01. Units a

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.

Power of 10	Prefix	Symbol
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{1}	deca	da

and Measurements

- **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
10^{-1}	deci	D
10^{-2}	centi	C
10^{-3}	mili	M
10^{-6}	mirco	μ
10^{-9}	nano	N
10^{-12}	pico	P
10^{-15}	femto	F
10^{-18}	atto	A

❒ **Units of Important Physical Quantities-**

Physical Quantity	Unit	
Angular Acceleration	Rad-s^{-2}	F
Moment of inertia	kg-m^2	F
Self inductance	Henry	S
Magnetic Flux	Weber	U
Pole Strength	A-m	D
Dynamic Viscosity	Pascal-sec or kg/ms	S
Kinematic Viscosity	m^2/s	F
Reactance	ohms(Ω)	F
Specific heat	J/kgºC	F
Strength of magnetic field	Tesla	F
Astronomical distance	Parsec	A

Dimensions of important Physical Quantities -

Physical Quantity	Dimensions
Momentum	$M^1L^1T^{-1}$
Calorie	$M^1L^2T^{-2}$
Latent heat capacity	$M^0L^2T^{-2}$
Self inductance	$M^1L^2T^{-2}A^{-2}$
Coefficient of thermal conductivity	$M^1L^1T^{-3}\theta^{-1}$
Power	$M^1L^2T^{-3}$
Impulse	$M^1L^1T^{-1}$
Hole mobility of a semiconductor	$M^{-1}L^0A^1T^2$
Bulk modulus of elasticity	$M^1L^{-1}T^{-2}$
Light year	$M^0L^1T^0$
Thermal resistance	$M^{-1}L^{-2}T^3\theta$
Coefficient of Viscosity	$M^1L^{-1}T^{-1}$

■ **Physical quantities which are dimensionless-**

Sr. No.	Physical Quantity
1.	Specific gravity
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 permittivi
9.	Relative density
10.	Trigonometric-ratios
11.	Distance gradient
12.	Relative permeability

■ **Physical quantities which have same dimensional fo**

S.No.	Physical Quantity
1.	Speed or Velocity
2.	Velocity of light in Vacuum (c)
3.	Distance travelled in n^{th} second (S_n^{th})
4.	Relative Velocity
5.	Frequency (ν)
6.	Angular frequency
7.	Angular velocity (ω)
8.	Velocity Gradient

Physical Quantity	Unit
Frequency	Hertz
Resistance	ohm(Ω)
Surface tension	Newton/m
Universal Gas Constant	Joule K^{-1} mol^{-1}
Dipole-moment	coulomb-meter
Stefan Constant	Watt m^{-2} K^{-4}
Permittivity of free space (ε_0)	$Coulomb^2/N\text{-}m^2$
Permeability of free space (μ_0)	Weber/A-m
Planck's constant	Joule-sec
Entropy	J/K
Angular Speed	Rad/sec

Physical Quantity	Dimensions
Capacitance	$M^{-1}L^{-2}T^{4}A^{2}$
Modulus of rigidity	$M^{1}L^{-1}T^{-2}$
Magnetic permeability	$M^{1}L^{1}T^{-2}A^{-2}$
Solar constant	$M^{1}L^{0}T^{-3}$
Magnetic flux	$M^{1}L^{2}T^{-2}A^{-1}$
Current density	$M^{0}L^{-2}T^{0}A^{1}$
Young's Modulus	$M^{1}L^{-1}T^{-2}$
Magnetic field intensity	$MT^{-2}A^{-1}$
Magnetic induction	$M^{1}T^{-2}A^{-1}$
Permittivity	$M^{-1}L^{-3}T^{4}A^{2}$
Electric field	$M^{1}L^{1}T^{-3}A^{-1}$
Resistance	$ML^{2}T^{-3}A^{-2}$

	Dimensional Formula
	$[M^0L^0T^0]$
ty	

rmula -

	Dimensional Formula
	$M^0L^1T^{-1}$
	$M^0L^0T^{-1}$

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9.	Work
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
18.	Pressure
19.	Stress
20.	Young's Modulus
21.	Bulk Modulus
22.	Modulus of rigidity
23.	Energy density
24.	Force
25.	Weight
26	Thrust
27.	Energy gradient
28.	Tension
29.	Acceleration
30.	Acceleration due to gravity
31.	Gravitational field intensity
32.	Plank's Constant (h)
33.	Angular momentum
34.	Mass
35.	Momentum
36.	Impulse
37.	Length
38.	Radius of gyration (K)
39.	Wavelength (λ)
40.	Force constant
41.	Surface tension
42.	Surface energy
43.	Area
44.	Volume
45.	Density
46.	Universal gravitational constant (G)
47.	Moment of Inertia
48.	Angular acceleration
49.	Rate of flow
50.	Mass per unit length
51.	Rydberg constant (R)
52.	Coefficient of viscosity (η)
53.	Kinematic viscosity
54.	Surface potential
55.	Specific volume
56	Power

■ 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

$M^1L^2T^{-2}$
$M^1L^{-1}T^{-2}$
$M^1L^1T^{-2}$
$[M^0L^1T^{-2}]$
$[M^1L^2T^{-1}]$
$[M^1L^0T^0]$
$[M^1L^1T^{-1}]$
$[M^0L^1T^0]$
$M^1L^0T^{-2}$
$M^0L^2T^0$
$M^0L^3T^0$
$M^1L^{-3}T^0$
$M^{-1}L^3T^{-2}$
$M^1L^2T^0$
$M^0L^0T^{-2}$
$M^0L^3T^{-1}$
$M^1L^{-1}T^0$
$M^0L^{-1}T^0$
$M^1L^{-1}T^{-1}$
$M^0L^2T^{-1}$
$M^0L^2T^{-2}$
$M^{-1}L^3T^0$
$M^1L^2T^{-3}$

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 $\left[\frac{d^n y}{dx^n}\right] = \left[\frac{y}{x^n}\right]$.
- Dimension of integrals $[\int y dx] = [yx]$ 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 $Q = n \times u$
  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/°C**
- 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 **- $\frac{kg-m}{sec^2}$ (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 **- $[ML^2T^{-2}]$**

- 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**

PREVIOUS YEA

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

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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.

- 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**

AR QUESTIONS

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

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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

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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

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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

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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) : Least count = $\frac{\text{Pitch}}{\text{no.of divisions}} = \frac{1}{50}$

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

$= \frac{1}{1000}$ 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,

■ 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.

■ Difference between Mass and Weight

	Mass
Definition	The amount of substance in body
Dependent on location	No The mass is same on the Moo as on Earth
Measured using	A beam balance
Unit	Kilogram

■ 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

$$F = ma$$
$$1N = 1kg \times 1m/s^2$$

Interaction	Particle affected	Range	Relative Strength
Strong Nuclear force	Quarks Hadrons	$\sim 10^{-15}$ m	1
Electromagnetic	Charged particles	∞	10^{-2}
Weak nuclear force	Quark & Leptons	$\sim 10^{-16}$ m	10^{-13}
Gravitational	All	∞	10^{-39}

Weight & Density

■ **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

	Weight
a	The gravitational pull acting on a body
n	Yes The weight is different on the Moon from Earth
	A spring balance
	Newton

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

Characteris -tics time	Particle exchange	Role in universe
10^{-23} sec	Gluons Mesons	Holds quark together to form nucleon. Hold nucleons together to form atomic nuclei.
10^{-20} sec	Photons	Determine structure of atoms, solids and liquid is important factor in astronomical universe.
10^{-10} sec	Intermediate boson	Mediate transformations of quarks & leptons helps determine composition of atomic nuclei
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-m-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 $= \frac{\Delta g}{g} \times 100 = \frac{h}{R_e} \times 100$

(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 $\lambda = 90^o$ and $g' = g$. Therefore, there is no effect of rotation of earth about its own axis at poles.
- At equator $\lambda = 0^o$ 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 $r = \infty$, $V = 0$ 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-

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

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

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

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

■ Gravitational Potential for different bodies -

(i) Potential due to a point mass -

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

(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 , $r > R,\ V = -\frac{GM}{r}$	
On the Surface, r = R $V_{surface} = -\frac{GM}{R}$	
Inside the Surface, $V = -\frac{GM}{2R}\left[3-\left(\frac{r}{R}\right)^2\right]V_{cen}$ $_{tre} = \frac{-3}{2}\frac{GM}{R}$	

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

$$dV = -E.dr$$

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

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

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

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

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

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

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

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

  This is the minimum time period of any earth's satellite.
- Binding energy $B.E = +\frac{GMm}{2r}$
- 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 -**

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

■ 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 – ——
- 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 $\sqrt{\ }$
- 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**

PREVIOUS YEA

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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- 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**

AR QUESTIONS

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

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

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

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

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

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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

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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 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

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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 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

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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

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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

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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

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

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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

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

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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

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Ans : (b) In equilibrium condition :-

$\sum m = 0$

$40 \times x = 20 \times 50$

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

$x = 25$ 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

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

$\therefore$ 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

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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

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

(d) $= \frac{0.192 \times 100000}{24} = \frac{19200}{24} = 800$ 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)

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

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

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) $= 10\ \text{m/s}^2$

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

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

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

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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

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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

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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

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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

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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

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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

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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

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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

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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.
$= 19.3 \times 1000$
$= 19300$ kg/m^3
$= 19.3 \times 10^3$ 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

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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) $PV/T = (1/\mu)R$

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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

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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

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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%

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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

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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

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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

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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

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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

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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

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

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

$g = 3.7 m/sec^2$

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

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) $\frac{D_1D_2}{D_1+D_2}$

(c) $\frac{2D_1D_2}{D_1+D_2}$ (d) $\frac{D_1+D_2}{D_1D_2}$

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

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

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

$$x = 0.9\ cm$$

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) $8 g/cm^3$

RRB Ranchi Signal Maintainer Group-III, 20.11.2005

Ans. (c) :

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

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

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

$$= 8$$

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.

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

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

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

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

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-

$$\text{density} = \frac{\text{mass}}{\text{volume}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(i)$$

(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-

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

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. S

- **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.

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

Speed and Velocity

(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 $\theta = 0°$ then , R_{max} = A+B

Case3- If $\theta = 180°$ 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-

$A_x = A\cos\theta$ $A_y = A\sin\theta$

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

MECHANICS

Kinematics	Dynamics (or Kinetics)
The word kinematics means 'science of motion' branch of the mechanics which deals with study of motion without going into the cause of motion,(i.e. force,torque etc).	It is branch of mechanics which is concerned about the causes (i.e. force, torque) that cause motion of bodies.

■ **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.Speed(V) = $\frac{\text{distance travelled(s)}}{\text{time taken(t)}}$

- 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
• $v = u + at$	$\vec{v} = \vec{u} + \vec{a}t$
• $s = ut + \frac{1}{2}at^2$	$\vec{s} = \vec{u}t + \frac{1}{2}\vec{a}t^2$
• $v^2 = u^2 + 2as$	$\vec{v}.\vec{v} - \vec{u}.\vec{u} = 2\vec{a}\vec{s}$

- $s = \left(\frac{u+v}{2}\right)t$ $\qquad$ $\vec{s} = \frac{1}{2}(\vec{u}+\vec{v})t$
- $s_n = u + \frac{a}{2}(2n-1)$ $\qquad$ $\vec{s}_n = \vec{u} + \frac{\vec{a}}{2}(2n-1)$
- Displacement of a particle in n^{th} 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, $\theta = 0^o$ $\left[t_{min} = \frac{d}{V_m}\right]$

■ 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 $= \frac{1}{2}g\left(t_1+t_2\right)^2$.	
● 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, $\left[\Delta x = \int v dt\right]$.
- a-t curve area gives change in velocity $\left[\Delta v = \int a dt\right]$

■ Key points -

$$\text{Displacement} \underset{\text{Integration}}{\overset{\text{Differentiation}}{\rightleftarrows}} \text{Velocity} \underset{\text{Integration}}{\overset{\text{Differentiation}}{\rightleftarrows}} \text{Acceleration}$$

- Displacement ≤ Distance.
- $\frac{\text{Velocity}}{\text{Speed}} \leq 1$
- $\frac{\text{Average velocity}}{\text{Average speed}} \leq 1$
- $\frac{\text{Instantaneous velocity}}{\text{Instantaneous speed}} = 1$

Different Motions and their Graphs :

Different Cases	V-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	

- 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, $\text{Average speed} = \frac{V_1 t_1 + V_2 t_2 + V_3 t_3}{t_1 + t_2 + t_3}$.....

- If particle travels with speed V_1 and V_2 for equal time intervals i.e $t_1 = t_2 = t$, then

$$\text{Average speed} = \frac{V_1 + V_2}{2}.$$

- 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 $\frac{2}{V} = \frac{1}{V_1} + \frac{1}{V_2}$

	S-t Graph

■ 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

$\overrightarrow{OP} = \overrightarrow{OA} + \overrightarrow{OB}$, $\vec{r} = x\hat{i} + y\hat{j}$

- 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-

$$V_{av} = \frac{\Delta x}{\Delta t}\hat{i} + \frac{\Delta y}{\Delta t}\hat{j} \quad , \quad = \Delta V_x \hat{i} + \Delta V_y \hat{j}$$

Direction of the velocity ΔV is given by-

$$\tan\theta = \frac{\Delta V_y}{\Delta V_x}$$

(ii) Instantaneous Velocity-

$$V = \lim_{x\to 0}\frac{\Delta r}{\Delta t} = \frac{dr}{dt} \quad , \quad V = \frac{dx}{dt}\hat{i} + \frac{dy}{dt}\hat{j} \quad , \quad V = V_x\hat{i} + V_y\hat{j}$$

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 $\overrightarrow{\Delta V}$

$$\vec{a}_{av} = \frac{\overrightarrow{\Delta V}}{\Delta t} \quad , \quad \vec{a}_{av} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$$

(ii)Instantaneous Acceleration -

- It is defined as the limit of the average acceleration as Δt approaches zero.

$$\vec{a} = \lim_{\Delta t\to 0}\frac{\Delta\vec{V}}{\Delta t} = \frac{d\vec{V}}{dt} \quad , \quad \vec{a} = \lim_{\Delta t\to 0}\left(\frac{\Delta V_x}{\Delta t}\hat{x} + \frac{\Delta V_y}{\Delta t}\hat{y} + \frac{\Delta V_z}{\Delta t}\hat{z}\right)$$

■ Motion in a plane with uniform acceleration-

$V_x = V_{ox} + a_x t,$ $\qquad V_y = V_{oy} + a_y t$

□ 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.

$$a_c = \omega^2 r = \frac{V^2}{r} = \omega V \left\{\because \quad \omega = \frac{V}{r}\right\}, \quad \vec{a}_c = \vec{\omega} \times \vec{V}$$

■ Centripetal Force (F_c) -

$$F_c = \frac{mv^2}{r}$$

$$F_c = m\alpha$$

$$F_c = m\omega^2 r$$

$$F_c = m\omega v$$

$$\vec{F}_c = m(\vec{v} \times \vec{\omega})$$

b

- 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 (v) = $\frac{1}{T}$

(ii) Relation between frequency angular velocity and time, $(\omega) = \frac{\theta}{t} = \frac{2\pi}{T} = 2\pi v$

(iii) Relation between linear acceleration and angular acceleration. $a = \alpha r$, $\vec{a} = \alpha \times \vec{r}$

■ Motion in Vertical circle -

- Motion in a vertical circle is non-uniform circular motion.

- Tension at the lowest point (P) $T_P = \frac{mV_P^2}{l} + mg$
- Tension at the highest point Q. $T_Q = \frac{mV_Q^2}{l} - mg$

  $T_Q = \frac{mV_P^2}{l} - 5mg$
- Tension at point R-

  $T_R = \frac{mV_R^2}{l}$, $T_R = \frac{mV_P^2}{l} - 2mg$
- $T_P > T_R > T_Q$ • $T_P - T_Q = 6$ mg • $T_P - T_R = 3$ mg
- Tension at any point A - $T = \frac{mV^2}{r} + mg\cos\theta$
- **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 $90^o < \theta < 180^o$. 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 -

$T \cos\theta = mg$, $T \sin\theta = \frac{mv^2}{r}$

$\tan\theta = \frac{v^2}{rg}$, $T = 2\pi\sqrt{\frac{l\cos\theta}{g}}$

■ Rounding a level curved Road -

- $\frac{mv^2}{r} \leq (F_1 + F_2)$

  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. $V_{max} = \sqrt{\frac{rg(\tan\theta + \mu_s)}{(1 - \mu_s \tan\theta)}}$

■ 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

  $\tan\theta = \frac{V^2}{rg}$

  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 (∵ 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-

  $V_y = U_y + a_y t,\ \ t = \frac{U\sin\theta}{g}$

- **Time of Flight (T) -**

  $T = 2t,\qquad T = \frac{2U\sin\theta}{g}$

- **Height attained by the body in projectile motion -**

  $H = \frac{U^2\sin^2\theta}{2g}$

- **Condition for maximum height attained (H_{max}) –**
  For maximum height,

  $\theta = 90^o$, $\sin\theta = 1$, $H_{max} = \frac{U^2}{2g}$
- **Range produced by the body in projectile motion -**

  $R = \frac{U^2 \sin 2\theta}{g}$
- **Condition for maximum Range : (R_{max}) –**

  $\sin 2\theta = 1 = \max = \sin 90^o$, $\theta = 45^o$, $R_{max} = \frac{U^2}{g}$
- **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 -**

$\theta_1 + \theta_2 = 90^o = \frac{\pi}{2}$

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 $\vec{F} = \left(6\hat{i} + 2\hat{j} - 3\hat{k}\right)$ acts on a particle and produces a displacement of $\vec{S} = \left(2\hat{i} - 3\hat{j} - x\hat{k}\right)$. 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 $x = \left(t^3 - 2t - 10\right)$ 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 **- $F \propto R^4$**
- "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**

PREVIOUS YEA

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) = $\frac{\Delta V}{t}$

$= \frac{5 m/sec}{5 sec}$

= 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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- 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.**

AR QUESTIONS

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,

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

$$x = \frac{1}{2} a \times 4$$

$$x = 2a \quad .... (i)$$

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

$x + y = \frac{1}{2} \times a \times 4 \times 4$

$x + y = 8a$ .... (ii)

From equation (i) and (ii), we get

$x + y = 8a$

$2a + y = 8a$

$y = 6a$

Given, $y = nx$

$y = 3 \times 2a$

$\Rightarrow$ $n = 3$

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 $\frac{dA}{dt} = \frac{1}{2} r \times \nu$ ...(i)

If distance is 4r then,

$\frac{dA}{dt} = \frac{1}{2} 4r \times \nu_2$ ...(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
$m_1 = 500kg$, $v_1 = 0$
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 = $P_1 + P_2$
$= (m_1v_1 + m_2 v_2)$
$= 1500 \times v_2$
sine, there is no external fore, the momentum is conserved
So, Momentum before explosion = Momentum after explosion
$2000 \times 600 = 1500\ v_2$
$v_2 = 800$ m/s

7. A body is thrown with a velocity 20 m/s at an angle of 30° 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) = 30°
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 ($g = 10m/s^2$)

(a) 2.5 m (b) 5 m
(c) 10 m (d) 3.5 m

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Ans. (b) : Given t = 1 second
$g = 10\ m/s^2$
Then, from Newton's first equation of motion
$v = g\,t = 1\times 10 \Rightarrow (v = 10m/s)$
From Newton's third equation of motion

$$h = \frac{v^2}{2g} = \frac{10\times 10}{2\times 10} = 5m \Rightarrow \boxed{h = 5m}$$

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

$$a_{total} = \frac{6\times 3}{6+3} = \frac{18}{9} = 2m/s^2$$

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 -

$v^2 - u^2 = 2as$
$(0)^2 - (10)^2 = 2\times a\times 5$
$-100 = 10a$
$a = -10m/s^2$

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. $W = f.d\cos\theta$

In uniform circular motion, dot product of two mutual perpendicular vectors is the angle between them is 90°.

Then, $\cos 90° = 0$

W = f.d.cos90°
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,

$t = 2\frac{1}{2}$ hour

$= \frac{5}{2}$ hour

s = 450km.

speed $= \frac{s}{t}$

$= \frac{450}{\frac{5}{2}} = 180\text{km/h}$

$= 180 \times \frac{5}{18}$

= 50m/s

31. A rocket travels 108 m in 0.3 seconds. Find its speed in km/hr.

(a) 1296 km/h (b) 6300 km/h
(c) 1692 km/h (d) 3600 km/h

RRB ALP & Tech. 08.02.2019 Shift-I

Ans : (a) : t = 0.3 sec
distance = 108 m

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$
$$= \frac{108}{0.3}$$
$$= 360 \text{ m/sec}$$
$$= 360 \times \frac{18}{5} \text{ km/hour}$$
$$= 72 \times 18$$
$$= 1296 \text{ km/hour}$$

32. A body starts moving form rest. Its displacement is propational to ____ when its acceleration is constant.

(a) Velocity (b) Work
(c) Time squared (d) Time

RRB ALP & Tech. 23.01.2019 Shift-III

Ans : (c) Let, constant acceleration is a initial velocity u = 0 ,

$$s = ut + \tfrac{1}{2}at^2$$
$$s = 0 \times t + \tfrac{1}{2}at^2$$
$$s = \tfrac{1}{2}at^2$$
$$\boxed{s \propto t^2}$$

Therefore, displacement of object is directly proportional to the square of time.

33. A motorcycle covers a distance of 1000 m at a speed of 36 km/hr. Find the time (in seconds) taken by the motorcycle to cover this distance.

(a) 300 (b) 200
(c) 100 (d) 400

RRB ALP & Tech. 23.01.2019 Shift-III

Ans : (c)

$$\text{Time} = \frac{\text{distance}}{\text{speed}}$$
$$= \frac{1000}{36 \times \frac{5}{18}}$$
$$= 100 \text{ second}$$

34. An object starts from rest at x = 0 m and rotates with a constant acceleration of 1.6 m/s^2 about the x-axis. What is its average velocity during its journey from x= 12.8 m to x= 20.0 m?

