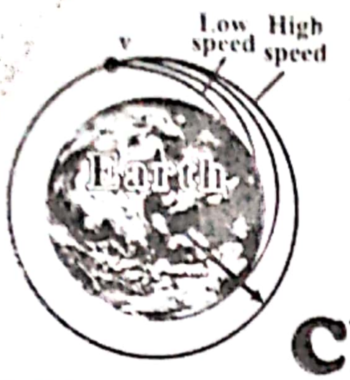


Chapter 5

CIRCULAR MOTION

KEY POINTS

Circular Motion:

Motion of bodies in circular path is called circular motion

Angular Displacement:

Angle subtended at the center of circle by a particle of the body while moving along the circumference of a circle in a given time.

- Angular displacement has direction along axis of rotation and can be determined by right hand rule.
- SI unit of angular displacement is radian.

$S = r\theta$

1 rad = 57.3°

or $1^0 = 1/57.3$ rad = 0.0174rad

Angular Velocity:

- Rate of change of angular displacement is called angular velocity:

$\vec{\omega} = \Delta\vec{\theta}/\Delta t$

- Angular velocity is a vector quantity.

$\vec{V} = \vec{\omega} \times \vec{r}$

- SI unit of angular velocity is rad/sec.

Angular Acceleration:

- Rate of change of angular velocity is called angular acceleration

$\vec{\alpha} = \Delta\vec{\omega}/\Delta t$

- SI unit of angular acceleration is rad/sec^2.
- Angular acceleration is a vector quantity.

$\vec{a} = \vec{\alpha} \times \vec{r}$

- Direction of angular acceleration is along axis of rotation and is determined by right hand rule.

Centripetal Acceleration & Force:

The force required to bend a straight line path of a body into the circular path is called centripetal force.

- Work done by centripetal force is zero

Relation Between Angular And Tangential Or Linear Quantities

- $S = r\theta$
- $v_T = r\omega$
- $a_T = r\alpha$

Comparison of Linear Motion and Angular Motion:

Linear motion	Angular motion
$v = \frac{S}{t}$	$\omega = \frac{\theta}{t}$
$V_f = V_i + at$	$\omega_f = \omega_i + \alpha t$
$S = V_i t + 1/2at^2$	$\theta = \omega_i t + 1/2\alpha t^2$
$2aS = V_f^2 - V_i^2$	$2\alpha\theta = \omega f^2 - \omega_i^2$
$F = ma$	$\tau = I\alpha$
$a = \frac{V_f - vi}{t}$	$\alpha = \frac{\omega_f - \omega i}{t}$
$p = mV$	$L = I\omega$
$K.E = \frac{1}{2}mv^2$	$K.E_{rot} = \frac{1}{2}I\omega^2$

Moment Of Inertia:

It is the rotational analogous of mass in linear motion. It depends on the mass and distribution of mass from the axis of rotation.

- Moment of inertia $= I = mr^2$
- It is measured in kgm^2

Moment of Inertia of Some Regular Bodies:

- For Rod: $I = 1/12\, mL^2$
- For thin ring or hoop: $I = mr^2$
- For Solid disc or cylinder: $I = \frac{1}{2}mr^2$
- For Sphere: $I = \frac{2}{5}mr^2$

Angular Momentum:

- Angular momentum is the product of moment of inertia and angular velocity.
- Angular moment is given as:

$$\vec{L} = \vec{r} \times \vec{p}$$
$$= m(\vec{r} \times \vec{v})$$
$$L = m\,r\,v \sin\theta$$

- If $\theta = 90°$, then

$$L = m\,r\,v$$
$$L = m\,r^2\omega \quad (\text{as } v = r\,\omega)$$
$$L = I\,\omega$$

Law of Conservation Of Angular Momentum:

Total angular momentum of all the bodies in a system remains constant in the absence of an external torque

- $L_1 = L_2$

$I_1\,\omega_1 = I_2\,\omega_2$

Rotational K.E:

- Rotational K.E is given by

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

- Rotational K.E of disc

$$K.E_{rot} = \frac{1}{4}mV^2 = \frac{1}{2}(K.E_{lin})$$

- Rotational K.E of hoop

$$K.E_{rot} = \frac{1}{2}mV^2 = (K.E_{lin})$$

- Velocity of hoop at the bottom of an inclined plane

$$V = \sqrt{gh}$$

- Velocity of disc at the bottom of an inclined plane

$$V = \sqrt{\frac{4}{3}gh} = \frac{2}{\sqrt{3}}\sqrt{gh}$$

Artificial Satellites:

The artificial satellite is the objects that orbit around the Earth due to gravity.

