QUESTION BANK (2019-20)

PHYSICS

IX

Chapter 1 - Measurements and Experimentation

Q1: What is meant by measurement?

Solution 1-

Measurement is the process of comparing a given physical quantity with a known standard quantity of the same nature.

Q2: What do you understand by the term Unit?

Solution 2

Unit is a quantity of constant magnitude which is used to measure the magnitudes of other quantities of the same manner.

Q3: What are the three requirements for selecting a unit of a Physical quantity?

Solution 3

The three requirements for selecting a unit of a physical quantity are
(i) It should be possible to define the unit without ambiguity.
(ii) The unit should be reproducible.
(iii) The value of units should not change with space and time.

Q4: Name & Define three fundamental quantities?

Solution 4

Definitions of three fundamental quantities:

S.I. unit of length (m): A metre was originally defined in 1889 as the distance between two marks drawn on a platinum-iridium (an alloy made of 90% platinum and 10% iridium) rod kept at 0°C in the International Bureau of Weights and Measures at serves near Paris.
S.I. unit of mass (kg): In 1889, one kilogramme was defined as the mass of a cylindrical piece of a platinum-iridium alloy kept at International Bureau of Weights and Measures at serves near Paris.

S.I. unit of time (s): A second is defined as 1/86400th part of a mean solar day, i.e.

Q5: Name the three systems of Unit & State the various fundamental Units in them?

Solution 5
Three systems of unit and their fundamental units:

(i) C.G.S. system (or French system): In this system, the unit of length is centimeter (cm), unit of mass is gramme (g) and unit of time is second (s).

(ii) F.P.S. system (or British system): In this system, the unit of length is foot (ft), unit of mass is pound (lb) and unit of time is second (s).

(iii) M.K.S. system (or metric system): In this system, the unit of length is metre (m), unit of mass is kilogramme (kg) and unit of time is second (s).

Q6: Define a fundamental unit?

Solution 6

A fundamental (or basic) unit is that which is independent of any other unit or which can neither be changed nor can be related to any other fundamental unit.

Q7: What are the fundamental units in S.I System? Name them along with their symbols?

Solution 7

Fundamental quantities, units and symbols in S.I. system are

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogramme	kg
Time	second	s
Temperature	kelvin	K
Luminous intensity	candela	cd
Electric current	ampere	A
Amount of substance	mole	mol
Angle	radian	rd
Solid angle	steradian	st-rd

Q8: Explain the meaning of Derived unit with the help of one example?

Solution 8
The units of quantities other than those measured in fundamental units can be obtained in terms of the fundamental units, and thus the units so obtained are called derived units.
Example:
Speed = Distance/time
Hence, the unit of speed = fundamental unit of distance/fundamental unit of time
Or, the unit of speed = metre/second or ms^{-1}.
As the unit of speed is derived from the fundamental units of distance and time, it is a derived unit.

Q9: Define Standard Meter?

Solution 9

A metre was originally defined in 1889 as the distance between two marks drawn on a platinum-iridium (an alloy with 90% platinum and 10% iridium) rod kept at 0^o C in the International Bureau of Weights and Measures at serves near Paris.

Q10- Name two units of length which are bigger then a meter. How are they related to the meter?

Solution 10

Astronomical unit (A.U.) and kilometer (km) are units of length which are bigger than a metre.
1 km = 1000 m
1 A.U. = 1.496×10^{11} m

Q11: Write the names of two units of length smaller then a meter. Express their relationship with meter?

Solution 11

Centimeter (cm) and millimeter (mm) are units of length smaller than a metre.
1 cm = 10^{-2} m
1 mm = 10^{-3} m

Q12: How is nano meter is related to Angstrom?

Solution 12

1 nm = 10

Q13: Name the three convenient units used to measure length ranging from very short to very long value. How are they related to the S.I Unit?

Solution 13

Three convenient units of length and their relation with the S.I. unit of length:
(i) 1 Angstrom (Å) = 10^{-10} m
(ii) 1 kilometre (km) = 10^{3} m
(iii) 1 light year (ly) = 9.46 × 10^{15} m

Q14: Name the S.I unit of Mass & define it?

Solution 14

S.I. unit of mass is 'kilogramme'.
In 1889, one kilogramme was defined as the mass of a cylindrical piece of a platinum-iridium alloy kept at the International Bureau of Weights and Measures at serves near Paris.

Q15: Complete the following:

(a) 1 light year = 9.46 × 10^{15} m

(b) 1 m = 10^{10}
(c) 1 m = 10^{6} μ (micron)

(d) 1 micron = 10^{4}
(e) 1 fermi = 10^{-15} m

Q16: State two units of mass smaller then a kilogram. How are they related to the kilogram?

Solution 16

The units 'gramme' (g) and 'milligramme' (mg) are two units of mass smaller than 'kilogramme'.
1 g = 10^{-3} kg
1 mg = 10^{-6} kg

Q17: State two units of Mass bigger then a Kilogram.Give their relationship with the kilogram?

Solution 17

The units 'quintal' and 'metric tonne' are two units of mass bigger than 'kilogramme'.
1 quintal = 100 kg
1 metric tonne = 1000 kg

Q18: Complete the following:

(a) 1 g = 10^{-3} kg
(b) 1 mg = 10^{-6} kg
(c) 1 quintal = 100 kg
(d) 1 a.m.u (or u) = 1.66 x 10^{-27} kg

Q19: Name the S.I unit of time & define it?

Solution 19

The S.I. unit of time is second (s).

A second is defined as 1/86400th part of a mean solar day, i.e.

1 s = 1/86400th × one mean solar day

Q20: Name two units of time bigger then a second. How are they related to the second?

Solution 20

The units 'minute' (min) and 'year' (yr) are two units of time bigger than second(s).
1 min = 60 s
1 yr = 3.1536×10^7 s

Q21: What is a Leap year?

Solution 21

A leap year is the year in which the month of February has 29 days.

Q22: The year 2016 will have February of 29days. Is this statement true?

Solution 22

Yes, the given statement is true.

Q23: What is a Lunar month?

Solution 23

One lunar month is the time in which the moon completes one revolution around the earth. A lunar month is made of nearly 4 weeks.

Q24: Complete the following:

(a) 1 nanosecond = 10^{-9} s
(b) 1 μs = 10^{-6} s
(c) 1 mean solar day = 86400 s
(d) 1 year = 3.15×10^7 s

Q25: Name the physical quantities which are measured in the following units:

(a) u (b) ly

(c) ns (d) nm

Solution 25

(a) Mass (b) Distance (or length) (c) Time (d) Length

Q26: Write the derived units of the following:

(a) Speed (b) fore

(c) work (d) pressure

Solution 26

(a) ms^{-1} (b) kg ms^{-2} (c) kg m^2s^{-2} (d) kg $m^{-1}s^{-2}$

Q27: How are the following derived units related to the fundamental units?

(a) newton (b) watt

(c) joule (d) pascal

Solution 27

(a) kg ms^{-2} (b) kg m^2s^{-3}
(c) kg m^2s^{-2} (d) kg $m^{-1}s^{-2}$

Q28: Name the physical quantities related to the following units?

(a) km^2 (b) newton

(c) joule (d) pascal (e) watt

Solution 28

(a) Area (b) Force (c) Energy
(d) Pressure (f) Power

NUMERICALS

Q1: The wavelength of light of a particular colour is 5800 $\mathring{A}$. Express it in (a) nanometer (b) meter

Solution 1:

Wavelength of light of particular colour = 5800 $\mathring{A}$
(a)
(i) 1 $\mathring{A}$ = 10^{-1} nm
∴ 5800 $\mathring{A}$ = 5800 × 10^{-1} nm
= 580 nm

(ii) 1 $\mathring{A}$ = 10^{-10} m
∴ 5800 $\mathring{A}$ = 5800 × 10^{-10} m
= 5.8 × 10^{-7} m
(b) The order of its magnitude in metre is 10^{-6} m because the numerical value of 5.8 is more than 3.2.

Q2: The size of bacteria is 1 μ. Find the number of bacteria in 1 m length?

Solution 2 :

Size of a bacteria = 1 μ
Since 1 μ = 10^{-6} m
∴ Number of the particle = Total length/size of one bacteria
= 1 m/10^{-6} m
= 10^6

Q3: The distance of a galaxy from the earth is 5.6 x 10^{25} m. Assuming the speed of light to be 3 × 10^8 m/s , find the time taken by light to travel this distance?

Solution 3:

Distance of galaxy = 5.6 × 10^{25} m
Speed of light = 3 × 10^8 m/s

(a) Time taken by light = Distance travelled/speed of light
= (5.6 × 10^{25} / 3 × 10^8) s
= 1.87 × 10^{17} s

(b) Order of magnitude = $10^0 \times 10^{17}$ s = 10^{17} s
(This is because the numerical value of 1.87 is less than the numerical value 3.2)

Q4: The wavelength of light is 589 nm. What is its wavelength in $\mathring{A}$?

Solution 4:

The wavelength of light = 589 nm

We know ,1 nm = 10 $\mathring{A}$

589 nm = 10 x 589 $\mathring{A}$ = 5890 $\mathring{A}$

Q5: The mass of an oxygen atom 16.00 u. Find mass in kg?

Solution 5 :

Mass of an oxygen atom = 16.00 u
Now, 1 u = 1.66×10^{-27} kg
Hence, mass of oxygen in kg = $16 \times 1.66 \times 10^{-27}$ kg
= 26.56×10^{-27} kg
Because the numerical value of 26.56 is greater than the numerical value of 3.2, the order of magnitude of mass of oxygen in kg
= $10^1 \times 10^{-27}$ kg
= 10^{-26} kg

Measurements and Experimentation -Exercise 1(B)

Q1: Explain the meaning of the term 'least count of the instrument' by taking a suitable example.

Solution 1

The least count of an instrument is the smallest measurement that can be taken accurately with it. For example, if an ammeter has 5 divisions between the marks 0 and 1A, then its least count is 1/5 = 0.2 A or it can measure current up to the value 0.2 accurately.

Q2: A boy makes a ruler with graduation in cm on it (i.e 100 division in 1 meter). To what accuracy this ruler can measure? How can this accuracy be increased?

Solution 2

Total length of the scale = 1 m = 100 cm
No. of divisions = 100
Length of each division = Total length/total no. of divisions
= 100 cm/100
= 1 cm
Thus, this scale can measure with an accuracy of 1 cm.

To increase the accuracy, the total number of divisions on the scale must be increased

Q3: A Boy measures the length of a pencil and expresses it to be 2.6cm. What is the accuracy of his measurement? Can he write it as 2.60 cm?

Solution 3

The least count of a metre rule is 1 cm.

The length cannot be expressed as 2.60 cm because a metre scale measures length correctly only up to one decimal place of a centimeter.

Q4: Define least count of a verniercalliper. How do you determine it?

Solution 4

The least count of verniercallipers is equal to the difference between the values of one main scale division and one vernier scale division.

Let n divisions on verniercallipers be of length equal to that of (n - 1) divisions on the main scale and the value of 1 main scale division be x. Then,
Value of n divisions on vernier = (n - 1) x

Alternatively, value of 1 division on vernier =
Hence,

Least count =
L.C. = (Value of one main scale division)/(Total no. of divisions on verniercallipers)
Value of one main scale division = 1 mm
Total no. of divisions on vernier = 10

Q5: Define the term ‘Vernier Constant’?

Solution 5

Vernier constant is equal to the difference between the values of one main scale division and one vernier scale division. It is the least count of verniercallipers.

Q6: When is a verniercalipers said to be free from Zero error?

Solution 6

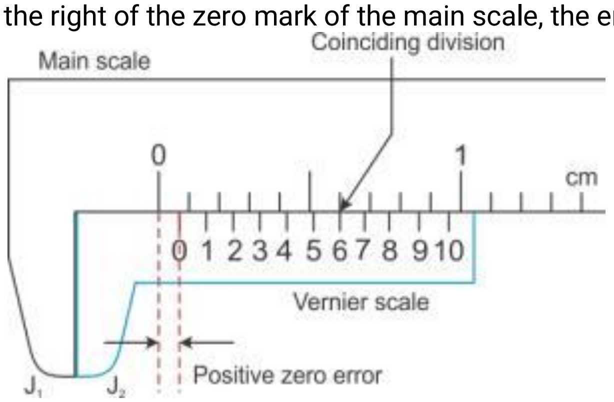
A vernier calipers is said to be free from zero error, if the zero mark of the vernier scale coincides with the zero mark of the main scale.

Q7: What is meant by Zero error of a verniercalipers? How is it determined? Draw neat diagrams to explain it?

Solution 7

Due to mechanical errors, sometimes the zero mark of the vernier scale does not coincide with the zero mark of the main scale, the verniercallipers is said to have zero error.
It is determined by measuring the distance between the zero mark of the main scale and the zero mark of the vernier scale.
The zero error is of two kinds
(i) Positive zero error
(ii) Negative zero error

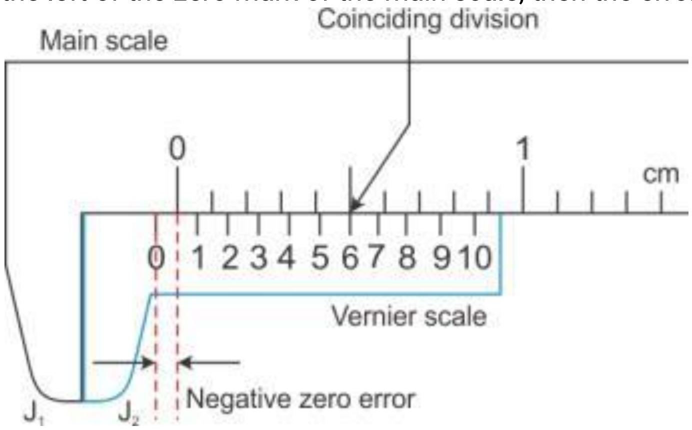
(i) **Positive zero error:** On bringing the two jaws together, if the zero mark of the vernier scale is on the right of the zero mark of the main scale, the error is said to be positive.



To find this error, we note the division of the vernier scale, which coincides with any division of the main scale. The number of this vernier division when multiplied by the least count of the verniercallipers, gives the zero error.
For example, for the scales shown, the least count is 0.01 cm and the 6^{th} division of the vernier scale coincides with a main scale division.

Zero error = +6 × L.C. = +6 × 0.01 cm
= +0.06 cm

(ii) **Negative zero error:** On bringing the two jaws together, if the zero mark of the vernier scale is on the left of the zero mark of the main scale, then the error is said to be negative.



To find this error, we note the division of the vernier scale coinciding with any division of the main scale. The number of this vernier division is subtracted from the total number of divisions on the vernier scale and then the difference is multiplied by the least count.

For example, for the scales shown, the least count is 0.01 cm and the sixth division of the vernier scale coincides with a certain division of the main scale. The total number of divisions on verniercallipers is 10.

Zero error = - (10 - 6) × L.C.
 = - 4 × 0.01 cm = - 0.04 cm

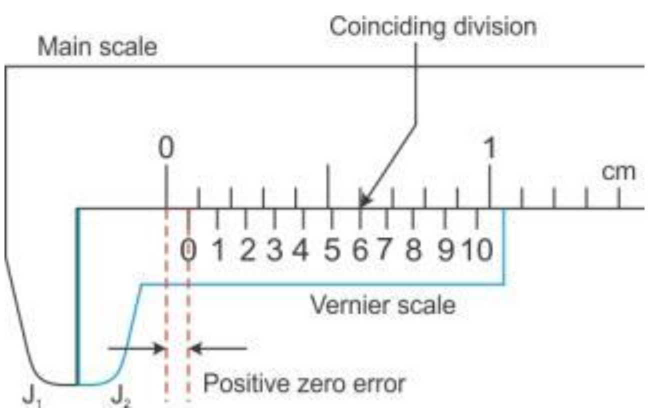
Correction:

To get correct measurement with verniercallipers having a zero error, the zero error with its proper sign is always subtracted from the observed reading.

Correct reading = Observed reading - zero error (with sign)

Q8: A verniercalipers has a Zero error + 0.06 cm. Draw a neat labeled diagram to represent it?

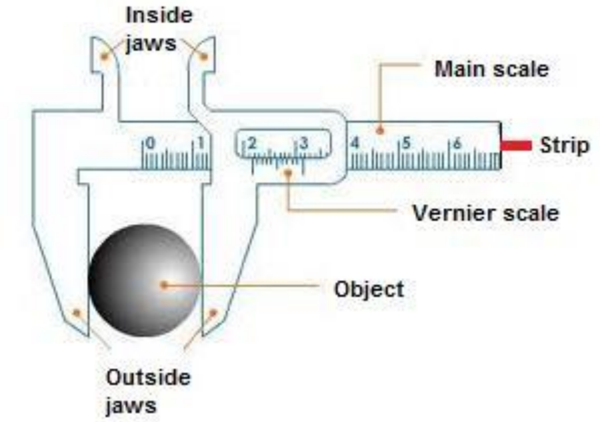
Solution 8



Q9: Draw a neat labeled diagram of a vernier caliper. Name its main parts and state their functions?

Solution 9

Diagram of vernier calipers:



<u>Main parts and their functions:</u>

Main scale: It is used to measure length correct up to 1 mm.
Vernier scale: It helps to measure length correct up to 0.1 mm.
Outside jaws: It helps to measure length of a rod, diameter of a sphere, external diameter of a hollow cylinder.
Inside jaws: It helps to measure the internal diameter of a hollow cylinder or pipe.
Strip: It helps to measure the depth of a beaker or a bottle.

Q10: State three uses of verniercalipers?

Solution 10

Three uses of vernier callipers are
(a) Measuring the internal diameter of a tube or a cylinder.
(b) Measuring the length of an object.
(c) Measuring the depth of a beaker or a bottle.

Q11: Name two scales of vernier calipers and explain how is it used to measure a length correct up to 0.01 cm?

Solution 11:

Two scales of vernier calipers are
(a) Main scale
(b) Vernier scale
The main scale is graduated to read up to 1 mm and on vernier scale, the length of 10 divisions is equal to the length of 9 divisions on the main scale.

Value of 1 division on the main scale= 1 mm
Total no. of divisions on the vernier scale = 10
Thus, L.C. = 1 mm /10 = 0.1 mm = 0.01 cm.

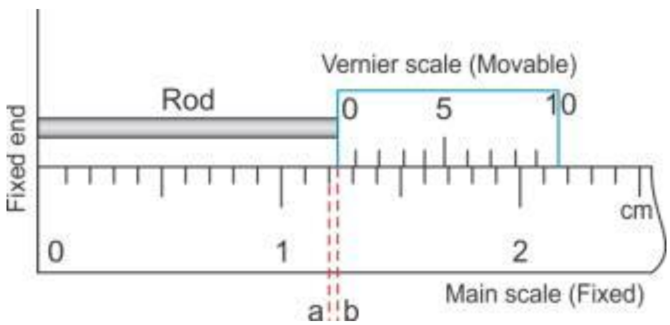
Hence, a verniercallipers can measure length correct up to 0.01 cm.

Q12: Describe in steps, how would you use a verniercalipers to measure the length of a small rod?

Solution 12:

Measuring the length of a small rod using vernier calipers:

The rod whose length is to be measured is placed in between the fixed end and the vernier scale as shown in the figure.



In this position, the zero mark of the vernier scale is ahead of 1.2 cm mark on main scale. Thus the actual length of the rod is 1.2 cm plus the length ab (i.e., the length between the 1.2 cm mark on the main scale and 0 mark on vernier scale).
To measure the length ab, we note the p^{th} division of the vernier scale, which coincides with any division of main scale.
Now, ab + length of p divisions on vernier scale = length of p divisions on main scale
Alternatively, ab = length of p divisions on the main scale - length of p divisions on the vernier scale.
= p (length of 1 division on main scale - length of 1 division on vernier scale)
= p × L.C.

Therefore, total reading = main scale reading + vernier scale reading
= 1.2 cm + (p × L.C.)

Q13: Name the part of the vernier calipers which is used to measure the following:

(a) external diameter of tube

(b) internal diameter of a mug

(c) depth of a small bottle

(d) thickness of a pencil

Solution 13

(a) Outside jaws
(b) Inside jaws
(c) Strip
(d) Outer jaws

Q14: Explain the terms (i) pitch (ii) least count of a screw gauge. How are they determined?

Solution 14

(i) **Pitch:** The pitch of a screw gauge is the distance moved by the screw along its axis in one complete rotation.
(ii) **Least count (L.C.) of a screw gauge:** The L.C. of a screw gauge is the distance moved by it in rotating the circular scale by one division.
Thus, L.C. = Pitch of the screw gauge/total no. of divisions on its circular scale.
If a screw moves by 1 mm in one rotation and it has 100 divisions on its circular scale, then pitch of screw = 1 mm.
Thus, L.C. = 1 mm / 100 = 0.01 mm = 0.001 cm

Q15: How can the least count of a screw gauge be decreased?

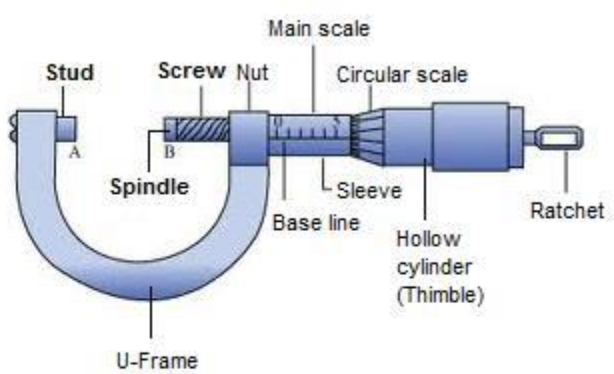
Solution 15:

The least count of a screw gauge can be increased by decreasing the pitch and increasing the total number of divisions on the circular scale.