(a) 2.4m/s (b) 3.6m/s
(c) 7.2m/s (d) 8.8m/s

RRB ALP & Tech. 23.01.2019 Shift-III

Ans:(c) T_1, T_2 and V_1, V_2 shows time and displacement respectively.

Initial velocity (u) = 0, acceleration (a) = 1.6 m/s^2

$$S = ut + \frac{1}{2}at_1^2$$
$$12.8 = 0 + \frac{1}{2} \times 1.6 \times t_1^2$$
$$1.6\, t_1^2 = 25.6$$

$t_1^2 = 16$
$t_1 = 4$
$v_1 = u + at_1$
$v_1 = 0 + 1.6 \times 4$
$v_1 = 6.4$ m/s

$$20 = ut + \frac{1}{2}at_2^2$$

$t_2 = 5$
$t_2 = 5$ sec
$v_2 = u + at_2$
$v_2 = 0 + 1.6 \times 5$
$v_2 = 8$ m/s

Average velocity $= \frac{v_1 + v_2}{2} = \frac{8 + 6.4}{2} = 7.2\,m/s$

35. An airoplane flies at a speed of 50 m/s. How much distance will it cover in 5 hours?
(a) 895 (b) 880
(c) 850 (d) 900

RRB ALP & Tech. 23.01.2019 Shift-III

Ans : (d) distance = speed × time

$$= 50 \times \frac{18}{5} \times 5 = 900 \text{ km.}$$

36. A ball is thrown vertically upward with a speed of 30 m/s. The magnitude of its displacement after 4 s will be _____.
(a) 30m (b) 50m
(c) 15m (d) 40m

RRB ALP & Tech. 22.01.2019 Shift-I

Ans : (d) Given:
u = 30 m/sec
t = 4 sec
g = 10 m/sec^2
h = ?

by 2nd equation of motion -

$h = ut - \frac{1}{2}gt^2$ (in ward directive)

$$h = 30 \times 4 - \frac{1}{2} \times 10 \times 4 \times 4$$

h = 120 – 80
h = 40 m

37. ..... is defined as the total path length travelled by an object divided by the total time interval during which the motion has taken place.
(a) Instantaneous acceleration
(b) Average speed
(c) Uniform acceleration
(d) Instantaneous velocity

RRB ALP & Tech. 22.01.2019 Shift-I

Ans : (b) Average speed is defined as the total path length covered by an object which is divided by time interval during which the motion occurred.

38. An object is moving with a speed 100 m/s. Find the distance travelled by this object in one minute.
(a) 100 km (b) 0.6 km
(c) 6 km (d) 10 km

RRB ALP & Tech. 22.01.2019 Shift-II

Ans : (c) : Distance = speed × time
= 100 × 60
= 6000 m {∵ 1 km = 1000 m}
= 6 km

39. An object starts from rest at x = 0 m and t = 0 sec. It moves with constant acceleration of 3 m/s^2 along x axis. What is its average velocity between time 4 s and 8 s?

(a) 6 m/s (b) 18 m/s
(c) 12 m/s (d) 3 m/s

RRB ALP & Tech. 22.01.2019 Shift-II

Ans : (b) : t = 8–4 = 4 sec

u = 0

a = 3 m/s^2

v = u + at

v = 0 + 3×4

V = 12 m/s

From 2nd equation of motion -

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

$$S = 12\times4+\frac{1}{2}\times4\times4\times3$$

S = 72 m

$$\text{Average velocity} = \frac{\text{total distance}}{\text{total time}} = \frac{72}{4} = 18 \text{ m/s}$$

40. An object starts moving from rest, with constant acceleration. Its velocity is:

(a) Directly proportional to time
(b) Inversely proportional to time
(c) Inversely proportional to time square
(d) Directly proportional to time square

RRB ALP & Tech. 22.01.2019 Shift-II

Ans : (a) : $\text{Acceleration} = \frac{\text{Velocity}}{\text{time}}$

Velocity = acceleration × time

Velocity $\propto$ time

Velocity of object is directly proportional to time.

41. When you double the speed of a car, it takes ..... times more distance to stop it.

(a) four (b) one
(c) two (d) three

RRB ALP & Tech. 21.01.2019 Shift-I

Ans : (a) : $v^2 = u^2 - 2as$

$0 = u^2 - 2as$

$$s = \frac{u^2}{2a}$$

If initial velocity is 2 time then distance will be 4 times,

42. An object starts from rest at x = 0 m and moves with constant acceleration of 3 m/s^2 along x axis. During its journey from x = 13.5 m to x = 54 m, its average velocity is :

(a) 13.5 m/s (b) 10.0 m/s
(c) 8.5 m/s (d) 12.0 m/s

RRB ALP & Tech. 21.01.2019 Shift-I

Ans : (a) : u = 0 a = 3 m/s^2

Motion A to B

$$v_B^2 = 0 + 2\times3\times13.5$$

$$v_B^2 = 6\times13.5$$

$$v_B^2 = 81.0$$

$v_B = 9$ m/s

motion $A \rightarrow C$

$u_A = 0$

$v_c = ?$

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

$v_c^2 = 0 + 2 \times 3 \times 54$

$v_c^2 = 6 \times 54$

$v_c^2 = 324$

$v_c = 18$ m/s

$v_{avg} = \frac{9+18}{2}$

$= \frac{27}{2} = 13.5 m/s$

43. Find the velocity (in m/s) that a car will achieve after 20 seconds if it starts and accelerates at 3.2 m/s^2.

(a) 72 (b) 36

(c) 108 (d) 64

RRB ALP & Tech. 21.01.2019 Shift-I

Ans : (d) : t = 20 second

a = 3.2 m/sec^2

u = 0

v = u + at

= 0 + 3.2 × 20

= 64 m/second

44. A car accelerating for two seconds would cover ..... times the distance of a car accelerating for only one second (cars starts from rest with the same acceleration in both the cases).

(a) Four (b) Three

(c) Two (d) One

RRB ALP & Tech. 21.01.2019 Shift-I

Ans : (a) : A car accelerating for two seconds would cover 4 time distance of a car accelerating for only one second.

45. An object covers the first distance of 200 m in 20s and takes 30s for the next 200m. What is the average speed of the object?

(a) 8m/s (b) 12m/s

(c) 4m/s (d) 6m/s

RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (a) Total distance = 200+200= 400m

total time = 20+30 = 50sec

$$\text{Average speed} = \frac{\text{total distacne}}{\text{total time}}$$

$$= \frac{400}{50}$$

= 8 m/sec

Average speed of object = 8 m/sec

46. An object starts from rest at X = 0m and t = 0 s and rotates with a constant accelerration of 4m/s^2 about the x-axis. What is its average velocity between the time 2s and 6s ?

(a) 12m/s (b) 16m/s

(c) 8m/s (d) 18m/s

RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (b) $a = \frac{dv}{dt}$

$$\int_{o}^{v} dv = \int_{2}^{6} adt$$

$$(v-0) = a\int_{2}^{6} dt$$

$$V = a(t)_{2}^{6}$$

$= 4[6–2] = 16m/s$ (given : $a = 4\ m/sec^2$)

Average velocity will be 16 m/sec

47. A ball is dropped freely from the top of building from an intial rest and attains a maximum velocity of 40m/s. What will be the height of the building ? (use g = 10m/s for the acceleration due to gravity)

(a) 70m (b) 80m

(c) 50m (d) 60m

RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (b) $v = u + gt$

$v = 0+gt$

$v = gt$

$$t = \frac{v}{g}$$

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

$$h = 0 + \frac{1}{2}g \times \left(\frac{v}{g}\right)^2$$

$$h = \frac{1}{2}g \times \frac{v^2}{g \times g}$$

$$h = \frac{1}{2} \times \frac{v^2}{g}$$

$$h = \frac{1}{2} \times \frac{40^2}{10}$$

$$h = \frac{1}{2} \times \frac{40 \times 40}{10}$$

$h = 80$ m

48. A car starts from rest with a constant acceleration of $3m/s^2$. Find the distance covered by this car in 10s.

(a) 250m (b) 100m

(c) 200m (d) 150m

RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (d) $a= 3m/s^2$

$t = 10s$

$S = ?$

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

$$S = 0 \times 10 + \frac{1}{2} \times 3 \times 10^2$$

$$S = \frac{1}{2} \times 300$$

$S= 150m$

Total distance covered by the car is 150 m.

49. The circumference of a planet is 36,000 km. If the planet makes no other movement and takes 20 hours for one complete rotation, what is the speed of a point on its equator?

(a) 500 m/s (b) 400 m/s
(c) 300 m/s (d) 200 m/s

RRB ALP & Tech. 21.01.2019 Shift-II

Ans : (a) : If $\Delta\theta$ is the augular displacement at a time Δt then the angular speed is given by –

$$\omega = \frac{\Delta\theta}{\Delta t}$$

Angular speed $(\omega) = \frac{2\pi r}{\text{time}}$

Given that-

Circumference of the planet $(2\pi r) = 36{,}000$ km

time = 20 hours

angular speed $(\omega) = \frac{36000}{20} = 1800 \text{ km/h}$

Now, converting km/h to m/sec

$\therefore$ Angular speed $(w) = 1800 \times \frac{5}{18} = 500 \text{ m/s}$

Hence, the speed of a point on its equator will be 500 m/s.

50. A bullet is fired vertically upwards with a velocity of 196 m/sec. What is the maximum height reached by the bullet? (Assuming g = 9.8 m/sec^2)

(a) 1960 m (b) 196 m
(c) 980 m (d) 490 m

RRB Bilaspur JE (red) , 14.12.2014

Ans. (a) : Given that,

$v = 196$ m/sec

$h = ?$

$(u) = 0$

$v^2 = u^2 + 2gh$

$(196)^2 = 0 + 2 \times 9.8 \times h$

$h = (1960)$m

The maximum height reached the bullet is 1960m.

51. One early morning, with no traffic on roads, Rahul while cycling down from Red Fort to his residence noted the distance covered and the total time taken to reach home. What can he calculate from this data ?

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

RRB SSE Secundrabad (Shift-I), 02.09.2015

Ans. (b) :

$$\text{Average speed} = \frac{\text{total distance}}{\text{total time}}$$

Average speed can be calculated from the given data.

52. In above graph ratio of average speed to average velocity is :

(a) 1 : 1 (b) 2 : 3

(c) 3 : 2 (d) 2 : 1

RRB Chennai Section Engineer, 12.02.2012

Ans. (c) :

$$\text{Average speed} = \frac{\text{total distance}}{\text{total time}}$$

$$= \frac{\frac{1}{2}\times 10\times 20 + \frac{1}{2}\times 10\times 4}{14} = \frac{120}{14}$$

$$\text{Average speed} = \frac{\text{Displacement}}{\text{time}}$$

$$= \frac{\frac{1}{2}\times 10\times 20 + \frac{1}{2}\times(-10)\times 4}{14}$$

$$= \frac{100-20}{14} = \frac{80}{14}$$

$$\therefore \frac{\text{Average speed}}{\text{Average velocity}} = \frac{120}{14} : \frac{80}{14} = \frac{3}{2}$$

53. A force F produces an acceleration of $3ms^{-2}$ in a body and $6ms^{-2}$ in another body. If both the bodies are tied together and same force is applied due to acceleration in the bodies will be :

(a) $3ms^{-2}$ (b) $9\ ms^{-2}$

(c) $4.5\ ms^{-2}$ (d) $2ms^{-2}$

RRB Kolkata Supervisor (P.Way), 20.02.2000

Ans. (d) : Common acceleration of two object -

$$a = \frac{a_1 a_2}{a_1 + a_2} = \frac{3\times 6}{3+6} = 2ms^{-2}$$

54. A car travels three equal parts of its journey with average speed of 60 kmh^{-1}, 80 kmh^{-1} and 120kmh^{-1}. Average speed of car during its journey will be.

(a) $60kmh^{-1}$ (b) $80\ kmh^{-1}$

(c) $100\ kmh^{-1}$ (d) $87\ kmh^{-1}$

RRB Kolkata Apprentice Supervisors, 14.10.2001

Ans. (b) :

x x x

$$t_1 = \frac{x}{60} \qquad t_2 = \frac{x}{80} \qquad t_3 = \frac{x}{120}$$

$$\text{average speed} = \frac{\text{total distance}}{\text{total time}}$$

$$= \frac{3x}{\frac{x}{60}+\frac{x}{80}+\frac{x}{120}}$$

$$= 3x \times \frac{240}{9x} = 80 kmh^{-1}$$

55. When ball is drop from the roof of a building. It takes 3 second for the ball to reach the ground. the acceleration of the ball towards the earth is 10 m/sec then height of the building is

(a) 40 m (b) 20 m

(c) 30 m (d) None of these

RRB RRB Patna/Allahabad ESM-II , 30.01.2011

Ans. (d) : Hight of building = vertical distance travelled by the ball –

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

$$h = 0 + \frac{1}{2} \times 10 \times (3)^2$$

$[\because u = 0]$, g = 10 m/sec^2

$$\boxed{h = 45m}$$

56. Which is the correct formula to find acceleration?

(a) $a = \frac{v-u}{t}$ (b) $a = u + vt$

(c) $a = \frac{v+u}{t}$ (d) $a = \frac{v+u}{2}$

RRB Ajmer (Tech.), 01.03.1998

Ans. (a) : By first equation of motion

$v = u + at$

$v - u = at$

$a = \frac{v-u}{t}$

57. If an object, on a free fall from a certain height, reaches the ground in 1 second, what is its velocity on the impact with the ground?

(a) 4.9 m/s (b) 9.8 m/s

(c) 14.7 m/s (d) 19.6 m/s

RRB Mumbai Electrical/Diesel Drivers', 03.06.2001

Ans. (b): t = 1 second

initial velocity (u) = 0

velocity of collision with earth = v m/s

$v = u + gt$

$v = 0 + 9.8 \times 1$

$v = 9.8$ m/s

58. In a projectile motion, a large angle with the horizontal produces .....

(a) flat trajectory

(b) curve trajectory

(c) straight trajectory

(d) high trajectory

RRB Bhubaneshwar (Tech.), 03.06.2001

Ans. (d) : When an object is project from a vertical plane making an angle with the horizontal its path is parabolic, this motion of the body is called projective motion -

$$h = \frac{u^2 \sin^2 \theta}{2g}$$

$$\theta = 90^0 \qquad h_{max} = \frac{u^2}{2g}$$

Hence, projective motion, a high trajectory is obtained at a large angle θ = 90° with the horizontal.

59. If a ball is thrown up, which of the following does not change?

(a) Acceleration (b) Speed
(c) Potential energy (d) Distance

RRB Bhubaneshwar App. Elec. Signal Maintainer, 19.08.2001

Ans. (a) : When a ball is thrown upwards, its path, is parabolic, in such a situation its speed, potential energy and distance change but acceleration remains unchanged. The value of this acceleration is always equal to g (acceleration due to gravity).

60. A 5 kg mass at rest on a frictionless table is acted upon by a constant force of 12 N. The distance travelled by it in 2s is–

(a) 1.2 m (b) 2.4 m
(c) 4.8 m (d) 9.6 m

RRB JE Bhopal Paper II (Shift-II), 26.08.2015

Ans. (c) : m = 5 kg
F = 12 N

$$F = m.a$$
$$12 = 5.a$$
$$a = \frac{12}{5} m/s^2$$

by 2nd equation of motion is :-

$$S = ut + \frac{1}{2}at^2 \qquad (u = 0)$$
$$S = \frac{1}{2} \times \frac{12}{5} \times (2)^2$$
$$S = \frac{24}{5}$$
$$\boxed{S = 4.8 m}$$

The distance travelled by it in 2 sec is 4.8 m.

61. A force of 1.5 Newton is applied on a body of mass 5kg for 2 second. the distance covered by the body is -

(a) 2 m (b) 1.6 m
(c) 1.2 m (d) 0.6 m

RRB Ranchi Diesel/Electric Assistant (Driver), 21.09.2003

Ans. (d): F = Ma

$$a = \frac{F}{M} = \frac{1.5}{5} = 0.3 \text{ m/sec}^2$$

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

$S = 0 \times 2 + \frac{1}{2}0.3 \times (2)^2$

$S = 0 + 0.3 \times 2$

$\boxed{S = 0.6m}$

62. A car travels from A to B at a speed of 20 km/h and returns at a speed of 30 km/h. The average speed of the car during this journey will be

(a) 5 km/hour (b) 24 km/hour

(c) 25 km/hour (d) 50 km/hour

RRB Asst. Loco Pilot (Guwahati)-2006

Ans. (b) : Average speed $= \frac{2v_1v_2}{v_1 + v_2} = \frac{2 \times 20 \times 30}{20 + 30}$

$V_{avg} = \frac{1200}{50} = 24$ km/hour.

63. When a ball is dropped from the roof of a building. It takes 3 second for the ball to reach the ground. The acceleration to the ball towards the earth is 10m/sec^2 then the height of the building is

(a) 40 Meter (b) 20 Meter

(c) 30 Meter (d) None of these

RRB Mahendrughat (Patna) Diesel Driver,11.11.2001

Ans. (d) : Given $u = 0$, $t = 3$ second $g = 10$ m/sec^2

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

$h = 0 \times t + \frac{1}{2}gt^2$

$= 0 + \frac{1}{2} \times 10 \times 3^2$

$h = 45$ meter.

64. A bullet of mass 20 grams moves with a speed of 10 m/sec. It can sink 8 cm into the target before coming the rest. if the target is only 6 cm thick, the speed with which the bullet will exist the target is.

(a) 10 m/sec (b) 7 m/sec

(c) 4 m/sec (d) 5 m/sec

RRB Asst. Loco Pilot (Guwahati)-2006

Ans. (d) : From equation of motion -

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

$0 = (10)^2 + 2 \times a \times (8 \times 10^{-2})$

$a = -\frac{1}{16} \times 10^4$ m/sec^2

Now, for the 6 cm thick target -

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

$v^2 = (10)^2 - 2 \times \frac{10^4}{16} \times (6 \times 10^{-2})$

$v = 5$ m/sec

04. Work, P

■ **Work:** Work is the process of applying force to an object to move it over a distance or to transfer energy from one system to another. Work is measured in joules (J) in the international system of Units (SI).

■ **Workdone –**

$$W = \int dw = \int \vec{F} \cdot \vec{dr} = \int F\, dr \cos\theta$$

Negative Work	Zero W

Positive Work: Positive work means that force (or its components) is parallel to displacement.

☛ **E.g.**

When a person lifts a body from the ground, the work done by the (Upward) lifting force is positive.

Negative Work:-

Negative work means that force (or its components) is opposite to displacement i.e, the negative work signifies that the external force opposes the motion of the body. E.g. When a person lifts a body from the ground, the work done by the (down ward) force of gravity is negative.

Zero Work:

Under three condition, work done becomes zero W= Fs cosθ =0

(1) If force is perpendicular to the displacement $[\vec{F} \perp \vec{S}]$

☛ **E.g:**

➲ When a coolie travels on a horizontal platform with a load on his head, work done against gravity by the coolie is zero.

➲ When a body moves in a circle the work done by the centripetal force is always zero.

(2) If there is no displacement [S=0]

Energy and Power

- $W = \vec{F}.\vec{d}$,For constant force.
- Unit = Newton - meter.
- $W = \int dw = \int F\,dx$, For unidirectional force.
- **Nature of work done -**Although work done is scalar quantity, yet its value may be +ve, –ve or zero.

Work	Positive Work

☛ **Eg.**

➲ When a person tries to displace a wall or heavy stone by applying a force and it does not move, then work done is zero .

➲ A weight lifter does work in lifting the weight off the ground but does not work in holding it up.

(3) If there is no force acting on the body [F=0] e.g- Motion of an isolated body in free space.

■ **Graph between force and displacement -**

(i) If constant force is acting on body

Area = F × d
= Work done

(ii) If direction of force on the body is reversed -

$W = A_1 - |A_2|$

(iii) If variable force is applied on the body

$dw = Fdx$

$\int dw = \int_{x_1}^{x_2} Fdx$

$w = \int_{x_1}^{x_2} Fdx$

☛ **Concept-**

- If $F = f(x)$, $W = \int_{x_1}^{x_2} Fdx$
- If $F = f(y)$, $W = \int_{y_1}^{y_2} Fdy$
- If $F = f(z)$, $W = \int_{z_1}^{z_2} Fdz$

But for more than one variable -

$$W = \int_{(x_1, y_1, z_1)}^{(x_2, y_2, z_2)} \vec{F}\left(dx\hat{i} + dy\hat{j} + dz\hat{k}\right)$$

■ Conservative Forces -

- Work done does not depend upon path.
- Work done in a round trip is zero.
- Central force, spring force etc are conservative forces.
- When only a conservative forces acts within a system, the kinetic energy and potential energy can change into each other. However, their sum of the mechanical energy of system doesn't change.
- Work done is completely recoverable.
- If $\vec{F}$ is a conservative force then- $\nabla \times \vec{F} = \vec{0}$ (i.e. curl of $\vec{F}$ is zero)

■ Non-Conservative Forces -

- Work done depends upon path.
- Work done in a round trip is not zero.
- Force are velocity dependent & regarding in nature e.g. friction, viscous force etc.
- Work done against a non-conservative force may be dissipated as heat energy.
- Work done is not recoverable.

■ Energy -

- The capacity of doing work is called energy.
- Energy possessed by the body by virtue of any cause is equal to the total work done by the body when the cause responsible for energy becomes completely extinct.
- The SI unit of energy is joule (J)
- Types of energy:- There are many types of energy like mechanical energy, electrical , magnetic, nuclear, solar, chemical etc.

■ **Mechanical Energy:** Mechanical energy is the sum of potential energy and kinetic energy in an object that is used to do a particular work.

