Railway Recruitment Board

RRB

TECHNICIAN

GRADE-I SIGNAL

Point to Point

Theory + MCQ's

Chapterwise Study Material & Question Bank

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Syllabus

Questions will be of objective type with multiple choice answers and are likely to cover topics pertaining to the following syllabus

- **General Awareness:** Knowledge of current affairs, Indian geography, culture and history of India including freedom struggle, Indian Polity and constitution, Indian and Economy, environmental issues concerning India and the World, Sports, General scientific and technological developments, etc.
- **General Intelligence and Reasoning:** Analogies, Alphabetical and Number series, Coding and Decoding, Mathematical operations, Relationships, Syllogism, Jumbling, Venn Diagram, Data Interpretation and sufficiency, Conclusions and decision making, Similarities and differences, Analytical reasoning, Classification, Directions, Statement - Arguments and Assumptions, etc.
- **Basics of Computers and Applications:** Architecture of Computers; input and output devices: Storage devices, Networking Operating System like Windows, Unix, Linux; MS Office; Various data representation; Internet and Email; Websites & Web Browsers; Computer Virus.
- **Mathematics:** Number system, Rational and irrational numbers, BODMAS rule, Quadratic Equations, Arithmetic Progression, Similar Triangles, Pythagoras Theorem, Co-ordinate Geometry, Trigonometrical Ratios, Heights and distances, Surface area and Volume; Sets: Set and their representations, Empty set, Finite and Infinite sets, Equal sets, Subsets, Subsets of a set of real numbers, Universal set, Venn diagrams, Union and Intersection of sets, Difference of sets, Complement of a set, Properties of Complement; Statistics: Measures of Dispersion: Range, Mean deviation, variance and standard deviation of ungrouped/grouped data; probability occurrence of events, exhaustive events, mutually exclusive events.
- **Basic Science and Engineering:**

  Physics' fundamentals- Units, Measurements, Mass, Weight, Density, Work Power, and Energy, Speed and Velocity, heat and Temperature;

  Electricity and Magnetism-Electric Charge, Field, and intensity, Electric Potential and Potential Difference, Simple Electric Circuits, Conductors, Non-conductors/Insulators, Ohm's Law and its Limitations, Resistances in Series and Parallel of a Circuit and Specific Resistance, Relation Between Electric Potential, Energy, and Power (Wattage) Ampere's Law, Magnetic Force on Moving Charged Particle and Long Straight Conductors, Electromagnetic Induction, Faraday's Law, and Electromagnetic Flux, Magnetic Field, Magnetic Induction;

  Electronics and Measurements-basic Electronics, Digital Electronics, Electronic Devices and Circuits, Microcontroller, Microprocessor, Electronic Measurements, Measuring Systems and Principles, Range Extension methods, Cathode Ray Oscilloscope, LCD LED Panel, Transducers.

Tentative Subject-wise break-up of questions and marks for CBT of Technician Gr-I Signal		
Subjects	**No. of Questions**	**Marks for Each Section**
General Awareness	**10**	**10**
General Intelligence and Reasoning	**15**	**15**
Basics of Computers and Applications	**20**	**20**
Mathematics	**20**	**20**
Basic Science & Engineering	**35**	**35**
Total	**100**	**100**

1. **Duration : 90 minutes (with 30 minutes extra time for PwBD candidates using scribe).**
2. **The Subject-wise distribution give above is merely indicative. The question papers may vary.**

01. Units and Measurements

Physical Quantity-

- A quantity which can be measured directly or indirectly or can be explained and expressed in the form of laws of physics are called physical quantity.
- A physical quantity is completely represented by its magnitude and unit.
- The magnitude of physical quantity and unit are inversely proportional to each other. Larger the unit smaller will be the magnitude.

Types of Physical Quantity -

- **Ratio (Numerical value only)-** When a physical quantity is a ratio of two similar quantities. It has no unit.

For example-

$$\text{Relative Density} = \frac{\text{Density of Object}}{\text{Density of Water}}$$

- **Scalar-** A physical quantity which has magnitude only and do not have any direction.

Example- Work, Energy, Length, Time.

- **Vector-** A physical quantity which has magnitude and direction both.

Example- Displacement, Velocity, Acceleration etc.

- **Units-** Measurement of any physical quantity involves comparison with a certain basic, arbitrarily chosen, internationally accepted reference standard called unit.

System of units-

- A system of unit is a complete set of unit. It is used to measure all kinds of fundamental and derived quantities.

Some system of units are as follows-

Units	CGS	MKS	FPS
Length	Cm	meter	foot
Mass	Gram	kg	pound
Time	Second	second	second

Fundamental and Derived Unit-

- **Fundamental Unit-** The units of those physical quantities which can neither be derived from one another, nor they can be further resolved into more simpler units. Example:- Units of Mass, Length etc.
- **Derived Unit-** Those units of physical quantities which are derived from units of fundamental quantities are called Derived units. Example:- Units of Velocity, Acceleration, Force, Work etc.

S.I. Unit-

- The S.I. unit is the international system of units. This system contains seven fundamental units and two supplementary fundamental units.

Fundamental quantities in S.I. System and their units-

Physical Quantity	Name of unit	Symbol of unit
Mass	Kilogram	Kg
Length	Meter	M
Time	Second	S
Temperature	Kelvin	K
Luminous Intensity	Candela	Cd
Electric Current	Ampere	A
Amount of Substance	Mole	Mol

Supplementary S.I Unit- (Dimensionless Unit)

Physical Quantity	Name of unit	Symbol of unit
Plane angle	Radian	Rad
Solid angle	Steradian	Sr

Dimension of Physical Quantity-

- The powers to which fundamental quantities must be in order to express the given physical quantity is called its dimension.
- It is used to express derived quantity in terms of fundamental quantities.

For example- Force = Mass× Acceleration

$$= \frac{\text{Mass} \times \text{Velocity}}{\text{Time}}$$

$$= \text{Mass} \times \text{Length} \times \text{Time}^{-2}$$

$$= [MLT^{-2}]$$

S.I. Prefixes-

- The magnitudes of physical quantities vary over a wide range. The CGPM recommended standard prefixes for magnitude too large or too small to be expressed more compactly for certain powers of 10.

Power of 10	Prefix	Symbol	Power of 10	Prefix	Symbol
10^{18}	exa	E	10^{-1}	deci	D
10^{15}	peta	P	10^{-2}	centi	C
10^{12}	tera	T	10^{-3}	mili	M
10^{9}	giga	G	10^{-6}	mirco	μ
10^{6}	mega	M	10^{-9}	nano	N
10^{3}	kilo	k	10^{-12}	pico	P
10^{2}	hecto	h	10^{-15}	femto	F
10^{1}	deca	da	10^{-18}	atto	A

❒ Units of Important Physical Quantities-

Physical Quantity	Unit	Physical Quantity	Unit
Angular Acceleration	Rad-s^{-2}	Frequency	Hertz
Moment of inertia	kg-m^2	Resistance	ohm(Ω)
Self inductance	Henry	Surface tension	Newton/m
Magnetic Flux	Weber	Universal Gas Constant	Joule K^{-1} mol^{-1}
Pole Strength	A-m	Dipole-moment	coulomb-meter
Dynamic Viscosity	Pascal-sec or kg/ms	Stefan Constant	Watt m^{-2} K^{-4}
Kinematic Viscosity	m^2/s	Permittivity of free space (ε_0)	$Coulomb^2/N\text{-}m^2$
Reactance	ohms(Ω)	Permeability of free space (μ_0)	Weber/A-m
Specific heat	J/kg°C	Planck's constant	Joule-sec
Strength of magnetic field	Tesla	Entropy	J/K
Astronomical distance	Parsec	Angular Speed	Rad/sec

Dimensions of important Physical Quantities -

Physical Quantity	Dimensions	Physical Quantity	Dimensions
Momentum	$M^1L^1T^{-1}$	Capacitance	$M^{-1}L^{-2}T^4A^2$
Calorie	$M^1L^2T^{-2}$	Modulus of rigidity	$M^1L^{-1}T^{-2}$
Latent heat capacity	$M^0L^2T^{-2}$	Magnetic permeability	$M^1L^1T^{-2}A^{-2}$
Self inductance	$M^1L^2T^{-2}A^{-2}$	Solar constant	$M^1L^0T^{-3}$
Coefficient of thermal conductivity	$M^1L^1T^{-3}\theta^{-1}$	Magnetic flux	$M^1L^2T^{-2}A^{-1}$
Power	$M^1L^2T^{-3}$	Current density	$M^0L^{-2}T^0A^1$
Impulse	$M^1L^1T^{-1}$	Young's Modulus	$M^1L^{-1}T^{-2}$
Hole mobility of a semiconductor	$M^{-1}L^0A^1T^2$	Magnetic field intensity	$MT^{-2}A^{-1}$
Bulk modulus of elasticity	$M^1L^{-1}T^{-2}$	Magnetic induction	$M^1T^{-2}A^{-1}$
Light year	$M^0L^1T^0$	Permittivity	$M^{-1}L^{-3}T^4A^2$
Thermal resistance	$M^{-1}L^{-2}T^3\theta$	Electric field	$M^1L^1T^{-3}A^{-1}$
Coefficient of Viscosity	$M^1L^{-1}T^{-1}$	Resistance	$ML^2T^{-3}A^{-2}$

■ Physical quantities which are dimensionless-

Sr. No.	Physical Quantity	Dimensional Formula
1.	Specific gravity	$[M^0L^0T^0]$
2.	Strain	
3.	Angle (θ)	
4.	Avogadro's number (N)	
5.	Reynold's number (N_R)	
6.	Refractive Index (μ)	
7.	Mechanical equivalent of heat (J)	
8.	Dielectric Constant (K) or relative permittivity	
9.	Relative density	
10.	Trigonometric-ratios	
11.	Distance gradient	
12.	Relative permeability	

■ Physical quantities which have same dimensional formula -

S.No.	Physical Quantity	Dimensional Formula
1.	Speed or Velocity	$M^0L^1T^{-1}$
2.	Velocity of light in Vacuum (c)	
3.	Distance travelled in n^{th} second ($S_n{}^{th}$)	
4.	Relative Velocity	
5.	Frequency (v)	$M^0L^0T^{-1}$
6.	Angular frequency	
7.	Angular velocity (ω)	
8.	Velocity Gradient	

9.	Work	$M^1L^2T^{-2}$
10.	Moment of force	
11.	Torque	
12.	Internal energy	
13.	Potential energy	
14.	Kinetic energy	
15.	Heat energy	
16.	Light energy	
17.	Coefficient of elasticity	$M^1L^{-1}T^{-2}$
18.	Pressure	
19.	Stress	
20.	Young's Modulus	
21.	Bulk Modulus	
22.	Modulus of rigidity	
23.	Energy density	
24.	Force	$M^1L^1T^{-2}$
25.	Weight	
26	Thrust	
27.	Energy gradient	
28.	Tension	
29.	Acceleration	$[M^0L^1T^{-2}]$
30.	Acceleration due to gravity	
31.	Gravitational field intensity	
32.	Plank's Constant (h)	$[M^1L^2T^{-1}]$
33.	Angular momentum	
34.	Mass	$[M^1L^0T^0]$
35.	Momentum	$[M^1L^1T^{-1}]$
36.	Impulse	
37.	Length	$[M^0L^1T^0]$
38.	Radius of gyration (K)	
39.	Wavelength (λ)	
40.	Force constant	$M^1L^0T^{-2}$
41.	Surface tension	
42.	Surface energy	
43.	Area	$M^0L^2T^0$
44.	Volume	$M^0L^3T^0$
45.	Density	$M^1L^{-3}T^0$
46.	Universal gravitational constant (G)	$M^{-1}L^3T^{-2}$
47.	Moment of Inertia	$M^1L^2T^0$
48.	Angular acceleration	$M^0L^0T^{-2}$
49.	Rate of flow	$M^0L^3T^{-1}$
50.	Mass per unit length	$M^1L^{-1}T^0$
51.	Rydberg constant (R)	$M^0L^{-1}T^0$
52.	Coefficient of viscosity (η)	$M^1L^{-1}T^{-1}$
53.	Kinematic viscosity	$M^0L^2T^{-1}$
54.	Surface potential	$M^0L^2T^{-2}$
55.	Specific volume	$M^{-1}L^3T^0$
56	Power	$M^1L^2T^{-3}$

■ Dimensional Analysis and Its Applications:-

- Dimensional analysis helps up in deducing certain relations among different physical quantities checking the derivation accuracy and dimensional consistency or homogeneity of various mathematical expressions.
- **Checking dimensional consistency of equations:** Principle of homogeneity states that dimensions of each of the terms of a dimensional equation on both sides should be the same. Mathematically [LHS] = [RHS].

☞ **Example -**

- Work done = force × displacement ;

$[ML^2T^{-2}] = [MLT^{-2}] \times [M^0LT^0]$

$[ML^2T^{-2}] = [ML^2T^{-2}]$

- $S = ut + \frac{1}{2}at^2$; Dimensionally,
  $[S] = [ut] = [at^2]$
  $[M^0LT^0] = [M^0LT^{-1}]\,[M^0L^0T] = [M^0LT^{-2}]\,[M^0L^0T^2]$
  $[M^0LT^0] = [M^0LT^0] = [M^0LT^0]$
- **To convert a physical quantity from one to another system of units**: $Q_1n_2 = Q_2n_1$; Where Q_1 = unit in 1st system, Q_2 = unit in 2nd system and n_1 and n_2 be constant value in 1st and 2nd system.

$$\therefore\ n_2 = \frac{Q_1n_1}{Q_2} \quad \Rightarrow n_2 = n_1\left[\frac{Q_1}{Q_2}\right]$$

Example -

Conversion of SI unit of force from Newton (MKS) into dyne (CGS),

Let $n_2 = x$, Q_2 = dyne (g cm s^{-2}), $n_1 = 1$, Q_1 = N(kg m/s^{-2})

Applying $n_2 = \left[\frac{Q_1}{Q_2}\right]n_1$

$$\therefore \quad x = 1\left[\frac{M_1}{M_2}\right]^a\left[\frac{L_1}{L_2}\right]^b\left[\frac{T_1}{T_2}\right]^c \text{ or}$$

$$x = 1\times\left[\frac{kg}{g}\right]^1\left[\frac{m}{cm}\right]^1\left[\frac{s}{s}\right]^{-2}$$

$$\text{or } x = 1\times\left[\frac{1000\text{ g}}{g}\right]\times\left[\frac{100\text{ cm}}{cm}\right]\times\left[\frac{1\text{ s}}{s}\right] \Rightarrow x = 10^5$$

$\therefore$ 1 N = 10^5 dynes.

- **Deducing relation among the physical quantities:** If we know the dependency of a physical quantity on the other quantities then using dimensional analysis relation between them can be derived.

Example- Time period of simple pendulum depends on mass of bob (m), length (l) of string and acceleration due to gravity (g).

$\therefore\ T \propto m^a\, l^b\, g^c$ **;** $T = k\, m^a\, l^b\, g^c$...............(i)

Here k is a dimensionless constant.

$[M^0L^0T] = [ML^0T^0]^a\,[M^0LT^0]^b\,[M^0LT^{-2}]^c$

$[M^0L^0T] = [M^aL^{b+c}T^{-2c}]$

Comparing the powers, we get a = 0, b + c = 0 and $-2c = 1$

$$\therefore\ c = \frac{-1}{2} \text{ and } b = \frac{1}{2}$$

Substituting values of a, b and c in equation (i), $T = k\, m^0\, l^{1/2}\, g^{-1/2}$

$\therefore\ T = k\sqrt{\frac{l}{g}}$ (k = a constant cannot be determined using dimensions)

Limitations of dimensional analysis:

- Dimensional method can be used only if the dependency is of multiplication type. The formulae containing exponential, trigonometric and logarithmic function can't be derived using this method. Formulae containing more than one term which are added or subtracted like $S = ut + \frac{1}{2}at^2$ also can't be derived.
- We cannot determine the value of constants in a relation.
- It gives no information whether a physical quantity is a scalar or a vector.
- In mechanics, the physical quantities depends on more than three quantities cannot be derived by dimensional method as there will be less number (= 3) of equations than the unknowns (> 3). However still we can check the correctness of equation dimensionally.
- Physical quantities having identical dimensions may be of entirely different in nature.

Application of Dimensional Analysis –

- . To convert physical quantity from one system of units to another.
- To check correctness of a given physical relation.
- To derive a relationship between different physical quantities.

- Trigonometric functions sin θ, cos θ, tan θ etc and their arrangements θ are dimensionless.
- Dimension of differential coefficients $\left[\frac{d^ny}{dx^n}\right] = \left[\frac{y}{x^n}\right]$.
- Dimension of integrals $[\int ydx] = [yx]$ we can not add or subtract two physical quantities of different dimensions.
- Independent quantity may be taken as fundamental quantities in a new system of units.
- Measure of a physical quantity = Numerical value of the physical quantity × Size of the unit
  i.e Q = n × u
  Thus, the numerical value (n) is inversely proportional to the size of the unit (u) .
  $n \propto \frac{1}{u}$ or nu = constant.

Some important units:-

1 Fermi = 10^{-15}m
1 X- ray Unit = 10^{-13}m
1 Astronomical unit = 1.49×10^{11}m (average distance b/w sun and earth)
1 Light Year = 9.46×10^{15}m.
1 Parsec = 3.08×10^{16}m = 3.26 light year
$1A^0 = 10^{-10}$m
1 Micron = 10^{-6}m
1 Mili micron = 10^{-9}m
1 Joule = 10^7 erg

Values of some important physical constants-

Acceleration due to gravity (g) = 9.8 m/s^2
Standard atmospheric pressure = 76 cm Hg = 1.01×10^5 N/m^2
Density of mercury = $13.59\times10^3 kgm^{-3}$
Gravitational constant (G) = 6.67×10^{-11} Nm^2/kg^2
Ideal gas = 8.3145 J. $mole^{-1}K^{-1}$
Speed of light (c) = 3×10^8m/s
Plank's Constant = 6.626×10^{-34}JS
Avogadro number = $6.023 \times 10^{23} mol^{-1}$

EXAM POINTS

- System of units are **- F.P.S, C.G.S and M.K.S**
- S.I unit is taken from **- M.K.S system**
- SI system was developed in **- 1971**
- No. of basic unit is **- Seven**
- In system that uses the meter for length, the kilogram for quantity, the second for time, Kelvin for temperature, ampere for electric current. The candela for luminous intensity and the mole for the amount of a substance is called **- SI system**
- No. of supplementary unit is **- Two**
- Plane angle (radian), Solid angle (steradian) are **- Supplementary unit**
- SI unit of temperature is **- Kelvin (K)**
- The SI unit of energy is **- Joule**
- The SI unit of torque is **- Newton-meter (Nm)**
- The SI unit of frequency is **- Hertz**
- The SI unit of electric current is **- Ampere**
- The SI unit of the physical quantity "Luminous intensity" is **- Candela (cd)**
- The SI unit of the physical quantity "magnetic flux intensity" is **- Tesla (T)**
- The SI unit of the physical quantity "magnetic flux"is **- Weber (wb)**
- The SI unit of the physical quantity "magnetic field intensity" is **- Amperes per meter**
- The SI unit for heat capacity will be **- Joule/ºC**
- The SI unit of luminous flux is **- Lumen**
- The SI unit of "force couple" is **- Newton-meter (Nm)**
- The SI unit of 'surface tension' is **- Newton/meter**
- The SI unit of viscosity is **- Poiseuille (PI)**
- The density of water in MKS system is **- 10^3 kg/m^3**
- Light year is the unit of **- Distance**
- Kilowatt hour is the unit of **- Energy**
- Tonne is the unit of **- Weight**
- Unit of angular velocity is **- Radian/second**
- Angstrom is the unit of **- Length**
- The derived unit of mass in MKS system is **- Kilogram**
- In MKS systems the unit of force is **- $\frac{\text{kg - m}}{\text{sec}^2}$ (Newton)**
- In FPS system, the unit of weight is **- Pound**
- The largest unit to measure the distance is **- Parsec**
- The unit of solid angle is **- Steradian**
- The unit that is used in all system **- second**
- The CGS unit of length is **- Centimeter**
- The unit of force in CGS system is **- Dyne**
- The unit of gravitational constant (G) is **- Nm^2/kg^2**
- "Calorie" is the unit of measurement of **- Heat**
- The unit of density in CGS system is **- gram/cm^3**
- Curie is the unit of **- Radio-activity**
- R.P.M. of a rotating fly wheel is measured by **- Stroboscope**
- Kilowatt-hour is unit of **- Electrical energy**
- The unit of Plank's constant is **- J-S**
- The unit of physical quantity "Jerk" is **- Meter per second cube (m/sec^3)**
- Those physical quantities which have only magnitude and no direction are called **- Scalar quantity**
- The unit of density in MKS system is **- Kilogram/cubic meter (kg/m^3)**
- How many miles are in 1 km **- 0.622 miles**
- How many millimeters are in one kilometer **-10^6 mm**
- How many liters in one cubic foot **- 28.316 liter (L)**
- How many feet are in 6 meters **- 19.68 feet (ft)**
- One hectare is equal to **- 2.47 acres**
- How many watts are in 5 (five) horse power (hp) **- 3728.5 watt**
- How many joules are in one K.W.H. **-36×10^5 Joules**
- How many inches are in one meter **- 39.37 inches**
- Unit of mass in SI/MKS system is **- kilogram (kg)**
- Weight of one kilogram amount is **-9.8Newton (N)**
- How many liters are in one gallon **- 3.785 liter**
- How many square feet will be in 3 square meters **- 32.3 square feet**
- Yard is one inch is **- 0.0278 Yard**
- How many hectares are in one acre **-.4047 hectares**
- Value of 2.5 gallons in liters will be **- 9.464**
- The physical quantities having magnitude and direction are called **- Vector quantity**
- 0.4047 hectare, 4047 square meter and 4840 square yard is equal to **- One acre**
- One angstrom is equal to **- 10^{-10} meter**
- How many gram are in an ounce **- 28.3 gram**
- One parsec is equal to **- 3.26 light years**
- How many liters are in one barrel of oil **- 159 liter**
- How many liters will be in 5 gallons **- 18.927 liters**
- How many kilograms in one tonne **- 10^3 kg**
- One horse power (HP) is equal to **- 746 watts**
- Value of 1000 watts in horse power (HP) will be **- 1.359 watts**
- 9.45×10^{12} km is equal to **- One light year**
- One kg of weight is in Newton **- 9.81 N**
- For 10^{12} prefix unit is used **- Tera**
- 5280 feet, 1.609 km and 1760 yard is equal to **- 1 mile**
- How many millimeter are in 24 inches **- 609.60 mm**
- How many joules are in one calorie **- 4.18 Joules**
- One milligram (mg) is equal to kilogram **- 10^{-6} kg**
- The value of 2 square miles converted into square km. will be **- 5.175 square km**
- One pound contains **- 453.592 gram**
- The value of 5 meters in inches will be **- 196.85 inches**
- The value of 5 square kilometer converted to square miles will be **- 1.932 square mile**
- The value of 95ºC is in Fahrenheit **- 203ºF**
- One pico-second is equal to **- 10^{-12} second**
- 10 micro meter is in meter **- 10^{-5} meter**
- One micron is equal to millimeter **- 0.001 mm**
- The value of 10 inches in mm will be **- 254 mm**
- Calories in one Joule are **- 0.24 caloric**
- 300 Kelvin (K) is the temperature in ºC **- 27ºC**
- The unit of young's modulus of elasticity in the SI system is **- Newton/meter^2**
- Momentum, mass and velocity are related to **- Momentum = mass × velocity**
- Joules and 'electron volt' are the unit of **- Energy**
- The dimensions of energy and work are **- [ML^{2}T^{-2}]**

- The dimension of gravitational constant (G) is **- $[M^{-1}L^3T^{-2}]$**
- The unit of moment of inertia is **- Kilogram×metre^2**
- The unit of angular momentum is **- Joule-second**
- The dimensional formula for angular momentum is **- $[ML^2T^{-1}]$**
- The dimensional formula of momentum and impulse is **- $[MLT^{-1}]$**
- In international measurement system, 'Kelvin' is the unit of **- Temperature**
- One Joule energy is equal to erg **- 10^7 ergs**
- The unit used to measure the ultrasonic speed is **- Knots**
- The number of base unit in the S.I. system is **- 7 (seven)**
- One nano is equal to **- 10^{-9} metre**
- One micro is equal to **- 10^{-6} metre**
- One pico is equal to **- 10^{-12} metre**
- 'Tesla' (T) is the unit of **- Intensity of magnetic field**
- A manometer is used to measure **- Pressure**
- In C.G.S system the name of the unit of charge is **- esu**
- The unit used to measure the distance of a star is **- Light year**
- Which type of scale is used to measure the distance between the sun and earth **- Indirect scale**
- Measured by direct scale **- distance, length, weight**
- The first type of measuring instrument is used **- simple scale**
- In the measurement of which physical quantity after making 2 transformations, the observation is presented **- Electric current**
- Expresses the range of a scale **- 0 to R_{max}**
- The span of a scale is shown by **- $R_{max} - R_{min}$**
- The accuracy of a measurement method is expressed in **- Close to the actual value**
- Accuracy shows **- The closeness of the actual value to the measured value**
- If the errors in a measuring instrument are less than its accuracy will be affected **- It will increase**
- The accuracy and error of a measuring instrument is related to **- Accuracy $\propto \frac{1}{\text{error}}$**
- Electric current is measured by **- Ammeter**
- The time taken by the earth to revolve around the sun is of the order of **- 10^7 second**
- The value of $1\mathring{A}$ in micron is **- 10^{-4} micron**
- The length of one division of the venier scale than the length of one division of the main scale is **- little less**
- How many millimeters (mm) are in one micron **- $\frac{1}{1000}$mm**
- One nanometer is equal to centimeter (cm) **- 10^{-7} cm**
- The minimum reading marked on the scale is called **Actual Value**
- The quality of an instrument which caste difference between two suitable values **-Transfer persistence**
- If the input were more in the measurement sub-section **-Ductility decreases**
- Mechanical measuring instruments are **-less sensitive**
- Electrical measuring instruments are **-Less durability**
- Nature of mechanical measuring instrument is **-Less sensitivity , more stability**
- What have an impact on stability when the sensitivity of a speech increases **-Decreases**
- The difference between the upper limit and lower limit of any measurement is called -**Tolerance**
- What effect on the auspiciousness, when the accuracy of the measuring instrument increases -**Decreases**
- In any type of measurement , there is a reasons for error - **Indirect and direct both**
- The function of measuring system is **-Pointer function, recording function, control function**

PREVIOUS YEAR QUESTIONS

1. Which one of the following physical quantities is a vector quantity?

(a) Gravitational Potential energy
(b) Electric Power
(c) Electric current
(d) Dipole Moment

RRB ALP CBT II Physics & Maths 21 .01.2019 Shift I

Ans. (d) :**Dipole moment** - The product of the charge and the distance between the two charges is called dipole moment. It is a vector quantity.

$$\vec{P} = q \times \vec{d}$$

Where, p = dipole moment
q = charge
d = distance.

