MECHANICS

DEFINITIONS AND LAWS

What is Mechanics ?

The branch of Physics dealing with the study of motion of object is called mechanics. It is the oldest and the most basic branch of Physics.

Statics :- The branch of Physics which deals with the study of object at rest is called statics.

Rests :- Rest is the no change of position of an object in the course of time or applying force.

Motion :- Motion is the change of position of an object in the course of time *e.g.* study of physical system with some property changing with time.

(i) ***One - dimensional motion :-*** A motion is said to be one-dimensional if only one of the three position co-ordinates (x, y, z) changes with time *e.g.,* if a body moves along a straight line e.g. bus moving on a road.

(ii) ***Two -dimensional motion :-*** A motion is said to be two-dimensional motion if only two of the three position co-ordinates changes with time *e.g.,* planet revolving around the sun.

(iii) ***Three-dimensional motion :-*** A body is said to possess three-dimensional motion if all of its three position co-ordinates change with time.

Physical quantities :- These are those quantities in which all physical law can be expressed and which can be measured directly and indirectly. Physical law *i.e.* velocity, acceleration, force, momentum, etc.

Vector quantity :- These are those quantities which have magnitude as well as direction. *e.g., velocity*, acceleration, displacement , force, momentum, electric field strength etc.

Scalar quantity :- These are those quantities which have magnitude but no direction. *e.g.,* energy, work, time, distance, angle, volume, density etc.

The magnitude of a vector is a scalar quantity.

$|\vec{A}| = A$ when $\vec{A}$ = Vector of A

A = Scalar quantity.

Speed :- It is the distance covered by a moving body in unit time along any direction while average speed of a body is given by the total distance covered by the body divided by the total time taken. or

$$\text{Average Speed} = \frac{\text{Distance Travelled}}{\text{Time taken}} = \frac{S}{t}$$

Displacement : Change of position = Final position – Initial position.

Velocity :- Rate of change of displacement with time

$$\text{Velocity } (v) = \frac{\text{Displacement}}{\text{Time}}$$

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Acceleration - The rate of change of velocity with respect to time is called acceleration. It is denoted by *a*.

$$\text{Acceleration } (a) = \frac{\text{Velocity}}{\text{Time}}$$

Retardation :- negative rate of change of velocity. It is negative acceleration.

Relation between Velocity, acceleration and time:

$v = u + at$ (Equation of newton)

Relation between Velocity, acceleration and distance :

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

Relation between distance, Velocity , acceleration and time:

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

Distance covered by the body for n th Sec

$$Sn^{th} = u + \frac{g}{2}[2n - 1]$$

Relative velocity :- The velocity of a body A with respect to velocity of the body (B) is known as relative velocity.

NEWTON'S LAWS OF MOTION

Newton's laws of motion.- ***(a) First Law.*** A body continues to be in its state of rest or of uniform motion in a straight line unless compelled by an external force to change that state. This law is also called law of inertia.

Force = Mass × acceleration. *i.e.,* F = m.a

(b) Second Law. The rate of change of momentum is directly proportional to their impressed force and takes place in the direction of the force. Or F = m . a

(c) Third Law. According to this law for every action, there is equal and opposite Reaction or action = – Reaction.

Momentum:- Total motion possessed by the body is called momentum. It is equal to the product of mass and velocity.

Momentum (P) = mass × velocity *i.e.,* **P = *mv***

Law of Conservation of momentum : It states that, " The total linear momentum of a system of interacting bodies on which no external unbalanced forces are acting remains constant.

∴ Linear momentum remains constant if no external force is applied.

Impulse :- The total effect of a force is known as Impulse. It is also measured by change in momentum and it depends on force and time.

Impulse = force × time = change in momentum

Distinction between mass and weight

	Mass	***Weight***
1.	The mass of a body is the quantity of matter possessed by it.	1. Weight of a given mass of body is that force which attracted towards the centre of earth.
2.	Mass is scalar quantity.	2. It is a vector quantity.
3.	S.I. unit of mass is kg.	3. S.I. unit of weight is newton.
4.	Mass remains constant everywhere	4. Weight changes from place to place.

Relation between newton and dyne :-

$1N = 1Kg \times 1\ m\ s^{-2}$

$= 1000\ g \times 100\ cm\ s^{-2}$

$= 10^5\ g\ cm\ s^{-2}$

$= 10^5$ dyne ($\because$ 1 dyne = 1 gm cms^{-2})

Friction :- It may be defined as the resistance offered to the motion of the object.

Kinds of Friction

1. Static Friction : Friction produced due to rest position of the body.

2. Dynamic friction : Friction produced due to motion of the body.

Laws of friction : *(i)* Magnitude of limiting friction is directly proportional to the normal reaction.

$F \propto R$ or $F = \mu R$

Where μ is the coefficient of limiting friction.

$$\text{Coefficient of limiting friction } (\mu) = \frac{F}{R}$$

(ii) The direction of frictional force is always opposite to the direction in which motion takes place or tends to take place.

Limiting Friction :- It is that force of friction when a body just begun to slides over the surface of the another body.

Law of Limiting Friction

1. The direction of force of friction (limiting friction) is always opposite to the direction of motion of the body takes place.
2. Force of friction is directly proportional to the normal reaction (R)

$F \propto R$

$F = \mu R$

$\mu = F / R$

Where

F = Force of limiting friction

R = Normal reaction

μ = Coefficient of limiting friction.

Hence coeff. of limiting friction may be defined as force of friction per unit normal reaction.

Rolling Friction : It is that force of friction between two surface of the body when surface of the one body rolls over the surface of the another body is known as rolling friction.

Laws of rolling friction :

1. The direction of force of friction is always opposite to the direction of

motion of the body takes place.

2. Force of friction is directly proportional to normal reaction (R) and inversely proportional to radius of the wheel

$$\text{or } f \propto \frac{R}{r}$$

where R = Normal reaction, r = radius of wheel

$$f = \frac{\mu_r R}{r}$$

μ_r = Coefficient of Rolling friction

Work :- Work is said to be done when point of application of force moves in a direction of applied force.

Work done = force × displacement or $W = \vec{F} \times \vec{S}$

Power :- The rate of doing work is called Power.

$$\text{Power} = \frac{\text{Work done}}{\text{Time}} = \frac{W}{T}, \qquad P = \frac{\text{Force} \times \text{Displacement}}{\text{Time}}$$

or P = force × velocity

Energy:- Capacity of doing work is called energy. Energy = work done stored

Types of Energy : (i) K.E. (Kinetic Energy) (ii) P.E. (Potential energy)

Kinetic Energy :- It may be defined as the energy possessed by the body due to its motion known as Kinetic Energy (K.E.) $K.E = \frac{1}{2}mv^2$

(ii) ***P.E:*** It may be defined as the energy possessed by body due to its position is called Potential Energy. P.E = mgh

e.g., Reservoir of large quantity of water in Bhakra Bandh.

Gravitation :- Gravitation is Universal property.

Gravity :- Every body experiences a force of attraction towards the earth which is called gravity.

Acceleration Due to Gravity :- All objects irrespective of their masses fall towards earth due to a acceleration which is called acceleration due to gravity . It is denoted by $g(g = 9.8\ m/sec^2)$

Inertial mass : Inertial mass of a body is the measure of its inertial property in translatory motion and is defined as the ratio of external applied on it to the magnitude of acceleration produced in it.

$$\text{Inertial mass} = \frac{\text{applied force}}{\text{magnitude of acceleration}}$$

Gravitational mass : It is the mass of body which determines the gravitational pull acting upon it.

Newton's Law of Gravitation: Every particle as matter in the universe attracts every other particle with a forcewhich is directly proportional to the product of their masses and inversely proportional to the square of distance between them.

Let us consider two bodies of mass m_1 and m_2. They are separated by a distance (r) then Gravitational force exists between them.

$$i.e., \quad F \propto \frac{m_1 m_2}{r^2}$$

$$\Rightarrow \quad F = \frac{G m_1 m_2}{r^2}$$

Where G is the Gravitational constant throughout the universe.