Q16: Draw a neat labeled diagram of a screw gauge. Name its main parts and states their function?

Solution 16

Diagram of screw gauge:



<u>Main parts and their functions:</u>

1. **Ratchet:** It advances the screw by turning it until the object is gently held between the stud and spindle of screw.
2. **Sleeve:** It marks the main scale and base line.
3. **Thimble:** It marks the circular scale.
4. **Main scale:** It helps to read the length correct up to 1 mm.
5. **Circular scale:** It helps to read length correct up to 0.01 mm.

Q17: State one use of screw gauge?

Solution 17

A screw gauge is used for measuring diameter of circular objects mostly wires with an accuracy of 0.001 cm.

Q18: State the purpose of ratchet in a screw gauge?

Solution 18

Ratchet helps to advance the screw by turning it until the object is gently held between the stud and spindle of the screw.

Q19: What do you mean by Zero error of a screw gauge?How is it accounted for ?

Solution 19

Due to mechanical errors, sometimes when the anvil and spindle end are brought in contact, the zero mark of the circular scale does not coincide with the base line of main scale. It is either above or below the base line of the main scale, in which case the screw gauge is said to have a zero error. It can be both positive and negative.
It is accounted by subtracting the zero error (with sign) from the observed reading in order to get the correct reading.
Correct reading = Observed reading - zero error (with sign)

Q20: A screw gauge has a least count 0.001cm and zero error + 0.007cm.Draw a neat diagram to represent it?

Solution 20

Diagram of a screw gauge with L.C. 0.001 cm and zero error +0.007 cm.

Measurements and Experimentation - Exercise 1(C)

Q1: What is a simple pendulum? Is the pendulum used in a pendulum clock simple pendulum? Give reason to your answer?

Solution 1

A simple pendulum is a heavy point mass (known as bob) suspended from a rigid support by a massless and inextensible string.
No, the pendulum used in pendulum clock is not a simple pendulum because the simple pendulum is an ideal case. We cannot have a heavy mass having the size of a point and string having no mass.

Q2: Define the terms (a) oscillations (b) amplitude (c) frequency (d) time period as related to a simple pendulum?

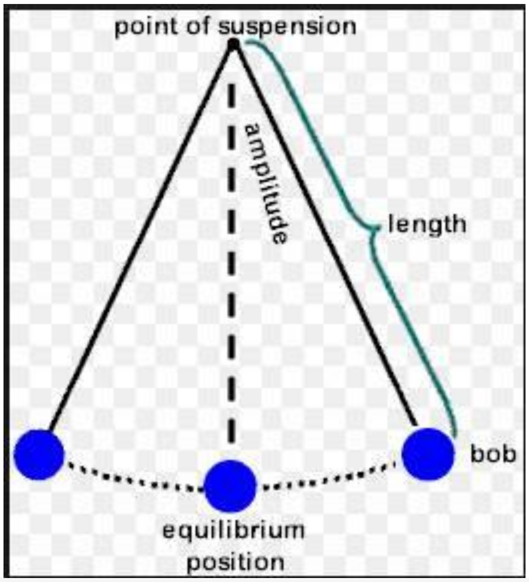
Solution 2

(i) **Oscillation:** One complete to and fro motion of the pendulum is called one oscillation.
(ii) **Amplitude:** The maximum displacement of the bob from its mean position on either side is called the amplitude of oscillation. It is measured in metres (m).
(iii) **Frequency:** It is the number of oscillations made in one second. Its unit is hertz (Hz).
(iv)**Time period:** This is the time taken to complete one oscillation. It is measured in second (s).

Q3:Draw a neat diagram of a simple pendulum. show on it the effective length of the pendulum and its one oscillations?

Solution 3

Simple Pendulum:



Q4: Name two factors on which the time period of a simple pendulum depends. Write the relation for the time period in terms of the above named factors?

Solution 4

Two factors on which the time period of a simple pendulum depends are

(i) Length of pendulum (l)
(ii) Acceleration due to gravity (g)

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Q5: Name two factors on which the time period of a simple pendulum does not depend?

Solution 5

Two factors on which the time period of a simple pendulum does not depend are
(i) Material of the bob
(ii) Amplitude

Q6: How is the time period of a simple pendulum affected, if at all,in the following situations:

(a) the length is made four times

(b) the acceleration due to gravity is reduced to one-fourth

Solution 6

We know that, $T = 2\pi\sqrt{\frac{l}{g}}$

(a) If length quadruples then,

$$T' = 2\pi\sqrt{\frac{4l}{g}}$$

$$or, \frac{T}{T'} = \frac{2\pi\sqrt{\frac{l}{g}}}{2\pi\sqrt{\frac{4l}{g}}} = \frac{1}{2}$$

$$or, T = 2T'$$

Therefore, the time period is doubled.

(b) If the acceleration due to gravity is reduced to one-fourth,

$$T' = 2\pi\sqrt{\frac{l}{\frac{1}{4}g}}$$

$$or, \frac{T}{T'} = \frac{2\pi\sqrt{\frac{l}{g}}}{2\pi\sqrt{\frac{l}{\frac{1}{4}g}}} = \frac{1}{2}$$

$$or, T = 2T'$$

Therefore, the time period is doubled.

Q7: How are the time period T & frequency f of an oscillation of simple pendulum related?

Solution 7

Time period of a simple pendulum is inversely proportional to its frequency.

$$f = \frac{1}{T}$$

Q8: How do you measure the time period of a given pendulum? Why do you note the time for more than one oscillation?

Solution 8

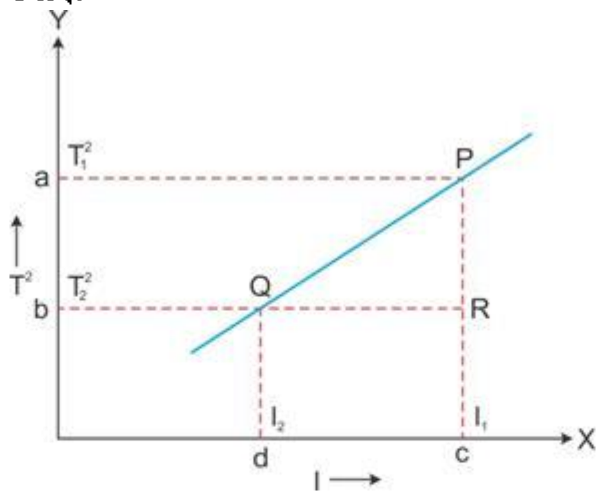
Measurement of time period of a simple pendulum:
(i) To measure the time period of a simple pendulum, the bob is slightly displaced from its mean position and is then released. This gives a to and fro motion about the mean position to the pendulum.
(ii) The time 't' for 20 complete oscillations is measured with the help of a stop watch.
(iii)Time period 'T' can be found by dividing 't' by 20.
To find the time period, the time for the number of oscillations more than 1 is noted because the least count of stop watch is either 1 s or 0.5 s. It cannot record the time period in fractions such as 1.2 or 1.4 and so on.

Q9: How does the time period (T) of a simple pendulum depends on its length l? Draw a graph showing the variation of T2 with l. How will you use this graph to determine the value of small g?

Solution 9

The time period of a simple pendulum is directly proportional to the square root of its effective length.

$$T \alpha \sqrt{l}$$



From this graph, the value of acceleration due to gravity (g) can be calculated as follows.

The slope of the straight line can be found by taking two points P and Q on the straight line and drawing normals from these points on the X- and Y-axis, respectively. Then, the value of T2 is to be noted at a nd b, the value of l at c and d. Then,

$$Slope = \frac{PR}{QR} = \frac{ab}{cd} = \frac{T_1^2 - T_2^2}{l_1 - l_2}$$

This slope is found to be constant at a place and is equal to $\frac{4\pi^2}{g}$, where g is the acceleration due to gravity at that place. Thus, g can be determined at a place from these measurements using the following relation:

$$g = \frac{4\pi^2}{Slope - of - T^2 - Vs - 1 - graph}$$

Q10: Two simple pendulums A & B have equal length, but their bobs weight 50gf and 100 gf. What would be the ratio of their time periods? Give reason for your answer?

Solution 10

The ratio of their time periods would be 1:1 because the time period does not depend on the weight of the bob.

Q11: Two simple pendulums A & B have lengths 1.0 meter and 4.0 meter. Which pendulum will make more oscillation in one minute?

Solution 11

Pendulum A will take more time (twice) in a given time because the time period of oscillation is directly proportional to the square root of the length of the pendulum. Therefore, the pendulum B will have a greater time period and thus making lesser oscillations.

Q12: State how does the time period of a simple pendulum depend on (a) length of pendulum (b) mass of bob (c) amplitude of oscillation (d) acceleration due to gravity?

Solution 12

(a) The time period of oscillations is directly proportional to the square root of the length of the pendulum.
(b) The time period of oscillations of simple pendulum does not depend on the mass of the bob.
(c) The time period of oscillations of simple pendulum does not depend on the amplitude of oscillations.
(d) The time period of oscillations of simple pendulum is inversely proportional to the square root of acceleration due to gravity.

Q13: What is a seconds' pendulum?

Solution 13

A pendulum with the time period of oscillation equal to two seconds is known as a second's pendulum.

Q14: State the numerical value of the frequency of oscillation of a seconds' pendulum. Does it depend on the amplitude?

Solution 14

The frequency of oscillation of a seconds' pendulum is 0.5 s^{-1}. It does not depend on the amplitude of oscillation.

NUMERICALS

Q1.A simple pendulum completes 40 oscillations in one minute. find its (a) frequency (b) time period.

Solution 1

(a) Frequency = Oscillations per second
= (40/60) s^{-1}
= 0.67 s^{-1}

(b) Time period = 1/frequency
= (1/0.67) s
= 1.5 s

Q2.The time period of a simple pendulum is 2 s. what is its frequency ?what name is given to such a pendulum?

Solution 2

Time period = 2 s
Frequency = 1/time period
= (½)s^{-1}
= 0.5 s^{-1}
Such a pendulum is called the seconds' pendulum.

Q3.Find the length of a seconds pendulum at a place where g= 10ms2.(take pai=3.14)

Solution 3:

Given, g= 10 m/s^2 and time period (T) = 2s
Let 'l' be the length of the seconds' pendulum.

We know that $T = 2\pi\sqrt{\frac{l}{g}}$

$$or, 2 = 2\pi\sqrt{\frac{l}{10}}$$

$$or, \frac{l}{10} = \frac{1}{\pi^2}$$

$$or, l = \frac{10}{(3.14)^2}$$

$$or, l = 1.0142s$$

Q.5. ***Name one unit of length which is bigger than a metre and one unit which is smaller. How are they related to the metre?***

Ans. Bigger unit : Light year

Smaller unit : Nanometer.

1 light year = 9.46×10^{15} m,

1 nanometer = 10^{-9} m

Q.6. ***Name two big units used to measure length. How are they related to each other?***

Ans. The two units are :

(*i*) Astronomical unit, and

(*ii*) Parsec. They are related as

1 parsec = 3.26 ly.

Q.7. ***Give two units of mass smaller and two bigger than a kilogram. How are they related to the kilogram ? Give their relationship with the kilogram.***

Ans. Bigger units : (*i*) Quintal, and (*ii*) metric tonne.

Smaller units : (*i*) Gram, and (*ii*) milligram.

1 quintal = 10^2 kg, 1 metric tonne = 10^3 kg

1 gram = 10^{-3} kg, 1 mg = 10^{-6} kg.

Q.8. ***Name two units of time bigger than a second. How are they related to the second?***

Ans. The two bigger units are : (*i*) minute, and (*ii*) hour

1 minute = 60 s and 1 hour = 3.6×10^3 s

Q.9. ***It is meaningless to call a physical quantity small or large without specifying a standard for comparison. Keeping this fact in mind, rewrite the following statements to make them meaningful.***

(i) Atomic nuclei are very small.

(ii) Speed of light is much greater than the speed of sound.

(iii) Mass of the sun is very large.

(iv) The speed of a jet plane is extremely high.

Ans. (*i*) Atomic nuclei possess a very small size of the order of 10^{-14} m.

(*ii*) Light travels with a speed which is about 10^6 times the speed of sound.

(*iii*) Mass of the sun is very large and is of the order of 10^{30} kg.

(*iv*) Jet planes travel with a speed greater than the speed of sound *i.e.*, > 332 ms^{-1}.

Q.10. ***While defining the standard of length, temperature is to be specified, at which the measurements are being made. Is it correct to call length as a fundamental quantity when another physical quantity has to be mentioned in selecting a standard?***

Ans. Initially, a metre bar was chosen as the standard of length which required the specification of temperature as length of an object varies with temperature. However, since now length is defined in terms of the speed of light in vacuum, which is not affected by temperature. Hence, we are now justified in calling length as a fundamental physical quantity.

Q.11. ***Which of the following is the most precise device for measuring length? (i) A vernier calliper with 20 divisions on the sliding scale. (ii) A screw gauge of pitch 1 mm and 100 divisions on the circular scale. (iii) An optical instrument that can measure length to within a wavelength of light.***

Ans. An optical instrument which can measure length within a wavelength of light (10^{-6} m) is the most precise device for measuring the length.

Q.12. ***How can you estimate the diameter of a thread with the help of a metre scale?***

Ans. It is not possible to estimate the diameter of a thread by using a metre scale only. However, it can be determined by winding a known number of turns touching each other round a pencil and measuring the length of these turns with a metre scale. Then

$$\text{Average diameter of thread} = \frac{\text{Length of turns}}{\text{Number of turns}}$$

Q.13. ***Define the term 'vernier constant'. How will you determine it?***

Ans. It is defined as the difference between the values of one main scale division and one vernier scale division.

Vernier constant = Value of one main scale division – Value of one vernier scale division

or $\quad VC = 1\text{ MSD} - 1\text{ VSD}$

Let n vernier scale divisions (VSD) coincide with $(n - 1)$ main scale divisions (MSD).

Then n VSD = $(n - 1)$ MSD

or $\quad 1\text{ VSD} = \frac{(n-1)}{n}\text{ MSD}$

Therefore, vernier constant is :

$VC = 1\text{ MSD} - 1\text{ VSD}$

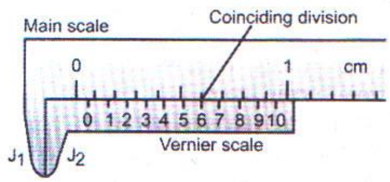
$= 1\text{ MSD} - \frac{(n-1)}{n}\text{ MSD} = \frac{1}{n}\text{ MSD}$

Therefore,

$$VC = \frac{\text{Smallest division on the main scale}}{\text{Number of divisions on the vernier scale}}$$

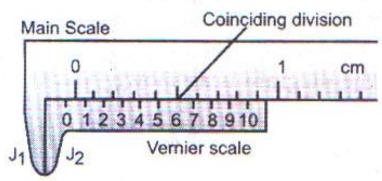
Q.14. ***A vernier calliper has a zero error + 0.06 cm. Draw a neat labelled diagram to represent it.***

Ans. The diagram is as shown :



Q.15. ***A vernier calliper has a zero error – 0.04 cm. Draw a neat labelled diagram to represent it.***

Ans. The diagram is as shown :



Q.16. ***The mean diameter of a thin brass rod is to be measured by a vernier calliper. Why is a set of 100 measurements of the diameter expected to yield a more reliable estimate than a set of 5 measurements only?***

Ans. It is due to the reason that random error involved in the mean value of 100 observations is much less than that involved in the mean value of 5 observations.

Q.17. ***Name the part of the vernier callipers which is used to measure the following : (a) external diameter of a tube, (b) internal diameter of a calorimeter, (c) depth of a calorimeter, (d) thickness of a pencil.***

Ans. (*a*) Outside jaws (*b*) Inside jaws

(*c*) Strip (*d*) Outside jaws.

Q.18. ***State three uses of a vernier calliper.***

Ans. It is used for the following :

(*i*) Measuring length of an object,

(*ii*) Measuring the internal diameter of hollow objects, and

(*iii*) Measuring depth of hollow objects.

Q.19. ***What do you understand by (i) pitch, (ii) linear scale, and (iii) circular scale of a screw gauge ?***

Ans. (*i*) **Pitch :** The linear distance moved by the screw, when it is given one complete rotation is equal to the distance between two consecutive threads, as measured along the axis of the screw. This distance is called the pitch of the screw gauge.

(*ii*) **Linear scale :** It is a scale running parallel to the axis of the screw. It is graduated into millimetre or half millimetre.

(*iii*) **Circular scale :** It is marked on the circumference of the circular disc or the cap attached to the screw.

Q.20. ***A screw gauge has a pitch of 1.0 mm and 200 divisions on the circular scale. Will it be possible to increase the accuracy of the gauge arbitrarily by increasing the number of divisions on the circular scale?***

Ans. The least count of gauge is given by

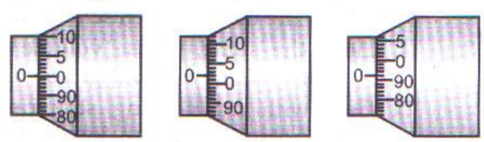
Least count

$$= \frac{\text{Pitch}}{\text{Number of divisions on the circular scale}}.$$

Hence, on increasing the number of divisions on the circular scale, the least count of the gauge gets decreased *i.e.,* accuracy of gauge can be increased by increasing the number of divisions on circular scale.

Q.21. ***With the help of diagrams, in case of a screw gauge, show (i) No zero error, (ii) Positive zero error, and (iii) Negative zero error.***

Ans. The diagrams are as shown :



(*a*) NO ZERO ERROR (*b*) POSITIVE ZERO ERROR (*c*) NEGATIVE ZERO ERROR

Q.22. ***What is backlash error? Why is it caused? How can it be reduced?***

Ans. On account of wear and tear or loose fitting, there is some space left for the play between the screw and the nut. In such instruments, if the screw is adjusted by turning it in one direction and then it is rotated back, the screw may not move along the axis for an appreciable rotation of the head. The error due to it is called backlash error of the screw.

Q.30. ***The bob of a simple pendulum is made of wood. What will be the effect on the time period if an identical bob of aluminium replaces the wooden bob?***

Ans. There is no change in the time period of the simple pendulum. As the wooden bob is replaced by the aluminium bob, the effective length of the pendulum remains same. Since time period of a simple pendulum does not depend upon the mass of the bob, therefore, it remains unaltered.

Q.31. ***The bob of a simple pendulum is hollow with a pinhole at its lower end. It is filled with water and allowed to oscillate. How does its time period vary with time?***

Ans. As the water drips away from the pinhole, the centre of gravity of the pendulum gets lowered. This increases the effective length of the simple pendulum. Since the time period of a pendulum depends directly on its length, therefore, there is an increase in the time period of the simple pendulum.

Q.32. ***Name two factors on which the time period of a simple pendulum does not depend.***

Ans. The two factors are : (*i*) Mass of the bob, and (*ii*) Nature of the material of the bob.

Q.33. ***How is the time period of a simple pendulum affected in the following situations ?***

(*i*) ***Amplitude of the pendulum is increased.***

(*ii*) ***The length of the pendulum is doubled.***

(*iii*) ***The brass bob is replaced with an identical aluminium bob.***

(*iv*) ***The value of g is made one-fourth.***

Ans. The time period of a pendulum is given by the expression $T = 2\pi\sqrt{\frac{L}{g}}$.

(*i*) The time period of a pendulum does not depend upon its amplitude, hence no change.

(*ii*) The time period of a pendulum is directly proportional to the square root of its length. When length is increased, the time period will also increase.

(*iii*) The time period of a pendulum does not depend upon its mass, hence there will be no change.

(*iv*) The time period of a pendulum is inversely proportional to the square root of g. When g is made one-fourth, the time period will increase.

Q.34. ***How do you measure the time period of a given simple pendulum? Why do you note the time for more than one oscillation ?***

Ans. The following procedure is used to measure the time period of a pendulum :

(*i*) The pendulum is set into vibration.

(*ii*) When the bob crosses the mean position towards one of the extreme positions, start the stopwatch and count zero. When the bob again crosses the mean position in the same direction, count one.

(*iii*) In this way count 20 vibrations and stop the stop clock.

(*iv*) Note the time taken to complete 20 oscillations.

(*v*) Divide the time taken to complete 20 oscillations by 20. This gives you the time period of the pendulum.

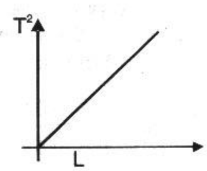
Noting the time for more than one oscillation reduces the error in the measurement.

Q.35. ***Two pendulums P and Q of lengths 2 m and 4 m are made to oscillate. Which pendulum will make more oscillations and why?***

Ans. The time period of a pendulum is given by the expression $T = 2\pi\sqrt{\frac{L}{g}}$. Since it depends directly on the square root of length, therefore, pendulum Q will have more time period than pendulum P. In other words, pendulum P will be oscillating faster than pendulum Q, therefore, in the same time pendulum P will make more oscillations than pendulum Q.

Q.36. ***Draw a graph showing the variation of T^2 with length of a simple pendulum. How will you use this graph to determine the value of g (acceleration due to gravity)?***

Ans. The graph is a straight line as shown :



The slope of the graph is used to find the value of g.

To reduce this error, the screw must always be rotated in the same direction, for a particular set of observations.

Q.23. ***Name the instrument which can accurately measure the following :***

(a) The diameter of a needle,

(b) The thickness of a paper,

(c) The internal diameter of the neck of a water bottle, and

(d) The diameter of a pencil.