■ **Solar Energy:** Energy generated from the radiation emitted by the sun is called as solar energy.

■ **Nuclear Energy:** Nuclear energy also called atomic energy. Nuclear energy is a form of energy released from the nucleus, the core of atoms, made up of protons and neutrons.

■ **Sound Energy:** Sound energy comes from vibration moving through something. Solids, liquids and gases all transmit sound as energy waves.

■ **Chemical Energy:** Chemical energy is energy stored in the bonds of atoms and molecules batteries, biomass, petroleum, natural gas and coal are example of chemical energy.

■ **Heat Energy:** Heat energy, also called thermal energy, is the energy an object has because of the movement of its molecules and heat can be transferred from one object to another object.

■ **Kinetic Energy-**

- K.E. = $\frac{1}{2}mv^2$
- K.E $\propto v^2$

- Percentage error in K.E - $\frac{\Delta K}{K} \times 100 = 2\frac{\Delta v}{v} \times 100$
- Relation between Kinetic energy (K.E) and Linear Momentum – K.E = $\frac{P^2}{2m}$, P = $\sqrt{2mK}$
- For same K.E of two particles - $\frac{P_1}{P_2} = \sqrt{\frac{m_1}{m_2}}$

Concept -

- Work done due to all types of forces acting on the body will be equal to only change in K.E of that body.

■ **Potential Energy -**

- The energy possessed by any object by virtue of its position or configuration is called potential energy.

- Potential energy is relative quantity.
- Potential energy is defined only for conservative force field.
- Relationship between conservative force field and potential energy.

$$\vec{F} = -\vec{\nabla}U = -\text{grad}(U) = -\left(\frac{\partial U}{\partial x}\hat{i} + \frac{\partial U}{\partial y}\hat{j} + \frac{\partial U}{\partial z}\hat{k}\right)$$

- If force varies only with one dimension (along x-axis) then

$$F = -\frac{dU}{dx} \Rightarrow U = -\int_{x_1}^{x_2} F\,dx$$

■ **Gravitational potential Energy:** Energy possessed by a body by virtue of its height above surface of earth is known as gravitational potential energy.

$$\boxed{G.P.E = mgh}$$

■ **Potential energy curve and equilibrium -**

- It is a curve which shows change in potential energy with position of a particle.

■ **Stable Equilibrium -**

- When a particle is slightly displaced from equilibrium position and it tends to come back towards equilibrium then it is said to be in stable equilibrium.

At Point C : Slope $\frac{dU}{dx}$ is negative so F is positive.

At Point D : Slope $\frac{dU}{dx}$ is positive so F is negative.

At Point A : It is the point of stable equilibrium.

At Point A : $U = U_{min}$, $\frac{dU}{dx}$ and $\frac{d^2U}{dx^2}$ = positive.

■ **Unstable Equilibrium –**

- When a particle is slightly displaced from equilibrium and it tends to move away from equilibrium position then it is said to be is unstable equilibrium.

At Point E : Slope $\frac{dU}{dx}$ is positive So, F is negative.

At Point G : Slope $\frac{dU}{dx}$ is negative so F is positive.

At Point B : It is the point of unstable equilibrium

At Point B : $U = U_{max}$, $\frac{dU}{dx} = 0$ and $\frac{d^2U}{dx^2}$ = negative.

■ **Neutral Equilibrium –**

- When a particle is slightly displaced from equilibrium position and no force acts on it then equilibrium is said to be neutral equilibrium point.

  U = constant : $\frac{dU}{dx} = 0, \frac{d^2U}{dx^2} = 0$

■ **Total Mechanical Energy of body-**

- Mechanical energy = K.E + P.E
- $E = K + U$ • $E = K_{max} + U_{min}$ • $E = K_{min} + U_{max}$

■ **Work energy theorem for constant force-**

- It states that the work done by the net force acting on a body is equal to the change in the K.E of the body.
  $W = K_f - K_i$
  Change in K.E of body = Work done in the body by net force.

■ **Work Energy theorem for variable force -**

$W = \Delta$ K.E

Change in Kinetic energy = Work done by all forces.

Joule	It is the absolute unit of work in the SI system of unit. Work done is said to be one joule, when a force of one Newton actually moves a body through a distance of one meter in the direction of applied force.
Erg	It is the absolute unit of work in the CGS system of unit. Work done is said to be one erg, when a force of one dyne actually moves a body through a distance of one cm in the direction of applied force.

■ **Power -**

- The rate of doing work with respect to time is called power. $P_{avg} = \frac{W}{t}$ & $P_{instantaneous} = \frac{dW}{dt}$
- Power is scalar quantity.
- S.I. unit of power is J/S or Watt.

- Because it is a ratio of two scalar quantities.
  Dimension formula = $[ML^2T^{-3}]$
- 1 mW = 10^{-3} W 1 MW = 10^6 W
  1 KW = 10^3 W 1 Horse Power = 746 Watt
- $P = \vec{F} \cdot \vec{V} = F\,V \cos\theta$
- If $\theta = 0^o$ If $\theta = 180^o$ If $\theta = 90^o$
  P = FV = +ve P= – FV = –ve P = 0

■ Graph between force and velocity –

➲

Area = FV = P = Power

➲

➲

$P = \int_{v_1}^{v_2} F\,dv$

■ Principle of Conservation of Energy –

- This law states that energy can neither be created nor destroyed but it can changed from one form to another.

☛ **Example:**
When a body falls freely, under gravity its potential energy gradually changes into Kinetic energy, but total mechanical energy (Kinetic energy + Potential energy) remains constant at any point of its motion.

Equipment	Transformation of energy
Microphone	Sound energy into electrical
Musical instruments	Mechanical energy into sound energy.
Heat engine	Thermal energy (Heat energy) mechanical energy.
Coal	Chemical energy into thermal energy.
Candle	Chemical energy into thermal energy.
Bulb/Tube	Electrical energy into light energy.
Heater	Electrical energy into thermal energy.
Electric motor	Electrical energy into mechanical energy.
Electric cell	Chemical energy into electrical energy.
Loudspeaker	Electrical energy into sound energy.
Solar cell	Solar energy into electrical energy.
Dynamo	Mechanical energy into electrical energy.
Battery	Chemical energy to electrical energy.

Efficiency:- Using the least amount of inputs to achieve the highest amount of output.

$$\eta = \frac{\text{Energy output}}{\text{Energy Input}} \times 100\%$$

EXAM POINTS

- In metric system, 1 HP is equal to **- 735.5 Watt**
- how much power is required to do 40 J of work on an object in 5 seconds **- 8 watt**
- If a man of mass 70 kg climbs up a mountain of height 150 m, then the work done by him will be **- 10,500 kg.m**
  [Hint, w = f×s= 70×150 =10,500 kg.m]
- Energy possessed by an object due to its motion is called **- Kinetic energy**
- In the British system, the value of 1 HP is **- 746 Watt**
- When we sit on the seat of a rubber mattress, it sinks down there, then the energy contained in the rubber mattress is **- Potential energy**
- The work done in lifting a 36.3 Newton up to a height of 3 meters is **- 108.9 Joule**
  [Hint- w = f × s]
- The capacity of a simple machine is usually expressed in **- Kilowatt**
- A person in standing with a load on his head, then the work done by the person will be **- Zero**
- When a particle performs simple harmonic motion then its kinetic energy is maximum at **-Mean position**
- The kinetic energies of both moving a car and train engine are equal, which will have more momentum **- Train engine**
- If the speed of an object is halved as compared to earlier then the kinetic energy remains as compared to earlier **- One fourth**
- Which type of energy is stored in a compressed spring **- Potential energy**
- If the linear momentum of a particle is doubled then the kinetic energy of that particle will be **- Four times**
- If the force is perpendicular to the direction of displacement, then the work done will be **- Zero**
- When an object moves in a circle at constant speed then the work done on it is **- No work (zero)**
- What will be change in kinetic energy if the velocity of kinetic energy is increased by 25% **- 56.25%**
- The SI unit of work done is **- Joule**
- On applying a force of 5 Newton on an object, there is a displacement of 8 meters in it, then the work will be **- 40 Joule**
  [Hint - w = f × s]
- The instrument used to measure work done is called **- Ergometer**
- A steam engine converts the heat energy of steam into **- Mechanical energy**
- In which form is the supplied heat energy stored during change in temperature of substance **- Kinetic energy**
- How much mechanical work must be done to completely melt 1 gram of ice of 0ºC **- 336 Joule**
- If the force is parallel to the direction of displacement, then the work done will be **- Maximum**
- The mechanical efficiency of an engine is **- $\frac{\text{B.H.P.}}{\text{I.H.P.}}$**

- Work done is said to be positive if the applied force and the displacement are in ..... direction **- Same**
- Kinetic energy and potential energy are collectively called as **- Mechanical energy**
- If the momentum of a moving object is p and mass is m, then the value of kinetic energy in terms of p and m is **-** $\frac{P^2}{2m}$
- When a body rolls down on inclined plane, it possesses **- Both kinetic and potential energy**
- The efficiency (η) of an ideal machine is equal to **- η = 100%**
- 1 Kilowatt hour is equal to **- 36×10^5 Joule**
- Which energy is used by the human body to do work **- Potential energy**
- If an applied force and displacement of the body are made at 90º to each other, then the work done is **- Zero**
- The kinetic energy of a body has quadrupled then new momentum will be **- Double from its initial value**
- The work done against by the friction is **- Positive**
- When two elastic bodies collide with each other then **- Both bodies start to regain their initial shape**
- Rocket works on the principle of **- Conservation of momentum**
- Both force and displacement are vectors, then the work which is the product of force and displacement is **- Scalar**
- The momentum of a light and a heavy body is the same which has more kinetic energy **- lighter body**
- A light and a heavy body have same kinetic energy which one has grater momentum **- heavier body**
- A truck and a car are moving with the same kinetic energy, then if a force is applied to stop them, then **- Both will cover the same distance before coming to rest**
- When the mass of body is doubled and velocity is halved then the kinetic energy of the body is **- Half**
- Erg is the unit of **- Energy**
- An object of mass 1 kg was moving with velocity 1 m/sec, then the value of kinetic energy will be **- 0.5 Joule**
- If the work done is +ve then direction of force is **- In the direction of displacement**
- When a body is rotating in an infinite plane then its have **- Both kinetic energy and potential energy**
- Efficiency of ideal machine is equal to **-100%**
- Energy used by human body to do work **- Potential energy**
- Rocket is based on the principle of **-Conservation of energy**

PREVIOUS YEA

1. An object of mass 10kg is moving with a uniform velocity of $6ms^{-1}$. What is the kinetic energy possessed by the object

(a) 180J (b) 18J
(c) 360J (d) 1800J

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Ans. (a) : Given:
Mass (m) = 10 kg
Velocity (v) = 6 m /sec.

We know that, Kinetic Energy (K.E) = $\frac{1}{2}mv^2$, where m is mass and v is the velocity

$\Rightarrow$ K.E = $\frac{1}{2}\times10\times6\times6$

So, K.E = 180 Joule

2. Which of the given statements are correct for a conservative force field

(p) The total mechanical energy is conserved.
(q) The work done round a closed path is zero
(r) Gain in kinetic energy = Loss in potential energy.

(a) (p) and (q) (b) Only (p)
(c) (p), (q) and (r) (d) (q) and (r)

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Ans. (c) : • Conservative force is defined as the force whose work done is independent of the path taken and depends only on the initial and final position.

• Gravitational forces, elastic forces, magnetic forces etc are the example of conservative force.

• The particle is moved around the loop and ends up at 'A' itself then the entire displacement of particle is zero which means that the total work done is zero in closed path which means that total mechanical energy is conserved.

• Total Energy = Potential Energy + Kinetic Energy. If total energy is conserved then gain in K.E is equal to the loss in P.E.

3. An electric heater is used on a 220V supply and it takes a current of 2A. How much power does it consume?

(a) 550 W (b) 440 W
(c) 400 W (d) 450 W

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Ans. (b) : Given :
Voltage = 220V
Current = 2A
Power (P) = Voltage × Current
= 220V × 2A = 440 W

4. An electric motor is marked 2 HP. The work done by the electric motor in 3 seconds will be nearly.

(a) 373 J (b) 497 J
(c) 1.5 kJ (d) 4.4 kJ

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AR QUESTIONS

Ans. (d) : Given:
Power of the motor (P) = 2 HP
Time (t) = 3 sec
From the work done formula- W = P × t
= 2 ×746 × 3 [∵ 1 HP = 746 W]
= 4476 Joule = 4.4 kJ

5. Identify the correct statement from among the following.
(a) Work and kinetic energy do not have the same unit
(b) Work = Energy × Power
(c) Work is equal to power per unit time
(d) Work and potential energy have the same unit

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Ans. (d) : The standard unit used to measure energy and work done is Joule, which is represented by J.
Work can be calculated by multiplying Force with Displacement in the direction of applied force.
W = F × d
The S.I. unit of work is Joule.
• Potential energy is stored in the form of energy that depends upon the relative position of various parts of a system.
P.E = mgh
The S.I. unit of Potential Energy is Joule.
Hence, Work and Potential Energy have the same unit.

6. When the momentum of a body is doubled, by keeping its mass unchanged, the kinetic energy is
(a) Halved
(b) Becomes three times of the original
(c) Becomes four times of the original
(d) Doubled

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Ans. (c) : The momentum of a body, (P) = mv
Where, m = Mass
v = Velocity of the particle
The relation between kinetic energy and the momentum is given by-

$$K.E. = \frac{P^2}{2m}$$

$$\Rightarrow \quad \frac{K.E_1}{K.E_2} = \frac{\frac{P^2}{2m}}{\frac{(2P)^2}{2m}} \text{ (According to question)}$$

$$\Rightarrow \quad \frac{K.E_1}{K.E_2} = \frac{1}{4}$$

Hence, If the momentum of a body is doubled, the kinetic energy becomes 4 times of the initial kinetic energy.

7. A shot is fired at 30° with the vertical from a point on the ground with kinetic energy K. If air resistance is ignored, the kinetic energy at the top of the trajectory is
(a) K/4 (b) 2K
(c) K (d) 3K

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Ans. (a) :

Here is the diagram when a shot is fired at 30º with the vertical from a point on the ground with kinetic energy K.

The path will be parabolic and we have separated it into the sine and cosine components as seen in the diagram.

The sine component will come to zero at top because gravity is acting on it and hence only V cos 60º will remain for the motion.

Initial kinetic energy is $K = \frac{1}{2}mV^2$ ...(i)

Now, we will calculate the kinetic energy at the top most point. It will be $K' = \frac{1}{2}m(V\cos 60^\circ)^2$.

The value of $\cos 60^\circ = \frac{1}{2}$ putting it in above equation we will get $K' = \frac{1}{8}mv^2$ ...(ii)

Dividing equation (ii) and (i) we get $\frac{K'}{K} = \frac{\frac{1}{8}mv^2}{\frac{1}{2}mv^2}$

$\Rightarrow K' = \frac{K}{4}$.

Thus the kinetic energy at the top of the trajectory is $\frac{K}{4}$.

8. A freely falling body takes 4 s to reach the ground. One second after release, the percentage of its potential energy, that is still retained is

(a) 25% (b) 37.5%
(c) 93.75% (d) 6.25%

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Ans. (c) : Given that,

Acceleration (a) = g = 10 m/s^2 (freefall)

Initial velocity (u) = 0

t = 4 sec

Height of the body(H) $= ut + \frac{1}{2}at^2$

$= 0 + \frac{1}{2} \times 10 \times 4^2 = 80$ m

After 1 sec releases :

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

$\Rightarrow \quad S = 0 + \frac{1}{2} \times 10 \times (1)^2$

$\Rightarrow \quad S = 5$m

So, height (h) = 80 – 5 = 75 m

Potential energy after 1 sec (PE') = mgh = mg × 75 $\Rightarrow$ (PE') = 75 mg

Initial potential energy (PE) = mgH = 80 mg

$$\% \text{ PE} = \frac{\text{PE}'}{\text{PE}} \times 100 = \frac{75 \text{ mg}}{80 \text{ mg}} \times 100$$

$\Rightarrow$ % PE = 93.75%

So, option (c) is correct.

9. Dams are constructed to collect water flowing in high altitude river. The stored water has a lot of

(a) Both KE and PE
(b) Kinetic energy (KE)
(c) Potential energy (PE)
(d) Neither KE nor PE

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Ans. (c) : The energy possessed by a body (or water) by virtue of its position or height is called as potential energy .

- The water stored in dam posses potential energy.
- Kinetic energy is possessed by flowing water.

10. A pump is required to lift 600 kg of water per minute from a well 25 m deep and to eject it with a speed 50m/s. If g = 10m/s^2, the power required to perform the above task is

(a) 20 kW (b) 15 kW
(c) 10 kW (d) 22.5 kW

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Ans. (b) : Given mass to be lift M = 600kg

Depth of well (h) = 25 m

Speed (v) = 50 m/s

g = 10 m/s^2

Total energy required = kinetic energy + Potential energy

$$E = \frac{1}{2}Mv^2 + Mgh$$

$$= \frac{1}{2} \times 600 \times (50)^2 + 600 \times 25 \times 10 = 900000 \text{ J}$$

$$\text{Power required} = \frac{\text{Work}}{\text{Time}} = \frac{\text{Energy}}{\text{time}} = \frac{900000}{60} = 15\text{kW}$$

11. A lorry and a car moving with the same kinetic energy are brought to rest by applying the same retarding force. Then:

(a) lorry will come to rest in a shorter distance
(b) car will come to rest in a shorter distance
(c) in order to know which one will come to rest in a shorter distance, one needs to know the masses of the lorry and the car
(d) both come to rest in same distance

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Ans. (d) : Stopping distance = $\frac{\text{Kinetic energy}}{\text{retarding force}}$

$$S = \frac{1}{2}\frac{mv^2}{F}$$

If lorry and car both posses same kinetic energy and retarding force is also equal then both will come to rest in the same distance.

12. A car of mass 800 Kg is moving on an expressway. In order to increase the speed of the car from 54 km/hr to 90 km/hr the work required to be done will be

(a) 150 KJ (b) 160 KJ
(c) 250 KJ (d) 200 KJ

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Ans. (b) : Given that,

Mass (m) = 800 kg

Initial velocity (v_1) = 54 km/hr

$$= \frac{54 \times 1000}{3600} = 15 \text{ m/sec}$$

Final velocity (v_2) = 90 km/hr

$$= \frac{90 \times 1000}{3600} = 25 \text{m/sec.}$$

Work done = change in kinetic energy

$= \Delta K.E$

$$= \frac{1}{2}m(v_2)^2 - \frac{1}{2}m(v_1)^2$$

$$= \frac{1}{2}m\left[(25)^2 - (15)^2\right]$$

$$= \frac{1}{2} \times 800(625 - 225) = \frac{1}{2} \times 800 \times 400$$

$= 16 \times 10^4$ Joule = 160 kJ

13. The radiant energy of the sun results from the process of

(a) Combustion (b) Nuclear fusion

(c) Nuclear fission (d) Chemical reaction

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Ans. (b) : The sun generates energy from a process called nuclear fusion. During nuclear fusion the high pressure and temperature in the sun's core cause nuclei to separate from their electrons. Hydrogen nuclei fuse to form one helium atom. During the fusion process radiant energy is released.

$$^2H_1 + ^2H_1 \xrightarrow{\text{at high } \Delta T} ^4He_2 \text{ (+Radiant energy)}$$

14. Find the work done (in kJ) if a force of 750 N pushes a cart of mass 30 kg by 16 m.

(a) 28 (b) 48

(c) 36 (d) 12

RRB ALP & Tech. 23.01.2019 Shift-I

Ans : (d) Given,

Force = 750 N

Displacement (s) = 16 m

Work done (w) = F.S cosθ

Where θ = 0, if cosθ = 1

W = 750 × 16 = 12000 J

$$W = \frac{12000}{1000} \text{kJ}$$

$\boxed{W = 12 \text{ kJ}}$

15. If the speed of a car increases from 54 km/hr to 90 km/hr, its kinetic energy would increase in the ratio———.

(a) 3/5 (b) 4/9

(c) 9/16 (d) 9/25

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Ans : (d) Initial velocity (u) = 54 km/hr

Final velocity (v) = 90 km/hr

$$\text{Kinetic energy} = \frac{1}{2} \times m \times v^2$$

(Where, m = mass, v = velocity)

Kinetic energy for the initial velocity

$$= \frac{1}{2} \times m \times 54 \times 54$$

Kinetic energy for the final velocity

$$= \frac{1}{2} \times m \times 90 \times 90$$

So, the ratio of kinetic energy

$$= \frac{\frac{1}{2} \times m \times 54 \times 54}{\frac{1}{2} \times m \times 90 \times 90} = \frac{54 \times 54}{90 \times 90}$$

$$= \frac{6.6}{10.10} = \frac{3.3}{5.5} = \frac{9}{25}$$

16. A truck of mass 5000 kg accelerates from 25 m/s to 35 m/s, Find the change in its kinetic energy (in MJ).

(a) 1.5 (b) 1
(c) 2 (d) 2.5

RRB ALP & Tech. 23.01.2019 Shift-I

Ans : (a) Given,
Mass (m) = 5000 kg
Initial velocity (u) = 25 m/s
Final velocity (v)= 35 m/s

Kinetic energy (KE) = $\frac{1}{2}mv^2$

Kinetic energy of initial velocity

$$= \frac{1}{2} \times 5000 \times (25)^2 = 1{,}562{,}500 \text{ J}$$

Kinetic energy of final velocity

$$= \frac{1}{2} \times 5000 \times (35)^2 = 3{,}062{,}500 \text{ J}$$

Change in Kinetic energy $(\Delta K.E.) = \frac{1}{2}m\left(v^2 - u^2\right)$

= 3, 06,2500 – 1,56, 2500
= 1500, 000 J = 1.5 MJ

17. A boy of 50 kg is riding a scooter of 100 kg mass at a speed of v m/s. Find v (in m/s) if the kinetic energy of the scooter and the boy is 76.8 kJ.