Relation between linear motion and angular motion

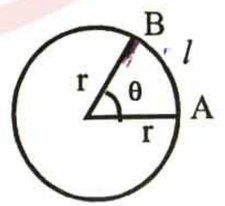
1. Distance = S (m)	1. Angle (ϑ) radian
2. Linear displacement = ds (m)	2. Angular displacement = ($d\vartheta$) radian
3. Speed = $\frac{S}{t}$ (m/Sec)	3. Angular speed = $\frac{\theta}{t}$ (rad / Sec)
4. Linear Velocity (V) = $\frac{ds}{dt}$ (m/Sec)	4. Angular velocity (ω) = $\frac{d\vartheta}{dt}$ (rad /Sec)
5. Mass = (m) kg	5. M.O.I (Moment of inertia) $I = \text{mass} \times (\text{distance})^2\ (kg.m^2)$
6. Liner acceleration (a) = $\frac{dv}{dt}$ (m/Sec^2)	6. Angular acceleration (α) $\alpha = \frac{d\omega}{dt} = (rad/Sec^2)$
7. Linear momentum (P) P= mv (Kg m / Sec)	7. Angular momentum (L) L= I.ω ($Kg.m^2/sec$)
8. Force = mass × acceleration = m.a (newton)	8. Torque = M.O.I × α $\tau = I\alpha$ = Force × distance
9. Impulse = Force × time = f × t (N Sec)	9. Angular impulse = Torque × time Nm × Sec = (Joule Sec)
10. Work done (ω) = f × ds, (Joule)	10. Work done = τ dθ
11. P = $\frac{\text{work done}}{\text{time}} = \frac{f \cdot ds}{dt} = f.v$ or Force × linear velocity watt	11. Power = $\frac{\text{work done}}{\text{time}} = \frac{d\theta}{dt}\tau$ watt

1. **Relation between linear velocity and angular velocity**

$$V = r\omega$$

$$\therefore \text{ Angle } (\theta) = \frac{l}{r} \text{ or } l = r\theta$$

Arc (AB) = l



Linear velocity (V) = $\frac{l}{t}$

Angular velocity (ω) = θ/t

$$V = \frac{l}{t} = \frac{r\theta}{t} = r\omega \qquad \text{or } V = r\omega$$

2. **Relation between Angular momentum (L) and M. O. I**

$$L = I\omega$$

We know that

L = Momentum × distance

$= mV \times r$

$= mr\omega \times r$ $[\because V = r\omega]$

$= mr^2\omega$ $[\because M.O.I = mr^2]$

$L = I\omega$ $[\because I = mr^2]$

3. **Relation between linear acc. and angular acc.**

$a = r\alpha$

4. **Relation between Torque and angular acc.**

$\tau = I\alpha$

We know that τ = force × distance

$= F \times r$

$= ma \times r$ $[\because F = ma]$

$= mr.\alpha \times r$ $[\because a = r\alpha\ ]$

$= mr^2.\alpha$ $[\because M.O.I = mr^2]$

$\tau = I\alpha$ $[\because I = mr^2]$

5. **Relation between Torque and angular momentum (L)**

$$\tau = \frac{dL}{dt}$$

We know that $L = P \times r$

Differentiating both sides w.r.t (t)

$$\frac{dL}{dt} = \frac{d}{dt}(\vec{P} \times \vec{r})$$

$$= P \times \frac{dr}{dt} + r \times \frac{d\vec{p}}{d\vec{t}} \qquad [\because rF = \tau] \ \& \ [\because V = \frac{dr}{dt}]$$

$[\because P = mV]$

$$= mV \times V + r \times F \qquad \left[\because F = \frac{dP}{dt}\right]$$

$$\frac{dL}{dt} = O + r \times F \qquad [\because \vec{V} \times \vec{V} = 0]$$

$$\frac{dL}{dt} = \tau$$

6. **Relation between K. E and M.O. I**

$K.E = \frac{1}{2} mV^2$ $[\because V = r\omega]$

$= \frac{1}{2} m \times r^2\omega^2$ $[\because I = mr^2]$

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

ROTATIONAL MOTION

Rotational motion :- A motion is said to be rotational motion when a body rotates in a circular path.

1. Three equation of rotational motion corresponding to three equation of linear motion are

(i) $\omega_2 = \omega_1 + \alpha t$ (ii) $\theta = \omega_1 t + \frac{1}{2} \alpha t^2$

(iii) $\omega_2^2 - \omega_1^2 = 2\alpha\theta$ Where the symbol have their usual meaning

2. M. O. I (Moment Of Inertia)

$I = MR^2$

3. Moment of inertia of a solid cylinder about its long axis of symmetry

$$I = \frac{MR^2}{2}$$

4. Moment of inertia of a hollow cylinder about its long axis of symmetry

$I = MR^2$

5. Moment of inertia of a solid sphere about its diameter

$$I = \frac{2}{5} MR^2$$

6. Moment of inertia of a hollow sphere or thin spherical shell about its diameter

$$I = \frac{2}{3} MR^2$$

7. Kinetic energy of rotation

$$E = \frac{1}{2} I\omega^2$$

8. Acceleration of a cylinder down a smooth inclined plane is

$$a = \frac{g \sin\theta}{(1 + I / MR^2)}$$

9. Condition for rolling of cylinder without slipping is that coefficient of static friction must be

$$\mu_s \geq \frac{1}{3} \tan\theta$$

10. Acceleration of a mass tied to a string wound over a cylinder and mounted on a horizontal axis in

$$a = \frac{mg}{(m + I / R^2)}$$

Tension in the string is given by

$$T = \frac{Im\,g}{(mR^2 + I)}$$

11. The external force (centerpetal force) required to move a body of mass (m) with a uniform speed (v) in a circle of radius (r) is

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

12. The minimum velocity of projection at the lowest point of a vertical circle so that the string does not slacken at the highest point is

$$V_2 = \sqrt{5gr}$$

Similarly velocity at highest point

$$V_H = \sqrt{gr}$$

Torque : Turning effect of a force about the axis of rotation is called torque.

Torque (Tau) $\tau = r \perp \times F$

where $r \perp$ is normal distance from axis of rotation and F is magnitude of the force.

Angular momentum : Turning moment of a particle about the axis of rotation. It is measured by the product of linear momentum *d* and normal. (perpendicular distance) from the axis of rotation.

Angular momentum $(l) = r \perp \times P$

Angular velocity : It is velocity which substends an angle in a circular path.

$$\text{Angular velocity } (\omega) = \frac{\text{Angle}}{\text{Time}}$$

Angular acceleration : Rate of change of angular velocity is called angular acceleration.

$$\text{Angular acceleration } (\alpha) = \frac{d\omega}{dt}$$

Moment of Inertia : It is equal to the sum of product of mass and square of perpendicular distance from the axis of rotation for the particle of a body.

M.O.I. of body $= \sum mr^2$

Concurrent forces : If two or more forces are acting in such away that their line of action intersects on the same point than they are called concurrent forces.

Equilibrium of Concurrent forces : When two or more forces are acting on the same point and the resultant force is zero than it is said to be equilibrium of concurrent forces.

Parallelogram law of vector addition : If two vectors acting simultaneously at a point, can be represented both in magnitude and direction by the adjacent sides of a parallelogram drawn from a point, then the resultant is represented completely both in magnitude and direction by the diogonal of the parallelogram passing through that point.

Parallelogram law of forces : Definition is same as above but we use force in place of vector.

Machine : It is a device, which enables us to multiply force or gain in speed or change the direction of applied force.

Centripetal force. :- It is a force which maintains a body into its uniform circular motion. Thus it changes the direction of motion of a body and the speed remains unchanged.

Centrifugal force. :- It is the friction force arising out of inertial reaction.

Satellites : A satellite is a body which constantly revolves at its own in an orbit around a comparatively much larger body *e.g.,* Moon is the satellite of Earth, Earth is the satellite of Sun.

Types of Satellites : (1) Natural Satellites (2) Artificial Satellites.

1. Natural Satellite:- Satellite which occurs in nature. Is known as natural Satellite e.g. Moon is the natural Satellite of earth.

2. Artificial Satellite:- A man made Satellite is known as artificial Satellite. e.g. Arya Bhatt, Insat-A, Insat-B.

Orbital velocity : Orbital velocity may be defined as the velocity required by the satellite, so that if may start revolving around the planet satellite into its orbit.

$$\text{Orbital velocity } (V_{orb}) = \sqrt{\frac{gR^2}{r}} = R\sqrt{\frac{g}{r}} = R\sqrt{\frac{g}{R+h}}$$

Where R = Radius of Earth, r = radius of the circular orbit of Satellite
h = height of Satellite.

Escape Velocity : The minimum velocity with which a body is to be projected so that it escapes the gravitational field of the earth or any planet is known as its escape velocity. Escape velocity for earth is 11.2 km/sec. and for moon is 2.4 km/s.

KEPLER'S LAW

Ist law : Every planet revolves in a elliptical path around the sun with at one of the foci.

II Law : The areal velocity of the planet is constant.

III Law : The square of time period of a planet around sun is proportional to the cube of semi-major axis.

$T^2 \propto R^3$

or $$\frac{T_1^2}{T_2^2} = \frac{R_1^3}{R_2^3}$$

where T_1 & T_2 are time period of two planets respectively and R_1 and R_2 are their respective semi-major axis or Radius.

Relation between g and G :- The acceleration due to gravity (g) and universal constant (G) is related as

$$g = \frac{GM}{R^2}$$

where M is the mass of the earth and R is radius of the earth.

