kinematics.

Ans: Kinematics is the study of **motion of objects without referring to forces**.

3. Define Dynamics.

Ans: Dynamics deals with **forces** and their **effects** on the motion of objects.

2.1 Scalars and Vectors

4. Write symbolical representation methods of vectors.

Ans: Symbolical Representation of Vectors:

(i) Symbol used for a vector is a bold face letter such as **A, V, F** and **d** etc.

(ii) A vector is written as the letter with a small arrow over it, i.e. $\vec{A}, \vec{v}, \vec{F}, \vec{d}$.

(iii) The magnitude of a vector is given by italic letter without arrow head.

5. What is x-axis and y-axis in Cartesian plane?

Ans: X-axis: Horizontal line (XOX′) in xy-plane is called x-axis.

Y-axis: Vertical line (YOY′) in xy-plane is called y-axis.

6. Define origin.

Ans: The point where both the axes meet is known as origin. The origin is usually denoted by O.

7. Define resultant vector.

Ans: A single vector having same effect as all othe original vector taken together is resultant vector.

8. What is reference line in graphical dirtection and Cartesian system?

Ans: For geographical direction, the reference line is north-south whereas for Cartesian system, positive x-axis is the reference line.

9. How are vector quantities important to us in our daily life?

Ans: **Importance of vectors:** Vector quantites are important to us in our daily life in engeering, building and drawing different techniques.

Example: We have horizontal and vertical length. By drawing vectors on paper graphically and adding it we can find out resultant easily which is difficult.

2.2 Rest and Motion

10. Explain briefly that state of rest and motion is relative. (CQs)

Ans: The state of rest and motion of a body is always relative.

Explanation: A person standing in the compartment of a moving train is at rest with respect to the other passengers in the compartment but he is in motion with respect to an observer standing on the platform of a railway station.

2.3 Types of Motion

11. Define Translatory Motion.

Ans: **Translatory Motion:** If the motion of a body is such that every particle of the body **moves uniformly** in the **same direction**, it is called tanslatory motion.

Example: The motion of a train or a car.

12. Define linear motion.

Ans: **Linear Motion:** If the body **moves** along a **straight line**, it is called linear motion.

Example: A freely falling body.

13. Define random motion.

Ans: **Random Motion:** If the body **moves** along an **irregular path**, the motion is called random motion.

Example: Motion of bee is random motion.

14. Define circular motion.

Ans: **Circular Motion:** The motion of a body along a circle is called circular motion.

Examples:

(i) If a ball tied to one end of a string is whirled, it moves along a circle.

(ii) Motion of a a Ferris wheel is circular motion.

15. Differentiate between rotatory and vibratory motion.

Ans:

Rotatory motion	Vibratory motion
If each point of a body moves around a fixed point (axis), the motion of this body is called rotatory motion.	When a body repeats its to and fro motion about a fixed position, the motion is called vibratory motion.
Example: The motion of a top.	**Example:** The motion of a swing in a children park

2.4 Distance and Displacement

16. Describe the SI unit of distance and displacement.

Ans: SI unit of both the distance and displacement is metere (m).

2.5 Speed and Velocity

17. Define speed. Write its formula and unit.

Ans: **Speed: Distance covered** by a body in **one second** is called speed.

Formula: $Speed = \frac{Distance}{Time}$ or $v = \frac{S}{t}$

Nature of Quantity: Speed is a scalar quantity.

SI unit: The SI unit of speed is ms^{-1} or kmh^{-1}.

18. Define instantaneous speed.

Ans: The speed of a vehicle that is shown by its speedometer at any instant is called **instantaneous speed.**

19. Write the name of fastest land mammal and fish.

Ans: Fastest land mammal is Cheetah and fastest fish is Sail fish. Both have the same highest recorded speed of 110 kmh^{-1}.

20. Define velocity. Write its formula and unit.

Ans: **Velocity:** The **net displacement** of a body in **unit time** is called velocity.

Formula: $Velocity = \frac{Displacement}{Time}$

Nature of Quantity: Velocity is a vector quantity.

Direction: The direction of velocity **v** is the same as that of displacement **d.**

SI unit: The SI unit of velocity is ms^{-1} or kmh^{-1}.

21. Define uniform velocity with example.

Ans: **Uniform Velocity:** The velocity is said to be uniform if the speed and direction of a moving body does not change.

Example: A body moving with uniform velocity is the downward motion of a paratrooper.

22. Define non-uniform velocity with example.

Ans: **Variable Velocity or Non-uniform Velocity:** The velocity is said to be non-uniform if the speed or direction or both of them change, it is known as variable velocity or non-uniform velocity.

Example: Practically, a vehicle does not move in a straight line throughout its journey. It changes its speed or its direction frequently. So, it has a variable velocity.

23. A player covers 80 m distance in 10 seconds. Find its average speed.

Ans: **Given Data:**

Time $= t = 10s$

Distance $= S = 80m$

To Find:

Average speed $= v_{av} = ?$

Calculations:

As we know that

$$v_{av} = \frac{S}{t} = \frac{80m}{10s}$$

$$v_{av} = 8ms^{-1}$$

2.6 Acceleration

24. Define acceleration. Write its formula and unit.

Ans: **Acceleration:** Acceleration is defined as the time rate of change of velocity.

Formula: $$Average\ acceleration = \frac{Change\ in\ velocity}{Time\ taken} \quad \text{or} \quad a = \frac{v_f - v_i}{t}$$

Nature of Quantity: Acceleration is a vector quantity like velocity. The direction of acceleration is that of change of velocity.

SI unit: The SI unit of acceleration is ms^{-2}.

25. Define positive and negative acceleration.

Ans: **Positive Acceleration:** The acceleration is positive if the velocity is increasing.

Negative Acceleration: The acceleration is negative if the velocity is decreasing. Negative acceleration is also called deceleration or retardation.

26. Define average acceleration.

Ans: **Average Acceleration:** If a body is moving with an initial velocity v_i and after some time t its velocity changes to v_f, the change in velocity is $\Delta v = v_f - v_i$ that occurs in time t. In this case, rate of change of velocity i.e., acceleration will be average acceleration.

27. Can a body moving at a constant speed have acceleration?

Ans: Yes, a body moving at constant speed has acceleration if the direction of motion is variable, i.e., a body moves in a circular path with constant speed.

28. What is retardation?

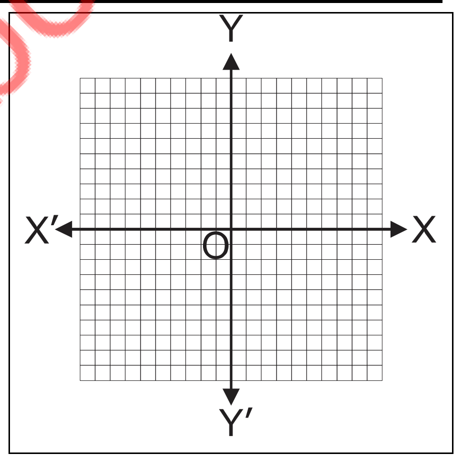
Ans: **Retardation:** Aceleration of a body whose velocity decreases is called retardation. It is called negative ace;lertaion of body.

Example: When moving bodies stops, it gives retardation.

2.7 Graphical Analysis of Motion

29. Define graph.

Ans: A graph is a pictorial diagram in the form of a straight line or a curve which shows the relationship between two physical quantities.



30. How independent variable is taken on xy-plane? (CQs)

Ans: Positive values along x-axis are taken to the right side of the origin and negative values are taken to the left side. In graph study, the independent quantity is taken along x-axis.

31. How dependent variable is taken on xy-plane? (CQs)

Ans: Positive values along y-axis are taken above the origin whereas negative values are taken below the origin. In graph study, dependent variable quantity along y-axis.

32. Define independent variable with respect to graph.

Ans: **Independent variable:** A quantity in graph which you can change is called independent variable.

Independent variable is always taken on x-axis.

Example: Time

33. Define dependent variable with respect to graph.

Ans: **Dependent variable:** A quantity in graph which varies with the independent quantity is called dependent variable.
Dependent variable is always taken on y-axis.
Examples: Acceleration, velocity and displacement.
Those variables which dependence on independent variables are called dependent varibles.

34. Convert 36 kmh^{-1} to ms^{-1}.

Ans: $36\,kmh^{-1} = \dfrac{36 \times 1000\,m}{3600\,s} = 10\,ms^{-1}$

35. Speed of a car is 72 kmh^{-1}. Convert this speed in ms^{-1}.

Ans: Speed of car in kmh^{-1} $= 72\,kmh^{-1}$

Speed of car in kmh^{-1} $= \dfrac{72 \times 1000\,m}{3600\,s} = 20\,ms^{-1}$

36. Convert ms^{-1} to kmh^{-1}.

Ans: $1\,ms^{-1} = \dfrac{1}{1000}km \times 3600\,h^{-1}$

$1\,ms^{-1} = 0.001\,km \times 3600\,h^{-1}$

$1\,ms^{-1} = 3.6\,kmh^{-1}$

2.8 Gradient of a Distance-Time Graph

37. Define gradient. What do gradients of distance-time graph represent?

Ans: **Gradient:** The gradient is the measure of slope of a line.
Gradient of the distance-graph: Gradient of the distance-graph represents the average speed of the body.

2.9 Speed time graph

38. If graph line of speed-time graph is straight line rising upward. What does its mean? (CQs)

Ans: If graph line of speed-time graph is straight line rising upward. This shows that speed increases by the same amount after every one second. This is a motion with uniform acceleration.

39. If graph line of speed time graph is horizontal to time x-axis. What does its mean? (CQs)

Ans: If graph line is horizontal i.e., parallel to time x-axis. It shows that speed does not change with change in time. This is a motion with constant speed.

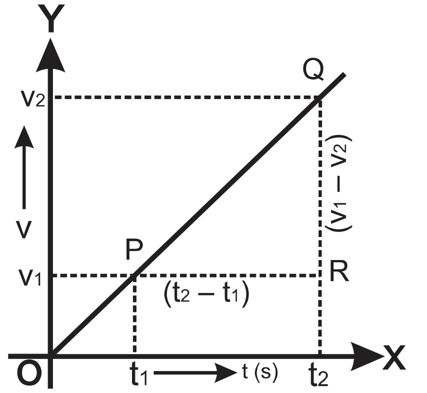
2.10 Gradient of a Speed-Time Graph

40. What do gradients of speed-time graph represent? (CQs)

Ans: Gradient of the speed-time graph represents the average acceleration of the body.

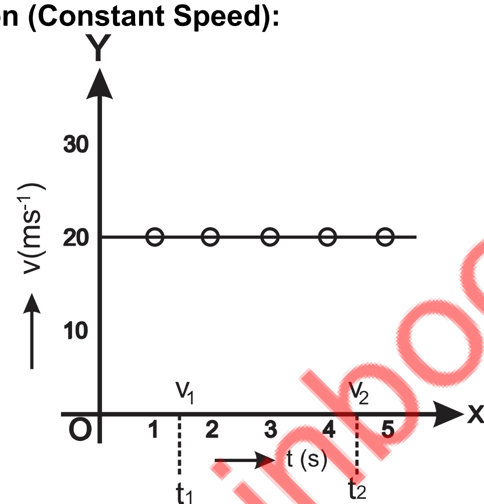
41. Draw a graph of constant acceleration. (CQs)

Ans:



42. Draw the graph of zero acceleration (constant speed). (CQs)

Ans: Zero Acceleration (Constant Speed):



2.11 Area Under Speed-Time Graph

43. Which term show Area undert sped-time graph? (CQs)

Ans: The area under speed-time graph upto the time axis is numerically equal to the distance covered by object.

2.12 Solving Problems for Motion Under Gravity

44. Write three equations of motion.

Ans: First equation of Motion: $v_f = v_i + at$

Second equation of Motion: $S = v_i t + \frac{1}{2}at^2$

Third equation of Motion: $2aS = v_f^2 - v_i^2$

2.13 Free Fall Acceleration

45. Write direction and values of gravitational acceleration.

Ans: Direction of Gravitational Acceleration: The direction of gravitational acceleration is always downwards.

Value of Gravitational Acceleration: Gravitational acceleration value is 9.8 ms^{-2}, but for convenience we shall use the value of g as 10 ms^{-2}.

46. Write three equations of motion under the action of gravity.

Ans: First equation of Motion under Gravity: $v_f = v_i + gt$

Second equation of Motion under Gravity: $S = v_i t + \frac{1}{2} g t^2$

Third equation of Motion under Gravity: $2gS = v_f^2 - v_i^2$

47. Write the value of speed of light.

Ans: Value of speed of light is approximately 3×10^8 ms^{-1}.

48. What do you know about Universal speed limit? (CQs)

Ans: Speed of light remains the same for all motions. Any object with mass cannot achieve speeds equal to or greater than that of light. This is known as universal speed limit.

Unit – 3 Dynamics

Q.1 Define Dynamics. Why we need dynamics?

Ans: Dynamics:

Dynamics is the branch of mechanics which deal with the study of **motion of bodies** under **action of forces**.

TUTOR

Force: A force moves or tends to move, stops and tends to stop the motion of a body. The force can also change the direction of motion of a body.

Why we need dynamics?

In kinematics, motion of objects is studied. If the position, velocity and acceleration were known at any time, then the position and velocity of the moving body at another time could be completely described. Dynamics is necessary to study the **cause of acceleration** produced in the body.

Explanation:

If a stone is dropped from a height, it is accelerated downward. It is because the Earth exerts a force of gravity on the stone that pulls it down. When we drive a car or motorcycle, the engine exerts a force which produces acceleration. We will observe that whenever there is acceleration, there is always a force present to cause that acceleration. Dynamics is concerned with the forces that produce change in the motions of bodies.

TUTOR

Action of Forces: The action of forces is when object exerts forces on each other in opposite directions. This is described by Newton's third law of motion.

3.1 Concept of Force

Q.1 Define Force. Explain concept of force.

Ans: Force:

Force is an agency which changes or tends to change the state of rest or of uniform motion of a body.

Concept of Force:

A common concept of a force is a push or a pull that starts, stops or changes the magnitude and direction of velocity of a body. We come across many forces in our daily life. Some of them we apply on other bodies and some are acting on us.

Fig: 3.1

Example:

When we open a door, we push or pull it by applying force. When we are sitting in a car, we push against the seat as the car turns round a corner.

Objective of Force:

Force transfers energy to an object.