(a) 32 (b) 64
(c) 40 (d) 80

RRB ALP & Tech. 23.01.2019 Shift-II

Ans : (a)
Total mass of boy and scooter = (50 + 100)kg
= 150 kg
Kinetic energy = 76.8 KJ = 76800 J
v = ?

Kinetic energy (K) = $\frac{1}{2}mv^2$

$\Rightarrow$ $76800 = \frac{1}{2} \times 150 \times (v)^2$

$\Rightarrow$ $76800 = 75\ v^2$

$v^2 = \frac{76800}{75} = 1024$

$v^2 = 1024 \Rightarrow v = 32$ m/s.

18. If 1,200 J of work is done in pushing a trolley by 20 m, what was the force (in N) employed?

(a) 30 (b) 90
(c) 120 (d) 60

RRB ALP & Tech. 23.01.2019 Shift-II

Ans : (d) Given,
Work (w) = 1200 J
Displacement (d) = 20 m
Force (F) = ?
Work = Force × displacement

$\Rightarrow$ $1200 = F \times 20$

$\Rightarrow$ $F = \frac{1200}{20}$

So, $F = 60$ N

19. Find the efficiency of a pump (rated 400 W) that can lift 500 kg of water by 30 m in 10 minutes. (Use g = 10m/s^2)

(a) 77.50% (b) 84.00%
(c) 62.50% (d) 92.00%

RRB ALP & Tech. 23.01.2019 Shift-II

Ans : (c) Given,
M = 500 kg
T = 10 min. = 600 sec.
Rate of power = 400 W
Distance = 30 m.
Work = F × s = mg×s = 500 × 10 × 30

$\Rightarrow$ $W = 15 \times 10^4$ Joule

So, power $(P) = \left(\frac{\text{work}}{\text{time}}\right) = \frac{15\times10^4}{600}$

$\Rightarrow$ $P = 2.5 \times 10^2$

Thus, efficiency $= \left(\frac{\text{Power}}{\text{Rate of power}}\right)\times100$

$= \frac{2.5\times10^2}{400}\times100$

Efficiency = 62.5%

20. A car loses 200 kJ of kinetic energy when its speed decreases from 25 m/s to 15 m/s. Find its mass in tonnes.

(a) 1 (b) 1.5
(c) 2 (d) 2.5

RRB ALP & Tech. 23.01.2019 Shift-II

Ans : (a) Change in kinetic energy

$= \frac{1}{2}\times m\times\left(v_2^2 - v_1^2\right)$

Let, $v_2 =$ 25m/sec and $v_1 = 15$ m/sec

$\Rightarrow$ $200\times10^3 = \frac{1}{2}\times m\times\left(25^2 - 15^2\right)$

$\Rightarrow$ $200\times10^3 = \frac{1}{2}\times m\times(625 - 225)$

$\Rightarrow$ $200\times10^3 = \frac{1}{2}\times m\times400$

$\Rightarrow$ $200 \times 10^3 = 200$ m

$\Rightarrow$ m = 1000 kg

So, m = 1 tonnes

21. A train of mass 50,000 kg accelerates from 5 m/s to 25 m/s. Find the change in its kinetic energy.

(a) 17.5 MJ (b) 12.5 MJ
(c) 15 MJ (d) 25 MJ

RRB ALP & Tech. 08.02.2019 Shift-I

Ans : (c) : Kinetic energy $= \frac{1}{2}mv^2$, let u = 5 m/sec and v = 25 m/sec.
According to the question,
The charge in kinetic energy of the train

$$= \frac{1}{2} \times 50000\left\{(25)^2 - (5)^2\right\}$$

$$= \frac{1}{2} \times 50000 \times 600 = 15 \times 10^6 \text{ Joule} = 15 \text{ MJ}$$

22. If the speed of a car increases from 64 km/hr to 120 km/hr then its kinetic energy would increase in the ratio_____.

(a) 15/8 (b) 225/64
(c) 25/16 (d) 125/32

RRB ALP & Tech. 08.02.2019 Shift-I

Ans : (b) v_1 = 64 km/hrs
v_2 = 120 Km/hrs
Mass is same then

Kinetic energy $(K_1) = \frac{1}{2}mv_1^2 = \frac{1}{2}m.(64)^2$

$= 2048$ ...(i)

$K_2 = \frac{1}{2}mv_2^2$

$= \frac{1}{2}(120)^2 = 7200$ ...(ii)

From equation (i) and (ii),

Proportionate increase $= \frac{7200}{2048} = \frac{225}{64}$

23. Find the power of a pump if it can lift 750 litres of water by 150 m in 25 minutes. (Assume 75% efficiency and use g = 10 m/s^2 and density of water as 1g/cm^3)

(a) 1.5kW (b) 1kW
(c) 1.2 kW (d) 2kW

RRB ALP & Tech. 08.02.2019 Shift-I

Ans : (b) :

Power of pump $= \left(\frac{\text{Total work done}}{\text{time}}\right) = \frac{mgh}{t}$

According to question $= \left(\frac{1 \times 750 \times 10 \times 150}{25 \times 60} \times \frac{100}{75}\right)$

= 1000 Joule/second
= 1 kilowatt

24. Find the work done if a force of 1200 N pushes a trolley of mass 45 kg by 30 m.

(a) 42 kJ (b) 24 kJ
(c) 54 kJ (d) 36 kJ

RRB ALP & Tech. 08.02.2019 Shift-I

Ans : (d) : Given,
Force (F) = 1200N
Mass (m) = 45kg
Displacement (S) = 30 m
Work done = F × S

$\Rightarrow$ W = 1200N × 30m
W = 36000Nm
W = 36000J
So, W = 36 KJ (1KJ = 1000 × J)

25. How much work is required to increase the speed of a ball of mass 1 kg from 2 m/s to 4 m/s?

(a) 10J (b) 12J
(c) 8J (d) 6J

RRB ALP & Tech. 23.01.2019 Shift-III

Ans: (d) Given $\Rightarrow$ m = 1kg
$v_2 = 4$m/sec
$v_1 = 2$m/sec
work done = change in kinetic energy (ΔU)

$$\Delta U = \frac{1}{2}m\left(v_2^2 - v_1^2\right)$$

$$\Delta U = \frac{1}{2}\times 1\times\left(4^2 - 2^2\right)$$

$$\Delta U = \frac{1}{2}(16-4)$$

$$\Delta U = \frac{12}{2} = 6 \text{ Joule}$$

Thus 6 J of work is needed to increase the speed of the ball from 2 m/sec to 4 m/sec

26. The potential energy of a 20-kg object at height h is 600 J. The value of h is ——— (Take g = 10 m/s^2).

(a) 1m (b) 3m
(c) 2m (d) 30m

RRB ALP & Tech. 22.01.2019 Shift-I

Ans : (b) Given,
Potential energy (U) = 600 J
m = 20 kg
g = 10 m/sec^2
$\because$ U = mgh $\Rightarrow$ 600 = 20 × 10 × h

$$h = \frac{600}{200} = 3 \text{ meter}$$

27. An object of mass 1 kg is moving with a velocity 10 m/s. Find the kinetic energy of the object.

(a) 100J (b) 10J
(c) 5J (d) 50J

RRB ALP & Tech. 22.01.2019 Shift-I

Ans : (d) given,
m = 1kg, v = 10 m/sec
KE = ?

$$KE = \frac{1}{2}mv^2$$

$$KE = \frac{1}{2}\times 1\times(10)^2$$

$$KE = \frac{100}{2} = 50 \text{ Joule}$$

28. _____ is defined as the time rate at which work is done or energy is transferred.

(a) Distance (b) Displaement
(c) Force (d) Power

RRB ALP & Tech. 22.01.2019 Shift-I

Ans : (d) Power is defined as the rate at which work is done or energy is transferred. Power is a scalar quantity. Its S.I. unit is joule/second or watt. If a person does (w) work in (t) time then power is-

$$P = \left(\frac{W}{t}\right) \text{ joule/second}$$

29. Work done will be maximum when the angle between the direction of force and the direction of displacement is.

(a) 45º (b) 0º (c) 90º (d) 60º

RRB ALP & Tech. 22.01.2019 Shift-II

Ans : (b) : Work = force acting in the direction of displacement

$$W = F.S \cos\theta$$

When, $\theta = 0$, work will be maximum because $\cos\theta = 1$

When the work done is maximum, then the direction of the force and the angle between direction of the displacement will be 0º or force acting in the direction of displacement.

30. How much work is done in moving a charge of 10 C across two points having a potential difference 20 V?

(a) 200J (b) 0.5J

(c) 10J (d) 2J

RRB ALP & Tech. 22.01.2019 Shift-II

Ans : (a) : Q = 10 C

V = 20 V

W = ?

$$\Rightarrow \quad V = \frac{\text{Work done(W)}}{\text{Charge(Q)}}$$

$$\Rightarrow \quad W = V \times Q = 20 \times 10 = 200 \text{ J}$$

31. A ball of mass m is dropped from a height H. At height H/3, the ratio of its potential energy (PE) to kinetic energy (KE) is equal to:

(a) 1 (b) 1/4 (c) 1/2 (d) 1/3

RRB ALP & Tech. 22.01.2019 Shift-II

Ans : (c) : By the principle of conversation of energy, = Potential energy + Kinetic energy always remain constant.

$$\frac{\text{P.E}}{\text{K.E}} = \left(\frac{\text{Remaining polential energy}}{\text{loss in polential energy}}\right)$$

The object is at $\frac{2H}{3}$ distance from the releasing point.

So, potential energy at this point = $\frac{2mgH}{3}$

Hence, loss in energy = $\frac{2mgH}{3}$ = kinetic energy at point.

At $\frac{H}{3}$ height, potential energy = $\frac{mgH}{3}$

$$\because \frac{\text{Potential energy}}{\text{Kinetic energy}} = \frac{mgH}{3} \times \frac{3}{2mgH} = \frac{1}{2}$$

32. If the total energy of the reactants is more than the products of the reaction, heat is released and the reaction is said to be a/an ___ reaction.

(a) Work (b) Endothermic

(c) Potential (d) Exothermic

RRB ALP & Tech. 22.01.2019 Shift-II

Ans : (d) : If the total energy of the reactants is more than the products of the reactions, then the energy is released, in such reactions in the form of heat and are called as an exothermic reaction.

Example:- formation of water, burning of graphic in air etc.

33. A girl of weight 440 N climbs up a rope through a height of 7 m in 20 s. The power expended by the girl is:

(a) 36 W (b) 15.4 W
(c) 72 W (d) 154 W

RRB ALP & Tech. 22.01.2019 Shift-II

Ans : (d) : Weight of girl (W) = mg = 440N
Height climed by the girl (h) = 7m [$g = 10\ m/s^2$]
Power (P) = work /time
And work = Force × distance = mgh

$$\text{Power} = \frac{mgh}{t} = \frac{440 \times 7}{20} = 154 \text{ watt}$$

34. A 0.5 kg ball is relased from the top of a building of height 20 m. Find the kinetic energy of the ball, just before it hits the ground (assume $g = 10\ m/s^2$).

(a) 20 J (b) 100J
(c) 40 J (d) 80J

RRB ALP & Tech. 21.01.2019 Shift-I

Ans : (b) : Given,
m = 0.5 kg, $g = 10 m/s^2$, h = 20 m
Kinetic energy of a body falling from a height = mgh
= 0.5 ×10 × 20
= 100J
Since the total potential energy (mgh) at the top of the building will be converted to kinetic energy before it reaches the ground.

35. 1 kilowatt hour (kWh) of energy = ... joule.

(a) 1.8×10^6 (b) 1.8×10^4
(c) 3.6×10^4 (d) 3.6×10^6

RRB ALP & Tech. 21.01.2019 Shift-I

Ans : (d) : 1 Kilowatt – hours = ? Joule
1 Kilowatt = 1000 watt
1Hours = 3600 second
1 Kilowatt = 1000 × 3600 Joule
= 3.6×10^6 Joule

36. A 100-gram ball is kept on the top of a building of 70 m height. Find the potential energy of the ball (assume $g = 10\ m/s^2$).

(a) 50 J (b) 70J
(c) 80 J (d) 60J

RRB ALP & Tech. 21.01.2019 Shift-I

Ans : (b) : Given,
mass = 100gm, Height = 70meter, $g = 10 m/sec^2$

$$\text{mass} = \frac{100}{1000} = 0.10 \text{ kg}$$

Potential energy of ball = 0.10 × 70 × 10
= 70 Joule

37. One horse - power (hp) 1 hp = ... W.

(a) 746 (b) 500
(c) 846 (d) 646

RRB ALP & Tech. 21.01.2019 Shift-I

Ans : (a) :1 Horse power (H.P.) = 746 Watt
≅ 0.75 Killowatt

38. A girl weighing 40 kg limbs a rope to a height of 6 m in 16s. What is the power spent by the girl ? (Assume $g = 10\ m/s^2$)

(a) 150W (b) 210W
(c) 240W (d) 40W

RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (a) mass of Girls = 40kg
time taken by rope = 16s
and height (h) = 6m
Power spent (P) = ?
Acceleration due to gravity (g) = $10 m/sc^2$
$W = f.d = 40\times10\times6 = 2400J$

$$P = \frac{W}{t} = \frac{2400}{16}$$

$P = 150W$

Hence, the power consumed by the girl will be =150.W

39. How much work required to be done to increase the speed of a ball of mass 0.4 kg from 1 m/s to 3m/s?

(a) 1.6J (b) 1.2J
(c) 0.8J (d) 0.4J

RRB ALP & Tech. 22.01.2019 Shift-III

Ans: (a) Let the mass of ball (M) = 0.4kg
Work (W) = Change in kinetic energy (ΔKE)

$$= \frac{1}{2}m\left(v_2^2 - v_1^2\right) = \frac{1}{2}\times(0.4)\times\left(3^2 - 1^2\right)$$

So, W = 1.6 J

40. If both the mass and speed of a ball are doubled, then how many times will the kinetic energy becomes?

(a) 4 (b) 2
(c) 8 (d) 16

RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (c) The kinetic energy, $K.E = \frac{1}{2}mv^2$
If $m' = 2m$ $v' = 2v$
Then the new kinetic energy $(K.E)' = \frac{1}{2}m'v'^2$

$$K.E' = \frac{1}{2}(2m).(2v)^2 = \frac{1}{2}mv^2.8$$

$$\boxed{K.E' = 8KE}$$

Hence the kinetic energy becomes 8 times.

41. A drum of mass 'm' kg was rolled down a ramp. At the bottom of the ramp its kinetic energy was 10 kJ and velocity was 20 m/s. With what velocity (in m/s) was it pushed down the ramp if its initial kinetic energy was 625 J?

(a) 10 (b) 5
(c) 7.5 (d) 2.5

RRB ALP & Tech. 21.01.2019 Shift-II

Ans : (b) Given,
mass of energy = mkg
Kinetic energy (KE) = 10 kJ = 10×10^3 J
Velocity (v) = 20 m/s

$$K.E = \frac{1}{2}mv^2$$

$$10\times10^3 = \frac{1}{2}\times m\times20^2$$

$$10\times10^3 = \left(\frac{1}{2}m.20^2\right)$$

mass (m) = 50 kg

So, we will get the mass of the drum as 50 kg. when the kinetic energy was 10 kJ.

Since, $KE = \frac{1}{2}mv^2$

$625 = \frac{1}{2} \times 50 \times v^2$

$v^2 = \frac{625}{25} = 25$

v = 5 m/sec

Hence, the drum was pushed down with a velocity of 5m/sec.

42. A bus runs with a force of 4000 N. The work done by the bus is 2000 J. What is the distance covered by the bus?

(a) 1 meter (b) 2 meter

(c) 1.5 meter (d) 0.5 meter

RRB Group-D 06-12-2018 (Shift-III)

RRB ALP & Tech. 21.01.2019 Shift-II

Ans : (d) : Work = force × displacement

Displacement = $\left(\frac{\text{Work}}{\text{Force}}\right) = \frac{2000}{4000} = \frac{2}{4} = 0.5$ meter

43. If a box of mass 25 kg is pushed 15 m by a force of 'F' N, work done in the process is 480 J. Find F:

(a) 16 (b) 32

(c) 25 (d) 50

RRB ALP & Tech. 21.01.2019 Shift-II

Ans : (b) : given,

Mass = 25 kg

displacement = 15 meter

work = 480 J

work = force × displacement

480 = F × 15

$F = \frac{480}{15} = 32N$

44. A car of 500 kg mass has a kinetic energy of 64 kJ. Find its speed (in m/s).

(a) 32 (b) 16

(c) 64 (d) 48

RRB ALP & Tech. 21.01.2019 Shift-II

Ans : (b) : Given,

Mass (m) = 500 kg

Kinetic energy (KE) = 64 kJ = 64×10^3 J

$KE = \frac{1}{2}mv^2$

$64 \times 10^3 = \frac{1}{2} \times 500 \times v^2$

$v^2 = 64 \times 4$

v = 16 m/s

∴ speed of car = 16 m/s

45. A force acting on an object of mass m changes its velocity during its course of motion. In which of the following cases, the work done by the force is maximum?

(a) When velocity of the object chages from 0 to v m/s

(b) When velocity of the object changes from v m/s to 3 v m/s

(c) When velocity of the object changes from 2 m/s to 3 v m/s

(d) When velocity of the object changes from 3 v m/s to 4 v m/s

RRB JE (Shift-I), 29.8.2015

Ans. (d) : When the velocity of the objects changes during the action of force on the object, the kinetic energy of the object also changes- therefore, the velocity change of the object for which the change in energy is maximum is equal to the maximum amount of work done.

(a) Change in kinetic energy of the object

$$(\Delta K.E.) = \frac{1}{2}mv^2 - 0 = 1\left(\frac{1}{2}mv^2\right)$$

(b) Change in kinetic energy of the object

$$(\Delta K.E.) = \frac{1}{2}m(2v)^2 - \frac{1}{2}mv^2 = 3\left(\frac{1}{2}mv^2\right)$$

(c) Change in kinetic energy of the object

$$(\Delta K.E.) = \frac{1}{2}m(3v)^2 - \frac{1}{2}m(2v)^2 = 5\left(\frac{1}{2}mv^2\right)$$

(d) Change in kinetic energy of the object

$$(\Delta K.E.) = \frac{1}{2}m(4v)^2 - \frac{1}{2}m(3v)^2 = 7\left(\frac{1}{2}mv^2\right)$$

Hence, maximum work is done on the object is in option (d).

46. A ball of mass 10 kg is moving with a velocity 5m/s. The kinetic energy of the ball is

(a) 50 J (b) 125 J
(c) 250 J (d) 25 J

RRB JE (Shift-I), 27.08.2015

Ans. (b) : mass of the ball m = 10 kg
velocity of the ball v = 5 m/s

K.E of the ball $(K.E) = \frac{1}{2}mv^2$

$$K.E = \frac{1}{2} \times 10 \times (5)^2$$

$$\boxed{K.E = 125\,\text{Joule}}$$

47. An object of 10 kg is raised through a height of 2 m. The work done is ($g = 9.8\ m/s^2$)

(a) 196 J (b) 98 J
(c) 19.6 J (d) 4.9 J

RRB JE Bhopal Paper II (Shift-II), 26.08.2015

Ans. (a): mass of an object m = 10 kg
Height gained by the object (h) = 2 m
Therefore, work done on the object during this time = potential energy acquired by object

W = mgh = 10 × 9.8 × 2

$$\boxed{W = 196\,\text{Joule}}$$

48. The quantity of work equal to one joule is also equivalent to–

(a) watt × second (b) watt/second
(c) watt/second^2 (d) watt

RRB JE (Shift-III), 27.08.2015

Ans. (a) : Work = Force × displacement
Unit of work = Newton × meter = Joule

$$\text{Power (P)} = \left[\frac{\text{Work (W)}}{\text{time (t)}}\right]$$

$$\text{Unit of power} = \frac{\text{Joule}}{\text{second}} = \text{Watt}$$

Therefore, watt × second = Joule

$\boxed{\text{Joule = watt × second}}$

49. A 50 kg man uses the energy of bread, which produces 100,000 calories of heat, to climb a hill If his body works at 30% efficiency, he can climb the hill by?

(a) 200m (b) 252m
(c) 246m (d) 258m

RRB Trivandrum (Technical), 11.04.1999

Ans. (b) : According to question,
Let the person climb the hill up to a height (h).

$$100000 \times \frac{30}{100} = \frac{50 \times 10 \times h}{4.2} \quad (1\text{Joule} = 4.2 \text{ calori})$$

$$h = \frac{30000 \times 4.2}{500}$$

$\boxed{h = 252 \text{ meter}}$

50. 1 J equivalent .

(a) 1 kg×1m (b) 1 HP×1m
(c) 1 N×1m (d) 1 N×1cm

RRB Chennai Technician (Engineering), 15.04.2007

Ans. (c) : If a force 1 Newton is applied on an object and it is displaced by 1 meter in the direction of force, then the work done by the force on the object will be 1 joule.

$$W = F \times S$$

$$W = N\text{–}m = \text{Joule}$$

In S.I system it is called absolute unit of work.

51. The S.I unit of power (watt) is equal to -

(a) kg-meter –second^{-2} (b) kg-meter^2 –second^{-2}
(c) kg-meter^2 –second^{-3} (d) None of these.