Electric Current - The rate of flow of charge is called electric current. It is a scalar quantity.

Gravitational Potential Energy- The energy stored in an object due to its position above the earth's surface is called gravitational potential energy. It is scalar quantity.

Electric Power: It is electrical energy per unit time.It is a scalar quantity.

2. Which of the following is not a vector quantity?

(a) Speed (b) Velocity
(c) Displacement (d) Acceleration

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Ans. (a) : **Vector Quantity -** A physical quantity which has both magnitude and direction. Displacement, velocity, acceleration, momentum, force, weight are examples of vector Quantity.

Scalar quantity- A scalar quantity only has a magnitude. Some common examples of scalar quantity are mass, speed, volume, temperature, density etc.

3. kgms^{-1} is the SI unit of ——

(a) Momentum (b) Pressure
(c) Force (d) Velocity

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Ans. (a) : Momentum - It is the product of the mass and velocity of an object whose change with respect to time gives force.

$P = m \times v$

Where P = momentum
m = mass of object
v = velocity

• The S.I. unit of momentum is kg-m/sec. and dimension is $[MLT^{-1}]$.

4. Which of the following has no unit

(a) Pressure (b) Density
(c) Distance (d) Relative Density

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Ans. (d) : Relative density - It is defined as the ratio of density of a substance with respect to the density of water. It is denoted by R.D.

$$R.D = \frac{\text{Density of substance}}{\text{Density of water}}$$

• Relative density is a dimensionless quantity.

Pressure - The force applied perpendicular to the surface area of an object is known as pressure. It is denoted by 'P'.

$$P = \frac{F}{A}$$

Where, F = Force applied by the body (N)
A= Total area of the object (m^2)

• The S.I unit of pressure is Pascal (Pa) or N/m^2.

Density - It is defined as mass per unit volume. It is denoted by ρ. The unit of Density is kg/m^3.

$$\rho = \frac{\text{Mass(m)}}{\text{Volume(v)}}$$

Distance - The complete path travelled by an object. The unit of Distance is meter (m).

5. Which among the following is a derived unit ?

(a) Length (b) Density
(c) Time (d) Mass

RRB ALP CBT II Physics & Maths 21 .01.2019 Shift II

Ans. (b) : Derived Unit :- The combination of two base units is called derived units.

• Density is derived unit because it is a combination of two basic units mass and volume and it is given by kg/m^3.

6. S.I. Unit of universal gravitational constant is

(a) Nkg^2/m^2 (b) kg^2/Nm^2
(c) Nm^2/kg^2 (d) N^2m^2/kg^2

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Ans. (c) : As per universal law of gravitations,

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

$$G = \frac{Fd^2}{Mm}$$

Where,
The SI units of Gravitational force = Newton (N)
The SI unit of Distance = Meter (m)
The SI units of Masses (M, m) = kg

Therefore, The SI unit of G = Nm^2kg^{-2} or $\frac{Nm^2}{Kg^2}$

7. The dimensional formula of speed

(a) $[MLT^{-1}]$ (b) $[M^0LT^{-1}]$
(c) $[ML^0T^{-1}]$ (d) $[MLT^2]$

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Ans. (b) : We know that,

$$\text{Speed}\left(v = \frac{d}{t}\right)$$

$$v = \frac{[L]}{[T]}$$

The dimensional Formula of speed = $[M^0LT^{-1}]$

- M = Mass
- L = Length
- T = Time

8. Light year is the unit of

(a) Length (b) Time
(c) Mass (d) Area

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Ans. (a) : The light year is a unit of length. It is used to express Astronomical distances.

• It is equal to about 9.46 trillion kilometers (9.46×10^{12}km) or 5.88 trillion miles (5.88×10^{12}miles).

9. Light year is the unit of a quantity whose unit can also be

(a) Second (b) Kg
(c) Square metre (d) Angstrom

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Ans. (d) : Light year is the unit of a quantity whose unit can also be Angstrom.

The distance travelled by light in one year is called one light - year. It is the unit of astronomical distance.

The unit of length which is equal to 10^{-10} meters is called 1 Angstrom. It is denoted by A°.

10. The distance covered by a particle in time 't' is given by s = at +bt^2 where 'a' and 'b' are two constants. The dimensional formula of 'b' is:

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

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Ans. (a) : Given : $S = at + bt^2$ --------(i)

From the principle of dimensional homogeneity , the L.H.S of the equation dimensionally equal to the R.H.S of the equation.

So, the dimension of (s), (at) and $(bt)^2$ is same.

Dimensional formula of distance (s) = $[L]$

For the first term

$\therefore [L] = [a][T]$

$[a] = \frac{[L]}{[T]} = [LT^{-1}]$

For the second term

$\therefore [L] = [b]\,[T^2]$

$[b] = \frac{[L]}{[T^2]} = [LT^{-2}]$

Hence, the dimensional formula of 'b' is $[M^o L^1 T^{-2}]$

11. Which of the following is dimensionless?

(a) Velocity (b) Angle

(c) Mass (d) Area

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Ans. (b) : Angle is defined as the ratio of the length of arc to the radius.

$$\text{Angle } (\theta) = \frac{\text{length of arc}(\ell)}{\text{radius}(r)}$$

$$\theta = \frac{[M^o LT^o]}{[M^o LT^o]} = 1$$

Hence, an angle is a dimensionless quantity.

12. The dimensional formula of force :

(a) $[ML^{-3}T^2]$ (b) $[MLT^{-2}]$

(c) $[ML^{-2}T^{-2}]$ (d) $[ML^{-1}T^{-1}]$

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Ans. (b) : Dimensional Formula of Force

Force = Mass ×Acceleration ....(i)

$\therefore$ Acceleration = Velocity/time

$$= \frac{\text{distance / time}}{\text{time}}$$

$$= \frac{L/T}{T} = [LT^{-2}]$$

$\therefore$ Mass = $[M]$

Put both the values in eq (i)

Force = $[M] \times [LT^{-2}] = [MLT^{-2}]$

13. Which one of the following physical quantities represent stress?

(a) Force/length (b) Impulse/volume

(c) Restoring force/area (d) Energy/area

RRB ALP CBT II Physics & Maths 22 .01.2019 Shift III

Ans. (c) : Stress a physical quantity that defines force per unit area applied to a material. It is denoted by σ.

$$\text{Stress} = \frac{\text{Force}}{\text{cross-sectional area}}$$

$$\sigma = \frac{F}{A}$$

The S.I. Unit of stress is Newton/meter^2 or Pascals (Pa).

$$\frac{\text{Force}}{\text{length}} = \text{Surface tension}$$

Surface tension is the attraction force found which is responsible for pulling surface molecules in the rest of the liquid.

14. Which one of the following physical quantities is a scalar quantity?

(a) Dipole moment

(b) Angular momentum

(c) Torque

(d) Electric current

RRB ALP CBT II Physics & Maths 22 .01.2019 Shift III

Ans. (d) :

- A scalar quantity is defined as the physical quantity that has only magnitude e.g. Mass, electric current, volume, speed, temperature etc.
- A vector quantity is defined as the physical quantity that has magnitude as well as direction e.g. Angular momentum, torque, force, acceleration, displacement, dipole moment etc.

15. Which of the following is not the SI base unit?

(a) Coulomb (b) Metre

(c) Kilogram (d) Ampere

RRB ALP CBT II Physics & Maths 22 .01.2019 Shift III

Ans. (a) : Fundamental unit/SI base unit:-

- The SI unit of a fundamental quantity is called a fundamental unit
- There are 7 fundamental quantities and their fundamental units are given below

Fundamental Quantities	
Quantities	**S.I. base unit**
Mass	Kilogram (kg)
Length	Meter (M)
Time	Second (s)
Temperature	Kelvin (K)
Electric current	Ampere (A)
Luminous intensity	Candela (cd)
Amount of substance	Mole (Mol)

- We can say that the coulomb is not the SI base unit. So option (a) is correct.

16. Which of the following is NOT a base unit?

(a) Radian (b) Mole

(c) Ampere (d) Candela

RRB ALP & Tech. 23.01.2019 Shift-I

Ans: (a) Fundamental quantities in SI system and their units **-**

Physical Quantity	Name of Unit	Symbol of Unit
Mass	Kilogram	kg
Length	Meter	m
Time	Second	S
Temperature	kelvin	K
Luminous intensity	Candela	Cd
Electric current	Ampere	A
Amount of substance	Mole	Mol

17. **Farad per meter is the unit of———.**
(a) Permeability
(b) Electric conductance
(c) Permittivity
(d) Watt per steradian

RRB ALP & Tech. 23.01.2019 Shift-I

Ans : (c) Farad per meter is the unit of permittivity.
• Electric conductance → Siemen (s)
• Permeability → Henry/ meter

18. **Henry per meter is the unit of ....**
(a) permeability
(b) electric conductance
(c) watt per steradian
(d) permittivity

RRB ALP & Tech. 23.01.2019 Shift-II

Ans : (b) Henry per meter is the unit of permittivity.

19. **Which of the following is NOT a derived unit?**
(a) Mol (b) Volt
(c) Radian (d) Lumen

RRB ALP & Tech. 23.01.2019 Shift-II

Ans : (a) Derived unit: Those units of physical quantities which are derived from units of fundamental quantities are called derived units. ex –
Unit of mass, length etc.
Mol is a fundamental unit.

20. **Which of the following is a base unit?**
(a) candela (b) hertz
(c) radian (d) ohm

RRB ALP & Tech. 08.02.2019 Shift-I

Ans : (a) : Candela is base unit, Hence option (a) is correct.

21. **Katal is the unit of_______.**
(a) catalytic activity (b) stress
(c) capacitance (d) entropy

RRB ALP & Tech. 08.02.2019 Shift-I

Ans : (a) : Katal is the unit of catalytic activity. It is equivalent to 1 mole/second.

22. **Which of the following option does not have SI unit?**
(a) Frequency
(b) Amount of substance
(c) Electric current
(d) Luminous Intensity

RRB ALP & Tech. 23.01.2019 Shift-III

Ans : (a) Frequency does not have S.I base unit. The SI unit of frequency is hertz which is the reciprocal of time period.

23. **One mile is approximately equivalent to ______ kilometers.**
(a) 0.8 (b) 1.2
(c) 1.4 (d) 1.6

RRB ALP & Tech. 22.01.2019 Shift-I

Ans : (d) 1 mile = 1.69344 Kilometers
Hence, option (d) is correct.

24. **Heat supplied to a system is measured in____.**
(a) joules (b) amperes
(c) kilowatts (d) degrees kelvin

RRB ALP & Tech. 22.01.2019 Shift-I

Ans : (a) Heat supplied to a system is measured in Joule or Calorie.
1 Calorie = 4.18 Joule

25. **Which meter is used for the measurement of heat ?**
(a) Energy meter (b) Calorimeter
(c) Ammeter (d) Wattmeter

RRB ALP & Tech. 21.01.2019 Shift-I

Ans : (b): Instrument	**Uses**
• Calorimeter	To measure the thermal change
• Ammeter	To measure current in the circuit
• Wattmeter	To measure and estimate the electric power
• Energy	To measure the total power

26. **When you convert one inch from British to SI unit, it becomes .... cm.**
(a) 25.4 (b) 12
(c) 2.54 (d) 0.254

RRB ALP & Tech. 21.01.2019 Shift-I

Ans : (c) : One inch from British to SI unit is equal to the 2.54 cm.

27. **The SI unit for electrical resistivity is :**
(a) Tesla (b) Ohm meter
(c) Ampere (d) Volt/meter

RRB ALP & Tech. 21.01.2019 Shift-I

Ans : (b) SI unit of electrical resistivity is ohm meter.
• Electric field Resistivity – Ohm-meter
• Magnetic field strength – Tesla or Ampere/meter
• Electric field strength – Volt/meter

28. **What is the S.I unit of potential difference ?**
(a) Coulomb (b) Tesla
(c) Volt (d) Ampere

RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (c)		**SI Unit**
Electric charge	–	Coulomb
Electric field	–	Tesla
Potential difference	–	Volt
Electric current	–	Ampere

29. **Generally, the capacity of a battery is expressed in -**
(a) Tesla (b) Kilowatt hour
(c) Ampere (d) Ampere hour

RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (d) An ampere hour is a unit in which capacity of battery can be expressed.
1 Ampere – hour is equal to 3600 Coulombs. It is a useful metric to determine the capacity of an energy storage device, such as a rechargeable battery or deep cycle battery.

30. **What is the S.I. unit of transferred heat energy?**
(a) Kelvin (b) Ampere
(c) Kilowatt (d) Joule

RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (d)

Physical quantity	SI unit
Temperature	Kelvin (K)
Electric current	Ampere (A)
Power	Killowatt (kW)
Heat energy	Joule.

31. **Which of the following is a unit of momentum?**
(a) Nm (b) kg m s^{-1}
(c) kg m s^{-2} (d) kg m^{-2}

RRB JE Bhopal Paper-I (Shift-II), 28.08.2015

Ans. (b) :

Physical quantity	Unit
Work done	N-m
Linear momentum	Kg-ms^{-1}
Force	Kg-ms^{-2}

32. **SI unit of force is-**
(a) kg-ms^{-2} (b) kg-ms^{-1}
(c) kg-m^2s^{-2} (d) kg-m^3s^{-1}

RRB Chennai Section Engineer, 12.02.2012

Ans. (a) : Force = mass × acceleration
Force = kg × m - s^{-2}
SI Unit of force is equal to kg – m-s^{-2}

33. **C.G.S. unit of force is-**
(a) Newton (b) kg
(c) Dyne (d) None of these

DMRC Junior Engineer (Electronics), 03.08.2014

Ans. (c) : Unit of force –

M. K. S	kg-m/sec^2
S.I	Newton
C.G.S	Dyne

34. **How much watt in one horse power-**
(a) 1000 (b) 750
(c) 746 (d) 748

RRB Trivandrum (Tech.), 09.11.1997

Ans. (c) : 1 horse power = 746 watt

35. **Kilowatt hour is the unit of-**
(a) mass
(b) time
(c) Electrical energy
(d) Electrical power

RRB Secunderabad Technical-III (Electrical), 11.12.2005

Ans. (c) : Kilowatt hour is a unit of electrical energy.

36. **eV is the unit of -**
(a) energy
(b) Charge of electron
(c) Potential difference
(d) Power

RRB Kolkata Technical-III, 20.08.2006

Ans. (a) : eV is a unit of energy.
1 eV= 1.602×10^{-19} Joule

37. **Which of the following is a vector quantity-**
(a) momentum
(b) pressure
(c) energy
(d) work

RRB Patna Technical Eng., 27.07.2008

Ans. (a) : Momentum is a vector quantity.

38. **'Parsec' is the unit measurement of**
(a) Density of stars
(b) Astronomical distance
(c) Brightness of heavenly bodies
(d) Orbital velocity of giant stars

RRB Chandigarh Section Eng. (Civil), 26.02.2012

Ans. (b) : Parsec is the unit of astronomical distance.
1 astronomical = 9.46×10^{15} meter

39. **One atmospheric pressure is equal to..........bar:**
(a) 1.01325 (b) 10.3
(c) 760 (d) 101.325

DMRC JE Mech. 18.02.2017

Ans : (a) 1 atm pressure = 1.01325 bar
= 10.3 meter (height of water)
= 760 mm (height of mercury)
= 101. 325 (kilo pascal)

40. **The specific gravity of liquids is usually measured by means of a:**
(a) Hygrometer
(b) Thermometer
(c) Piezometer
(d) Hydrometer

DMRC JE Mech. 07.09.2014

Ans : (d) The specific gravity of liquids usually measured by means of hydrometer.

Hygrometer	– To measure amount of humidity
Piezometer	– To measure underground water pressure
Thermometer	– To measure temperature of matter

41. **What does the voltmeter measure?**
(a) Strength of current
(b) Potential difference between two points
(c) Resistance
(d) Energy consumed

RRB Ajmer (Technical), 25.01.1998

Ans. (b): Voltmeter is used to measure electric potential difference between two point in an electric circuit.

42. **A barometer is used to measure :**
(a) Very low pressure
(b) Very High pressure
(c) Pressure difference between two points
(d) Atmospheric pressure

RRB JE Bhopal Paper-I (Shift-II), 28.08.2015

Ans. (d) : A barometer is used to measure atmospheric pressure.

43. **Which one of the following instruments will be used for measuring electric current?**
(a) Voltmeter
(b) Ammeter
(c) Ohmmeter
(d) Wavemeter

RRB Bilaspur JE (red) , 14.12.2014

Ans. (b) : Ammeter is used to measure electric current.

44. **The order of magnitude of 0.00542 is –**
(a) 10^{-5} (b) 10^{-4}
(c) 10^{-3} (d) 10^{-2}

RRB Ajmer (Technical), 01.03.1998

Ans. (d) : If given no is greater than 3.16 then given no is multiplied by 10^1 i,e

$5.42 > 3.16$

$\Rightarrow \quad 5.42 \times 10^{-3} \times 10^{1}$

$\Rightarrow \quad 5.42 \times 10^{-2}$

Order of magnitude is 10^{-2}

If given no is less than 3.16 then the given value is unchanged.

45. **The order of magnitude of 1.6×10^6 is-**
(a) 10^7 (b) 10^8
(c) 10^0 (d) 10^6

RRB Trivandrum (Technical), 11.04.1999

Ans. (d) : The order of magnitude of 1.6×10^6 is 10^6.

46. **In one measurement, the diameter is 1.308 cm, the significant no is.**
(a) 2 (b) 4
(c) 5 (d) 0

RRB Trivandrum (Technical), 29.06.1999

Ans. (b) : The significant no of 1.308 is 4.

47. **What is the order of magnitude of time taken by the earth to revolve around the sun.**
(a) 10^5 second
(b) 10^7 second
(c) 10^9 second
(d) None of the above

RRB Kolkata (Technical), 29.08.1999

Ans. (b) : The time taken by the earth to revolve the sun is-

$= 365 \times 24 \times 60 \times 60$

$= 3.1536 \times 10^7$ second

$= 10^7$ second

48. **The value of 1 A° is.**
(a) 10^{-10} Micron
(b) 10^{-6} Micron
(c) 10^{-4} Micron
(d) 10^{-2} Micron

RRB Bangalore Technical (Engineering), 22.04.2007

Ans. (c) : $1\ A° = 10^{-10}$

$= 10^{-10} \times 10^6$ micron

$= 10^{-4}$ micron

49. **The length of one division of the vernier scale is equal to the length of one division of the main scale**
(a) less than (b) greater than
(c) equal (d) (a) and (b)

RRB Asst. Loco Pilot (Chandigarh)-2003

Ans. (a) : The length of one division of the vernier scale is slightly less than the length of one division of the main scale.

50. **If the observed measurement of an object is 2.85 cm. When object is measured with vernier calipers having a positive error of 0.05 cm then actual measurement of the object will be**
(a) 2.90 cm
(b) [2.85 + (0.05/2)] cm
(c) 2.80 cm
(d) None of these

RRB Asst. Loco Pilot (Gorakhpur)-2003

Ans. (c): Actual measurement of the object = observed value + error value

Note:- decrease on positive value and increase on negative value

Actual value = 2.85-0.05 = 2.80

51. **The top scale of screw gauge is marked with 50 division, if the pitch of the screw is 1 mm then the least count of the screw gauge.**
(a) 0.50 mm (b) 0.002 mm
(c) 0.02 mm (d) 0.05 mm

RRB Asst. Loco Pilot (Mumbai)-2005

Ans. (c) : $\text{Least count} = \dfrac{\text{Pitch}}{\text{no.of divisions}} = \dfrac{1}{50}$

L. C = 0.02 mm

52. **The no of significant figure in 0.00237×10^5 is.**
(a) 1 (b) 2 (c) 3 (d) 4

RRB Asst. Loco Pilot (Ranchi)-2005

Ans. (c) : Standard from $= 2.37 \times 10^2$

Significant no $= 3$

Order of magnitude $= 10^2$

53. **1 micron is equal to**
(a) 1/10 mm (b) 1/100 mm
(c) 1/1000 mm (d) 1/10000 mm

RRB Asst. Loco Pilot (Kolkata)-2006

Ans. (c) : 1 micron $= 10^{-6}$ m $= 10^{-3}$ mm

$= \dfrac{1}{1000}$ mm

54. **One nanometer is**
(a) 10^{-6} cm (b) 10^{-7} cm
(c) 10^{-8} cm (d) 10^{-9} cm

RRB Asst. Loco Pilot (Kolkata)-2006

Ans. (b) : 1 nanometer $= 1.0 \times 10^{-9}$ m $= 10^{-7}$ cm

02. Mass, Weight & Density

■ Mass:

The mass (m) of a body of matter is quantitative measure of its inertia i.e., its resistance to a change in the state of rest or motion of the body, when a force is applied.

The mass of a body is the amount of substance in the body.

- SI unit of mass is the kilogram (kg).
- It is a scalar quantity.
- The greater the mass of a body, the smaller the rate of change in motion.

■ Weight:

- The weight of an object is defined as the force of gravity on the object and may be calculated as the mass times the acceleration of gravity, w = mg.
  Since the weight is a force, its SI unit is the Newton.
- For an object in free fall, so that gravity is the only force acting on it, Then the expression for weight follows from Newton's second law.
  $W = F = M \times g$
  Where W = weight
  M= mass
  F = net external force
  g = acceleration due to gravity

■ Difference between Mass and Weight

	Mass	Weight
Definition	The amount of substance in a body	The gravitational pull acting on a body
Dependent on location	No The mass is same on the Moon as on Earth	Yes The weight is different on the Moon from Earth
Measured using	A beam balance	A spring balance
Unit	Kilogram	Newton

■ Force -

- A push or pull that one object exerts on another.
- One dyne is that much force which produces an acceleration of $1 cm/s^2$ in a mass of 1 gm.
  $1 \text{ dyne} = 1 gm \times 1 cm/s^2 = 1 \text{ gm.cms}^{-2}$
  One Newton is that much force which produces an acceleration of $1 m/s^2$ in a mass of 1 kg.
  Using
  $F = ma$
  $1N = 1kg \times 1m/s^2$
  Or
  $= 1 kg\ m/s^2$
  $1N = 1000\ gm \times 100\ cm/s^2$
  $1N = 10^5$ dyne.
- There are four fundamental forces in nature-

1. Gravitational force
2. Electromagnetic force
3. Strong nuclear force
4. Weak force

Interaction	Particle affected	Range	Relative Strength	Characteris-tics time	Particle exchange	Role in universe
Strong Nuclear force	Quarks Hadrons	$\sim 10^{-15}$ m	1	10^{-23} sec	Gluons Mesons	Holds quark together to form nucleon. Hold nucleons together to form atomic nuclei.
Electromagnetic	Charged particles	∞	10^{-2}	10^{-20} sec	Photons	Determine structure of atoms, solids and liquid is important factor in astronomical universe.
Weak nuclear force	Quark & Leptons	$\sim 10^{-16}$ m	10^{-13}	10^{-10} sec	Intermediate boson	Mediate transformations of quarks & leptons helps determine composition of atomic nuclei
Gravitational	All	∞	10^{-39}	10^{-16} sec	Gravitons → Not experim-entally detected	Assemble matter into planet, stars and galaxies

☛**Types of forces on macroscopic objects –**

■ **Field Force or Range Forces -**

These are the forces in which contact between two objects is not necessary.

☛**Ex.** (i) Gravitational force between two bodies.
(ii) Electrostatic force between two charges.

■ **Contact force -**

Contact forces exist only as long as the objects are touching each other.
(i) Normal force
(ii) Frictional force.