Real and Apparent weight:

- The real weight of an object is the gravitational pull of the earth.
- Weight of an object is measured by a spring balance.
- When lift is in the state of rest then: T = w
- When the lift is accelerating upwards: T = w + ma
- When the lift is accelerating downward: T = w – ma
- When lift is falling freely under gravity: T = 0

Orbital Velocity:

Orbital velocity is the tangential velocity to put a satellite in orbit around the earth.

- $v_o = \sqrt{2gh}$
- $v_o = 7.9 kms^{-1}$

Artificial Gravity:

Artificial gravity is the gravity like effect produced in an orbiting space ship to overcome weightlessness by spinning the spaceship about its own axis.

- $f = \frac{1}{2\pi}\sqrt{\frac{g}{R}}$

Geostationary Satellites:

Geo stationary satellite is the one whose orbital motion is synchronized with the rotation of earth.

Or

A satellite whose position does not change w.r.t a certain point on earth is called geo-stationary satellite.

- $r = \left(\frac{GMT^2}{4\pi^2}\right)^{\frac{1}{3}}$ $[r^3 \alpha T^2]$
- $r = 4.23 \times 10^4$km

Newton's views of Gravitation:

According to Newton "gravitation is the intrinsic property of matter that every particle attracts every other particle with a force which is directly proportional to the product of there masses and is inversely proportional to the square of distance between them".

Einstein's Views of Gravitation:

Albert Einstein viewed as a space –time curvature around an object.

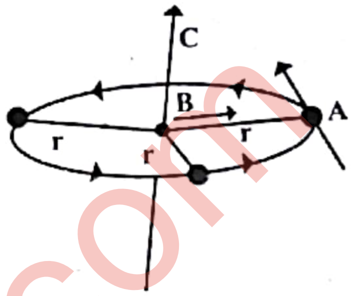
TOPICAL MULTIPLE CHOICE QUESTIONS

Topic 5.1:

Angular Displacement

(1) **A body of mass "m" is moving along a circular path as shown in the figure. In which direction the angular displacement is produced?**

(a) A (b) B
(c) C (d) Does not have direction



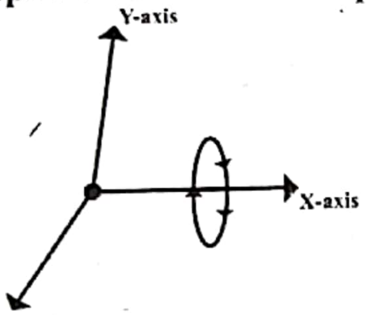
(2) **One radian is equal to**

(a) 5.73° (b) 0.73°
(c) 57.3° (d) 2π

(3) **For a small θ, angular displacement is quantity**

(a) scalar (b) vector
(c) neither scalar nor vector (d) none

(4) **For which of the following directions of rotations angular displacement is taken as positive?**

(a)


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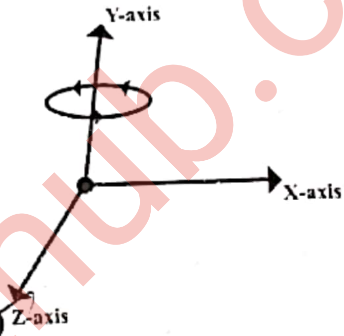
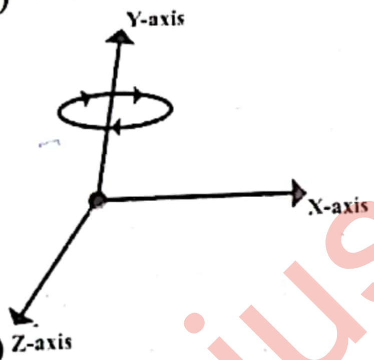


(c)


(d) All of these

(5) **The direction of angular displacement along the axis of rotation is given by**