RRB Asst. Loco Pilot (Gorakhpur)-2001

Ans. (c) : The rate of doing work is called power. The S.I unit of power is the watt.

$$1 \text{ Watt} = \frac{1 \text{ Joule}}{\text{second}} = \frac{1\text{N} \times \text{m}}{\text{second}} = \frac{\text{kg} \times \text{m} \times \text{m}}{\text{sec}^2 \times \text{sec}}$$

$$1 \text{ Watt} = \frac{\text{m}^2 \times \text{kg}}{\text{second}^3}$$

$\boxed{1 \text{ Watt} = 1 \text{ kg} - \text{m}^2 \text{second}^{-3}}$

52. A force of 40 Newton's acts on a body. if an angle of 45° is formed between the line force and the direction of displacement, then tell the value of the work done in displacing the body by 2 meters

(a) $40\sqrt{2}$ Joule (b) $30\sqrt{2}$ Joule
(c) $20\sqrt{2}$ Joule (d) 20 Joule

RRB Asst. Loco Pilot (Kolkata)-2002

Ans. (a) : Work $W = F.s \cos\theta$

$$= (40 \times 2 \times \cos 45^0)$$

$$= 40 \times 2 \times \frac{1}{\sqrt{2}} = 40\sqrt{2} \text{ Joule}$$

53. Two bodies of equal mass of are moving with velocities 3v and 2v respectively. The ratio of its kinetic energy will

(a) 9:4 (b) 8:2
(c) 4:9 (d) 2:3

RRB Asst. Loco Pilot (Ajmer)-2005

Ans. (a) : According to question,

$V_1 = 3v,$ $V_2 = 2v$

and masses are equal.

Then the ratio of kinetic energy will be-

$$= \frac{K_1}{K_2} = \frac{\frac{1}{2}mV_1^2}{\frac{1}{2}mV_2^2} = \frac{V_1^2}{V_2^2} = \frac{(3v)^2}{(2v)^2} = \frac{9v^2}{4v^2}$$

$$\frac{K_1}{K_2} = \frac{9}{4}$$

54. A man of mass of 60 kg climbs 30 steps of length 20 cm each in 20 second. Calculate the total work done by the person and his power. g = 10 m/sec^2

(a) 130 watt (b) 180 watt
(c) 100 watt (d) 50 watt

RRB Asst. Loco Pilot (Patna)-2007

Ans. (b): Total height of 30 steps.

$h = 30 \times 20 = 600$ cm = 6 meter

$\therefore$ Total work done by the person

$W = mgh = 60 \times 10 \times 6 = 3600$ Joule

$$P = \frac{W}{t} = \frac{3600}{20} = 180 \text{ watt}$$

55. Doubling the mass and halving the velocity of body but its kinetic energy will be?

(a) Half (b) Quarter
(c) Doubled (d) unchanged

RRB Asst. Loco Pilot (Chandigarh)-2008

Ans. (a) : Suppose a body of mass m moves with velocity (v). The kinetic energy of the body be given by-

$$K.E = \frac{1}{2}mv^2$$

According to question.

$$KE' = \frac{1}{2}(2m)\left(\frac{v}{2}\right)^2$$

$$K.E' = \frac{1}{2}2m \times \frac{v^2}{4} \Rightarrow KE' = \frac{1}{2}mv^2\left(\frac{1}{2}\right)$$

$$\boxed{KE' = \frac{KE}{2}}$$

56. Erg is unit of.

(a) work (b) force
(d) power (c) energy

RRB Asst. Loco Pilot (Bhuvneshwar)-2009

Ans. (a) The unit of work is Joule while 1 Joule = 10^7 ergs. That's why the unit of work is also erg.

57. A pump lifts 160kg of water to a height of 5m per second. The power of the pump will be- (g = 10 m/sec^2)

(a) 5000 watt (b) 4000 watt
(c) 6000 watt (d) 8000 watt

RRB Chandigarh Section Engineer (Mech.), 26.02.2012

Ans. (d) : Work done by the pump $W = mgh$

$W = 160 \times 10 \times 5 = 8000$

Power of pump $= \frac{W}{t} = \frac{8000}{1} = 8000$ Watt

58. A stone of mass 1 kg is observed falling down in front of a window 2 m high. The speed of the stone at the top of the window was 4m/sec. While reaching from the upper end of the window to the lower end, its kinetic energy be increased by

(a) 19.6 Joule (b) 16 Joule
(c) 8 Joule (d) 39.2 Joule

DMRC Junior Engineer (Electronics), 03.08.2014

Ans. (a): Increase in kinetic energy = decrease in potential energy.

$= mgh = 1 \times 9.8 \times 2$

$= 19.6$ Joule

59. A 40kg body runs up a ladder and reaches the first floor 9m height in $\left(\frac{1}{2}\right)$ of a minutes. The power developed by the boy is

(a) 600 watt (b) 120 watt
(c) 420 watt (d) 640 watt

RRB Bhubaneshwar App. Electrical , 19.08.2001

Ans. (b) :

$$\text{Power of the boy (P)} = \frac{\text{Work done by the boy}}{\text{Total time taken to do the work}}$$

$$P = \frac{W}{t} = \frac{mg \times h}{t} = \frac{40 \times 10 \times 9}{30} = 120 \text{ watt}$$

60. A frictional force of 100 Newton acts on a cyclist. He is going with a speed of 2m/sec his power will be

(a) 100 watt (b) 200 watt
(c) 300 watt (d) 400 watt

P. WAY/SUPERVISOR/CHASING INSPECTORr

Ans. (b) : Friction force acts on the cycle $F = 100$ N

speed of cycle $v = 2$m/s

The power of cyclist $P = \frac{W}{t} = \frac{F.s}{t} = F.V$

$P = 100 \times 2 = 200$ watt.

61. A man does 6×10^4 Joule of work in one minutes. man's power will be

(a) 10^4 watt
(b) 66×10^4 watt
(c) 110^3 watt
(d) 6×10^3 watt

Delhi Metro Rail Corporation Train Operators', 14.09.2003

Ans. (c) :

$$\text{Efficiency of man} = \frac{\text{work done by man}}{\text{Total time taken to do the work}}$$

$$\text{Power of man} = \frac{6 \times 10^4}{60} = 10^3 \text{ watt}$$

62. A box is lifted by a pulley system to a distance of 20m in 10 second with a force of 100 Newton. The power used in this will be-

(a) 50 watt (b) 20,000 watt
(c) 2000 watt (d) 200 watt

RRB Trivandrum (Tech.), 11.04.1999

Ans. (d):

Power used $P = \frac{W}{t} = \frac{F \times s}{t} = \frac{100 \times 20}{10} = 200$ watt

63. When a force of 6 Newton is applied on a body, the body travels a distance of 2 meters then the value of the work done will be

(a) 6×2 Joule (b) 6×2^2 Joule
(c) 4 Joule (d) 6/2 Joule

RRB Bangalore (Tech.), 22.08.1999

Ans. (a) : Work done on the body
= force × displacement
$= 6 \times 2 = 12$ Joule

64. A motor of 1.5k W power raises water 1.5 m high, the work (in Joules) done by the motor in one hours will be

(a) 3.6×10^6 Watt (b) 5.4×10^6 Watt
(c) 36×10^6 Watt (d) 54×10^6 Watt

RRB Kolkata (Tech.), 29.08.1999

Ans. (b) :
Power of motor (P) = 1.5 kilowatt = 1500 watt
Then in one hours = 60 × 60 = 3600 second
work done by the motor (W) = P × t = 1500 × 3600
$= 540 \times 10^4 = 5.4 \times 10^6$ watt

65. When a force of 50 Newton is applied to a body, the body is displaced by 5 m making an angle of 30°. With the line action of the force. The work done on the body is

(a) 125 Joule (b) $125\sqrt{2}$ Joule
(c) $125\sqrt{3}$ Joule (d) $205\sqrt{3}$ Joule

RRB Bhubaneshwar (Tech.), 03.06.2001

Ans. (c) : Work = F.s. cosθ
$= 50 \times 5 \times \cos 30^0$
$= 50 \times \frac{5\sqrt{3}}{2} = 125\sqrt{3}$ Joule

66. To lift a body of mass 30 kg 4000 Joules of work is done. How high is the body raised (g = 9.8 Newton/kg)

(a) 136 meter (b) 1.36 meter
(c) 13.6 meter (d) 0.136 meter

RRB Bhubaneshwar App. Elec. Signal Maintainer, 19.08.2001

Ans. (c) : Work done = increase in potential energy of the body.

$W = mgh \Rightarrow 4000 = 30 \times 9.8 \times h$

$\Rightarrow \quad h = \frac{4000}{30 \times 9.8} = 13.6$ meter

05. Heat

■ **Temperature:-** Temperature is a relative measure or indication of hotness or coldness of the body.

- The SI unit of temperature is Kelvin (K)
- Commonly used unit of temperature is degree Celsius (ºC)

■ **Types of Temperature Scale**

Name of the scale	Symbol for each scale	Lower point
Celsius	ºC	0ºC
Fahrenheit	ºF	32 º
Kelvin	K	273.1

■ **Relationship among different Temperature scale.**

$$\frac{C-0}{100-0}=\frac{F-32}{212-32}=\frac{K-273.15}{373.15-273.15}=\frac{X-LFP}{UFP-LFP}$$

- Two familiar temperature scales are the Fahrenheit temperature scale and the Celsius temperature scale.
- The Celsius Temperature (t_C) and the Fahrenheit temperature (t_F) are related by

$$t_F=\frac{9}{5}t_C+32$$

- Absolute Zero Temperature (0K = –273.15ºC)
  Absolute zero is the temperature at which a system is in the state of lowest possible energy. It is also known as thermodynamic temperature.

■ Measurement of Temperature

- **Thermometer:-** The instrument used to measure the temperature is called thermometer. The thermometers work on the thermometric property, i.e the property which changes with temperature like any physical quantity such as length, volume pressure and resistance etc. These quantities varies linearly with a certain range of temperature.Common liquids used in glass thermometers are mercury, alcohol etc. whose volume varies linearly with temperature over a wide range.

S. No.	Thermometer	Therm
1.	Constant volume gas thermometer	
2.	Constant pressure gas thermometer	
3.	Electrical resistance thermometer	Resistance
4.	Thermocouple	Thermal E.M
5.	Liquid- in- glass thermometer	Length
6.	Pyrometer	Infrared rad
7.	Magnetic thermometer	Paramagnet

t and Temperature

- **Heat:-** Heat is a form of energy that flows between a body and its surrounding medium by virtue of temperature difference between them.
- The SI unit of heat energy transferred is expressed in Joule (J).

fixed (LFP)	Upper fixed point (UFP)	Number of Divisions on the scale
C	100 ºC	100
ºF	212 ºF	180
.5K	373.15K	100

Different types of thermometers

- **Mercury thermometer:-**
  In these thermometers the length of mercury thread is taken as thermometric property if length of mercury column at 0º and 100º are ℓ_0 and ℓ_{100} respectively.
- **Gas Thermometer:-**
  In such thermometers, the pressure of a given mass of an ideal gas (at constant volume) or volume of a given mass of an ideal gas (at constant pressure) is the thermometric property. The reference temperature is taken as 0ºC (ice point) and 100ºC (Boiling point). The unknown temperature can be calculated as

  $t(^\circ C) = \left(\frac{P_t - P_0}{P_{100} - P_0}\right) \times 100$ (Constant volume gas thermometer)

  $t(^\circ C) = \left(\frac{V_t - V_0}{V_{100} - V_0}\right) \times 100$ (Constant pressure gas thermometer) (0ºC) and steam point.
- **Platinum Resistance Thermometer**
  In this thermometer, the resistance of platinum wire is taken as thermometric property. The reference temperatures are ice point (100ºC). The unknown temperature in ºC is given by.

  $$t(^\circ C) = \left(\frac{R_t - R_0}{R_{100} - R_0} \times 100\right)^\circ C = \left(\frac{R_t}{R_{tr}} \times 273.16\right) K$$

  Here, temperature coefficient of Resistance (α) is given by $\alpha = \left(\frac{R_{100} - R_0}{R_0 \times 100}\right)$

nometric property	Principle
Pressure	Ideal gas equation
Volume	Ideal gas equation
	Wheat- stone bridge
M.F.	Seebeck effect
	Volumetric expansion
iation flux	Radiation
ic	Curie's law

- The number of molecules present in 1 gm mole of a gas is defined as Avogadro number N. $N = 6.023\times10^{23}$ per gm mole $= 6.023\times10^{26}$ per kg mole.

■ **Thermometry:-** The branch of physics which deals with the measurement of temperature is called thermometry.

Few Terms used in Thermometry:-

- **Melting: -** Conversion of solid into liquid state at constant temperature is called melting.
- **Fusion and Freezing point:-**The process of change of state from liquid to solid is called fusion. The temperature at which liquid starts to freeze is known as the freezing point of the liquid.
- **Evaporation: -** Conversion of liquid into vapour at all temperatures (even below its boiling point) is called evaporation
- **Sublimation: -** The conversion of a solid into vapour state is called sublimation.
- **Hoar - Frost:-** The conversion of vapour into solid state is called Hoar frost.

■ Thermal Expansion

Almost all substances (solids, liquids and gases) expand on heating and contract on cooling.

The expansion of a substance on heating is called thermal expansion of substance.

Water from 0ºC to 4 ºC and silver iodide from 80ºC to 141ºC contract on heating and expand on cooling.

➲ **Linear expansion:-** By Experiments it is observed that on heating a rod, the increase in its length is directly proportional to its original length, as increase in its temperature.

$$\boxed{\Delta\ell = \ell\alpha\Delta T} \Rightarrow \boxed{\alpha = \frac{\Delta\ell}{\ell\times\Delta.T}}$$

Where,

$\Delta\ell$ = Increase in length, ℓ = Original length

α = Coefficient of linear expansion

ΔT = Change in Temperature

S. No.	Materials	Coefficient of linear expansion (α) in K^{-1}
1.	Aluminium	2.5×10^{-5}
2.	Brass	1.8×10^{-5}
3.	Iron	1.2×10^{-5}
4.	Copper	1.7×10^{-5}
5.	Silver	1.9×10^{-5}
6.	Gold	1.4×10^{-5}
7.	Glass (pyrex)	0.32×10^{-5}
8.	Lead	0.29×10^{-5}

➲ **Superficial Expansion:-** Superficial expansion of the material of a lamina is equal to the increase in unit area of the lamina when its temperature rises to 1ºC.

$$\boxed{\Delta A = A\beta\Delta T} \Rightarrow \boxed{\beta = \frac{\Delta A}{A \times \Delta T}}$$

Where,
ΔA = Change in Area, A = Original Area
ΔT = change in Temperature
β = Coefficient of superficial expansion

➲ **Cubical (volumetric) Expansion:-** Expansion in volume on heating is called cubical expansion.

$$\boxed{\Delta V = V\gamma\Delta T} \Rightarrow \boxed{\gamma = \frac{\Delta V}{V\Delta T}}$$

Where,
ΔV = Increase in Volume
V = Original Volume
γ = Coefficient of cubical expansion
ΔT = Increase in temperature.

- **Relation between α, β and γ are**
  $\beta = 2\alpha$ and $\gamma = 3\alpha$, $\boxed{\alpha : \beta : \gamma = 1 : 2 : 3}$
- Dimension of α, β and γ are $[\theta^{-1}]$ and units are k^{-1} or $(^{o}C)^{-1}$

Expansion of Liquids
- Apparent Expansion of liquids
- Real Expansion of liquids

(i) Apparent Expansion of Liquids:-
When expansion of the container containing liquid, on heating is not taken into account, then observed expansion is called apparent expansion of liquids.
Coefficient of apparent expansion of a liquid.

$$\gamma_a = \frac{\text{apparent (or observed) increase in volume}}{\text{original volume} \times \text{change in temperature}}$$

$$\gamma_a = \left(\frac{\Delta V_a}{V \times \Delta T}\right) {}^{o}C^{-1}$$

(ii) Real Expansion of Liquids
When expansion of the container, containing liquid, on heating is also taken into account then observed expansion is called real expansion of liquids.
Real Expansion of Liquid = Apparent expansion of liquid + volume expansion of vessel.
Coefficient of real expansion of a liquid

$$\gamma_r = \frac{\text{real increase in liquid}}{\text{original volume} \times \text{change in temperature}}$$

$$= \left(\frac{\Delta V_r}{V \times \Delta T}\right) {}^{o}C^{-1}$$

Relation between coefficient of real and apparent expansions- $\boxed{\gamma_r = \gamma_a + Y_g}$

■ Anomalous Expansion of water

When temperature of water is increased from 0ºC, then its volume decreases upto 4ºC, becomes minimum at 4ºC and then increases. Hence density of water is maximum at 4ºC because at this point

volume is minimum. This behaviour of water around 4°C is called anomalous expansion of water.

■ **Thermal Expansion of Gases**

There are two types of coefficient of expansion in gases.

(i) Volume Coefficient (γ_v) : At constant pressure, the change in volume per unit volume per degree Celsius is called volume coefficient.

$$\gamma_v = \frac{\Delta V}{V_0 \times (\Delta T)}$$

Where,

ΔV = change in volumes of the gas

V_0 = original volume

ΔT = change in Temperature.

(ii) Pressure coefficient (γ_P)

At constant volume, the change in pressure per unit pressure per degree Celsius is called pressure coefficient. $\gamma_P = \dfrac{\Delta P}{P_0 \times (\Delta T)}$

Where,

ΔP = change in pressure

P_0 = original pressure

ΔT = change in Temperature

■ **Practical Applications of Thermal Expansion**

- A glass stopper Jammed in the neck of a glass bottle can be taken out by heating the neck of the bottle.
- When rails are laid down of the ground space is provided between the ends of two rails.

Substance	Specific heat capacity ($J\ kg^{-1} K^{-1}$)
Aluminium	900.0
Carbon	506.5
Copper	386.4
Lead	127.7
Silver	236.1
Tungesten	134.4
Water	4186.0

- Gases have two types of specific heat such as specific heat capacity at constant volume C_v and at constant pressure C_p.

  For molar specific heats $C_p - C_v = R$ where R = gas constant and this relation is called **Mayer's formula.**
- Specific heat ratio of adiabatic index is given as,

$$\gamma = \frac{C_p}{C_v}$$

The value of γ depends on atomicity of the gas.

➢ The transmission cable are not tightly fixed to the poles.

■ **Triple point of water-**

The values of pressure and temperature at which water coexists in equilibrium in all three states of matter, i.e. ice, water and vapour is called triple point of water.

Temperature at triple point = 0.01°C = 273.16 K.

Pressure at triple point = 0.006 P_{atm} = 4.58 mm of Hg

■ **Specific Heat:-**

Specific heat of a substance is the amount of heat required to raise the temperature of the unit mass of the substance through a unit degree (1° C or 1K). It is denoted by C or S.

- Its SI unit is Joule/kilogram- °C or J kg^{-1} K^{-1} and its dimensional formula is $[L^2T^{-2}\theta^{-1}]$

  The value of specific heat (S) will depend upon nature of the substance, and will obviously be different for different substances. $S = \frac{Q}{m\Delta T}$
- The specific heat of water = 4180 J kg^{-1} K^{-1}
- Specific heat for Hydrogen is maximum (3.5 cal/(g°C)) and for water 1 cal g^{-1} $°C^{-1}$.
- For Radon and Actinium, specific heat is minimum (= 0.022 cal g^{-1} $°C^{-1}$)
- Specific heat of a substance depends also on the state of the substance i.e solid, liquid or gas. For example

  Specific heat of ice = 0.5 cal g^{-1} $°C^{-1}$

  Specific heat of water = 1 cal g^{-1} $°C^{-1}$

  Specific heat of steam = 0.47 cal g^{-1} $°C^{-1}$

Substance	Specific heat capacity (J kg^{-1} K^{-1})
Ice	2060
Glass	840
Iron	450
Kerosene	2118
Edible oil	1965
Mercury	140

■ **Heat capacity or Thermal Capacity.**

The capacity of a body is defined as the amount of heat required to raise the temperature of the (whole) body through 1°C or 1K. $\Delta Q = ms\Delta T$

When,

$\Delta T = 1$, $\Delta Q = ms$

ΔQ = Thermal capacity

Hence thermal capacity of a body is the product of mass and specific heat of the body.

Its unit is Jk^{-1} or Cal $°C^{-1}$

- **Water Equivalent:-**
  It is the quantity of water whose thermal capacity is same as the heat capacity of the body. It is denoted by W
  W = ms = heat capacity of the body.
  Its expressed in the unit gram.
- **Latent Heat:-**
  Latent heat of a substance is the amount of heat energy required to change the state of unit mass of the substance from solid to liquid and from liquid to gas/vapour without any change in Temperature.

  $$\text{Latent heat (L)} = \frac{\text{Quantity of heat (Q)}}{\text{Mass of substance (M)}}$$

- Its unit is measured in J kg^{-1} or Cal g^{-1}
- Latent heat of fusion of ice = 80 cal. g^{-1} =3.33×10^5 J/kg
- Latent heat of vaporisation of water is 540 cal g^{-1} or 22.6×10^5 J/kg.
- **Few examples to understand Latent heat**
- It is more painful to get burnt by steam rather than by boiling water at 100ºC.
- Steam converted to water at 100ºC , then it gives out 536 cal of heat, so it is clear that steam at 100ºC has more heat than water at 100ºC (i.e boiling of water).
- After snow falls, the temperature of the atmosphere becomes very low. This is because the snow absorbs the heat from the atmosphere to melt down. So in the mountains, when snow falls, one does not feel too cold but when ice melts he feels too cold.
- There is more shivering effect of ice-cream on teeth as compared to that of water (obtained from ice). This is because when ice-cream melts down, it absorbs large amount of heat from teeth.
- **Joule's Law:-**
  According to Joule, when ever heat is converted into work or work is converted into heat, then the ratio between work and heat is constant.

  $\frac{W}{Q} = J$, Where J is mechanical equivalent of heat and $J = 4.2$ J. Cal^{-1}
- **Calorimetry**
  This is the branch of heat transfer that deals with the measurement of heat. The heat is usually measured in calories or kilo calories.
- **Principle of calorimetry:-**
  When a hot body is mixed with a cold body, then heat lost by hot body is equal to the heat gained by cold body.

  Heat lost = Heat gained.