■ **Attachment to another body -**

Tension (T) in a string and spring force (F = kx) comes in this group.

■ **Friction-** If there is relative motion or tendency of relative motion between two bodies an opposing force parallel to surface comes into play preventing the relative motion. This is called friction.

■ The frictional force on each body is in a direction opposite to its motion relative to the other body i.e frictional always oppose the relative motion.

■ **Classification of friction-**

1. **Static friction-** The force of friction that comes into play between the surface of two bodies before the body actually starts moving is called static friction. As long as there is no relative motion net force is direction of expected motion is zero, so the object remains in equilibrium, the maximum value of static frictional force is called limiting, frictional force.
2. **Kinetic friction-** the force of friction between two surfaces when one surface is motion over the other surface is called kinetic friction. Force of kinetic friction is slightly less than force of limiting friction. Kinetic friction does not depend upon relative velocity.

■ Kinetic friction is of two types
(a) Sliding friction
(b) Rolling friction

■ **Co-efficient of friction-**

■ co-efficient of static friction.

$$\boxed{\mu_S = \frac{F_L}{R}}$$

Where, F = Limiting force of friction
R = Normal relation
μ_S = Co-efficient of static friction

■ Coefficient of kinetic friction,

$$\mu_K = \frac{F_K}{R}$$

■ μ_S can be greater than μ_K as well.

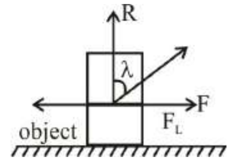
■ Force of friction does not depend upon shape, size or area of contact, as long as the normal reaction remains the same. It is so, because force of friction is given by

$$F = \mu R$$

Where μ = a constant.

■ **Angle of friction (λ)-** The angle which is resultant of normal reaction and limiting friction makes with direction of normal reaction is called angle of friction.

$$\boxed{\mu_S = \tan\lambda = \frac{F_L}{R}}$$



■ **Law of friction-** There are four laws of friction.

- When two bodies are in contact, then the friction force (F) is directly proportion to normal reaction (normal force) R between them i.e. $F \propto R$.
- The direction of friction force is always opposite to the direction of motion of one body over the other.
- The friction force does not depend upon the area of contact unless the normal reaction remains same.
- The friction force depends on material and nature of two surfaces in contact.

■ Newton's Law of Motion –

- First law (Galileo's law of inertia)
- Second law (Law of force)
- Third law (Law of action and reaction)

(i) Newton's First law (Galileo's law of inertia)

- If $\vec{F}_{external} = 0$ and $\vec{V} = 0$ i.e body is in rest then it always in rest.

☛ **Ex.** A person who is standing freely in bus is thrown backward when the bus starts suddenly.

(ii) Newton's Second law (Law of force) -

- The rate of change of linear momentum w.r.t. time is equal to applied force and change in momentum takes place in the direction of applied force.

$$F = \frac{\Delta P}{\Delta t}$$

If P = f(t) then,

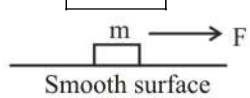
$$F = \frac{dP}{dt}$$

- If $\frac{\Delta P}{\Delta t} = \frac{P_f - P_i}{\Delta t} = \frac{mv - mu}{\Delta t} = m\frac{\Delta v}{\Delta t} = ma$
- $\vec{F} = m\vec{a}$
- Unit - 1 Kg-m/s^2 = 1 Newton (In M.K.S.)
1 Newton = 10^5 Dyne (In C.G.S.)
- For Horizontal motion -
F = ma
Where, m = Inertial mass
- For vertical motion -
W = mg
Where, m = Gravitational mass.

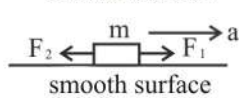
■ **Concept -**

The force (F) acting on a moving object is the product of the mass (m) and acceleration (a)

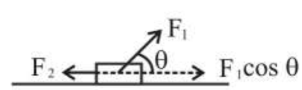
$$\boxed{F = ma}$$

(i) 

F = ma

(ii) 

$F_1 - F_2 = ma$

(iii) 

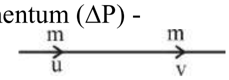
$F_1 \cos\theta - F_2 = ma$

Momentum (P) -

- It is the product of the mass and velocity of a body i.e

$$\vec{P} = m\vec{v}$$

- Change in linear momentum (ΔP) -



$$\Delta P = P_f - P_i$$

Where, P_f = Final momentum, P_i = Initial momentum.

$$\Delta P = mv - mu$$
$$\Delta P = m(v - u)$$
$$\Delta P = m\,(v - u)$$

- S.I. unit is $Kg\text{-}m\text{-}s^{-1}$ or N-sec
- Dimension of linear momentum = $[MLT^{-1}]$.

■ **Impulse -**

- If a force is applied on the body for very small time interval then-

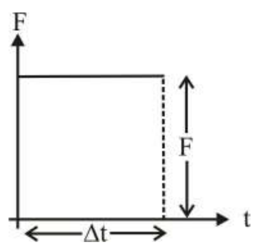
$$I = \vec{F}\,\Delta t$$

$$I = \frac{\Delta P}{\Delta t} \times \Delta t$$

$\boxed{\vec{I} = \Delta\vec{P}}$ Impulse = changing in momentum.

☛Area bounded by F - T Graph -

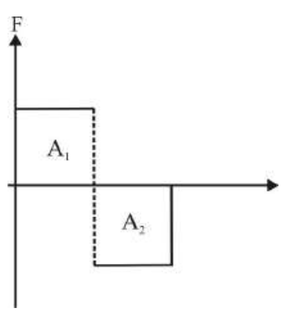
(a) If constant force acting on the body-



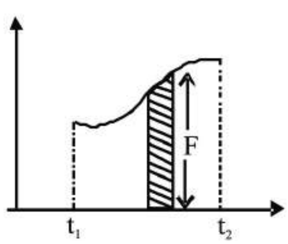
Area = length × breadth
= F × Δt

(b) If direction of force on the body is reversed.

$I = \Delta P = |A_1| - |A_2|$

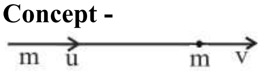


(c) If variable force is acting on the body i.e F = f(t)



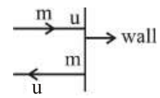
☛ **Concept -**

(i)



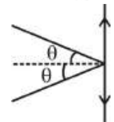
$$F = \frac{\Delta p}{\Delta t} = \frac{mv - mu}{\Delta t}$$

(ii)



$$F = \frac{2mu}{\Delta t}$$

(iii)



$$F = \frac{\Delta p}{\Delta t} = \frac{2mu\cos\theta}{\Delta t}$$

■ **Newton's Third Law (Law of action and reaction)**

- According to this law, for every action there is always equal and opposite reaction i.e the forces of action and reaction are always equal and opposite.

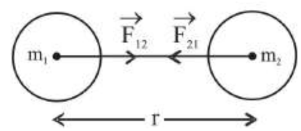
Example -

- When you walk you interact with the floor, you push against the floor and the floor pushes against you. The pair of forces occurs at the same time.
- Likewise, the tires of car push against the road while the road pushes back on the tires the tires and the road simultaneously push against each car.

NOTE: Normal force will be perpendicular to the surface of contact.

Gravitation - It is the force of attraction between any bodies.

■ Newton's Law of Gravitation-



● Force of attraction between two masses m_1 and m_2 separated by a distance r -

$$F = \frac{Gm_1m_2}{r^2}$$

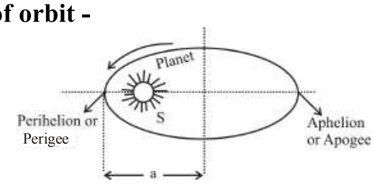
Where, G = Universal gravitational constant

$G = 6.67\times10^{-11}\ Nm^2\ kg^{-2}$

$\vec{F}_{12} = -\vec{F}_{21}$

■ Kepler's Law's of Planetary Motion –

◻ **Laws of orbit -**

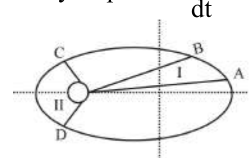


- Every planet revolves around the earth in an elliptical orbit and sun is at its focus.

◻ **Law of area -**

- The radius vector drawn from the sun to a planet sweeps out equal areas in equal intervals of time i.e that areal velocity of the planet around the sun is constant.

$$\text{Areal velocity of planet } \frac{dA}{dt} = \frac{L}{2m} = \text{constant}$$



Where, L = angular momentum
m = mass of the planet

Laws of period -

- The square of the time period of revolution of a planet around the sun is directly proportional to the cube of semi-major axis of its elliptical orbit.

$$T^2 \propto a^3 \text{ or } \left(\frac{T_1}{T_2}\right)^2 = \left(\frac{a_1}{a_2}\right)^3$$

Acceleration due to gravity –

- The uniform acceleration produced in a freely falling object due to the gravitational pull of the earth.

$$g = \frac{GM}{R^2} = \frac{4}{3}(\pi\rho GR)$$

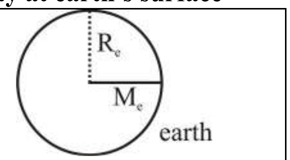
- For same material on two planet -

$$g \propto R, \quad \frac{g_1}{g_2} = \frac{R_1}{R_2}$$

Where, ρ = density of earth, M = mass of earth and R = radius of earth

Acceleration due to gravity at earth's surface –

G_e =
Where,
$M_e = 6\times10^{24}$ kg
$R_e = 6.4 \times10^6$ m or 6400 km



Acceleration due to gravity at moon surface –

$$g_{moon} = \frac{GM_m}{R_m^2}, \quad g_{moon} = \frac{g_{earth}}{6}$$

Where, $M_m = 7.34\times10^{22}$ kg
$R_m = 1.74 \times10^6$ m or 1737.4 km

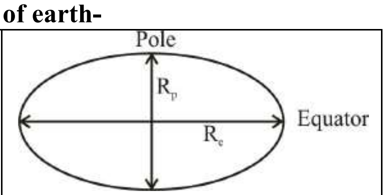
Variation of gravity –

(i) Due to top shape of earth-

$$g = \frac{GM_e}{R_e^2}$$

$$g \propto \frac{1}{R_e^2}$$

$R_{equator} > R_{polar}$
$g_{equator} < g_{polar}$
$R_{equator} - R_{polar}$ = 21 km

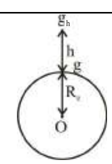


(ii) Due to height from earth surface –

$$g_h = \frac{g}{\left(1+\frac{h}{R_e}\right)^2}$$

- The value of 'g' decrease with height. It varies inversely as the square of the distance from the center of the earth.

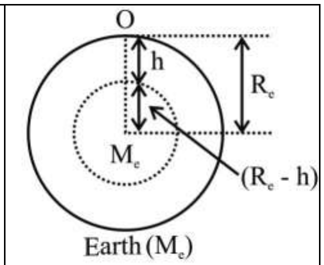
If $h = R_e$, $g' = \frac{g}{4}$
If $h \to \infty$, $g' = 0$
Decrease in the value of g with height is $g' - g_h = \frac{2hg}{R_e}$
Fractional decrease in the value of $g = \frac{g' - g_h}{g} = \frac{2h}{R_e}$



(iii) Due to depth from earth surface –

$$g' = g\left(1 - \frac{h}{R_e}\right)$$

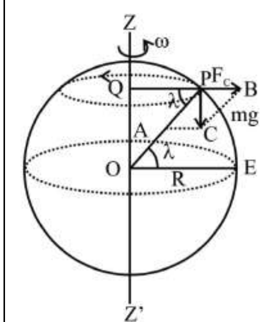
If $h = R_e$, $g'_{centre} = 0$
Decrease in the value of 'g' with depth is $\Delta g = g - g' = \frac{gh}{R_e}$
Fractional decrease in the value of 'g' with depth is $\frac{\Delta g}{g} = \frac{g - g'}{g} = \frac{h}{R_e}$
Percentage error in g is $= \frac{\Delta g}{g}\times100 = \frac{h}{R_e}\times100$



(iv) Rotation of earth about its own axis-

If ω is the angular velocity of rotation of earth about its own axis then acceleration due to gravity at a place having latitude λ is given by - $g' = g - R\omega^2\cos^2\lambda$.

- At poles $\lambda = 90^\circ$ and $g' = g$. Therefore, there is no effect of rotation of earth about its own axis at poles.
- At equator $\lambda = 0^\circ$ and $g' = g - R\omega^2$. Therefore value of g is minimum at equator.
- If earth stops its rotation about its own axis, then g will remain unchanged at poles but increase by $R\omega^2$ at equator.



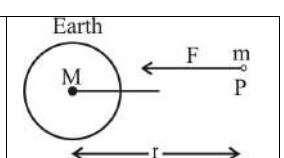
Gravitational field –

- The space around a body in which its gravitational pull works, is called gravitational field.
- The gravitational force acting per unit mass at any point in gravitational field is called intensity of gravitational field at that point.
- It is denoted by E.

$$\vec{E} = \frac{\vec{F}}{m}$$

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

$$\vec{E} = -\frac{GM}{r^2}\vec{e}_r$$

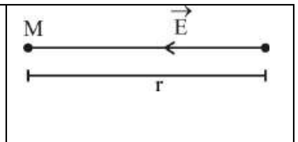
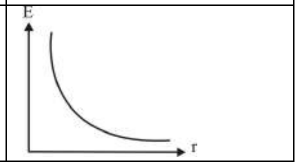


Where, $\vec{e}_r$ is the unit vector along $\vec{r}$
– ive sign shows force of attraction

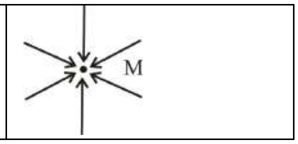
- **Intensity is zero at infinite distance from the body.**

Gravitational field intensity for different bodies –

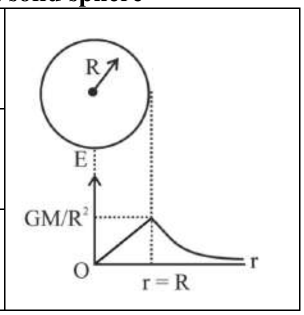
(1) Intensity due to point mass -

$\vec{E} = -\frac{GM}{r^2}\vec{e}_r$ Where, $\vec{e}_r$ is the unit vector along $\vec{r}$	
If r = 0, E = ∞ If r = ∞, E = 0	

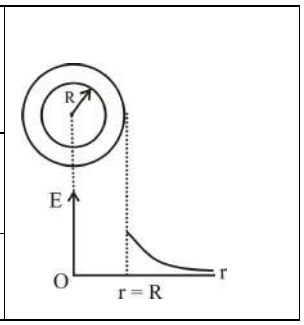
Concept

• Gravitational field intensity always towards the mass (M) of the body.	

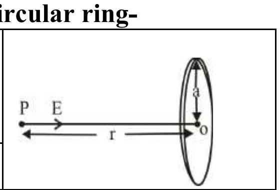
(2)Intensity due to uniform solid sphere –

Outside the Surface , $r > R$ $\vec{E} = -\frac{GM}{r^2}$	
On the Surface, r = R $\vec{E} = -\frac{GM}{R^2}$	
Inside the Surface, r < R $E = -\frac{GMr}{R^3}$	

(3)Intensity due to Spherical shell -

Outside the surface , r > R $E = -\frac{GM}{r^2}$	
On the surface, r = R $E = -\frac{GM}{R^2}$	
Inside the surface, r < R E = 0	

(4)Intensity due to uniform circular ring-

At a point on its axis $E = \frac{GMr}{(a^2+r^2)^{3/2}}$	
At the centre of ring, E = 0	

■ **Gravitational Potential (V) –**

- It is amount of work done in bringing a unit mass m_0 from infinity to a point in the gravitational field without acceleration.

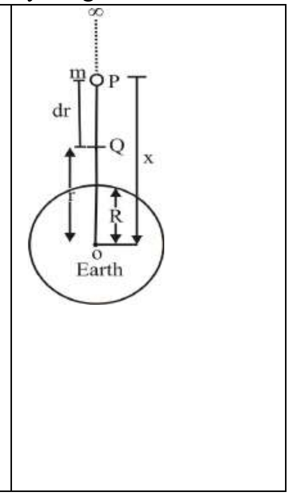
$$V = \int_{+\infty}^{r} \frac{GM}{r^2} dr$$

$$V = -\frac{GM}{r} = \frac{W}{r}$$

- **If r = R (Surface of earth)**

$$V = \frac{-GM}{R}$$

- If r = ∞, V = 0 means 'V' is maximum at infinity.
- Its S.I. units is J/Kg.
- It is a scalar quantity.
- Since, work W is obtained i.e. it is negative, the gravitational potential is always negative.

Gravitational potential energy at height 'h' from surface of earth $U_h = -\frac{GMm}{R+h} = \frac{mgR}{1+\frac{h}{R}}$ P.E. of the body decreases when it brought close to the earth. Change in P.E. of a body, which is at a height 'h' above the surface of the earth. $\Delta U = mgh$	

□ **Gravitational Potential Energy of a two particle system-**

$$U = -\frac{Gm_1m_2}{r}$$

m_1 ●– – – r – – –● m_2

□ **Gravitational Potential Energy for a System of more than two particles-** (say m_1, m_2, m_3 & m_4)

$$U = -G\left[\frac{m_4m_3}{r_{43}} + \frac{m_4m_2}{r_{42}} + \frac{m_4m_1}{r_{41}} + \frac{m_3m_2}{r_{32}} + \frac{m_3m_1}{r_{31}} + \frac{m_2m_1}{r_{21}}\right]$$

∴ for n particle system there are $\frac{n(n-1)}{2}$ pairs

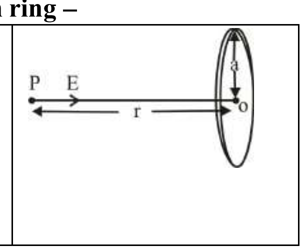
■ **Gravitational Potential for different bodies -**

(i) Potential due to a point mass -

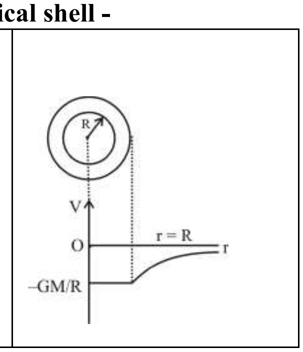
$$V = -\frac{GM}{r}$$

0 ●– – – r – – –● **P**
M

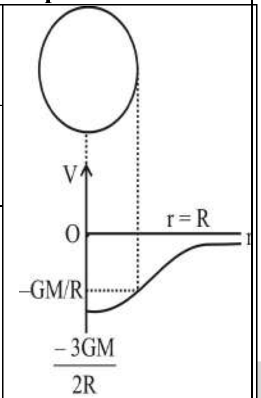
(ii) Potential due to uniform ring –

At a point on its axis $V = -\frac{GM}{\sqrt{a^2+r^2}}$ At the centre of ring, $V = -\frac{GM}{a}$	

(iii) Potential due to spherical shell -

Outside the Surface , $r > R,\ V = -\frac{GM}{r}$ On the Surface, r = R $V = -\frac{GM}{R}$ Inside the Surface, $r < R,\ V = -\frac{GM}{r}$	

(iv) Potential due to uniform solid sphere -

Outside the Surface , $r > R$, $V = -\dfrac{GM}{r}$	
On the Surface, $r = R$ $V_{surface} = -\dfrac{GM}{R}$	
Inside the Surface, $V = -\dfrac{GM}{2R}\left[3-\left(\dfrac{r}{R}\right)^2\right]$ $V_{centre} = \dfrac{-3}{2}\dfrac{GM}{R}$	

■ **Relation between Gravitational Field and Potential –**

$dV = -E.dr$

Where, $E = E_x\hat{i} + E_y\hat{j} + E_z\hat{k}$

$dr = dx\hat{i} + dy\hat{j} + dz\hat{k}$

$dV = -E_x dx - E_y dy - E_z dz$

$\mathbf{E_x} = \dfrac{-\delta v}{\delta x}$, $E_y = \dfrac{-\delta v}{\delta y}$, $E_z = \dfrac{-\delta v}{\delta z}$,

■ **Orbital Velocity -**

- Orbital velocity of satellite is the minimum velocity required to put the satellite into a given orbit around earth.

$$V_o = \sqrt{\frac{GM}{r}} = R\sqrt{\frac{g}{R+h}}$$

Where, M = mass of the planet
R = radius of the planet
h = height of the satellite from planets surface.

- If satellite revolving near the earth's surface then r = (R + h) ≈ 7.92 Km/s.
- If V is the speed of satellite in its orbit and V_o is the required orbital velocity.

➢ If $V < V_o$, then satellite will move on a parabolic path and satellite will fall back to earth.
➢ If $V = V_o$, the satellite will revolve in circular path/orbit around earth.
➢ If $V_o < V < V_e$, then satellite will remove around earth in elliptical orbit.

■ **Escape Velocity -**

- Escape velocity of earth is the minimum velocity with which a body has to be projected vertically upwards from the earth surface, so that it just crosses the earth's gravitational field and never returns.

Case-1

- Escape velocity does not depend upon the mass, shape and size of the body as well as direction of projection of body.

$$V_e = \sqrt{\frac{2GM}{R}} = \sqrt{2gR}\ ,\ V_e \propto m^o$$

Case-2 Escape velocity in terms of density of that planet -

$$\rho = \frac{M}{V},\qquad V_e = R\sqrt{\frac{8}{3}\pi G\rho}$$

Case- 3 – Condition for black hole of any planet –

Escape velocity of the planet = $\sqrt{\dfrac{2\,GM}{R}}$	≥light velocity (3×10^8)

Case-4

- If projection velocity (V_p) of a body from earth-surface is more than escape velocity (V_e) then to determine the velocity of that body in space -

$$V_s = \sqrt{V_p^2 - V_e^2}$$

☛ **Some important escape velocity –**

Heavenly body	Escape Velocity
Moon	2.3 Km/sec
Mercury	4.28 Km/sec
Earth	11.2 Km/sec
Jupiter	60 Km/sec
Sun	618 Km/sec
Neutron star	2×10^5 Km/sec

Relation between escape velocity and orbital velocity–

$$V_e = \sqrt{2}V_o$$

■ **Motion of Satellite –**

- Orbital velocity $V_o = \sqrt{\dfrac{GM}{r}}$
- Time period $T = \dfrac{2\pi}{\sqrt{GM}} r^{3/2}$
- Kinetic energy $K = \dfrac{GMm}{2r}$
- Potential energy $U = -\dfrac{GMm}{r}$
- Total mechanical energy $E = -\dfrac{GMm}{2r}$
- Near the surface of earth,

  $r \approx R$ and $V_o = \sqrt{\dfrac{GM}{R}} = \sqrt{Rg} = \dfrac{V_e}{\sqrt{2}} = 7.9\text{Kms}^{-1}$

  This is the maximum speed of any earth's satellite.
- Time period of such satellite would be

  $T = \dfrac{2\pi}{\sqrt{GM}}R^{3/2} = 2\pi\sqrt{\dfrac{R}{g}} = 84.6$ min

  This is the minimum time period of any earth's satellite.
- Binding energy $B.E = +\dfrac{GMm}{2r}$
- Angular momentum of satellite, $L = \sqrt{m^2GMr}$
- Effective weight in a satellite, W = 0 and satellite behaves like a free fall body.

■ Geostationary or Parking Satellites –

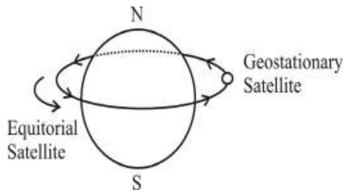
- A satellite which appears to be at a fixed position at a definite height to an observer on earth is called geostationary or parking satellite. They rotate from west to east.

Height from earth's surface = 36000 Km

Time period = 24 hour

Orbital velocity = 3 Km/sec

Angular velocity = $\frac{2\pi}{24} = \frac{\pi}{12}$ rad/min



- These satellite are used in communication purpose.
- INSAT 2B and INSAT 2C are geostationary satellite of India.

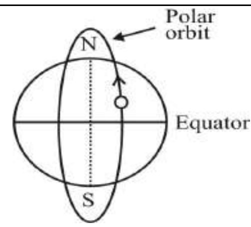
■ Polar Satellites –

- These are satellites which revolve in the polar orbits around earth.
- **Height form earth's surface ≈ 880 km**

Time period ≈ 90 min

Orbital velocity ≈ 8 km/sec

Angular velocity ≈ $\frac{2\pi}{90} = \frac{\pi}{45}$ rad/min



- These satellite revolve around the earth in polar orbits.
- These satellites are used in forecasting weather studying the upper region of the atmosphere in mapping etc.
- PSLV series satellites are polar satellites of India.

➲	At the centre of earth, a body has centre of mass, but no centre of gravity.
➲	The centre of mass and centre of gravity of body coincide if gravitational field is uniform.
➲	We does not experience gravitational force in daily life due to objects of same size as value of G is very small.
➲	Moon travelers tie heavy weight at there back before landing on moon due to smaller value of g at moon.
➲	Space rockets are usually launched in equatorial line from west to east because g is minimum at equator and earth rotates from west to east about its axis.
➲	Angular momentum is gravitational field is conserved because gravitational force is central force.
➲	Kepler's second law or constancy of areal velocity is a consequence of conservation of angular momentum.
➲	The energy required by satellite to leave its orbit around the earth (planet) and escape to infinity is called binding energy of satellite.