Variation of g due to

(i) Altitude : Acceleration due to gravity decreases with increase in altitude (height)

$$g_h = g\left[1-\frac{2h}{R}\right]$$

(ii) Depth : Acceleration due to gravity g at a depth is

$$g_d = g\left[1-\frac{d}{R}\right]$$

Centre of the earth (g) is = 0

Bernoulli's theorem :- It states that when a non-viscous and in compressible fluid flowing steadily, the sum of pressure head, velocity head and potential head remains constant.

$$\text{Pressure head} = \frac{PV}{m} = \frac{P}{\rho} \qquad \rho = \frac{m}{V}$$

$$\text{Kinetic head (Velocity head)} = \frac{\text{K.E.}}{\text{weight of body}} = \frac{1}{2}\frac{mV^2}{mg} = \frac{1}{2}\frac{V^2}{g}$$

$$\text{Potential head} = \frac{\text{P.E.}}{mg} = \frac{mgh}{mg} = h$$

$$\frac{P}{\rho} + \frac{1}{2}\frac{V^2}{g} + h = \text{Constant}$$

$$\frac{P}{\rho}_1 + \frac{1}{2}\frac{V_1^2}{g} + h_1 = \frac{P}{\rho}_2 + \frac{1}{2}\frac{V_2^2}{g} + h_2$$

Elasticity :- It is the property of the body to regain its original shape and size, when the external deforming forces acting on it are removed.

Plasticity :- It is the property of the body not to regain its shape and size after removing external deforming forces acting on it.

Strain:- It is the ratio of change in configuration to the original configuration.

Kinds of strain (i) Longitudinal strain (ii) Volumetric strain
(iii) Shearing strain

Stress :- It may be defined as the restoring force per unit area

$$\text{Stress} = \frac{F}{A}$$

Hook's Law :- According to this law within elastic limit stress is directly proportional to strain

i.e. stress $\propto$ strain

$$\frac{\text{stress}}{\text{strain}} = \text{constant} = E$$

$$\Rightarrow \quad E = \frac{\text{stress}}{\text{strain}} \text{ ; where E is the modulus of elasticity}$$

Young modulus : Within elastic limit, the ratio of longitudnal stress to longitudinal strain.

Bulk modulus : Within elastic limit, the ratio of normal stress to volumetric strain.

Shear modulus : It is the ratio of shearing stress to shearing strain.

Fluids :- Liquid and gases are different from solid. These begin to flow under the effect of external force. So both of these collectively termed as fluid.

Thrust :- Total force exerted by a fluid on any surface in contact with it is known as thrust.

Pressure :- The thrust exerted by a fluid per unit area of the surface in contact with it is known as pressure.

$$\text{Pressure} = \frac{\text{thrust}}{\text{area}}$$

Surface tension : The property of a liquid by virtue of which free surface behaves like an elastic membrane under tension tending to contract so as to have minimum surface is known as surface tension.

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

Surface energy : The P.E. (potential energy of the surface film of a liquid is called its surface energy)

Atmospheric pressure : The earth is surrounded by a gaseous envelope known as atmosphere. The pressure exerted by the atmosphere on the surface of earth is called atmospheric pressure.

Pascal's law : It states that, "The pressure exerted at any point on an enclosed liquid is transmitted equally in all directions."

Archimedes' principle : This principle may be stated as , "If a body is wholly or partially immersed in a fluid it experiences an upward thrust (loss in weight) equal to weight of the fluid displaced by it and this upthrust acts through the centre of gravity of the displaced fluid."

Cause of upthrust (Buoyancy) : According to Buoyancy, value of the upthrust is equal to the weight of the fluid displaced by the immersed body. The point through which the upward thrust acts known as the centre of buoyancy.

LAWS OF FLOATING BODIES

Floating bodies : Whenever a body is immersed in a fluid, it is subjected to

two forces namely.

The weight (W) of the body acting vertically downwards through its centre of gravity and upward thrust (W) equal to the weight of the fluid displaced acting vertically upward through the centre of buoyancy. It has three possibilities:

(*i*) W > W' *i.e.,* actual weight of the given body is greater than the weight of the fluid displaced, then the net force acting on the body is W – W' in the downward direction. The body sinks to the bottom.

(*ii*) If W = W' the body will remain in equilibrium any where inside the given fluid. The body will just float.

(iii) If W < W', a net force acts upward. The body continues to move up till the weights become equal then it will float in the liquid.

General formula for the floating bodies :-

$$\frac{\text{Volume of Immersed part}}{\text{Total volume of the body}} = \frac{\text{Density of the given body}}{\text{Density of fluid}}$$

Condition for floating : (*i*) Weight of the floating body must be equal to the weight of fluid displaced (ii) The centre of gravity of the body and centre of buoyancy must lie along the same vertical line.

Viscosity : It is the property by virtue of which a fluid opposes the relative motion between its various layers is termed as viscosity or internal liquid friction.

Coefficient of viscosity : It may be defined as the tangential force required per unit surface area in order to maintain a unit velocity gradient between two adjacent liquid layers.

Stream line and Turbulent flow : The flow of fluid through a pipe is said to be stream line if the particles of the fluid move along fixed path known as stream lines and the velocity of the particles remains same passing one after other through a given pipe.

When the velocity of the fluid is high, the flow becomes zig-zag and motion ceases to be orderly. This type of flow is known as turbulent flow.

Critical velocity : It is that velocity of a fluid upto which its flow is stream lined and above which its flow is turbulent.

Reynold number : Whether the flow of a fluid is stream line or turbulent depends on a number is known as Reynold number.

If $N_R > 3000 \rightarrow$ turbulent.

If $2000 < N_R < 3000 \rightarrow$ unstable

If $N_R < 2000 \rightarrow$ stream line

SOME IMPORTANT GAS LAWS

(1) Boyle's law : It states that the volume (V) of a given mass of a gas is inversely proportional to its pressure (P) provided temperature remain constant.

$$V \propto \frac{I}{P} \quad \text{or} \quad PV = \text{Constant}$$

(2) Charle's law : It states that volume of a given mass of a gas is directly proportional to temperature provided the pressure remains constant.

$$V \propto T \quad \text{or} \quad \frac{V}{T} = \text{constant}$$

(3) Gay Lussac's law : It states that pressure of a given mass of a gas is directly proportional to the absolute temperature provided the volume constant P $\propto$ T.

(4) Graham law of diffusion : It states that Rate of diffusion of a gas is inversely proportional to the Square root of its density.

(5) Avogadro's Law : It states that equal volume of all gases under similar conditions of temperature and pressure contain equal number of molecules.

(6) Standard gas equation :

$$PV = RT$$

for n mole standard gas equation.

$$PV = n\,RT$$

(7) Dalton's law of partial pressure : It states that the resultant pressure exerted by a mixture of non-interacting gases in any way is equal to the sum of their individual pressure.

Law of Conservation of energy : it states that energy can neither be created nor be destroyed, and it can be converted one form to another.

Efficiency : It is ratio of output energy to the input energy. it is denoted by η, efficiency $\eta = \frac{\text{Output}}{\text{Input}}$

Capillary : It is the phenomenon of rise or fall of liquid in a capillary tube. The required formula for ascent or descent of liquid in the capillary tube of radius r is given by

$$\sigma = \frac{r\rho g}{2\cos\theta}\left[h + \frac{r}{3}\right]$$

σ = Surface tension of liquid.

If the tube is very fine *i.e.,* $\frac{r}{3} << h$, then formula is modified to

$$\sigma = \frac{r\rho gh}{2\cos\theta} \quad \text{or} \quad h = \frac{2\sigma\cos\theta}{r\rho g}$$

Lever : Lever is a advantage of simple machine. Livers are divided in three different types depending of the fulcrum, the point of application of effort (weight) and force (power)

(i) First kind of lever has fulcrum in middle *i.e.,* see saw, scissors, crow bar

etc.

(ii) Second kind of lever has load (weight) in middle *i.e.,* a nut cracker, door, wheel barrow etc.

(iii) Third kind of lever has the power (force) in middle *i.e.,* Forceps, fire tongs, arm of man etc.

IMPORTANT POINTS

- The range of the projectile is maximum for the angle of projection $\theta = 45^\circ$.
- The height attained by a projectile is maximum, when $\theta = 90^\circ$. The maximum height possible for the projectile is given by

  $H_{max} = \frac{u^2}{2g}$
- All bodies fall freely with the same acceleration.
- The acceleration of the falling bodies does not depend on the mass of the body.
- If two bodies are dropped from the same height, they reach the ground in the same time and with the same velocity in vacuum.
- If a body is thrown upwards with velocity u from the top of a tower and another body is thrown downwards from the same point and with the same velocity, then both reach the ground with the equal velocity.
- If a body is dropped from a height h, it reaches the ground with speed $v = (2gh)^{1/2}$. The time taken by it to reach the ground is $t = (2h/g)^{1/2}$. The speed on reaching the ground is $v = gt$. (When we say that body is dropped ,we mean that the intial velocity of the body is zero.)
- If a body dropped from a height h reaches the ground with speed υ , then $h = v^2/2g$ and time taken to reach the ground is $t = v/g$.
- If a body is dropped from a certain height, then the distance covered in nth second is $\frac{1}{2}g(2n-1)$.
- If a body is thrown upwards with a velocity u, then its instantaneous velocity is given by

  $v = u - gt$ and its instantaneous height is given by $h = ut - \frac{1}{2}gt^2$. Also, in such a case its instantaneous speed at a height h is given by : $v^2 = u^2 - 2gh$
- Suppose a body is projected upwards from the ground and with the velocity u. It is assumed that the friction of the air is negligible. The characteristics of motion of such a body are as follows.