Explanation:

Take the example of a man who moves a wheel barrow with its load. The man first applies force to lift it and then applies force to push it (Fig.3.1). He applies a different amount of force on each handle when turning the wheelbarrow around the corner in order to keep it from tipping over. The examples of forces acting on us are the force of gravity acting downward, the force of friction which helps us to walk on the ground and many others.

Q.2(a) How many major types of forces? Write their names.
(b) Define Contact Force. Explain Contact Forces with examples.
(c) What are Non-contact Forces? Explain it with examples.

(a) How many major types of forces? Write their names.

Ans: There are two major types of forces:

- Contact Forces
- Non-contact Forces

(b) Define Contact Force. Explain Contact Forces with examples.

Ans: Contact Forces:

A contact force is a force that is exerted by one object on the other at the point of contact.

TUTOR
Physical contact means **direct or indirect** physical interaction that occurs between two entities.

Examples:

- Push, pull and twist are examples of contact forces.

Types of Contact Forces:

Some other examples of Contact Forces are following:

(i) Friction:

Friction is the force that resists motion when the surface of one object comes in contact with the surface of another.

TUTOR
The force that opposes the motion of moving object is called **friction**.

(ii) Drag:

The drag force is the resistant force caused by the motion of a body through a fluid. It acts opposite to the relative motion of any object moving with respect to surrounding fluid.

(iii) Thrust:

Thrust is an upward force exerted by a liquid on an object immersed in it.

Explanation:

When we try to immerse an object in water, we feel an upward force exerted on the object. This force increases as we push the object deeper into the water. A ship can float in the sea due to this force which balances the weight of the ship.

(iv) Normal Force:

Normal force is the force of reaction exerted by the surface on an object lying on it.

TUTOR
Normal Force is a contact force. If two surfaces are not in contact, they cannot exert a normal force on each other.

Explanation:

Normal force acts outward and perpendicular to the surface. It is also called the support force upon the object.

(v) Air Resistance:

Air Resistance is the resistance (opposition) offered by air when an object falls through it.

(vi) Tension Force:

Tension Force is the force experienced by a rope when a person or load pulls it.

(vii) Elastic Force

Elastic Force is a force that brings certain materials back to their original shape after being deformed.

TUTOR

Elasticity is the ability of a material to return to its original shape after being strtetched or compressed.

Examples:

Examples are rubber bands, springs, trampoline, etc.

(c) What are Non-contact Forces? Explain it with examples.

Ans: Non-contact Forces:

A non-contact force is defined as the force between two objects which are not in physical contact.

Other names of Non-contact Forces:

The non-contact forces can work from a distance. That is why, these are sometimes called as **action-at-a-distance**. There is always a field linked with a non-contact force. Due to this property, non-contact forces are also called **field forces**.

Examples:

A few examples of non-contact forces are described below:

(i) Gravitational Force:

Gravitational Force is an attractive force that exists among all bodies which have mass.

Example:

An apple falling down from a tree is one of the best examples of gravitational force (Fig. 3.2). When we throw an object upward, it is the gravitational force of the Earth that brings it back to the Earth.

Fig 3.2

Characteristic of Gravitational Force:

Gravitational Force is a long-range force

According to Newton's Law of Gravitation:

Gravitational Force is defined by Newton's law of gravitation as:

$$F = G\frac{m_1 m_2}{r^2}$$

where m_1 and m_2 are two masses distant r apart and G is constant of gravitation.

Value of Gravitational Constant:

The value of Gravitational constant is 6.67×10^{-11} $Nm^2\ kg^{-2}$.

Explanation:

The Sun's gravitational force keeps the Earth and all other planets of our solar system in fixed orbits.

TUTOR

Every object in the universe attracts every other object with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. This is known as **Newton's law of Gravitation**.

The gravitational force of the Earth keeps the moon in its orbit. It also keeps the atmosphere and oceans fixed to the surface of the Earth. Even an object resting on a surface exerts a downward force called its **weight** due to attractive force of the Earth also known as gravity.

(ii) Electrostatic Force:

An electrostatic force acts between two charged objects. The opposite charges attract each other and similar charges repel each other (Fig 3.3).

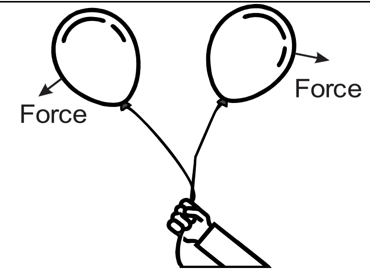


Fig 3.3

TUTOR
Electrostatic Force:
Electrostatic attraction is the force of attraction between two particles with opposite charges.

Long Force Range:

Like gravitational force, electrostatic force is also a long-range force.

(iii) Magnetic Force:

Magnetic Force is a force which a magnet exerts on other magnets and magnetic materials like iron, nickel and cobalt.

Explanation:

Iron pins attracted in the presence of a magnet without any physical contact (Fig.3.4). Magnetic force between the poles of two magnets can be either attractive or repulsive. This can be observed very easily by bringing different poles of two magnets close to each other. Like poles repel and unlike poles attract each other.

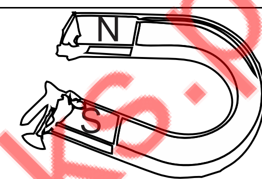


Fig 3.4

TUTOR
Magnetic force is the force of attraction or repulsion between electrically charged particles that are moving.

(iv) Strong and Weak Nuclear Forces:

Strong and Weak Nuclear Forces are non-contact forces which are acting between the subatomic particles.

3.2 Fundamental Forces

Q.3(a) How many fundamental forces in nature? Write their names.
(b) Write a brief note on Gravitational force and Electromagnetic force.
(c) Write a brief note on Strong and Weak Nuclear force.

(a) How many fundamental forces in nature? Write their names.

Ans: There are four fundamental forces in nature. These are:

1. Gravitational force
2. Electromagnetic force
3. Strong nuclear force
4. Weak nuclear force

Every force comes under any of these forces.

(b) Write a brief note on Gravitational force and Electromagnetic force.

Ans:

1. Gravitational Force:

The gravitational force is an attractive force that exists among all bodies which have mass.

TUTOR
The force due to which every body of universe attracts every other body is called **force of gravitation**.

Characteristics of Gravitational Force:

i) Gravitational Force is the weakest one among all four forces.

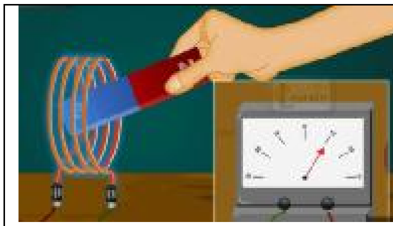


Fig: 3.5 A moving magnet produces electric electric current

ii) Gravitational force is a long range force.

iii) Gravitational force extends to infinite distance although it becomes weaker and weaker.

2. Electromagnetic Force:

Electromagnetic Force is the force that causes the **interaction** between **electrically charged particles**.

Electrostatic and magnetic forces come under this category.

Characteristics of Electromagnetic Force:

i) Electromagnetic Force are long-range forces.

ii) The areas in which these forces act are called **electromagnetic fields**.

iii) Electromagnetic forces are stronger than gravitational and weak nuclear forces.

iv) Electromagnetic force causes all **chemical reactions**.

v) Electromagnetic force binds together atoms, molecules and crystals etc.

vi) At macroscopic level, it is a possible cause of friction between different surfaces in relative motion.

TUTOR

An **electromagnetic field** can be static, slowly changing or form waves.

TUTOR

A process in which, one or more substances, the reactants, are converted to one or more different substances the products, is called **chemical reaction**.

TUTOR

Electromagnetism is a physical interaction among electric charges, magnetic moments and **electromagnetic fields**.

(b) Write a brief note on Strong and Weak Nuclear force. Also write their unification.

Ans:

3. Strong Nuclear Forces:

Strong Nuclear Forces holds the atomic nuclei together by binding the protons and neutrons in the nucleus over coming repulsive electromagnetic force between positively charged protons.

Characteristics of Strong Nuclear Forces:

i) Strong Nuclear Forces is a short-range force with the order of 10^{-14} *m*.

ii) If the distance between nucleons increases beyond this range, this force ceases to act.

TUTOR

Nuclear forces are the forces that bind protons and netron together in the nucleus of an atom. They are also known as **strong forces** because they are about **10 million times** stronger than the forces that bind the atoms together in molecules.

4. Weak Nuclear Force

Weak nuclear force is responsible for the disintegration of a nucleus.

Example:

The weak nuclear force executes the β-decay (beta decay) of a neutron, in which a neutron transforms into a proton (Fig.3.7).

Explanation:

In the process, a β-particle (electron) and an uncharged particle called **antineutrino** are emitted.

In other words, we can say that due to weak nuclear force **radioactive decay** of atoms occurs.

Characteristics of Weak Nuclear Forces:

i) Weak nuclear force is stronger than the gravitational force but weaker than the electromagnetic force.

ii) Weak nuclear is a short-range force of the order $10^{-17}\ m$.

Unification of Weak Nuclear and Electromagnetic Forces:

A Pakistani scientist **Dr. Abdus Salam** along with **Sheldon Glashow** and **Steven** Weinberg were awarded in **1979 Nobel Prize in Physics** for their contributions to the unification of the weak nuclear force and electromagnetic force as electroweak force. Although these two forces appear to be different in everyday phenomena, but the theory models them as two different aspects of the same force. Its effects are observed for the interactions taking place at **very high energy**.

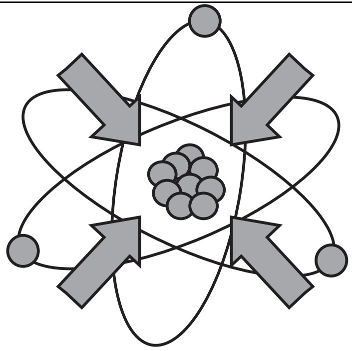


Fig: 3.6
The binding force of protons and neutrons in the nucleus

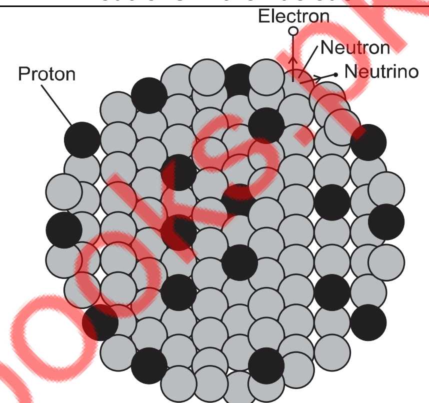


Fig. 3.7

3.3 Forces in a Free-Body Diagram

Q.4 Explain forces in a free-body diagram.

Ans: Forces in a Free-Body Diagram:

External forces acting on an object may include friction, gravity, normal force, drag, tension in a string or a human force due to pushing or pulling.

TUTOR

A force that acts on an object from another object, that is not part of the system, is called **external force**.

Example:

A book is pushed over the surface of a table top as shown in Fig.3.8(a).

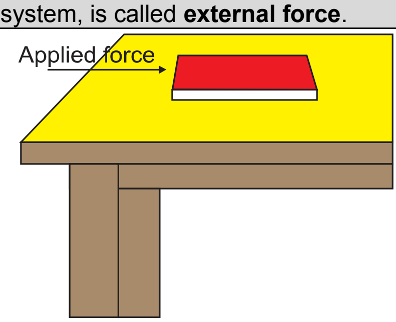


Fig. 3.8 (a)

Representation of External Forces by Free-Body Diagrams:

Free-body diagrams are used to show the relative magnitudes and directions of all the forces acting on an object in a given situation.

Vector diagram:

In other words, a free-body diagram is a special example of the vector diagrams.

Usually, the object is represented by a box and the force arrows are drawn outward from the centre of the box in the directions of forces as shown in Fig.3.8(b). The length of a force arrow (line) reflects the magnitude of the force and the arrow head indicates the direction in which the force acts.

Each force is labelled to indicate the exact type of force.

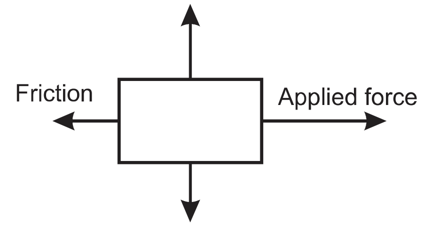


Fig. 3.8 (b)

3.4 Newton's Laws of Motion

Q.5(a)State Newton's First Law of Motion. Explain with examples.

(b) Define force is term of Newton's First law of motion.

Ans: Newton's First Law of Motion:

Statement:

"A body continues its state of rest or of uniform motion in a straight line unless acted upon by some external force."

Explanation:

It is our common observation that a force is required to move or to stop a body.

Do You Know?

Sir Isaac Newton was born in Lincolnshire on January 4, 1643. The name of his famous book is "Principia Mathematica".

Example (i):

A book placed on a table remains there unless a force is applied to move it (Fig.3.9).

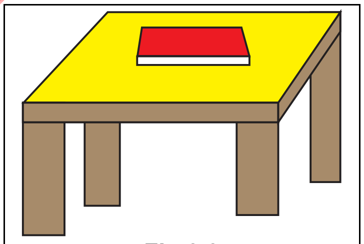


Fig.3.9

Example (ii):

A ball rolling on floor should continue to move with the same velocity in the absence of an applied force. But practically, we see that it is not true. The ball stops after covering some distance. In fact, an opposing force (friction) causes the ball to stop.

(b) Define force is term of Newton's First law of motion.

Ans: The first law of motion provides us another definition of force which is stated as follows:

Force:

Force is an agency which changes or tends to change the state of rest or of uniform motion of a body.

Explanation:

In simple words, we can say that force causes acceleration.

Q.6 Why passengers tend to bend farword, when a fast moving bus stops suddenly? Justify your answer by first law of motion.

Ans: When a fast moving bus stops suddenly, the passengers tend to bend forward.

Reason:

It is because they want to continue their motion. On the other hand, when the bus starts moving quickly from rest, the passengers are pushed back against the seat. This time, the tendency of passengers is to retain their state of rest.

In Terms of Newton's First Law of Motion:

According to first law of motion, a bus moving on the road should continue its motion without any force exerted by the engine. But practically, we see that if the engine stops working, the bus comes to rest after covering some distance. It is because of the friction between the tyres of the bus and the road. All the bodies moving on the Earth are stopped by the force of friction. If you were in outer space and throw an object away where no force is acted upon it, the object would continue to move for ever with constant velocity.