■ Density -

- The density of any material is defined as its mass per unit volume. If a body of mass M occupies volume V, then its density is.- $\rho = \frac{M}{V}$
- Density is positive scalar quantity.
- As liquids are incompressible, their density remains constant at all pressures.
- Density of a gas varies largely with pressure.

Example- water = 1.0×10^3 kg-m^{-3} **,** Mercury = 13.6×10^3 kg-m^{-3} , Air = 1.29 kg-m^{-3}

■ Relative density/ Specific Gravity-

- Relative density of a substance is the ratio of its density to the density of water at 4 °C

$$R.D = \frac{\text{Density of sustance}}{\text{Density of water at 4°C}}$$

- Water has highest density at 4°C = 1g cm^3 =10^3kg/m^3
- Relative density is a unit less quantity.

☛Example -

$$(R.D)_{Hg} = \frac{13.6\times10^3\,kg/m^3}{10^3\,kg/m^3} = 13.6$$

■ Buoyancy-

The up-thrust force experienced by a body when partly or wholly immersed in a fluid is called up-thrust or buoyant force .The phenomena responsible for this force is called buoyancy

■ Archimedes Principle -

- Archimedes Principle states that when a body is partially or wholly immersed in a fluid, it experiences an upward thrust equal to the weight of the fluid displaced by it and its up-thrust acts through the center of gravity of the displaced fluid.
  Up-thrust or buoyant force = weight of liquid displaced.
- Apparent weight of immersed body -
  Apparent weight = Actual weight – Buoyant force

$$W_{app} = W\left(1-\frac{\rho}{\sigma}\right)$$

Where , W = V σg = weight of the body, σ = density of the body, ρ = density of liquid

V = volume of liquid displaced.

EXAM POINTS

- ■ Three liquids whose densities are d, 2d and 3d respectively are mixed in equal volumes, then the density of the mixture will be **- 2d**
- ■ To find the relative density and specific gravity of liquids and the relative density of solids. It is used **- Hydrometer**
- ■ Two pieces of metal immersed in water exert equal buoyant force, then **- Both pieces have the same volume**
- ■ Form of hydrometer is **- Lactometer**
- ■ The ratio of mass and volume is **- Density**
- ■ The value of relative density of a substance in different measurement method is **- Same**
- ■ Part of unit volume of a substance is called **- Density**

- The instrument used to obtain the specific gravity of a substance is **- Nicholson Hydrometer**
- The specific gravity of water at 50ºC will be **- Less than one**
- In CGS system, the unit of density is **- gram/cm^3**
- The relative density of alcohol is **- 0.8**
- The instrument used to measure the humidity in the atmosphere is called **- Hygrometer**
- Beaufort scale is used to measure **- Wind speed**
- Eudiometer measures **- Volume of gas**
- When ice floats on top of water, then the part of it that remains outside the water is **- 0.1 part**
- In which sport players must have knowledge of Pascal's law **- Scuba diving**
- A sudden fall in the reading of the barometer means **- Storm**
- The mass of the body at the center of the earth is **- Zero**
- Density of solid metals on heating **- Decreases**
- In general, the density of a liquid on increasing the temperature **- Decreases**
- Which have higher density in the same amount of viscous (thick) liquid and non-viscous liquids **- Viscous liquid**
- A piece of iron floats in mercury and sinks in water because **- Density of mercury is greater than the density of water**
- When a solid object is completely immersed in a liquid, it feels. The upward force of an abject depends on **- Density of solid**
- The theory which explains the buoyant force experienced by a body while it is immersed in a liquid, was proposed by **- Archimedes**
- A bottle of soda lime is held by the neck and rapidly rotated in a vertical circle near which part of the bottle will the bubbles collect **- Near the neck**
- The floating of clouds in the atmosphere is due to **- Low density of cloud**
- When an air bubble rises from the bottom of a lake to the upper surface, then its size will **- Increase**
- If the mass of the Earth remains the same and radius decreases by 1% then, the value of 'g' at the surface of the Earth is **- Increase by 2%**
- A polythene balloon is filled with hydrogen gas then released from the surface of the Earth. As the balloon rises to an altitude up in the atmosphere then size of balloon will **- Increase**
- What will remain unchanged when the quantity of the object changes **- Density**
- Ink starts leaking out of the pen while traveling in an aeroplane due to **- Lack of air pressure**
- An iron nail sinks in water but it floats in mercury due to **- Density of iron is more than that of water**
- Why do the pendulum clocks go slow in summer **- Length of pendulum increases due to which the time period increases and pendulum takes more time to complete one oscillation.**
- A boat will submerged when it displaces water equal to its own **- Weight**
- An astronaut can Jump higher on the moon than on Earth because **- Gravitational force on the moon surface is very small as compared to the Earth surface**
- The tendency of a liquid drop to contract and occupy minimum volume is due to **- surface tension**
- The amount of buoyancy obtained by a solid partially or fully immersed in a liquid depends on **- The amount of liquid displaced by the solid.**
- If the volume of a bubble rising from the bottom of a lake increases, then the pressure exerted on that bubble will **- Decreases**
- Escape velocity from a planet of mass M and radius R will be **- $\sqrt{\frac{2GM}{R}}$**
- Geotropism is **- Response to gravity or the pull of the Earth**
- Who is the inventor of the laws of gravity **- Newton**
- If the speed of rotation of the Earth increases, then the weight of the object lying on its surface will **- Decrease**
- An object is moved from the equator towards the poles then its weight **- Increases**
- 'Hydraulic brakes' and 'Hydraulic lift' are devices in which fluid are used for transmitting **- Pressure**
- Relation between g and G is $-g = \frac{GM}{R^2}$
- Value of gravitational constant at different places on the surface of the earth **-Same**
- Acceleration due to gravity is different at different places on the surface of the earth and it is smaller at the equator than at poles because **-g is inversely proportional to the radius.**
- When an object place at height h from the surface of earth then value of g is **- Decreases**
- When an object placed at depth 'd' from the surface of earth then value of g is **- Decreases**
- Ratio between the escape velocity and orbital velocity is $\sqrt{2}:1$
- According to the third law of Kepler's, the time period of revolution of a planet around the sun is **- $T^2 \propto a^3$**
- An artificial satellite revolving around the earth does not fall down because of the attraction of the earth- **Its curve generates acceleration for motion on the earth.**
- If the earth losses its gravity, then for body - **Weight becomes zero while mass are not zero.**
- Acceleration due to gravity, from the earth surface at height h is - $\frac{gR^2}{(R+h)^2}$
- If two men talk on the surface of the moon, then **-Cannot hear each other voices because there is no medium (i.e. air).**
- A storm is predicted when the pressure of the atmosphere - **Suddenly decreases.**
- Eggs sink in normal water but floats in concentrated solution of salt because **-The density of solution of salt is greater than the density of egg.**
- Bernoulli theorem is based on the principle of **- Conservation of energy**
- An iron needle sinks in water but a ship floats. It is based on the principle of **- Archimedes**

- Archimedes law is related **- law of flotation**
- When an object is fully or partially immersed in a liquid then its weight appears decreases and equal to the weight appears decreases and equal to the weight of the liquid displaced by that object. It is based on the principle of **-Archimedes Principle**
- The scientist related to buoyancy is **- Archimedes**
- A piece of iron should not float on the surface of the water is due to **- The weight of the mass displaced by it is less than iron ball.**
- Which country did the great scientist Archimedes belong. **-Greece**
- When a stone is brought from the surface of the moon to the earth, then **- Its weight will change but mass not change.**
- A person sitting in a lift feel his weight more when **-lift moving upward with uniform velocity**
- The tennis ball lands higher on a hill than on the field due to **- Earth's Gravitational acceleration on mountains gets less.**
- If the gravitational force of the earth suddenly vanishes, then **- The weight of the object will become zero, but the value remain the same.**
- Steel bullet floats in mercury because **-The density of mercury is higher than that of steel.**
- When a boat goes to sea from river then **- Rises slightly upward.**
- On changing the quantity of the object will remain unchanged **-Density**
- The wall below the dam is built thick because **-Pressure of liquid increases with increases in depth.**
- The distance covered by a body free fall is proportional to **- Square of time of fall**

PREVIOUS YEAR QUESTIONS

1. A 10 N force is applied on a body which produces in it an acceleration of 2 m/s^2. The mass of the body is

(a) 5 kg (b) 10 kg
(c) 15 kg (d) 20 kg

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Ans. (a) : Given, F = 10 Newton
Acceleration (a) = 2 m/s^2
The mass of the body = ?

$F = m \times a$

$10 = m \times 2$

$m = 5$ kg

2. If a force of 250 N acts on a body at rest, the momentum required is 125 kgm/s. The time for which the force acts on the body is

(a) 0.5 s (b) 0.2 s
(c) 0.1 s (d) 0.3 s

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Ans. (a) : Given that,
F = 250 N
Change in momentum = Impulse (ΔP) = 125 Kgm/s

$\Delta t = ?$

$\Delta P = F \times \Delta t$

$\Delta t = \frac{\Delta P}{F}$

$\Delta t = \frac{125}{250}$

$\Delta t = 0.5$ sec

3. Two spheres of masses m and M are situated in air and the gravitational force between them is F. The space between the masses is now filled with a liquid of specific gravity 3. The gravitational force will now be

(a) F/3 (b) F/9
(c) 3F (d) F

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Ans. (d) : Gravitational force is given by

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

Clearly the Gravitational force is dependent only on mass of objects and distances between them. It does not depend on any medium between them. Hence, the force will remain same i.e. F.

4. If three particles, each of mass M are placed at the three corners of an equilateral triangle of side a , the force exerted by this system on another particle of mass M placed at the midpoint of a side is

(a) $4GM^2/2a^2$ (b) $4GM^2/3a^2$
(c) $2GM^2/3a^2$ (d) $2GM^2/5a^2$

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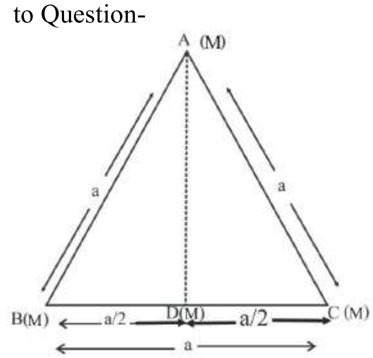
Ans. (b) : We know that,

$$\left[F = \frac{GM_1M_2}{R^2}\right]$$

According to Question-



The gravitational force at D due to A is

$F_{AD} = \frac{GMM}{AD^2}$

Now,
$AC^2 = AD^2 + DC^2$

$$(a)^2 = (AD)^2 + \left(\frac{a}{2}\right)^2$$

$$a^2 - \frac{a^2}{4} = AD^2$$

$$\boxed{\frac{3a^2}{4} = AD^2}$$

Then,

$$\boxed{F_{AD} = \frac{4GM^2}{3a^2}}$$

5. The quantity of motion of a body is best represented by

(a) Its velocity
(b) Its speed
(c) Its mass
(d) Its linear momentum

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Ans. (d) : ⇒ The quantity of motion of a body is best represented by 'its linear momentum'.

$$\boxed{P = m \times V}$$

Where,
P = Momentum
m = Mass
V = Velocity

6. A spring when compressed by 4 cm has 2 J energy stored in it. The force required to extend it by 8 cm will be

(a) 2 N (b) 20 N
(c) 2000 N (d) 200 N

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Ans. (d) : Energy stored in a spring is given by,

$$E = \frac{1}{2}Kx^2$$

Where K is spring constant and x is compression/ expansion of spring

$$E = \frac{1}{2} \times K \times x^2$$

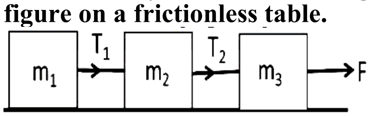
$$2 = \frac{1}{2} \times K \times 16 \times 10^{-4}$$

$$K = \frac{4}{16 \times 10^{-4}} = 2500\,N/m$$

Now force required to extend it by 8 cm is

$$F = Kx = 2500 \times 8 \times 10^{-2} \Rightarrow \boxed{F = 200N}$$

7. Three blocks of masses m_1, m_2 and m_3 are connected by mass less strings as shown in figure on a frictionless table.



They are pulled with a force F = 40 N. If m_1 = 10 kg, m_2 = 6 kg and m_3 = 4 kg then tensions T_2 will be

(a) 20 N (b) 40 N
(c) 10 N (d) 32 N

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Ans. (d) : Given,

F = 40N
m_1 = 10 kg, m_2 = 6 kg, m_3 = 4 kg

We know that,
F = ma

Total mass of the system
$m = m_1 + m_2 + m_3$
= 10 + 6 + 4
= 20 kg

Then,
Total acceleration of the system

$$40 = 20 \times a \Rightarrow \boxed{a = 2m/s^2}$$

Now,
Tension T_2 will be,
$T_2 = (m_1 + m_2)\, a = (10+6) \times 2$
$T_2 = 16 \times 2$

$$\Rightarrow \boxed{T_2 = 32N}$$

8. Which of the following force is conservative?

(a) Frictional force (b) Air resistance
(c) Electrostatic force (d) Viscous force

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Ans. (c) : A conservative force is one for which the work done is independent of path.
For example - Gravity force, Electrostatic force.
The electrostatic force is an attractive as well as repulsive force caused by the electric charge particles. It is also known as Coulomb's force.

9. A man weighs 'W' on the surface of earth and his weight at a height '2R' from surface of earth is (R is the Radius of earth).

(a) $\frac{w}{9}$ (b) $\frac{w}{6}$
(c) w (d) $\frac{w}{3}$

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Ans. (a) : $g = \frac{GM}{R^2}$ [given h = 2R]

$$g' = \frac{GM}{(R+h)^2}$$

$$g' = \frac{GM}{(R+2R)^2} = \frac{GM}{(3R)^2} = \frac{GM}{9R^2} = \frac{g}{9}$$

w = mg
w' = mg'

$$w' = \frac{mg}{9}$$

$$\boxed{w' = \frac{w}{9}}$$

10. A bullet of mass 0.05 kg is moving with a speed of 90 m/s and hits a heavy wooden block. The bullet enters the block and stops at a depth of 30 cm. Then the average force exerted by the wooden block on the bullet to resist the motion is

(a) 675 N (b) 150 N
(c) 250 N (d) 270 N

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Ans. (a) : Given that,

Mass(m) = 0.05 kg

Initial speed (u) = 90m/sec

Travelling distance (s) = 30 cm = $\frac{30}{100}$ m

Finally the bullet comes to rest after travelling some distance i.e. Final velocity (v) = 0

From 3rd equation of motion :

$v^2 - u^2 = 2as$

Put the value in above equation

$$0 - (90)^2 = \frac{2 \times a \times 30}{100}$$

$$-8100 = \frac{3a}{5}$$

$$a = \frac{-8100 \times 5}{3}$$

$a = -13500$ m/sec^2

Negative sign shows that it is retardation,

$a = 13500$ m/sec^2

Force = mass × acceleration

= 0.05 × 13500

= 675N

11. Two wires, A and B, of same material and length are stretched by applying the same load. If the diameter of wire A is twice that of wire B, then the ratio of the extensions produced in the wires by applying the same load will be

(a) 1 : 2 (b) 2 : 1

(c) 1 : 4 (d) 1 : 1

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Ans. (c) : Given that,

Diameter of A = 2× diameter of B

Let diameter of B = d,

So,

diameter of A = 2d

Change in length $(\Delta\ell) = \frac{F.\ell}{\gamma.A}$

Where, F = Force or load

ℓ = original length

γ= Young's modules

A = cross section area

From the questions,

The force, original length (ℓ) and young's modulus is same for both wire.

So,

Change in length of wire A, $(\Delta\ell)_A = \frac{F.\ell}{\gamma.A}$

$(\Delta\ell)_B = \frac{F.\ell}{\gamma.A'}$

Area of wire $B_A(A') = \frac{\pi(2d)^2}{4}$

Area of wire A(A) = $\frac{\pi d^2}{4}$

Put the value of Area of wire A and B

So, $$\frac{(\Delta\ell)_A}{(\Delta\ell)_B} = \frac{\dfrac{F\ell}{\gamma\frac{\pi}{4}(2d)^2}}{\dfrac{F.\ell}{\gamma\frac{\pi}{4}d^2}}$$

ratio = $\frac{(\Delta\ell)_A}{(\Delta\ell)_B} = \frac{1}{4}$

12. Moment of inertia of a thin circular ring of mass M and R rotating about an axis, passing through its centre and perpendicular to the plane is

(a) MR^2 (b) $MR^2/4$

(c) $MR^2/2$ (d) $(2/5)\ MR^2$

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Ans. (a) : Given, the mass of the circulating ring is 'M' and radius 'R'.

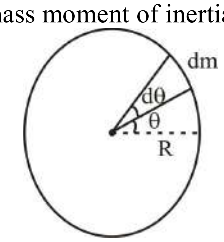
We take elementary unit section of the ring

$$dm = \frac{M}{2\pi R}$$

So, $dI = dm(R)^2 \qquad \because I = mr^2$

$$dI = \frac{M}{2\pi R}.R^2$$

Integrating the mass moment of inertia



$$\int dI = \int \frac{M}{2\pi R}.R^2.dx$$

$$I = \frac{M}{2\pi}.R\int_0^{2\pi R} dx$$

$$= \frac{M}{2\pi}.R(2\pi R - 0)$$

$I = MR^2$

13. Which of the following will not exist for a liquid in a gravity – free space

(a) Viscosity (b) Surface tension

(c) Upward thrust (d) Pressure

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Ans. (c) :

Upward thrust is defined as the force that is exerted on an object by the fluid when the object is submerged. It is also called as buoyant force. It always acts upwards. It always acts against the weight of an object.

$F_{buoyant} = \rho \times g \times V$

Where, ρ = density of fluid

g = acceleration due to gravity

V = volume of fluid

In gravity free space,

$F_{buoyant} = 0$

That is upward thrust will not exist in a gravity free space.

Viscosity : The property of a fluid which opposes the relative motion between the layer is called viscosity.

Surface tension : It is a property of liquids characterized by the surface molecules tendency to shrink into a lower surface area as a result of bulk force from inner molecules.

$$\text{surface tension} = \frac{\text{force}}{\text{length}}$$

Pressure : Fluid pressure is a measurement of the force per unit area on an object in the fluid or on the surface of a closed container.

• Viscosity, surface tension and pressure does not depends on the gravity.

14. Two objects A and B of masses 4 kg and 6 kg are acted upon by the forces F_1 and F_2 required to accelerate them at 7 m/s^2 and 4 m/s^2 respectively. Which of the following relationships between the force F_1 and F_2 holds true for the required purpose?

(a) $F_1 > F_2$ only
(b) $F_1 = F_2$
(c) $F_1 < F_2$ or $F_1 > F_2$, depending on the mass density of the material of the objects.
(d) $F_1 < F_2$ only

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Ans. (a) : Given that,
Mass (m_1) = 4 kg
Mass (m_2) = 6 kg
Acceleration (a_1) = 7 m/sec^2
Acceleration (a_2) = 4m/sec^2
We know that,
Force (F) = Mass (m) × Acceleration (a)
So,

$$F_1 = m_1 \times a_1 = 4 \times 7 = 28\text{ N}$$

$$F_2 = m_2 \times a_2 = 6 \times 4 = 24\text{N}$$

Relationship between the force = $F_1 > F_2$.
So option (a) is correct.

15. Dirt can be removed from a carpet by shaking it vigorously for some time in process that is based on

(a) Second law of motion
(b) Both third and second laws of motion
(c) Third law of motion
(d) First law of motion

RRB ALP CBT II Physics & Maths 22 .01.2019 Shift III

Ans. (d) :

- Newton's first law of motion also known as the law of inertia. The property of inertia is the property of a body that causes it to tend to stay in a steady state of motion or at rest unless an external force is applied to the body.
- When a carpet is shaken with a stick the material of the carpet moves in forward and backward directions. The dust particles on the carpet tend to remain at rest due to their property of inertia. Since the dust particles get separated from the carpet because they are still at rest, they fall under the force of gravity. Thus it is based on the first law of motion.

16. What is the relative density of a solid of mass 50 gm which when fully immersed in water weighs 10 gm?

(a) 0.8 (b) 1.25
(c) 2.5 (d) 5

RRB ALP & Tech. 23.01.2019 Shift-I

Ans : (b)
Mass of solid = 50 gram
Decrease in weight of solid = 50-10 = 40 gram
density of water = 1 gm/cc
Volume of solid = 40 cc

Hence, the density of solid $= \frac{\text{Mass}}{\text{Volume}} = \frac{50}{40} = 1.25$ gm/cc

$$\text{relative density} = \frac{\text{density of solid}}{\text{density of water}} = \frac{1.25}{1} = 1.25\text{ gm/cc}$$

17. Find the length (in cm) of the edge of a cube of a piece of wood which weighs 80 N. (Use g = 10 m/s^2, density of wood = $1g/cm^3$)

(a) 60 (b) 20
(c) 80 (d) 40

RRB ALP & Tech. 23.01.2019 Shift-I

Ans : (b) Let the side of cubical piece = a
Volume = a^3
Force = 80 N
g = $10m/s^2$
density (ρ) = $1g/cm^3 = 1000\text{ kg/m}^3$
Force = m × g
80 = m × 10
m = 8 kg

$$\text{density}(\rho) = \frac{\text{m (mass)}}{\text{v (volume)}}$$

$$1000 = \frac{8}{v}$$

$$V = \frac{8}{1000}$$

$$(a)^3 = \frac{8}{1000}$$

$$a = \frac{2}{10}\text{ m}$$

$$a = \frac{2}{10} \times 100\text{ cm}$$

$$\boxed{a = 20\text{ cm}}$$

18. Find mass of an iron cube of side 2 cm. (Density of iron is 7.8 gm/cm^3)

(a) 15.6gm (b) 3.9gm
(c) 0.975gm (d) 62.4gm

RRB ALP & Tech. 23.01.2019 Shift-I

Ans : (d) Volume of iron cube = 2 × 2 × 2 = 8 cm^3
Mass of cube = volume × density
= 8 × 7.8
= 62.4 gm

19. An object with greater———has greater inertia

(a) Acceleration (b) Mass

(c) Velocity (d) Volume

RRB ALP & Tech. 23.01.2019 Shift-I

Ans : (b) Inertia is depend on the mass of the object Hence, an object with greater mass has greater inertia.

20. Acceleration due to gravity on moon is 1/6th that on earth. How would an astronaut weigh on moon if he weight 90 kgf on earth? (acceleration due to gravity on earth = $10m/s^2$)

(a) 9N (b) 90N

(c) 150N (d) J15

RRB ALP & Tech. 23.01.2019 Shift-I

Ans : (c) Mass (m) = 90 kg

acceleration due to gravity = 10 m/sec^2

Astronaut weight on earth,

W = m × g

= 90 × 10

= 900 N

$$\text{Weight on moon} = \frac{1}{6} \times \text{weight on earth}$$

$$= \frac{1}{6} \times 900$$

= 150 N

21. Acceleration due to gravity on Jupiter is two and a half times that on earth. How much would a 250 kg satellite weight (in N) on Jupiter? (acceleration due to gravity on earth = $10m/s^2$)

(a) 6250 (b) 10

(c) 625 (d) 100

RRB ALP & Tech. 23.01.2019 Shift-II

Ans : (a) Mass on earth (m) = 250 kg

Acceleration due to gravity (g) = 10 m/s^2

Weight on earth (w) = m × g

= 250 × 10

= 2500 N

$$\text{Weight on Jupiter} = \frac{5}{2} \times 2500 = 6250 \text{ N}$$

22. A block of metal of mass 500 g has a relative density of 2.5. What will be its apparent mass when it is fully immersed in water?

(a) 250g (b) 300g

(c) 200g (d) 400g

RRB ALP & Tech. 23.01.2019 Shift-II

Ans : (b) Actual mass = 500

relative density = 2.5

apparent mass = ?

$$\text{Relative density} = \frac{\text{Actual mass}}{\text{Actual mas - appearant mass}}$$

$$2.5 = \frac{500}{500 - x}$$

2.5 (500–x) = 500

1250 – 2.5x = 500

2.5x = 1250 – 500

$$x = \frac{750}{2.5}$$

$\boxed{x = 300g}$

23. A uniform meter scale weights 50g. It is pivoted at the 70cm mark. Where should a 40 g mass be placed so that the scale is in equilibrium?

(a) At the 45 cm mark (b) At the 25 cm mark

(c) At the 95 cm mark (d) At the 5 cm mark

RRB ALP & Tech. 23.01.2019 Shift-II

Ans : (b) In equilibrium condition :-

$\sum m = 0$

40 × x = 20 × 50

$$x = \frac{20 \times 50}{40}$$

x = 25 cm

24. Find the mass (in kg) of a tank completely filled with kerosene of dimensions 5m × 2m × 1m (Density of kerosene is 800 kg/m^3)

(a) 8000 (b) 1250

(c) 800 (d) 12500

RRB ALP & Tech. 23.01.2019 Shift-II

Ans : (a) $\text{density} = \frac{\text{Mass}}{\text{Volume}}$

∴ mass = density × volume

mass of kerosene = 800 × 5 × 2 ×1 = 8000 kg

25. Acceleration due to gravity is highest at_____.

(a) the poles (b) the equator

(c) at an infinite distance from the earth

(d) the center of the earth

RRB ALP & Tech. 23.01.2019 Shift-II

Ans : (a) Acceleration due to gravity (g) is highest at the poles. As the distance decreases from the centre g decrease and vice – versa.