  (i) The maximum height attained = $H = \frac{u^2}{2g}$

  (ii) Time taken to go up (ascent) = Time taken to come down (descent) = $t = \frac{u}{g}$

  (iii) Time of flight $T = 2t = \frac{2u}{g}$

  (iv) The speed of the body on return to the ground = speed with which it was thrown upwards.
- When the particle moves along the circular path with constant speed, the angular velocity is also constant. But linear velocity, momentum as well as centripetal acceleration change in direction, although their magnitude remains unchanged.
- For circular motion with uniform speed, the angular speed is same for all particles, but linear speed varies directly as the radius of the circular path described by the particle ($v \propto r$)
- Centripetal force is always directed towards the centre of the circular path.
- When a body rotates with uniform velocity, its different particles have centripetal acceleration directly proportional to the radius ($a_C \propto 1/r$).
- There can be no circular motion without centripetal force.
- Centripetal force can be mechanical, electrical or magnetic force.
- Planets go round the earth in circular orbits due to the centripetal force provided by the gravitational pull of the sun.
- The centrifugal force appears to act on the agency which exerts the centripetal force.
- The centrifugal force cannot balance the centripetal force because they act on the different bodies.
- The torque is not essential for rotation. Torque causes variation in angular velocity.
- Rocket works on the principle of conservation of momentum.
- Rocket ejects gases backwards and as a result acquires a forward momentum.
- The apparent weight of a body is zero, when a lift fails and falls freely as it $\vec{a} = \vec{g}$. It is the case of weight lessness.
- If the lift falls with $a < g$, the apparent weight of the body decreases.
- If the lift accelerates upwards, the apparent weight of the body increases.
- If the lift rises or falls with constant speed, the apparent weight = true weight
- A system or a body is said to be in equilibrium, when the net force acting on it is zero.
- A body in equilibrium can moves with constant speed along a straight line path.
- A body in equilibrium cannot change the direction of motion.
- Friction depends on the nature of surfaces in contact.
- Friction is more when the surface in contact are rough.
- The rolling friction is less than the kinetic friction.
- The static friction always opposes the tendency of body to move on the other body.

(i) It is a variable force.
(ii) It is equal and opposite to the applied force.
(iii) It has a maximum value called limiting friction.
(iv) The limiting friction is directly proportional to the normal reaction.
That is $F \propto R$

- $1\ J = 10^7$ erg.
- The area under the force-displacement graph is equal to the work done.
- The area under the pressure-volume graph is equal to the work done.
- Power is also measured in horse power (hp). It is the *f ps* unit of power. 1 hp = 746 W.
- Body or the external agency dissipates power against friction.
- When a body moves along a circular path with constant speed, its kinetic energy remains constant.
- Kinetic energy is always positive.
- When work is done on a body, its kinetic or potential energy increases.
- When the work is done by the body, its potential or kinetic energy decreases.
- Mass and energy are inter-convertible. That is mass can be converted into energy and energy can be converted into mass.
- The total energy (including mass energy) of the universe remains constant.
- Kinetic energy can change into potential energy and vice versa.
- When a body falls, potential energy is converted into kinetic energy.
- Collision is the phenomenon in which two bodies exert mutual force on each other.
- Moment of inertia is defined with respect to the axis of rotation.
- Gravitation is central force. It acts along the line joining the particles.
- The acceleration due to gravity on the earth is $g = 9.81 ms^{-2}$ (mean value). Its value on the moon is about one sixth of that on the earth and that on the sun is about 27 times that on the earth.
- Among the planets, the g is minimum on the Mercury.
- The g decreases both when we go above the surface or below the surface of the earth. Its value is maximum on the surface of the earth.
- The value of g at the centre of the earth is zero.
- The g is maximum at the poles and is minimum at the equator. At poles $g_p = 9.83\ m/s^2$ and at the equator $g_e = 9.8\ m/s^2$.
- If the earth stops rotating about its own axis, the value of g on the poles will remain unchanged but that at the equator will increase by about 0.35%
- The gravitational pull of the earth is called true weight of the body. If M be the mass of a body and g be the acceleration due to gravity, the true weight of the body $W_t = Mg$.
- The unit of weight is newton. It is often expressed in kilogram weight (*kg wt*) or kilogram force (*kgf*).
$1\ kg\ wt = 1\ kgf \cong 9.8\ N$

- In a freely falling system, the time period of simple pendulum is infinity.
- Geostationary satellite is a satellite which appears stationary to the observers on the earth. It is also called geosynchronous satellite. It orbits in accordance with the following conditions.
(i) Its orbit is circular and in the equatorial plane of the earth.
(ii) Its period of revolution is equal to the period of rotation of the earth about its own axis, that is one day = 86400 s
(iii) The height of the geostationary satellite above the surface of the earth $h \cong$ 36000 km. Radius of orbit is 42400 km. And orbital velocity is about 3.08 kms^{-1}.
(iv) All communication satellites are geostationary satellites.
(v) Its angular velocity is equal and is in the same direction as that of earth about its own axis.
- Escape is the least velocity required by a body to escape away from the gravitational pull of the earth.
- Escape velocity from the surface of the earth = $\sqrt{2gR} = 11.20\ kms^{-1}$.
- Body does not return to the earth when fired with escape velocity, irrespective of the angle of projection.
- The escape velocity from the moon is $2.4\ kms^{-1}$.
- There is no atmosphere on the moon because escape velocity on the moon is less than the rms velocity of the gas molecules.
- Gravity holds the atmosphere around the earth.
- If a packet is just released from an artificial satellite, it does not fall to the earth,. On the other hand it will continue orbiting along with the satellite.
- If the radius of the earth is doubled keeping the density unchanged the escape velocity will be doubled.
- Planets revolve around the sun in elliptical orbits with the sun at the one of the focii.

MULTIPLE CHOICE QUESTIONS

Velocity and Acceleration

1. Which is a vector quantity in the following :
(a) time (b) momentum (c) volume (d) density
2. Which of the following is a scalar quantity:
(a) velocity (b) acceleration (c) force (d) distance
3. Which of the following is scalar quantity :
(a) electric potential (b) displacement
(c) magnetic intensity (d) force
4. Which of the following is vector quantity :
(a) power (b) density
(c) temperature (d) angular momentum

5. When an object undergoes acceleration :
(a) its velocity always changes (b) a force acts on it
(c) its momentum remains constant (d) its speed increases

6. Which of the following is a scaler quantity
(a) Electric current (b) Electric field
(c) Acceleration (d) Linear momentum

7. To accelerate a 2.0 kg mass by 4 m/s^2 we need a force of :
(a) 2 N (b) 4 N (c) 8 N (d) 16 N

8. All bodies large or small fall with the same :
(a) Velocity (b) acceleration (c) force (d) momentum

9. The relation between initial velocity u, final velocity v and acceleration a, is
(a) $v = u + aS$ (b) $v^2 - u^2 = 2aS$ (c) $v^2 - u^2 = 1aS$ (b) $v + u = 2aS$

10. Which equation is wrong in the following :
(a) $s = ut + 1/2\ at^2$ (b) $v = u + at$ (c) $v^2 - u^2 = 2aS$ (d) $v = u + aS$

11. A particle experiences constant acceleration for 6 seconds after starting from rest. If it travels a distance S_1 in the first 2 seconds, a distance S_2 in the next two seconds and a distance S_3 in the last two seconds, then :
(a) $S_1 : S_2 : S_3 = 1 : 1 : 1$ (b) $S_1 : S_2 : S_3 = 1 : 2 : 3$
(c) $S_1 : S_2 : S_3 = 1 : 3 : 5$ (d) $S_1 : S_2 : S_3 = 1 : 5 : 9$

12. A particle revolves around a circular path in uniform motion. The acceleration of the particle is :
(a) along the tangent (b) Radially inward
(c) along the circumference of the circle
(d) Radially outward.

13. In which motion is the acceleration always directed normal to the direction of motion.
(a) Linear motion (b) circular motion
(c) projectile motion (d) simple harmonic motion

14. Impulse can be expressed as :
(a) Force × time (b) force ×distance
(c) force× velocity (d) force/time

15. Newton's second law of motion gives a relation between :
(a) momentum and velocity
(b) momentum and acceleration
(c) rate of change of force and momentum
(d) force and rate of change of momentum.