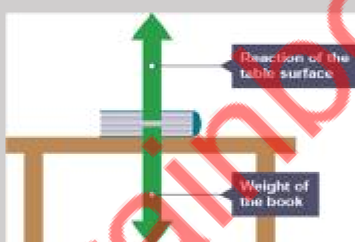
TUTOR

When a bus takes a sharp turn, passengers fall in the outward direction. It is due to inertia that they want to continue their motion in a straight line and thus fall outwards.

TUTOR

First Part of Newton's Law of Motion

The book on the table will in the state of rest because no net force is acting on it as shown in figure.

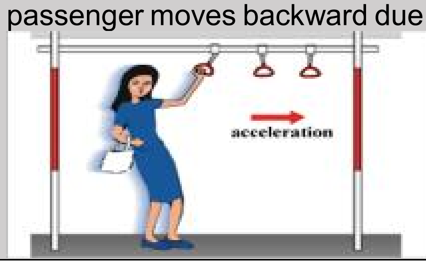


Inertia and Forward Motion:

When a running bus stops suddenly, passenger moves forward due to inertia.

Inertia and Backward Motion:

When bus starts to run suddenly, passenger moves backward due to inertia.



Q.7 Define inertia in term of Newton's First Law of Motion.

Ans: Inertia:

The property of a body to maintain its state of rest or of uniform motion in a straight line is called inertia.

Explanation:

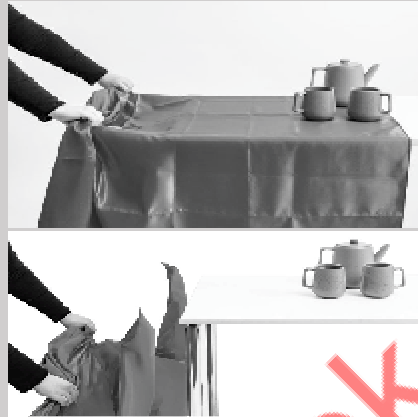
A **net force** is required to change the velocity of objects. For instance, a net force may cause a bicycle to pick up speed quickly. But when the same force is applied to a truck, any change in the motion may not be observed. We say that the truck has more inertia than a bicycle.

The **mass** of an object is a **measure** of its inertia. The greater the mass of an object, the greater is its inertia.

Law of inertia:

As a result of the role of inertia in Newton's first law, this law is sometimes called as law of inertia.

A Demonstration of Property of Inertia



When the table cloth is pulled abruptly, the objects remain in their original position on the table.

TUTOR

Relation between Mass and Inertia

Q. Which trolley has more interia, the empty one or the loaded one?

Ans: Greater is the mass of a body greater is its inertia (loaded one).

TUTOR

Net force is the resultant of all the forces acting on a body.

Q.8(a) State and derive Newton's Second Law of Motion.

(b) Write effect of force on velocity.

(a) State and derive Newton's Second Law of Motion.

Ans: Newton's Second Law of Motion:

Statement:

"If a net external force acts upon a body, it accelerates the body in the direction of force. The magnitude of acceleration is directly proportional to the magnitude of force and is inversely proportional to the mass of the body."

Explanation:

Newton's first law indicates that if no net force acts on an object, then the velocity of the object remains unchanged. The second law deals with the acceleration produced in a body when a net force acts upon it.

Mathematical Derivation:

If a net force of magnitude F acts on a body of mass m and produces an acceleration of magnitude a, then the second law can be written mathematically as:

$$a \propto F \quad \text{and} \quad a \propto \frac{1}{m}$$

So, $$a \propto \frac{F}{m}$$

$$a = (constant)\frac{F}{m}$$

According to SI units, if m = 1 kg, a = 1 ms^{-2}, F = 1 N, then the value of the constant will be 1. Therefore, the above equation can be written as:

$$a = 1 \times \frac{F}{m}$$

$$F = ma \qquad (3.1)$$

Unit of Force:

Th SI unit of force is newton (N).

Definition of Newton:

One newton is the force which produces an acceleration of 1 ms^{-2} in a body of mass 1 kg.

From Eq (3.1)

$$1 \text{ N} = 1 \text{ kg ms}^{-2}$$

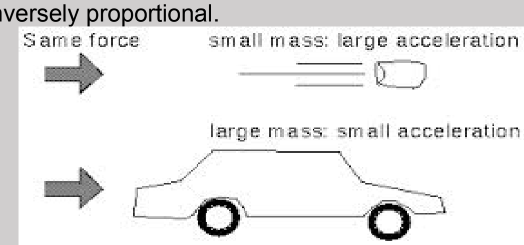
Relation between 1st Law and 2nd Law of Motion

Newton's First law of motion provides the defintion i.e., a force produce an acceleration in a body in a body. By Newton's second law of motion (F=ma), we can calculate mathematically, the amount of force required to produce a certain amount of acceration in a body of known mass.

TUTOR (Newton's 2nd Law of Motion)

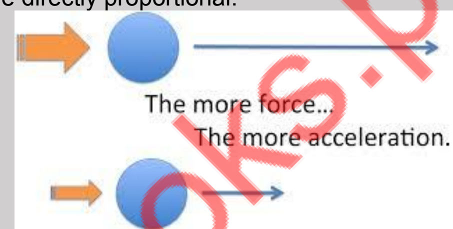
Acceleration and Mass:

The diagram shows that mass and acceleration are inversely proportional.



Acceleration and Force:

The diagram shows that force and acceleration are directly proportional.



(b) Write effect of force on velocity.

Ans: Effect of Force on Velocity:

Newton's second law also tells that a force can change the velocity of a body by producing acceleration or deceleration in it. As velocity is a vector quantity, so the change may be in its magnitude, direction or in both of them.

Q.9(a) State Newton's Third Law of Motion. Explain with example.

(b) Explain the term "Forces act in pairs" with reference of Newton's Third Law of Motion.

(a) State Newton's Third Law of Motion. Explain with example.

Ans: Newton's Third Law of Motion:

Statement:

"For every action, there is always an equal and opposite reaction."

Explanation:

Whenever there is an interaction between two bodies A and B, such that the body A exerts a force on body B, the force is known as **action** of A on B. In response to this action, the body B exerts a force on the body A. This force is known as **reaction** of B on A.

Since, action and reaction do not act on the same body but they act on two different bodies, so they can never balance each other.

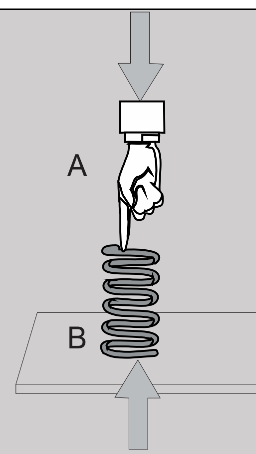


Fig. 3.10

Example:

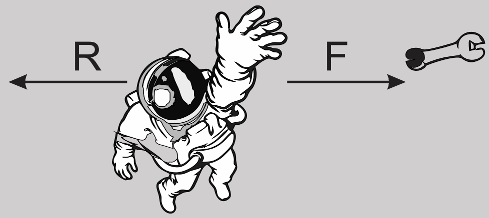
When we press a spring, the force exerted by our hand on the spring is action. Our hand also experiences a force exerted by the spring. This is the force of reaction (Fig. 3.10).

Newton's third law of Motion expressed in other way:

Newton's third law can also be expressed as follows:

If one body exerts a force on a second body, the second body also exerts an equal and opposite force on the first body.

Do You Know?



In space, an astronaut throws a wrench, as a reaction he moves in opposite direction.

(b) Explain the term "Forces act in pairs" with reference of Newton's Third Law of Motion.

Ans: Forces Act in Pairs:

Let two forces act in pairs when two objects interact, i.e., action and reaction forces. We often notice a force that seems to make something happen but usually we do not notice the other force involved.

Example 1:

Consider a block lying on a table (Fig.3.11). The force acting downward on the block is the weight. The block exerts a downward force on the table equal to its weight **w**. The table also exerts a reaction force $\mathbf{F_n}$ on the block. The two forces on the block balance each other and the block remains at rest.

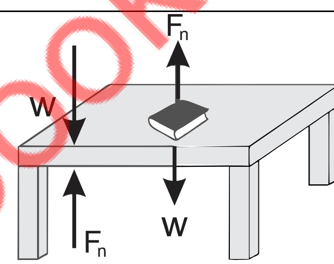


Fig: 3.11

Example 2:

When a bullet is fired from a gun, the bullet moves in the forward direction with a force **F**. This is the force of action. The gun recoils in the backward direction with a reaction force **R** (Fig.3.12).

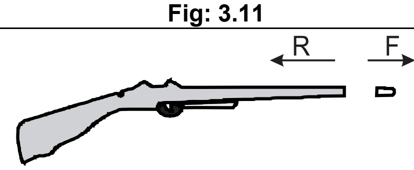


Fig: 3.12

3.5 Limitations of Newton's Laws of Motion

Q.10 Write Limitations of Newton's Third Law of Motion.

Ans: Newton's laws of motion can be applied with very high degree of accuracy to the motion of objects and velocities which we come across in everyday life.

The problems arise when we deal with the motion of elementary particles having velocities close to that of light. For that purpose, **relativistic mechanics** developed by Albert Einstein is applicable.

Thus, Newton's laws of motion are not exact for all types of motion, but provide a good approximation, unless an object is small enough or moving close to the speed of light.

TUTOR

Newton's laws of motion are applicable in Newtonian Mechnics.
Albert Einstein's working in Mehanics is related to **relavistic mechanics** which deals with speed approximated to **speed of light**.

Mini Exercise

Look at the photographs below. Identify the pairs of forces acting in each photograph.

Fig. 3.13

Fig. 3.14

Fig. 3.15

Ans:

- In figure 3.13, "hot gases forced out back of the rocket's force" (action) and "gases exert on the rocket propelling it upward (reaction) are the pairs of forces.
- In figure 3.14, "force that push ground back" (action) and "frictional force of ground that pull you farword" (reaction) are the pairs of forces.
- In figure 3.15, "swimmer arm push water backward force" (action) and "water pushed force swimmer forward" (reaction) are the pair of forces.

3.6 Mass and Weight

Q.11(a) Differentiate between Mass and Weight.

(b) Describe gravitational field and gravitational field strength.

(c) Explain variation in gravitational acceleration "g" from place to place.

(a) Differentiate between Mass and Weight.

Ans:

Mass	Weight
Definition: The characteristic of a body which determines the magnitude of acceleration produced when a certain force acts upon it is known as mass of the body.	**Definition:** The weight of an object is equal to the force with which the Earth attracts the body towards its centre.
Explanation: The simplest definition of mass is that it is a measure of the quantity of matter in a body.	**Explanation:** Weight is a gravitational force acting on the object.
Nature of Quantity: Mass is a scalar quantity denoted by *m*.	**Nature of Quantity:** Weight is a vector quantity directed downward, towards the centre of the Earth.
Measurement: Practically, mass is measured by an ordinary balance.	**Measurement:** Weight is measured by a spring balance.

Variation: Mass remains the same everywhere.	**Variation:** Weight remains the same everywhere.
SI Unit: The SI unit of mass is kilogram (kg).	**SI unit:** The SI unit of weight is newton (N).

(b) Describe gravitational field and gravitational field strength.

Ans: Gravitational Field:

The gravitational field is a space around a mass in which another mass experiences a force due to gravitational attraction.

Gravitational Field Strength:

The gravitational field strength is defined as the gravitational force acting on unit mass.

Value of Gravitational Field Strength:

Mass m on the surface of the Earth exerts a force known as its weight **w** given by **w** =m**g**. where **g** is the gravitational field strength. Its value is $10\ Nkg^{-1}$.

(c) Explain variation in gravitational acceleration "g" from place to place.

Ans: By Newton's second law, **F =** *ma,* the weight of a body **w** will be given by **w =** *m***g**, where **g** is the gravitational acceleration. As the value of **g** varies from place to place and also with altitude, therefore, the value of weight does not remain the same everywhere.

Variation in Gravitatioian Acceleration "g":

It varies from place to place according to variation in **g.** Though an object's weight may vary from one place to another, but at any particular location, its weight is proportional to its mass. Thus, we can conveniently compare the masses of two objects at a given location by comparing their weights.

3.7 Mechanical and Electronic Balances

Q.12(a) Describe the use of Balance scales.

(b) Write a note on mechanical balance.

(a) Describe the use of Baslance scales.

Ans: Balance scales are commonly used to compare masses of objects or to weight objects by balancing them with standard weights.

(b) Write a note on Mechanical Balance.

Ans: Mechanical Balance:

A mechanical balance consists of a rigid horizontal beam that oscillates on a central knife edge as a fulcrum. It has two end knife edges equidistant from the centre.

Measurement from Mechanical Balance:

Mechanical Balance measure mass of object in kilograms or its multiples.

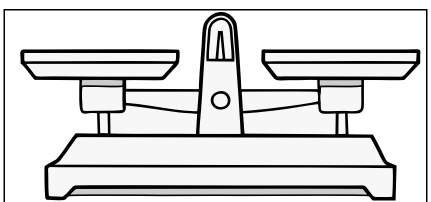


Fig. 3.16

Working of Mechanical Balance:

In Mechanical Balance, two pans are hung from bearings on the end knife edges (Fig.3.16). The material to be weighed is put in one pan. Standard weights are put on the other pan. The deflection of the balance may be indicated by a pointer attaches to the beam. The weights on the pan are adjusted to bring the beam in equilibrium.

Fig: 3.17

Types of Mechanical Balances:

There is another type of mechanical balances which are used to weigh heavy items like flour bags, cement bags, steel bars, etc. These are called **mechanical platform balances** (Fig.3.17).

Working of Mechnical Plateform Balance:

Standard weights are not required to use this balance. Its reason is that the fulcrum of the beam of such a balance is kept very near to its one end. Therefore, much smaller weights have to be put at the other end of beam to bring it to equilibrium. These smaller weights have already been calibrated to the standard weights.

Q.13 Write a note on Electronic Balance.

Ans: Electronic Balances:

A kind of measuring scale that is employed to precisely determine an object's mass is called **electronic balance**.

Fig. 3.18

Construction of Electronic Balance:

No standard weights are required to use in an electronic balance (Fig.3.18). Only it has to be connected to a power supply. There are some models which can operate by using dry cell batteries.