26. Find the density (in kg/m^3) of a piece of wood measuring 6cm×8cm×5cm and weighing 1.92N ($g = 10m/sec^2$)

(a) 3000 (b) 300

(c) 8000 (d) 800

RRB ALP & Tech. 23.01.2019 Shift-II

Ans : (d) Given that,

Volume (V) = 6 cm × 8 cm × 5 cm

$$= \frac{240}{1000000} = \frac{24}{100000} m^3$$

Weight (W) = 1.92 N

(g) = 10 m/s^2

w = mg

1.92 = m × 10

$$m = \frac{1.92}{10}$$

m = 0.192 kg

$$(\text{density})\ (d) = \frac{\text{mass(m)}}{\text{volume(v)}} = \frac{0.192}{\frac{24}{100000}}$$

$$(d) = \frac{0.192 \times 100000}{24} = \frac{19200}{24} = 800 \text{ kg/m}^3$$

27. Find the length of the edge of a metal cube of density 8 g/cm^3 which weight 17.28 kN. (Use $g = 10 m/s^2$)

(a) 9 cm (b) 8 cm

(c) 10 cm (d) 6 cm

RRB ALP & Tech. 08.02.2019 Shift-I

Ans : (d) : volume $= \frac{\text{mass}}{\text{density}}$

Volume of cube $= \frac{17.28\times10^3}{10\times8} = 216\text{cm}^3$

$\because$ Volume of cube $= a^3$ (a = side of cube)

$a^3 = 216\text{ cm}^3$

$a = (216)^{\frac{1}{3}}$ cm = 6 cm

28. Two children of 24 kg and 16 kg sit on one side of a see-saw at a distance of 1 m and 0.625 m respectively, from the fulcrum. If a body of 'm' kg sits on the other side of the see-saw at a distance of 1.6 m from the fulcrum and the see-saw is in equilibrium. Find m.

(a) 21.25 kg (b) 32.25 kg
(c) 27.75 kg (d) 36.75 kg

RRB ALP & Tech. 08.02.2019 Shift-I

Ans : (a) : Since, the children of 24kg and 16kg are sitting on the one side and one child of mass 'm' is sitting on another side of mass 'm'. Therefore in equilibrium position -

$(24\times1) + (16\times0.625) = m\times1.6$

$24 + 10 = m \times 1.6$

$m = \frac{34}{1.6}$

m = 21.25 kg

Hence, the weight of the child sitting on the other side will be 21.25kg.

29. The gravitational acceleration is ______m/s^2 at the equator.

(a) 9.87 (b) 9.72
(c) 9.78 (d) 9.83

RRB ALP & Tech. 08.02.2019 Shift-I

Ans : (c) : The acceleration due to gravity at the equator is 9.78 m/sec. The diameter of the earth at the equator is approximately 12,756 km. The equator divides the earth into the Northern Hemisphere and southern hemisphere.

30. Acceleration due to gravity on Mars is 1/3rd that on earth. How much would an astronaut weight on Mars if he weighs 72 kg on earth? (Acceleration due to gravity on earth = 10 m/s^2)

(a) 720 N (b) 240 N
(c) 120 N (d) 360 N

RRB ALP & Tech. 08.02.2019 Shift-I

Ans: (b) : Weight on earth $(W_1) = 72$ kg

Acceleration due to gravity (g) $= 10\ m/s^2$

Gravity on mars (g) $= g/3$

$= \frac{10}{3}\ m/s^2$

$g' = \frac{g}{3} = \frac{72}{3} = 24$ kg

Weight on mars $= 24\times10 = 240$ N

31. What is the relative density of a solid of mass 75 gm which when fully immersed in water weighs 25 gm?

(a) 1.5 (b) 0.8
(c) 1.6 (d) 2.5

RRB ALP & Tech. 08.02.2019 Shift-I

Ans : (a) :
Weight of solid = 75 gm
Weight of solid on sinking = 25 gm
Amount of water displaced by solid (75-25) = 50 gm

$\text{relative density} = \frac{\text{mass of solid}}{\text{amount of water displaced by solid}}$

$= \frac{75}{50} = \frac{3}{2} = 1.5$

32. The effort done to shift a load is 15 units and the work done by the machine is 3. Then find the weight.

(a) 45unit (b) 3unit
(c) 5 unit (d) 15 unit

RRB ALP & Tech. 23.01.2019 Shift-III

Ans : (a) The effort done to shift a load is 15 units and the work done by the machine is 3 units. The weight will be 45 unit.

33. If the specific gravity of a body is less than 1, it will float on ___.

(a) Water (b) Liquid
(c) Mercury (d) Air

RRB ALP & Tech. 23.01.2019 Shift-III

Ans : (a) If specific gravity comes out to be less than one. It simply means that it is less than dense than water. Hence, it will float on water, And if the value is more than one, it means it is denser than water and it would sink in water.

34. The volume of a certain amount of water between 0°C to 4°C is ____.

(a) Increases (b) Decreases
(c) Remains constant (d) Zero

RRB ALP & Tech. 23.01.2019 Shift-III

Ans : (b) The density of water is highest at 4°C and the volume is least. The volume of water increase when is heated or cooled at a temperature higher or lower than 4°C. Thus, volume of given amount of water decrease between 0°C and 4°C while it increase above 4°C.

35. If a body is not homogeneous, then its density is a function of its ____.

(a) Pressure (b) Position
(c) acceleration (d) velocity

RRB ALP & Tech. 23.01.2019 Shift-III

Ans : (b) If a body is not homogeneous, then its density is a function of its position. The density of a substance is equal to mass per unit volume. The density of a homogeneous material is equal at all points on an object.

36. It is mainly due to the gravitational effect of the ____ on the rotating earth that the level of water in the sea rises and falls.

(a) Moon (b) Venus
(c) Mercury (d) Sun

RRB ALP & Tech. 23.01.2019 Shift-III

Ans : (a) The rise and fall of sea level is mainly due to the gravitational effect of the moon on the rotating earth.

37. **An object weighs X units on the earth. If we take the same object to the moon, its weight there will be........**
(a) more than X (b) equal to X
(c) less than X (d) zero
RRB ALP & Tech. 23.01.2019 Shift-III

Ans : (c) The value of acceleration due to gravity on the moon is $\frac{1}{6}$ of the acceleration due to gravity on the earth. If the weight of the object is x unit on the earth than weight of the object on the moon is $\left(w = \frac{m \times g}{6}\right)$ decreases by $\frac{x}{6}$ unit. Hence, if we take the same object to the moon, its weight decrease.

38. **A block of wood floats on water, with 65% of its volume under water. Its density (in kg/m^3) is approximately.**
(a) 0.55×10^3 (b) 0.35×10^2
(c) 0.25×10^2 (d) 0.65×10^3
RRB ALP & Tech. 22.01.2019 Shift-I

Ans : (d) Total volume of wood = 100%
Volume of wood immersed in water = 65%
Density of water = 1000kg/m^3
Density of wood = x = ?

$$\frac{\text{Volume of wood immersed in water}}{\text{Total Volume of wood}} = \frac{\text{Density of wood}}{\text{density of water}}$$

$$\frac{65}{100} = \frac{x}{1000}$$

$x = 650$ kg/m^3
$x = 0.65 \times 10^3$ kg/m^3

39. **The density of fresh water is_____ the density of salt water :**
(a) less than (b) more than
(c) negligible compared with
(d) equal to
RRB ALP & Tech. 22.01.2019 Shift-I

Ans: (a) When salt is dissolved in fresh water the density of water increase due to the increase in the mass of the water therefore, the density, of fresh water is less than the density of salt water.

40. **The mass density or density of a material is defined as its _________.**
(a) mass per unit volume
(b) mass per unit length
(c) mass per unit area
(d) mass per ampere
RRB ALP & Tech. 22.01.2019 Shift-I

Ans : (a) Density $= \frac{\text{mass}}{\text{volume}}$
Density is scalar quantity. Unit of density is kg/m^3.

41. **Let W_e and W_m be the weight of an object on the Earth and the Moon, respectively. Then, the ratio W_e/W_m is equal to ________.**
(a) 2 (b) 1
(c) 6 (d) 4
RRB ALP & Tech. 22.01.2019 Shift-I

Ans : (c) Let, mass of object = m
Weight on earth surface = $W_e = m\times g$
Weight on moon surface = $W_m = m\times\frac{g}{6}$

$$\frac{W_e}{W_m} = \frac{m\times g}{m\times\frac{g}{6}}$$

$$\frac{W_e}{W_m} = 6$$

42. **The relative density of gold is 19.3. Its density in SI unit is:**
(a) 19.3 kg/m^3 (b) 19.3×10^3 kg/m^3
(c) 1.93×10^2 kg/m^3 (d) 19.3×10 kg/m^3
RRB ALP & Tech. 22.01.2019 Shift-II

Ans : (b) Relative density of gold = 19.3

$$\text{relative density} = \frac{\text{density of object}}{\text{density of water}}$$

density of gold = relative density × density of water gold.
$= 19.3\times1000$
$= 19300$ kg/m^3
$= 19.3\times10^3$ kg/m^3

43. **If an object has a mass of 100 kg on Earth, what would be its mass on the Moon?**
(a) 980 kg (b) 100 kg
(c) 0 kg (d) 16.7 kg
RRB ALP & Tech. 22.01.2019 Shift-II

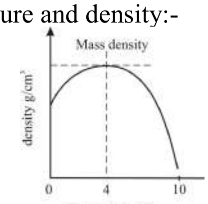
Ans : (b) : If an object has a mass of 100 kg on earth, then its mass on the moon is 100 kg i.e. remains same.
Weight = mass × gravity
$\boxed{W = mg}$

44. **The Ideal-gas equation is ____.**
(a) $P/VT = \mu R$ (b) $T/PV = \mu R$
(c) $PV/T = \mu R$ (d) $PV/T = (1/\mu)R$
RRB ALP & Tech. 22.01.2019 Shift-II

Ans : (c) : Ideal gas equation:-
$PV = \mu RT$ _______ equ.(i).
Where,
P = atmospheric pressure
V = volume
μ = mole of the gas
R = Gas constant
T = Temperature
equ. (i) $\Rightarrow \frac{PV}{T} = \mu R$

45. **Water has the maximum density at ___°C.**
(a) 4 (b) 22
(c) 2 (d) 0
RRB ALP & Tech. 22.01.2019 Shift-II

Ans : (a) : Water has maximum density at 4°C. Graph between temperature and density:-



46. **Consider a planet whose mass and radius both are one half to that of Earth. An object of weight W on Earth will weigh ____ on that planet.**
(a) W/2 (b) 2W
(c) W/4 (d) W
RRB ALP & Tech. 22.01.2019 Shift-II

Ans : (d) : There will be no change in the mass of object. only the weight will change due to gravitational acceleration. The mass of the object remain unchanged.

47. **A cubical block of side 10 cm and with a mass of 600 g floats in water. How much of the cube is submerged?**
(a) 30% (b) 40%
(c) 60% (d) 50%
RRB ALP & Tech. 22.01.2019 Shift-II
RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (c) : Side of cube = 10 cm
Volume of cube = $(10)^3 = 1000\ cm^3$
Mass of cube = 600 g = 0.6 kg
density of cube (d) = m/V

$$= \frac{600}{1000} = 0.6 g/cm^3$$

Percentage of immersed cube in water
= 0.6×100= 60%

48. **The actual weight of a person is determined by his:**
(a) Mass and the acceleration due to gravity
(b) Mass
(c) Mass and width
(d) Mass and height
RRB ALP & Tech. 22.01.2019 Shift-II

Ans : (a) : The actual weight of a person is:-
Weight = mass of object × gravity

$$\boxed{W = mg}$$

49. **The acceleration due to gravity on the Moon is (1/6) of that on the Earth. Hence, an object weighing 12 N on the Earth will weigh .... on the Moon.**
(a) 6 N (b) 72 N
(c) 2 N (d) 12 N
RRB ALP & Tech. 21.01.2019 Shift-I

Ans : (c) : Weight of body on the earth (W) = 12N
Weight of body on the moon

$$= \frac{1}{6} \times W$$

$$= \frac{1}{6} \times 12N$$

$$= \boxed{2N}$$

50. **Identify the variable from below that does not describe the behaviour of a gas.**
(a) Temperature (b) Volume
(c) Pressure (d) Time
RRB ALP & Tech. 21.01.2019 Shift-I

Ans : (d) : Ideal gas equation is –
PV = nRT
Where, P = atmospheric pressure
V = Volume
n = no. of moles
R = Gas constant
T = Temperature
Hence, time is not describe the behaviour of gas.

51. **The density of an ideal gas can be doubled by halving the :**
(a) Absolute temperature (b) Velocity
(c) Mass (d) Pressure
RRB ALP & Tech. 21.01.2019 Shift-I

Ans : (a) : From ideal gas equation :-
PV = nRT

$$P = \frac{n}{V} RT$$

$$P = \frac{\rho}{M} RT$$

$$\rho = \frac{MP}{RT} \quad \ldots\ldots(eq^n(i))$$

From eq^n (i), It is clear that the density of an ideal gas can be doubled by halving the temperature.

52. **An object of a specific mass will weigh -**
(a) more on earth than on the moon
(b) same on both earth and moon
(c) less on the earth than on the moon
(d) zero on the earth
RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (a) We know that
W = mg ... eq(i)

On the moon, $g' = \frac{g}{6}$ ...eq(ii)

From equation(i), it is clear that the weight is directly proportional to the acceleration due to gravity.
From equation (ii) and equation (i) it is clear that the weight on the surface of earth is more than that on the Moon's surface.

53. **The density of ice is ———— compared to the density of water.**
(a) Equal (b) Negligible
(c) Less (d) More
RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (c) The density of ice is less compared to the density of water. Ice has low density than water because it has a cage like structure. In this structure, a lot of vacant spaces are left when water molecules linked in ice.

54. **The mass of an object is a numerical measure of its ————.**
(a) Velocity (b) Gravity
(c) Inertia (d) Acceleration
RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (c) The tendency of an object to resist changes in its state of motion varies with mass is called inertia of an object, Inertia is basically a measure of the mass of the body.

55. **The apparent mass of a piece of metal when fully immersed in water is 60 gm. If the relative density of this metal piece is 2.5, find its actual mass (in gm)?**
(a) 300 (b) 40
(c) 400 (d) 100
RRB ALP & Tech. 21.01.2019 Shift-II

Ans : (d) : Given : relative density = 2.5
Apperant mass = 60 gram
Actual mass = x

$$\text{relative density} = \frac{\text{Actual Mass}}{\text{Actual Mass} - \text{Appearant Mass}}$$

$$2.5 = \frac{x}{x-60}$$

$$\frac{5}{2} = \frac{x}{x-60}$$

$5x - 300 = 2x$
$3x = 300$
$x = 100$ gram

56. Find the volume (in cm^3) of a piece of metal of density 5000 kg/m^3 and which weights 10.8 N. (Use g = 10 m/s^2)
(a) 21.6 (b) 216
(c) 540 (d) 54

RRB ALP & Tech. 21.01.2019 Shift-II

Ans : (b) : Given : density (d) = 5000kg/m^3
Weight (W) = 10.8 N
Gravitation (g) = 10m/sec^2

$W = mg$
$10.8 = m \times 10$

$$m = \frac{108}{100} =$$

$m = 1.08$ kg

$$d = \frac{m}{V}$$

$$V = \frac{m}{d} = \frac{1.08}{5000} m^3$$

$$V = \frac{1.08}{5000} \times 10^6 cm^3 \ [\because 1m = 100cm]$$

$= 216\ cm^3$

57. A body of mass 60 kg weight 222 N on Mars. What is the acceleration due to gravity (in m/s^2) on Mars?
(a) 4.9 (b) 13.32
(c) 19.8 (d) 3.7

RRB ALP & Tech. 21.01.2019 Shift-II

Ans : (d) : Given,
m = 60 kg
W = 222 N
g = ?
From W = mg

$$g = \frac{W}{m}$$

$$g = \frac{222}{60}$$

$g = 3.7m/sec^2$
Hence, on the mars acceleration due to gravity will be $3.7m/sec^2$.

58. The weight of the object appears on one pan of a faulty scale as W_1 and on the other pan as W_2. True weight of the object-
(a) (W_1+W_2) (b) $\frac{W_1 + W_2}{2}$
(c) $\sqrt{W_1 \times W_2}$ (d) $W_1 \times W_2$

RRB Asst. Loco Pilot/Technician (Ahmedabad)-2014

Ans. (c) : According to the question, it the weight of an object is W in one pan of an defective scale and W_2 on the other pan, then the correct weight of the object is equal to the geometrical mean of W_1 and W_2.
i.e

$$W = \sqrt{W_2 \times W_2}$$

59. On the placing of body successively in the pans of a faulty balance. whose sides are unequal, its weight appeared to be 6.4 grains and 10 grams. The correct weight of the body is –
(a) 10 gm (b) 14 gm
(c) 8.2 gm (d) 8 gm

RRB Asst. Loco Pilot/Technician (Ranchi)-2014

Ans. (d): Actual weight $= \sqrt{W_1 \times W_2}$
$= \sqrt{6.4 \times 10}$
= 8 gram.

60. A wooden plank can rotate on a horizontal axis fixed in the middle. A child of mass 20 kg sits on one side the axis at a distance of 1.5m from the axis and on the other side another child of weight 16 kg sits at a distance of 2.0 m from the axis, then which boy will rise.
(a) 20 kg-weight (b) 16 kg-weight
(c) None of these (d) both (a) and (b)

RRB Asst. Loco Pilot/Technician (Kolkata)-2014

Ans. (a) : The child whose torque is less about the middle point of the frame will rise up. the torque of the 20W boy is 20 × 1.5, less then the torque (16 × 2 = 32) of the 16 W boy. therefore, 20W boy will rise up.

61. In comparison to the measurement of the surface of the Earth, those on top of Mr. Everest demonstrate :
(a) decrease in weight with mass remaining the same
(b) increase in the mass with weight remaining the same
(c) decrease in both mass and weight
(d) increase in both mass and weight

RRB SSE Secundrabad (Shift-I), 01.09.2015

Ans. (a) : The mass of a system is always a constant, i.e same in each case but the value of g decrease on going above or below the surface of the earth. The weight of an object always depends on the acceleration due to gravity (g). Hence the weight of the object decrease at the height but mass remains the same.

62. If two liquids of same mass and densities D_1 and D_2 are mixed then density of mixture-
(a) $\frac{D_1 + D_2}{2}$ (b) $\frac{D_1 D_2}{D_1 + D_2}$
(c) $\frac{2D_1 D_2}{D_1 + D_2}$ (d) $\frac{D_1 + D_2}{D_1 D_2}$

RRB Kolkata Chemical & Metallurgical Er., 01.12.2002

Ans. (c) : Density of mixture (D) = $\frac{\text{Total mass(m)}}{\text{total volume(V)}}$

$$= \frac{m+m}{\frac{m}{D_1}+\frac{m}{D_2}}$$

$$D = \frac{2D_1D_2}{D_1+D_2}$$

63. The mass of an object is 100kg. If acceleration due to gravity on the moon is $\frac{1}{6}$ then mass of an object on the surface of the moon will be –

(a) 100/6 kg (b) 60 kg
(c) 100 kg (d) 600 kg

RRB Bangalore Section Engineer (Civil) 01.02.2009

Ans. (c) Mass always remains constant. Therefore the mass on the moon will be only 100 kg.

64. It is easier to swim in the sea than in the river because –

(a) Sea water is deep
(b) Density of sea
(c) Water keep rising in the ocean
(d) The density of water in the sea is less

DMRC Mechanical Engineering, 18.02.2017

Ans. (b) : It is easier to swim in the sea than in the river because the density of sea water is more in comparison to river.

65. The weight of an object is maximum

(a) on the equator
(b) on the surface of the earth
(c) at the centre of the earth
(d) on the poles of the earth

RRB Chandigarh Section Engineer (Civil), 26.02.2012

Ans. (d) : The weight of a body is maximum at the poles of the earth because the value of acceleration due to gravity is maximum at the poles while the weight of the body at the equator is minimum. The weight of the object at the centre of the earth is zero.

66. The weight of a body at the centre of earth is:

(a) half the weight at the surface
(b) infinite
(c) twice the weight at the surface
(d) zero

RRB Chandigarh Section Engineer (Mech.), 26.02.2012

Ans. (d) The weight of the object at the centre of the earth is zero because the value of accretion due to gravity is zero.

at centre $h = R_e$

$g' = 0$

The acceleration due to gravity at any depth is given as –

$$g_d = g\left(1-\frac{d}{R}\right)$$

Where, g_d = acceleration due to gravity at some depth.

d = depth from its surface.

at centre d = R

$$\boxed{g_d = 0}$$

$$W = mg_d$$

$$\boxed{W = 0}$$

67. The relative density of ice is 0.9 then what part of it will be above the water when it is put in water?

(a) 0.9 (b) 0.1
(c) zero (d) None of these

DMRC Electronics Engineering, 21.09.2014

Ans. (b) : Let volume of cube = $(1\times1\times1)$ cm^3

relative density of ice = 0.9

$$\frac{\rho_{ice}}{\rho_w} = \frac{x}{h}$$

$$\frac{0.9}{1} = \frac{x}{1}$$

$$x = 0.9 \text{ cm}$$

Therefore, 0.9 part of ice under the water and 0.1 cm part of ice above the water.

68. The weight of body in air is 30g and when immersed in water is 26.25g. The relative density of the material of the body is –

(a) $\frac{8}{9}$ (b) $\frac{8}{7}$
(c) 8 (d) 8g/cm^3

RRB Ranchi Signal Maintainer Group-III, 20.11.2005

Ans. (c) :

Relative density of substance = $\frac{\text{Wair}}{W_{air} - W_{water}}$

$$= \frac{30}{(30-26.25)}$$

$$= \frac{30}{3.75}$$

$$= 8$$

69. Two liquids which are equal to weight, are mixed, their density are ρ_1 and ρ_2 respectively. The density of mixture will be -

(a) $\frac{\rho_1+\rho_2}{2}$ (b) $\frac{2\rho_1\rho_2}{\rho_1+\rho_2}$
(c) $\frac{\rho_1+\rho_2}{\rho_1\rho_2}$ (d) $\frac{\rho_2-\rho_1}{2}$

RRB Allahabad Signal Maintainer-II, 22.01.2006

Ans. (b) : Let, weight of the liquids are W and volume are V_1 and V_2.

$$\text{density of mixture} = \frac{\text{total mass of maxture}}{\text{total volume of mixture}}$$

$$\frac{(M_1+M_2)}{(V_1+V_2)} = \frac{2M}{\frac{M}{\rho_1}+\frac{M}{\rho_2}} \begin{Bmatrix} \because W_1 = W_2 = W \\ \therefore M_1 = M_2 = M \end{Bmatrix}$$

$$= \frac{2}{\frac{1}{\rho_1}+\frac{1}{\rho_2}} = \frac{2}{\frac{\rho_1+\rho_1}{\rho_1\rho_2}}$$

$$\boxed{\text{Density of mixture} = \frac{2\rho_1\rho_2}{\rho_1+\rho_2}}$$

70. **A vessel has, mercury (density =13.6 g/cm^3) at the bottom and oil (density 0.8 g/cm^3) at the top. Half of the volume of a floating homogeneous sphere is immersed in mercury and half, in oil. The density (g/cm^3) of the material of the sphere.**

(a) 3.3 (b) 6.4 (c) 7.2 (d) 12.8

Delhi Metro Rail Corporation Train Operators', 14.09.2003

Ans. (c) : Density of substance of sphere $= \frac{\rho_{Hg} + \rho_{oil}}{2}$

$$= \frac{(13.6 + 0.81)}{2}$$

$$= \frac{14.4}{2} = 7.2$$

71. **The reading of spring balance when a block of air is suspended from it is 60 N. When the block is immersed in less volume in water. The reading of a balance changes to 40 N – the relative density of the block should be -**

(a) 3 (b) 2 (c) 6 (d) $\frac{3}{2}$

RRB Bangalore Material Superintendent, 21.11.2004

Ans. (a) : Relative density of block $= \frac{W_{air}}{W_{air} - W_{water}}$

$$= \frac{60}{(60-40)}$$

$$= \frac{60}{20} = 3$$

72. **A vessel is filled with oil of relative density 1.2 up to a height of 3cm and water is filled up to 10 cm above it. If the relative density of mercury is 13.6 then the bottom of the vessel will be.**

(a) Equal to 1 cm of Hg (b) Equal to 5 cm of Hg
(c) Equal to 13cm of Hg
(d) Equal to 15 cm of Hg.

RRB Trivandrum (Tech.), 09.11.1997

Ans. (a) : According to the question-

$\rho_{Hg}\, gh = \rho_{oil}\, gh_1 + \rho_{water}\, gh_2$

$13.6 \times gh = 1.2 \times g \times 3 + 1 \times g \times 10$

$13.6\ h = 3.6 + 10$

$h = \frac{13.6}{13.6}$

h =1 cm of Hg.