Ans. (*a*) Screw gauge (*b*) Screw gauge

(*c*) Vernier calliper (*d*) Screw gauge.

Q.24. ***(a) Identify the high accuracy instrument from the following for measuring length: metre scale, vernier calliper, screw gauge.***

(b) Name the instrument which has the least count (i) 0.1 mm (ii) 1 mm (iii) 0.01 mm.

Ans. (*a*) Screw gauge

(*b*) (*i*) Vernier calliper

(*ii*) Metre scale

(*iii*) Screw gauge

Q.25. ***You are given a measuring cylinder, a string, a stone and water. Describe in steps with neat diagrams, the method to find the volume of the stone. What is this method called?***

Ans. To measure the volume of a stone, which is not soluble in water the following steps are involved :

1. Take a clean measuring cylinder and fill it partly with water.
2. Remove air bubbles sticking to the sides with a clean glass rod.
3. Take the reading V_1 (in mL or cm^3) of the water at the same level as the lower part of the concave meniscus of water.
4. Clean the stone, whose volume has to be measured, of dirt and grease if any.
5. Tie it with a thin string, strong enough to hold its weight and lower it gently into the cylinder taking care not to splash any water.
6. When the stone is well below the water surface (completely immersed in water), remove any air bubbles sticking to it. Take the reading V_2 of the water level as before.

   This level is higher due to the displaced water. The difference in readings *i.e.,* $V_2 - V_1 = V$ is the volume of the stone.

This method is called the displacement method.

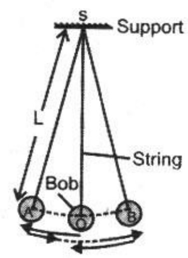
Q.26. ***Give some examples of repetitive phenomenon occurring in nature which could be used for defining the standard of time. Which phenomenon will be most appropriate for measuring the time ?***

Ans. Following repetitive phenomenon occurring in nature can serve as standard for measuring time : (*i*) Beating of human heart. (*ii*) Oscillations of a simple pendulum. (*iii*) Revolution of earth about sun. (*iv*) Rotation of the earth about its own axis. (*v*) Period of radiations emitted from certain atoms.

Previously, the rotation of the earth about its own axis was adopted to define the standard of time. But nowadays, the period of radiation corresponding to the unperturbed transition between two hyperfine levels of the ground state of caesium-133 atom is used to define the time standard.

Q.27. ***Draw a neat diagram of a simple pendulum. Show on it the effective length of pendulum and one oscillation of pendulum.***

Ans. The diagram is as shown below :



Q.28. ***The bob of a simple pendulum is made of ice. How will the period of oscillation change when the ice starts melting?***

Ans. There is no change in the time period of the simple pendulum. As the ice melts, the length of the pendulum remains unaltered. Since time period of a simple pendulum does not depend upon the mass of the bob, therefore, it remains unaltered.

Q.29. ***Name the factors on which the time period of a simple pendulum depends. Write the relation for the time period in terms of the above named factors.***

Ans. The time period of a simple pendulum depends upon (*i*) Its length, and (*ii*) acceleration due to gravity. These are related as $T = 2\pi\sqrt{\frac{L}{g}}$.

(*c*) ***Observed diameter***

(*d*) ***Corrected diameter***

Sol. (*a*)

$$\text{Pitch} = \frac{\text{Distance moved on the main scale}}{\text{Number of rotations}}$$

$$= \frac{1\text{ cm}}{10} = 0.1\text{ cm}$$

(*b*) Therefore, Least count of the screw gauge

$$LC = \frac{\text{Pitch}}{\text{Number of division on the circular scale}}$$

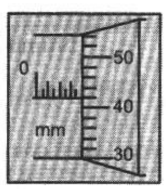
$$= \frac{0.1}{100} = 0.001\text{ cm}$$

(*c*) Observed diameter of wire: Main scale reading + LC × CSD coinciding
= 0.2 cm + 0.001 cm × 79 = 0.279 cm

(*d*) Negative error = 7 divisions.
Negative correction = LC × 7 div. = 0.001 cm × 7 = 0.007 cm

Therefore, corrected diameter = 0.279 cm + 0.007 cm = 0.286 cm.

Q.17. ***The pitch of a screw is 1 mm. What is the value of the reading as shown in figure, if the circular scale has 100 divisions ?***



Sol. Given : Pitch = 1 mm

Therefore, Least count

$$LC = \frac{\text{Pitch}}{\text{Number of divisions on the circular scale}}$$

$$= \frac{1\text{ mm}}{100} = 0.01\text{ mm} = 0.001\text{ cm}$$

Therefore, reading shown by the screw gauge
= Main scale reading + LC × CSD coinciding
= 3.5 mm + 0.001 cm × 41 = 0.35 cm + 0.041cm
= 0.391 cm

Q.18. ***In measuring the volume of a piece of cork, it is observed that the initial level of water in a measuring cylinder is 20.3 mL. When an iron piece is immersed the new reading becomes 27.5 mL. When the iron piece and a cork piece tied together are now immersed, the reading becomes 30.3 mL. Find the volume of (i) iron piece, and (ii) the cork piece.***

Sol. Given : Initial volume of water V_1 = 20.3 mL

Reading with iron piece V_2 = 27.5 mL

Reading with both iron piece and cork piece V_3 = 30.3 mL

Volume of iron piece = $V_2 - V_1$ = (27.5 – 20.3) mL = 7.2 mL

Volume of cork piece = $V_3 - V_2$ = (30.3 – 27.5) mL = 2.8 mL.

Q.19. ***A pendulum whose length is 36 cm has time period 1.2 s. Find the time period of another pendulum whose length is 81 cm.***

Sol. Given :

L_1 = 36 cm, T_1 = 1.2 s;

L_2 = 81 cm, T_2 = ?

We know that the time period of a simple pendulum is given by

$$T = 2\pi\sqrt{\frac{L}{g}}, \text{ therefore, we have}$$

$$\frac{T_2}{T_1} = \sqrt{\frac{L_2}{L_1}} \text{ or } \frac{T_2}{1.2} = \sqrt{\frac{81}{36}} = \frac{9}{6}, \text{ therefore,}$$

$$T_2 = 1.2 \times \frac{9}{6} = 1.8\text{ s}$$

Q.20. ***Calculate the length of second's pendulum on the surface of moon, when acceleration due to gravity on moon is 1.63 ms^{-2}.***

Sol. Given : T = 2 s, g = 1.63 ms^{-2} and L = ?

We know that the time period of a simple pendulum is given by

$$T = 2\pi\sqrt{\frac{L}{g}}, \text{ therefore, we have}$$

$$2 = 2 \times \frac{22}{7}\sqrt{\frac{L}{1.63}}, \text{ Squaring both sides, we have}$$

$$4 = 4 \times \frac{484}{49} \times \frac{L}{1.63}, \text{ therefore,}$$

$$L = \frac{4 \times 49 \times 1.63}{4 \times 484} = 0.165\text{ m}$$

Q.21. ***The lengths of two pendulums are 27.5 cm and 110 cm respectively. Calculate the ratio of their time periods.***

Sol. Given :

$L_1 = 27.5$ cm,

$L_2 = 110$ cm

We know that the time period of a simple pendulum is given by

$T = 2\pi\sqrt{\frac{L}{g}}$, therefore, we have

$$\frac{T_1}{T_2} = \sqrt{\frac{L_1}{L_2}} \text{ or } \frac{T_1}{T_2} = \sqrt{\frac{27.5}{110}} = \sqrt{\frac{1}{4}} = \frac{1}{2}$$

Q.22. ***The time periods of two pendulums is 0.36 s and 1.44 s respectively. Calculate the ratio of their lengths.***

Sol. Given : $T_1 = 0.36$ s, $T_2 = 1.44$ s

We know that the time period of a simple pendulum is given by

$T = 2\pi\sqrt{\frac{L}{g}}$, therefore, we have

$$\frac{T_1}{T_2} = \sqrt{\frac{L_1}{L_2}} \text{ or } \frac{L_1}{L_2} = \frac{T_1^2}{T_2^2} = \frac{(0.36)^2}{(1.44)^2} = \left(\frac{1}{4}\right)^2 = \frac{1}{16}$$

Q.23. ***Calculate the mass of air enclosed in a room of length, width and height 5 m, 3 m and 4 m respectively. Given density of air is 1.293 kgm^{-3}.***

Sol. Given : length = 5 m, width = 3 m and height = 4 m

Therefore, volume of room = length × width × height = 5 × 3 × 4 = 60 m^3

Therefore, mass of air in the room = volume × density = 60 × 1.293 = 77.58 kg

Q.24. ***The density of a substance is 8.9 gcm^{-3}. What is its density in SI?***

Sol. Given : density in cgs = 8.9 gcm^{-3}

Therefore, density in SI is

$$\text{Density} = \frac{8.9}{1000} \times 100 \times 100 \times 100 = 8900 \text{ kgm}^{-3}$$

Q.25. ***A wooden block of dimensions 10 cm × 20 cm × 50 cm weighs 6.5 kg. calculate the (i) Volume (ii) density of the block in cgs and (iii) density in SI.***

Sol. Given : Dimensions = 10 cm × 20 cm × 50 cm

Mass = 6.5 kg = 6500 g,

Volume = 10 cm × 20 cm × 50 cm = 10000 cm^3

$$\text{Density in cgs} = \frac{\text{Mass}}{\text{Volume}} = \frac{6500}{10000} = 0.65 \text{ gcm}^{-3}$$

$$\text{Density in SI} = \frac{0.65}{1000} \times 100 \times 100 \times 100$$

$$= 650 \text{ kgm}^{-3}$$

Q.26. ***An iron cylinder of 1.4 cm radius and 8 cm length has a mass of 370 g. Calculate (i) volume of cylinder (ii) density of iron in cgs and (iii) in SI.***

Sol. Given : Radius of cylinder = 1.4 cm

Length of cylinder = 8 cm

Mass of cylinder = 370 g

Volume of cylinder = $\pi r^2 l$ = 3.14 × $(1.4)^2$ × 8

= 49.24 cm^3

Density of cylinder in cgs

$$= \frac{\text{Mass}}{\text{Volume}} = \frac{370}{49.24} = 7.5 \text{ gcm}^{-3}$$

Density of cylinder in SI

$$= \frac{7.5}{1000} \times 100 \times 100 \times 100 = 7500 \text{ kg m}^{-3}$$

Q.27. ***An iron cylinder of length 80 cm has an area of cross-section 0.75 m^2 has a density of 7500 kg m^{-3}. Calculate the mass of the cylinder.***

Sol. Given : Length of cylinder L = 80 cm = 0.8 m

Area of cross-section A = 0.75 m^2

Density of iron = 7500 kgm^{-3}

Now, Mass = Volume × Density = A L × Density = 0.8 × 0.75 × 7500 = 4500 kg

Chapter 2 - Motion in One Dimension-Exercise 2(A)

Q1: Differentiate between scalar and vector quantities, giving two examples of each?

Solution 1

Scalar	Vector
They are expressed only by their magnitudes.	They are expressed by magnitude as well as direction.
They can be added, subtracted, multiplied or divided by simple arithmetic methods.	They can be added, subtracted or multiplied following a different algebra.
They are symbolically written by English letter.	They are symbolically written by their English letter with an arrow on top of the letter.
Example: mass, speed	Example: force, velocity

Q2: State whether the following quantity is a scalar or vector:

(a) pressure (b) force (c) momentum
(d) energy (e) weight (f) speed

Solution 2:

a) Pressure is a scalar quantity.
b) Momentum is a vector quantity.
c) Weight is a vector quantity.
d) Force is a vector quantity.
e) Energy is a scalar quantity.
f) Speed is a scalar quantity.

Q3: When is a body said to be at rest?

Solution 3:

A body is said to be at rest if it does not change its position with respect to its immediate surroundings.

Q4: When is a body said to be at motion?

Solution 4:

A body is said to be in motion if it changes its position with respect to its immediate surroundings.

Q5: What do you mean by motion in one direction?

Solution 5:

When a body moves along a straight line path, its motion is said to be one-dimensional motion.

Q6: Define displacement. State its unit?

Solution 6:

The shortest distance from the initial to the final position of the body is called the magnitude of displacement. It is in the direction from the initial position to the final position.
Its SI unit is metre (m).

Q7: Differentiate between distance and displacement?

Solution 7

Distance is a scalar quantity, while displacement is a vector quantity. The magnitude of displacement is either equal to or less than the distance. The distance is the length of path travelled by the body so it is always positive, but the displacement is the shortest length in direction from initial to the final position so it can be positive or negative depending on its direction. The displacement can be zero even if the distance is not zero.

Q8: Can displacement be Zero even if distance is not Zero? Give one example to explain your answer?

Solution 8:

Yes, displacement can be zero even if the distance is not zero.
For example, when a body is thrown vertically upwards from a point A on the ground, after sometime it comes back to the same point A. Then, the displacement is zero, but the distance travelled by the body is not zero (it is 2h; h is the maximum height attained by the body).

Q9: When is the magnitude of displacement equal to the distance?

Solution 9

The magnitude of displacement is equal to distance if the motion of the body is one-dimensional.
Q10: Define velocity. State its unit?

Solution 10

The velocity of a body is the distance travelled per second by the body in a specified direction.
Its SI unit is metre/second (m/s).

Q11: Define speed. What is its S.I Unit?

Solution 11

The speed of a body is the rate of change of distance with time.
Its SI unit is metre/second (m/s).

Q12: Distinguish between speed and velocity?

Solution 12

Speed is a scalar quantity, while velocity is a vector quantity. The speed is always positive-it is the magnitude of velocity, but the velocity is given a positive or negative sign depending upon its direction of motion. The average velocity can be zero but the average speed is never zero.

Q13: Which of the quantity speed or velocity gives the direction of motion of body?

Solution 13

Velocity gives the direction of motion of the body.

Q14: When is the instantaneous speed saying as the average speed?

Solution 14

Instantaneous velocity is equal to average velocity if the body is in uniform motion.

Q15: Distinguish between uniform velocity and the variable velocity?

Solution 15

If a body travels equal distances in equal intervals of time along a particular direction, then the body is said to be moving with a uniform velocity. However, if a body travels unequal distances in a particular direction in equal intervals of time or it moves equal distances in equal intervals of time but its direction of motion does not remain same, then the velocity of the body is said to be variable (or non-uniform).

Q16: Distinguish between the average speed and the average velocity?

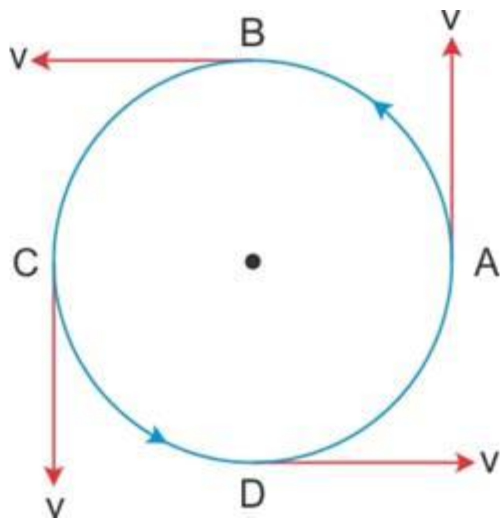
Solution 16

Average speed is the ratio of the total distance travelled by the body to the total time of journey, it is never zero. If the velocity of a body moving in a particular direction changes with time, then the ratio of displacement to the time taken in entire journey is called its average velocity. Average velocity of a body can be zero even if its average speed is not zero.

Q17: Give an example of the motion of a body moving with a constant speed, but with a variable velocity. Draw a diagram to represent such a motion?

Solution 17

The motion of a body in a circular path with uniform speed has a variable velocity because in the circular path, the direction of motion of the body continuously changes with time.



Q18: Give an example of motion in which average speed is not Zero but the average velocity is Zero?

Solution 18

If a body starts its motion from a point and comes back to the same point after a certain time, then the displacement is zero, average velocity is also zero, but the total distance travelled is not zero, and therefore, the average speed in not zero.

Q19: Define acceleration. State its S.I Unit?

Solution 19

Acceleration is the rate of change of velocity with time.
Its SI unit is metre/second^2 (m/s^2).

Q20: Distinguish between acceleration and retardation?

Solution 20

Acceleration is the increase in velocity per second, while retardation is the decrease in velocity per second. Thus, retardation is negative acceleration. In general, acceleration is taken positive, while retardation is taken negative.

Q21: Differentiate between uniform acceleration and variable acceleration?

Solution 21

The acceleration is said to be uniform when equal changes in velocity take place in equal intervals of time, but if the change in velocity is not the same in the same intervals of time, the acceleration is said to be variable.

Q22: What is meant by the term retardation? Name its S.I Unit?

Solution 22

Retardation is the decrease in velocity per second.
Its SI unit is metre/second^2 (m/s^2).

Q23: Which of the quantity velocity or acceleration determines the direction of motion?

Solution 23

Velocity determines the direction of motion.

Q24: Define the term acceleration due to gravity. State its average value?

Solution 26

When a body falls freely under gravity, the acceleration produced in the body due to the Earth's gravitational acceleration is called the acceleration due to gravity (g). The average value of g is 9.8 m/s^2.

Q25: The value of g remains same at all places on the earth surface. Is this statement true? Give reason for your answer?

Solution 27

No. The value of 'g' varies from place to place. It is maximum at poles and minimum at the Equator on the surface of the Earth.

Chapter 2 - Motion in One Dimension-Exercise 2(B)

Q1: For the motion with uniform velocity, how is the distance travelled related to the time?

Solution 1

For the motion with uniform velocity, distance is directly proportional to time.

Q2: What information about the motion of a body is obtained from the displacement time graph?

Solution 2

From displacement-time graph, the nature of motion (or state of rest) can be understood. The slope of this graph gives the value of velocity of the body at any instant of time, using which the velocity-time graph can also be drawn.

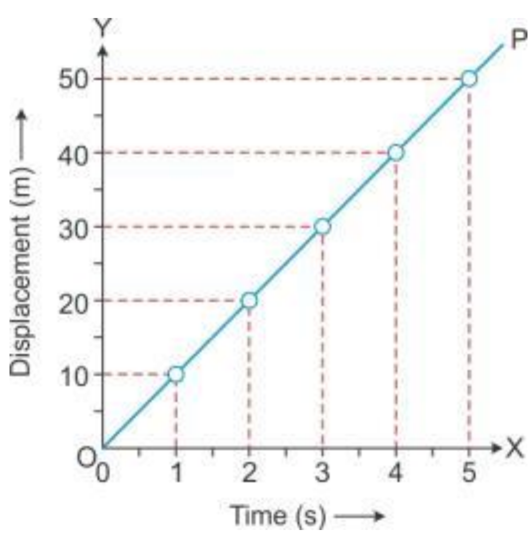
Q3: (a) What does the slope of a displacement –time graph represent? (b) Can displacement – time sketch be parallel to the displacement axis? Give reason to your answer?

Solution 3

(a) Slope of a displacement-time graph represents velocity.
(b) The displacement-time graph can never be parallel to the displacement axis because such a line would mean that the distance covered by the body in a certain direction increases without any increase in time, which is not possible.

Q4: Draw a displacement-time graph for a boy going to school with uniform velocity?

Solution 4:



Q5: State how the velocity time graph can be used to find:

(i) the acceleration of a body

(ii) the distance travelled by the body in a given time

(iii) the displacement of the body in a given time

Solution 5:

(i) The slope of the velocity-time graph gives the value of acceleration.
(ii) The total distance travelled by a body in a given time is given by the area enclosed between the velocity-time graph and X-axis (without any sign).
(iii) The displacement of a body in a given time is given by the area enclosed between the velocity-time graph and X-axis (with proper signs).

Q6: What can you say about the nature of motion of a body if its displacement- time graph is :

(a) A straight line parallel to time axis?

(b) A straight line inclined to the time axis with an acute angle?

(c) A straight line inclined to the time axis with an obtuse angle?

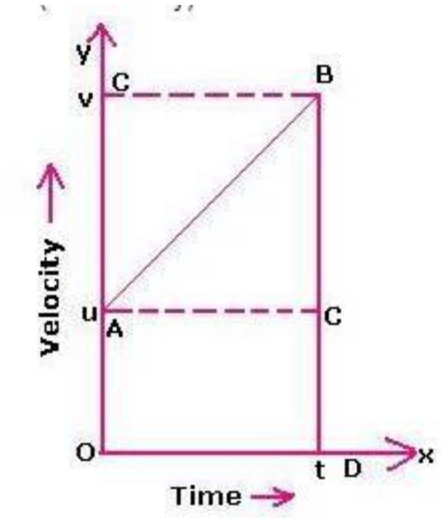
(d) A curve

Solution 6:

(a) There is no motion, the body is at rest.
(b) It depicts that the body is moving away from the starting point with uniform velocity.
(c) It depicts that the body is moving towards the starting point with uniform velocity.
(d) It depicts that the body is moving with variable velocity.

Q7: Draw a velocity time graph for a body moving with initial velocity u and uniform acceleration f. Use this graph to find the distance travelled by the body in time t?

Solution 7:



In this graph, initial velocity = u
Velocity at time t = v
Let acceleration be 'a'
Time = t
Then, distance travelled by the body in t s = area between the v-t graph and X-axis
Or distance travelled by the body in t s = area of the trapezium OABD
= (1/2) × (sum of parallel sides) × (perpendicular distance between them)
= (1/2) × (u + v) × (t)
= (u + v)t /2

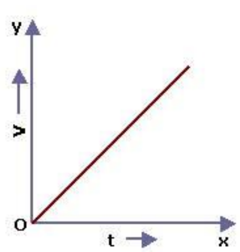
Q8: What does the slope of velocity time graph represent?