Measurement from Electronic Balance:

Electronic Balance measures mass of objects in kilograms or its multiples.

Advantage of Electronic Balance:

An electronic balance is more precise than mechanical balance. When an object is placed on it, its mass is displayed on its screen. Now-a-days, electronic balances also display the total price of the material if the rate per kg is fed to the balance.

TUTOR

A piece of lab equipment that is used to precisely measure the weight of materials is called an **electronic balance**.

Q.14 Write a detailed note on force metre.

Ans: Force Meter:

A force meter is a scientific instrument that measures force. It is also called as a **newton meter or a spring balance** (Fig.3.19). Now a days digital force meters are also available.

Measurement from Force meter:

Force meter measures force directly in newtons (N).

Construction of Forece Meter:

An ordinary force meter has a spring inside it. Upper end of the spring is attached to a handle. A hook is attached to the lower end the spring that holds the object. A pointer is also attached to the spring at its upper end. A scale in newtons is provided along the spring such that the pointer coincides with zero of the scale when nothing is hung with the hook.

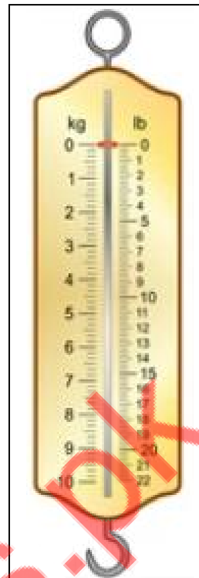


Fig. 3.19

Working of Force Meter:

The object to be weighed is hung with the hook. The mass of the object causes the spring to compress. The pointer indicates the weight of the object. However, some force meters are also based on the stretching of the spring when a load is hung. In this case, the pointer is attached at the lower end of the spring.

In some spring balances, the scale measures the mass which can be readily converted into newtons by multiplying the mass in kg with the value of g = 10 ms^{-2}.

Digital Force Meter:

Now-a-days, digital force meters are also available i.

A digital force meter measure directly the weight of an object in newtons (Fig. 3.20).

Fig. 3.20

TUTOR
The weight of 100 g mass is 1 N.

3.8 Friction

Q.15 Define friction. Explain its dissipative effects.

Ans: Friction:

The force that tends to prevent the bodies from sliding over each other.

OR Friction uis the force that resists the motion of two surface slining against each other.

Explanation:

When a cricket ball is hit by the bat, it moves on the ground with a reasonably large velocity. According to Newton's first law of motion, it should continue to move with constant velocity. But, practically, we observe that it eventually stops after covering some distance.This is because of the force of friction between the ball and the ground that opposes the motion of the ball.

Dissipative Effect of Friction:

Friction is a dissipative force due to which the energy is wasted in doing work to overcome against friction.The lost energy appears in the form of heat.

Example:

- **Rubbing hands:**
  A very common example of energy dissipation is the rubbing of hands (Fig.3.21). When we rub our hands, heat is produced due to friction and our hands become warm.

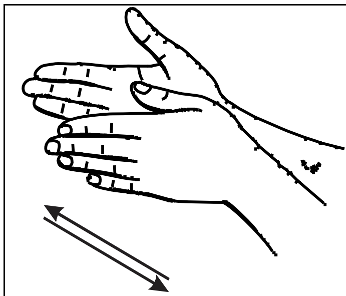


Fig. 3.21 Rubbing hands

- **Temperaute of machines:**
  The temperature of machines rises due to friction between its moving parts that can cause many problems.

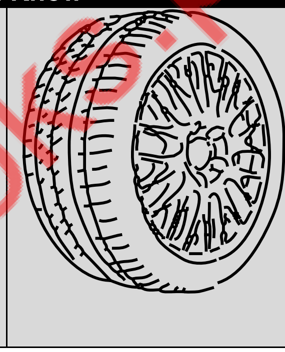
- **Tyres of Vehicles:**
  The tyres of vehicles wear out after becoming too hot due to friction between tyres and road.

- **Shooting of stars:**
  Shooting of stars seen in the sky at night also happen due to friction of air. These are actually asteroids that enter the Earth's atmosphere. As they are moving, air resistance causes generation of heat. Their temperature becomes so high that they start burning and ultimately disintegrate.

Do You Know

Q. Describe the advantages of tread pattern on the tyre.

Ans: On a wet road, the water does not form wet layer between the tyre surface and the road surface due to the spaces in the tread pattern on the tyre. This reduces the chances of skidding of vechicles on wet roads.



Q.16 Define Sliding Friction. Explain its categories.

Ans: Sliding Friction:

The friction between two solid surfaces is called sliding friction.

Categories of Sliding Friction:

There are two categories of friction.

(i) Static friction

(ii) Kinetic friction

(i) Static Friction:

The force of friction arising due to applied external force before motion of one body over the other.

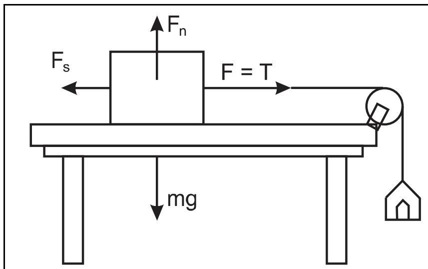
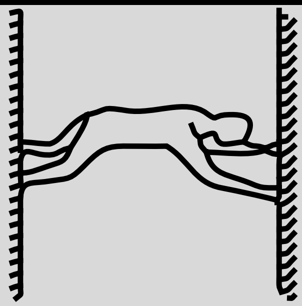


Fig: 3.22

Explanation:

Consider the motion of a block on a horizontal surface. The arrangement is shown in Fig. 3.22. When a weight is put in the pan, a force **F = T** equal to the sum of this weight and weight of the pan acts on the block. This force tends to pull the block. At the same time an opposing force appears that does not let the block move. This force is the static friction $\mathbf{F_s}$.

TUTOR

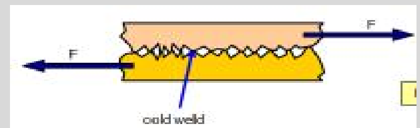


Pushing the opposite walls by palms and feet increases friction. This enables the boy to move up on the walls.

TUTOR

Cold Welds

When two surfaces move one on another than ups and down in the surfaces gets interlocked with each other due to which cold welds are formed.



(ii) Kinetic Friction:

Fricition during motion is known as kinetic friction.

Explanation:

If we go to adding more weigh in the pan one by one in small steps, a stage will come when the block starts sliding on the horizontal surface.

This is the limit of static friction that is equal to the total weights including pan. When the block is sliding, friction still exists. It is known as kinetic friction.

For Your Information!

Some frogs can cling to a vertical surface such as this leaf, because of the static friction between the feet and the surface.

Do You Know?

When a shuttle re-enters the Earth's atmosphere, the friction caused by the atmosphere raises the surface temperature of the shuttle to over 950°C.

Q.17 Explain the term terminal velocity briefly.

Ans: Terminal Velocity:

When upward air resistance balances the downward force of gravity on a falling object, it falls down with constant (safe) velocity, it is called terminal velocity.

Explanation:

When an object falls freely, it is accelerated by an amount g = 10 ms^{-2}. But practically the acceleration may be different. Air resistance plays an important role in determining how fast an object accelerates when it falls.

Examples:

If we drop a cricket ball and a piece of Styrofoam of the same weight from a certain height, they will hit the ground at the same time only if there were no air resistance. Both would fall with the same acceleration $g = 10\ ms^{-2}$. Practically, the ball in air, would drop faster. The Styrofoam having larger surface would face greater opposing force of the air and thus moves slowly.

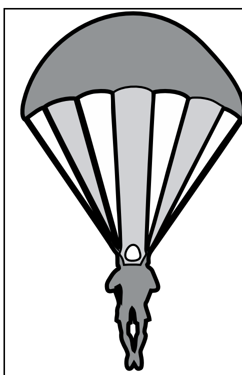


Fig. 3.23
A paratrooper falling with terminal velocity

Experiment:

Experiments have been made in this respect and it was found that the faster an object falls the more air resistance will be exerted on it. A speed is finally attained at which the upward force of air resistance balances the downward force of gravity. When this happens, the object stops accelerating. It keeps falling at a constant velocity. This constant velocity achieved by an object is called its **terminal velocity**. Even a heavy object like a meteorite does not gain an infinite velocity as it falls to the Earth.

Pactical Example:

The principle of terminal velocity applies to paratroopers. Air resistance acting against the large surface area of a parachute allows for descent at a safer velocity (Fig.3.23).

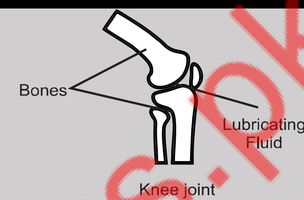
TUTOR

The uniform velocity of free falling objects attains is called **terminal velocity**.

Do You Know?

Q. Why friction is very low in human joints?

Ans: Friction in human joints is very low because our bodies contain a natural lubricating system. Consequently, though our bones rub against each other at the points as we move, yet bones do not normally wear out, even after many years of use.



Q.17 Explain the term rolling friction briefly.

Ans: Rolling Friction:

When an object rolls over a surface, the friction produced is called rolling friction.

Explanation:

Concept of Wheel:

The idea of rolling friction is associated with the concept of wheel. In our everyday life, we observe that a body with wheels faces less friction as compared to a body of the same size without wheels.

For Your Information!

Practically, the contact point is not perfectly circular; it becomes flat under pressure as shown in figure. This flat portion of the wheel has the tendency to slide against the surface and does produce a frictional force.

Ball bearings:

Ball bearings play the same role as is played by the wheels. Many machines in industry are designed with ball bearings so that the moving parts roll on the ball bearing and friction is greatly reduced.

Relation between Sliding Friction and Rolling Friction:

The rolling friction is about one hundred times smaller than the sliding friction.

The reason for the rolling friction to be less than the sliding friction is that there is no relative motion between the wheel and the surface over which it rolls. The wheel touches the surface only at a point. It does not slide.

For Your Information!

A hovercraft is a kind of ship that can move over the surface of water and ground both. Air is ejected underneath by powerful fans forming a cushion of air. The hovercraft moves over the cushion of air which offers very small resistance.

Q.18 Describe methods to reduce friction.

Ans: Methods to Reduce Friction:

The following methods are used to reduce friction:

(i) The parts which slide against each other are highly polished.

(ii) Since, the friction of liquids is less than that of solid surfaces, therefore, oil or grease is applied between the moving parts of the machinery.

(iii) As rolling friction is much less than the sliding friction, so sliding friction is converted into rolling friction by the use of ball bearings (Fig. 3.24) in the machines and wheels under the heavy objects.

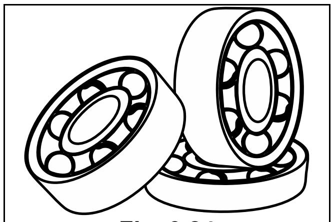


Fig. 3.24

(iv) Frictional force does not act only among solids, high speed vehicles, aeroplanes and ships also face friction while moving through air or water. If the front of a vehicle is flat, it faces more resistance by air or water. Therefore, the bodies moving through air or water are streamlined to minimize air or water friction.

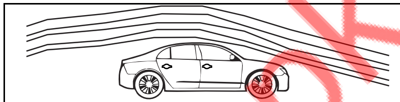


Fig. 3.25 Streamline air flow over a speedy car

In this case, the air passes smoothly over the slanting surface of vehicle. This type of flow of air is known as **streamline flow**. A streamline flow over the car(Fig. 3.25). The vehicles designed pointed from the front are said to be streamlined.

3.9 Momentum and Impulse

Q.19(a) Define and explain momentum and impulse. Also derive mathematical form of Impulse.

(b) State Newton's Second Law of Motion in terms of Momentum.

(a) Define and explain momentum and impulse. Also derive mathematical form of impulse.

Ans: Momentum:

The momentum of a moving body is the product of mass and velocity.

Formula: $p = m \times v$

SI unit: The SI unit of momentum is ($kgms^{-1}$). It can also be written as (Ns).

Nature of Quantity: Momentum is a vector quantity.

Explanation:

Suppose that a bicycle rider and a heavy truck are moving with the same speed, which one can be stopped easily, depends on the quantity of motion of the moving body. It is our common observation that quantity of motion in a moving body depends on its mass and velocity. Greater is the mass, the greater will be the quantity of motion. Similarly, greater is the velocity, the greater will be quantity of motion.

Impulse:

Impulse is defined as the product of $F \times \Delta t = m \times \Delta v$ = total change in momentum.

Explanation:

When a ball is hit by a bat, the force is exerted on the ball for a very short interval of time. In such cases, it is very difficult to calculate the exact magnitude of the force. This force acts ona body for a very short time the product of the force and the time for which the force acts is called impulse.

Mathematical Derivation of Impulse:

If initial velocity v_i of the ball and final velocity v_f after collision is calculated during a time interval Δt, the average acceleration a is given by:

$$\boldsymbol{a} = \frac{\Delta \boldsymbol{v}}{\Delta t} = \frac{\boldsymbol{v}_f - \boldsymbol{v}_i}{\Delta t} \qquad (3.3)$$

According to Newton's second law of motion, the value of average force acting during the interval Δt will be:

$$\boldsymbol{F} = m\boldsymbol{a} = m\left(\frac{\Delta \boldsymbol{v}}{\Delta t}\right)$$

$$\boldsymbol{F} \times t = m(\Delta \boldsymbol{v}) = m(\boldsymbol{v}_f - \boldsymbol{v}_i) \quad (3.4)$$

Equation (3.4) shows that $\boldsymbol{F}$ and Δt cannot be exactly known but their product which is equal to the change of momentum $(m\boldsymbol{v}_f - m\boldsymbol{v}_i)$ can be calculated. For such cases, the product $\boldsymbol{F} \times t$ is called as **Impulse** of the force.

When a large force F acts on an object for a short interval of time, the impulse of the force is defined as the total change in momentum of the object.

(b) State Newton's Second Law of Motion in terms of Momentum.