73. **Among four substance M_1, M_2, M_3 and M_4 of different masses having the same volume. Which substance will have the least density If $M_2 > M_3 > M_1 > M_4$ then.**

(a) M_1 (b) M_3 (c) M_4 (d) M_2

RRB Trivandrum (Tech.), 11.04.1999

Ans. (c): By formula, density $= \frac{\text{mass}}{\text{volume}}$

According to the question, given that $M_2 > M_3 > M_1 > M_4$ and volume is constant and by the formula M_4 has least density

74. **If the volume of four bodies of equal mass are V_1, V_2, V_3 and V_4 respectively then which body will have greater density if $V_4 > V_2 > V_3 > V_1$ then**

(a) V_2 (b) V_3
(c) V_1 (d) V_4

RRB Trivandrum (Tech.), 29.06.1999

Ans. (c) : By the formula-

density $= \frac{\text{mass}}{\text{volume}}$ ……………….(i)

(Mass is same for all bodies)
According to the equation (i), which body has less volume, has more density.
Hence, V_1 has density. (given: $V_4 > V_2 > V_3 > V_1$)

75. **What is density. of solid metals when hearted**

(a) Increases (b) Decreases
(c) Equal (d) None of these

RRB Kolkata (Tech.), 29.08.1999

Ans. (b) : When metals are heated, they expand due to which volume increase but mass remains constant by formula-

density $= \frac{\text{mass}}{\text{volume}}$

therefore, when metals are heated, their density decrease.

76. **Generally, the density of any liquid increases with increases temperature -**

(a) decrease (b) increase
(c) remains constant
(d) first increase and then decreases

RRB Kolkata Supervisor (P. Way), 20.02.2000

Ans. (a) : Generally, the density of a liquid decrease with increase in temperature. Because by increasing the temperature the volume of a liquid increase. But the mass remains constant.

77. **Whose density will be higher in the same quantity of viscous (thick) liquid and non-viscous liquid.**

(a) viscous (b) non-viscous liquid
(c) None (d) both (a) and (b)

RRB Mumbai Electrical/ Diesel Drivers', 03.06.2001

Ans. (a) : If the quantity of thick (viscous) and non-viscous liquid are equal then the no. of molecules in the viscous liquid will be more than the no. of molecules in the non-viscous liquid. Hence, the mass of the viscous (thick) liquid will also be more. The density will be higher than that of a viscous liquid.

78. **A body of a substance whose density is d is immersed in a liquid of density &, which completely sinks then -**

(a) $d > \rho$ (b) $\rho > d$
(c) $d = \rho$ (d) None of these

RRB Bhopal Section Engineer, 24.11.2002

Ans. (a) : If a body made of a substance is placed in a liquid and the body is completely submerged then the density of the body is greater than the density of the liquid. So, $d > \rho$

03. Speed and Velocity

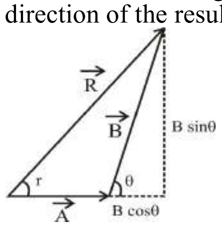
- **Scalars:-** Those physical quantity which require only magnitude but no direction for their complete representation are called Scalars. Ex- Distance, Speed, Work, Mass, Energy, Power, Temperature, Area, Volume, etc .
- **Vectors:-** A physical quantity which requires magnitude and direction both for representation. Ex.- Force, Displacements, Momentum, Acceleration, Velocity, Impulse, Pressure, Gravity , Electric flux, Weight, Torque.
- **Tensors-** A quantity that has different values in different direction is called Tensors.
  Tensors can be classified according to following order.

- **Zeroth-Order Tensors (Scalars):** Among some of the quantities that have magnitude but not direction are e.g.: mass density, temperature, and pressure.
- All scalars are isotropic zero- order tensor (a quantity that has only magnitude such as temperature, entropy or mass.
- **First-Order Tensors (Vectors):** Quantities that have both magnitude and direction e.g.: velocity, force. The first-order tensor is symbolized with a boldface letter and by and arrow at the top part of the vector, i.e.: $\vec{0}$.
- The isotropic first order tensor (vector) is zero vector.
- **Second-Order Tensors:** Quantities that have magnitude and two directions, e.g. stress and strain. The second-order and higher-order tensors are symbolized with a boldface letter.

Vector addition-

(i) Triangle law of vector addition -

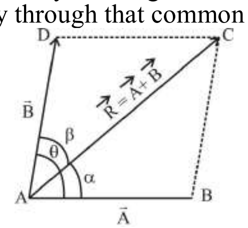
When two vectors are represented as two sides of the triangle with the order of magnitude and direction then the third side of the triangle represents the magnitude and direction of the resultant vector.



- $\vec{R} = \vec{A} + \vec{B}$

(ii) Parallelogram law of vector addition-

If two vectors are represented by two adjacent sides of a parallelogram which are directed away from their common point then their sum (i.e. resultant vector) is given by the diagonal of the parallelogram passing away through that common point.



$\overline{AB} + \overline{AD} = \overline{AC} = \vec{R}$ or $\vec{A} + \vec{B} = \vec{R}$

(a) Resultant of vectors A and B is given by -

$$R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$$

(b) If the resultant vector R subtend an angle β with vector B and angle α with vector A, then

$$\tan\alpha = \frac{B\sin\theta}{A + B\cos\theta} \;\&\; \tan\beta = \frac{A\sin\theta}{B + A\cos\theta}$$

Case1- If A=B then R= $2A\cos\frac{\theta}{2}$ & $\alpha = \frac{\theta}{2}$

Case2- If θ = 0° then , R_{max} = A+B

Case3- If θ = 180° then R_{min} = A-B

Vector subtraction-

Subtraction of vector B from a vector A is defined as the addition of vector =B (negative of vector B) to vector A. Thus, $\vec{A} - \vec{B} = \vec{A} + \left(-\vec{B}\right)$

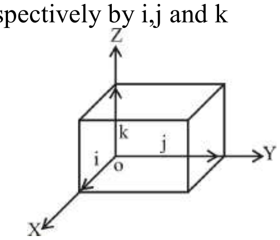
Rotation of a vector -

(i) If a vector is rotated through an angle θ, which is not an integral multiple of 2π the vector changes.

(ii) If the frame of reference is rotated or translated the given vector does not change, the components of a vector may change.

The rectangular unit vector-

It is an important set of unit vectors and are those vectors having the direction of the positive x,y and z axis of a three dimensional co-ordinate system and denoted respectively by i,j and k



Rectangular component-

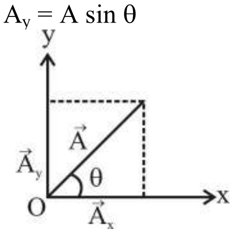
When a vector is resolved along two mutually perpendicular directions the components so obtained are called rectangular components of a given vector.

Rectangular components of a vector in a plane-

$\vec{A} = \vec{A}_x + \vec{A}_y$, $\vec{A} = A_x\hat{i} + A_y\hat{j}$

If $\vec{A}$ makes an angle θ with x-axis then-

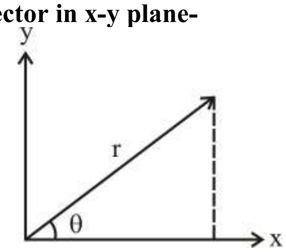
A_x = A cos θ A_y = A sin θ



- **Magnitude of vector -**

$$A = \sqrt{A_x^2 + A_y^2} \quad \tan\theta = \frac{A_y}{A_x} \Rightarrow \theta = \tan^{-1}\left(\frac{A_y}{A_x}\right)$$

- **General vector in x-y plane-**



$\vec{r} = x\hat{i} + y\hat{j}$

If $\vec{r}$ makes an angle θ with x-axis, then
x= r cos θ and y = r sin θ

$\vec{r} = r\left(\cos\theta\hat{i} + \sin\theta\hat{j}\right)$

■ The Dot or Scalar product -

The dot or scalar product of two vector is defined as the product of the magnitudes of A and B and the cosine of the angle θ between them.

$\vec{A}\cdot\vec{B} = |A||B|\cos\theta \qquad (0 \le \theta \le \pi)$

NOTE

- $\vec{A}\cdot\vec{B}$ is a scalar not a vector.
- $\vec{A}\cdot\vec{B}$ is +ve if θ is acute.
- $\vec{A}\cdot\vec{B}$ is –ve if θ is obtuse.
- $\vec{A}\cdot\vec{B}$ is zero if θ is right angle.

Example of dot product-

- Work (W) = $\vec{F}.\vec{d} = F\,d\cos\theta$ Where, F → Force, d → Displacement
- Power (P) = $\vec{F}.\vec{v} = F.v\cos\theta$ Where, F → Force, v → Velocity
- Electric Flux ϕ_E = $\vec{E}.\vec{A} = E\,A\cos\theta$ Where, E → Electric field, A → Area
- Magnetic flux ϕ_B = $\vec{B}.\vec{A} = B\,A\cos\theta$ Where, B → Magnetic field, A → Area
- Potential energy of dipole in uniform field $\vec{U} = -\vec{p}.\vec{E}$ Where, $\vec{p}$ → Dipole moment, E → Electric field.

■ Cross Product (or Vector Product)-

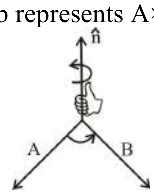
The magnitude of cross or vector product of A and B i.e. A×B is defined as the product of the magnitude of A and B and the sine of the angle θ between them. then,

$$\vec{A}\times\vec{B} = |A||B|\sin\theta\hat{n}$$

where, $\hat{n}$ is a vector perpendicular to $\vec{A}$ & $\vec{B}$ or their plane and its direction given by right hand thumb rule.

■ Right hand thumb rule-

Curl the fingers of your right hand from A to B through the smaller angle between them. Then, the direction of thumb represents A×B or $\hat{n}$.



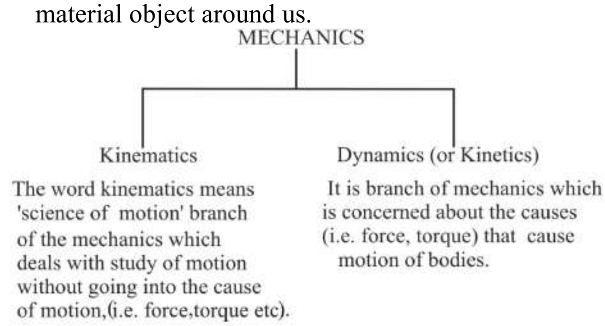
- The thumb represents the direction of motion of the conductor.
- The first finger reprsents the direction of the field (North to South).

Examples of Cross product-

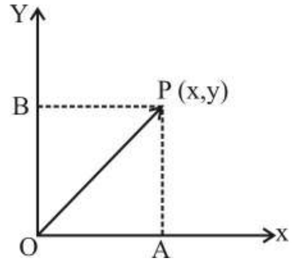
- Torque $\vec{\tau} = \vec{r}\times\vec{F}$ Where, $\vec{r}$ → position vector, F → force
- Angular momentum $\vec{J} = \vec{r}\times\vec{p}$ Where, $\vec{r}$ → position vector , p → linear momentum
- Linear velocity $\vec{V} = \vec{\omega}\times\vec{r}$ Where, $\vec{r}$ → position vector, ω → angular velocity
- Torque on dipole placed in electric field $\vec{\tau} = \vec{p}\times\vec{E}$ Where, p → dipole moment, E → Electric field

- A scalar quantity is a one dimensional quantity.
- A scalar quantities obey the rules of arithmetic and ordinary algebra. But vectors are added according to vector laws of addition.
- We cannot add vectors and scalars together.
- Scalar quantities change when their magnitude changes. But in vector quantities both magnitude and direction change.
- A vector quantity can be either two dimensional with components in the x and y direction, or three dimensional with components in the x,y and z directions.
- A scalar is a zero rank tensor
- A vector is a first rank tensor.
- Electric current is not a vector because it does not obey the vector addition.
- A unit vector has no unit.
- A scalar or a vector can never be divided by any vector
- To a vector only a vector of same type can be added and resultant is a vector of same type.

■ **Mechanics-:** Mechanics is the branch of physics that deals with the condition of rest or motion of the material object around us.



■ **Position:** If a particle is restricted to move along a given straight line (assumed along x-axis), its position is represented by the x- coordinate relative to a fixed origin .If the particle moves in a plane (let x-y plane) its position is completely known when the x coordinates of its position are known with respect to the given coordinate axes Ox and Oy.



■ **Rest:** When a body does not change its position with respect to time, the body is said to be in rest.

☛ **Example:** A bed lying in a room is in the state of rest, because it does not change its position with respect to time.

■ **Motion:** When a body changes its position with respect to its surrounding, it is said to be in motion.

☛ **Example:** A train moving on rails

■ **Rest and motion as relative terms -** Rest and motion are relative states. It means an object which is at rest in one frame of reference can be in motion in another frame of reference.

Types of Motion –

On the basis of direction:-

1. **One dimensional Motion-** if only one out of three co-ordinates specifying the position of the object with respect to time, then it is called one dimensional motion or rectilinear motion.

☛ **For Example -** (i) Motion of car on straight road.
(ii) Motion of a body under gravity.

2. **Two dimensional Motion -** If only two out of three co-ordinates specifying the position of the object with respect to time, then the motion is called two dimensional motion.

☛ **For Example –**
(i) A gymnast on a balance beam.
(ii) Motion of planets around the sun.
(iii) A car moving along zig-zag path on a level road.

3. **Three dimensional motion -**
The motion of three co-ordinates specifying its position change with respect to time.

☛**For example –**
(i) Movement of gyroscope.
(ii) A kite flying on a windy day.
(iii) Motion of an Aeroplane in space.

On the basis of moving object in space:-

1. **Uniform Motion**: When moving objects cover equal distances in equal time intervals.
2. **Non Uniform Motion**: When moving objects cover different distances in equal time intervals.

■ **Frame of reference-**

A Frame of reference is a well defined co-ordinate system and with respect to this the state of rest or motion of a body is described. There are two types of frame of reference.

(i) Inertial frame of reference- A frame of reference in which a body continues to be in a state of rest or in a state of a uniform motion, If no external force act on the body is called an inertial frame of reference.

(ii) Non- inertial frame of reference-
A frame of reference in which a body is accelerated without applying any external force on a body is called accelerated or non-inertial frame of reference.

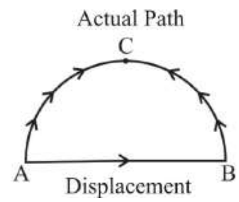
■ **Distance and Displacement -**

□ **Distance (x) -**

- Total path x-ACB travelled by the body between initial and final position in definite interval is called Distance
- It is a scalar quantity.
- It have no direction
- Distance will be always positive.
- Distance have infinite function.
- Distance covered by particle never decreases.
- Its SI unit is meter (m) and dimensional formula is $[M^0L^1T^0]$

Displacement ($\vec{x}$) -

- Displacement is the minimum possible path (AB) between initial and final position.
- It is a vector quantity.
- Its direction will be always from initial to final position.
- It may be +ve, –ve or zero.
- It have only one unique function.
- Its SI unit is meter and dimensional formula is $[M^0L^1T^0]$.



■ **Speed and Velocity-**

■ **Speed-:** The rate of change of position of an object with respect to time in any direction is called its speed. $\text{Speed(V)} = \dfrac{\text{distance travelled(s)}}{\text{time taken(t)}}$

- It is a scalar quantity
- It is always +ve
- It's S.I unit is m/sec.

Uniform Speed-

If a body covers equal distance in equal intervals of time it is said to be moving with uniform speed.

☛ **Example-**
(i) A rotating fan
(ii) A rocket moving in a space.

Variable speed or Non-Uniform speed:-

If a body covers unequal distances in equal intervals of time. It is said to be moving with a variable speed.

☛ **Example-**
(i) A train starting from a station.
(ii) A dog chasing a cat.

Average speed :

The ratio of total distance travelled by the object to the total time taken is called average speed.

$$\text{Average speed} = \frac{\text{Distance travelled}}{\text{time interval}}$$

Instantaneous speed:

If the speed of a body is continuously changing with time. Then the speed at some particular instant during the motion is called instantaneous speed.

☛ **For example -** Speedometer of a moving automobile measures instantaneous speed.

■ **Velocity :** The rate of change of displacement with respect to time the body in specified direction is called velocity.

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time taken}}$$

- It is a vector quantity.
- It may be +ve, -ve or zero.
- It's S.I. unit is m/sec.

Uniform velocity -
When a body covers equal distances in equal intervals of time in a particular direction the body is said to be moving with uniform velocity.

Non-uniform velocity- when a body covers unequal distances in equal intervals of time in a particular direction the body is said to be non-uniform velocity .

Average Velocity- The ratio of the total displacement to the total time taken by the body is called average velocity.

$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time taken}}$$

Instantaneous Velocity –
The velocity of a particle at any instant of time is known as instantaneous velocity Instantaneous velocity = $\lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$

■ **Acceleration -**
The rate of change of velocity with respect to time is known as acceleration.

$$\text{Acceleration} = \frac{\text{Change in velocity } (\Delta V)}{\text{Time interval } (\Delta t)}$$

- Its S.I unit is m/sec^2
- It is a vector quantity
- It may be +ve, -ve or zero
- If velocity increases then acceleration is +ve
- If velocity decreases then retardation and 'it' is -ve.
- If velocity is constant then a = 0 (i.e uniform motion)

Uniform Acceleration - When a body describes equal changes in velocity in equal intervals of time , it is said to be moving with uniform acceleration.

Non- Uniform Acceleration-
If an object is moving with non-uniform acceleration, it means that change in velocity is unequal for equal interval of time.

Average Acceleration-
The ratio of the total acceleration to the total time taken by the body is called average acceleration.

Instantaneous Acceleration-
It is defined as the acceleration of body at any instant of time.

$$\text{Instantaneous Acceleration} = \lim_{\Delta t \to 0} \frac{\Delta V}{\Delta t} = \frac{dV}{dt}$$

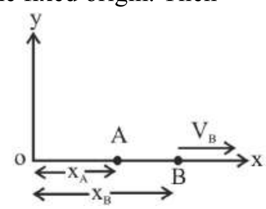
■ **Formula and concept for uniformly accelerated motion in a straight line**

Scalar form	Vector form
$v = u + at$	$\vec{v} = \vec{u} + \vec{a}t$
$s = ut + \frac{1}{2}at^2$	$\vec{s} = \vec{u}t + \frac{1}{2}\vec{a}t^2$
$v^2 = u^2 + 2as$	$\vec{v}.\vec{v} - \vec{u}.\vec{u} = 2\vec{a}\vec{s}$
$s = \left(\frac{u+v}{2}\right)t$	$\vec{s} = \frac{1}{2}(\vec{u}+\vec{v})t$
$s_n = u + \frac{a}{2}(2n-1)$	$\vec{s}_n = \vec{u} + \frac{\vec{a}}{2}(2n-1)$

- Displacement of a particle in nth second of its motion in uniformly accelerated motion-

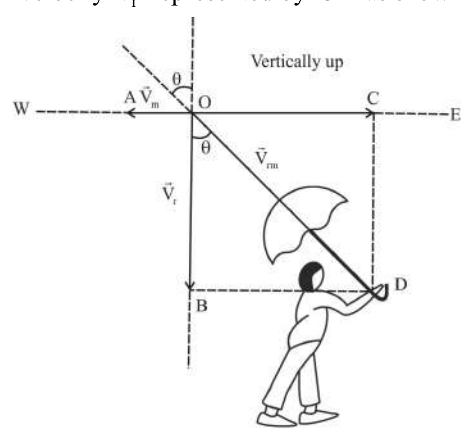
$D_n = u + \frac{a}{2}(2n\text{-}1)$

■ **Relative motion in one Dimension ;-** If $\vec{x}_A$ and $\vec{x}_B$ are their respective displacements with respect to the fixed origin. Then



- The relative displacement of B with respect to A is defined as - $\vec{x}_{BA} = \vec{x}_B - \vec{x}_A$
- The relative velocity of B with respect to A is defined as- $\vec{V}_{BA} = \vec{V}_B - \vec{V}_A$
- The relative acceleration of B with respect to A is defined as - $\vec{a}_{BA} = \vec{a}_B - \vec{a}_A$

Relative velocity of Rain with respect the Moving man -
A man walking west with velocity $\vec{v}_m$, represented by $\overrightarrow{OA}$. Let the rain be falling vertically downwards with velocity $\vec{v}_r$ represented by $\overrightarrow{OB}$ as shown in



The relative velocity of rain with respect to man $\vec{V}_{rm} = \vec{V}_r - \vec{V}_m$

Will be represented by diagonal $\overrightarrow{OD}$ of rectangle OBDC.

$\therefore V_{rm} = \sqrt{V_r^2 + V_m^2 + 2V_rV_m\cos 90^\circ} = \sqrt{V_r^2 + V_m^2}$

If θ is the angle which $\vec{V}_{rm}$ makes with the vertical direction then

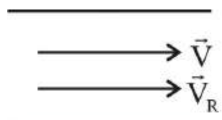
$\tan\theta = \frac{BD}{OB} = \frac{V_m}{V_r} \Rightarrow \theta = \tan^{-1}\frac{V_m}{V_r}$

- **Swimming into the River-**

  A man can swim with velocity $\vec{V}$ i.e it is the velocity of man with respect to still water. If water is also flowing with velocity $\vec{V}_R$, then velocity of man relative to ground. $\vec{V}_m = \vec{V} + \vec{V}_R$

Case I -

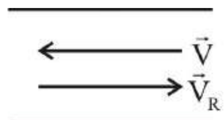
- If the swimming is in the direction of flow of water or downstream then-



$$\vec{V}_m = \vec{V} + \vec{V}_R$$

Case II -

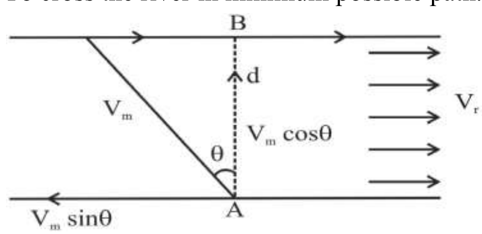
- If the swimming is in the direction opposite to the flow of water or then-



$$\vec{V}_m = \vec{V} - \vec{V}_R$$

Case-III To cross the river from one bank to another bank.

(i) To cross the river in minimum possible path.



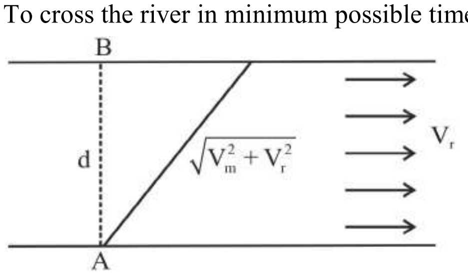
d = width of river to reach from A to B,

$V_m \sin\theta = V_r$, $\sin\theta = \frac{V_r}{V_m}$, $\theta = \sin^{-1}\frac{V_r}{V_m}$

(ii) Time taken to cross the river -

$$t = \frac{d}{V_m \cos\theta} = \frac{d}{\sqrt{V_m^2 - V_r^2}}$$

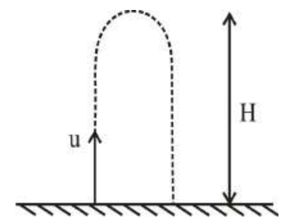
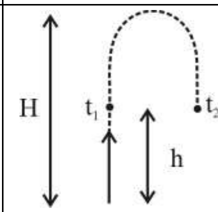
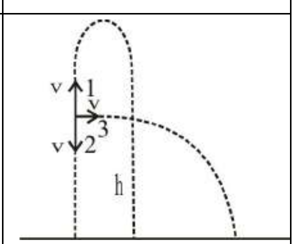
(iii) To cross the river in minimum possible time-



$t = \frac{d}{V_m \cos\theta}$ For minimum, θ = 0° $\left[t_{min} = \frac{d}{V_m}\right]$

■ Motion Under Gravity –

- If a body is thrown vertically up with a velocity u in the uniform gravitational field (neglecting air resistance), then-

● Maximum height attained $H = \frac{u^2}{2g}$	
● Time of ascent = time of descent = $\frac{u}{g}$	
● Total time of flight = $\frac{2u}{g}$	
● Velocity of all at the point of projection = u (downwards)	
● Gallileo's law of odd numbers : For a freely falling body ratio of successive distance covered in equal time interval 't'$S_1 : S_2 : S_3$ .... = 1 : 3 : 5 : .... : 2n – 1.	
● At any point on its path the body will have same speed for upward journey and downward journey.	
● If a body throws upward crosses point in time t_1 & t_2 respectively, then height of point $h = \frac{1}{2}gt_1t_2$ and maximum height $H = \frac{1}{2}g(t_1+t_2)^2$.	
● A body is thrown upward, downward & horizontally with same speed takes time t_1, t_2 & t_3 respectively to reach the ground then $t_3 = \sqrt{t_1t_2}$ & height from where the particle was thrown is- $H = \frac{1}{2}g\,t_1t_2$.	