16. A bomb of 12 kg explodes into pieces of mass 4kg and 8 kg. The velocity of 8 kg mass is 6 m/s. The velocity of the other mass is :
(a) 3 m/s (b) 12 m/s (c) -12 m/s (d) -3 m/s

17. An explosion breaks a rock into pieces, one piece of mass 2 kg, goes towards the east with a speed of 10 m/s. The speed with which second piece flies off is 20 m/s. What is the mass of second piece
(a) 20 g (b) 1 kg (c) 2 kg (d) 3 kg

18. Centripetal force acting on the body of mass (m) moving in a circular path of radius (r) with constant speed is expressed as :
(a) $F = \frac{mv^2}{r}$ (b) $F = \frac{mr^2}{r}$ (c) $F = \frac{v^2}{mr}$ (d) $F = \frac{mr}{v^2}$

19. Cream get separated out of milk when it is churned because of :
(a) centrifugal force (b) fractional force
(c) centripetal force (d) gravitational force

20. If the speed of a particle undergoing circular motion is doubled and its radius halved the centripetal force will
(a) increase 4 times (b) decrease 4 times
(c) increase 2 times (d) increase 8 times

21. With the uniform speed the work done by the centripetal force is
(a) finite (b) zero (c) infinite (d) indetermine

22. The moment of inertia of a body comes into play :
(a) in motion along a curved path (b) in linear motion
(c) in rotational motion (d) in vibrational motion

23. Moment of inertia × angular acceleration is equal to
(a) torque (b) force
(c) angular momentum (d) work done

24. Angular momentum is equal to :
(a) mass × velocity
(b) moment of inertia × angular velocity
(c) moment of inertia × angular acceleration
(d) velocity × time

25. When a constant force is applied to a body it moves with uniform
(a) speed (b) velocity (c) acceleration (d) momentum

26. All the known planets moves in :
(a) elliptical orbit (b) circular orbit
(c) parabolic orbit (d) hyperbolic orbit

27. Two balls moving towards each other collide and move apart. Physical quantity whose value is the same before the collision as after it :
(a) force (b) momentum (c) velocity (d) acceleration

28. If a body is let fall from the window of a moving train, the body will hit the ground following :
(a) straight line path (b) circular path
(c) hyperbolic path (d) parabolic path

29. A satellite revolves around the earth in an elliptical orbit. Its speed will be greatest when :
(a) it is nearest to the earth (b) it is farthest from the earth
(c) it is directly over the observer's meridian
(d) it occupies any position other than the above mentioned

30. Working of rocket is based on the principle of :
(a) Kepler's Law (b) Newton's Law

(c) Columb's Law (d) Conservation of momentum

31. Swimming becomes possible because of law of motion :
(a) first (b) second (c) third (d) none of these

32. Wheel of a bicycle has motion of :
(a) rotation (b) translation
(c) rotation as well as translation (d) none of these.

33. The term Radius of gravitation relates to :
(a) Moment of force (b) Moment of inertia
(c) Law of gravitation (c) Simple harmonic motion

34. A ball is projected upwards. Its acceleration at the highest points is
(a) zero (b) directed upwards
(c) directed downwards (d) such as cannot be predicted

35. A car moving with a velocity of 48 km/h is brought to rest in 11 seconds to avoid a collision with the wall. What is the acceleration of the car in ms^{-2}?
(a) -1.21 ms^{-2} (b) 2.42 ms^{-2} (c) 1.21 ms^{-2} (d) -2.42 ms^{-2}

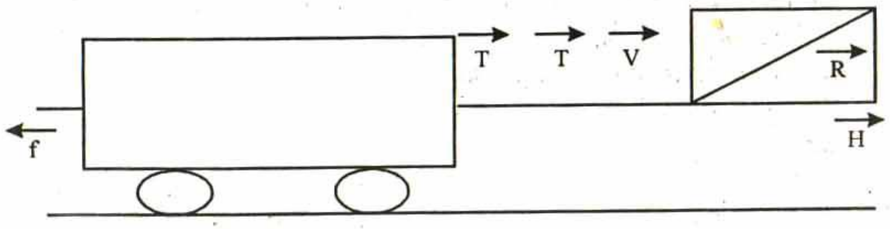
36. Rate of change of momentum is known as
(a) velocity (b) work (c) energy (d) force

37. In uniform circular motion of a body
(a) the velocity is constant but speed changes
(b) the speed is constant but velocity changes.
(c) both speed as well as velocity changes.
(d) both speed as well as velocity is constant.

38. In which motion, the acceleration is always directed normal to the direction of motion.
(a) linear motion (b) circular motion
(c) projectile motion (d) simple transmit motion.

39. If a body moves with uniform speed 'v' in a circular path of radius 'r' its acceleration is :
(a) equal to zero
(b) equal to acceleration due to gravity directed downward
(c) equal to $\frac{V^2}{r}$ directed towards the centre of the circle.
(d) equal to $\frac{V^2}{r}$ directed away from the centre of the circle.

40. In the following horse cart system in what condition will be in motion



(a) H > f (b) f > H (c) H = f (d) H < f

41. Two billiard balls each of mass 0.05 kg moving in opposite direction with speed 4 m/s collide and rebound with same speed. What is the impulse imparted to each ball due to other :
(a) 0.20 kg ms^{-1} (b) 0.30 kg ms^{-1} (c) –0.20 kg ms^{-1} (d) .40 kg ms^{-1}

42. If the velocity of a moving body is doubled which of the following quantity is doubled:
(a) acceleration (b) weight (c) K.E (d) momentum

43. A body of mass 5 kg initially at rest is subjected to a force of 20 N. What is the K.E. energy acquired by the body at the end of 10 seconds ?
(a) 4000 J (b) 2000 J (c) 3000 J (d) 5000 J

44. A person walking on a horizontal road with a load on his head does net work because :
(a) $W = \vec{F} \times \vec{S} = F \times S \cos 90° = 0$
(b) $W = \vec{F} \times \vec{S} = F \times S \cos 0° = F \times S$
(c) $W = \vec{F} \times \vec{S} = F \times S \sin 180° = -F \times S$
(d) $W = \vec{F} \times \vec{S} = F \times S \sin 90° = F \times S.$

45. The static friction is :
(a) always greater than the dynamic friction
(b) equal to the dynamics friction
(c) always less than the dynamics friction
(d) sometimes greater and sometimes less than dynamics friction.

46. Which is a/are suitable method of decreasing friction.
(a) ball and roller bearing (b) lubrication
(c) polishing (d) all of the above.

47. When a body moves at a constant speed in a circular path it has :
(a) an acceleration directed tangentially
(b) an acceleration directed radially inward
(c) an acceleration away from the centre of the circular path
(d) no acceleration is directed

48. In planetary motion :
(a) the angular momentum remains constant
(b) angular speed remains constant
(c) the linear speed remains constant
(d) linear momentum remains constant

49. When a force of one newton acts on a body of mass 1 kg, the body which is capable of moving freely receives :
(a) a speed of 1 m/sec. (b) an acceleration of 80 cm/sec^2
(c) an acceleration of 1 m/sec^2 (d) a speed of 1 m/sec.

50. The first law of motion supplies the definition of :
(a) inertia (b) velocity (c) acceleration (d) momentum.

51. The frictional force which comes into play after the motion has started is called the :
(a) Dynamic friction (b) Static motion
(c) Normal reaction (d) limiting friction

52. Ratio of limiting friction to normal reaction is called :
(a) Rolling friction (b) limiting friction
(c) Normal reaction (d) coefficient of friction

53. The tangent of the angle of friction is numerically equal to the
(a) coefficient of friction (b) limiting friction
(c) Normal reaction (d) None of the above

54. A unit force is that which produces :
(a) a unit acceleration in a unit mass
(b) a unit acceleration in a unit weight.
(c) a unit de-acceleration in a unit weight
(d) a unit de-acceleration in a unit mass..

55. Neglecting air resistance, the path traced by a particle that flies of a moving automobile type is :
(a) parabola (b) A hyperbola (c) A straight line (d) ellipse

56. A body starting from rest moves with a constant acceleration of 4 m/sec². Find the distance covered by the body after 10 sec.
(a) 40 m (b) 80 m (c) 120 m (d) 200 m

57. In vacuum all freely falling bodies have the same:
(a) speed (b) velocity (c) acceleration (d) force

58. In case of rectilinear uniform motion distance time graph is a :
(a) parabolic (b) straight line (c) hyperbola (d) curved line

59. What type of force acts on a car moving round a curve ?
(a) centrifugal force (b) centripetal force
(c) cohesive force (d) all of these

60. Electron revolves round the nucleus because of:
(a) cohesive force (b) adhesive force
(c) centripetal force (d) centrifugal force.

61. In Physics the term power means the rate of doing work. If certain agent is able to complete 'W' unit of work in 't' second we have :
(a) $P = W \times T$ (b) $P = W/T$ (c) $P = T/W$ (d) $P = W \times T/2$

62. Which of the following statement is wrong :
(a) a kite flying on a Rainy day has three dimensions
(b) a speeding car on a long straight highway has one dimension
(c) an insect crawling on a globe has two dimensions
(d) a common coin rebounding from the side of the board has one dimension.