Ans: Mathematically:

$$\boldsymbol{F} \times t = m(\Delta \boldsymbol{v})$$

Dividing both sides of above Eq.3.4 by Δt, we

$$\boldsymbol{F} = \frac{m(\Delta \boldsymbol{v})}{\Delta t} \qquad (3.5)$$

where $m(\Delta \boldsymbol{v})$ is the change in momentum $\Delta \boldsymbol{p}$. Equation (3.5) gives the value of force in terms of momentum i.e., force acting on an object is equal to the change in momentum of the object per unit time.

$$\boldsymbol{F} = \frac{\Delta \boldsymbol{p}}{\Delta t} \qquad (3.6)$$

Newton's Second Law of Motion in Terms of Momentum:

Equation (3.6) suggests to define Newton's second law of motion in terms of momentum i.e.,

Statement:

The rate of change of momentum of a body is equal to the force acting on it.

Direction of change in momentum:

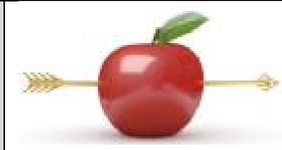
The direction of change in momentum is that of the force.

Do You Know?

A cricketer draws his hands back to reduce the impact of the ball by increasing the time.

For Your Information!

The arrow penetrates into the apple, and in response, the momentum of the apple changes. Conversely, the apple applies an opposing force to the arrow, and in reopose, the momentum of the arrow changes.



Packing of Fragile Objects

Fragile objects such as glassware may break easily due to jerks or by the direct impact with hard objects during their transportation.
To protect them soft, packing materials are used for these objects. These materials reduce the effect of quick change in momentum. Consequently, the force acting on the fragile objects is greatly reduced. Special materials like Styrofoam, corrugated cardboard sheets, bubble wrap are used for the packing of such objects.

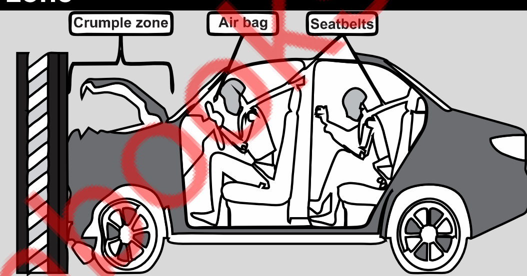
Crumple zone

Q. What is Crumple zone?

Ans: A crumple zone of an automobile is a structural feature designed to compress during an accident to absorb deformation energy from the impact. Typically, crumple zones are located in front and behind of the main body of the vehicle.

Q. How crumple zone works?

Ans: Crumple zones work by managing crash energy absorbing within the outer parts of the vehicle, rather than being directly transmitted to the occupants. This is achieved by controlled weakling of outer parts (plastic bumpers, etc.) of the vehicle, while strengthening of the passenger cabin.



3.10 Principle of Conservation of Momentum

Q.20(a) Define System and Isolated System.

(b) State and explain Law of Conservation of Momentum.

(c) Discuss the case of the collision of two identical balls in which the second ball is at rest.

(a) Define System and Isolated System.

Ans: System:

The collection of objects is known as a 'system'.

Isolated System:

If no external force acts on any object of the system, it is known as isolated system.

(b) State and explain Law of Conservation of Momentum.

Ans: Law of Conservation of Momentum:

Statement:

If no external force acts on an isolated system, the final total momentum of the system is equal to the initial total momentum of the system.

Explanation:

Consider a system of two balls of masses m_1 and m_2. Suppose that the balls are moving with velocities v_1 and v_2 along a straight line in the same direction. If $v_1 > v_2$, the balls will collide (Fig. 3.26). If their velocities become, v'_1 and v'_2 respectively after collision, then:

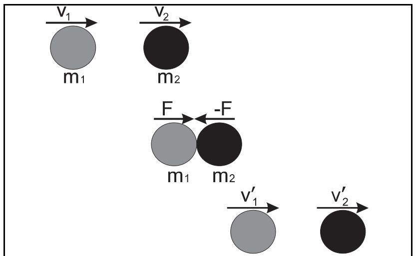


Fig. 3.26

Total momentum of the system before collision $= m_1v_1 + m_2v_2$

Total momentum of the system after collision $= m_1v'_1 + m_2v'_2$

Acording to principle of conservation of momentum:

Total momentum of the system after collision = Total momentum of the system before collision

$$m_1v_1 + m_2v_2 = m_1v'_1 + m_2v'_2$$

(c) Discuss the case of the collision of two identical balls in which the second ball is at rest.

Ans: Consider the collision of two identical balls in which the second ball is at rest. When there is collision of two balls, there is a transfer of momentum from one ball to another. The ball at rest gains momentum and starts moving whereas the striking ball slows down. If the balls are identical, we will observe that there is a total transfer of momentum. The striking ball comes to rest and the other ball starts moving with the same speed (Fig.3.27).

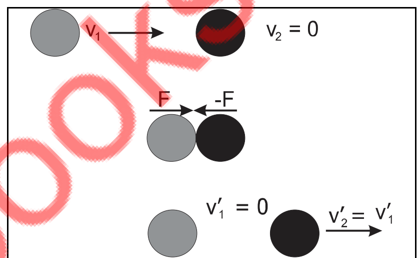
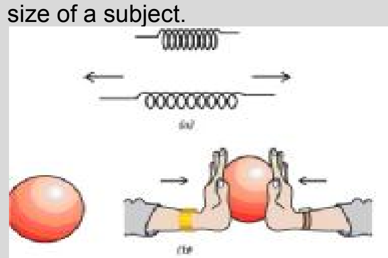


Fig. 3.27

It means that second ball gains momentum equal to that lost by the first one. If the first ball stops after collision, the second ball moves with the momentum of the first ball. This suggests that the total momentum of the two balls after collision remains the same as total momentum before collision.

TUTOR

Force can change the shape and size of a subject.



The principle of conservation of momentum is applicable to both macro-objects and micro-objects like atoms and molecules.

Seat belts

When a moving car stops suddenly, the passengers move toward forward towards the windshield. Seatbelts prevent the passengers for, moving. Thus, chances of hitting the passengers against the windshield or steering wheel are reduced.

KEY POINTS

- A **force** is a push or a pull that starts, stops and changes the magnitude and direction of velocity of a body.
- A **contact force** is a force that acts at the point of contact between two objects.
- **Non-contact force** is a force between two objects which are not in physical contact.
- Gravitational force, electromagnetic force, strong nuclear force and weak nuclear force are the **four fundamental forces in nature**.
- Every object in the universe attracts every other object with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. This is known as **Newton's law of gravitation**.
- **Newton's first law of motion** states that a body continues its state of rest or of uniform motion with the same constant velocity, unless acted upon by some net external force.
- The property of a body to maintain its state of rest or of uniform motion is called **inertia**.
- **The second law of motion** states that when a net force acts upon a body, it produces an acceleration in the direction of force and the magnitude of acceleration is directly proportional to the force and is inversely proportional to the mass.
- **The third law of motion** states that to every action there is an equal but opposite reaction.
- Action and reaction do not act on the same body but act on two different bodies.
- **Mass of a body** is the quantity of matter in it. It determines the magnitude of acceleration produced when a force acts on it. Mass of a body does not vary. It is a scalar quantity and its unit is kilogram (kg).
- The **weight** of an object is equal to the force with which the Earth attracts a body towards its centre.
- **Force meter** is a scientific instrument that measures force in newtons (N).
- **Friction** is the force that tends to prevent the bodies from sliding over each other.
- The resisting force between the two surfaces before the motion starts is called the **static friction**. The maximum value of the static friction is called a **limiting friction**.
- The friction during motion is called **kinetic friction**.
- When a body moves with the help of wheels, the friction in this case is known as **rolling friction**. Rolling friction is much less as compared to the sliding friction.
- **Energy** is wasted in doing work against friction that appears in the form of heat.
- When upward air resistance balances the downward force of gravity on a falling object, it falls down with constant (safe) velocity, it is called **terminal velocity**.
- The product of mass and velocity of a moving body is called **momentum**.
- The **principle of conservation of momentum** states that if no external force acts on an isolated system, the final total momentum of the system is equal to the initial total momentum of the system.
- **Impulse** is defined as the product of $F \times \Delta t = m \times \Delta v$ = total change in momentum.

IMPORTANT FORMULAE

Newton's second law of motion, $F = ma$

Momentum $p = mv$

Recoil velocity $v_2 = \frac{-m_1 v_1}{m_2}$

Law of conversion of momentum,

Total momentum before collision = Total momentum after collision

or $m_1\mathbf{v}_1 + m_2\mathbf{v}_2 = m_1\mathbf{v}'_1 + m_2\mathbf{v}'_2$

Netwon's second law of motion in term of momentum:

Impulse: $\boldsymbol{I} = \boldsymbol{F} \times t = m(\Delta\boldsymbol{v})$

SOLVED EXAMPLES

Example 3.1

A 10 kg block moves on a frictionless horizontal surface with an acceleration of 2 ms^{-2}. What is the force acting on the block? (3.6)

Solution: Given Data:

Mass of a block = m = 10 kg

Acceleration = a = 2ms^{-2}

To Find:

Force = F = ?

Caculations:

By Newton's second law of motion, $F = ma$

Putting the values, F = 10kg × 2 ms^{-2} = 20 kgms^{-2} =20 N $\quad (\because 1\text{kgms}^{-2} = 1\text{N})$

Example 3.2

A force of 7500 N is applied to move a truck of mass 3000 kg. Find the acceleration produced in the truck. How long will it take to accelerate the truck from 36 kmh^{-1} to 72 kmh^{-1} speed? (3.6)

Solution: Given Data:

Mass of truck = m = 3000 kg

Force applied = F = 7500 N

Initial speed = v_i = 36 kmh^{-1}

$$= \frac{36 \times 1000\,m}{3600\,s} = 10\,ms^{-1}$$

Final velocity = v_f = 72 kmh^{-1}

$$= \frac{72 \times 1000\,m}{3600\,s} = 20\,ms^{-1}$$

To Find:

a) Acceleration = a = ?

b) Time = t = ?

Caculations:

a) By Newton's second law:

$$F = ma$$

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

Putting the values,

$$a = \frac{7500\,N}{3000\,kg} = \frac{7500\,kgms^{-2}}{3000\,kg}$$

$$a = 2.5\,ms^{-2}$$

b) By using first equation of motion

$$v_f = v_i + at$$

$$t = \frac{v_f - v_i}{a}$$

$$t = \frac{20\,ms^{-1} - 10\,ms^{-1}}{2.5\,ms^{-2}} = 4\,s$$

Example 3.3

A bullet of mass 15 g is fired by a gun. If the velocity of the bullet is 150 ms^{-1}, what is its momentum? (3.9)

Solution: Given Data:

Mass of bullet $= m = 15g = 0.015\ kg$

Velocity of bullet $= v = 150\ ms^{-1}$

To Find:

Momentum $= p = ?$

Calculations:

As, we know that

$p = mv$

Putting the value,

$p = 0.015\ kg \times 150\ ms^{-1}$

or $p = 2.25\ kg\ ms^{-1}$

Example 3.4

A cricket ball of mass 160 g is hit by a bat. The ball leaves the bat with a velocity of 52 ms^{-1}. If the ball strikes the bat with a velocity of –28 ms^{-1} (opposite direction) before hitting, find the average force exerted on the ball by the bat. The ball remains in contact with the bat for 4×10^{-3} s. (3.9)

Solution: Given Data:

Mass of ball $= m = 160\ g = 0.16\ kg$

Initial velocity $= v_i = -28\ ms^{-1}$

Final velocity $= v_f = 52\ ms^{-1}$

Time of contact $= t = 4\times10^{-3}\ s$

To Find:

Average force $= F = ?$

Calculations:

As we know that

$$F = \frac{m\left(v_f - v_i\right)}{t}$$

Putting the values,

$$F = \frac{0.16\,kg\left(52\,ms^{-1} - \left(-28\,ms^{-1}\right)\right)}{4\times10^{-3}\,s}$$

$$F = 3200\,N$$

Example 3.5

A bullet of mass is fired by a gun of mass m_2. Find the velocity of the gun in terms of velocity of bullet v_1 just after firing. (3.10)

Ans: Caculations:

Before firing, the velocity of bullet as well as that of gun was zero. Therefore, total momentum of bullet and gun was also zero. After firing, the bullet moves forward with velocity v_1 whereas the gun moves with velocity v_2.

According to law of conservation of momentum,

Total momentum before firing= Total momentum after firing

Putting the values, $0 = m_1v_1 + m_2v_2$

$m_2v_2 = -m_1v_1$

or $$v_2 = \frac{-m_1v_1}{m_2}$$

The negative sign in this equation, indicates that the gun moves backward, i.e. opposite to the bullet. It is because of the backward motion of the gun that the shooter gets a jerk on his shoulder.

Example 3.6

A ball of mass 3 kg moving with a velocity of 5 ms^{-1} collides with a stationary ball of mass 2 kg and then both of them move together. If the friction is negligible, find out the velocity with which both the balls will move after collision. (3.10)

Solution: Given Data:

Mass of first ball = m_1 = 3 kg
Velocity of first ball before collision = v_1 = 5 ms^{-1}
Mass of second ball = m_2 = 2 kg
Velocity of second ball before collision = v_2 = 0

To Find:

Velocity of both the balls after collision = v = ?

Caculations:

Total mass of balls after collision = $m_1 + m_2$
By law of conversion of momentum,
Total momentum before collision = Total momentum after collision

or $$m_1v_1 + m_2v_2 = (m_1 + m_2)v$$

Putting the values,

$$3kg \times 5ms^{-1} + 0 = (3kg + 2kg)v$$

$$15kgms^{-1} = 5kg \times v \quad \Rightarrow \quad v = \frac{15kgms^{-1}}{5kg}$$

$$v = 3ms^{-1}$$

EXERCISE

A Multiple Choice Questions

1. Tick (✓) the correct answer.

3.1 When we kick a stone, we get hurt. This is due to: (3.4)
(a) inertia (b) velocity (c) momentum ✓ (d) reaction

3.2 An object will continue its motion with constant acceleration until: (3.4)
(a) the resultant force on it begins to decrease
(b) the resultant force on it is zero ✓
(c) the resultant force on it begins to increase
(d) the resultant force is at right angle to its tangential velocity

3.3 Which of the following is a non-contact force? (3.1)
(a) Friction (b) Air resistance ✓
(c) Electrostatic force (d) Tension in the string

3.4 A ball with initial momentum p hits a solid wall and bounces back with the same velocity. Its momentum p' after collision will be: (3.10)
(a) $p = p'$ (b) $p = -p'$ ✓ (c) $p' = 2p$ (d) $p' = -2p$

3.5 A particle of mass m moving with a velocity v collides with another particle of the same mass at rest. The velocity of the first particle after collision is: (3.10)
(a) v (b) $-v$ (c) 0 ✓ (d) -1/2

3.6 Conservation of linear momentum is equivalent to: (3.10)

(a) Newton's first law of motion (b) Newton's second law of motion

(c) Newton's third law of motion ✓ (d) None of these

3.7 An object with a mass of 5 kg moves at constant velocity of 10 ms^{-1}. A constant force then acts for 5 seconds on the object and gives it a velocity of 2 ms^{-1} in the opposite direction. The force acting on the object is: (3.9)

(a) 5 N (b) -10 N (c) -12 N ✓ (d) -15 N

3.8. A large force acts on an object for a very short interval of time. In this case, it is easy to determine: (3.9)

(a) magnitude of force (b) time interval

(c) product of force and time ✓ (d) none of these

3.9. A lubricant is usually introduced between two surfaces to decrease friction. The lubricant: (3.8)

(a) decreases temperature (b) acts as ball bearings

(c) prevents direct contact of the surfaces ✓ (d) provides rolling friction

B Short Answer Questions

3.1. What kind of changes in motion may be produced by a force? (3.1)

Ans: When a force is produced, it can cause different types of changes i.e., an object to accelerate, to decelerate, to stop, or to change direction.