Important points about graphical analysis of motion -

- Instantaneous velocity is the slope of position time curve $\left(V = \frac{dx}{dt}\right)$.
- Slope of velocity time curve = instantaneous acceleration $\left(a = \frac{dv}{dt}\right)$.
- V-t curve area gives displacement, $\left[\Delta x = \int vdt\right]$.
- a-t curve area gives change in velocity $\left[\Delta v = \int adt\right]$

■ Key points -

$$\boxed{\text{Displacement}} \underset{\text{Integration}}{\overset{\text{Differentiation}}{\rightleftarrows}} \boxed{\text{Velocity}} \underset{\text{Integration}}{\overset{\text{Differentiation}}{\rightleftarrows}} \boxed{\text{Acceleration}}$$

- Displacement ≤ Distance. • $\frac{\text{Velocity}}{\text{Speed}} \le 1$
- $\frac{\text{Average velocity}}{\text{Average speed}} \le 1$ • $\frac{\text{Instantaneous velocity}}{\text{Instantaneous speed}} = 1$

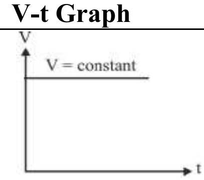
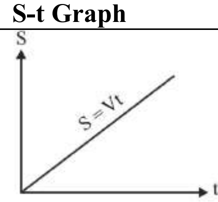
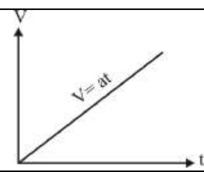
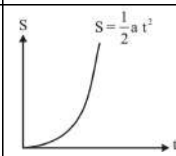
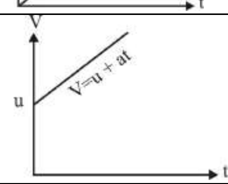
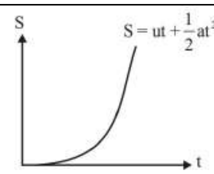
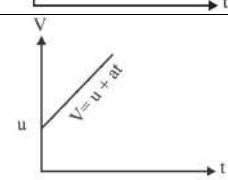
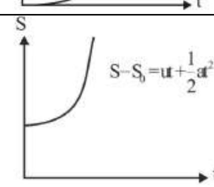
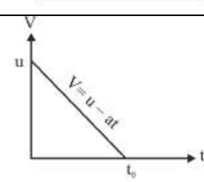
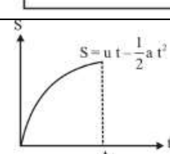
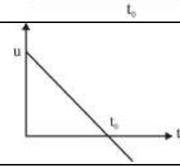
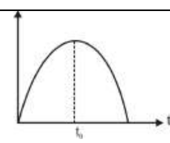
- If distance > |displacement| this implies -
  - ➢ At least at one point in path, velocity is zero.
  - ➢ The body must have retarded during the motion.
- If particle travels distances S_1, S_2, S_3, ... with speeds V_1, V_2, V_3, ... then,

$$\text{Average speed} = \frac{S_1 + S_2 + S_3}{\left(\frac{S_1}{V_1} + \frac{S_2}{V_2} + \frac{S_3}{V_3}......\right)}$$

- If particle travels equal distances ($S_1 = S_2 = S$) with velocities V_1, V_2, V_3, ... during time intervals t_1, t_2, t_3 then, $\text{Average speed} = \frac{V_1t_1 + V_2t_2 + V_3t_3}{t_1 + t_2 + t_3}$...........
- If particle travels with speed V_1 and V_2 for equal time intervals i.e $t_1 = t_2 = t$, then

  Average speed = $\frac{V_1 + V_2}{2}$.
- When a body travels equal distances with speed V_1 and V_2, the average speed (V) is the harmonic mean of two speeds i.e $\frac{2}{V} = \frac{1}{V_1} + \frac{1}{V_2}$

Different Motions and their Graphs :

Different Cases	V-t Graph	S-t Graph
1. Uniform motion		
2. Uniform accelerated motion with u = 0 at t = 0		
3. Uniformly accelerated with u ≠ 0 at t = 0		
4. Uniformly accelerated motion with u ≠ 0 and S= S_0 at t = 0		
5. Uniformly retarded motion till velocity becomes zero		
6. Uniformly retarded then accelerated in opposite direction		

■ Motion in a Plane

- Motion in a plane is also called as a motion in two dimension.

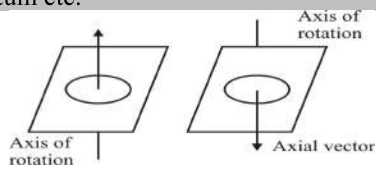
☛ **For example -** circular motion, projectile motion etc.

Polar Vectors - The polar vectors which have a starting point and describe the translation motion.

☛ **Example-** Displacement, Velocity, Force etc are polar vectors.

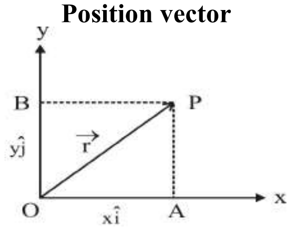
Axial Vectors- The vector which represent rotational effect and act along the axis of rotation in accordance with right hand screw rule are called axial vector.

☛ **Example:-** Angular velocity, Torque, Angular momentum etc.



■ Terms Related to motion in a plane -

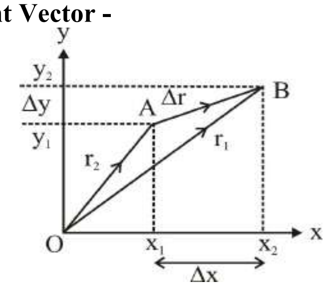
Position vector



$$\overrightarrow{OP} = \overrightarrow{OA} + \overrightarrow{OB}, \quad \vec{r} = x\hat{i} + y\hat{j}$$

- This equation express position vector $\vec{r}$ in terms of its rectangular component x and y.

Displacement Vector -



- In plane, displacement can be represented as -

$$\Delta r = (x_2 - x_1)\hat{i} + (y_2 - y_1)\hat{j}$$

- Magnitude of displacement vector

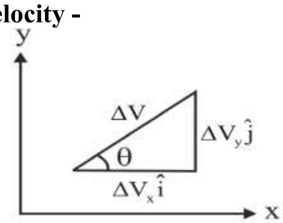
$$|\Delta r| = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

- Direction of the displacement vector Δr is given by -

$$\tan\theta = \frac{\Delta y}{\Delta x}$$

Velocity Vector-

(i) Average Velocity -



$$V_{av} = \frac{\Delta r}{\Delta t} = \frac{r_2 - r_1}{t_2 - t_1}$$

Average velocity in component form-

$$V_{av} = \frac{\Delta x}{\Delta t}\hat{i} + \frac{\Delta y}{\Delta t}\hat{j}, \quad = \Delta V_x\hat{i} + \Delta V_y\hat{j}$$

Direction of the velocity ΔV is given by-

$$\tan\theta = \frac{\Delta V_y}{\Delta V_x}$$

(ii) Instantaneous Velocity-

$$V = \lim_{x\to 0}\frac{\Delta r}{\Delta t} = \frac{dr}{dt}, \quad V = \frac{dx}{dt}\hat{i} + \frac{dy}{dt}\hat{j}, \quad V = V_x\hat{i} + V_y\hat{j}$$

Magnitude of Instantaneous Velocity-

$$|V| = \sqrt{V_x^2 + V_y^2}$$

Direction of V is given by- $\tan\theta = \frac{V_y}{V_x}$

Acceleration Vector -

(i) Average Acceleration-

- The average acceleration vector is defined as the rate at which the velocity changes. It is in the direction of the change in velocity $\overrightarrow{\Delta V}$

$$\vec{a}_{av} = \frac{\overrightarrow{\Delta V}}{\Delta t}, \quad \vec{a}_{av} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$$

(ii) Instantaneous Acceleration -

- It is defined as the limit of the average acceleration as Δt approaches zero.

$$\vec{a} = \lim_{\Delta t\to 0}\frac{\Delta\vec{V}}{\Delta t} = \frac{d\vec{V}}{dt}, \quad \vec{a} = \lim_{\Delta t\to 0}\left(\frac{\Delta V_x}{\Delta t}\hat{x} + \frac{\Delta V_y}{\Delta t}\hat{y} + \frac{\Delta V_z}{\Delta t}\hat{z}\right)$$

■ Motion in a plane with uniform acceleration-

$V_x = V_{ox} + a_x t$, $\quad V_y = V_{oy} + a_y t$

☐ Path of particle Under constant Acceleration-

$$x = x_0 + V_{ox}t + \frac{1}{2}a_x t^2 \text{ .... along x-axis}$$

$$y = y_0 + V_{oy}t + \frac{1}{2}a_y t^2 \text{ .... along y-axis}$$

■ Circular Motion -

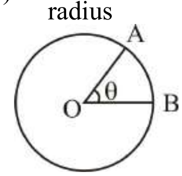
- When object is moving on a circular path on the circumference of the circle, then the motion is called circular motion.

Uniform Circular Motion-

- When object is moving on a circular path on the circumference of the circle, covers equal distances in equal intervals of time then the motion is called uniform circular motion.

■ Angular displacement (θ)-

- It is the angle traced out by the radius vector at the circular path. angle $(\theta) = \frac{\text{arc}}{\text{radius}}$



It is a vector quantity.

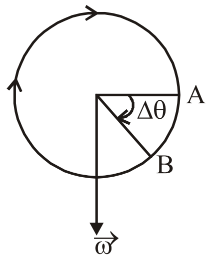
■ Angular Velocity $(\vec{\omega})$ -

- It is the time rate of change of angular displacement.

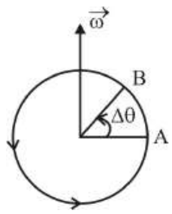
  SI unit is rad/sec. $\vec{\omega} = \dfrac{\text{Angular displacement}}{\text{Time taken}}$
- Instantaneous angular velocity $\omega = \dfrac{d\theta}{dt}$
- Average angular velocity

  $\omega = \vec{\omega}_{av} = \dfrac{\text{Total angular displacement}}{\text{Total time taken}} = \dfrac{\Delta\theta}{\Delta t}$
- For clockwise rotation $\vec{\omega}$

  $\vec{\omega}$ is directed downwards



- For anti-clockwise rotation $\vec{\omega}$ is directed upwards.



■ **Time Period (T):-** The taken by object to completed one revolution on its circular path.

■ **Frequency (ν):-**The number of revolution per unit time on the circular path.

■ Angular acceleration (α) -

- It is the time rate of change of angular velocity

  $\alpha = \dfrac{d\vec{\omega}}{dt}$
- SI unit radian/second^2
- When a body moves with constant angular velocity, its angular acceleration is zero.

■ Centripetal Acceleration (a_c) -

- Acceleration of an object moving with uniformly on the circular, it acts along the radius towards the centre of the circular path.

  $a_c = \omega^2 r = \dfrac{V^2}{r} = \omega V \left\{\because \quad \omega = \dfrac{V}{r}\right\}$, $\vec{a}_c = \vec{\omega} \times \vec{V}$

■ Centripetal Force (F_c) -

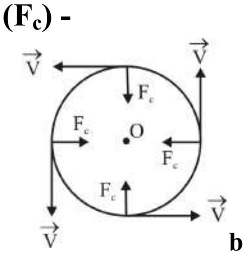
$F_c = \dfrac{mv^2}{r}$

$F_c = m\alpha$

$F_c = m\omega^2 r$

$F_c = m\omega v$

$\vec{F}_c = m(\vec{v} \times \vec{\omega})$



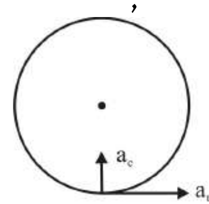
- The work done by centripetal force is zero.
- Centripetal force is essential for circular motion, without it the body cannot move in circular path.
- The K.E. and angular momentum cannot be increased by centripetal force.

■ Tangential Acceleration (a_t) -

- The acceleration which acts along the tangent to the circular path. $a_t = \alpha\, r$, $\vec{a}_t = \vec{\alpha} \times \vec{r}$

■ Total acceleration ($\vec{a}$) -

$\vec{a} = \alpha \times \vec{r} + \vec{\omega} \times \vec{v}$, $a = \sqrt{a_t^2 + a_c^2}$



Where, a_t = Tangential acceleration -

a_c = Centripetal acceleration

■ Some relations -

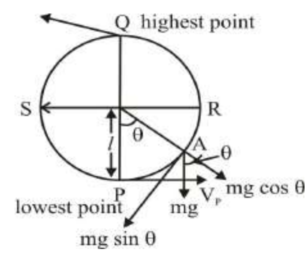
(i) Relation between time period and frequency $(\nu) = \dfrac{1}{T}$

(ii) Relation between frequency angular velocity and time, $(\omega) = \dfrac{\theta}{t} = \dfrac{2\pi}{T} = 2\pi\nu$

(iii) Relation between linear acceleration and angular acceleration. $a = \alpha\, r$, $\vec{a} = \vec{\alpha} \times \vec{r}$

■ Motion in Vertical circle -

- Motion in a vertical circle is non-uniform circular motion.



- Tension at the lowest point (P) $T_P = \dfrac{mV_P^2}{l} + mg$
- Tension at the highest point Q. $T_Q = \dfrac{mV_Q^2}{l} - mg$

  $T_Q = \dfrac{mV_P^2}{l} - 5mg$
- Tension at point R-

  $T_R = \dfrac{mV_R^2}{l}$, $T_R = \dfrac{mV_P^2}{l} - 2mg$
- $T_P > T_R > T_Q$ • $T_P - T_Q = 6$ mg • $T_P - T_R = 3$ mg
- Tension at any point A - $T = \dfrac{mV^2}{r} + mg\cos\theta$
- **Minimum velocity for vertical circular motion -**

(a) V_P at $P \geq \sqrt{5gl}$ (b) V_Q at $Q \geq \sqrt{gl}$

(c) V_R at $R \geq \sqrt{3gl}$

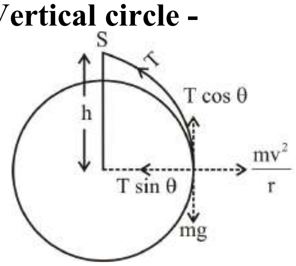
- **In case of minimum velocity-**

(a) $T_P \geq 6$ mg (b) $T_Q = 0$ (c) $T_R \geq 3$ mg

- If $T_{min} < 0$, the string will slack and the body will fall down from the highest point. Hence, for "looping the loop" or completing the vertical circle $T_{min} \geq 0$.
- If $V_P = \sqrt{2gl}$, velocity and tension becomes zero at R and S and particle will oscillate along semi-circular path.
- If $V_P < \sqrt{2gl}$, velocity becomes zero between P and R and particle oscillate about with the lower point P.
- If $V_P > \sqrt{5gl}$ tension never becomes zero and particle will just complete the circle.
- For leaving. the vertical circle somewhere between $90^\circ < \theta < 180^\circ$. Tension becomes zero (T = 0) at the point of leaving but the velocity will not be zero.

$$\sqrt{2gl} < V_P < \sqrt{5gl}$$

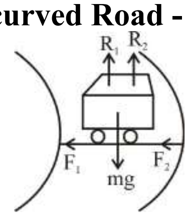
■ Motion in Vertical circle -



$T \cos\theta = mg$, $T \sin\theta = \dfrac{mv^2}{r}$

$\tan\theta = \dfrac{v^2}{rg}$, $T = 2\pi\sqrt{\dfrac{l\cos\theta}{g}}$

■ Rounding a level curved Road -



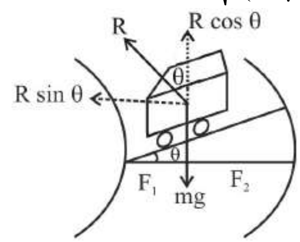
- $\dfrac{mv^2}{r} \leq (F_1 + F_2)$

  Where, $F_1 = \mu R_1$ and $F_2 = \mu R_2$ μ = Coefficient of friction between tyres and road.
- $V \leq \sqrt{\mu rg}$, $V_{max} = \sqrt{\mu rg}$

  This is the maximum speed without skidding.
- If centripetal force is obtained only by the banking of roads, then the speed (v) of the vehicle for a safe turn.

$$v = \sqrt{r\,g\tan\theta}$$

- If speed of vehicle is less than $\sqrt{r\,g\tan\theta}$. Then it will move inward (down) and (r) will decrease and if speed is more than $\sqrt{r\,g\tan\theta}$ then it will move toward (up) and (r) will increases.
- In normal life, the centripetal force is obtained by the friction force between the road and tyres as well as by the banking of the roads.
- Therefore the maximum permissible speed for the vehicle is much greater than the optimum value of the speed on a banked road.
- When centripetal force is obtained from friction force as well as banking of roads then maximum safe value of speed of vehicle. $V_{max} = \sqrt{\dfrac{rg(\tan\theta + \mu_s)}{(1 - \mu_s\tan\theta)}}$



■ Bending of cyclist -

- When a cyclist takes turn at road, he inclines himself from the verticle slows down this speed and moves on a circular path larger radius.

  If a cyclist is inclined at an angle θ, then

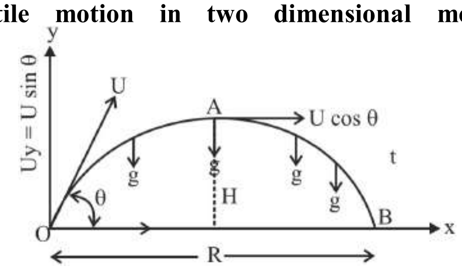
  $\tan\theta = \dfrac{V^2}{rg}$

  Where, V = Speed of the cyclist
  r = Radius of path
  g = Acceleration due to gravity

■ Projectile Motion –

- When any object is thrown from horizontal at an angle θ except 90º then it moves on a parabolic known as trajectory. The object is called projectile and its motion is called projectile motion.

Projectile motion in two dimensional motion:-



$U_x = U\cos\theta$ = Horizontal motion
= Responsible for range produced
= Constant acceleration ($\because a = 0$)

But,
$U_y = U\sin\theta$ = Vertical component
= Variable ($a_y = -g$)
= Responsible for height produced.

☛Concept -

x-axis	y-axis
$U_x = U\cos\theta$	$U_y = U\sin\theta$
$a_x = 0$	$a_y = -g$

- **Time of ascending (t) -**

  along y axis-

  $V_y = U_y + a_y t$, $t = \dfrac{U\sin\theta}{g}$
- **Time of Flight (T) -**

  $T = 2t$, $T = \dfrac{2U\sin\theta}{g}$
- **Height attained by the body in projectile motion -**

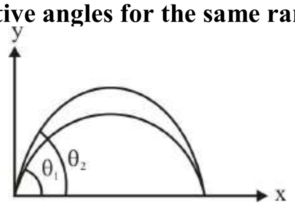
  $H = \dfrac{U^2\sin^2\theta}{2g}$

- **Condition for maximum height attained (H_{max}) –** For maximum height,

  $\theta = 90^\circ$, $\sin\theta = 1$, $H_{max} = \frac{U^2}{2g}$
- **Range produced by the body in projectile motion -**

  $R = \frac{U^2 \sin 2\theta}{g}$
- **Condition for maximum Range : (R_{max}) –**

  $\sin 2\theta = 1 = \max = \sin 90^\circ$, $\theta = 45^\circ$, $R_{max} = \frac{U^2}{g}$
- **Ratio -** $\frac{R_{max}}{H_{max}} = \frac{\frac{U^2}{g}}{\frac{U^2}{2g}} = 2$ $R_{max} = 2 \times H_{max}$
- **Two projective angles for the same range -**



$\theta_1 + \theta_2 = 90^\circ = \frac{\pi}{2}$

NOTE

- Projectile refers to an object that is in flight along the horizontal and vertical direction simultaneously.
- Acceleration acts only in the vertical direction due to gravity (g).
- The horizontal velocity of a projectile is constant. So there is no acceleration in vertical direction.
- Projectiles travel with a parabolic trajectory due to the influence of gravity.

EXAM POINTS

- Newton's first law of motion gives the definition of **- Force**
- The velocity of one moving body with respect to another moving body is called **- Relative velocity**
- If the magnitude of velocity of an object is increasing with time, then the acceleration of the object is **- Positive**
- The formula for velocity is **- $\frac{s}{t}$**
- The rate of change of displacement is called **- Velocity**
- For every action, there is an equal and opposite reaction **- Newton's third law of motion**
- Which formula is used to convert the angular momentum of a body moving on a circular path into linear momentum **- a = r×a**
- The tendency to resist the change in the present situation is called **- Inertia**
- The rate of change of velocity is called **- Acceleration**
- The maximum speed of a body can be **- 3×10^8 m/sec**
- The distance covered per unit time is called **- speed**
- The rate of change of momentum is directly proportional to the external force acting on the body. This statement is of **- Second law of motion**
- The weight of a body is maximum at **- Poles of the Earth**
- The rate of change of velocity of an object while its velocity is increasing is called **- Acceleration**
- If two objects are thrown upwards with velocities V_1 and V_2 then the ratio of their maximum heights will be **- $\frac{V_1^2}{V_2^2}$**
- The unit of momentum is CGS system is **- Dyne × second**
- Motion of Earth around Sun is an example of **- Circular Motion**
- If an object is at rest, it will remain at rest, if it is in motion, it will remain in motion unless an external force is applied to it. This Statement is known as **- Newton's first law of motion**
- The first equation of motion is **- v = u + at**
- An iron ball and wooden ball of the same radius are released from the height h in vacuum. The time taken by both of them to reach the ground will be the **- Same**
- The slope of a velocity-time graph represents **- Acceleration**
- A cannon ball has been fired. The motion of this ball is an example of **- Projectile motion**
- The speed of a train is an example of **- Translatory motion**
- In a projectile motion, a large angle with the horizontal produces **- High trajectory**
- If the axis of rotation passes through an object while it is in motion, then that motion is called **- Rotational motion**
- If a ball is thrown up, so what does not change **- Mass (m)**
- If an object is moving in a circular path and completes one revolution in one second then its average speed will be **- Zero**
- Newton's first law of motion given the concept of **- Inertia**
- The part of the body on which all the weight of the body is concentrated is known as **- Center of mass**
- Earth has its own atmosphere **- Due to gravitational force**
- It is difficult to fix a nail on a freely suspended wooden frame which law supports for this statement **- Newton's third law**
- The appropriate relation between the time period (T) and particle of mass (m) performing simple harmonic motion is **- $T = 2\pi\sqrt{\frac{m}{k}}$**
- The time period of the simple pendulum will be **- $2\pi\sqrt{\frac{\ell}{g}}$**
- The correct relationship between moment of inertia (I), torque (τ) and angular acceleration (α) is **- $\tau = \alpha \times I$**

- Who can change the speed direction and shape of an object **- Force**
- If a pendulum oscillates in a vacuum, its time period will **- Decrease**
- The change in seasons on the Earth occurs because **- Earth's revolution and inclination of its axis**
- A large force exerted on a rotating object result in **- Large torque**
- It is difficult to walk an ice because **- Very less friction**
- If the wavelength of an electron and photon are the same then their linear momentum will be **- Same**
- When the earth is orbited by a spacecraft weightlessness is felt due to **- zero gravity**
- If an object is thrown upwards, its velocity on reaching the maximum height will be **-Zero (0 m/sec)**
- What will happen to the force between the two positive charge which are released after being held near each other **- Force will decrease**
- The velocity time graph of a body comes in a straight line and touches the x-axis passing through the origin the body is moving with **- Changing in Acceleration**
- A body strikes the ground vertically downwards with a velocity μ and rebounds with the same speed. The change in velocity would be **- –2μ**
- In a vacuum all free falling objects have **- Same acceleration**
- An object is moving with non-uniform velocity and uniform acceleration, then **- Velocity-time graph will be linear**
- If the velocity time graph is parallel to the time axis then **- object is moving with a constant velocity**
- The acceleration of the body represents **- $\frac{dv}{dt}$**
- If the velocity time graph is parallel to the time axis, then the speed is **- uniform**
- The velocity time graph for uniform accelerated motion is **- Straight line**
- In uniform circular motion **- Speed is constant and velocity is variable**
- Velocity of a body is said to be uniform, when **- Both the magnitude and direction of velocity are constant**
- The formula to find acceleration is **- $\alpha = \frac{v - u}{t}$**
- If a ball is thrown up, what does not change **- Acceleration (due to gravity)**
- Cyclist bends or leans while taking a turn because **- It tilts so that the center of gravity remains inside the base. It will keep him from falling**
- A truck and a car are running at the same speed. If the mass of the truck is 10 times more than the mass of the car. The ratio between their kinetic energy will be **- 10:1**
- A rocket works on the principle of **- Newton's third law of motion or conservation of linear momentum**
- Newton's law of motion apply when the nature of matter is **- particle nature**
- If the velocity time graph of a particle is represented by v = mt + c, then the particle is moving with **- Constant acceleration**
- A person climbing a hill leans forward because **- To increase stability**
- A girl is swinging on a swing in sitting position when the girl stands up the period of swing will be **- Shorter**
- The working principle of washing machine is **- Centrifugation**
- A hunter aim his gun at a point between the eyebrows of a monkey sitting on a branch of a tree. Just as he fires, the monkey jumps down the bullet will **- Hit the monkey at the point aimed**
- If a person sitting in a lift then when will he feel that his weight gets increased **- When the elevator going upward with speed**
- If the horse starts moving suddenly the rider on the horse fall back because **- Interia of rest**
- A cricketer pull his hands back word while catching a fast moving ball because **- Ball may come to rest**
- When a force of 5 Newton is applied to a mass of 2 kg the acceleration produced will be **- 2.5 m/sec^2**
- If a sphere is rolling the ratio of its rational energy to total kinetic energy will be **- 2 : 7**
- The velocity of a particle located at the center of a pipeline will be **- Maximum**
- An force $\vec{F} = (6\hat{i} + 2\hat{j} - 3\hat{k})$ acts on a particle and produces a displacement of $\vec{S} = (2\hat{i} - 3\hat{j} - x\hat{k})$. If the work done is zero, the value of x is **- 2**
- the frequency of transverse vibration of a thread is 100 cycle/sec. If the tension of the thread is increased to 4 times, then the frequency will be **- 200 cycle/sec**
- In the moving state of the lift the apparent weight becomes twice the actual weight when **- lift goes up with acceleration g**
- Generally 'key' is used between two parts to stop which motion **- Rotation**
- A particle of mass 10 kg is moving in a straight line. If its displacement x, with time t, is given by $x = (t^3 - 2t - 10)$m, then the force acting on it at the end of 4 seconds is **- 240 Newton**
- The Motion of the wheels of a bullock-cart while moving on the road is an example of **- Translatory and rotatory motion**
- A particle is moving with the same speed but its direction is constantly changing. Then path of the particle will be **- Circular**
- Two spheres made of the same material and same radius are placed to each other, the gravitational force 'F' between them is **- F ∝ R^4**
- "There is no change in the position and direction of any stationary or moving object unless an external force acts on it." **- Newton's first law of motion**
- Name the property of bodies due to which they resist change in their state of rest or state of uniform motion along a straight line **- Inertia**
- When the length of the pendulum clock becomes 4 times then its time period is **- doubled**
- The minimum number of forces to keep a particle in equilibrium is **- 2**
- Newton-second is the unit of **- Impulse**
- The speed of a car increases from 20 km/hr to 50 km/hr in 10 second moving on a straight road. The acceleration of that car is **- 0.83 m/sec^2**