Solution 8:

The slope of the velocity-time graph represents acceleration.

Q9: Draw the slope of velocity time graph for a body moving with (a) uniform velocity (b) uniform acceleration?

Solution 9:

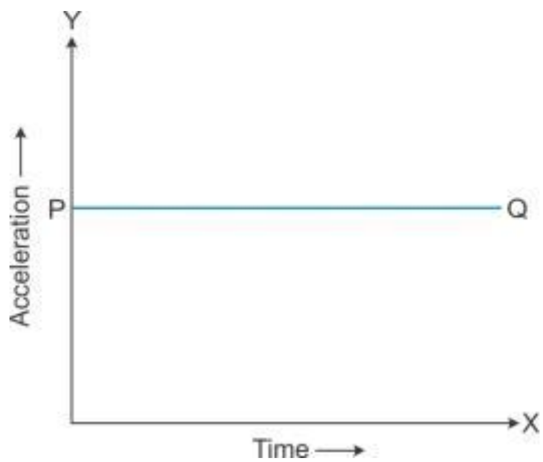


Velocity-time for a body moving with uniform velocity and uniform acceleration.

Q10: The velocity time graph for a uniformly retarded body is a straight line inclined to the time axis with an obtuse angle. How is retardation calculated from the velocity time graph?

Q11: Draw a graph for acceleration against time for a uniformly accelerated motion. How can it be used to find the change in speed in a certain interval of time?

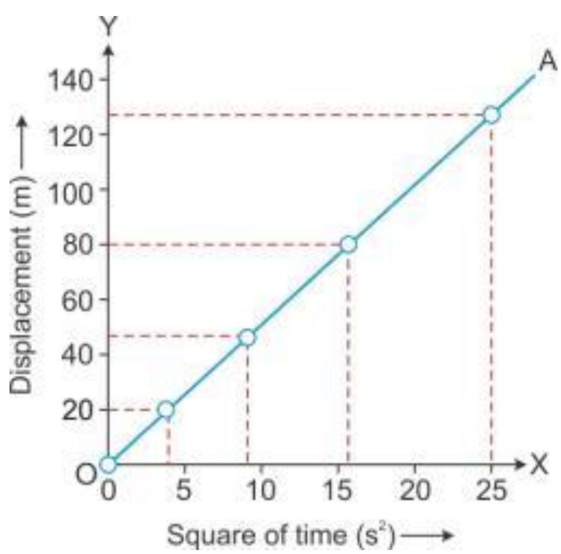
Solution 11:



The area enclosed between the straight line and time axis for each interval of time gives the value of change in speed in that interval of time.

Q12: Draw a velocity time graph for free fall of a body under gravity, starting from rest?

Solution 12:



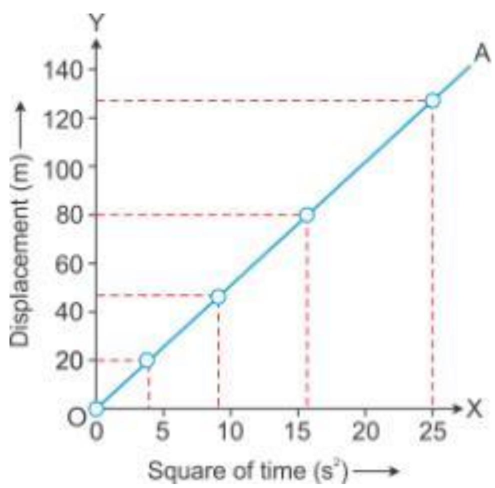
Q13: How is the distance related with time for the motion under uniform acceleration such as the motion of a freely falling body?

Solution 13:

For motion under uniform acceleration, such as the motion of a freely falling body, distance is directly proportion to the square of the time.

Q14: A body falls freely from a certain height. Show graphically the relation between the distance fallen and square of time. How will you determine g from this graph?

Solution 14:



The value of acceleration due to gravity (g) can be obtained by doubling the slope of the $S - t^2$ graph for a freely falling body.

Chapter 2 - Motion in One Dimension-Exercise 2(C)

Q1: Write three equitation's of uniformly accelerated motion relating initial velocity (u), final velocity (v), time (t), acceleration (a) and displacement(S)?

Solution 1:

Three equations of a uniformly accelerated motion are

v = u + at

s = ut + (1/2)at^2

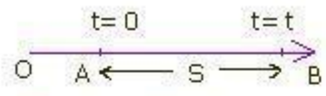
$v^2 = u^2 + 2as$

Q2: Derived the following equitation for a uniformly accelerated motion:

(i) $v = u + at$
(ii) $s = ut + (1/2)at^2$
(iii) $v^2 = u^2 + 2as$

Solution 2:

Derivation of equations of motion
First equation of motion:
Consider a particle moving along a straight line with uniform acceleration 'a'. At t = 0, let the particle be at A and u be its initial velocity, and at t = t, let v be its final velocity.



First law of Motion

Acceleration = *Change in velocity/Time* $a = (v - u)/t$ $at = v - u$ **$v = u + at$ ... First equation of motion.**

Second equation of motion: Average velocity = *Total distance traveled/Total time taken* Average velocity = s/t ...(1)
Average velocity can be written as $(u+v)/2$ Average velocity = $(u+v)/2$ ...(2)
From equations (1) and (2) $s/t = (u+v)/2$ ...(3)
The first equation of motion is $v = u + at$.
Substituting the value of v in equation (3), we get
$s/t = (u + u + at)/2$ $s = (2u + at)\, t/2 = 2ut + at^2/2 = 2ut/2 + at^2/2$
$s = ut + (1/2)\, at^2$ ...Second equation of motion.
Third equation of motion: The first equation of motion is $v = u + at$. $v - u = at$ ... (1)
Average velocity = s/t ...(2)
Average velocity $=(u+v)/2$ ...(3)
From equation (2) and equation (3) we get,
$(u + v)/2 = s/t$ ...(4)
Multiplying eq (1) and eq (4) we get,
$(v - u)(v + u) = at \times (2s/t)$ $(v - u)(v + u) = 2as$
[We make the use of the identity $a^2 - b^2 = (a + b)(a - b)$]
$v^2 - u^2 = 2as$ ...Third equation of motion.

Q3: Write an expression for the distance S covered in time t by a body which is initially at rest and starts moving with a constant acceleration a?

Solution 3:

Distance = s, time = t, initial velocity u = 0 and acceleration = a.
Using the second equation of motion and substituting the above values we get,

$s = ut + (1/2) at^2$

$$s = \frac{1}{2}at^2$$

Q.1. ***When is a body said to be at rest ? When is a body said to be in motion ?***

Ans. A body is said to be at rest if it does not change its position with respect to the surroundings. A body is said to be in motion if it changes its position with respect to the surroundings.

Q.2. ***Distinguish between displacement and distance.***

Ans.

Distance	Displacement
Distance is the length of the actual path traversed by a body irrespective of its motion.	Displacement is the shortest distance between the initial and final positions of body in a given direction.
Distance between two points may be same or different for different paths chosen.	Displacement between two given points is always same.
It is a scalar quantity.	It is a vector quantity.
Distance covered may be positive or zero.	Displacement covered may be positive, negative or zero.

Q.3. ***Under what condition will the displacement and distance have the same magnitude ?***

Ans. When the object has uniform motion.

Q.4. ***Read each statement below carefully and state with reasons and examples, if it is true or false. A particle in one-dimensional motion:***

(a) with zero speed at an instant may have non-zero acceleration at the instant,

(b) with zero speed may have non-zero velocity,

(c) with constant speed must have zero acceleration, and

(d) with positive value of acceleration must be speeding up.

Ans. (*a*) True. When a body begins to fall freely under gravity, its speed is zero but it has non-zero acceleration of 9.8 ms^{-2}.

(*b*) False. Speed is the magnitude of velocity and the magnitude of non-zero velocity cannot be zero.

(*c*) True. When a particle moves with a constant speed in the same direction, neither the magnitude nor the direction of velocity changes and so acceleration is zero. In case a particle rebounds instantly with the same speed, its acceleration will be infinite which is physically not possible.

(*d*) False. If the initial velocity of body is negative, then even in case of positive acceleration, the body speeds down. A body speeds up when the acceleration acts in the direction of motion.

Q.5. ***Can displacement be zero even if distance is not zero ? Give one example to explain your answer.***

Ans. Yes. If a body returns to its initial position, displacement is zero while distance is not zero.

Q.6. ***A boy hits a football high up into the air. He runs and catches the football before it hits the ground. Which of the two, the boy or the football has had greater displacement ?***

Ans. Both have undergone the same displacement, although the distance travelled by the football is greater than the distance travelled by the boy.

Q.7. ***What is the nature of the displacement-time graph of a body moving with constant velocity ?***

Ans. Straight line, passing through the origin.

Q.8. ***What is the slope of the displacement-time graph when the body has uniform motion ?***

Ans. The slope of the displacement-time graph gives the value of the uniform velocity.

Q.9. ***What is the nature of the displacement-time graph of a body moving with constant acceleration ?***

Ans. The graph is a parabola.

Q.10. ***How can you find the distance travelled by body in uniform motion from the velocity-time graph ?***

Ans. The area under the velocity-time graph gives the distance travelled by the particle.

Q.11. ***Distinguish between velocity and speed.***

Ans. Rate of change of displacement with time is called velocity. It is a vector. Rate of distance covered with time is called speed. It is a scalar.

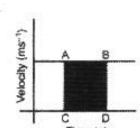
Q.12. ***Distinguish between speed and velocity.***

Ans. The table below distinguishes between speed and velocity :

S.No.	Speed	Velocity
1.	It is defined as the rate of change of distance.	It is defined as the rate of change of displacement.
2.	It is a scalar quantity.	It is a vector quantity.
3.	It can never be negative or zero.	It can be negative, zero or positive.
4.	Speed is velocity without direction.	Velocity is directed speed.
5.	Speed may or may not be equal to velocity.	A body may possess different velocities but the same speed.
6.	Speed never decreases with time. For a moving body it is never zero.	Velocity can decrease with time. For a moving body it can be zero.
7.	Speed in SI is measured in ms^{-1} and in cgs as cms^{-1}.	Velocity in SI, is measured in ms^{-1} and is cgs as cms^{-1}.

Q.13. ***Give an example of the motion of a body moving with a constant speed, but with a variable velocity. Draw a diagram to represent such a motion.***

Ans. This is the case of a body moving with uniform speed along a circular path. The diagram is as shown.



Q.14. ***Differentiate between uniform acceleration and variable acceleration.***

Ans. Acceleration is said to be uniform when there are equal changes in velocities in equal intervals of time. If the change in velocity is not same in equal intervals of time, the acceleration is said to be non-uniform.

Q.15. ***Give one example of each type of following motion :***

(a) uniform velocity (b) variable velocity (c) variable acceleration (d) uniform retardation.

Ans. (*a*) Motion of a ball on a frictionless floor.

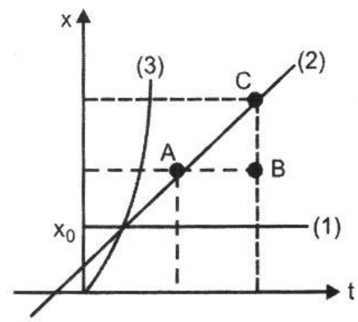
(*b*) Motion of a ball on a rough floor.

(*c*) The motion of a vehicle on a crowded road.

(*d*) Motion of a vehicle under the action of brakes.

Q.16. ***What is x-t graph ? Explain.***

Ans. A graph between position and time is called a *x*-*t* graph. Some *x*-*t* graphs are as shown.



Slope of *x*-*t* graph gives instantaneous velocity of motion.

Graph (1) refers to a body at rest since position (x_0) remains same at all times.

Graph (2) refers to a body with constant velocity, since slope remains same.

Graph (3) refers to accelerated motion. Slope of graph (3) is more than that of graph (2) at all points. Therefore, the velocity in graph (3) is more than that of graph (2) at all instants.

Q.17. ***What information is obtained about the motion of a body from the displacement-time graph ?***

Ans. The following information is obtained :

(*i*) If the graph is a straight line parallel to the time axis, the object is stationary. If the graph is a straight line inclined to the time axis, the motion is with uniform velocity. If the graph is a curve, the motion is with non-uniform velocity.

(*ii*) The slope of the straight line (or the tangent to the curve at an instant) gives the velocity of object at that instant. If the slope is positive, it represents motion away from the origin (or reference point) and if the slope is negative, it represents the motion towards the origin.

Q.18. ***What does the slope of a displacement-time graph represent ? Can displacement-time sketch be parallel to the displacement axis ? Give reason to your answer.***

Ans. It gives the value of instantaneous velocity. No, this is not possible as this would mean infinity velocity, which is not possible.

Q.19. ***What will be the nature of motion of a body if its displacement-time graph is :***

(a) a straight line parallel to time axis ?

(b) a straight line inclined to the time axis with an acute angle ?

(c) a straight line inclined to the time axis with an obtuse angle ?

(d) a curve ?

Ans. (*a*) Body is stationary.

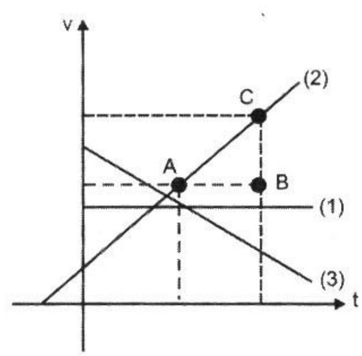
(*b*) Motion away from the starting point with uniform velocity.

(*c*) Motion towards the starting point with uniform velocity.

(*d*) Motion with variable velocity.

Q.20. ***What is a v-t graph ? Explain.***

Ans. A graphical representation of velocity versus time is called *v-t* graph. Some *v-t* graphs are as shown.



Slope of velocity-time graph gives acceleration.

Graph (1) refers to uniform motion since velocity is constant, so acceleration is zero.

Graph (2) refers to uniformly accelerated motion, since slope is constant and positive.

Graph (3) refers to uniformly decelerated motion, since slope is negative, velocity decreases with increasing time.

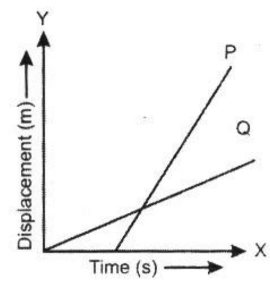
Q.21. ***How is the velocity-time graph be used to find (i) the acceleration of a body, (ii) the distance travelled by the body in a given time, and (iii) the displacement of the body in a given time ?***

Ans. (*i*) The slope of the *v-t* graph gives the value of acceleration of the body.

(*ii*) The area under the velocity-time graph gives the value of distance travelled by a body.

(*iii*) The area under the velocity-time graph gives the value of displacement travelled by a body. The area under the graph will be taken as negative and that above the graph will be taken as positive.

Q.22. ***Fig. below shows the displacement-time graphs of two objects P and Q moving along a straight line. Identify with reason which object is moving faster.***



Ans. The slope of the displacement-time graph gives the value of velocity of the object. As the slope of object P is greater than that of object Q, therefore, object P is travelling faster.

Q.23. ***Can a body have constant speed and still be accelerating ?***

Ans. Yes. When the body moves along a circular path with uniform speed, it possesses centripetal acceleration.

Q.24. ***If the displacement of a body is proportional to the time elapsed, what type of motion does the body possess ?***

Ans. The body possesses uniform motion.

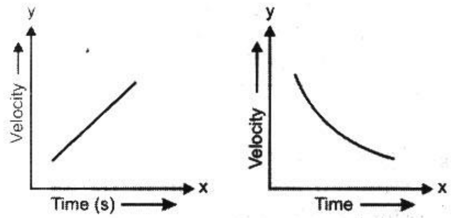
Q.25. ***If the acceleration of a particle is constant in magnitude but not in direction, what type of path is followed by the particle ?***

Ans. The particle follows a circular path.

Q.26. ***If the displacement of a body is proportional to the square of the time elapsed, what type of motion does the body possess ?***

Ans. The body has uniform acceleration.

Q.27. ***State the type of motion represented by the graphs shown below :***



Ans. (*a*) Uniform acceleration

(*b*) Non-uniform retardation.

Q.28. ***When is an object in motion considered to be a point object ?***

Ans. The object in motion is considered to be a point object if the distance it travels is very large as compared to the dimensions of the object.

Q.29. ***Can the speed of a body be negative ?***

Ans. No, because the speed of a body is the ratio of distance and time and distance travelled is never negative.

Q.30. ***If the displacement-time graph for a particle is parallel to displacement axis, what is the velocity of the particle ?***

Ans. Infinity.

Q.31. ***If the displacement-time graph for a particle is parallel to time axis, what is the velocity of the particle ?***

Ans. Zero.

Q.32. ***What determines the direction of motion of an object : velocity or acceleration ?***

Ans. Velocity.

Q.33. ***Mention some uses of velocity-time graphs.***

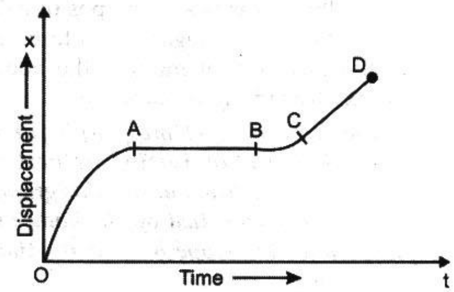
Ans. The velocity-time graphs have the following uses :

(*i*) To determine the total distance travelled by a particle.

(*ii*) To determine the instantaneous velocity of the particle.

(*iii*) To determine the acceleration of the object.

Q.34. ***Figure shows the x-t graph of a particle moving along a straight line. What is the sign of the acceleration during the intervals OA, AB, BC and CD ?***



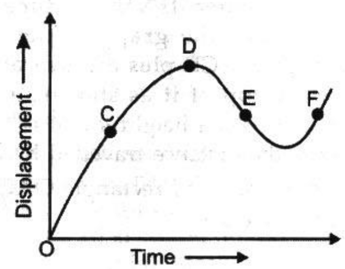
Ans. (*i*) Acceleration is negative during the interval OA.

(*ii*) Acceleration is zero during the interval AB.

(*iii*) Acceleration is positive during the interval BC.

(*iv*) Acceleration is zero during the interval CD.

Q.35. ***The x–t graph of a moving particle is as shown. Comment on the signs of the velocities at the points C, D, E and F.***



Ans. (*i*) At C, the velocity is positive. The tangent to the displacement-time graph at C makes an acute angle with the time-axis. So slope and hence velocity is positive.

(*ii*) At D, the velocity is zero.

(*iii*) At E, the velocity is negative.

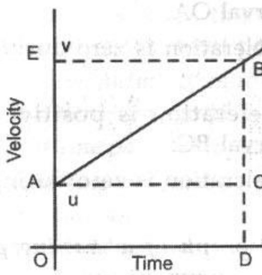
(*iv*) At F, the velocity is positive.

Q.36. ***A particle in one dimensional motion with positive value of acceleration must be speeding up. Is it true ? Explain.***

Ans. The answer depends on the choice of the positive direction of position-axis. To explain, let us consider the motion of a body falling freely under gravity and the positive direction of position to be a vertical line in downward direction. It follows that when the positive direction of positive-axis is along the direction of motion, the body speeds up. On the other hand, when a body is projected vertically upwards and the positive direction of position-axis is regarded as to be opposite to the direction of motion, the body slows down, instead of speeding up.

Q.37. ***Draw a velocity-time graph for a body moving with an initial velocity u and uniform acceleration a. Use this graph to find the distance travelled by the body in time t. What does the slope of velocity-time graph represent ?***

Ans. The graph is as shown below :



The distance travelled by a body is equal to the area under its velocity-time graph. The area under the graph is the area of the rectangle OACD plus the area of the triangle ABC on top of it as shown in figure. The rectangle has a height u and a length t. This area is the distance travelled by the object.

Thus, S = area of rectangle OACD + area of ΔABC. Hence,

$$S = ut + \frac{1}{2}(v-u)t \quad ....(1)$$

But from equation $v = u + at$ or we have $at = v - u$. Substituting in equation (1), we have

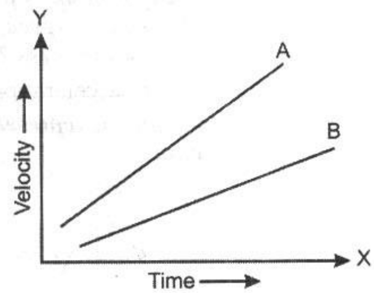
$$S = ut + \frac{1}{2}(at)t = ut + \frac{1}{2}at^2 \quad ....(2)$$

The slope of the graph gives the acceleration of the body.

Q.38. ***A car manufacturer advertises that the brakes are so perfect that the car stops instantaneously. Comment.***

Ans. His claim is not true. If the car stops instantaneously, then it must possess infinite retardation, which is not possible.

Q.39. ***Fig. below shows the velocity-time graphs for two objects A and B moving in same direction. Which object has the greater acceleration ? Why ?***



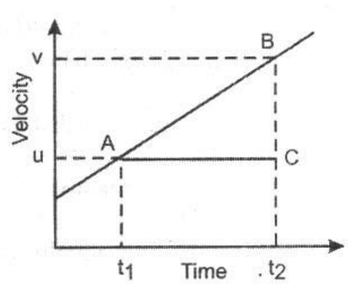
Ans. The slope of the velocity-time graph gives the value of acceleration of the body. As the slope of object A is greater than that of object B, therefore, object A has greater acceleration.