3.2. Give 5 examples of contact forces. (3.1)

Ans:

(i) Friction (ii) Drag (iii) Thrust

(iv) Normal Force (v) Air Resistance

3.3. An object moves with constant velocity in free space. How long will the object continue to move with this velocity? (3.1)

Ans: If an object is moving with constant velocity in free space, it will continue to move with constant velocity **indefinitely**. It is because there is **no external or frictional force** in space.

3.4. Define impulse of force. (3.9)

Ans: **Impulse:** Impulse is defined as the product of $F \times \Delta t = m \times \Delta v$ =total change in momentum.

Explanation: If a large force applied for a short interval of time, the momentum produced is equal to the impulse.

3.5. Why has not Newton's first law been proved on the Earth? (3.4)

Ans: **Newton's First Law of Motion:** A body continues its state of rest or of uniform motion in a straight line unless acted upon by some external force.

Explanation: Newton's first law of motion has not been proved on the Earth because **External forces or frictional forces** exist on Earth.

3.6. When sitting in a car which suddenly accelerates from rest, you are pushed back into the seat, why? (3.4)

Ans: When a car accelerates suddenly, your body resists the change in motion due to **inertia**, causing you to feel pushed back into the seat while the car moves forward.

3.7. The force expressed in Newton's second law is a net force. Why is it so? (3.4)

Ans: The force in Newton's second law is a net force because it represents the total force resulting from the combination of all individual forces acting on an object, which determines its acceleration.

3.8. How can you show that rolling friction is lesser than the sliding friction? (3.8)

Ans: Rolling friction is about one hundred times smaller than the sliding friction. It is because for the rolling friction to be less than the sliding friction is that there is **no relative motion** between the **wheel** and the **surface over** which it **rolls**. The **wheel touches** the **surface** only **at a point**. It does **not slide**.
These points shows that rolling friction is lesser than the sliding friction.

3.9. Define terminal velocity of an object. (3.8)

Ans: When upward air resistance balances the downward force of gravity on a falling object, it falls down with constant (safe) velocity, it is called terminal velocity.

3.10. An astronaut walking in space wants to return to his spaceship by firing a hand rocket. In what direction does he fire the rocket? (3.8)

Ans: Astronaut should fire the hand rocket **away from the spaceship**.
Explanation: This is because, according to Newton's third law of motion, for every action, there is an equal and opposite reaction. When the astronaut fires the rocket, the force of the rocket's exhaust will push the astronaut in the opposite direction, causing him to move towards the spaceship.

C Constructed Response Questions

3.1 Two ice skaters weighing 60 kg and 80 kg push off against each other on a frictionless ice track. The 60 kg skater gains a velocity of 4 ms^{-1}. Considering all the relevant calculations involved, explain how Newton's third law applies to this situation. (3.4)

Ans: When the 60 kg and 80 kg skaters push off each other, they exert equal and opposite forces, as per Newton's third law. The 60 kg skater gains a velocity of 4 ms^{-1}, and by momentum conservation, the 80 kg skater moves in the **opposite direction** with a velocity of 3 ms^{-1}.

3.2 Inflatable air bags are installed in the vehicles as safety equipment. In terms of momentum, what is the advantage of air bags over seatbelts? (3.10)

Ans: Airbags increase the time over which a passenger’s momentum is reduced during a collision, which lowers the force experienced. This is because a longer time for deceleration results in a smaller force, making airbags safer than seatbelts, which apply a more sudden force.

3.3 A horse refuses to pull a cart. The horse argues, "according to Newton's third law, whatever force I exert on the cart, the cart will exert an equal and opposite force on me. Since the net force will be zero, therefore, I have no chance of accelerating (pulling) the cart." What is wrong with this reasoning? (3.4)

Ans: In horse argues, the part “whatever force I exert on the cart, the cart will exert an equal and opposite force on me. Since the net force will be zero” is wrong. This is because it neglects or does not account the frictional force in it. When we account frictional force, the net force will be non-zero. Hence, the car accelerates (pulls).

3.4. When a cricket ball hits high, a fielder tries to catch it. While holding the ball he/she draws hands backward. Why? (3.9)

Ans: When a fielder draws their hands backward while catching a cricket ball, they are **increasing the time** over which the **ball's momentum** is **brought to zero**.

By **extending the time** of the **catch**, the **force** on the hands is **reduced** according to the impulse-momentum theorem, which states:

$$F.\,\Delta t = \Delta p$$

By increasing the time (Δt), the force (F) experienced by the fielder is decreased, reducing the **risk of injury** and making the **catch easier**.

3.5. When someone jumps from a small boat onto the river bank, why does the jumper often fall into the water? Explain. (3.4)

Ans: When someone jumps from a small boat, he pushs the boat backward (due to Newton's third law). The **boat's backward motion** causes the jumper to **lose balance**, often resulting in a fall into the water.

3.6. Imagine that if friction vanishes suddenly from everything, then what could be the scenario of daily life activities? (3.8)

Ans: If friction vanishes suddenly from everything, then we cannot do work.

For example, we cannot **walk**, **drive** a vehicle and **hold objects**. It is becauseas there would be no **grip or friction**. **Writing**, **operating machines**, and using tools would also fail, severely disrupting daily activities.

D Comprehensive Questions

3.1. Explain the concept of force by practical examples. (3.1)

Ans: For answer, See Question # 1

3.2. Describe Newton's laws of motion. (3.4)

Ans: For answer, See Question # 5(a)+8(a)+9(a)

3.3. Define momentum and express Newton's 2nd law of motion in terms of change in momentum. (3.9)

Ans: For answer, See Question # 19(a)+(b)

3.4. State and explain the principle of conservation of momentum. (3.10)

Ans: For answer, See Question # 20(b)

3.5. Describe the motion of a block on a table taking into account the friction between the two surfaces. What is the static friction and kinetic friction? (3.8)

Ans: For answer, See Question # 16

3.6. Explain the effect of friction on the motion of vehicles in context of tyre surface and braking force. (3.8)

Ans: For answer, See Question # 15 + 17

E Numerical Problems

3.1. A 10 kg block is placed on a smooth horizontal surface. A horizontal force of 5 N is applied to the block. Find: (3.4)

(a) the acceleration produced in the block.

(b) the velocity of block after 5 seconds. (0.5 ms^{-2}, 2.5 ms^{-1})

Solution: Given Data:

Mass of block $= m = 10\,kg$

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

Force applied $= F = 5\,N = 5\,kgms^{-2}$

Time taken $= t = 5\,s$

Initial velocity $= v_i = 0\,ms^{-1}$ (block at rest)

To Find:

a) Acceleration $= a = ?$

b) Final velocity $= v_f = ?$

Calculations:

a) By Newton's second law of motion,

$$F = ma$$

By putting values

$$a = \frac{5\,kgms^{-2}}{10\,kg}$$

$$a = 0.5\,ms^{-2}$$

b) By Newton's first equation of motion

$$v_f = v_i + at$$

By putting values

$$v_f = 0 + \left(0.5\,ms^{-2}\right)\left(5\,s\right)$$

$$v_f = 2.5\,ms^{-1}$$

3.2. The mass of a person is 80 kg. What will be his weight on the Earth? What will be his weight on the Moon? The value of acceleration due to gravity of Moon is 1.6 ms^{-2}. **(3.6)**

(800 N, 128 N)

Solution: Given Data:

Mass of body $= m = 80\,kg$

Earth's Gravitational force

$= g_e = 10\,ms^{-2}$

Moon's Gravitational force

$= g_m = 1.6\,ms^{-2}$

To Find:

a) Weight of person at Earth $= w_e = ?$

b) Weight of person at Moon $= w_m = ?$

Calculations:

As we know that

$$F = w = mg$$

a) Weight of person at Earth $= w_e = ?$

$$w_e = mg_e$$

By putting values

$$w_e = \left(80\,kg\right)\left(10\,ms^{-2}\right)$$

$$w_e = 800\,kgms^{-2} = 800\,N$$

b) Weight of person at Moon $= w_m = ?$

$$w_m = mg_m$$

By putting values

$$w_m = \left(80\,kg\right)\left(1.6\,ms^{-2}\right)$$

$$w_m = 128\,kgms^{-2} = 128\,N$$

3.3. What force is required to increase the velocity of 800 kg car from 10 ms^{-1} to 30 ms^{-1} in 10 seconds? **(3.9)**

(1600N)

Solution: Given Data:

Mass of car $= m = 800\,kg$

Initialy velocity $= v_i = 10\,ms^{-1}$

Final velocity $= v_f = 30\,ms^{-1}$

Time taken $= t = 10\,s$

To Find:

Force required $= F = ?$

Calculations:

As, we know that

$$F \times \Delta t = m\left(v_f - v_i\right)$$

$$F = \frac{m\left(v_f - v_i\right)}{\Delta t}$$

By putting values

$$F = \frac{\left(800\,kg\right)\left(30\,ms^{-1} - 10\,ms^{-1}\right)}{10\,s}$$

$$F = \frac{\left(800\,kg\right)\left(20\,ms^{-1}\right)}{10\,s}$$

$$F = 1600\,kgms^{-2} = 1600\,N$$

3.4. A 5 g bullet is fired by a gun. The bullet moves with a velocity of 300 ms^{-1}. If the mass of the gun is 10 kg, find the recoil speed of the gun. (3.10)
(-0.15 ms^{-1})

Solution: Given Data:

Mass of bullet $= m_1 = 5g = \frac{5}{1000}kg$

$= 5\times10^{-3}kg$

Velocity of bullet $= v_1 = 300\,ms^{-1}$

Mass of gun $= m_2 = 10\,kg$

To Find:

Recoil speed of gun $= v_2 = ?$

Calculations:

As, we know that

$$v_2 = \frac{-m_1v_1}{m_2}$$

By putting values

$$v_2 = \frac{-\left(5\times10^{-3}kg\right)\left(300\,ms^{-1}\right)}{10\,kg}$$

$$v_2 = -\,0.15\,ms^{-1}$$

3.5. An astronaut weighs 70 kg. He throws a wrench of mass 300 g at a speed of 3.5 ms^{-1}. Determine:
(a) the speed of astronaut as he recoils away from the wrench.
(b) the distance covered by the astronaut in 30 minutes. (3.10)
(-1.5×10^{-2} ms^{-1}, 27 m)

Solution: Given Data:

Mass of astronaut $= m_2 = 70\,kg$

Mass of wrench $= m_1 = 300\,g = 0.3\,kg$

Speed of wrench $= v_1 = 3.5\,ms^{-1}$

Time $= t = 30\,minutes = 30\times60\,s = 1800\,s$

To Find:

(a) Speed of astranaut $= v_2 = ?$

(b) Distance covered by astronaut $= S = ?$

Calculations:

(a) Speed of astronout $= v_2 = ?$

As, we know that

$$v_2 = \frac{-m_1v_1}{m_2}$$

By putting values

$$v_2 = \frac{-\left(0.3\,kg\right)\left(3.5\,ms^{-1}\right)}{70\,kg}$$

$$v_2 = -\,0.015\,ms^{-2}$$

$$v_2 = -\,1.5\times10^{-2}\,ms^{-2}$$

(b) Distance covered by astronaut

Since, speed of astronaut

$= v = 0.015\,ms^{-1}$

Distance = speed × time

$$S = v\times t$$

$$S = 0.015\,ms^{-1}\times1800\,s$$

$$S = 27\,m$$

3.6. A 6.5 × 10^3 kg bogie of a goods train is moving with a velocity of 0.8 ms^{-1}. Another bogie of mass 9.2 × 10^3 kg coming from behind with a velocity of 1.2 ms^{-1} collides with the first one and couples to it. Find the common velocity of the two bogies after they become coupled. (3.10)
(1.03 ms^{-1})

Solution: Given Data:

Mass of first bogie $= m_1 = 6.5\times10^3\,kg$

Velocity of first bogie $= v_1 = 0.8\,ms^{-1}$

Mass of second bogie $= m_2 = 9.2\times10^3\,kg$

Velocity of second bogie $= v_2 = 1.2\,ms^{-1}$

To Find:

Common velocities of bogies $= v = ?$

Calculations:

As, we know that

Total momentum before collision = Total momentum after collision

$$m_1v_1 + m_2v_2 = (m_1 + m_2)v$$

By putting values

$$(6.5\times 10^3\,kg)(0.8\,ms^{-1}) + (9.2\times 10^3\,kg)(1.2\,ms^{-1}) = (6.5\times 10^3\,kg + 9.2\times 10^3\,kg)v$$

$$5.2\times 10^3\,kgms^{-1} + 11.04\times 10^3\,kgms^{-1} = (15.7\times 10^3\,kg)v$$

$$16.24\times 10^3\,kgms^{-1} = (15.7\times 10^3\,kg)v$$

$$v = \frac{16.24\times 10^3\,kgms^{-1}}{15.7\times 10^3\,kg} \Rightarrow v = 1.03\,ms^{-1}$$

3.7. A cyclist weighing 55 kg rides a bicycle of mass 5 kg. He starts from rest and applies a force of 90 N for 8 seconds. Then he continues at a constant speed for another 8 seconds. Calculate the total distance travelled by the cyclist.