  If two substances having masses m_1 and m_2, specific heats C_1 and C_2 kept at temperature T_1 and T_2 ($T_1 > T_2$) are mixed, such that, temperature of mixture at equilibrium is T_{mix} then,

  $$m_1C_1 (T_2 - T_{mix}) = m_2C_2 (T_{mix} - T_2)$$

  $$T_{mix} = \frac{m_1C_1T_1 + m_2C_2T_2}{m_1C_1 + m_2C_2}$$

NOTE

Principle of calorimetry follows the law of conservation of heat energy.

■ **Heating curve:-**

When a substance is given the heat, it undergoes rise in temperature and change of state at specific temperatures. The graph showing the change in temperature and state of the substance with time is called the heating curve.

- Specific heat (or thermal capacity) $\propto \dfrac{1}{\text{Slope of curve}}$
- Latent heat $\propto$ Length of horizontal line.

■ **Heating curve of water:-**

Modes of Heat Transfer

■ **Transfer of Heat**

Heat is a form of energy which can be transferred from one part of the system to another part of system due to temperature difference.

■ **There are three modes of heat transfer**

(I) Conduction (II) Convection (III) Radiation

❒ **Conduction:-** In conduction, heat is transferred from one point to another point without the actual motion of heated particles.

- ➲ Heat Transfer due to Temperature difference.
- ➲ Heat transfer due to free electron or vibration of molecules.
- ➲ Heat transfer in solid body (in mercury also)
- ➲ It is slow process.
- ➲ In conduction irregular path follows

■ **Fourier law of heat Conduction-**

Rate of heat flow $Q = -\dfrac{kAdT}{dx}$

■ **Thermal conductivity:-**

Thermal conductivity of a solid is a measure of the ability of the solid to conduct heat through it. It is denoted by 'k'

Rate of heat flow $\dfrac{dQ}{dt} = \dfrac{-kAdT}{dx}$ or $\dfrac{Q}{t} = \dfrac{kA(T_1 - T_2)}{\ell}$

Thermal resistance $R_H = \dfrac{\ell}{kA}$

SI units of k are $\dfrac{\text{Joule/sec}}{m^2 k/m} = Wm^{-1}K^{-1}$

CGS unit of k are cal $sec^{-1}cm^{-1}{}^{o}C^{-1}$

- The value of k is large in case of good conductors and it small in the case of insulator.
- $k_{solid} > k_{liquid} > k_{gas}$ (due to shape & size of matter or orientation of atoms in molecules)

■ **Variation of Thermal conductivity with Temperatur**

S. No.	Phase	Temperature	
1.	Solid	Increase	
2.	Liquid	Increase	
3.	Gas	Increase	

■ **Applications:-**

(a) Rods in series

Total equivalent thermal resistance (R) is equal to sum of individual thermal resistances i.e.

$$R_{eq} = R_1 + R_2 + R_3 + \ldots = \left(\frac{1}{k_1}\frac{\ell_1}{A_1}\right) + \left(\frac{1}{k_2}\frac{\ell_2}{A_2}\right) + \ldots..$$

■ **Rods in parallel:**

In parallel, the total thermal resistance is given by -

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots. = \frac{1}{\left(\frac{1}{k_1}\frac{\ell_1}{A_1}\right)} + \frac{1}{\left(\frac{1}{k_2}\frac{\ell_2}{A_2}\right)} + \ldots..$$

❒ **Convection:-** It is a mode of transfer of heat from one part of the medium to another part by the actual movement of heated particles of the medium.

Heat transfer due to density difference
In convection actual motion of particles.
Heat transfer in fluids (Liquid & Gas)
It is slow process.
It follow irregular path.

■ **Newton's law of cooling:-**

It states that the rate of loss of heat of a body is directly proportional to the difference in temperature of the body and the surroundings, provided the difference in temperature is small, not more than 40ºC

$$\boxed{\frac{dT}{dt} = k(T_1 - T_0) \Rightarrow T = T_0 + (T_1 - T_0)e^{-kt}}$$

Where ,
T = Temperature of body
T_0 = Temperature of surrounding
k = constant of proportionality
When a body cools from T_1 to T_2 in time 't' in a surrounding of temperature T_0 then,

$$\frac{T_1 - T_2}{t} = k\left(\frac{T_1 - T_2}{2} - T_0\right)$$

e -

Effect	Cause
Conductivity decrease	The crystal configuration of solid is affected and they start to occupy random positions.
Conductivity decrease	The liquids expand and try to attain gaseous configuration.
Conductivity Increases	The gas molecules collide at higher rate and momentum transfer due to collision increases.

❒ **Radiation:-**Radiation is the energy emitted by the matter by the mechanism of photon emission or electromagnetic wave emission as result of changes in the electronic configuration of the atoms and molecules. Because the mechanism of transmission is photon emission, unlike conduction and convection, there is no need of intermediate matter to enable to transmission. In radiation, the internal energy of the object decreases.

Electromagnetic Spectrum:-

All the electromagnetic waves are classified in terms of the wave length and are propagated at the speed of light (c) i.e., 3×10^8 m/s. The difference between one form of radiation and another lies only in its frequency (*f*) and wavelength (λ) which is related by the given figure.

The emission of thermal radiation which (range are lies between wavelength of 10^{-5} μm and 10^4 μm) depends upon the nature, temperature and state of the emitting surface. However, with gases the dependence is also upon the thickness of the emitting layer and the pressure.

- Heat transfer without any medium.
- It is an Electromagnetic radiation
- Radiation acts in all form (Solid + liquid + Gas)
- It is fast process (with speed of light $c=3\times10^8 ms^{-1}$)
- Path of radiation is straight line like "light"

■ **Stefan's Boltzmann law:-**

Radiated energy emitted by a perfect black body per unit area per second is directly proportional to fourth power of absolute temperature.

$$E \propto T^4 \text{ or } E = \sigma T^4$$

Where σ is a constant of proportionality and is called Stefan's constant. Its value is 5.67×10^{-8} $Wm^{-2}K^{-4}$

- If the body at temperature T is surrounded by a body at temperature T_0 then Stefan's law -

$$E = \sigma (T_1^4 - T_0^4)$$

- **For a general body**: $\boxed{E = \varepsilon\sigma\,(T_1^4 - T_0^4)}$

  Here 'ε' is taken as emissivity of both the body and the enclosure.

■ **Prevost's theory of heat exchange:-**

A body is simultaneously emitting radiations to its surrounding and absorbing radiations from the surroundings.

If surrounding temperature is T_0 then

$$\boxed{E_{net} = \varepsilon\sigma\,(T_1^4 - T_0^4)}$$

■ **Kirchhoff's Law**

- According to Kirchhoff's law, the ratio of emissive power to absorptive power is same for all surfaces at the same temperature and is equal to the emissive power of a perfectly black body at that temperature.
- If a and e represent absorptive and emissive power of a perfectly black body then $\frac{e}{a} = \frac{E}{A} =$ constant for all surface.
- For a perfectly black body A = 1 so, for any surface $\frac{e}{a} = E$ for the radiation of a particular wavelength

$$\boxed{\frac{e_\lambda}{a_\lambda} = \frac{E_\lambda}{A_\lambda} \Rightarrow \frac{e_\lambda}{a_\lambda} = E_\lambda}.$$

Since E_λ is constant at a given temperature hence according to this law, if a surface is a good absorber of a particular wavelength it is also a good absorber and bad emitter.

■ **Perfectly black body**

- A perfectly black body is that which absorbs completely all the radiation of all wavelengths incident on it.
- A perfectly Black body maintained at a suitable temperature emits radiations of all wavelengths.
- A perfectly black body neither reflects nor transmits any radiation, it will always appear black whatever be the colour of the incident radiation

■ **Absorptive Power:-**

Absorptive power of a surface is defined as the ratio of the radiant energy absorbed by it in a given time to the total radiant energy incident on it in the same time. It is represented by 'a'

$$a = \frac{(\Delta Q)_{absorbed}}{(\Delta Q)_{incident}}$$

- For a perfectly black body absorptive power is maximum and it is unity.
- It has no units and dimension.

■ **Emissive power:-**

- For a given surface it is defined as the radiant energy emitted per unit area of the surface.
- It is represented by 'e'
- Emissive power of a surface depends on its nature and temperature.
- Emissive power (e) of given wavelengths of radiations emitted range from 0 to ∞, $e = \int_0^\infty e_\lambda d\lambda$

  'e' is measured in Joule sec^{-1} $metre^{-2}$ or Wm^{-2}

- **Wein's Displacement law:-**
  Product of the wavelength λ_m of most intense radiation emitted by a black body and absolute temperature of the black body is a constant, $\lambda_m T = b = 2.89\times10^{-3}$mK
  where b = Wein's constant.

- Area under $e_\lambda - \lambda$ graph = $\int_0^\infty e_\lambda d\lambda = \sigma T^4$
- **Solar constant:-**
  The solar radiant energy received per unit area per unit time by a black surface held at right angles to the sun's rays and placed at the mean distance of the earth (in the absence of atmosphere) is called solar constant. Solar constant is represented by 's'

$$s = \frac{P}{4\pi r^2} = \frac{4\pi R_s^2 \sigma T^4}{4\pi r^2} = \sigma\left(\frac{R_S}{r}\right)^2 T^4$$

Where,
R_S = Radius of sun
r = average distance between Sun and Earth.
s = 2 cal cm^{-2} min = 1.4 kWm^{-2}
T = Temperature of sun ≈ 5800K

EXAM POINTS

- The SI unit of temperature is **- Kelvin**
- The SI unit of energy is **- Joule**
- Who invented the centigrade scale **- Anders Celsius**
- Temperature of distant luminous bodies can be determined by **- Pyrometers**
- In which layer of atmosphere, temperature remains constant with increase in altitude. **- Stratosphere**
- Heat is transmitted from higher to lower temperature through actual motion of the molecules by **- Convection**
- If the temperature of a liquid is 32ºF, then its temperature in Celsius is **- 0ºC**
- Water is used in hot water bags because **- It has high specific heat**
- Why does ice covered in sawdust not melt quickly? **- Sawdust is a bad conductor of heat**
- The difference in boiling point of liquids is due to **- Difference in pressure**
- Which is most important for absorption of heat radiated from the sun as well as from the earth **- Carbon dioxide**
- At what temperature (in Fahrenheit) pure water freezes **- 32ºF**
- Heat transfer horizontally with in the atmosphere is called **- Advection**
- The direction of flow of heat between two bodies depends on **- Their temperature**
- Earth's surface emits heat into space in the form of **- Infrared radiation**

- A real gas behaves like an ideal gas if its **- High temperature and low pressure**
- The time taken by the light to travel from the sun to the earth is approximately **- 8 minutes**
- What is the temperature reading at which we get the same reading on both the centigrade and Fahrenheit scale **- –40º**
- Ice is floating on water in a beaker. When the ice melts completely, the level of water in the beaker will be **- Remains same**
- When water is filled in a bottle and is allowed to freeze, the bottle breaks because **- Water expands on freezing**
- At what temperature is the density of water maximum **- At 4ºC**
- When two pieces of ice are pressed together, then they stick together because **- An increase in pressure decreases the melting point of ice.**
- Which law justified, that energy can neither be created nor destroyed **- Conservation of energy**
- The normal temperature of the human body in terms of Kelvin is **- 310 K**
- The normal body temperature of the human being is **- 98ºF**
- The body temperature of a healthy human being is **- 37ºC**
- The transmission of heat by molecular movement is called **- Convection**
- Dew is not formed in turbulent (high wind blow) night because **- Rate of evaporation is greater**
- The process of vaporizing camphor from solid camphor is called **- Sublimation**
- Humans feel discomfort due to humidity, this is because **- Sweat does not evaporate due to humidity**
- A liquid is converted into vapour below its boiling point the process is called **- Vaporization**
- Steam produces more severe burns than boiling water because **- Steam has more latent heat**
- The first law of thermodynamics confirms the law of **- Conservation of energy**
- When water is heated from 0ºC to 10ºC then its volume **- First decreases and then increases**
- A white and smooth surface is **- A poor absorber and a good reflector of heat**
- Which has the highest specific heat capacity **- Water (4.186 kJ/grºC)**
- Which device is used to measure very high temperatures **- Thermoelectric thermometer**
- Water droplets are see on the outer surface of glass containing ice because **- The water vapour presents in air, on coming in contact with the cold glass of water, losses energy and gets converted to liquid state.**
- The unit of physical quantity "heat capacity" is **- Joule/Kelvin**
- The instrument for measuring low temperatures is called **- Cryometer**
- The zeroth law of thermodynamics defines **- The temperature**
- Triple point is **- It is point at which all the three phases solid, liquid and gas are found together**

- The heat produced by the burning of one gram of fuel is **- Calorific value**
- For a dry bulb temperature as the relative humidity decreases then the wet bulb temperature will **- Increase**
- Which color combination is best for umbrellas to protect from the Sun **- White one the top and black on the inside**
- The function of the thermostat in the refrigerator is **- To maintain uniform temperature**
- By increasing the temperature of sugar solution, then the solubility of sugar **- Increases**
- A small space is left at the points of rails in a railway track because **- Metal expands on heating and contracts on cooling**
- The amount of heat required to change the temperature of one gram of a substance by 1ºC is called **- Specific heat**
- How much temperature can be measured by radiation pyrometer **- Above 500ºC**
- When the door of a refrigerator is kept open then the room temperature will be **- Increases**
- The device which converts thermal energy into mechanical energy is **- Steam engine**
- When salt is mixed with ice, then the freezing point of ice is **- decreases**
- During hot summer days, the water kept in the earthen pot to keep it cooled by **- Evaporation**
- A clinical thermometer indicates the temperature in degrees Fahrenheit from **- 94 to 108**
- How does water get heated in an electric kettle **- By convection**
- The process by which solid directly changes into vapour in known as **- Sublimation**
- Salt is added when we boil vegetables because **- It increases the boiling point of water**
- You placed a car in an open parking area in a summer day. After a few hours, you noticed that the heat is trapped inside a car. This phenomenon is known as **- Green house effect**
- Cooking utensils in kitchen are coated black because **- Black material absorbs more heat**
- When an object is cooled, then its molecules motion **- Decreases**
- Which scientist first melted two pieces of ice by rubbing them together **- Humphry Davy**
- What happens to melting point of ice when pressure is increased **- The melting point of ice decreases**
- A gas thermometer is more sensitive than a liquid thermometer because a gas **- Expands more than a liquid**
- Extremtly high temperature are measured by **- Platinum resistance thermometer**
- Total radiation pyrometer is based on the principle of **- Stefan Boltzmann law**
- If a metal is used for making cooking utensils, then the thermal conductivity should be **- High**
- Which radiations of sunlight are used in heating a solar cooker **- Infrared radiation**

- The morning sun is not as hot as the mid day sun because
  - Sun's rays travel a longer distance through the atmosphere in the morning
- Woolen clothes are warmer than cotton clothes because **- They are good insulator of heat**
- "Good emitters are good absorbers". This is the rule of **- Kirchhoff's radiation law**
- The rate of cooling of an object is directly proportional to the temperature difference between the object and medium around it". This law is
  - Newton's law of cooling
- Newton's law of cooling is applicable only when
  - Difference in temperature is not very large
- Who invented the thermos flask **- James Dewar**
- A thermos flask prevents loss of heat by
  - Conduction, convection and radiation
- The temperature at which a solid substance turns into a liquid is called **- Melting point**
- The temperature at which a liquid changes into a vapour is called **- Boiling point**
- The addition of any other substance to a pure substance will cause its melting point to **- Decrease**
- The process of converting a liquid into vapour before its boiling point is called **- Evaporation**
- The quantity of heat required to change the unit mass of a substance from solid state to liquid state at its melting point is known as
  - Latent heat of fusion of the solid
- The value of latent heat of fusion of ice is
  - 80 cal/ g = 336×10^3 J/kg
- Latent heat of vaporization of water is
  - 536 cal/g = 2.25×10^6 J/kg
- Which is conserved by first law of thermodynamics
  - Energy
- The concept of internal energy is given by
  - First law of thermodynamics
- What type of weather do we feel more cold during winters **- Clear weather**
- Water and ice crystal are in equilibrium at 0ºC. When pressure is applied to this system
  - More of ice becomes water
- Which instrument is used to measure temperature
  - Thermometer
- One calorie is equal to **- 4.186 Joule**
- Which law of thermodynamics defines the concept temperature **- Zeroth law of thermodynamics**
- The fractional change in the length of a solid with a change in temperature of 1ºC is called
  - Coefficient of linear expansion
- There is a hole in the copper disc. When it is heated the diameter of the hole is **- Increases**
- If a bimetallic strip is heated, it will
  - Bend towards the metal with lower thermal coefficient of expansion
- An iron ball is heated the percentage increase will be largest in **- Volume**
- If the pressure of the atmosphere is increased, then the latent heat of steam is **- Decreases**
- Which energy of the molecules of the substance decreases in melting and boiling **- Potential energy**
- Hygrometer is the instrument which is used to measure **- Humidity or amount of water vapour in the air**

- Compared to a burn due to water at 100ºC, a burn due to steam at 100ºC is **- More dangerous**
- The temperature at which the air becomes saturated with water vapour actually present in a given volume of air is called **- Dew point temperature**
- The study of any physical process at a temperature lower than that of liquid air is called **- Cryogenics**
- If specific heat of a substance in infinite, it means **- No change in temperature whether heat is takes in or given out**
- In isothermal condition, the heat supplied to a gas is used **- to do external work**
- The internal energy of an ideal gas depends only **- Temperature**
- During an isothermal expansion of an ideal gas, its mean **- temperature is constant**
- The specific heat of a gas in an isothermal process is **- Infinite**
- A thermos flask is polished well **- To reflect all radiations from outside**
- When heat is radiated from one place to another, the temperature of the medium is remains **- Unchanged**
- A perfect black body is the one that **- Absorbs all the radiation**
- A wire is heated gradually as temperature rises, at first it appears **- Red**
- A hot body will emit radiations more rapidly if its surface is **- Black and rough**
- By which process is heat transmitted from the filament of an evacuated electric bulb to the glass **- Radiation**
- The amount of water vapour absorbed by the atmosphere can **- Increased with increase in air temperature**
- In cold regions, where the temperature can drop below 0ºC, farmers fill their fields with water to protect the crops from damage because **- Water has high specific heat capacity**
- A mechanic wants to fit a brass plug to in steel plate with a hole in the middle. It would be better when **- Brass plug is cold and the steel plate is heated**
- The speed of heat radiation is equal to that of **- Speed of light**
- A black body can absorb radiation of **- All wavelengths**
- During adiabatic compression of a gas, its temperature **- Rises**
- The temperature at which a ferromagnetic substance converts into a paramagnetic substance is called **- Curie temperature**
- When two pieces of ice are pressed together, they combine to form one single piece. This phenomenon is called **- Regelation**
- Two spheres are made of same size and same metal but one is hollow and other one is solid. If both are heated to the same temperature then **- Both the spheres will expand equally**
- The function of quartz crystal in the watch is based on **- Piezoelectric effect**
- The temperature of the boiling point of any liquid **- Increases with increase in pressure**
- The device that converts sunlight directly into electrical energy is called **- Solar cell**

- Buffaloes in summers are ofter seen in ponds, this is because **- Their color absorbs more heat**
- With increase in temperature, the thermal conductivity of air is **- Also increase**
- Two thin woollen blankets are less colder than a thick wollen blanket because **- Air is trapped between the blankets**
- A bucket of lukewarm water will melt more ice than a cup of boiling water because **-Bucket of water contains more heat**
- the maximum temperature at which human life cannot be possible is **- More than 108ºF**
- The lowest mark on the thermometer is marked at 95ºF. Its meaning is **- Humans cannot live below this temperature**
- At what temperature does water exist in both solid and liquid states **- 0ºC**
- Water boils at lower temperature on hills or high altitude because **- There is less air pressure on the hills**
- When the vapour pressure of a liquid is equal to its atmospheric pressure, then the liquid **- Boils**
- The purity of solid substance can be checked by its **- Melting point**
- A rubber balloon filled with Hydrogen gets burst when it goes up because of **- Air pressure decreases**
- A closed vessel is maintained at a constant temperature. It is first evacuated and them steam is introduced in it continuously. The pressure of steam in the vessel is **- First increases and then becomes constant**
- Sun temperature is measured by **-Pyrometer**
- The cycle tube explodes in summer due to **- Expansion of pressure in the wall increases**
- Water pipelines burst on the mountains in extreme cold. It has due to **-Water expands when it freezes in a pipe**
- When a table fan is used in a closed room the air in the room will be **-Hot**
- People with dark skin in Africa compared to people with white skin in Britain **-Feel overheated**
- The inner walls of the thermos flask are polished because **-To prevent heat loss by radiation**
- The walls of a thermos flask galvanized to minimize heat transfer by the method of **-Radiation**
- During the day, the earth heats up very quickly in comparison to the surface of ocean because **-The specific heat capacity of water is greater**
- For cooling the car radiator, water is used because of **-High specific heat capacity of water.**
- Cryogenic engine is used in **-Rocket Technology**
- Sublimate substance are **-Camphor, Naphthalene, Ammonium Chloride.**
- Some other substance is added to the pure substance then its melting point **-Decreases**
- On the high hills snow fall due to **- The temperature on the high hills is below the freezing point, so the water vapor freezes and becomes ice.**

- It takes more time to cook potato on mountain stoves, because **- Atmospheric pressure is less.**
- Steam burns hand more in comparison to boiling water. **-Steam has latent heat**
- First law of thermodynamics is based on the principle of **-Conservation of energy**
- In adiabatic process **-Heat remains constant**
- Due to impurities boiling point of water **- Increases**
- A thermometer suitable for measuring temperature 2000^0C **-Absolute radiation pyrometer**
- If there is sudden increase in the temperature of a place, the relative humidity **- Decreases**
- Energy is lost to the molecules of matter during boiling and melting **-Potential Energy**
- Hygrometer is instruments which is used for **-To measure the amount of vapor in atmosphere.**
- Internal energy of ideal gas depends only on **-Temperature**
- If work is done by the gas then temperature **-Decreases**
- The process by which heat is converted into work **-Heat engine**
- Isothermal expansion in ideal that means **-Temperature is constants**
- In Ideal gas specific heat capacity is **-Infinite.**
- When air rises in the atmosphere, it cools because **-Diffusion take place due to low atmospheric pressure**
- We sweat maximum when **-The temperature is high and it is humid**
- In cold region where the temperature can drop below 0^0C, farmer flood their crops from damage, because **-Water has maximum specific heat**
- Purity of solid is decided by **-Melting point**
- The capacity of air conditioned plants **-In tons**
- In piezoelectric effect, production of electricity by **-Pressure**
- If T_1 is boiling point of Delhi and T_2 is boiling point of Shimla then relation between T_1 and T_2 are **-$T_1>T_2$**
- Thermister is **-Thermal resistance**
- Quantity of heat absorbed by a substance depends on **-Mass of substance, specific heat and change in temperature**
- In watch, work of the quartz crystal based on the principle of **-Piezoelectric effect**
- The safe temperature for keeping food fresh in the refrigerator **- 4^0C**
- The water used in the radiator of car due to **-High specific heat capacity**
- If the coefficient of volumetric expansion of glass and mercury is equal then the mercury glass tube in the thermometer will **- Does not work**
- Out of aluminum , copper, iron and brass, which one has maximum coefficient of linear expansion **-Aluminum**
- Values of elastic measurements with the increase in temperature **-Decreases**
- With the help of hygrometer, we measure **-Relative humidity**

PREVIOUS YEA

1. The efficiency of a heat energy can never be

(a) 10% (b) 80%
(c) 100% (d) 50%

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Ans. (c) : Heat energy is the result of the movement of tiny particles called atoms, molecules or ions in solids, liquid and gases.