Q.40. ***Is the rate of change of acceleration with time important to mechanics ? Comment.***

Ans. The rate of change of acceleration with time can be defined but it is not important to mechanics. It is because, the basic laws of motion involve only acceleration and the quantity - the rate of change of acceleration is not required at all. Galileo and Newton discovered that to understand and explain motion, it is enough to define velocity (rate of change of position) and acceleration (rate of change of velocity).

Q.41. ***Show that area under the velocity-time graph of an object moving with constant acceleration in a straight line in certain time interval is equal to the distance covered by the object in that interval.***

Ans. The velocity-time graph of a body in uniformly accelerated motion is as shown in figure.



Consider two points A and B on the graph such that A corresponds to time t_1 and velocity u and B corresponds to time t_2 and velocity v.

$$a = \frac{v-u}{t_2 - t_1} \Rightarrow t_2 - t_1 = \frac{v-u}{a}$$

Now, area of trapezium = ½ × sum of parallel sides × perpendicular distance

Therefore,

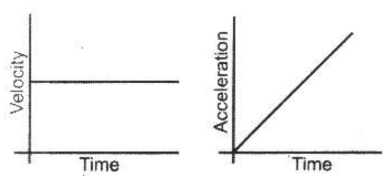
$$\text{Area} = \frac{1}{2}[v+u][t_2 - t_1] = \frac{1}{2}[v+u]\left[\frac{v-u}{a}\right] = \frac{1}{2}\left[\frac{v^2 - u^2}{a}\right]$$

Comparing with equation $2aS = \left[v^2 - u^2\right]$, we have

Area under velocity time graph = Distance travelled

Q.42. ***Sketch the shape of the velocity-time graph for a body moving with (a) uniform velocity, (b) uniform acceleration.***

Ans. The graphs are as shown below :



Q.43. ***Distinguish between terms distance and displacement.***

Ans. Distance is the length of the actual path traversed between its initial and final positions. It is a scalar quantity and can never be negative.

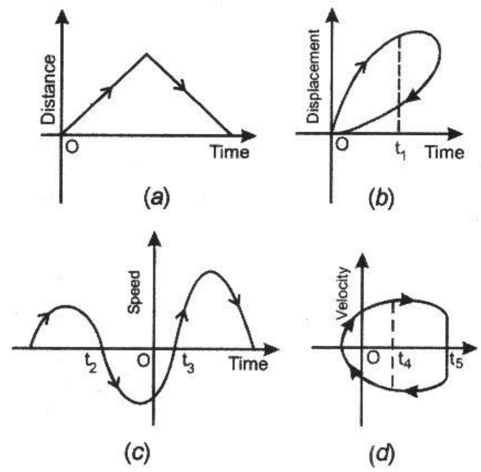
Displacement is the shortest path between the initial and the final positions of the particle. It is a vector quantity and can be positive, negative or zero.

Q.44. ***Distinguish between terms speed and velocity.***

Ans. Speed is the rate of change of distance. It is a scalar quantity and is always positive.

Velocity is the rate of change of displacement. It is a vector quantity and can be positive negative or zero.

Q.45. ***Explain with reason, which of the following graphs can possibly represent the motion of a particle observed in nature.***



Ans. (*a*) This graph shows that with increase in time distance first increases and then decreases. However, distance can never decrease with time, so this graph is not possible.

(*b*) This graph shows that at a certain time t_1 the body is present at two positions. It also shows that first time increases and then decreases. Since both these conditions cannot be realised in practice, hence this graph is not possible.

(*c*) This graph shows that speed is negative for some interval of time. Since speed cannot be negative, this graph is also not possible.

(*d*) This graph shows that at a given instant of time the particle has two velocities. Also, it shows that at some time it has infinite acceleration (graph parallel to the velocity axis). Both these conditions cannot be achieved in practice; therefore, this graph is also not possible.

Q.46. ***Draw a velocity-time graph for a body which :***

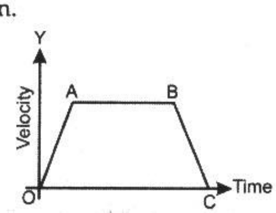
(i) accelerates uniformly from rest.

(ii) then moves with uniform velocity.

(iii) finally retarded uniformly and comes to rest.

Ans. In this graph :

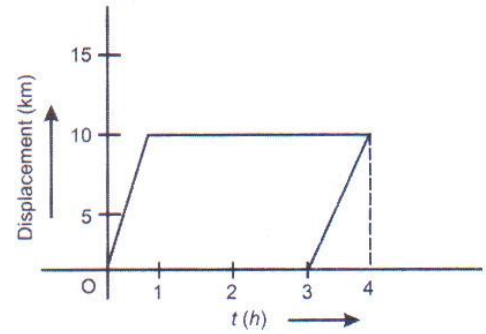
(*i*) OA represents uniformly accelerated motion.



(*ii*) AB represents motion with constant (uniform) velocity.

(*iii*) Finally BC represents uniformly retarded motion.

Q.47. ***Can the given graph be a displacement-time graph of an automobile going from one place to another and then returning back ?***



Ans. This displacement-time graph for the motion of an automobile is not possible because between 3 and 4 hours, the displacement has two values for the same time.

Q.1. ***Derive graphically the following equations of motion (i) $v = u + at$ and $S = ut + \frac{1}{2} at^2$.***

Ans. Let u be the velocity of the body at $t = 0$ and v be its velocity at $t = t$. Let the body possess uniform acceleration. The slope of the velocity-time graph tells us the acceleration of the object. If we use the symbol 'a' for acceleration, then from the graph, we have

$$\text{Slope of graph} = \frac{BC}{AC} = \frac{BD - CD}{AC} = \frac{v-u}{t} \quad ......(1)$$

Since the slope of the velocity time graph gives the value of acceleration, therefore, we have from equation (1)

$$a = \frac{v-u}{t} \quad ......(2)$$

Rewriting the above equation, we have

$$v = u + at \quad ......(3)$$

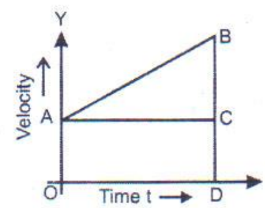
This gives the first equation of motion.

The distance travelled by a body is equal to the area under its velocity-time graph. The area under the graph is the area of the rectangle OACD plus the area of the triangle ABC on top of it as shown in figure. The rectangle has a height u and a length t. This area is the distance travelled by the object.

Thus, S = area of rectangle OACD + area of triangle ABC. Hence,

$$S = ut + \frac{1}{2}(v-u)t \quad ......(4)$$

But from equation (3), we have $v = u + at$ or we have $at = v - u$. Substituting in equation (4), we have



$$S = ut + \frac{1}{2}(at)t = ut + \frac{1}{2}at^2 \quad ......(5)$$

Q.3. *Starting from station A, a train takes 2 h to reach station B, and then 3 h to return from station B to station A. If the distance between the two stations is 240 km. Find (i) the average speed, (ii) the average velocity of the train.*

Sol. Given : total distance travelled S = 240 + 240 = 480 km

Total time taken = 2 + 3 = 5 hours

Therefore,

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}} = \frac{480}{5} = 96\ \text{kmh}^{-1}$$

Since the net displacement is zero, therefore,

$$\text{Average velocity} = \frac{\text{Displacement}}{\text{Total time}} = \frac{0}{5} = 0\ \text{kmh}^{-1}$$

Q.4. *A car moving with a uniform velocity of 36 kmh^{-1} comes to a stop in 3s. Find the retardation of the car in SI units.*

Sol. Given : $u = 36\ \text{kmh}^{-1} = 10\ \text{ms}^{-1}$, $t = 3$ s, $v = 0$

By definition of acceleration, we have

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time}} = \frac{0-10}{3} = -3.3\ \text{ms}^{-2}$$

Q.5. *A car is moving with a velocity 20 ms^{-1}. The brakes are applied to retard it at a rate of 2 ms^{-2}. What will be the velocity after 5 s of applying the brakes ?*

Sol. Given : $u = 20\ \text{ms}^{-1}$, $a = -2\ \text{ms}^{-2}$, $t = 5$ s, v = ?

Using the expression $v = u + at$, we have

$v = 20 + (-2) \times 5 = 10\ \text{ms}^{-1}$

Q.6. *Two cars moving in the opposite directions cover the same distance 'S' in one hour. If the cars are moving in the north-south direction, what will be their displacement in one hour ?*

Sol. The displacement of each car will be 'S' along north and south respectively.

Q.7. *The velocity of a car is 18 ms^{-1}. Express this velocity in kmh^{-1}.*

Sol. $$\text{Velocity} = \frac{18}{1000} \times \frac{1}{1/3600} = 64.8\ \text{kmh}^{-1}$$

Q.8. *An electric engine has a velocity of 120 kmh^{-1}. How much distance will it travel in 30 s ?*

Sol. $$\text{Velocity} = \frac{\text{Distance}}{\text{Time}} \text{ or Distance} = \text{Velocity} \times \text{Time}.$$

Therefore, $$S = \frac{120 \times 1000}{3600} \times 30 = 1000\ \text{m}$$

Q.9. *A body is moving with a uniform velocity of 10 ms^{-1}. Find its velocity after 10 s ?*

Sol. As the motion is uniform, therefore, the velocity of the body will remain same even after 10 s. Therefore, the velocity of the body will be 10 ms^{-1}.

Q.10. *All automobiles are fitted with a speedometer and an odometer, which respectively measures the instantaneous speed and the distance travelled by the automobile. An automobile's odometer shows a reading of 1048 km and 1096 km in time duration of 40 minute. Calculate the average velocity of the automobile. Will the speedometer show this reading ? Justify your answer.*

Sol. Average speed is given by

$$V_{av} = \frac{\text{Distance travelled}}{\text{Time taken}}$$

The automobile travels a distance of 1096 –1048 = 48 km = 48000 m in a time 40 min = 2400 s

Therefore,

$$V_{av} = \frac{\text{Distance travelled}}{\text{Time taken}} = \frac{48000}{2400} = 20\ \text{ms}^{-1}$$

The speedometer measures the instantaneous speed and not the average speed, therefore, it will not show this speed.

Q.11. *The driver of a train travelling at 40 ms^{-1} applies the brakes as the train enters a station. The train slows down at a rate of 2 ms^{-2}. The platform is 400 m long. Will the train stop in time ?*

Sol. Given : $u = 40\ \text{ms}^{-1}$, $v = 0$, $a = -2\ \text{ms}^{-2}$, S = ?

Using equation, we have

$$0 = (40)^2 + 2(-2)S \text{ or } 4S = 1600 \text{ or } S = 400 \text{ m}.$$

Thus, the train stops in 400 m. Since the platform is 400 m long therefore, the train just stops in time.

Q.12. *A girl running a race accelerates at 2.5 ms^{-2} for the first 4 s of the race. How far does she travel in this time ?*

Sol. Given : $u = 0$, $a = 2.5\ \text{ms}^{-2}$, $t = 4$ s and S = ?

Substituting the values in equation

$$S = ut + \frac{1}{2}at^2$$

We have $$S = 0 \times 4 + \frac{1}{2} \times 2.5 \times 4^2 = 20\ \text{m}$$

Q.13. ***Two trains A and B of length 400 m each are moving on two parallel tracks with uniform speed of 72 kmh^{-1} in the same direction with A ahead of B. The driver of B decides to overtake A and accelerates by 1 ms^{-2}. If after 50 s, the guard of B just passes the driver of A, what was the original distance between them ?***

Sol. Given : initial speed of each train $u = 72\ kmh^{-1} = 20\ ms^{-1}$

Distance travelled by train A in 50 s

$= 20 \times 50 = 1000$ m

Distance travelled by train B in 50 s with an acceleration of 1 ms^{-2} is

$$20 \times 50 + \frac{1}{2}(1) \times (50)^2 = 2250 \text{ m}$$

$$\text{Using } S = ut + \frac{1}{2}at^2$$

Therefore, the original distance between the trains is 2250 –1000 = 1250 m

Q.14. ***The cheetah is the fastest animal on land (in short spurts) and can achieve a peak velocity of 100 kmh^{-1} upto distances less than 500 m. If a cheetah spots his prey at a distance of 100 m, what is the minimum time it will take to get to its prey, if the average velocity attained by it is 90 kmh^{-1} ?***

Sol. Given : speed of the cheetah in ms^{-1} is $100 \times \frac{5}{18}\ ms^{-1} = \frac{250}{9}\ ms^{-1}$.

Distance of the prey = 100 m

Therefore, time to catch the prey

$$= \frac{\text{Distance}}{\text{Speed}} = \frac{100}{250/9} = \frac{100 \times 9}{250} = 3.6 \text{ s}$$

Q.15. ***A cyclist driving at 5 ms^{-1} picks a velocity of 10 ms^{-1}, over a distance of 50 m. Calculate (i) acceleration (ii) time in which the cyclist picks up the above velocity.***

Sol. Given : $u = 5\ ms^{-1}$, $v = 10\ ms^{-1}$, S = 50 m, $a = ?$, $t = ?$

(*i*) Applying $v^2 - u^2 = 2aS$

$$(10)^2 - 5^2 = 2 \times a \times 50$$
$$75 = 100\,a$$
$$a = 0.75\ ms^{-2}$$

and $v = u + at$

$$10 = 5 + 0.75 \times t$$

Therefore, $t = \frac{5}{0.75} = 6.67$ s

Q.16. ***An aeroplane lands at 216 kmh^{-1} and stops after covering a runway of 2 km. Calculate the acceleration and the time, in which its comes to rest.***

Sol. Given : $u = 216\ kmh^{-1} = 60\ ms^{-1}$, $v = 0$, S = 2 km = 2000 m, $a = ?$, $t = ?$

(*i*) Applying $v^2 - u^2 = 2aS$, we have

$$(0)^2 - (60)^2 = 2 \times a \times 2000$$
$$a = -\frac{3600}{4000} = -0.90\ ms^{-2}$$

(*ii*) Applying $v = u + at$

$$0 = 60 - 0.90\,t$$
$$0.90\,t = 60 \text{ or } t = \frac{60}{0.90} = 66.67 \text{ s}$$

Q.17. ***A train is travelling at a speed of 90 kmh^{-1}. Brakes are applied so as to produce a uniform retardation of 0.5 ms^{-2}. Find how far the train goes before it stops.***

Sol. Given : $a = -0.5\ ms^{-2}$, $u = 90\ kmh^{-1} = 25\ ms^{-1}$, $v = 0\ ms^{-1}$, S = ?

Using the equation $v^2 - u^2 = 2aS$, we have

$$S = \frac{v^2 - u^2}{2a} = \frac{0 - (25)^2}{2 \times (-0.5)} = 625 \text{ m}$$

Q.18. ***Find the initial velocity of a train which can be stopped in 20 s, by applying brakes, which produce a uniform retardation of 1.5 ms^{-2}.***

Sol. Given : $u = ?$, $t = 20$ s, $v = 0\ ms^{-1}$, $a = -1.5\ ms^{-2}$

Using the equation $v = u + at$, we have

$u = v - at = 0 - (-1.5) \times 20 = 30\ ms^{-1}$

Q.19. ***A body, initially at rest, starts moving with a constant acceleration 2 ms^{-2}. Calculate the velocity acquired and the distance travelled in 5 s.***

Sol. Given : $u = 0\ ms^{-1}$, $a = 2\ ms^{-2}$, $v = ?$, S = ?, $t = 5$ s

(*i*) Using the expression

$v = u + at = 0 + 2 \times 5 = 10\ ms^{-1}$

(*ii*) Using the expression

$S = ut + ½\,at^2 = 0 + ½ \times 2 \times (5)^2 = 25$ m

Q.20. *A car travels a distance 100 m with constant acceleration and an average velocity of 20 ms^{-1}. The final velocity acquired by the car is 25 ms^{-1}. Find : (i) the initial velocity and (ii) acceleration of car.*

Sol. Given : v_{av} = 20 ms^{-1}, S = 100 m, v = 25 ms^{-1}, u = ?, a = ?

Using the expression $v_{av} = S/t$, we have

$t = S/v_{av} = 100/20 = 5$ s

(i) Using the expression

$v_{av} = (u + v)/2$ or $u = 2v_{av} - v$

$= 2 \times 20 - 25 = 15$ ms^{-1}

(ii) Using the expression $v = u + at$, we have

$a = (v - u)/t = (25 - 15)/5 = 2$ ms^{-2}

Q.21. *A body starts from rest with a uniform acceleration and travels 270 m in 3 s. Find the velocity of the body after 10 s of its start.*

Sol. Given : u = 0 ms^{-1}, S = 270 m, t = 3 s, t_1 = 10 s, v = ?

Using the expression $S = ut + ½ at^2$, we have

$a = 2S/t^2 = (2 \times 270)/(3)^2 = 60$ ms^{-2}

Using the expression

$v = u + at$, we have

$v = 0 + 60 \times 10 = 600$ ms^{-1}

Q.22. *A car driver driving at a velocity of 36 kmh^{-1} on seeing a child at a distance of 55 m immediately applies brakes so as to retard the vehicle at the rate 1 ms^{-2}. How long the vehicle will take to come to halt and how far from the child will it stop ?*

Sol. Given : u = 36 kmh^{-1} = 10 ms^{-1}, S = 55 m, a = – 1 ms^{-2}, v = 0

Using the expression

$v = u + at$, we have

$0 = 10 + (-1) \times t$

Therefore, t = 10 s

Also, $v^2 - u^2 = 2aS$ or $v^2 = u^2 + 2aS$

$0 = (10)^2 + 2 \times (-1) \times S$

Therefore, S = 50 m

Hence, the car stops

55 – 50 = 5 m

before the child.

Chapter 3 - Laws of Motion Page-Exercise 3(D)

Q1: State the usefulness of Newton's third law of motion?

Solution 1

Newton's third law explains how a force acts on an object.

Q2: State Newton's third law of motion?

Solution 2

According to Newton's third law of motion, to every action there is always an equal and opposite reaction. The action and reaction act simultaneously on two different bodies.

Q3: State and explain the law of action and reaction by giving two example?

Solution 3

Law of action and reaction: In an interaction of two bodies A and B, the magnitude of action, i.e. the force F_{AB}applied by the body B on the body A, is equal in magnitude to the reaction, i.e., the force F_{BA} applied by the body A on the body B, but they are in directions opposite to each other.

Examples:

(i) When a book is placed on a table, it does not move downwards. It implies that the resultant force on the book is zero, which is possible only if the table exerts an upward force of reaction on the book, equal to the weight of the book.
(ii) While moving on the ground, we exert a force by our feet to push the ground backwards; the ground exerts a force of the same magnitude on our feet forward, which makes it easier for us to move.

Explanation: In the above stated example, there are two objects and two forces. In the first example, the weight of the book acts downwards (action) and the force of the table acts upwards (reaction). In the second example, our feet exerts a force on the ground (action) and the ground exerts an equal and opposite force (reaction) on our feet.

Q4: Name and state the action and reaction in the following cases:

(a) Firing of a bullet from a gun, (b) hammering a nail, (c) a book lying on a table, (d) a moving rocket, (e) a person moving on the floor, and (f) a moving train colliding with a stationary train.

Solution 4

(a) Action: Force exerted on the bullet.
Reaction: Recoil experienced by the gun.

(b) Action: The force exerted by the hammer on the nail.
Reaction: The force applied by the nail on the hammer.

(c) Action: Weight of the book acting downwards.
Reaction: Force acted by the table upwards.

(d) Action: Force exerted by the rocket on the gases backwards.
Reaction: Force exerted by outgoing gases on the rocket in forward direction.
(e) Action: Force exerted by the feet on the ground in backward direction.
Reaction: Force exerted by the ground on feet in forward direction.

(f) Action: Force exerted by a moving train on a stationary train.
Reaction: Force exerted by a stationary train on a moving train

Q5: Explain the motion of a rocket with the help of Newton’s third law?

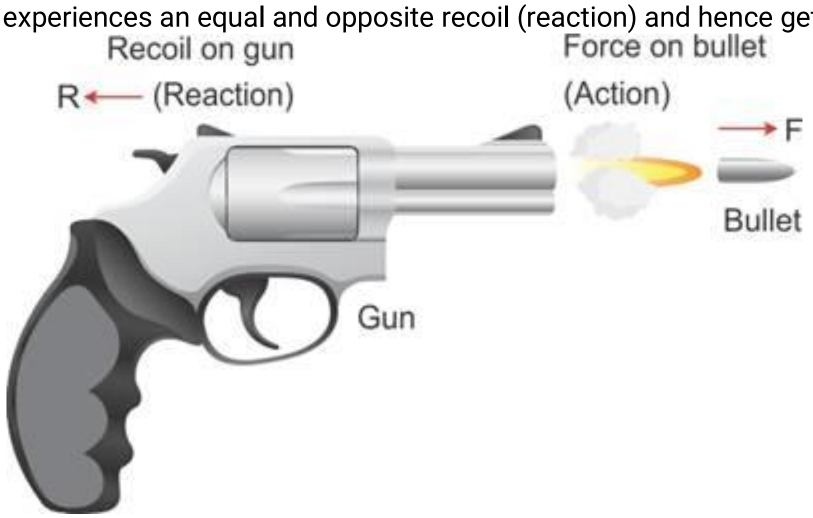
Solution 5:

When a rocket moves in space, it pushes gases outside, i.e. the rocket applies force on the gases in the backward direction. As a reaction, the gases put equal amount of force on the rocket in the opposite direction and the rocket moves in the forward direction.

Q6: When a shoot id fired from a gun, the gun gets recoiled. Explain

Solution 6:

When a man fires a bullet from a gun, a force F is exerted on the bullet (action), and the gun experiences an equal and opposite recoil (reaction) and hence gets recoiled.