63. If a particle moving with a velocity 12 m/sec after time 3 s it stops. Find distance covered by the body.
(a) 16 m (b) 12 m (c) 18 m (d) 20 m

64. If the velocity of the body is 4 m/s and its mass 12 kg, find momentum :
(a) 48 kg m/s (b) 40 kg m/s (c) 42 kg m/s (d) 46 kg m/s

65. A force of 10 N acting on a certain mass for 5 seconds gives it a velocity of 10 m/s. Find the mass :
(a) 5 kg (b) 10 kg (c) 20 kg (d) 12 kg

66. An athlete completes one round of a circular track of radius R in 40 Sec. What will be his displacement at the end of 2 min. 20 Sec.
(a) Zero (b) 2R (c) 2πR (d) 7πR

67. A body dropped from a top of a tower fall 40 m during the last two second of its fall. The height of tower is : (g) = 10 m / Sec² .
(a) 60 m (b) 45m (c) 80 m (d) 50 m

68. Two bodies of different masses are dropped from height of 16 m and 25 m respectively. Then ratio of their velocity at the earth is :
(a) 25/16 (b) 5/4 (c) 4/5 (d) 16/25

69. Given the earth sun distance as 1.5×10^8 Km, Velocity of light 3×10^5 Km / Sec. The sun light reaches on earth in time.
(a) 300 Sec (b) 400 Sec (c) 500 Sec (d) 600 Sec

70. The correct statement from the following is
(a) A body having zero velocity will not necessarily have zero acceleration.
(b) A body having zero velocity will necessarily have zero acceleration.
(c) A body having uniform speed can have only uniform acceleration.
(d) A body having non-uniform velocity will have zero acceleration.

71. A body moving in a circular path with constant speed has :
(a) constant retardation (b) variable acceleration
(c) readily outward acceleration (d) constant acceleration

72. It is easier to pull a lawn roller than to push it because pulling :
(a) involves sliding friction (b) involves dry friction
(c) increases the effective weight (d) decreases normal reaction

73. An electric fan is placed on a stationary boat and air is blown with it on the sail of the boat. Which of the following statements is correct ?
(a) The boat will start moving with uniform speed.
(b) The boat will be uniformly accelerated in the direction of the flow of the air
(c) The boat will be uniformly accelerated opposite to the direction of flow of the air.
(d) The boat will remain stationary as before.

74. A bird is sitting in a wire cage hanging from the spring balance. Let the reading of the spring balance be W_1. If the bird files about inside the cage, the reading of the spring balance is W_2 . Which of the following is true ?
(a) $W_1 = W_2$ (b) $W_1 > W_2$
(c) $W_1 < W_2$ (d) None of these

75. A particle starting from rest moves upto 20 Sec with constant acceleration. If S_1 is the distance covered in first 10 Sec and S_2 is the distance covered in last 10 Sec from

(a) $S_2 = S_1$ (b) $S_2 = 2S_1$ (c) $S_2 = 3S_1$ (d) $S_2 = 4S_1$

76. A body falls freely from rest. It covers as much distance in the last second of its motion as covered in the first three seconds. The body has fallen for a time of:
(a) 3 Sec (b) 5 Sec (c) 7 Sec (d) 9 Sec

77. A car drives along straight level frictionless road by an engine delivering constant power then velocity is directly proportional to
(a) t (b) $\frac{1}{\sqrt{t}}$ (c) $\sqrt{t}$ (d) None of these

78. If the displacement of a particle varies with time as $\sqrt{x} = t + 3$ the velocity of the particle is proportional to
(a) $\sqrt{t}$ (b) t (c) t^2 (d) 1/t

79. Why a horse need to pull harder during the first few steps in pulling the cart
(a) Limiting friction is greater than dynamic friction.
(b) Sliding friction is greater than rolling friction.
(c) No frictional force acts after the cart comes in motion.
(d) Air friction is greater during first law steps of motion.

80. Two vector have their resultant equal to either of them. The angle between them is
(a) 45° (b) 75° (c) 90° (d) 120°

81. A man weighing 100 kgf carries a load of 10 kgf on his head. He jumps from a tower with the load on this head. What will be the weight of the load as experienced by the man ? Take $g = 10ms^{-2}$
(a) zero (b) 10 kgf
(c) slightly more than 10 kgf (d) 110 kgf

82. A man drops an apple in the lift. He finds that the apple remains stationary and does not fall on the floor of the lift. The lift is :
(a) going up with constant speed
(b) going down with constant speed
(c) going up with constant acceleration
(d) going down with constant acceleration

83. A ball is projected upwards. As it rises, there is increase in its :
(a) momentum (b) retardation
(c) kinetic energy (d) potential energy

84. The moment of inertia of a body does not depend upon :
(a) the angular speed (b) mass of the body
(c) nature of distribution of the mass (d) location of the axis of rotation

85. Which of the following statements is true for the planets orbiting around the sun :
(a) Their velocity increases when they are nearest to the sun in accordance with the conservation of angular momentum
(b) Their velocity decreases when they are nearest to the sun in accordance with the conservation of angular momentum
(c) A real velocity of the planet varies with time to conserve the energy
(d) A real velocity of the planet is directly proportional to the distance of the planet from the sun.

86. If the earth shrinks to half of its radius without change in mass, the duration of the day will be :
(a) 48 hours (b) 24 hours (c) 12 hours (d) 6 hours

87. A particle is moving on a circular path with constant speed. Which of the following statements about the particle is true :
(a) It possesses radial acceleration
(b) It possesses radial velocity
(c) It possesses tangential acceleration
(d) It does not possess tangential velocity

88. A body is moving along a circular path with constant speed. If the direction of rotation is reversed and the speed is doubled, then :
(a) direction of centripetal acceleration is reversed
(b) magnitude of centripetal acceleration is double
(c) the direction of centripetal acceleration remains unchanged
(d) the magnitude of centripetal acceleration is halved

89. A body is moving along a circular path with constant speed. Which of the following statements about its motion is true :
(a) No work is done on the body
(b) The acceleration of the body is zero
(c) No force acts on the body
(d) The body moves with constant velocity

ROTATIONAL MOTION

90. What happens to the centripetal acceleration of a particle, when its speed is doubled and angular velocity is halved :
(a) Halved (b) Remains unchanged
(c) Doubled (d) Becomes four times

91. A Car takes a turn around a circular curve if it turns at double the speed, the tendency to over turn is
(a) Halved (b) Doubled (c) Quadrupled (d) Unchanged

92. What is the optimum speed for a car, when friction is not required to negotiate a curve of radius (r) with angle of banking (θ)?
(a) $r^2 g \tan\theta$ (b) $\sqrt{rg\tan\theta}$
(c) $(rg\tan\theta)^2$ (d) None of the above

93. A body of mass (m) tied to a string is moved in a vertical circle of radius (r). The difference in tension at the lowest point and the highest point is
(a) 2 mg (b) 6 mg (c) 4 mg (d) 8 mg

94. The K.E of a body rotating with an angular speed $\theta\omega_1$ depends on
(a) Distribution of mass (b) Angular speed

(c) Both a and b (d) Neither @ and nor b

95. Find the minimum speed of a bike at higher point of a globe of diameter 19.6 m
(a) 9.8 m/Sec (b) 19.6 m/Sec (c) 4.9 m/Sec (d) 39.2 m/Sec

96. A sphere is suspended by a thread of length L. The minimum horizontal velocity which has to be imparted to the sphere for it to reach the height of suspension
(a) $\sqrt{gl}$ (b) $\sqrt{2gl}$ (c) 2gl (d) gl

97. A body of mass 5 kg is whirled in a vertical circle by a string 1m long. Calculate velocity at the top of circle for just looping the vertical loop
(a) 3.1 m/Sec (b) 7 m/Sec (c) 9 m/Sec (d) 7.3 m/Sec

98. The angular acceleration of a particle moving along a circular path with uniform speed is
(a) uniform but non zero (b) zero
(c) variable (d) can not predicted.

99. If the resultant of all external forces is zero then velocity of centre of mass will be
(a) Zero (b) Constant
(c) Either (a) or (b) (b) (d) Neither (a) nor (b)

100. The motion of centre of mass depends on
(a) Total external forces (b) Total internal forces
(c) Sum of (a) and (b) (d) None of these

101 The centre of mass of a rigid body lies
(a) Inside the body (b) Outside the body
(c) On its surface (d) Any one of these

102. The centre of mass of two particle lies on the line
(a) Joining the particles
(b) Perpendicular to the line joining the particles
(c) At any angle to this line
(d) Nothing can be said

103. The sum of moments of masses of all the particles in a system about the centre of mass is always
(a) Maximum (b) Minimum (c) infinite (d) Zero

104. The angular speed of hour's hand of a watch is
(a) $\frac{\pi}{60 \times 60}$ rad / Sec (b) $\frac{2\pi}{60 \times 60}$ rad / Sec
(c) $\frac{\pi}{12 \times 60 \times 60}$ rad / Sec (d) $\frac{\pi}{6 \times 60 \times 60}$ rad / Sec

105. The angular speed of seconds hand of a watch is
(a) $\frac{\pi}{30}$ rad / Sec (b) $\frac{\pi}{60}$ rad / Sec (c) $\frac{\pi}{45}$ rad / Sec (d) None of above

106. A solid spherical ball rolls on a table. Ratio of rotational K.E to the total K.E is :
(a) 2/7 (b) 1/2 (c) 1/5 (d) 7/10

107. Moment of inertia of a solid sphere about an axis tangential to its surface is
(a) 2/3 mR^2 (b) 2/5 mR^2 (c) 7/5 mR^2 (d) 5/3 mR^2