- Heat energy can be transferred from one object to another. Its transfer or flow is done by the difference in temperature between the two bodies.
- According to second law of thermodynamics, it is impossible to get 100% of efficiency because of environmental changes and some other factors. So, the efficiency of a heat energy can never be 100%.

2. The heat generated while transferring 96000 coulomb of charge is one hour through a potential difference of 50 V is

(a) 4.8×10^4 J (b) 1.33×10^3J
(c) 4.8×10^6J (d) 1.33×10^4 J

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Ans. (c) : Given,

V = 50 V
Q = 96000
t = 1 hour = 3600 sec

We know that-

$$H = V\,I\,t = \frac{V \times Q.t}{t} = V \times Q = 50 \times 96000$$

$$\Rightarrow \quad \boxed{H = 4.8 \times 10^6\,J}$$

3. The specific heat capacity of water is

(a) 540 J/kg°C (b) 4186 J/kg°C
(c) 2260 J/kg°C (d) 335 J/kg°C

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Ans. (b) : Specific heat capacity of water = 4186 J/kg°C

4. The thermal coefficient of linear expansion of a material is α. Then the thermal coefficient of its volume expansion will be

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

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Ans. (b) : First Method- Linear expansion - when the expansion due to heating occurs only along one direction. Then linear expansion,

$$\Delta\ell = \alpha\,\ell.\Delta T$$

where, $\Delta\ell$ = Change in length

ℓ = Length

ΔT = Change in temperature

α = Coefficient of linear expansion

(S.I. Unit C^{-1} or K^{-1})

Volumetric expansion - change in volume (ΔV) is directly proportional to volume (V) and ΔT

So, $\Delta V \propto \Delta T$ and $\Delta V \propto V$

$\Delta V \propto V.\Delta T$

$\Delta V = \gamma V.\Delta T \rightarrow (3)$

Where γ = the coefficient of volume expansion.

AR QUESTIONS

When the temperature of a cube of material of side length (ℓ) is increased by $d\ell$ then the volume will be increased by an amount dV is given by,

$$dV = \left(\frac{dV}{d\ell}\right).d\ell$$

Volume of cube (V) = ℓ^3

Put the value of V in equation (3)

$$dV = \frac{d(\ell^3)}{d\ell} \times d\ell = 3\ell^2.d\ell$$

Put the value of $d\ell$

$$dV = 3\ell^2.(\ell\ \alpha dT)$$

$$= 3\ell^3\ \alpha\ dT \qquad \because V = \ell^3$$

$$= 3\ \alpha\ VdT$$

$$dV = \gamma VdT$$

Thus, $\gamma = 3\alpha$

Second Method- We know that

$$\alpha : \beta : \gamma = 1 : 2 : 3$$

α = Coefficient of linear expansion

γ = Coefficient of volume expansion

β = Coefficient of Areal expansion

So, $\gamma = 3\alpha$

$\beta = 2\alpha$

5. If half litre of a hot water at 90° C is mixed with three and a half liters of cold water at 10° C, find the final equilibrium temperature (in °C) if no heat is lost.

(a) 50 (b) 20 (c) 40 (d) 30

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Ans : (b) Heat lost = Heat gain

$m_1c\ \Delta T_1 = m_2c\ \Delta T_2$

$m_1\ \Delta T_1 = m_2\ \Delta T_2$

$$\frac{1}{2}(90 - T) = \frac{7}{2}(T - 10)$$

$(90 - T) = (7T - 70)$

$8T = 160$

$$T = \frac{160}{8}$$

$\boxed{T = 20°C}$

6. Find the heat capacity of a pan of mass 200 g if its temperature rises by 8° C on receiving 20000 J of heat.

(a) $250JK^{-1}$ (b) $50JkG^{-1}K^{-1}$

(c) $1.25Jkg^{-1}K^{-1}$ (d) $5JK^{-1}$

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Ans : (a) Given, mass (m) = 200 gm

Difference in temperature (ΔT) = 8°C

and heat (ΔQ) = 2000 J

$$\text{Quantity of heat} = \left(\frac{\text{Heat capacity}}{\text{Temperature increases}}\right)$$

$$= \frac{\Delta Q}{\Delta T} = \frac{2000}{8} = 250\ Jk^{-1}$$

7. Find the specific latent heat of vaporisation of 1.25 g of (in Jg^{-1}), if it releases 250 joules of heat when it condenses at its boiling point of 196° C.

(a) 500 (b) 200
(c) 312.5 (d) 469

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Ans : (b) Latent heat:- Latent heat is the heat required to change the state of unit mass of a substance at a constant temperature is called latent heat of the substance. It is denoted by L.

$$Q = mL$$

or $$L = \frac{Q}{M}$$

Given that m = 1.25 gm

Q = 250 J

Then, latent heat $(L) = \frac{Q}{M} = \frac{250}{1.25} = 200$

8. Find the specific heat capacity (in $Jg^{-1}\ K^{-1}$) of a block of metal of mass 500 g, the temperature of which rises by 80° C when it absorbs 10 kJ of heat?

(a) 1.56 (b) 0.25
(c) 0.4 (d) 0.16

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Ans : (b) Given,

Mass of metal (m) = 500 gm

Heat (Q) = 10 kJ = 10,000 J

Increase in temperature $(\Delta T) = 80°C$

Then $Q = mc\,\Delta T$

Where Q = Heat (or thermal energy)

m = mass

c = specific heat

ΔT = increase in temperature

When $C = \frac{Q}{m \times \Delta T} = \frac{10000}{500 \times 80}$

$= 0.25\ Jg^{-1}k^{-1}$

9. – 100° Celsius = ——— Fahrenheit

(a) -148° (b) -373°
(c) 173° (d) -212°

RRB ALP & Tech. 23.01.2019 Shift-I

Ans : (a) –Using the formula = $C = \frac{5}{9}(F-32)$

$$-100 = \frac{5}{9}(F-32)$$

$$-\frac{100 \times 9}{5} = F - 32$$

$$-180 = F - 32$$

$$F = -180 + 32$$

$$\boxed{F = -148}$$

10. Two litres of superheated water at 190°C is mixed with six litres of cold water at 20°C. Find the final equilibrium temperature (in °C) if no heat is lost.

(a) 47.5 (b) 95
(c) 62.5 (d) 55

RRB ALP & Tech. 23.01.2019 Shift-II

Ans : (c) $T_1 = 190°$
$T_2 = 20°$
$m_1 = 2$ litre
$m_2 = 6$ litre

Here, with no heat loss, let the final equilibrium temperature be T.

Heat loss	=	Heat gain
$m_1C\Delta T_1$	=	$m_2C\Delta T_2$
$m_1\Delta T_1$	=	$m_2\Delta T_2$
$2(190 - T)$	=	$6(T-20)$
$380 - 2T$	=	$6T - 120$
$8T$	=	500

$$T = \frac{500}{8}$$
$$T = 62.5°C$$

11. _____ ° Celsius = 167°Fahrenheite

(a) 348 (b) 103
(c) 198 (d) 75

RRB ALP & Tech. 23.01.2019 Shift-II

Ans : (d) We know that, $°C = \frac{5}{9}(F-32)$

$$C = \frac{5}{9}(167-32) = \frac{5}{9}\times 135$$
$$C = 75°$$

12. The specific latent heat of fusion of ethyl alcohol is 100 Jg^{-1}. Find the heat absorbed (in J) by 2.25 g of ethyl alcohol when it melts at its melting point of -114°C.

(a) 311 (b) 45
(c) 225 (d) 100

RRB ALP & Tech. 23.01.2019 Shift-II

Ans: (c) Given,
(M) = 2.25 gm
specific heat (L) = 100 Jg^{-1}
(Q) = ?

$$\because \text{ Specific heat (L)} = \left(\frac{\text{Heat (Q)}}{\text{mass}}\right)$$
$$100 = \frac{Q}{2.25}$$
$$Q = 2.25\times 100$$
$$Q = 225 \text{ Joule}$$

13. Find the heat capacity of a steel vessel of mass 2.5 kg if its temperature rises by 10 degrees. Specific heat capacity of steel is 500 $Jkg^{-1}K^{-1}$.

(a) $1250JK^{-1}$ (b) $20\ Jkg^{-1}K^{-1}$
(c) $200Jkg^{-1}K^{-1}$ (d) $125JK^{-1}$

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Ans : (a) Given,
mass of steel (m) = 2.5 kg
Increase in its temperature (ΔT) = 10°C
And specific heat (c) = (500 $Jkg^{-1}k^{-1}$)
Heat $Q = mC\Delta T$
$= 2.5 \times 500 \times 10$
$Q = 12500$

$$\text{Heat capacity} = \left(\frac{\text{amount of heat}}{\text{Increase in temperature}}\right)$$
$$= \frac{12500}{10} = 1250\ JK^{-1}$$

14. Find the mass (in g) of a copper calorimeter if its temperature rises by 45° when it absorbs 3.6kJ of heat. The specific heat capacity of copper is $0.4 Jg^{-1}K^{-1}$.

(a) 500 (b) 405
(c) 648 (d) 200

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Ans : (d) Heat absorbed (Q) = 3.6 kJ
Increase in temperature (ΔT) = 45°
Specific heat capacitance (C) = $0.4 Jg^{-1}k^{-1}$
mass (m) = ?
$Q = m C\Delta T$
$3.6 = m \times 0.4 \times 45$
$m = \frac{3.6}{18}$
m = 0.2 kg
m = 200 gram

15. Find the heat capacity of a pan of mass 180 g, if its temperature rises by 50 degree on receiving 2400 J of heat.

(a) $48 JK^{-1}$ (b) $16.67 Jkg^{-1}K^{-1}$
(c) $13.33 Jkg^{-1}K^{-1}$ (d) $36 JK^{-1}$

RRB ALP & Tech. 08.02.2019 Shift-I

Ans: (a) : mass (m) · 180 gram = 0.18 kg
Q = 2400 Joule C = ?
Temperature (ΔT) = 50 Kelvin
Heat capacity (C)= $\frac{Q}{\Delta T} = \frac{2400}{50} = 48 J K^{-1}$

16. If one and a half litres of hot water at 80°C is mixed with two and a half a litres of colder water at 40°C, find the final equilibrium temperature if no heat is lost.

(a) 50ºC (b) 55ºC
(c) 60ºC (d) 65ºC

RRB ALP & Tech. 08.02.2019 Shift-I

Ans : (b) : Let final equivalent temperature = TºC
We know that specific heat of water = $4200 Jkg^{-1}{}^{o}C^{-1}$
Then,
Heat consumed by hot water = 1.5 × 4200 (80 – T)
Heat obtained by cold water = 2.5 × 4200 (T – 40)
According to the principle of mixing,
Heat loss = Heat gained
1.5 × 4200 (80 – T) = 2.5 × 4200 (T – 40)
120 – 1.5T = 2.5T – 100
4T = 220
T = 55ºC

17. Find the specific heat capacity of a block of metal of mass 300 g, the temperature of which rises by 50 degrees when it absorbs 12 kJ of heat?

(a) $2.5 Jg^{-1}K^{-1}$ (b) $1.25 Jg^{-1}K^{-1}$
(c) $0.5 Jg^{-1}K^{-1}$ (d) $0.8 Jg^{-1}K^{-1}$

RRB ALP & Tech. 08.02.2019 Shift-I

Ans : (d) : Given, m = 300 gm,
$\Delta T = 50°C$,
and Q = 12 KJ = 12000J
Specific heat (s) = ?
$Q = m.s. \Delta T$
$s = \frac{Q}{m.\Delta T} = \frac{12000}{50 \times 300} = \frac{4}{5} = 0.8 J g^{-1}K^{-1}$

18. – 150° Celsius = ____ Fahrenheit

(a) –238° (b) –212°
(c) –418° (d) –373°

RRB ALP & Tech. 08.02.2019 Shift-I

Ans:(a): Formula convert degree Celsius to Fahrenheit:-

$$°F = °C \times \frac{9}{5} + 32 \quad \text{or} \quad \left(F = C \times \frac{9}{5} + 32\right)$$

Given, $C = -150$

$$F = -150 \times \frac{9}{5} + 32$$

$F = -270 + 32$

$F = -238$

So, we can say that – 150°C is equivalent to – 238°F.

19. Find the specific latent heat of vapourisation of 4.5 gm of nitrogen, if it releases 990 joules of heat when it condenses at its boiling point of – 196°C.

(a) 180 J/g (b) 220 J/g
(c) 200 J/g (d) 160 J/g

RRB ALP & Tech. 08.02.2019 Shift-I

Ans : (b) : Given,
mass (m) = 4.5 gram
Heat (Q) = 990 Joule
If the latent heat of the substance is L, then the heat required to change the state of mass of mass (m) of the substance is.

$Q = mL$

$990 = 4.5 \times L$

$$L = \frac{990}{4.5}$$

L = 220 Joule/gram

20. Which of the following is equal to 86°F?

(a) 20°C (b) 30°C
(c) 10°C (d) 34°C

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Ans : (b)

$$\frac{C}{5} = \frac{F-32}{9} \quad \text{[Formula]}$$

$$\frac{C}{5} = \frac{86° - 32°}{9}$$

$$\frac{C}{5} = \frac{54°}{9}$$

$$\frac{C}{5} = 6°$$

$C = 30°$

21. The higher the ____ value of a material, the faster it will conduct heat.

(a) Resilence
(b) Melting point
(c) Latent Heat
(d) Thermal conductance

RRB ALP & Tech. 23.01.2019 Shift-III

Ans : (d) The greater the value of the thermal conductivity of material. The more rapidly it will conduct heat.

22. What is the molar specific heat capacity of a substance?

(a) $\left(\frac{1}{\mu}\right)\left(\frac{\Delta Q}{\Delta T}\right)$ (b) $\mu\left(\frac{\Delta Q}{\Delta T}\right)$

(c) $\left(\frac{1}{\mu}\right)\left(\frac{\Delta T}{\Delta Q}\right)$ (d) $(\mu)\left(\frac{\Delta T}{\Delta Q}\right)$

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Ans : (a) Molar specific heat of a substance is the amount of heat required to raise the temperature of 1 mole of a solid or liquid by 1K or 1°C. It is denoted by C_n.

$$C_n = \frac{1}{\mu}\left(\frac{\Delta Q}{\Delta T}\right)$$

23. A brass rod (conductivity 109J/(m-K)) has an area of corss section 0.042 m^2 and length 20 cm. If a temperature difference of 200 J°C is maintained at the two ends of the rod, what will be the rate of heat flow through the rod?

(a) 2.32kJ/s (b) 3.42kJ/s

(c) 4.36kJ/s (d) 5.80kJ/s

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Ans : (c) Rod of conductivity (K) = 109 J (m–k)

Area of transverse cut (A) = 0.04 m^2

length of rod (l) = 0.20 m

Difference of temperature (ΔT) = 200J°C

Rate of heat flow through rod, $Q = K\left(\frac{A}{l}\right)(\Delta T)$

$$= 109\left(\frac{0.04}{0.20}\right) \times 200$$

$$= 109 \times \frac{1}{5} \times 200$$

= 4360 J/s = 4.36 kJ/s

24. Identify the material which has high coefficient of volume expansion.

(a) Alcohol (b) Glass

(c) Brass (d) Water

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Ans : (a) Coefficient of volume expansion:- It is the measure of the fractional change of size per unit change in the temperature with the surrounding pressure being constant. This coefficient is most applicable to fluids.

Material	**Volume coefficient expansion (/°C)**
Alcohol	– 1490
Glass	– 27.6
Brass	– 57
Water	– 210

out of given option, alcohol has higher coefficient of volume expansion.

25. Identify the material having the highest coefficient of volume expansion.

(a) Iron (b) Brass

(c) Aluminium (d) Mercury

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Ans : (d) Coefficient of volume expansion is most efficient for fluids. Among the given option, the order of the coefficient of volume expansion is given below-

Metal	**Volume expansion of coefficient (/°C)**
Iron	35×10^{-6}
Brass	56 × 10–6
Aluminum	75×10^{-6}
Mercury	180×10^{-6}

26. ____ is a mode of heat transfer by actual motion of matter.

(a) Conduction (b) Radiation
(c) Convection (d) Vaporisation

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Ans : (c) There are the three main methods of transfer or transmission of heat (energy) between substance from one place to another place-
1. Conduction
2. Convection
3. Radiation

Convection is the method of heat transfer from one place to another due to movement of fluid.

27. A 100-g block of lead is heated from 20°C to 50°C. Calculate the amount of heat transferred to the block (specific heat of lead = 127 J kg^{-1} K^{-1})

(a) 321J (b) 381J
(c) 127J (d) 230J

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Ans : (b) Given,
m = 100 gm = 0.1 kg
Difference in temperture $\Delta T = (50°C - 20°C) = 30°C$
Specific heat of lead (c) = 127 $JKg^{-1}.K^{-1}$
$\Delta Q = ?$
$\Delta Q = m.c.\Delta T$
$\Delta Q = 0.1 \times 127 \times 30$
$\Delta Q = 381$ Joule

28. Conduction and convection modes of heat transfer CANNOT operate between bodies separated by.....

(a) ice (b) aluminium
(c) vacuum (d) water

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Ans : (c) Conduction and convection modes of heat transfer cannot operate between bodies separated by vacuum because both are require the presence of material medium to take place.

29. The Fahrenheit and Celsius scales converge at _____.

(a) -50^0 (b) -40^0
(c) -30^0 (d) -20^0

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Ans : (b) Let the Fahrenheit and Celsius scale are oriented one (x).
then,

$$\frac{C}{5} = \frac{F-32}{9}$$

Where, $C° = F° = x°$

$$\frac{x°}{5} = \frac{x°-32}{9}$$

$9x° = 5x° - 32 \times 5$

$9x° = 5x° – 160$
$4x° = – 160$
$x° = -\frac{160}{4}$
So, $x° = – 40°$

30. _____ is the unit of thermal conductivity.

(a) $J \cdot s^{-1} \cdot K$ (b) $J \cdot s^{-1} \cdot m^{-1} \cdot K^{-1}$
(c) $J^{-1} \cdot s^{-1} \cdot kg^{-1}$ (d) $J \cdot s \cdot K$

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Ans : (b) In physics, heat conductivity is that property of substance which shows how easily heat can flow through that substance. Silver metal has the highest heat and electrical conductivity among metals. Thermal conductivity is a scalar quantity. Its unit is watt meter^{-1} kelvin^{-1} ($W.m^{-1}.K^{-1}$) or (Joule second^{-1} meter^{-1}Kelvin^{-1})

31. ..... is the heat per unit mass required to change a substance from solid into liquid at the same temperature and pressure.

(a) Sublimation
(b) Vaporisation
(c) Regelation
(d) Latent heat of fusion

RRB ALP & Tech. 22.01.2019 Shift-I

Ans : (d) When a solid substance is heated, its temperature increase and at a specific temperature the solid substance starts melting. This temperature is called the melting points of the solid. At the same melting point, temperature and atmospheric pressure, the amount of heat that can change the unit mass of a solid substance into liquid without changing its temperature is called the latent heat of fusion. Thus, the heat required per unit mass of a substance to change from solid to liquid at the same temperature and pressure is called latent heat of fusion.

32. Identify the conductor having the lowest resistivity.

(a) Silver (b) Aluminium
(c) Iron (d) Copper

RRB ALP & Tech. 22.01.2019 Shift-I

Ans : (a) Silver metal has the highest electrical conductivity and least electrical resistivity among metal. Therefore, out of the above options, silver metal is a good conductor with minimum resistivity. The order of the resistivity of the given metal is as follows-
Irons > Aluminum > copper > silver
Hence the resistivity of silver is minimum.