Q7: When you step ashore from a stationery boat, it tends to leave the shore. Explain

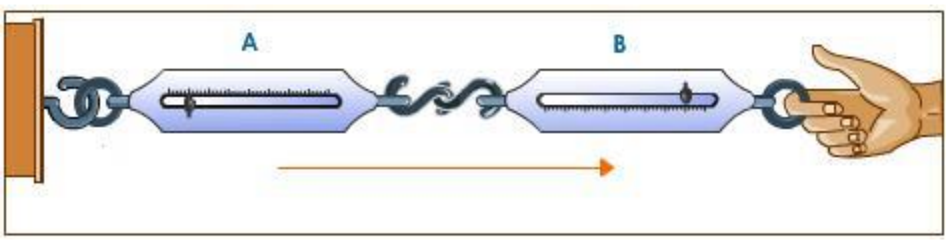
Solution 7

When a man exerts a force (action) on the boat by stepping into it, its force of reaction makes him step out of the boat, and the boat tends to leave the shore due to the force exerted by the man (i.e. action).

Q8: When two spring balance joined at their free ends, are pulled apart, both show the same reading. Explain.

Solution 8:

Couple two spring balances A and B as shown in the figure. When we pull the balance B, both the balances show the same reading indicating that both the action and reaction forces are equal and opposite. In this case, the pull of either of the two spring balances can be regarded as action and that of the other balance as the reaction.



Q9: To move a boat ahead in water, boatman has to push the water backwards by his oar. Explain

Solution 9:

To move a boat, the boatman pushes (action) the water backwards with his oar. In this response, the water exerts an equal and opposite force (reaction) in the forward direction on the boat due to which the boat moves ahead.

Q10: A person pushing a wall hard is liable to fall back. Give reason

Solution 10:

A person pushing a wall hard (action) by his palm, experiences a force (reaction) exerted by the wall on his palm in the opposite direction; thus, he is liable to fall backwards.

Q11: 'The action and reaction both act simultaneously'. Is this statement true?

Solution 11:

Yes, action and reaction act simultaneously.

Q12: 'The action and reaction are equal in magnitude.' Is this statement true?

Solution 12

Yes, action and reaction are equal in magnitude.

Q13: A light ball falling on ground, after striking the ground rises upwards. Explain the reason.

Solution 13

When a falling ball strikes the ground, it exerts a force on the ground. The ground exerts a force back at the ball in the opposite direction. This is the reason the ball rises upwards.

Q14: Comment n the statement 'the sum of action and reaction on a body is zero'

Solution 14

The given statement is wrong.
Reason: According to Newton's third law of motion, the action and reaction act simultaneously on different bodies. Hence they do not cancel each other.

Chapter 3 - Laws of Motion Page-Exercise 3(E)

Q1: State Newton's law of gravitation?

Solution 1:

Newton's law of gravitation: Every particle in the universe attracts every other particle with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them, and the direction of the force is along the line joining the masses.

Q2: State whether the gravitational force between two masses is attractive or repulsive?

Solution 2:

Gravitational force is always attractive.

Q3: Write an expression for the gravitational force of attraction between two bodies of masses m1 and m2 separated by a distance r.

Solution 3:

$$F \propto \frac{Gm_1m_2}{d^2}$$

Here G is a constant of proportionality called the universal gravitational constant.

Q4: How does the gravitational force of attraction between two masses depends on the distance between them?

Solution 4:

The gravitational force of attraction between two masses is inversely proportional to the square of distance between them.

Q5: How is the gravitational force between two masses affected id the separation between them is doubled?

Solution 5:

$$F \propto \frac{Gm_1m_2}{d^2}$$

If the distance between the masses becomes half, the force reduces to one-fourth.

Q6: Define gravitational constant G.

Solution 6:

The gravitational constant is defined as the force of attraction between two bodies of unit mass separated by a unit distance.

Q7: Write the numerical value of gravitational constant G with its S.I. unit?

Solution 7:

The value of G in the S.I. system is $6.67 \times 10^{-11} Nm^2kg^{-2}$.

Q8: What is the importance of the law of gravitation?

Solution 8:

The gravitational force of attraction is significant to explain the motion of heavenly bodies, e.g. motion of planets around the Sun, motion of the Moon around the Earth etc.

Q9: What do you understand by the term force due to gravity?

Solution 9:

The force with which the Earth attracts a body towards its centre is called the force due to gravity.

Q10: Write an expression for the force due to gravity on a body of mass m and explain the meaning of the symbols used in it?

Solution 10:

The force due to gravity on a body of mass m kept on the surface of Earth (mass=M and radius=R) is equal to the force of attraction between the Earth and that body.

$$F = \frac{GMm}{R^2}$$

Q11: Define the term acceleration due to gravity? Write its S.I unit.

Solution 11:

The rate at which the velocity of a freely falling body increases is called acceleration due to gravity. Its S.I. unit is m/s^2.

Q12: Write down the average value of g on the earth's surface

Solution 12:

The average value of 'g' on the Earth's surface is $9.8\ m/s^2$

Q13: How is the acceleration due to gravity on the surface of earth related to its mass and radius?

Solution 13:

Let g be the acceleration due to gravity on the Earth's surface (mass = M and radius = R).

Then, $g = \frac{GM}{R^2}$.

Q14: How are g and G related?

Solution 14:

Acceleration due to gravity (g) is directly proportional to universal gravitational constant (G).

Q15: A body falls freely under gravity from rest and reached the ground in time t. Write expression for the height fallen by the body

Solution 15:

Initial velocity, u = 0.
Time taken = t.
Acceleration due to gravity = g.
Let 'h' be the height fallen.

$$h = ut + \frac{1}{2}gt^2$$

$$h = \frac{1}{2}gt^2$$

Q.1. ***A ball moving on a table top eventually stops. Explain the reason.***

Ans. The motion of the ball is opposed by a force. This is the force of friction acting between the ball and the table top.

Q.2. ***'More the mass, the more difficult it is to move the body from rest'. Explain this statement by giving an example.***

Ans. A net force may cause a bicycle to pick up speed quickly. But when the same force is applied to a freight train, any resulting change in the motion is imperceptible. Accordingly, we say that the train has more inertia than the bicycle. Thus, greater the mass, greater is the force required to move it.

Q.3. ***Name the three kinds of inertia. Give one example of each.***

Ans. The three types of inertia are (*i*) Inertia of rest (*ii*) Inertia of motion (*iii*) Inertia of direction.

Inertia of rest : When a train suddenly starts moving forward, the passenger standing in the compartment tends to fall backwards.

Inertia of motion : When a passenger jumps out of a moving train, he falls down.

Inertia of direction : While sharpening a knife, sparks fly off tangentially from the grinding stone, due to inertia of direction.

Q.4. ***State the Newton's first law of motion.***

Ans. It states, "Everybody in the universe stays in a state of rest or of uniform motion along a

straight line until unless compelled by an external force to change its state."

Q.5. ***Two similar vehicles are moving with same velocity on the road, such that one of them is loaded and the other one is empty. Which of the two vehicles will require larger force to stop it ?***

Ans. A large force is required to stop the loaded vehicle. It is because; loaded vehicle has greater momentum than the empty vehicle as the mass of loaded vehicle is more than that of the empty vehicle. Thus, it requires a greater force to stop.

Q.6. ***Explain why some of the leaves may fall from a tree, if we vigorously shake its branch.***

Ans. When the branch is suddenly set in motion, the leaves attached to it tend to continue in their state of rest, on account of inertia of motion. Thus, a lot of strain acts on the junction of the leaves and the branches. Due to this strain the weakly held leaves are left behind and, hence, fall off the branch.

Q.7. ***When a carpet is beaten with a stick, dust comes out. Explain.***

Ans. In fact, it is the carpet which comes out of the dust. When the carpet is beaten it is set into motion, whereas the dust remains in a state of rest due to inertia of rest. Hence, the carpet comes out of the dust giving a notion as if dust has come out of the carpet.

Q.8. ***What happens when you shake a wet piece of cloth? Explain your observation.***

Ans. Initially, the piece of cloth and the loose water in it are in a state of rest. When the cloth is shaken, it is suddenly set into motion, but the loose water in it, on account of inertia of rest continues in its state of rest. Thus, water comes out of cloth in the form of fine particles.

Q.9. ***When a train starts suddenly, a passenger tends to experience a backward jerk, why ?***

Ans. The lower part of body of the passenger is in contact with the train. As the train starts moving, the lower part of passenger's body shares the motion of the train, but the upper part due to inertia of rest cannot share the motion of the train simultaneously and so it remains at rest. Consequently, the lower part of the body moves ahead and the upper part seems to be left behind due to the inertia of rest and the passenger tends to experience a backward jerk.

Q.10. ***Why does a coin, placed on a card, drop into the tumbler when the card is given a sudden push ?***

Ans. The reason is that when the card is pushed suddenly, a momentary force acts on the card, so it moves away. But the coin kept on it does not share the motion at once, due to inertia of rest, and it remains at its place. As a result the coin falls down into the tumbler due to the pull of gravity.

Q.11. ***A javelin throw is marked foul if an athlete crosses over the line marked for throw. Explain why the athletes often fail to stop themselves before the line.***

Ans. It is on account of inertia of motion. The athlete runs a considerable distance so as to build up momentum, which is helpful in throwing the javelin a longer distance. However, sometimes the large momentum of athlete prevents him from stopping before the marked line, therefore, the throw is declared foul.

Q.12. ***Why it is advised to tie the luggage with a rope on the roof of buses ?***

Ans. When a bus suddenly starts, the luggage on its top has a tendency to continue in its state of rest due to inertia of rest, hence, it is left behind. Thus, the luggage has a tendency to fall in the backward direction. Conversely, when a moving bus stops suddenly, the luggage on its top has a tendency to continue in its state of motion due to inertia of motion hence; it falls in the forward direction. Thus, to prevent the falling of the luggage it is tied with rope, so as to hold it in place.

Q.13. ***When a passenger jumps out of a moving train, he falls down, why? How can this be avoided ?***

Ans. This is so because inside the train, his complete body was in a state of motion with the train. On jumping out of the moving train as soon as his feet touch the ground, the lower part of his body comes to rest, while the upper part still remains in motion due to the inertia of motion. This makes him fall in the direction of motion of the train. To avoid falling, the passenger should run on the ground in the direction of motion of the train for some distance as soon as his feet touch the ground.

Q.14. ***A ball thrown vertically upwards by a person in a moving train comes back to his hand, why ?***

Ans. The reason is that at the moment the ball was thrown, the ball was in motion along with the person and the train, due to the inertia of motion. So during the time ball remains in air, both the person and the ball move ahead by the same distance. This makes the ball come back to his hand on its return.

Q.15. ***If someone jumps to the shore from a boat, the boat moves in the opposite direction. Explain.***

Ans. It is based on Newton's third law of motion. When a man jumps from the boat he pushes the boat backward with his feet. Now, as the boat is in water, it reacts to the man's force and, hence, moves in the opposite direction of the shore.

Q.16. ***A large truck and a car, both moving with speed v, have a head-on collision and both of them come to halt after that. If the collision lasts for 10s,***

(i) Which vehicle experiences the greater force of impact ?

(ii) Which vehicle experiences the greater momentum change ?

(iii) Which vehicle experiences the greater acceleration ?

(iv) Why is the car likely to suffer more damage than the truck ?

Ans. (i) Both the vehicles experience same force of impact as action and reaction are equal and opposite.

(ii) The truck experiences a greater change in momentum on account of its greater mass.

(iii) The car experiences greater change in acceleration as force remaining same, acceleration is inversely proportional to mass.

(iv) Because of greater change in acceleration the car will suffer more damage.

Q.17. ***How is it that a stone dropped from a certain height falls much more rapidly as compared to parachute under similar conditions ?***

Ans. The surface area of a parachute is much larger as compared to the surface area of stone. So, the air-resistance in the case of a parachute is much larger than in the case of a stone. This explains as to why parachute descends slowly.

Q.18. ***Show that Newton's second law of motion is given by F = ma.***

Ans. For a body of mass m moving with velocity v, the linear momentum is $p = mv$. In time Δt if its linear momentum changes by Δp due to the application of force on it, then rate of change of linear momentum is,

$$\frac{\Delta p}{\Delta t} = \frac{\Delta(mv)}{\Delta t} = m\frac{\Delta v}{\Delta t}$$

But, $\frac{\Delta v}{\Delta t} = a$

Therefore, Rate of change of momentum is

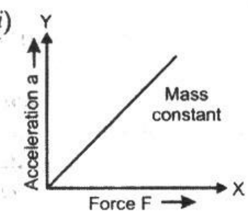
$$\frac{\Delta p}{\Delta t} = ma$$

Hence, $F = ma$

Q.19. ***Plot graphs showing the variation of (i) acceleration with force, and (ii) force with mass for constant acceleration.***

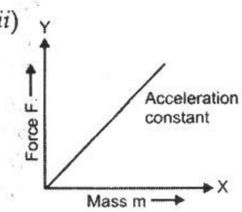
Ans. The graphs are as shown below :

(i)



Graph showing the variation of acceleration with force.

(ii)



Graph showing the variation of force with mass.

Q.20. ***A body of mass m moving with a velocity v is acted upon by a force. Write the expression for the change in momentum in each of the following cases: (i) when v << c (ii) when v → c (iii) when v << c but m does not remain constant. Here, c is the speed of light.***

Ans. (i) When $v \ll c$, then we have $\Delta p = m\,\Delta v$, since m is constant.

(ii) When $v \rightarrow c$, then $\Delta p = \Delta(mv)$, since m changes.

(iii) When $v \ll c$, and m is not constant, then we have $\Delta p = \Delta(mv)$.

Q.21. ***Two bodies A and B, of same masses are moving with velocities v and 2 v respectively. Compare their (i) inertia, (ii) momentum.***

Ans. (*i*) Inertia depends only upon the mass of the bodies. Since their masses are equal, therefore, the ratio of their inertia is 1 : 1.

(*ii*) Momentum is given by the product of mass and velocity. Since velocity of one body is greater than that of the other by a factor 2, therefore, ratio of their momenta is 1 : 2.

Q.22. ***State Newton's second law of motion. Under what condition it takes the form F = ma ? How does it differ from the first law of motion?***

Ans. It states, "The rate of change of momentum is directly proportional to the applied force and the change takes place in the direction of the applied force".

It takes the form F = *ma* when the mass of the body is constant, usually at low speeds.

It gives the quantitative definition of force while the first law gives the qualitative definition of force.

Q.23. ***According to Newton's third law, every force is accompanied by an equal (in magnitude), and opposite (in direction) force. Then, how can a movement ever take place ?***

Ans. Since action and reaction act on different bodies, therefore, motion is possible.

Q.24. ***Suppose you are seated in a cabin which has no doors, no windows, etc. and is sound-proof, shall it be possible for you to detect the uniform velocity with which this cabin is moving ?***

Ans. No, this is because when the cabin is moving with uniform velocity; there will be no net unbalanced force.

Q.25. ***A disc of mass m is placed on a table. A stiff spring is attached to it and is vertical. To the other end of the spring is attached a disc of negligible mass. What minimum force should be applied to the upper disc to press the spring such that the lower disc is lifted off the table when the external force is suddenly removed ?***

Ans. The minimum force should be *mg*. When a force *mg* is applied vertically downwards on the upper disc, the lower disc will be pressed against the floor with a force *mg*. The floor will exert an upward reaction *mg*. When the external force is suddenly removed, this reaction will just lift the lower disc.

Q.26. ***Two blocks of masses m_1 and m_2 are connected by a light spring on a smooth horizontal surface. The two masses are pulled apart and then released. Prove that the ratio of their accelerations is inversely proportional to their masses.***

Ans. The forces F_1 and F_2 due to masses m_1 and m_2 respectively act on the stretched spring in opposite directions. The system as a whole is at rest. $F_1 + F_2 = 0$ or $m_1a_1 + m_2a_2 = 0$, where a_1 and a_2 are the accelerations of the masses m_1 and m_2 respectively in the opposite directions. Now, $m_1a_1 = -m_2a_2$ or $\frac{a_1}{a_2} = -\frac{m_2}{m_1}$

which was to be proved.

Q.27. ***A sand glass is being weighed on a sensitive balance, first when the sand is dropping in a steady stream from the upper to the lower part and then again after the upper part is empty. Are the two weights the same or not ? Explain your answer.***

Ans. The two weights are the same. The stream of sand leaving the upper part exerts force upward and the stream of sand reaching the lower part exerts the same downward force, that is, the sand stream being continuous from upper to lower part of vessel, the two forces become the internal forces of the system and so equilibrium is not affected. However, at the moment the last element of the stream leaves the upper part the falling elements exert greater force than their weights on account of their gained momentum under gravity and so momentarily the balance will read more. But when all the sand has collected and there is no stream, the balance reading will be steady and again it will give the same reading.

Q.28. ***How can you reconcile the sailing of a sailboat into the wind with the principle of conservation of momentum ?***

Ans. Considering the boat + wind as a system free from external force, we can reconcile the sailing of a sailboat into the wind. Here, the momentum of the wind is transferred to the boat.

Q.29. *Both the statements are correct; explain them. Two teams having a tug-of-war must always pull equally hard against one another. The team that pushes harder against the ground wins.*

Ans. The harder each team pulls the other, the greater the force it exerts on the other team through the rope and so to win each team must pull hard on the other team. The harder the team pushes against the ground, the greater the reaction of the ground and the greater the component of the reaction helping the team to pull over the other team to its side.

Q.30. *A monkey holds one end of a massless rope, which passes over a frictionless pulley. A mirror, which has the same weight as the monkey is attached to the other end of the rope at the monkey's level. Can the monkey ever get away from his image ? Explain.*

Ans. No, since the two weights are equal, if the monkey lets the rope loose, both will have the same downward acceleration. If the monkey goes up with acceleration, the tension in the rope must be greater than the weight of the monkey and the same tension will be effective on the mirror. The mirror being of the same mass will have the same upward acceleration. Thus, the monkey can never get away from his image.

Q.31. *Can we predict the direction of motion of a body from the direction of the force acting on it ?*

Ans. No. According to Newton's second law, the resultant force acting on a body determines the magnitude and direction of its acceleration and not its velocity. So from the direction of the force acting on a body we cannot predict the direction of motion of the body. For example, in circular motion, motion takes place at right angle to the force but acceleration is definitely along the direction of the force, that is, towards the centre of the circle.

Q.32. *Newton's first law of motion is also called law of inertia. Why ?*

Ans. According to first law of motion, a body at rest tries to be at rest and a body in motion continues to move in a straight line in the absence of an external force, *i.e.*, a body cannot change its state of rest or motion itself. This inability of a body is called inertia. That is why we call Newton's second law of motion, law of inertia.

Q.33. *Explain the motion of a rocket with the help of Newton's third law.*

Ans. In a rocket, the fuel is burnt inside the rocket and the burnt gases at high pressure and high temperature are expelled out of the rocket through a nozzle at the bottom. Thus, the rocket exerts a force (action) on the gases to expel them through the nozzle backwards. The outgoing gases exert an equal and opposite force (reaction) on the rocket due to which it moves in the forward direction.

Q.34. *Why does a gun recoil when a shot is fired from it?*

Ans. When a man fires a gun, the gunpowder in the shot evaporates and applies a force on the bullet. The bullet in turn applies a backward force on the gun in accordance with Newton's third law of motion.

Q.35. *When you step ashore from a boat, it tends to move away from the shore. Explain.*

Ans. The reason is that the man needs a force of reaction to step out of the boat for which he exerts a force (action) on the boat. The boat thus tends to leave the shore.

Q.36. *In what sense does the moon fall towards the earth ? Why does it not actually fall on the surface of Earth ?*

Ans. The moon circling around the Earth is a kind of projectile. It has just the right speed in the horizontal direction. When the gravitational force of the earth pulls the moon towards itself the trajectory of moon completely misses the Earth. It is because as the trajectory of the moon curves toward the Earth, the surface of the Earth also curves away from the moon. Thus, the moon continues falling forever, but never reaches the Earth. Instead, it starts circling around the Earth at a constant speed.

Q.37. *If the Earth attracts an apple does the apple also attract the Earth. If so, why does the Earth not move towards the apple ?*

Ans. Yes, the apple attracts the Earth with same force as the force with which the Earth attracts an apple. Because of the large mass of the Earth the acceleration produced in it is negligible, which goes unnoticed. Thus, the Earth does not seem to move towards the apple.

Q.38. ***If the force of gravity somehow vanished away, why would we be sent flying in space?***

Ans. Earth is a huge ball spinning about its axis. Due to this spinning, every object on the surface of the Earth experiences a centrifugal force. This centrifugal force tries to throw the object outward away from the centre of the Earth. However, the objects do not fly off the surface of the earth, because the force of gravity pulls the objects towards the centre of the Earth, thereby balancing the centrifugal force. However, if the force of gravity somehow disappears, then centrifugal force will throw the bodies on the surface of the Earth into space.

Q.39. ***There are two kinds of balances, that is, a beam balance and a spring balance. If both the balances give same measure of a given body on the surface of the Earth, will they give same measures on the surface of Moon ? Explain your answer.***

Ans. The beam balance compares the mass of two bodies placed in its two pans as the acceleration due to gravity of the Earth acting on both pans nullify each other. Furthermore, mass of a given body is a constant quantity. The spring balance gives the measure of weight and is the product of the mass of the body and the acceleration due to gravity of the earth. On the surface of moon the beam balance will show the same reading as on earth, because the acceleration due to gravity of the moon acting on both pans nullifies each other. However, the spring balance shows a weight which is one-sixth of the measure on the surface of the earth, because the acceleration due to gravity of the moon is one-sixth of the acceleration due to gravity on the surface of the earth.