108. A stone is put on between a fold string and is made to rotate in a circular path by holding the other end of the string. If one side of string is let off, the stone flies off tangentially to the circular path. This happens because of :
(a) centripetal force (b) centrifugal force
(c) inertia (d) none of the above

109. For a particle moving along a circular path with a constant speed, the acceleration is constant in :
(a) magnitude (b) direction
(c) both magnitude and direction (d) neither magnitude nor direction

110. Which of the following statements about the Gravitational constant is true :
(a) It has no units
(b) It has same value in all systems of units
(c) It is a force
(d) It does not depend upon the nature of medium in which the bodies lie

111. If the mass and radius of a planet are doubled, then acceleration due to gravity on its surface will become :
(a) one fourth (b) one half (c) double (d) four times

112. An iron sphere and an aluminium sphere, both of same radius are dropped from the slope of a hill 100 M high. At a height 40 m above the ground, both of them will have same :
(a) momentum (b) kinetic energy (c) potential energy (d) acceleration

113. A stationary satellite of a planet orbits at :
(a) any height
(b) a definite height independent of its own mass
(c) a height depending upon its own mass
(d) a definite height independent of the mass of the planet

114. The synchronous satellite of the earth orbits from :
(a) north to south in the polar plane (b) south to north in the polar plane
(c) east to west in equatorial plane (d) west to east in equatorial plane

GRAVITATION AND GRAVITY

115. The value of `g' is zero at :
(a) Surface of the earth (b) centre of the earth
(c) in the Indian ocean (d) on Mount Everest

116. If the earth stops rotating, the weight of a body at equator will :
(a) increase (b) decrease (c) remain constant (d) become zero

117. If the speed of the rotation of the earth increases the weight of a body at equator will:

(a) increase (b) decrease
(c) remain constant (d) be zero

118. Choose the wrong statement :
(a) The weight of a body is grater at the poles and less at the equator
(b) The weight of a body is greater in plane and less on hill tops
(c) The weight of the body on the moon is less than on earth
(d) All the statements are correct

119. The value of `g' the acceleration due to gravity on the earth's surface changes due to :
(a) shape of the earth (b) rotation of the earth
(c) both of these (d) none of these

120. The value of `g' is equal to :
(a) GM/R^2 (b) GR^2/M (c) GM/R (d) GM/d

121. The value of `g' is maximum at :
(a) centre of the earth (b) 100 m altitude
(c) 100 m depth (d) surface of earth

122. Bodies of different masses are released to fall down vertically under gravity from the same height simultaneously. At the instant when they strike the ground which of the following differ for different bodies :
(a) momentum (b) velocity (c) speed (d) acceleration

123. A hole is drilling through the earth on equator and a stone is dropped in it. What will be the position of stone at centre of earth :
(a) motion (b) rest (c) acceleration (d) speed

124. The weight of an object on the moon is .....its weight on the earth :
(a) 6 times (b) equal (c) 1/2 (d) 1/6

125. If the distance from the earth to the sun doubled, the gravitational attraction between the sun and the earth will become :
(a) double (b) the same (c) 1/2 (d) 1/4

126. A body is thrown vertically upward and gains a certain height then falls freely on the earth, then which of the following statement is wrong about it:
(a) time of ascent is more than time of descent
(b) time of ascent and time of descent are equal
(c) the initial velocity of upward and the final velocity of downward are equal
(d) the downward acceleration is gained due to 'g'.

127. A body is thrown vertically up with initial velocity of 10 m/s. Its downward velocity when it comes to the same point is :
(a) 0 (b) 10 m/s (c) 20 m/s (d) 100 m/s.

128. A body is thrown vertically upward with a velocity of 50 ms^{-1}. On return journey, its velocity at the starting point will be :
(a) 50 ms^{-1} (b) 9.8 ms^{-1} (c) 100 ms^{-1} (d) 25 ms^{-1}

129. A stone is thrown vertically upward and it gains 39.2 m height in 2 seconds and falls freely on the earth. Find the time of its coming on earth :
(a) 2 sec (b) 3 sec (c) 1.5 sec (d) 4 sec

130. The weight of a freely falling body under the action of gravity becomes :
(a) double (b) zero (c) half (d) remains the same

131. The weight of a body is :
(a) the force with which it is attracted to the earth (b) mass
(c) force (d) momentum

132. If a body is taken from the surface of the earth to the moon its weight will become zero at a point where the force(s) of attraction due to :
(a) moon is zero (d) earth is zero
(c) earth and moon are equal and opposite (d) sun is zero

133. A body starts from rest and falls freely on earth. At the end of first second its velocity will be :
(a) 7.6 m/s (b) 5 m/s (c) 10 m/s (d) 9 m/s

134. If the distance between two given masses is doubled then gravitational force between them :
(a) decreases by factor ½ (b) decreases by factor 1/4
(c) increases by 4 times (d) increases double

135. The gravitational and inertial masses of a body are
(a) exactly equal (b) nearly equal (c) unrelated (d) unequal

136. The force which keeps the planet in regular orbit is :
(a) electrostatic (b) magnetic (c) gravitational (d) nuclear

137. If the radius of earth becomes double then its present value, while its mass remains same, the weight of an object on the surface of earth will become
(a) twice (b) thrice (c) same (d) one fourth part

138. A force of attraction between the two bodies does not depend on :
(a) their separation (b) the product of their masses
(c) the sum of their masses (d) the gravitational constant

139. A planet existed whose mass was twice that of the earth and whose radius 3 times greater, a 10kg mass on its surface would weight :
(a) 21.7 N (b) 4.4 N (c) 6.7 N (d) 13.3 N

140. If a body's weight is 36 kg on the surface of the earth, how much would it weight on the surface of a planet whose mass is 1/9 and radius 1/3 of the earth
(a) 32 kg (b) 36 kg (c) 12 kg (d) 10 kg

141. If a man weight 12.5kg on the moon how much will his weight on the earth :
(a) 75 kg (b) 62.5 kg (c) 50 kg (d) 80 kg

142. A man's weight on the surface of the earth is 75 kg. How much would be weight in a rocket at a distance of 30000 km from the earth? *(Radius of earth is taken 6000 km) :*
(6) 6kg (b) 5 kg (c) 3 kg (d) 2 kg

143. The weight of a body on the surface of the earth is 480 kg. What will its weight on moon :
(a) 2880 kg (b) 80 kg (c) 90 kg (d) 70 kg

144. If the mass of moon is 7.58×10^{22} kg and its radius is 1.74×10^{6} m, find value of 'g' at moon. (*Value of* $G = 6.67 \times 10^{-11}\ Nm^2/kg^2$)
(a) 1.67 m/s² (b) 9.8 m/s² (c) 1.55 m/s² (d) 7 m/s²

145. If the mass of the earth is 5.98×10^{24} kg and radius of the earth 6.38×10^{6}m, what is value of 'g' at the surface of the earth ?
(*Value of Gravitational constant is* $6.67 \times 10^{-11}\ Nm^2/kg^2$) :
(a) 1.67 m/s² (b) 9.8 m/s² (c) 7 m/s² (d) 9m/s²

146. At what height above the surface of the earth, value of acceleration due to gravity is equal to mine 100 m deep of :
(a) 200 m (b) 100 m (c) 50 m (d) 80 m

147. Let g_1, g_2, g_3, be the values of acceleration due to gravity on the surface of earth, 2km above the earth's surface and 2 km inside earth's surface respectively then :
(a) $g_1 > g_2 = g_3$ (b) $g_1 > g_3 > g_2$ (c) $g_3 > g_1 > g_2$ (d) $g_2 = g_3 > g_1$

148. A given object has mass (m) and weight (W) on the surface of earth, the same object has mass m' and weight W_1 on the moon, then
(a) $m=m', W = W_1$ (b) $m= m', W \# W_1$
(c) $m/m', W=W_1$ (d) $m \# m', W \# W_1$

149. The acceleration due to gravity :
(a) has the same value every where in space
(b) has the same value every where on the earth
(c) varies with the latitude on the earth
(d) is greater on small diameter planet than bigger planet

150. The weight of an object :
(a) is gravity of the matter it contains
(b) refers to its inertia
(c) is the same as its mass but expressed in different units
(d) is the force with which it is attracted to the earth

151. A boy dropped a stone from a bridge and noticed that it struck water in just 3 seconds. What is the speed of the stone when it just struck water ?
(a) 29.4 m/s (b) 39.2 m/s (c) 13.1 m/s (d) 41 m/s

152. A girl dropped a stone from a bridge and noticed that it struck water in just 3 seconds. What is the height of the bridge above the water level ?
(a) 44.1 m (b) 46.7 m (c) 52 m (d) 40 m

153. When a ball is thrown vertically upward with a height 19.6 m with velocity 19.6 m/s, find total time to return the same point :
(a) 4 s (b) 3 s (c) 5 s (d) 2 s

154. Centre of gravity of a uniform meterstic is nearest to the line marked :
(a) 100 cm (b) 50 cm (c) 40 cm (d) 1 cm

155. An object is projected upward with a velocity 49 m/s. It will come to the ground after a time :
(a) 5 sec (b) 10 sec (c) 2.5 sec (d) 20 sec

156. A marble 'A' is dropped vertically, another identical marble B is projected horizontally from the same point at the same instant :
(a) A will reach the ground earlier than B
(b) B will reach the ground earlier than A
(c) Both A and B will reach the ground at the same time.
(d) Nothing is certain.