(3.4)

(144 m)

Solution: Given Data:

Initial velocity $= v_i = 0\,ms^{-1}$

(cyclist starts from rest)

Mass of cyclist $= m_1 = 55\,kg$

Mass of bicycle $= m_2 = 5\,kg$

Force applied $= F = 90\,N = 90\,kgms^{-2}$

First time interval $= t_1 = 8\,s$

Second time interval $= t_2 = 8\,s$

To Find:

Total distance travelled by cyclist $= S = ?$

Calculations:

As, Total mass

$= m = m_1 + m_2 = 55\,kg + 5\,kg = 60\,kg$

Now, by Newton's second law of motion

$$F = ma$$

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

By putting values

$$a = \frac{90\,kgms^{-2}}{60\,kg} = 1.5\,ms^{-2}$$

$$S_1 = 48\,m$$

Distance covered in 1st time interval is $48\,m$.

Distance travelled in Second time interval:

Now, we have to find the final velocity (v_f) of first time interval

By Newton's 1st equation of motion

$$v_f = v_i + at$$

By putting values

$$v_f = 0\,ms^{-1} + (1.5\,ms^{-2})(8\,s)$$

$$v_f = 12\,ms^{-1}$$

This is the final velocity for first time interval. According to condition of question, this final velocity is the average constant velocity for second time interval $v_{av} = v_f = 12\,ms^{-1}$.

Since, we know that

Distance travelled = Average velocity × time interval

So, $S_2 = v_{av} \times t_2$

Distance travelled in First time interval:

Distance travelled in first time interval can be find by Newton's 2nd equation of motion

$$S_1 = v_i t_1 + \frac{1}{2}at_1^2$$

By putting values

$$S_1 = \left(0\,ms^{-1}\right)(8s) + \frac{1}{2}\left(1.5\,ms^{-2}\right)(8s)^2$$

$$S_1 = 0 + \left(0.75\,ms^{-2}\right)\left(64\,s^2\right)$$

By putting values

$$S_2 = 12\,ms^{-1} \times 8\,s = 96\,m$$

Distance covered in 2nd time interval $96\,m$.

Distance travelled in total time:

Now,

Total distance covered =

Distance covered in 1st time interval + Distance covered in 2nd time interval

$$S = S_1 + S_2$$

$$S = 48\,m + 96\,m = 144\,m$$

Thus, total distance is $144\,m$.

3.8. A ball of mass 0.4 kg is dropped on the floor from a height of 1.8 m.The ball rebounds straight upward to a height of 0.8 m. What is the magnitude and direction of the impulse applied to the ball by the floor? (3.9)

(4 N s)

Solution: Given Data:

Mass of ball $= m = 0.4\,kg$

Height of bat from ground $= h_1 = 1.8\,m$

Ball rebound from ground to height $= h_2 = 0.8\,m$

Initial velocity $= v_i = 0\,ms^{-1}$ (ball from height in rest form)

To Find:

Impulse $= \Delta I = ?$

Calculations:

The velocity of the ball just before hiting the ground can be calculated by Newton's third equation of motion freely falling. As,

$$2gh_1 = v_f^2 - v_i^2$$

Since, ball is dropped, so, $v_i = 0\,ms^{-1}$ and $g = 10\,ms^{-2}$ (fall downward). By putting values

$$2\left(10\,ms^{-2}\right)(1.8\,m) = v_f^2 - \left(0\,ms^{-1}\right)^2$$

$$36\,m^2 s^{-2} = v_f^2$$

$$\sqrt{v_f^2} = \pm\sqrt{36\,m^2 s^{-2}} \quad \Rightarrow \quad v_f = \pm 6\,ms^{-1}$$

(velocity is taking as negative because motion is downward)

$$v_f = -6\,ms^{-1}$$

If the velocity taken as velocity before collision.

Now, when the ball is reboud, $v_f = 0\,ms^{-1}$ and $g = -10\,ms^{-2}$ (moving upward). By putting values

$$2\left(-10\,ms^{-2}\right)\left(0.8\,m\right)=\left(0\,ms^{-1}\right)^2-v_i^2$$

$$-16m^2s^{-2}=0-v_i^2$$

$$\sqrt{v_i^2}=\pm\sqrt{16m^2s^{-2}} \quad \Rightarrow \quad v_i=\pm 4\,ms^{-1}$$

$$v_i=+4ms^{-1}$$

If the velocity taken as velocity after collision.

Now, the change in velocity = velocity after collision - velocity before collision

$$\Delta v=4\,ms^{-1}-\left(-6\,ms^{-1}\right)=10\,ms^{-1}$$

Impulse can be calculated as:

$$\Delta I=m\left(\Delta v\right)=\left(0.4\,kg\right)\left(10\,ms^{-1}\right)$$

$$\Delta I=4\,kgms^{-1}=4\,Ns$$

3.9. Two balls of masses 0.2 kg and 0.4 kg are moving towards each other with velocities 20 ms^{-1} and 5 ms^{-1} respectively. After collision, the velocity of 0.2 kg ball becomes 6 ms^{-1}. What will be the velocity of 0.4 kg ball? (3.10)

(2 ms^{-1})

Solution: Given Data:

Mass of 1st ball $=m_1=0.2\,kg$

Mass of 2nd ball $=m_2=0.4\,kg$

Velocity of 1st ball before collision $=v_1=20\,ms^{-1}$

Velocity of 2nd ball before collision $=v_2=-5\,ms^{-1}$ (opposite to v_1)

Velocity of 1st ball after collision $=v_1'=6\,ms^{-1}$

To Find:

Velocity of 2nd ball after collision $=v_2'=?$

Calculations:

By law of conservation of linear momentum

$$m_1v_1+m_2v_2=m_1v_1'+m_2v_2'$$

$$\left(0.2\,kg\right)\left(20\,ms^{-1}\right)+\left(0.4\,kg\right)\left(-5\,ms^{-1}\right)=\left(0.2\,kg\right)\left(6\,ms^{-1}\right)+\left(0.4\,kg\right)v_2'$$

$$4\,kgms^{-1}-2\,kgms^{-1}=1.2\,kgms^{-1}+\left(0.4\,kg\right)\left(v_2'\right)$$

$$2\,kgms^{-1}-1.2\,kgms^{-1}=\left(0.4\,kg\right)\left(v_2'\right)$$

$$0.8\,kgms^{-1}=\left(0.4\,kg\right)\left(v_2'\right)$$

$$v_2'=\frac{0.8\,kgms^{-1}}{0.4\,kg} \quad \Rightarrow \quad v_2'=2\,ms^{-1}$$

General MCQs with Conceptual Questions (CQs)

3.1 Concept of Force

1. How many major types of force?
(A) One (B) Two ✓ (C) Three (D) Four

2. Which of the following is a contact force? (CQs)
(A) Gravitational force (B) Magnetic force
(C) Normal force ✓ (D) Electrostatic force

3. Which of the following is not a non-contact force? (CQs)
(A) Tension force (B) Elastic force
(C) Air resistance (D) Nuclear force ✓

4. SI unit of Gravitational constant is:
(A) $Nm^{-2}\ kg^{-2}$ (B) $Nm^{2}\ kg^{-2}$ ✓ (C) $Nm^{2}\ kg^{2}$ (D) $Nm\ kg^{-2}$

5. Value of Gravitational constant is:
(A) 6.67×10^{-9} (B) 6.67×10^{-11} ✓ (C) 6.67×10^{-13} (D) 6.67×10^{-15}

6. Gravitational force is a _____ force.
(A) Non-contact (B) Contact (C) Field (D) Both (A) and (C) ✓

7. Which of the following is an example of elastic force? (CQs)
(A) Rubber bands (B) Springs (C) Trampline (D) All of above ✓

8. Which of the following is a long range force?
(A) Magnetic force (B) Weak nuclear force
(C) Gravitational force ✓ (D) Strong nuclear force

9. According to the Law of Gravitational "*F*" is equal to:
(A) $G\frac{m_1m_2}{d^5}$ (B) $G\frac{m_1m_2}{d^4}$ (C) $G\frac{m_1m_2}{d^3}$ (D) $G\frac{m_1m_2}{d^2}$ ✓

10. Concept of Gravity was put up first by:
(A) Eistein (B) Hook (C) Newton ✓ (D) Galileo

11. Which of the following is an example of contact force? (CQs)
(A) Push (B) Pull (C) Twist (D) All of above ✓

3.2 Fundamental Forces

12. How many fundamental forces are in nature?
(A) One (B) Two (C) Three (D) Four ✓

13. Which of the following fundamental force is weakest? (CQs)
(A) Gravitational force ✓ (B) Electromagnetic force
(C) Strong nuclear force (D) Weak nuclear force

14. What is the range of strong nuclear force?
(A) 10^{-12} m (B) 10^{-14} m ✓ (C) 10^{-16} m (D) 10^{-18} m

15. What is the range of weak nuclear force?
(A) 10^{-19} m (B) 10^{-18} m (C) 10^{-17} m ✓ (D) 10^{-16} m

16. A Pakistani scientist _____ awarded Nobel prize in Physics.
(A) Dr. Abdul Qadder Khan (B) Dr. Samar Mabarak
(C) Dr. Abdus Salam ✓ (D) Dr. Abdul Hameed Nayyar

17. Which scientist was awarded the Nobel prize in 1979?
(A) Dr. Abdus Salam (B) Sheldon Glashow
(C) Steven Weinberg (D) All of above ✓

18. Which of the following is short range force? (CQs)
(A) Weak nuclear force (B) Strong nuclear force
(C) Gravitational force (D) Both(A) and (B) ✓

3.3 Forces in a Free-Body Diagram

19. A free body diagram is a special example of the ______ diagram.
(A) Graph (B) Vector ✓ (C) Curve (D) Scalar

3.4 Newton's Laws of Motion

20. Inertia is related with:
(A) Mass ✓ (B) Force (C) Weight (D) Energy

21. Law of inertia is known as:
(A) First law of motion ✓ (B) Second law of motion
(C) Third law of motion (D) Momentum

22. The resultant of all the forces acting on a body is called:
(A) Net force ✓ (B) Frictional force (C) Gravitational force (D) Force

23. Famous book of Sir Isaac Newton is:
(A) Principia of Mathematica ✓ (B) Principia Physics
(C) Principia chemistry (D) Principia science

24. Sir Isaac Newton was born in Lincolnshire on:
(A) April 4, 1643 (B) March 4, 1643
(C) February 4, 1643 (D) January 4, 1643 ✓

25. The property of a body to maintain its state of rest or of unifotm motion in a straight line is:
(A) Gravity (B) Acceleration (C) Inertia ✓ (D) Force

26. The formula for Newton's second Law of motion is:
(A) $F = ma$ ✓ (B) $F = \frac{m}{a}$ (C) $F = \frac{a}{m}$ (D) $F = m^2a^2$

27. Product of mass and acceleration is:
(A) Inertia (B) Torque (C) Force ✓ (D) Momentum

28. A force of 20 N produces an acceleration of 2.5 ms^{-2} in a body. The mass of the body is:
(A) 10 kg (B) 50 kg (C) 8 kg ✓ (D) 0.25 kg

29. Weight "w" is equal to:
(A) $w = mg$ ✓ (B) $w = \frac{m}{g}$ (C) $w = \frac{g}{m}$ (D) $w = \frac{1}{mg}$

30. The value of acceleration produced by a 20 N force in a mass of 8 kg is:
(A) 2.5 ms^{-2} ✓ (B) 3.5 ms^{-2} (C) 5.5 ms^{-2} (D) 7.5 ms^{-2}

31. One newton is equal to:
(A) kgm^2s^{-2} (B) $kgms^{-2}$ ✓ (C) $kgm^{-2}s^{-2}$ (D) $kgms^{-2}$

32. SI unit of force is:
(A) joule (B) newton (C) pascal (D) ampere

33. Rocket works on:
(A) First law of motion (B) Second law of motion
(C) Third law of motion ✓ (D) Law of Gravitation

34. Which of the following is an example of Newton's 3rd law of motion?
(A) Book lying on table (B) Bullet is fired from a gun
(C) Birds are flying (D) All of these ✓

35. When a horse puls a cart, the action is on the:
(A) Cart (B) Horse (C) Earth ✓ (D) Earth and cart

3.5 Limitations of Newton's Laws of Motion

36. Relativistic meachanics developed by:
(A) Albert Einstein ✓ (B) Isaac Newton
(C) Pascal (D) Joule

3.6 Mass and Weight

37. The mass of a body is 40 kg. Its weight on Earth will be:
(A) 200 N (B) 300 N (C) 400 N ✓ (D) 500 N

38. SI unit of mass is:
(A) newton (B) joule (C) pascal (D) kilogram ✓

39. SI unit of weight is:
(A) kilogram (B) gram (C) pascal (D) newton ✓

40. Which of the following is not a vector quantity? (CQs)
(A) Weight (B) Force (C) Mass ✓ (D) Acceleration

41. The value of gravitational field strength is:
(A) 10 ms^{-2} (B) 10 N kg^{-1} ✓ (C) 9.8 ms^{-2} (D) 9.8 kg^{-1}

42. The gravitational force acting on unit mass is called:
(A) Electric field strength (B) Gravitational field strength ✓
(C) Gravitational acceleration (D) Gravitational constant

43. The weight of a body is 147 N. Its mass will be when g = 10 ms^{-2}.
(A) 1.47 kg ✓ (B) 14.7 kg (C) 0.147 kg (D) 147 kg

3.7 Mechanical and Electronic Balances

44. Heavy weight of items can be measure by:
(A) Electronic balance (B) Force meter
(C) Mechanical plateform balance ✓ (D) Mechanical balance

45. Other name of force meter is:
(A) Newton meter (B) Spring balance
(C) Mechnical balance (D) Both (A) and (B) ✓

46. The weight of 100 g mass is equal to:
(A) 1 N ✓ (B) 2 N (C) 3 N (D) 4 N

47. A digital force meter measures directly the weight of the object in:
(A) kilogram (B) joule (C) newton ✓ (D) pascal

48. To run, what is neede to push the ground backward? (CQs)
(A) Momentum (B) Weight (C) Aceleration (D) Friction ✓

49. Which is highly desirable when climbing up a hill? (CQs)
(A) Power (B) Velocity (C) Speed (D) Friction ✓

3.8 Friction

50. How many categories of sliding friction?
(A) One (B) Two ✓ (C) Three (D) Four

51. Which of the following isexample of terminal velocity? (CQs)
(A) Moving car (B) Paratrooper (C) Rubbing hands (D) All of above ✓