33. A brick wall having a thickness of 24 cm has an inner surface temperature of 25ºC and an outer surface temperature of 5ºC. The rate of heat loss through per square metre of the wall (thermal conductivity = 0.15 J/(s.m.K) is :

(a) 18.2J/s (b) 20.0J/s
(c) 12.5J/s (d) 23.0J/s

RRB ALP & Tech. 22.01.2019 Shift-I

Ans: (c) Given,
Thickness of wall (d) = 24 cm = 0.24 m
k = 0.15J/s.m.K
Temperature difference ($\Delta\theta$) = 25 – 5 = 20°C
Area of wall = 1 m^2, time = 1 second

$$\theta = \left(\frac{K.A.\Delta\theta.t}{d}\right)$$

$$\theta = \frac{0.15 \times 1 \times 20 \times 1}{0.24}$$

$$\theta = \frac{15 \times 20}{24} = \frac{300}{24} = 12.5 \text{ J/second}$$

34. When 1 kg of water is cooled from 4ºC to 0ºC, its volume _____.

(a) first decreases and then increases
(b) decreses
(c) remains the same
(d) increases

RRB ALP & Tech. 22.01.2019 Shift-I

Ans : (d) The density of water is maximum at 4°C and volume of a given sample of water is minimum at this temperature. But when the water cooled from 4ºC to 0ºC, its volume increases due to **Anomalous expansion** of water.

35. Identify the material having the highest coefficient of volume expansion.

(a) Iron (b) Mercury
(c) Hard rubber (d) Brass

RRB ALP & Tech. 22.01.2019 Shift-II

Ans : (c) : Hard rubber has the highest coefficient of volume expansion. The increase in volume of solid when heated is known as volumetric expansion.

Volume expansion (/ºC) of the other materials is-

Iron	-	3.55×10^{-5}
mercury	-	18.2×10^{-5}
Brass	-	6×10^{-5}
Hard rubber	-	24×10^{-5}

36. Copper expands about ____ times more than glass for the same rise in the temperature.

(a) Three (b) Five
(c) Four (d) Six

RRB ALP & Tech. 22.01.2019 Shift-II

Ans : (b) : Copper expands five times more than glass with the same increase in temperature.

37. A 50g block of copper is heated from 20°C to 60°C. How much heat is transferred to the block (specific heat of copper 386 $Jkg^{-1}K^{-1}$)?

(a) 852 J (b) 572 J
(c) 320 J (d) 772 J

RRB ALP & Tech. 22.01.2019 Shift-II

Ans : (d) : $\Delta T = (60–20) = 40°C$

$m = 50 \text{ gm} = 0.05 \text{ kg}$

specific heat (c) = 386 J Kg^{-1} K^{-1}

Transferred heat $Q = m.c.\Delta T$

$= 0.05 \times 386 \times 40$

$= 772$ J

38. The boiling and freezing points of water are exactly ____ degrees apart on the Fahrenheit scale.

(a) 273 (b) 50
(c) 100 (d) 180

RRB ALP & Tech. 22.01.2019 Shift-II

Ans : (d) : In Fahrenheit scale-

B.P of water = 212 ºF

Freezing point of water = 32 ºF

Body temperature = 98.6 ºF

And the boiling point and freezing point of water exactly 180º apart on the Fahrenheit scale.

39. 95 ºF = _____ ºC

(a) 15 (b) 25
(c) 35 (d) 45

RRB ALP & Tech. 22.01.2019 Shift-II

Ans : (c) : Formula $\left[\frac{C}{5}=\frac{F-32}{9}\right]$

Given F = 95°F

$$\frac{C}{5}=\frac{F-32}{9}$$

$$\frac{C}{5}=\frac{63}{9}\Rightarrow\frac{C}{5}=\frac{7}{1}\Rightarrow \quad C=35°$$

40. 77^0F is equal to :

(a) 25ºC (b) 20ºC
(c) 15ºC (d) 10ºC

RRB ALP & Tech. 21.01.2019 Shift-I

Ans : (a) : Fahrenheit scale was proposed by Daniel Gabriel Fahrenheit in the year 1724 AD.

Formula $\frac{C}{5}=\frac{F-32}{9}$

$$\frac{C}{5}=\frac{77-32}{9}$$

$$\frac{C}{5}=\frac{45}{9}$$

$$\frac{C}{5}=\frac{5}{1}$$

$$\boxed{C=25°C}$$

41. A steel rod with the thermal conductivity of 50.2 W/(m-K) has an area of cross-section 0.02 m^2 and length 15 cm. If the two ends of the rod are maintained at a temperature difference of 300^0C, the rate of heat flow through the rod is : 50.2 W

(a) 4.0 kJ/s (b) 1.0 kJ/s
(c) 3.0 kJ/s (d) 2.0 kJ/s

RRB ALP & Tech. 21.01.2019 Shift-I

Ans: (d) : Thermal conductivity (K) = 50.2 W/(m-K)
Length of rod (l) = 15 cm = 0.15 m
Area of cross-section of rod (A) = 0.02 m^2
Temperature difference betweens $(\theta_1-\theta_2)$ = 300°C

Rate of flow of heat (Q) $\frac{KA(\theta_1-\theta_2)}{l}$

$$=\frac{50.2\times0.02\times300}{0.15}=2008 \text{ J/s}$$

= 2 kJ/second

42. How much heat should be transferred to a 100 g block of aluminum (specific heat 900 $Jkg^{-1}K^{-1}$) to increase its temperature by 10^0C ?

(a) 90 J (b) 9 J
(c) 9000 J (d) 900 J

RRB ALP & Tech. 21.01.2019 Shift-I

Ans : (d) : Given,

m = 100g = 0.1 kg
c = 900 $Jkg^{-1}k^{-1}$
$\Delta T = 10^0C$
$Q = m.c.\Delta T \Rightarrow Q = 0.1\times900\times10$
Q = 900 Joule

43. Identify the substance from the below having highest specific heat capacity :

(a) Kerosene (b) Aluminium
(c) Water (d) Ice

RRB ALP & Tech. 21.01.2019 Shift-I

Ans : (c) : Water has the highest specific capacity strong hydrogen bonding is found between water molecular, due to which the inter molecular force between water molecules is high, which requires more heat to break. Therefore the specific heat water is high. The specific heat of water is given as 4.18 J/g°C.

44. How much heat must be transferred to a block of silver weighing 100g so that its temperature increase by 40°C ? (The Specific heat of silver is 236 $Jkg^{-1}k^{-1}$).

(a) 450J (b) 1270J
(c) 1988J (d) 944J

RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (d)

Let the weight (mass) silver (m) = $\frac{100\text{ gram}}{1000\text{gram}}$

$= 0.1\text{kg}$

Temperature $(\Delta T) = 40^{o}C$

Specific heat of silver = 236 Jkg^{-1}

$Q = MC\Delta T = 0.1\times236\times40 = 944J$

Hence 944J of heat will be transferred to the silver block.

45. 152° Fahrenheit is equal to ————° celsius.

(a) 36.67 (b) 66.67
(c) 86.67 (d) 56.67

RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (b) $\frac{C}{5} = \frac{F-32}{9}$

Given F = 152°

$\frac{C}{5} = \frac{152-32}{9}$ $\frac{C}{5} = \frac{120}{9}$

9C = 120.5

$C = \left(\frac{120\times5}{5}\right) = \frac{40\times5}{3}$

$= \left(\frac{200}{3}\right)$

$= 66.67°C$

46. The change from the state of ice to the state of water is due to the ———.

(a) Increase in temperature
(b) Absorption of heat
(c) Emission of heat
(d) Decrease in temperature

RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (b) The change of state of ice into water is due to the absorption of heat because when ice (solid state) is converted into water (liquid state), heat is absorbed by ice and the crystalline nature of ice broken and it is available to us as water.

47. When the temperature of a certain quantity of water is increased from 0°C to 4°C, its volume ----------

(a) Decreases
(b) Increases

(c) First increases and then decreases
(d) Remains the same

RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (a) When the temperature of a certain amount of water increases from 0°C to 4°C its volume decreases and density increases. This is called abnormal expansion of water. If water is cooled from its boiling point 100°C, then from 100°C to 4°C the volume of water decrease like other liquids, but from 4°C to °C the volume of water increases, that is the volume of liquids increases according to their freezing point whereas the volume of water is minimum at a temperature slightly higher than its freezing point.

48. A styrofoam sheet 5 cm thick and 0.25 m in area has a temperature difference of 40°C between its inner and outer saerfaces. What is the rate of heat flow on the sheet ? (Thermal Conductivity is 0.01 J(smk))

(a) 2.0J/s (b) 1.0J/s
(c) 4.0J/s (d) 3.0J/s

RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (a) Thickness of Styrofoam sheet (a) = 5cm
And its area (A) = $0.25m^2$
Temperature $\Delta T = 40^oC$
Thermal conductivity k = 0.01 J/smk
The rate of heat flow through the sheet can be calculated as-

$$\frac{Q}{t} = \frac{kA\Delta T}{a}$$

$$\frac{Q}{t} = \frac{0.01 \times 0.25 \times 40}{0.05}$$

$$\frac{Q}{t} = 2.0 \text{ J/sec}$$

Hence, the rate of heat flow is 2.0 J/sec.

49. When to bodies are in thermal contact, heat will flow between them when their ———— are different.

(a) Specific heath (b) Mass
(c) Temperature (d) Density

RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (c) When two bodies comes in thermal contact, heat will flow between then when their temperature are different i.e. heat can not flow from an object of lower temperature to an object of Higher temperature unless an external source is used for energy. This is according to the second law of thermodynamics.

50. The boiling and freezing points of water are exactly——degree apart on the fahrenheit seale.

(a) 90 (b) 270
(c) 180 (d) 360

RRB ALP & Tech. 22.01.2019 Shift-III

Ans : (c) The boiling point of water in Celsius is always 100°C. But in Fahrenheit it is 212 F° and the Freezing point is 32F°. that is, in English units, the boiling point of water (212F°) and the freezing point (32F°) will be exactly 180° apart.

51. Specific heat capacity of lead is 125 $Jkg^{-1}K^{-1}$. If the temperature of a block of 250 g of lead rises by 10ºC on absorbing 5 kJ of heat, then find its heat capacity.

(a) 250 $Jkg^{-1}K^{-1}$ (b) 325 $Jkg^{-1}K^{-1}$

(c) 500 JK^{-1} (d) 200 JK^{-1}

RRB ALP & Tech. 21.01.2019 Shift-II

Ans : (c) : Given,
Absorbed heat (Q) = 5 KJ

$Q = 5 \times 1000$ J. [$\because$ 1 KJ = 1000J].

Q = 5000 J

Specific heat capacity (c) = 125 J kg^{-1}, K^{-1}
mass (m) = 250 gm = 0.25 kg
Rise in temperature (ΔT) = 10^0C
The amount of heat required to raises the temperature of a substance by 1°C. Such quantity of heat is called its heat capacity.

$$\boxed{\text{Heat capacity} = \frac{\text{Amount heat absorbed}}{\text{Raise in temperature}}}$$

$$= \frac{5000}{10} = 500\ JK^{-1}$$

$\therefore$ $\boxed{\text{Heat capacity} = 500\ J\ K^{-1}}$

52. If 2.5 *l* of hot water at 85ºC is mixed with 4.5 1 of cold water then the temperature of the cold water rises by 15ºC when equilibrium is reached. Find the initial temperature (in ºC) of the water assuming no heat is lost.

(a) 48 (b) 43
(c) 15 (d) 25

RRB ALP & Tech. 21.01.2019 Shift-II

Ans : (b) : mass of Hot water (m) = 2.5 litre
Temperature (T_1) = 85^0C
mass of cold water (m_2) = 4.5 litre
change in temperature of cold water ($T_1 - T_2$) = 15^0C
Final temperature = T^0C
The specific heat capacity is 'C'

Formula $\boxed{Q = mC\Delta T}$

$m_1c_1 (T_1 - T) = m_2c_2 (T_1 - T_2)$

$\boxed{C_1 = C_2 = C}$

$2.5 (85 - T) = 4.5 (T_1 - T_2)$
$2.5 (85 - T) = 4.5 \times 15$
$212.5 - 2.5T = 67.5$
$2.5\ T = 145$

$\boxed{T = 58^0C}$

Hence final temperature of cold water (T) = 58^0C
Change in temperature (T_2) = 15^0C
Thus, the initial temperature of cold water is
= 58^0C – 15^0C
= 43°C

53. By how many degrees Celsius should an 800 g calorimeter made of aluminium be heated so that it absorbs 43.2 kJ of heat? Specific heat capacity of aluminium is 0.9 $Jkg^{-1}K^{-1}$.

(a) 120 (b) 60
(c) 67.5 (d) 42.5

RRB ALP & Tech. 21.01.2019 Shift-II

Ans : (b) : ΔQ = 43.2 KJ
m = 800 gm = 0.8 kg
C = 0.9 $Jkg^{-1}K^{-1}$
ΔT = ?
From $\Delta Q = m.c.\ \Delta T$,

$$\Delta T = \frac{\Delta Q}{m.c.}$$

$$\Delta T = \frac{43.2}{0.8 \times 0.9}$$

$$\Delta T = \frac{43.2}{0.72} = 60°C$$

54. Watt/steradian is the unit of _____.

(a) electric conductance (b) permittivity
(c) radiant intensity (d) permeability

RRB ALP & Tech. 21.01.2019 Shift-II

Ans : (c) : Radiant intensity- The radiant energy that is emitted by a source per unit time per unit solid angle. Watt/ steradian is the unit of 'radiant intensity.

Electrical conductivity:- Ability of materials to conduct electric current. The measurement is called ' Electrical conductivity' it is denoted by 'σ'.

Permeability :- permeability in the content of electromagnetism is the ability of magnetic lines of force to pass through a medium is called the magnetic permeability of the medium. It is denoted by 'μ'. The SI units of permeability is Henry/meter.

Permittivity:- Electrical permittivity is the content of electricity. It is the property of a substance which helps in general applying an electric field in that substance. But it tells the measure of 'resistance' displayed by that material.

55. Woolen clothes keep the body warm in winter because–

(a) Wool is a bad conductor of heat
(b) Wool is a good conductor of heat
(c) Wool increases body temperature
(d) Wool decreases body temperature

RRB SSE Bilaspur (green) , 21.12.2014

Ans. (a) : Woolen clothes protect the body in winter and keeps warm due to the following reasons.

(i) wool is a bad conductor of heat. Hence the heat is of body does not escape.
(ii) the pores of wool do not allow air to enter. These holes acts as a barrier for air.

56. Which has higher temperature between boiling water or and water vapor?

(a) Boiling of water
(b) Vapour of water
(c) None of these
(d) Depends on heat supply

RRB Asst. Loco Pilot (Patna)-2001

Ans. (c) : Temperature of boiling water and water vapor the temperature is constant (100°C) and heat is given to boiling water is spent in its state change (water to vapour) this heat does not change the temperature. That's why it is called latent heat.

57. Black buffaloes remain lying in ponds in summer the reason for this is -

(a) It is their habit
(b) They feel hot
(c) Their color absorb more heat
(d) They feel more thirsty

Ans. (c) : Since black color absorbs more heat and reflects less. Hence buffaloes feel very hot and they like to sit in the pond.

58. Explain how thin blankets causes less cold than a single thick blanket because -

(a) Thickness increase
(b) Air comes between them
(c) The body gets double the heat
(d) None of these

Ans. (b) : Two thin woolen blankets are warmer than a thick wollen blanket because there is an extra layer of air trapped between thin blankets which act as an insulator and does not allow the body heat to flow out.

59. A bucket of Luke warm water will melt more ice than a cup of boiling water because

(a) The volume of bucket is more
(b) There is more water in the bucket
(c) There is more heat in water in the bucket
(d) The temperature of the water in the bucket is flowing

RRB Asst. Loco Pilot (Mumbai/Bhopal)-2003

Ans. (c) : One bucket of luke warm water will melt more ice than a cup of boiling water because there is more heat in it.

60. It is not cold on the mountains at the time of snowfall but more after. It has a reason.

(a) Ice keeps cooling the air
(b) The temperature of ice starts falling later
(c) cools the surrounding object to melt ice
(d) Jakes heat from the atmosphere to melt ice

RRB Bhopal (Technical), 21.11.1999

Ans. (d) : It is not cold on the mountains at the time of snow fall but it is more cold later because the snow absorbs heat from the atmosphere to melt, due to which the temperature of the atmosphere decreases slightly and we feel cold.

61. The value of mechanical equivalent of heat is.

(a) 4.2×10^7ergs/cal (b) 4.2 ergs/ cal
(c) 4.2×10^7 Joule/cal (d) 4.2×10^7 joule/kcal

Ans. (a) According to Joule law- work is directly proportional to heat.

$W \propto H$
$W = JH$
Where J is Joules constant.
Which is called mechanical equivalent of heat.
Hence J = 4.2 Joule/calori
or $J = 4.2 \times 10^7$ erg/calori

62. The value of specific heat depends on:-

(a) On the nature of matter
(b) On the amount of external work done due to expansion of the substance due to increase in temperature
(c) Both (a) and (b)
(d) Neither (a) and (b)

Ans. (a) : Specific heat is characteristic property of a substance which depends on the nature of the substance.

63. Which will have the highest specific heat?

(a) Water (b) Copper
(c) Mercury (d) None of these

Ans. (a) : The specific heat of metals is less than that of liquid and the specific heat of liquid is more than of gasses.

Specific heat of water = 1 Calori/ gram°C
Specific heat of mercury = 0.3 calori / gram°C
Specific head of Copper = 0.1 Calori/gram°C

64. The unit of linear expansion coefficient is-

(a) ^0C (b) $m–^0C^{-1}$

(c) $^0C^{-1}$ (d) $m–^0C$

RRB Bhopal (Secunderabad) 2001

Ans:(c)

Linear expansion coefficient $(\alpha) = \left(\frac{\Delta L}{L \times \Delta T}\right)$

Unit of $\alpha = \left(\frac{\text{increase in length}}{\text{per unit length} \times \text{temperature}}\right)$

Unit of $\alpha = {}^0C^{-1}$

65. There is different of 25°C is the temperature of two object, this difference will be on the Fahrenheit scale

(a) 26^0F (b) 45^0F

(c) 52^0F (d) 54^0F

RRB Asst. Loco Pilot (Ranchi)-2005

Ans. (b) : $\frac{\Delta C}{5} = \frac{\Delta F}{9}$

$\therefore \quad \Delta F = \left(\frac{\Delta C}{5}\right) \times 9 = \frac{25}{5} \times 9 = 45^0 F$

66. Absolute zero temperature is-

(a) 0^0F (b) $–212^0F$

(c) $–459.40^0F$ (d) None of these

RRB Asst. Loco Pilot (Ranchi)-2005

Ans. (c) : $\frac{K-273}{5} = \frac{F-32}{9}$,

For absolute zero temperature is - $(K = 0)$

$$\frac{0-273}{5} = \frac{F-32}{9}$$

$$F = \frac{2297}{5} = -459.4^0 F$$

67. The maximum temperature at which human life cannot be possible is

(a) Less than 110°C

(b) Less than 110°K

(c) Less than 110°F

(d) At 110°F

RRB Asst. Loco Pilot (Patna)-2007

Ans. (c) : The normal body temperature of a healthy human being is 98°F (37°C). If human body temperature exceeds 110°F, human life is not possible.

68. The lowest mark in the thermometer is marked at 95°F. This mean-

(a) Can not measure temperature below this

(b) Man can not live below this temperature

(c) To make the calorimeter smaller

(d) Mercury can not fall below this mark

RRB Asst. Loco Pilot (Muzaffarpur)-2009

Ans. (b) : The lowest mark in the thermometer is marked at 95°F i.e. below this temperature man can not live.

69. Specific heat capacity of copper is 0.1 cal/gm. Its value in J/kg^{0}C is :

(a) 0.84×10^3 J/kg^{0}C (b) 0.42×10^3 J/kg^{0}C

(c) 0.24×10^3 J/kg^{0}C (d) 4.2×10^3 J/kg^{0}C

RRB Asst. Loco Pilot (Patna)-2001

Ans.: (b) Specific heat of copper = 0.10 calori/ gram

Specific heat of copper = (Joule/kg – °C)

$= 0.10 \times 4.2\times10^3$

= Joule/kg – °C

$= 0.42 \times 10^3$ Joule/kg –°C

70. Heat is supplied to 50 grams of a solid at the rate of 5 calori/second and the temperature rises by 11°C per minute. The specific of solid substance is calori/ gram°C.

(a) 0.545 (b) 0.90

(c) 0.45 (d) None of these

RRB Kolkata Supervisor (P.Way), 20.02.2000

Ans. (a) :

According to Question $Q = H.t = ms\Delta T$

$\Rightarrow$ $5 \times (60 \times 1) = 50\times s\times 11$

$300 = 550 \times s$

$s = \frac{300}{550}$

s = 0.545 Calori/gram^{0}C

71. The mass of a metal is 500 grams and its specific heat is 0.5 calori/g°C. Its capacity is.

(a) 250 Calori/°C (b) 2500 Calori/°C

(c) 0.25 Calori/°C (d) 25 Calori/°C

RRB Bangalore (Tech.), 22.08.1999

Ans. (a) :

Heat capacity of metal C = mass×specific heat.

$C = 500 \times 0.5$

C = 250 Calori/^{0}C

72. The mass of the copper calorimeter is 50 grams and the specific heat of copper is 0.1 calori/gram°C the water equivalent of the calorimeter will be

(a) 5 Calori (b) 5 gram/°C

(c) 50 Calori (d) 50 gram

RRB Kolkata (Tech.), 29.08.1999

Ans. (b) : The water equivalent = $m \times 5$

$= 50\times0.1 = 5$ gram/^{0}C

73. The heat capacities of two objects made of the same metal are in the ratio 3:4. the ratio of their masse will be

(a) 3 : 4 (b) 3 : 7

(c) 4 : 3 (d) 4 : 7

RRB Kolkata Supervisor (P. Way), 20.02.2000

Ans. (a) : Heat capacity, $C = ms$

Then $\frac{C_1}{C_2} = \frac{m_1 s_1}{m_2 s_2}$

For material made of same metal $s_1 = s_2$

$\boxed{\frac{3}{4} = \frac{m_1}{m_2}}$