Q.40. ***A bag of sugar weighs W at some place on the equator. If this bag is taken to Antarctica, will it weigh same, more or less? Give a reason for your answer.***

Ans. The bag of sugar will weigh more at Antarctica *i.e.,* the poles.

Reason : The polar radius of the earth is less than the equatorial radius of the earth. The acceleration due to gravity is inversely proportional to the square of the radius of the Earth. Hence, its value at the poles is greater than its value at the equator. Thus, a body weighs more at the poles than at the equator. Since weight is the product of mass and acceleration due to gravity, therefore, the bag of sugar will weigh more at Antarctica.

Q.41. ***Which is greater : the attraction of earth for 1 kg of lead or attraction of 1 kg lead for earth ?***

Ans. The force of gravitational attraction between two bodies depends upon the product of their masses. Hence, the attraction of 1 kg of lead for earth is equal but opposite to the attraction of earth for 1 kg of lead.

Q.42. ***The weight of a man on the earth is 100 kg. Does this weight on the moon increase or decrease ?***

Ans. As the acceleration due to gravity on the moon is one-sixth that on the earth, hence the weight of the man will decrease on the surface of moon.

Q.43. ***When dropped from the same height a body reaches the ground quicker at poles than at the equator. Why ?***

Ans. The acceleration due to gravity is more at the poles than at the equator. When the initial velocities and the distance travelled are the same, time taken for a body is smaller if the acceleration due to gravity is more. Hence, when dropped from the same height a body reaches the ground quicker at poles than at the equator.

Q.44. ***What would be the effect on the weight of a body if the earth stopped rotating ?***

Ans. When the earth stops rotating the weight increase due to the absence of centrifugal force. However, the weight at the poles remains same.

Q.45. ***A man at the top of a tower throws an object horizontally whereas he simply drops another. Will these two objects reach the earth at the same time ?***

Ans. Yes, as the vertical distance travelled by both is same and takes place under the same acceleration due to gravity.

Q.46. ***If gravitation is the power by which all bodies tend towards each other, then why do all bodies tend towards the centre of the earth ?***

Ans. This is due to the reason that the force of gravitational attraction between the bodies is very small on account of their small masses. On the other hand, due to the large mass of the earth, the force of gravitational attraction between the earth and the bodies is large.

Q.47. ***What is weightlessness ?***

Ans. It is a state when objects do not weigh anything. This occurs when bodies are in a state of free fall under the effect of gravity.

Q.48. ***How does the gravitational force of attraction between two masses depend on the distance between them ? How is the gravitational force between two masses affected if the separation between them is doubled ?***

Ans. It is inversely proportional to the square of the distance between the masses.

The force reduces to one-fourth.

Q.49. ***Define gravitational constant G. Write its numerical value with its SI unit.***

Ans. It is defined as the force of attraction between two masses each of mass 1 kg placed 1 m apart.

Its numerical value is 6.67×10^{-11} N m^2 kg^{-2}

Q.50. ***Distinguish between g and G.***

Ans. The table below brings out the difference between g and G.

Acceleration due to gravity (g)	Universal gravitational constant (G)
Acceleration with which bodies fall towards the surface of a planet.	Force of attraction between two unit masses placed unit distance apart.
Changes from place to place.	Constant throughout the universe.
Depends upon the mass and radius of the planet.	Independent of all parameters.
It is a vector.	It is a scalar.
It is measured in ms^{-2}.	It is measured in N m^2 kg^{-2}.

Q.51. ***Distinguish between mass and weight.***

Ans. The table below brings out the distinction between mass and weight.

Mass	Weight
It is the amount of matter contained in a body.	It is a force equal to the gravitational pull exerted by a planet.
It is a constant quantity and does not change with respect to position or place.	It is a variable quantity and changes with the change in acceleration due to gravity of a place.
Mass of a body can never be zero.	Weight of a body can be zero during free fall.
It is measured by using a physical balance.	It is measured by using a spring balance.
It is a scalar quantity.	It is a vector quantity.
It is measured in kilogram.	It is measured in newton.

Q.52. ***Give some applications of Newton's law of gravitation.***

Ans. Newton's law of gravitation has a large number of applications. Some of these are :

1. It can be used to estimate the mass of the earth by using the expression $g = \frac{GM}{R^2}$.
2. It can also be used to estimate the mass of the moon, the sun and other planets.
3. It is used to study the binary stars; a system of two stars orbiting around their common centre, the centripetal force being provided by the gravitational force of attraction between them. Any distortion in the orbit of a star indicates the presence of a companion such that the system moves as a double star. Newton's law of gravitation can be used to estimate the masses of these stars.

4. The wobbling (irregularity in the motion of a star) of a star can be detected by modern techniques. By using the law of gravitation we can estimate the mass of these stars.

Q.53. ***(a) State the universal law of gravitation.***

(b) Write the formula to find the magnitude of the gravitational force between the earth and an object on the surface of the earth.

Ans. Every particle in this universe attracts every other particle with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.

The formula is $F = \frac{GMm}{R^2}$, where M is the mass of the earth, m is the mass of the object on the surface of the earth and R is the radius of the earth.

Q.54. ***How does the force of gravitation between two objects change when the distance between them is reduced to half?***

Ans. The gravitational force of attraction between two objects is given by the expression $F = \frac{Gm_1m_2}{r^2}$. When all other variables remain constant, then the force varies inversely as the square of distance between the centres of the objects. As the distance is reduced to half, the force will become four times its previous value.

Q.55. ***Gravitational force acts on all objects in proportion to their masses. Why then, a heavy object does not fall faster than a light object?***

Ans. The acceleration of a freely falling object is given by the expression $g = \frac{GM}{R^2}$. This acceleration is independent of the mass of the object. Therefore, all objects, irrespective of their masses, fall with the same acceleration and hence the same speed.

Q.56. ***The earth and the moon are attracted to each other by gravitational force. Does the earth attract the moon with a force that is greater or smaller or the same as the force with which the moon attracts the earth ? Why ?***

Ans. The earth attracts the moon with the same force with which the moon attracts the earth because the gravitational force between any two bodies is mutual and equal according to Newton's universal law of gravitation.

Q.57. ***If the moon attracts the earth, why does the earth not move towards the moon?***

Ans. The earth does not move towards the moon because the force exerted by the earth or the moon on each other is insufficient to move earth on account of its huge mass.

Q.58. ***What happens to the force between two objects, if :***

(i) the mass of one object is doubled?

(ii) the distance between the objects is doubled and tripled?

(iii) the masses of both objects are doubled?

Ans. The force between two objects is given by

$$F = \frac{Gm_1m_2}{r^2}.$$

(*i*) If mass of one object is doubled, the force becomes twice its original value.

(*ii*) The force of gravitation decreases 4 times if the distance between them is doubled. If the distance between the objects is tripled the force of gravitation decreases 9 times.

(*iii*) The force of gravitation becomes 4 times.

Q.59. ***What is the importance of universal law of gravitation?***

Ans. Importance of universal law of gravitation is as follows :

(*i*) It is the gravitational force between the sun and the earth, which makes the earth to move around the sun with a uniform speed. Similarly, it is the gravitational force between the earth and the moon, which makes the moon move around the earth with uniform speed. Infact the gravitational force is responsible for the existence of our solar system.

(*ii*) The tides formed in the sea are because of gravitational pull exerted by the sun and the moon on the surface of water.

(*iii*) It is the gravitational pull of the earth, which keeps us and other bodies firmly on the ground.

Pressure in Fluids & Atmospheric Pressure

Q.1. ***Define Pressure and give its SI units.***

Ans. Pressure at a point is defined as the force experienced per unit area. Mathematically, we have P = F/A. In SI, it is measured in pascal (Pa).

Q.2. ***Identify the physical quantity which is measured in bar. How is the unit bar related to the SI unit pascal ?***

Ans. The physical quantity is pressure. 1 bar = 10^5 Nm^{-2}.

Q.3. ***How does the pressure exerted by a thrust depend on the area of surface on which it acts ? Explain with a suitable example.***

Ans. Relation between Pressure and Thrust is given by :

$$\text{Pressure} = \frac{\text{Thrust}}{\text{Area}} \text{ or } P = \frac{F}{A}.$$

Thus, Pressure exerted on a surface depends upon (*i*) The thrust (*ii*) Area on which thrust is applied. The effect of thrust is less on a large area whereas it is more on a small area.

Example : if you stand on loose sand, your feet sink into the sand, but if you lie on that sand, your body does not sink into the sand. The Thrust exerted on the sand is the same (equal to your weight) in both the cases. When you stand, the thrust acts on a small area and when you lie on the sand the thrust acts on a large area.

Q.4. ***What does the unit pascal measure ?***

Ans. It measures pressure.

Q.5. ***State if pressure at a point in a liquid is a vector or a scalar quantity.***

Ans. Pressure is a scalar quantity.

Q.6. ***Explain the following:***

(*a*) ***It is easier to cut with a sharp knife than with a blunt one.***

(*b*) ***Sleepers are laid below the railway track.***

Ans. (*a*) A sharp knife has a small area as compared to a blunt knife. This allows a smaller thrust to cause a greater pressure at the edges and cutting can be done with less effort.

(*b*) Sleepers are placed below the railway tracks so that the pressure exerted by the rails on the ground becomes less.

Q.7. *Describe a simple experiment to demonstrate that a liquid enclosed in a vessel exerts pressure in all directions.*

Ans. Consider a round bottom flask having a number of holes on all sides. Fit the flask with an airtight piston. We find that when the piston is pushed downwards, jets of water gush out of each hole. We find that the water comes out with the same pressure from all the holes. This shows that an additional pressure applied by the piston at the top of the liquid is transmitted undiminished in all directions.

Q.8. *State three factors on which the pressure at a point in a liquid depends.*

Ans. The three factors are :

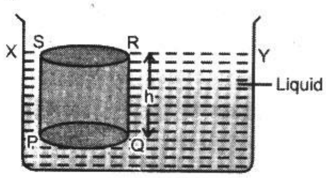
(*i*) depth of the point below the free surface (h),

(*ii*) density of liquid (ρ),

(*iii*) acceleration due to gravity (g).

Q.9. *Deduce an expression for the pressure at a depth 'h' inside a liquid.*

Ans. Consider a vessel containing a liquid of density ρ. Let the liquid be stationary. Consider a horizontal circular surface PQ of area A at a depth h below the free surface XY of the liquid as shown in fig. Assume a cylinder PQRS of height h with PQ as its base and top face RS lying on the free surface XY of the liquid.



The total thrust acting on the surface PQ will be equal to the weight of the liquid column PQRS *i.e.,*

Thrust exerted on the surface PQ = Weight of the liquid column PQRS

= Volume of liquid column PQRS × density × g

= (Area of base PQ × height) × density × g

= $(A \times h) \times \rho \times g = Ah\rho g$

This thrust is exerted on the surface PQ of area A. Therefore, the thrust exerted per unit area *i.e.,* pressure

$$P = \frac{\text{Thrust}}{\text{Area}} = \frac{Ah\rho g}{A} = h\rho g$$

Thus, P = depth of fluid × density of liquid × acceleration due to gravity.

Q.10. *A glass jar contains a liquid of density ρ upto a height 'h' at a place where acceleration due to gravity is 'g', the atmospheric pressure is P_A : (i) What is the pressure at the free surface of the liquid? (ii) Write an expression for the total pressure at the base of the jar. (iii) What will be the lateral pressure at this depth on the inner side of the jar ?*

Ans. (*i*) The pressure at the free surface of the liquid is P_A.

(*ii*) The pressure at the base of the jar is :

$P = P_A + \rho \times h \times g$

(*iii*) same as in (*ii*).

Q.11. *State the law of transmission of pressure in liquids.*

Ans. It states that "A change in pressure applied to an enclosed liquid is transmitted undiminished to every point of the liquid and the walls of the containing vessel."

Q.12. *Write down the formula for pressure at any given point in a liquid and explain the various symbols used.*

Ans. The expression for pressure at any given point in a liquid is $P = h\rho g$, where h is height of liquid, ρ is density of liquid and g is the acceleration due to gravity.

Q.13. *The neck and bottom of a bottle have diameters 2 cm and 8 cm respectively. The bottle is completely filled with kerosene. If the cork in the neck is pressed with a force of 10 N, what force is exerted on the bottom of the bottle ? Name the law /principle you have used to find this force.*

Ans. By Pascal's law, the pressure exerted at the neck of the bottle will be transmitted undiminished to the bottom of the bottle. Therefore,

$$P = \frac{F_N}{A_N} = \frac{F_B}{A_B}$$

$$\text{or } F_B = F_N \times \frac{A_B}{A_N} = 10 \times \frac{\pi D_B^2}{\pi D_N^2} = 10 \times \frac{64}{4} = 160 \text{ N}$$

The law involved is Pascal's law.

Q.14. *How does the pressure at a certain depth in sea water differ from that at the same depth in river water ? Explain.*

Ans. The liquid pressure is directly proportional to the density ρ of the liquid. The density of sea water is more than the density of river water, so pressure at a certain depth in sea water is more than that at the same depth in river water.

Q.15. *An inflated gas balloon is placed in a jar which is connected to an evacuating pump. What will be observed if the air inside the jar is pumped out ? Give a reason justifying your answers.*

Ans. When the air in the jar is pumped out, the balloon will expand rapidly and burst. This is because of the following reason. The balloon contains gas at a pressure which is more than the atmospheric pressure, *i.e.*, the pressure outside the balloon. This atmospheric pressure opposes the pressure of the gas inside the balloon. When the air in the jar is removed, there is no opposition to the pressure exerted by the gas in the balloon, thus, it expands rapidly and bursts.

Q.16. *Explain why a gas bubble released at the bottom of a lake grows in size as it rises to the surface of the lake.*

Ans. At the bottom of the lake, the pressure exerted on the bubble is the atmospheric pressure plus the pressure due to the water column above it. As the gas bubble rises, the pressure exerted on it decreases. By Boyle's law, PV = constant, so the volume of bubble increases due to the decrease in pressure, *i.e.*, the bubble grows in size.

Q.17. *Answer the following :*

(i) A dam has broader walls at the bottom than at the top. Explain.

(ii) Why do sea divers need special protective suit ?

Ans. (*i*) The pressure exerted by a liquid increases with its depth. Thus, more and more pressure is exerted by water on the walls of the dam as depth increases. A thicker wall is required to withstand a greater pressure, therefore, the thickness of the wall of the dam increases towards the bottom.

(*ii*) The sea divers need special protective suit to wear because in deep sea, the total pressure exerted on the diver's body becomes much more than his blood pressure. To withstand it, he needs to wear a special protective suit.

Q.18. *What do you mean by the statement "the atmospheric pressure is 1 atm ?" State its value in pascal.*

Ans. It is the pressure which the atmosphere exerts on bodies on the surface of the earth. It is equal to 10^5 pascal.

Q.19. *Explain the following :*

(i) Sense of hearing is affected while rapidly gaining or losing height.

(ii) The nose of some people starts bleeding, when an aeroplane climbs up rapidly.

(iii) A soda straw does not draw liquid, if there is a tiny hole near its upper end.

(iv) Why are passenger cabins in an aeroplane pressurised ?

(v) Why do the bodies of deep sea fishes burst, on bringing them above the sea level ?

(vi) Why does an ink pen start leaking at higher altitudes ?

(vii) Why are special suits worn by astronauts while floating in space ?

(viii) Why are weather observation balloons filled partially with helium at ground level ?

(ix) Why are two holes made in oil tin to remove oil from it ?

(x) Why does not liquid run out of a dropper, unless rubber bulb is pressed ?

Ans. (*i*) When a person rapidly gains or loses height, the air pressure outside the eardrum changes with respect to air pressure on the other side of eardrum in Eustachian tube. Thus, the eardrum either bulges in or out and hence does not vibrate properly. It is on account of this reason that hearing is affected.

(*ii*) When one suddenly gains height, the atmospheric pressure suddenly drops. Thus, the pressure of dissolved air in blood becomes too large as compared to air outside. This difference in atmospheric pressure sometimes bursts the fine capillaries in the nose and hence they start bleeding.

(*iii*) If there is a hole near the upper end of soda straw, the atmospheric pressure does not fall due to suction. As atmospheric pressure within the straw does not fall, therefore, air pressure will not force the liquid up in the straw.

(*iv*) This is done so that passengers do not feel the ill effects of sudden drop in pressure, such as bleeding nose or vomiting.

(*v*) The blood of deep sea fishes contains dissolved oxygen at a very high pressure as compared to atmospheric pressure. Thus, when such fishes are brought to the sea level, the difference in pressure of oxygen within their bodies and atmosphere burst open their bodies.

(*vi*) When the atmospheric pressure on high altitudes decreases, the air present within the tube of ink pen at higher pressure, forces the ink out. Thus, the ink pen starts leaking.

(*vii*) There is no atmospheric pressure in space. Thus, bodies of astronauts can burst due to internal pressure of dissolved oxygen in the blood, if not properly protected. It is for this reason that astronauts wear special suits, which keep the pressure outside their bodies equal to pressure inside their bodies.

(*viii*) On higher altitudes atmospheric pressure decreases. Thus, the balloon starts expanding because of difference of pressure inside and outside the balloon. Thus, to allow expansion, so that fabric of balloon does not burst, the balloon is filled partially with helium at ground level.

(*ix*) If the single hole is made, the oil will not flow out because it will be supported by atmospheric pressure. Thus, in order to force out oil, two holes are made, so that air enters from one hole, exerts pressure on oil and forces it out from the other hole.

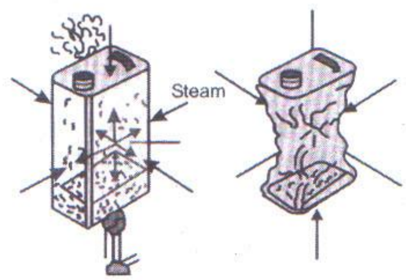
(*x*) It is because, the liquid is supported by atmospheric pressure. However, when we press the rubber bulb, the pressure of air within the dropper becomes more than atmospheric pressure and hence it forces out the liquid.

Q.20. ***We do not feel uneasy even under enormous pressure of the atmosphere above as well as around us. Give a reason.***

Ans. This is because our blood pressure is slightly greater than the atmospheric pressure.

Q.21. ***Describe an experiment to demonstrate that air exerts pressure.***

Ans. Take a metal can with some water in it. When its cap is open, the atmospheric pressure is the same inside and outside the can. Replace the screw cap and tighten it so that the air inside the can is sealed from the atmosphere. The pressure of the gas inside the can is still the atmospheric pressure, but it is clearly no longer due to the weight of the column of air above it. The pressure exerted by the air trapped inside the can is due to the molecular bombardment on the walls of the can.



Now, heat some water in the open can until it boils. The steam pushes the air out from the can and fills it. The molecules of steam exert a pressure equal to the atmospheric pressure due to their bombardment on the walls of the can. Remove the can from the heat and seal it by screwing back the cap tightly. Then quickly cool it by running cold water over it. The can suddenly crumples as shown in figure. This is due to the fact that on pouring water the steam inside the can is condensed, thereby creating a partial vacuum. The air pressure outside is now more than that inside the can. Hence, the can crumples under the effect of atmospheric pressure.

Q.22. ***Explain why a gas bubble released at the bottom of a lake grows in size as it rises to the surface of the lake.***

Ans. This is because there is more pressure at the bottom of the lake than at its surface. Therefore, as the bubble rises up, the pressure of water on it goes on decreasing as a result its volume goes on increasing.

Q.23. *Explain the following :*

(*i*) *Sucking a drink with a straw.*

(*ii*) *Filling of a fountain pen.*

(*iii*) *Action of rubber suckers.*

Ans. (*i*) Drinking straw : When a drink is sucked with the help of a straw the air inside the straw goes into our lungs and thus air pressure in the straw decreases. The atmospheric pressure acting on the free surface of the liquid pushes the liquid into the straw and then into our mouth.

(*ii*) Fountain pen : Ink can be filled in a fountain pen with the help of atmospheric pressure. When the tube of the pen is squeezed the air in it rushes out so that the pressure in the tube decreases. The air pressure outside the tube now pushes the ink into the pen.

(*iii*) The rubber sucker : The moistened concave surface of a rubber sucker is pressed against the flat surface of a wall (say). The air between the two surfaces is squeezed out leaving the pressure in the enclosed space much reduced. The external atmospheric pressure acting on the sucker forces the sucker against the flat surface.

Q.24. *How is the barometric height of a simple barometer affected if :*

(*a*) *its tube is pushed down into the trough of mercury ?*

(*b*) *its tube is slightly tilted from vertical ?*

(*c*) *a drop of liquid is inserted inside the tube ?*

Ans. (*a*) The barometric height remains unaffected.

(*b*) The barometric height remains unaffected.

(*c*) The barometric height decreases as the liquid converts into vapour which applies a pressure on the mercury.

Q.25. *Give three reasons for use of mercury as a barometric liquid.*

Ans. (*i*) Mercury has a high density, therefore, the height of mercury required to balance the atmospheric pressure is small.

(*ii*) The vapour pressure of mercury is negligible, so it does not affect the barometric height.

(*iii*) The mercury neither wets nor does it stick to the glass tube. Therefore, it gives the correct reading.

Q.26. *Give three reasons why water is not a suitable barometric liquid.*

Ans. (*i*) Water has a small density, therefore, the height of water required to balance the atmospheric pressure will be very large (about 10.4 m).