- Which force is responsible for providing the necessary centripetal force to plants moving around the Sun **- Gravitational force**
- If we suspend the pendulum in a vessel filled with liquid **- The pendulum will stop soon**
- How much force is required to rotate a body of mass 6 kg in a circle of radius 3m with a velocity of 10 m/sec. **- 200 N**
- A particle is moving in a uniform circular motion with a uniform speed 'v' parallel to a circle of radius r. The acceleration of a particle is **- $\frac{v^2}{r}$**
- If the horizontal range of a projectile if four times the maximum height, then the angle of projection is **- 45º**
- What is the magnitude of force which when applied on a body of mass 0.6 kg produces an acceleration of 0.08 m/sec^2. **- 0.048 N**
- A force of 30 N acts on a body of 5 kg for 2 seconds then the acceleration will be **- 6 m/sec^2**
- A second's pendulum is taken in a transport vehicle find the period of oscillation when the vehicle moves with an acceleration of 4 m/sec^2 vertically upwards **- 1.93 second**
- What will be the speed of the body after three seconds if the body is mioving along a straing line at a speed of 20 m/sec and under goes an acceleration of 4 m/sec^2 **- 32 m/sec**
- A stone is dropped from a cliff its speed after it has fallen 100 m is **- 44.72 m/sec**
- Friction between two objects is due to **- Irregularities on the surface**
- A thumb-tripped nail goes easily into wood because **- Move force acts on less area**
- When a gun is fired, it exerts a forward force on the bullet. The bullet also exerts on equal and opposite reaction force on the gun. This phenomenon is explained by **- Third law of motion**
- When a moving bus suddenly applies brakes, the passengers fall in the forward direction. It is because **- Newton's law of inertia**
- A boy sitting in a train moving with constant speed throws a ball straight in the air, then the ball will fall **- into the Hand**
- When an object is moving with uniform velocity with respect to time then velocity-time graph represents **- Straight line**
- An object is moving with non- uniform velocity and uniform acceleration then **- Velocity time graph will be linear**
- If the velocity- time graph is parallel to the time axis, then **- The object is moving with constant velocity**
- The time - graph for uniformly accelerated body **- Straight line.**
- An iron ball and a wooden ball of equal radius are dropped from height h in vacuum. The time taken by both to reach the earth is - **Approximately same.**
- Velocity of body is said to be uniform when **- Both the value and direction of velocity are constant.**

PREVIOUS YEAR QUESTIONS

1. A car accelerates uniformly from 5 ms^{-1} to 10ms^{-1} in five seconds. Find the acceleration of the car

(a) 1 ms^2 (b) 1 ms^{-2}
(c) 1 ms^1 (d) 1 ms^{-1}

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Ans. (b) : Given :

Initial velocity = 5 m/sec.
Final velocity = 10 m/sec.
Time = 5sec.

ΔV = Final velocity – Initial velocity
= 10 – 5
= 5 m/sec.

Acceleration of car (a) = $\frac{\Delta V}{t}$

$= \frac{5m/sec}{5sec}$

= 1 m/sec^2 or, 1ms^{-2}

2. Which one of the following physical quantities is a scalar quantity?

(a) Electric current (b) Electric field
(c) Torque (d) Impulse

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Ans. (a) : Scalars are the physical quantities that only have the magnitude and other characteristics. A scalar is unvaried by any changes in the coordinate system.
Examples: volume, energy, mass, density, time, electric current are scalar quantity.
A vector Quantity is one which is characterized by both magnitude and direction. Examples are: Torque, Impulse, Electric field.

3. A particle starts moving from rest under uniform acceleration. It travels a distance 'x' in the first two seconds and a distance 'y' in the next two seconds. If y = nx, then n =

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

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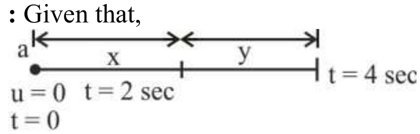
Ans. (b) : Given that,



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

$x = \frac{1}{2} a \times 4$

x = 2a .... (i)

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

$x + y = \frac{1}{2} \times a \times 4 \times 4$

$x + y = 8a \quad .... (ii)$

From equation (i) and (ii), we get

$x + y = 8a$

$2a + y = 8a$

$y = 6a$

Given, $y = nx$

$y = 3 \times 2a$

$\Rightarrow \quad n = 3$

4. A planet moves around the sun in elliptical orbit. When earth is closest from the sun, it is at a distance *r* having a speed ν. When it is at a distance *4r* from the sun its speed is

(a) ν/4 (b) 4ν (c) 2ν (d) ν/2

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Ans. (a) :

Kepler's second law $\frac{dA}{dt} = \frac{1}{2} r \times \nu \quad ...(i)$

If distance is 4r then,

$\frac{dA}{dt} = \frac{1}{2} 4r \times \nu_2 \quad ...(ii)$

From equation (i) and (ii)

According to question,

$\frac{1}{2} \times r \times \nu = \frac{1}{2} \times 4r \times \nu_2$

$\nu_2 = \frac{\nu}{4}$

5. A car moving with a speed of 50 km/hr can be stopped by brake after travelling at least 6 m. If the same car is moving at a speed of 100 km/hr, the minimum stopping distance is

(a) 18 m (b) 12 m (c) 24 m (d) 6 m

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Ans. (c) : Speed of the car when stopping distance is 6 m is given as, $u_1 = 50 \frac{km}{hr}$ and $u_2 = 100 \frac{km}{hr}$

Now,

$v^2 = u^2 - 2aS$

$0 = u^2 - 2aS$

$S = \frac{u^2}{2a}$

$S \propto u^2$

(a is constant and negative as considering retarding)

$\therefore \quad \frac{S_2}{S_1} = \frac{(u_2)^2}{(u_1)^2}$

$\frac{S_2}{S_1} = \frac{(100)^2}{(50)^2}$

$\frac{S_2}{S_1} = 4$

$S_2 = 4S_1$

$S_2 = 4 \times 6$

$S_2 = 24m$

6. A spacecraft of mass 2000 kg moving with a velocity of 600m/s suddenly explodes into two pieces. One piece of mass 500 kg is left stationary. The velocity of the other part must be (in m/s)

(a) 1000 (b) 600

(c) 800 (d) 1500

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Ans. (c) : Given that,

mass (m) = 2000kg

velocity (v) = 600m/s

$m_1 = 500kg, \quad v_1 = 0$

Explodes in two piece, then mass = $m_1 + m_2$

$2000 = 500 + m_2$

$m_2 = 1500kg$

Formula P = mv

Momentum before explosion = 2000 × 600

Momentum after explosion = $P_1 + P_2$

$= (m_1 v_1 + m_2 v_2)$

$= 1500 \times v_2$

sine, there is no external fore, the momentum is conserved

So, Momentum before explosion = Momentum after explosion

$2000 \times 600 = 1500 \, v_2$

$v_2 = 800 \text{ m/s}$

7. A body is thrown with a velocity 20 m/s at an angle of 30º with the horizontal. The time taken to reach the maximum height is (Take g = $10m/s^2$)

(a) 2 s (b) 5 s

(c) 4 s (d) 1 s

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Ans. (d) : Given,

Initial velocity (u) = 20 m/s

The angle of inclination (θ) = 30º

The time taken to reach the maximum height is equal to half of the time of flight.

Time of flight (T) = ?

$T = \frac{2 \cdot u \cdot \sin\theta}{g}$

$= \frac{2 \times 20 \times \sin 30^\circ}{10}$

$= \frac{2 \times 20 \times \frac{1}{2}}{10} = 2 \text{ sec}$

The time taken to reach the maximum height is, $\frac{T}{2} = 1 \text{ sec}$

Hence, option (d) is correct.

8. A body is projected horizontally with a velocity u from a point which is at a height h above the ground level. The range (R) is (Take acceleration due to gravity = g units)

(a) $R = h\sqrt{\frac{2u}{g}}$ (b) $R = u\sqrt{\frac{2g}{h}}$

(c) $R = g\sqrt{\frac{2h}{u}}$ (d) $R = u\sqrt{\frac{2h}{g}}$

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Ans. (d): Horizontal distance covered is = velocity × time

$$R = ut$$

Vertical displacement

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

Given, v = 0, for vertical displacement

$$\Rightarrow \quad h = 0 + \frac{1}{2}gt^2$$

$$\Rightarrow \quad \boxed{t = \sqrt{\frac{2h}{g}}}$$

Now,

$$R = ut$$

$$\boxed{R = u\sqrt{\frac{2h}{g}}}$$

9. An automobile that is towing a trailer is accelerating on a level road. The force that the automobile exerts on the trailer is

(a) Equal to the force the trailer exerts on the automobile
(b) Greater than the force the trailer exerts on the automobile
(c) Equal to the force the trailer exerts on the road
(d) Equal to the force the road exerts on the trailer

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Ans. (a) : An automobile that is towing a trailer is accelerating on a level road. According to Newton's third law The force that the automobile exerts on the trailer is equal to the force the trailer exerts on the automobile.

10. A body falling from rest has a velocity 'v'. After it falls through a distance 'h', the distance it has to fall down further, for its velocity to become double is _______ time 'h'.

(a) 0.5 (b) 1.5
(c) 2 (d) 3

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Ans. (d) : We know that, $v^2 = u^2 + 2gh$

Given, $v_1 = v$

$v_2 = 2v$

Then,

$$v_1^2 = u^2 + 2gh$$

$$h = \boxed{h = \frac{v^2}{2g}} \quad \{\because u = 0 \text{ as body initially at rest}\}$$

$$v_2^2 = u^2 + 2gh_2$$

$$(2v)^2 = u^2 + 2gh_2$$

$$4v^2 = 2gh_2$$

$$\boxed{h_2 = \frac{4v^2}{2g}}$$

Required distance, $h_1 = h_2 - h$

$= 4h - h = 3h \Rightarrow \boxed{h_1 = 3h}$

11. An object of mass 3 kg is at rest. Now a 6 N force is applied on the object for 3 second. Find the velocity of the object acquired by it in m/s.

(a) 12 (b) 6
(c) 9 (d) 8

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Ans. (b) : Given, An object of mass (m) = 3 kg
Force (F) = 6 N
time (t) = 3 second
v =?
From Newton's second law.

$$F = m\left(\frac{v-u}{t}\right)$$

$$\Rightarrow 6 = 3\left(\frac{v-0}{3}\right) \Rightarrow \boxed{v = 6m/s}$$

12. If 'c' is the velocity of light in free space, the time taken by light to travel a distance x in medium of refractive index μ is given by

(a) μxc (b) $\frac{\mu x}{c}$
(c) $\frac{\mu c}{x}$ (d) $\frac{x}{\mu c}$

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Ans. (b) :

Refractive index of a medium is given by $\mu = \frac{c}{v}$

Where v is velocity of light in given medium
Distance = speed × time

$$\Rightarrow \text{Time (t)} = \frac{\text{distance }(x)}{\text{speed}(v)}$$

$$\Rightarrow \boxed{t = \frac{\mu x}{c}}$$

13. A boy throws two balls in air in such a manner that when the first ball is at maximum height he throws the second ball. If the balls are thrown with the time difference of one second, the maximum height attained by each ball is (g = 10m/s²)

(a) 2.5 m (b) 5 m
(c) 10 m (d) 3.5 m

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Ans. (b) : Given t = 1 second

$g = 10 \text{ m/s}^2$

Then, from Newton's first equation of motion

$v = g\,t = 1\times10 \Rightarrow (v = 10\text{m/s})$

From Newton's third equation of motion

$$h = \frac{v^2}{2g} = \frac{10\times10}{2\times10} = 5m \Rightarrow \boxed{h = 5m}$$

14. Average Acceleration =

(a) $\frac{\text{toatal displacement}}{\text{total time}}$ (b) $\frac{\text{change in velocity}}{\text{time taken}}$
(c) $\frac{\text{distance}}{\text{time}}$ (d) $\frac{\text{change in mass}}{\text{time}}$

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Ans. (b) : The change in velocity divided by the elapsed time is the average acceleration. i.e.

$$\text{Average Acceleration} = \frac{\text{Change in velocity}}{\text{time taken}}$$

15. A body is allowed to slide down a frictionless track from rest position at its top under gravity. The track ends in a circular loop of diameter D. Then, the minimum height of the inclined track (in terms of D) so that it may complete successfully the loop is

(a) 3D/4 (b) 9D/4
(c) 5D/4 (d) 7D/4

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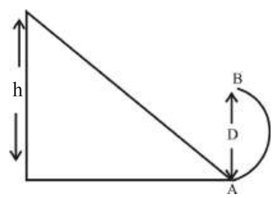
Ans. (c) :



For the body to reach point B, the body must have least velocity of $\sqrt{5gr}$ (from vertical circular motion) at A.

So, for a body falling from height h

Velocity (v) = $\sqrt{2gh}$

From both the velocities

$$\sqrt{5gr} = \sqrt{2gh}$$

$$\sqrt{5g\frac{D}{2}} = \sqrt{2gh}$$

On squaring both sides, we get

$$5g\frac{D}{2} = 2gh$$

$$\boxed{h = \frac{5D}{4}}$$

Hence, the loop is $\frac{5D}{4}$

16. A rope of length 10 m and linear density 0.5 kg/m is lying length wise on a smooth horizontal floor. It is pulled by a force of 25 N. The tension in the rope at a point 6 m away from the point of application is:

(a) 10 N (b) 20 N
(c) 15 N (d) 5 N

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Ans. (a) : Given : Length of rope (L) = 10 m

Linear Density (λ) = 0.5 kg/m

Force (F) = 25N

L_1 = 6 m, L_2 = 4 m

Total mass of rope = $\lambda \times L$

= 0.5×10

= 5 kg

Acceleration of rope $[F = ma]$

$$a = \frac{F}{m} = \frac{25}{5} = 5 m/s^2$$

T = m' × a

m' = 0.5 kg/m × 4m = 2 kg

T = 2 ×5 = 10 N

17. A constant force (F) is applied on a stationary particle of mass 'm' They velocity attained by the particle after a certain displacement will be proportional to

(a) $\frac{1}{\sqrt{m}}$ (b) m (c) 1/m (d) $\sqrt{m}$

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Ans. (a) : Given : Force = F , Mass = m

Initial velocity (u) = 0 m/s

Acceleration of particle, $a = \frac{F}{M}$

The equation of motion of the particle after moving a certain displacement is given by-

$v^2 - u^2 = 2as$

Put the values.

$$v^2 = (0)^2 = 2\left(\frac{F}{M}\right)s$$

$$v = \sqrt{2\left(\frac{F}{M}\right)s}$$

From the above equation, it is clear

$$\boxed{v = \frac{1}{\sqrt{m}}}$$

18. A horizontal force F produces an acceleration of 6m/s^2 on a block resting on a smooth horizontal surface. The same force produces an acceleration of 3 m/s^2 on a second block resting on a smooth horizontal surface. If the two blocks are tied together and the same force acts, the acceleration produced will be

(a) 1 m/s^2 (b) 2 m/s^2
(c) 4.5 m/s^2 (d) 9m/s^2

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Ans. (b) : Given:

Acceleration of first block (a_1) = 6m/s^2

Acceleration of second block (a_2) = 3m/s^2

Given that force acted on the block is same.

So,

$$F_1 = F_2 = F$$

Force, F = ma

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

The mass of first block -

$$m_1 = \frac{F}{a_1} \text{ ---------(i)}$$

The mass of second block -

$$m_2 = \frac{F}{a_2} \text{ – – – – – – –(ii)}$$

Add equation (i) & (ii), we get

$$m = m_1 + m_2$$

$$\frac{F}{a} = \frac{F}{a_1} + \frac{F}{a_2}$$

$$\frac{1}{a} = \frac{1}{a_1} + \frac{1}{a_2} = \frac{a_2 + a_1}{a_1 a_2}$$

$$a_{total} = = \frac{a_1 a_2}{a_1 + a_2}$$

Put the given values of a_1 & a_2 , we get

$$a_{total} = \frac{6\times3}{6+3} = \frac{18}{9} = 2m/s^2$$

Hence, the acceleration produced will be $2m/s^2$

19. To keep a particle moving with constant velocity on a frictionless surface, an external force:

(a) should act continuously
(b) should act opposite to the direction of motion
(c) is not necessary
(d) should be of variable magnitude

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Ans. (c) : To keep a particle moving with constant velocity on a frictionless surface, an external force is not necessary.

This is based on Newton's first law of motion - A body remains at rest, or in motion at a constant speed in a straight line, unless acted upon by a force.

20. When light travels from one medium to another, which of the following does not change?

(a) Wavelength (b) Intensity
(c) Velocity (d) Frequency

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Ans. (d) : Whenever light goes from one medium to another (from air to glass), the frequency of light and phase of light does not change. However, the velocity of light and wavelength of light change.

21. By applying the brakes without causing a skid, the driver of a car is able to stop his car within a distance of 5m, if it is going at 36 kmph. If the car were going at 72 kmph, using the same brakes, he can stop the car over a distance of:

(a) 10 m (b) 20 m
(c) 40 m (d) 2.5 m

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Ans. (b) :

Given: Initial velocity (u_1) = 36 km/h = $36\times\frac{5}{18}$ = 10 m/s

Distance (s) = 5m

Final velocity (v_1) = 0

Using second equation of motion -

$v^2 - u^2 = 2as$

$(0)^2 - (10)^2 = 2\times a\times5$

$-100 = 10a$

$a = -10m/s^2$

Now again from question–

Initial velocity (u_2) = 72 km/h = $72\times\frac{5}{18} = 20m/s$

Final velocity (v_2) = 0 m/s

& Acceleration (a) = -10 m/s^2

Distance (s) = ?

Again, using second equation of motion –

$v_2 - u_2 = 2as$

$(0)^2 - (20)^2 = 2\times(-10)\times s$

$-400 = -20\times s$

s = 20m

22. A rigid body is made to rotate about an axis of rotation. Its moment of inertia about the axis of rotation depends on

(a) Its angular momentum only
(b) Its angular velocity only
(c) The distribution of its mass about the axis about which it rotates, and also the orientation and position of this axis of rotation
(d) The torque applied only

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Ans. (c) : Moment of inertia of a rigid body about a fixed axis is defined as the sum of the product of the masses of the particles constituting the body and its square of a distance from the axis of rotation.

$I = mr^2$

Moment of inertia of a body made up of number of particles $= m_1r_1^2 + m_2r_2^2 + m_3r_3^2 + ...$

So it can be said that moment of inertia depends on the mass and its distribution about the axis which it rotates. So, option (c) is correct.

23. A ball, having speed V_0 moves in a straight line under the influence of a constant acceleration a. Then its final speed after travelling a distance x for time t will be

(a) $\left(\frac{x}{t}\right) - v_0$ (b) $V_0^2 + 2ax$
(c) $V_0 + \frac{1}{2}\ at^2$ (d) $\left(\frac{2x}{t}\right) - v_0$

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Ans. (b) :

Given that,

Initial velocity (u) = V_0

Acceleration (a) = a

Distance (s) = x

The motion of the equation is only valid when -

- Acceleration is constant
- The motion is in straight line.

From third motion equation,

$v^2 = u^2 + 2as$ -------- (1)

Where, v = Final velocity

Put the values in equation (1)

So, $V^2 = V_0^2 + 2ax$

24. An object of mass m follows a circular path of radius r with a constant speed v in uniform circular motion. Then, the work done by the centripetal force for the object to move once in a full circle is

(a) $(MV^2/r).2r$ (b) Zero
(c) $(Mv^2/r).2\pi r$ (d) $(MV^2/r).2\pi r$

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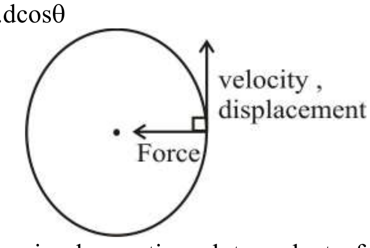
Ans. (b) : Work done on an object is the force applied and the displacement covered in the direction of the force applied.

i.e. W = f.dcosθ



In uniform circular motion, dot product of two mutual perpendicular vectors is the angle between them is 90°.

Then, cos90° = 0

$W = f.d.\cos 90°$
$W = 0$
Hence, the work done in a uniform circular motion is always zero.

25. A ball is thrown vertically upwards with initial velocity V_0 and returns to its starting point in 6 seconds then the initial velocity with which the ball was thrown will be
(a) 58.8 m/s (b) 19.6 m/s
(c) 39.2 m/s (d) 29.4 m/s
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Ans. (d) : Given that,
Time (t) = 6 second
Initial velocity (u) = V_0
Acceleration (a) = $-g = -9.8$ m/sec^2
The ball returns to its initial point, so displacement (s) = 0
According to motion equation
$$S = ut + \frac{1}{2}at^2$$
$$0 = 6V_0 + \frac{1}{2}(-9.8)\times(6)^2$$
$$6V_0 = \frac{1}{2}\times 9.8\times 36$$
$V_0 = 29.4$ m/sec.

26. An object is made to move with uniform speed such that the magnitude of its velocity remains constant with its direction of motion continuously changing with time. Then, the unbalanced force acting on the object will be in the direction.
(a) Inclined at an angle of 60° with the direction of its acceleration
(b) Opposite to that of its velocity
(c) Parallel to that of its velocity
(d) Parallel to the direction of its acceleration
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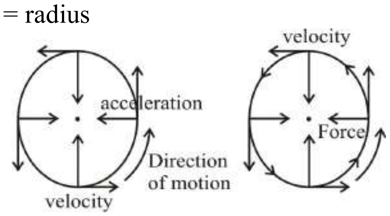
Ans. (d): From the question it is example of uniform circular motion.
• The circular motion in which the speed of the particle remains constant is called uniform circular motion. In uniform circular motion, force supplies the centripetal acceleration.
$$a_c = \frac{v^2}{r}$$
where, v = velocity
r = radius



Uniform Circular motion

• In uniform circular motion, force is parallel to the direction of its acceleration i.e. towards the center.

27. A bullet travels 90 m in 0.2 seconds. Find its speed in km/hr.
(a) 162 (b) 1620
(c) 125 (d) 1250
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Ans : (b) Speed of bullet = $\frac{\text{distance}}{\text{time}}$
$$= \frac{90}{0.2}\times\frac{18}{5}$$
= 1620km/hr

28. Two cars, X and Y, travel from A to B at average speeds of 50 km/hr and 75 km/hr respectively. If X takes 2 hours more than Y for the journey, then the distance between A and B in km is——.
(a) 800 (b) 400
(c) 300 (d) 600
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Ans : (c) Let, y take t hours to reach from A to B, therefore, time taken by x to reach from A to B = (t +2) hours.
from, $r_1t_1 = r_2t_2$
$50\times(t+2) = 75\times t$
$50t + 100 = 75t$
$25t = 100$
$t = 4$ hours
So, desired distance = 75 ×4
= 300km

29. By cycling 7/9 times his usual speed, Anwar reaches his school 4 minutes late. How many minutes does Anwar take to reach school at his usual cycling speed?
(a) 14 (b) 20 (c) 18 (d) 16
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Ans : (a) Let, the normal speed of answer be x and with this speed its time to reach school.
From, $s_1t_1 = s_2t_2$
$$x\times t = \frac{7}{9}x\times(t+4)$$
$\Rightarrow$ $9t = 7t + 28$
$\Rightarrow$ $2t = 28$
$\Rightarrow$ $t = 14$ min
Hence, answer takes 14 min to reach school at normal speed.

30. A truck travels 450 km in two and a half hours. Find its speed in m/s.
(a) 60 (b) 90
(c) 50 (d) 75
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Ans : (c) Given,
$$t = 2\frac{1}{2}\text{ hour}$$
$$= \frac{5}{2}\text{ hour}$$
s = 450km.
$$\text{speed} = \frac{s}{t}$$
$$= \frac{450}{\frac{5}{2}} = 180\text{km/h}$$
$$= 180\times\frac{5}{18}$$
= 50m/s