157. When a ball is thrown upward, there is an increase in its :
(a) Kinetic energy (b) acceleration
(c) Gravitational potential energy (d) power

158. If two bodies of unequal masses are thrown vertically upward with same initial velocity, the ratio of the time period required to reach the ground is equal to
(a) the ratio of their masses (b) one
(c) the inverse of the ratio of there masses
(d) product of their masses

159. An iron ball and a wooden ball of the same radius are released from the height `h' in vacuum. Time taken by both of them to reach the ground are
(a) unequal (b) exactly equal (c) roughly equal (d) zero

160. The mass of a body which measures its inertia and determines the internal force required to move it along a horizontal frictional surface is known as :
(a) Gravitational mass (b) Inertial mass
(c) Weight (d) none of these.

161. A cricketer can throw a ball to a maximum horizontal distance of 100 m. How much high above the ground can the cricketer throw the ball
(a) 50 m (b) 100 m (c) 25 m (d) 75 m

162. A missile is projected into the air, it follows :
(a) straight line path (b) parabolic path
(c) elliptical path (d) hyperbolic path

163. Which of the following statement is true :
(a) Acceleration due to gravity in vacuum is same irrespective of size and mass of the body
(b) Acceleration due to gravity in vacuum depends on the mass of body
(c) There is no acceleration due to gravity in vacuum.
(d) Acceleration due to gravity in vacuum depends on the quality of matter.

164. The velocity with which a body moves around the earth is known as :
(a) Escape velocity (b) Orbital velocity
(c) Angular velocity (d) Areal velocity

165. The escape velocity from the earth's surface is given by :
(a) 7.2 m/s (b) 11.2 km/sec (c) 8 km/s (d) 4.2m/s

166. The relation between escape velocity and the orbital velocity is :
(a) $V_{es} = \cong 2\ V_{orb}$ (b) $V_{es} = 1/\cong 2\ V_{orb}$ (c) $V_{es} = 2\ V_{orb}$ (d) $V_{es} = \cong 3\ V_{orb}$

167. Potential energy of revolving satellite is always :
(a) negative (b) positive

(c) depends on velocity (d) depends on distance

168. Kinetic energy of a revolving satellite is always :
(a) negative (b) positive
(c) depends on distance (d) depends on velocity

169. If a body describes a circular motion under inverse square field (*e.g. a* gravitational field) the time taken to complete one revolution T is related to the radius of the circular orbit r as :
(a) $T \propto r$ (b) $T \propto r^2$ (c) $T \propto r^{3/2}$ (d) $T \propto r^3$

170. A planet revolving around the earth remains in weightlessness condition because :
(a) no acceleration due to gravity
(b) it is equal to freely falling body
(c) due to zero acceleration due to gravity.
(d) acceleration due to gravity equal between them

171. Orbital velocity of a satellite revolving around earth is independent of :
(a) mass of earth (b) radius of earth
(c) mass of the satellite
(d) distance of the satellite from the surface of the earth.

172 Ratio of inertial mass to gravitational mass is
(a) 0.1 (b) 1 (c) 2 (d) No fixed number

173. If mass of a body is M on the earth surface then the mass of the same body on moon surface is
(a) m/6 (b) Zero (c) M (d) None of these

174. If the earth suddenly shrinks to half of its present radius the acceleration due to gravity will be
(a) g/2 (b) 4g (c) g/4 (d) 12 g

175. A jet engine works on the principle of
(a) Conservation of mass (b) Conservation of energy
(c) Conservation of linear momentum (d) Conservation of angular momentum

176. Newton's law of Gravitation is universal because
(a) It is always attractive (b) It is not affected by the medium
(c) Act on all masses at any distance (d) All the above

177. If the universal gravitational constant was time dependent then which of following quantities would be conserved ?
(a) Potential energy (b) Kinetic energy
(c) Linear momentum (d) Angular momentum

178. The acceleration on the surface of earth varies
(a)Directly with longitude (b) Directly with latitude
(c)Inversely with longitude (d) Inversely with latitude

179. Unit of gravitational intensity is
(a) $m\ Sec^{-1}$ (b) $N\ kg^{-1}$ (c) $kg\ m\ Sec^{-1}$ (d) $kg\ m\ Sec^{-2}$

180. Time period of a seconds pendulum in a satellite is
(a) Zero (b) 2
(c) infinity (d) Depends on mass of bob

181. In a satellite if the time of revolution is T then K.E is proportional to
(a) $\frac{1}{T^{2/3}}$ (b) $\frac{1}{T}$ (c) $\frac{1}{T^2}$ (d) $\frac{1}{T^3}$

182. Periodic time of communication satellite is
(a) 6 hours (b) 12 hours (c) 18 hours (d) 24 hours

183. A body of mass (m) is moved to a height (h) equal to the radius of the earth. The increase in P.E is
(a) 2 mg R (b) mg R (c) 1/2 mg R (d) 1/4 mg R

184. What is the weight of a 700 g of body on a planet whose mass is 1/7th that of earth and radius is 1/2 times of earth.
(a) 400 g (b) 300 g (c) 700 g (d) 500 g

185. Who among the following gave first the experimental value of G ?
(a) Cavendish (b) Copernicus (c) Brook Teylor (d) None of these

186. If the radius of earth orbit is made 1/4 th, then duration of an year will becomes
(a) 8 times (b) 4 times (c) 1/8 times (d) 1/4 times

187. A pendulum is taken inside 1 Km from sea level in one day it
(a) Losses 13.5 Sec b) Gains 13.5 Sec
(c) Losses 7 Sec (d) Gains 7 Sec

188. If earth revolves around the sun in one year. If the distance between them becomes double, the new period of revolution will be
(a) 1/2 years (b) $2\sqrt{2}$ years (c) years (d) 8 years

189. A force of 1 kg weight produce in mass of 9.8 kg. an acceleration of -
(a) 1 m/sec^2 (b) $\frac{1}{9.8}$ m/sec^2 (c) 9.8 m/sec^2 (d) 1 cm/sec^2

190. Kepler III[rd] law i.e. $T^2 \alpha R^3$ is a consequence of law of conservation of
(a) Linear momentum (b) Angular momentum
(c) Energy
(d) Law of quentisation of angular momentum

191. The weight of a body is lesser at the surface of the moon than on the earth, because
(a) Moon has no atmosphere (b) Moon is far away from the earth
(c) Moon is far away from the sun (d) The value of g is less on moon

192. At a height equal to earth's radius above the earth's surface, the acceleration due to gravity is :
(a) g (b) g/2 (c) g/4 (d) g/8

193. The escape velocity of a particle of mass (m) varies directly
(a) m^n (b) m (c) m^o (d) $m^{\cong 1}$

194. The kinetic energy required to make a body more to infinity from the earth's surface is
(a) Infinite (b) 2 mg R (c) 1/2 mg R (d) mg R

195. There is no atmosphere on moon as :
(a) It is closer to earth (b) It revolves around the earth
(c) It gets light from the sun
(d) The escape velocity of gas molecule is less than their r.m.s. velocity on moon

196. Orbital velocity of an artificial satellite does not depend upon
(a) Mass of earth (b) Mass of satellite
(c) Radius of earth (d) Acceleration due to gravity

197. Which of the following is independent of the mass of the earth ?
(a) orbital velocity (b) escape velocity
(c) gravitational intensity (d) none of these

198. An artificial satellite of mass (m) is revolving round the earth in an orbit of radius R, the work done in one revolution is
(a) mg R (b) mg R / 2 (c) 2πmg R (d) Zero

199. At what point acceleration due to gravity is maximum
(a) Surface of earth (b) At centre of the earth
(c) At altitude (d) At latitude

200. If weight of a body is 500 N on the surface of the earth than what will be the weight of body when it is brought half way towards the centre of the earth :
(a) 250 N (b) 150 N (c) 1000 N (d) 2000 N

201. At what height a body is projected vertically upwards. When acceleration due to gravity becomes, 4 % of earth surface
(a) 3200 kms (b) 6400 kms (c) 1600 kms (d) 25600 kms

202. Gravitational constant is known as universal constant because
(a) The value of (G) remains same at every point on the surface of the earth
(b) The value of (G) varies point to point
(c) Value of (G) is zero at the surface of the earth
(d) Value of (G) is increases with altitude and decrease with latitude

203. Which law tell us time period revolutions of planet around the sun
(a) Law of area (b) Law of orbit
(c) Harmonic law (d) Newton law of gravitation

204. Height at which the value of (g) becomes one-fourth to that on earth is
(a) R (b) 2R (c) 3/2 R (d) 4 R