52. Which of the following material lowers friction when pushed between metal plates? (CQs)
(A) Water (B) Fine marble powder (C) Air (D) Oil ✓

3.9 Momentum and Impulse

53. Equation of momentum is:
(A) $P=\frac{m}{v}$ (B) $P=mv^2$ (C) $P=(mv)^2$ (D) $P=mv$ ✓

54. Momentum is the product of mass and:
(A) Acceleration (B) Velocity (C) Force (D) Work

55. The rate of change in momentum of a body is equal to:
(A) Impulse (B) Torque (C) Velocity (D) Force ✓

56. SI unit of impulse is equivalent to:
(A) Zero (B) Momentum ✓ (C) Acceleration (D) Velocity

57. In the absence of external force, the impulse of a body is:
(A) Zero ✓ (B) Constant (C) Maximum (D) Minimum

58. The ratio of change of momentum of a body freely is equal its:
(A) Energy (B) Weight ✓ (C) Power (D) Momentum

59. Which of the following can be possessed by a moving object? (CQs)
(A) Force (B) Mometum ✓ (C) Impulse (D) Power

60. Name the quantity which is vector? (CQs)
(A) Density (B) Power (C) Impulse ✓ (D) Charge

61. The product $\vec{F}\times\Delta t$ is called:
(A) Impulse ✓ (B) Momentum (C) Torque (D) Acceleration

3.10 Principle of Conservation of Momentum

62. According to the law of conservation of momentum:
(A) $v=\frac{-mv}{M}$ ✓ (B) $v=\frac{M}{mv}$ (C) $v=\frac{m}{Mv}$ (D) $v=-\frac{M}{mv}$

63. In an isolated system the momentum after collision of two bodies is:
(A) Increases (B) Constant ✓ (C) Decreases (D) Zero

64. Principle of conservation of momentum is applicable on:
(A) Macro objects (B) Micro objects (C) Both (A) and (B) ✓ (D) None of these

General Short Questions with Conceptual Questions (CQs)

3.0 Introduction

1. Define Dynamics.

Ans: Dynamics is the branch of mechanics which deal with the study of **motion of bodies** under **action of forces**.

3.1 Concept of Force

2. Define Force. Write the names of its types.

Ans: **Force:** The agent that changes or tends to change the state of a body.

Types of Forces: There are two major types of forces:

i) Contact Forces ii) Non-contact Forces

3. Define Contact Forces with example.

Ans: **Contact Forces:** A contact force is a force that is exerted by one object on the other at the point of contact.

Examples: Push, pull and twist are examples of contact forces.

4. Differentiate between friction and drag force.

Ans:

Friction	Drag force
Friction is the force that resists motion when the surface of one object comes in contact with the surface of another.	The drag force is the resistant force caused by the motion of a body through a fluid. It acts opposite to the relative motion of any object moving with respect to surrounding fluid.

5. What is thrust force? (CQs)

Ans: **Thurst force:** Thrust is an upward force exerted by a liquid on an object immersed in it.

6. Differentiate between normal force and tension.

Ans:

Normal force	Tension
Normal force is the force of reaction exerted by the surface on an object lying on it.	Tenision is the force experienced by a rope when a person or load pulls it.
Normal force acts outward and perpendicular to the surface. It is also called the support force upon the object.	The force acting along a string is called tension. It is denoted by T.

7. Define air resistance.

Ans: Air resistance is the resistance (opposition) offered by air when an object falls through it.

8. What is elastic force? Give its examples. (CQs)

Ans: **Elastic force:** A force that brings certain materials back to their original shape after being deformed is called elastic force.

Examples: Rubber bands, springs and trampoline.

9. Define non-contact force.

Ans: **Non-contact forces:** A non-contact force is defined as the force between two objects which are not in physical contact.

10. Define gravitational force with an example.

Ans: **Gravitational force:** The gravitational force is an attractive force that exists among all bodies which have mass.

Example: An apple falling down from a tree is one of the best examples of gravitational force. When we throw an object upward, it is the gravitational force of the Earth that brings it back to the Earth.

11. Define gravitational field.

Ans: The region in space around the Earth within which Earth can attract other bodies is called gravitational field.

12. Write the value of Gravitational Constant.

Ans: The value of Gravitational constant is $6.67 \times 10^{-11}\ Nm^2\ kg^{-2}$.

13. Differentiate between electrostatic force and magnetic force.

Ans:

Electrostatic force	Magnetic force
An electrostatic force acts between two charged objects.	Magnetic force is a force which a magnet exerts on other magnets and magnetic materials like iron, nickel and cobalt.
The opposite charges attract each other and similar charges repel each other.	Magnetic force between the poles of two magnets can be either attractive or repulsive.
Like gravitational force, electrostatic force is also a long-range force.	Like poles repel and unlike poles attract each other.

3.2 Fundamental Forces

14. Write the names of fundamental forces in nature.

Ans: There are four fundamental forces in nature. These are:

(i) Gravitational force (ii) Electromagnetic force

(iii) Strong nuclear force (iv) Weak nuclear force

15. Give characteristics of gravitational force.

Ans:

i) Gravitational force is the weakest one among all four forces.

ii) Gravitational force is a long range force.

iii) Gravitational force extends to infinite distance although it becomes weaker and weaker.

16. What is electromagnetic force?

Ans: Electromagnetic force is the force that causes the **interaction** between **electrically charged particles**

17. Give characteristics of Electromagnetic Force.

Ans:

i) Electromagnetic forces are long-range forces.

ii) The areas in which these forces act are called electromagnetic fields.

iii) Electromagnetic forces are stronger than gravitational and weak nuclear forces.

iv) Electromagnetic force causes all chemical reactions.

v) Electromagnetic force binds together atoms, molecules and crystals etc.

vi) At macroscopic level, it is a possible cause of friction between different surfaces in relative motion.

18. Describe Strong Nuclear Forces.

Ans: Strong nuclear forces holds the atomic nuclei together by binding the protons and neutrons in the nucleus over coming repulsive electromagnetic force between positively charged protons.

19. Give characteristics of Strong Nuclear Forces.

Ans:

i) Strong Nuclear Forces is a short-range force with the order of 10^{-14} m.

ii) If the distance between nucleons increases beyond this range, this force ceases to act.

20. Describe Weak Nuclear Force.

Ans: **Weak nuclear force:** Weak nuclear force is responsible for the disintegration of a nucleus.

Example: The weak nuclear force executes the for β-decay (beta decay) of a neutron, in which a neutron transforms into a proton.

21. What do you know about Dr. Abdus Salam?

Ans: A Pakistani scientist **Dr. Abdus Salam** along with **Sheldon Glashow** and **Steven Weinberg** were awarded in **1979 Nobel Prize in Physics** for their contributions to the unification of the weak nuclear force and electromagnetic force as **electroweak force**.

3.3 Forces in a Free-Body Diagram

22. Define external forces.

Ans: **External forces** acting on an object may include friction, gravity, normal force, drag, tension in a string or a human force due to pushing or pulling.

3.4 Newton's Laws of Motion

23. Define force in term of First law of Newton.

Ans: The first law of motion states that:

Force is an agency which changes or tends to change the state of rest or of uniform motion of a body.

24. Why passengers tend to bend farword, when a fast moving bus stops suddenly? (CQs)

Ans: When a fast-moving bus stops suddenly, the passengers tend to bend forward. It is because they want to continue their motion. On the other hand, when the bus starts moving quickly from rest, the passengers are pushed back against the seat. This time, the tendency of passengers is to retain their state of rest.

25. Define inertia.

Ans: The property of a body to maintain its state of rest or of uniform motion in a straight line is called inertia.

26. Which thing inertia measures?

Ans: The **mass** of an object is a **measure** of its inertia. The greater the mass of an object, the greater is its inertia.

27. State Second Law of Newton.

Ans: Newton's second law of motion states that:

If a net external force acts upon a body, it accelerates the body in the direction of force. The magnitude of acceleration is directly proportional to the magnitude of force and is inversely proportional to the mass of the body.

Formula: F = ma

28. Derive F = ma by Second Law of Newton.

Ans: If a net force of magnitude F acts on a body of mass m and produces an acceleration of magnitude a, then the second law can be written mathematically as:

$$a \propto F \quad \text{and} \quad a \propto \frac{1}{m}$$

So, $a \propto \frac{F}{m}$, $a = (constant)\frac{F}{m}$

According to SI units, if m = 1 kg, a = 1 ms^{-2}, F = 1 N, then the value of the constant will be 1. Therefore, the above equation can be written as:

$$a = 1 \times \frac{F}{m}$$

$$F = ma$$

29. Define Newton.

Ans: One newton is the force which produces an acceleration of 1 ms^{-2} in a body of mass 1 kg.

As, $F = ma$

1 N = 1 kg ms^{-2}

30. State Newton's Third Law of Motion? Explain with example.

Ans: **Newton's Third Law of Motion:** For every action, there is always an equal and opposite reaction.

Example: When we press a spring, the force exerted by our hand on the spring is action. Our hand also experiences a force exerted by the spring. This is the force of reaction.

31. Write the names of famous book of Isaac Newton.

Ans: Name of famous book of Isaac Newton is "Principia Mathematica".

3.5 Limitations of Newton's Laws of Motion

32. Write Limitations of Newton's Third Law of Motion.

Ans: Newton's laws of motion can be applied with very **high degree of accuracy** to the motion of objects and velocities which we come across in everyday life.

The problems arise when we deal with the motion of elementary particles having velocities close to that of light. For that purpose, **relativistic mechanics** developed by Albert Einstein is applicable.

Thus, Newton's laws of motion are not exact for all types of motion, but provide a good approximation, unless an object is small enough or moving close to the speed of light.

3.6 Mass and Weight

33. Define mass of an object.

Ans: **Mass:** The simplest definition of mass is that it is a measure of the quantity of matter in a body.

Nature of quantity: Mass is a scalar quantity denoted by *m*. It remains the same everywhere.

Measurement: Practically, mass is measured by an ordinary balance.

SI unit: The SI unit of mass is kilogram (kg).

34. Define weight of an object.

Ans: **Weight:** Weight is a gravitational force acting on the object.

Nature of quantity: It is a vector quantity directed downward, towards the centre of the Earth.

Measurement: Weight is measured by spring balance.

SI unit: The SI unit of weight is newton (N).

35. Define Gravitational Field Strength.

Ans: The gravitational field strength is defined as the gravitational force acting on unit mass.

36. Write the value of Gravitational Field Strength.

Ans: Value of the gravitational field strength is $10\ Nkg^{-1}$.

3.7 Mechanical and Electronic Balances

37. What is mechanical balance?

Ans: A mechanical balance consists of a rigid horizontal beam that oscillates on a central knife edge as a fulcrum. It has two end knife edges equidistant from the centre.

38. What is electronic balance?

Ans: No standard weights are required to use in an electronic balance. Only it has to be connected to a power supply. There are some models which can operate by using dry cell batteries.

39. Write an advantage of Electronic Balance over Mechanical Balance.

Ans: An electronic balance is more precise than mechanical balance. When an object is placed on it, its mass is displayed on its screen. Now-a-days, electronic balances also display the total price of the material if the rate per kg is fed to the balance.

40. Define force metre.

Ans: A force meter is a scientific instrument that measures force. It is also called as a newton meter or a spring balance. Now a days digital force meters are also available.

41. What do you know about measurement taken form force meter? (CQs)

Ans: A digital force meter measures directly the weight of the object in newton (N).

3.8 Friction

42. Define friction with example.

Ans: **Friction:** The force that tends to prevent the bodies from sliding over each other.

Example: When a cricket ball is hit by the bat, it moves on the ground with a reasonably large velocity. According to Newton's first law of motion, it should continue to move with constant velocity. But, practically, we observe that it eventually stops after covering some distance.This is because of the force of friction between the ball and the ground that opposes the motion of the ball.

43. What is dissipative effect of friction? Give example. (CQs)

Ans: **Dissipative Effect of Friction:** Friction is a dissipative force due to which the energy is wasted in doing work to overcome against friction.The lost energy appears in the form of heat.

Example: A very common example of energy dissipation is the rubbing of hands.

44. Define Sliding Friction. Write the name of its categories.

Ans: **Sliding Friction:** The friction between two solid surfaces is called sliding friction.

Categories of Friction: There are two categories of friction.

i) Static friction ii) Kinetic friction

45. Differentiate between Static friction and Kinetic friction.

Ans:

Static friction	Kinetic friction
The force of friction arising due to applied external force before motion of one body over the other.	Fricition during motion is known as kinetic friction.

46. Define rolling friction.

Ans: When an object rolls over a surface, the friction produced is called rolling friction.

47. What are Ball bearings?

Ans: Ball bearings play the same role as is played by the wheels. Many machines in industry are designed with ball bearings so that the moving parts roll on the ball bearing and friction is greatly reduced. The rolling friction is about one hundred times smaller than the sliding friction.

48. Write two methods to reduce friction.

Ans:

(i) The parts which slide against each other are highly polished.

(ii) As rolling friction is much less than the sliding friction, so sliding friction is converted into rolling friction by the use of ball bearings in the machines and wheels under the heavy objects.

49. Define terminal velocity.

Ans: Maximum constant velolcity acquired by a body while falling through a viscous medium is called its terminal velocity.

50. Give an example of terminal velocity.

Ans: A paratrooper falling with terminal velocity.

3.9 Momentum and Impulse

51. Define momentum. Write its unit.

Ans: **Momentum:** The momentum of a moving body is the product of its mass and velocity.

Formula: $p = m \times v$

SI unit: The SI unit of momentum is ($kgms^{-1}$). It can also be written as (Ns).

Nature of Quantity: Momentum is a vector quantity.

52. State Newton's second law of motion in terms of momentum.

Ans: The rate of change of momentum of a body is equal to the force acting on it.

3.10 Principle of Conservation of Momentum

53. Define System and Isolated System.

Ans: **System:** The collection of objects is known as a 'system'.

Isolate System: If no external force acts on any object of the system, it is known as isolated system.

54. State Law of Conservation of Momentum.

Ans: Law of Conservation of Momentum states that:

If no external force acts on an isolated system, the final total momentum of the system is equal to the initial total momentum of the system.