(*ii*) Water sticks with the glass tube and wets it, so the reading becomes inaccurate.

(*iii*) Water being transparent, so its surface is not easily seen while taking the observation.

Q.27. *State three major defects of a simple barometer.*

Ans. (*i*) There is no protection for the glass tube.

(*ii*) The surface of mercury in the trough is open, therefore, there are chances that the impurities may fall in and get mixed with the mercury of the trough.

(*iii*) It is inconvenient to move the barometer from one place to another.

Q.28. *State two advantages of an aneroid barometer over a simple barometer.*

Ans. (*i*) It does not use liquid.

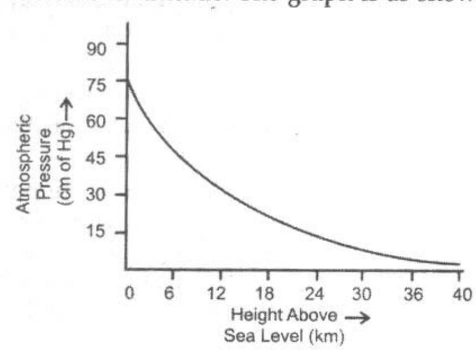
(*ii*) It is is convenient, compact and portable.

Q.29. *What is an altimeter ? State its principle. How is its scale calibrated ?*

Ans. It is an instrument used in aircraft to measure its altitude. It is based on the principle that atmospheric pressure decreases with height. The scale of altimeter is graduated with height increasing towards left because the atmospheric pressure decreases with increase of height above the sea level.

Q.30. *How does the atmospheric pressure change with altitude ? Draw an approximate graph to show this variation.*

Ans. The atmospheric pressure decreases with the increase in altitude. The graph is as shown.



Q.31. ***What do the following indicate in a barometer regarding weather :***

(a) gradual fall in the mercury level,

(b) sudden fall in the mercury level,

(c) gradual rise in the mercury level ?

Ans. (*a*) If the mercury level in the barometer gradually falls, it indicates that the moisture is increasing, *i.e.*, there is a possibility of rain.

(*b*) If the mercury level in the barometer at a place suddenly falls, it means that the pressure at that place has suddenly fallen. Hence, it indicates the coming of a storm or cyclone.

(*c*) If the mercury level in the barometer at a place increases gradually it means that the moisture in air is decreasing. This indicates dry weather.

Q.32. ***State the forecast in the following situations :***

(i) Air is hot and dry and the atmospheric pressure falls suddenly :

(ii) Air is humid and barometer pressure falls suddenly.

(iii) Barometric pressure rises steeply.

(iv) Barometric pressure does not change.

(v) Barometric pressure falls gradually over a number of days.

Ans. (*i*) The forecast is a dust storm.

(*ii*) The forecast is rains storm.

(*iii*) The forecast is dry weather with strong anticyclonic winds.

(*iv*) The forecast is fair weather.

(*v*) The forecast is that weather gradually changes from fair to windy over a number of days.

Q.33. **Explain the following :**

(i) Why is water, not a suitable barometric liquid ?

(ii) Why is mercury used as a barometric liquid?

(iii) Name two factors which do not affect barometric height at a given place.

(iv) Name four factors which affect barometric height at a given place.

Ans. (*i*) (*a*) Water barometer will support 10.34 m of water at sea level. It is impractical to have such a long tube.

(*b*) Water vaporises under vacuum conditions and hence water barometer will never show true atmospheric pressure.

(*ii*) (*a*) The vapour pressure of mercury is almost negligible under vacuum conditions. Thus, mercury barometer shows true atmospheric pressure.

(*b*) Mercury is the densest liquid (13.6 g cm^{-3}) at room temperature. Thus, a short column of mercury can exert as much pressure as the entire atmosphere.

(*c*) Mercury does not wet the sides of glass and can be had in pure state.

(*iii*) (*a*) Barometric height is independent of area of cross-section of barometric tube.

(*b*) Barometric height is independent of angle to which barometer tube is held.

(*iv*) (*a*) Barometric height changes with change in temperature.

(*b*) Barometric height changes with change in humidity in air.

(*c*) Barometric height changes if mercury is impure.

(*d*) Barometric height changes if tube is not dry.

Q.34. ***A body dipped into a liquid experiences an upthrust. State the factors on which the upthrust on the body depends.***

Ans. The upthrust depends upon the following :

(*i*) The volume of the body submerged in the liquid.

(*ii*) The density of the liquid in which the body is immersed.

Q.35. ***While floating, is the weight of the body greater than, equal to or lesser than the upthrust ?***

Ans. The weight of the body is completely balanced by the upthrust. Thus, the weight is equal to the upthrust.

Q.36. ***Explain briefly why a balloon filled with helium gas rises in air. Why does the balloon rise to a particular height above the ground and does not rise further ?***

Ans. The mass of the balloon filled with helium is less than the mass of air displaced by it. Hence, upthrust acting on the balloon is more than its weight. As a result the balloon rises in the air. As the balloon rises, the upthrust acting on it decreases as the density of the air decreases with height. At a certain point the weight of the balloon is completely balanced by the upthrust. Thereafter the balloon stops rising.

Q.37. ***What is the effect of upthrust? Describe an experiment to show that a body immersed in a liquid appears lighter than it really is.***

Ans. The effect of upthrust is that the weight of a body immersed in a fluid appears to be less than its actual weight. This can be demonstrated by the following experiment.

Take an empty bucket and tie a long rope to it. Immerse the bucket in the water of the well keeping one end of the rope in your hand. Lift the bucket when full of water. You will notice that it is easy to lift the bucket as long as it is inside water. But when it starts coming out of the water surface, it appears to become heavy and it becomes difficult to lift it, *i.e.,* much more force is needed now to lift it. This experiment shows that the bucket of water appears lighter than its actual weight when it is immersed in water.

Q.38. ***A stone tied to a thread is hanging from the hook of a spring balance. The stone is gradually lowered into the water placed in a trough. What changes do you expect in readings of the spring balance? Explain your answer.***

Ans. Initially the spring balance will give the weight of the stone in air. When the stone is immersed in water the reading of the spring balance will go on decreasing. The reading will become minimum when the stone is completely immersed in water. This is due to the fact that the stone experiences upthrust as it is dipped in water, the upthrust being maximum when the stone is completely immersed in water.

Q.39. ***An iceberg floats in freshwater with a part of it outside the water surface. Calculate the fraction of volume of iceberg which is below the water surface. Given: Density of ice = 917 kg m^{-3}. Density of freshwater = 1000 kg m^{-3}.***

Ans. Given :

Density of ice 917 kgm^{-3}.

Density of freshwater = 1000 kgm^{-3}.

Fraction of iceberg which is below water is obtained from the expression

$$\frac{V_2}{V_1} = \frac{\text{density of ice water}}{\text{density of freshwater}}$$

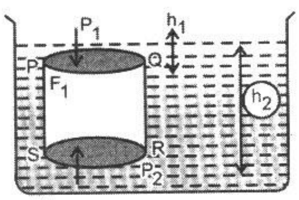
$$= \frac{917}{1000} = 0.917$$

Q.40. ***State Archimedes' principle.***

Ans. When a body is partially or completely immersed in a fluid, the fluid exerts an upward force on the body equal to the weight of the fluid displaced by the body.

Q.41. ***Prove that the loss in weight of a body when immersed wholly or partially in a liquid is equal to the buoyant force (or upthrust).***

Ans. Consider a cylindrical body PQRS of cross-sectional area A immersed in a liquid of density ρ. Let the upper surface PQ of the body be at a depth h_1 below the free surface of liquid and the lower surface RS of the body be at a depth h_2 below the free surface of liquid.



At depth h_1, pressure on the upper surface PQ $P_1 = h_1 \rho g$

Therefore,

Downward thrust on the upper surface PQ, F_1 = pressure × area = $h_1 \rho g A$ ....(1)

At depth h_2, pressure on the lower surface RS, $P_2 = h_2 \rho g$

Therefore,

Upward thrust on the lower surface RS $F_2 = h_2 \rho g A$ ....(2)

The horizontal thrusts at various points on the vertical sides of the cylinder get balanced because the liquid pressure is same at all points at the same depth.

From above eqns. (1) and (2), it is clear that $F_2 > F_1$ as $h_2 > h_1$, therefore, the cylinder will experience a net upward force given by

Resultant upward thrust (or buoyant force) on the body $F_B = h_2 \rho g A - h_1 \rho g A$

$= A (h_2 - h_1) \rho g$

But A $(h_2 - h_1)$ = V, the volume of cylinder submerged in liquid.

Since a solid when immersed in a liquid, displaces liquid equal to the volume of its submerged part, therefore,

$V\rho g$ = Volume of solid immersed × density of liquid × acceleration due to gravity.

= Volume of liquid displaced × density of liquid × acceleration due to gravity.

= mass of liquid displaced × acceleration due to gravity.

= Weight of the liquid displaced by the submerged part of the body.

Q.42. ***A man first swims in sea water and then in river water. (i) Compare the weight of sea water and river water displaced by him. (ii) Where does he find it easier to swim and why ?***

Ans. (*i*) Weight of sea water displaced = weight of river water displaced.

(*ii*) He finds it easier to swim in sea water, because sea water is denser. So he floats with lesser of his volume inside water.

Q.43. ***Two spheres one of iron and another of wood both of same radii are placed on the surface of water. Which of the two will sink? Give reason to your answer.***

Ans. The sphere of iron will sink. The density of iron is greater than the density of water so weight of iron sphere will be more than upthrust on it due to water. But density of wood is less than the density of water so sphere of wood will float with its that much volume submerged inside water by which upthrust on it due to water balances its weight.

Q.44. ***Will the weight of an 'Iron sinker plus cork' combination in water be more or less than that of the iron sinker alone in water ? Give a brief explanation for your answer.***

Ans. The weight of the iron sinker plus cork combination, under water, will be less than the weight of the iron sinker alone under water.

The buoyant force, on the cork, when fully immersed in water is more than the weight of the cork itself. This implies that the effective weight of the cork in water is actually negative. As a result, the combined weight of the iron sinker and the cork is less than the weight of the iron sinker alone.

Q.45. ***Will a body weigh more in air or in vacuum when weighed with a spring balance ? Give reason for your answer.***

Ans. The body will weigh more in vacuum than in air. This is because it does not experience any upthrust when weighed in vacuum, but it does experience an upthrust when weighed in air. Thus it loses a small part of its weight when weighed in air.

Q.46. ***A body of volume V and density ρ is completely immersed in a liquid of density ρ_L. if g is the acceleration due to gravity, write expressions for the following :***

(i) the weight of the body,

(ii) the upthrust on the body,

(iii) the apparent weight of the body in liquid,

(iv) the loss in weight of the body.

Ans. (*i*) $V\rho g$ (*ii*) $V\rho_L g$ (*iii*) $V(\rho - \rho_L)g$ (*iv*) $V\rho_L g$

Q.47. ***A block of wood is so weighted that it just floats in water in a jar at room temperature. (i) If the water is now heated, what change will occur in the state of floatation of the block? (ii) If the water in the jar is cooled to 4°C what change will be observed in the state of floatation? (iii) Give reasons for the above.***

Ans. We know that,

(*i*) The density of water is maximum at 4°C, and

(*ii*) the density of water decreases, with increase in temperature, above 4°C.

We also know that a floating object dips to a

(*i*) greater extent in a lighter (less dense) liquid, and to lesser extent in a heavier (more dense) liquid.

Therefore,

When water is heated above the room temperature, it becomes (slightly) lighter (less dense), hence the block of wood, that was just floating, would now tend to sink a little in the jar.

(*ii*) When the water is cooled to 4°C, it becomes (slightly) heavier (denser). Hence, the block of wood, that was just floating, would now tend to rise (a little bit) above the surface of water in the jar.

Q.48. ***State the law of floatation.***

Ans. It states that when a body is floating in a liquid, the weight of the body is equal to the weight of the liquid displaced by it.

Q.49. ***A piece of ice floating in a glass of water melts but the level of water in the glass does not change. Explain this phenomenon.***

Ans. The density of ice is nearly 0.9 times that of water. Ice, therefore, floats in water with (nearly) 0.9 of its volume under water and (nearly) 0.1 of its volume above water. The volume of water, displaced by a piece of ice of volume V, is, therefore, 0.9 V. When the ice melts, the volume of water so formed, from a volume V of ice, is only (nearly) 0.9 V. Hence, when the ice melts, there is no overall change in the level of water. There is, therefore, no overflowing of water, from the glass of water, filled to the brim.

Q.50. ***Explain why it is difficult to push a tin can into water keeping its mouth upwards than when its mouth is kept downwards, inside the water.***

Ans. When the tin can is pushed into the water keeping its mouth upwards, it displaces more volume of water, and, therefore, it experiences more upthrust. But when it is pushed into the water with its mouth (downwards), it displaces less volume of water (as water enters it). As a result the upthrust is also less. Thus, it is comparatively easier to push a tin can into water with its mouth (downwards).

Q.51. ***A piece of ice is gently placed on the surface of water filled in glass tumbler, so the water rises to the brim. What will happen to the level of water when the ice melts ? Will the water overflow ? If not, explain with reason.***

Ans. Since ice floats in water, its weight is equal to the weight of displaced water. Suppose ice weighs mgf, then the weight of displaced water will also be mgf. When the ice melts, mgf of water is obtained which is equal to the weight of displaced water so there will be no change in the level of water.

Q.52. ***You are provided with a hollow iron ball of volume 20 cm^3, and mass of 15 g and a solid iron ball of mass 20 g. Both are placed on the surface of water contained in a large tub. Which will float ? Give reason for your answer. (Density of solid iron = 1.8 g cm^{-3}.***

Ans. The hollow iron ball will float since its average density is $15g/20\ cm^3 = 0.75g\ cm^{-3}$ which is less than the density of water ($1g\ cm^{-3}$), whereas the solid iron ball will sink since its density is 1.8 g cm^{-3} which is more than that of water.

Q.53. ***Explain the following :***

(*i*) ***Icebergs floating in the sea are dangerous for the ship.***

(*ii*) ***An egg sinks in freshwater but floats in a strong solution of salt.***

(*iii*) ***An iron nail sinks in water, but a ship made of iron floats.***

(*iv*) ***A ship sinks to a great depth in river water than in sea water.***

(*v*) ***Iceberg floats in sea. Why?***

(*vi*) ***It is easier for a man to swim in sea water than in river water.***

(*vii*) ***A dead body floats, with its head immersed in water.***

(*viii*) ***A hydrometer is made heavy near the bottom.***

Ans. (*i*) It is found that an iceberg floats in sea water with 90% of its volume below water and 10% of its volume above sea water. Icebergs are extremely dangerous for shipping as under water ice can hit the ship and sink it.

(*ii*) When salt is mixed with water it increases the density of solution and, hence, its density becomes greater than that of the density of egg which now floats on it.

(*iii*) If we place an iron nail on the surface of water, it sinks. This is because the density of iron is greater than that of water, so the weight of the nail is more than the upthrust of water on it. On the other hand, a ship made of iron does not sink. This is because the ship is hollow and the empty space contains air which makes the average density of the ship less than that of water. Therefore, even with a small part of it submerged into water, the weight of the water displaced becomes equal to the total weight of the ship and hence the ship floats.

(*iv*) The density of sea water, due to the presence of impurities like salt, etc., is greater than that of river water.

Therefore, lesser volume of ship will be immersed in sea water to balance its weight.

(*v*) The iceberg has smaller density (0.917 gcm^{-3}) than sea water at the same temperature. The density of sea water is about 1.018 gcm^{-3} and hence an iceberg floats with nearly one-twelfth of its volume outside water.

(*vi*) Due to the presence of minerals, the density of sea water is more than the density of river water, therefore, upthrust is large. Hence, with a smaller portion submerged in sea water, the weight of sea water displaced is equal to the total weight of the body, while to displace the same weight of river water a larger portion of the body will have to be submerged in water. Therefore, it is easier to swim in sea water than in river water.

(*vii*) Dead bodies always float on the surface of water, but the head stays within water. The reason is that when the dead body decays its volume increases. Thus, it becomes lighter than water and, hence, floats. However, head being heavy cannot displace water more than its own weight hence it remains underwater.

(*viii*) A hydrometer is made heavy near its bottom so that it can float with the stem in the vertical position.

Q.54. ***Explain briefly why a balloon filled with helium gas rises in air. Why does the balloon not rise indefinitely ?***

Ans. The mass of the balloon filled with helium is less than the mass of the air displaced by it. Hence, upthrust acting on the balloon is more than its weight. As a result the balloon experiences a net upthrust which makes it rise. As the balloon rises it experiences lesser and lesser upthrust due to the fact that with height the density of air decreases. At a certain point the weight of the balloon may be completely balanced by the upthrust acting on it. Thereafter the balloon stops rising.

Q.55. ***A solid brass cylinder tied to a thread is hanging from the hook of a spring balance. The cylinder is gradually dipped into the water contained in a jar. What changes do you expect in the reading of the spring balance? Give reason for your answer.***

Ans. When the brass cylinder is in air, the reading of the spring balance is a maximum since it reads the weight of the cylinder in air. On gradually dipping the cylinder into the water contained in a jar, the reading of spring balance goes on decreasing as more and more volume of the cylinder gets submerged into the water. This is because the volume of water displaced by the cylinder goes on increasing as it is gradually submerged into water. Thus, the upthrust on cylinder (= weight of the water displaced) gradually increases due to which its apparent weight decreases. When the cylinder gets completely submerged into water, the reading of the spring balance becomes minimum. On further dipping the cylinder inside water, there is no change in upthrust and hence no further change in the reading of spring balance.

Q.56. ***A cargo ship is loaded in sea water to maximum capacity. What will happen if this ship is moved to river water ? Give reason for your answer.***

Ans. The ship will sink more in river water. This is because the density of river water is less than that of sea water. The loaded ship will, therefore, have to displace a larger volume of river water to balance its weight along with its cargo. Since the ship is loaded to its maximum capacity (in sea water), therefore, it will sink deeper when moved in river water.

Q.57. ***A body of mass 100 g is floating in water. What will be its apparent weight? Justify your answer.***

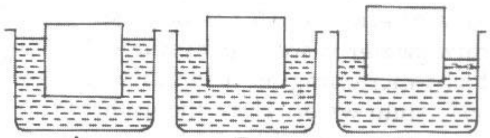
Ans. The apparent weight of the body, when floating would be zero. This is because the upthrust on a floating body is always equal to the weight of the body. Thus, the net force on the body is zero.

Q.58. ***Relative density of silver is 10.8. What is the density of silver in SI unit?***

Ans. Density of silver in cgs unit is 10.8 gcm^{-3}. Therefore, in SI it will be 10.8×10^3 kgm^{-3} as $1\ g\ cm^{-3} = 10^3\ kgm^{-3}$.

Q.59. ***Fig. below shows the same block of wood floating in three different liquids A, B and C of densities ρ_1, ρ_2 and ρ_3 respectively. Which of the liquid has the highest density? Give reason for your answer.***

Ans. Liquid C has the highest density. The upthrust applied on the body by each liquid is the same and it is equal to the weight of the body. But upthrust = volume submerged × ρ_L × g. For liquid C, since volume submerged is least so density ρ_3 should be maximum.



Q.60. ***A balloon filled with helium gas is placed in a big closed jar which is connected to an evacuating pump. What will be your observation, if the air from the jar is pumped out ? Explain your answer.***

Ans. The balloon will sink. As the air is pumped out from the jar, the density of air in the jar decreases, so the upthrust on the balloon decreases and it becomes zero when the jar gets fully evacuated.

Q.61. ***A block of wood is so loaded that it just floats in water at room temperature. What change will occur in the state of floatation, if (a) some salt is added to water, (b) water is heated ? Give reason for your answer.***

Ans. (a) The block of wood will float with some part outside water. On adding some salt to water, the density of water increases, so the upthrust on the block of wood increases and hence the block rises up till the weight of the water displaced by the submerged part of the block becomes equal to the weight of the block.

(b) The block of wood will sink. On heating, the density of water decreases, so the upthrust on block decreases and the block sinks in water.

Q.62. ***A solid of volume V and density ρ_S floats with volume v inside a liquid of density ρ_L. Show that $\frac{v}{V} = \frac{\rho_S}{\rho_L}$.***

Ans. Let V be the volume of the solid of density ρ_S. Let the solid be floating with its volume v immersed inside a liquid of density ρ_L, then

Weight of the body W = Volume of body × density of body × g = V ρ_S g.

Weight of liquid displaced by the body or upthrust F_B = Volume of displaced liquid × density of liquid × $g = v \rho_L g$

For floatation, W = F_B

$V\rho_S g = v\rho_L g$

$$\frac{v}{V} = \frac{\rho_S}{\rho_L}$$

Q.63. ***What is a hydrometer ? Name and state the principle on which it works.***

Ans. A hydrometer is an instrument which is used for measuring the relative density of a liquid (heavier or lighter than water) directly and hence to test the purity of a liquid.

A hydrometer works on the principle of floatation which states that for a body to float its weight should be equal to the upthrust acting on it.

Q.64. ***How can a hydrometer be used to measure the relative density of a liquid?***

Ans. To measure the relative density of a liquid, the hydrometer is placed in that liquid to stand vertical. At the steady position of hydrometer, the graduation mark on the stem touching the liquid surface is read which gives directly the relative density of that liquid.

Q.65. ***Draw a labelled diagram of an acid hydrometer and explain how it indicates whether a car battery needs recharging.***

Ans. A labelled diagram of an acid battery hydrometer is shown below. We use this hydrometer to check the density of the acid in the acid battery. If the density lies in the