(a) right hand rule (b) left hand rule
(c) head to tail rule (d) none of these

(6) **The S.I unit of angular displacement**

(a) degree (b) radian
(c) revolution (d) all of these

(7) **The dimension of angular displacement is**

(a) $[ML^{-1}]$ (b) $[ML^{-2}]$
(c) $[LT^{-1}]$ (d) dimensionless

(8) **Radian is defined as the angle subtended at the center of a circle by an**

(a) arc whose length is parallel to the radius of circle
(b) arc whose length is greater than the radius of circle
(c) arc whose length is less than the radius of circle
(d) arc whose length is equal to the radius of circle

(9) A satellite orbiting around the earth is an example of
(a) circular motion (b) vibratory motion
(c) rectilinear velocity (d) all of these

Topic 5.2:

Angular Velocity

(10) **When a body moves in a circle, the angle between its linear velocity 'v' and angular velocity 'ω' is always.**
(a) 180° (b) 0°
(c) 90° (d) 45°

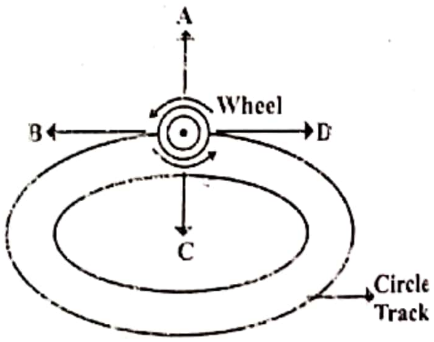
(11) **For a particle moving in a horizontal circle with constant angular velocity**
(a) the linear momentum is constant but the energy varies
(b) the energy is constant but the linear momentum varies
(c) both energy and linear momentum are constant
(d) neither the linear momentum nor the energy is constant

(12) **Unit of angular velocity is**
(a) rev / sec (b) rad/sec
(c) degree / sec (d) all

(13) **A cart is moving on a circular track whose wheel is shown in the figure. In which direction the angular velocity acts?**
(a) A (b) B
(c) C (d) D

(14) **The direction of angular velocity of a body moving in a circle is**
(a) towards the axis of rotation (b) away from the axis of rotation
(c) along the axis of rotation (d) above the axis of rotation

(15) **The angular speed of fly wheel making 120 revolutions per minutes is**
(a) π rad/s (b) 3π rad/s
(c) 6π rad/s (d) 4π rad/s



(16) **The dimension of angular velocity is**
(a) $[LT^{-1}]$ (b) $[LT]$
(c) $[T^{-2}]$ (d) $[T^{-1}]$

(17) **In the limit when Δt approaches to zero, the angular displacement would be**
(a) zero (b) infinitesimally small
(c) infinitesimally large (d) none of these

(18) **For which condition $\vec{\theta}$ and $\vec{\omega}$ makes an angle of 180° with each other?**
(a) $\vec{\omega}$ increases (b) $\vec{\omega}$ decreases
(c) $\vec{\omega}$ remains same (d) Note possible

Topic 5.3:

Angular Acceleration

(19) **The rate of change in angular velocity is called**
(a) angular displacement (b) angular momentum
(c) angular velocity (d) angular acceleration

(20) **For which condition $\vec{\omega}$ and $\vec{\alpha}$ becomes anti-parallel?**
(a) Rotational K.E decreases (b) An opposite torque acts on the system
(c) w decreases whether α increases (d) All

(21) **The direction of angular acceleration is**
(a) perpendicular to radius of circle
(b) along the axis of rotation
(c) along the radius of circle
(d) both a and b

(22) **Dimension of angular acceleration is**
(a) $[LT^{-2}]$
(b) $[LT^{-1}]$
(c) $[T^{-2}]$
(d) $[T^{-1}]$

(23) **Angular acceleration is expressed in units of**
(a) ms^{-2}
(b) rad s^{-1}
(c) rev s^{-1}
(d) rad s^{-2}

(24) **Which of the following acceleration whenever is present it produces angular acceleration?**
(a) a_c
(b) a_t
(c) Both A and B
(d) None of these

(25) **The angular acceleration is produced due to**
(a) centripetal force
(b) Torque
(c) Force
(d) centrifugal force

Topic 5.4:

Relation between Angular and Linear Velocities

(26) **The relation between linear acceleration and angular acceleration is**
(a) $\vec{\alpha} = \vec{a} \times \vec{r}$
(b) $\vec{a} = \vec{\alpha} \times \vec{r}$
(c) $\vec{a} = \vec{r} \times \vec{\alpha}$
(d) $\vec{r} = \vec{a} \times \vec{\alpha}$

(27) **The angle between angular velocity and angular acceleration when angular velocity decreases is**
(a) 30°
(b) 45°
(c) 180°
(d) 90°

(28) **The acceleration of a motor car is 8 m/s². If the diameter of its wheel be 2m. It's angular acceleration will be**
(a) 8 rad/s²
(b) 10 m/s²
(c) 16 rad/s²
(d) 10 rad/s²

(29) **Relation between linear and angular velocity is**
(a) $\omega = \frac{r}{v}$
(b) $\omega = \frac{a_c}{v}$
(c) $\omega = \frac{v}{r}$
(d) both b and c

(30) **Which of the following is correct relation?**
(a) $\vec{v} = \vec{r} \times \vec{\omega}$
(b) $\vec{v} = \vec{\omega} \times \vec{r}$
(c) $\vec{\omega} = \vec{v} \times \vec{r}$
(d) $\vec{\omega} = \vec{r} \times \vec{v}$

(31) **The relation between tangential and angular acceleration is expressed by**
(a) $a_t = r\alpha$
(b) $a_t = \frac{r}{\alpha}$
(c) $a_t = \frac{\alpha}{r}$
(d) $a_t = \frac{1}{\alpha r}$

(32) **When a wheel 1m in diameter makes 30 rev/min, the linear speed of point on it's rim in ms⁻¹ is**
(a) 2π
(b) $\frac{\pi}{2}$
(c) 3π
(d) 4π

(33) **If a car moves with uniform speed of 2m/s in a circle of radius 0.4 m. It's angular speed is**
(a) 4 rad/s
(b) 5 rad/s
(c) 6 rad/s
(d) 7 rad/s

(34) **When the axis of rotation is fixed then all the angular vectors have**
(a) same direction
(b) directionless
(c) different direction
(d) none of these

(35) **The linear velocity in circular path is also called**
(a) tangential velocity
(b) instantaneous velocity
(c) relative velocity
(d) angular velocity

(36) **The direction of motion changes continuously in**
(a) rectilinear motion
(b) circular motion
(c) linear motion
(d) none of these

Topic 5.5

Centripetal Force

(37) **Centripetal force performs.**
(a) maximum work
(b) minimum work
(c) negative work
(d) no work

(38) **Rotational counter part of force is**
(a) torque
(b) angular velocity
(c) angular momentum
(d) momentum

(39) **Which of the following forces cannot produce torque?**
(a) F_c
(b) F_T
(c) Both
(d) Both can produce torque

40) **The mud flies off the tyre of a fast moving car in the direction**
(a) parallel to the moving tyre
(b) anti parallel to the moving tyre
(c) tangent to the moving tyre
(d) none of these

41) **The force which provides the necessary centripetal force to keep the mud in circular path is called**
(a) cohesive force
(b) frictional force
(c) adhesive force
(d) gravitational force

42) **The relation for centripetal acceleration is given by**
(a) $\frac{v^2}{r}$
(b) $r\omega^2$
(c) $v\omega$
(d) all of these

43) **A body is rotated in a vertical circle by a string. The tension in the string is minimum at the**
(a) top
(b) Bottom
(c) Midway between top and bottom
(d) Remains same

44) **A body is rotated in a vertical circle by a string. The tension in the string is maximum at the**
(a) top
(b) Bottom
(c) Midway between top and bottom
(d) Remains same

45) **The centripetal force acting on a body of mass m in a circle of radius r is**
(a) $\frac{mv^2}{r}$
(b) $mr^2\omega$
(c) $mr\omega^2$
(d) both a and c

(46) **The necessary centripetal force to the moving car round a corner track is provided by**
(a) centrifugal force
(b) gravitational force
(c) frictional force
(d) electric force

(47) **The period of circular motion is**
(a) $T = \frac{2\pi}{\omega}$
(b) $T = \frac{\omega}{2\pi}$
(c) $T = 2\pi\omega$
(d) $T = \frac{\pi\omega}{2}$

(48) **A car of mass 1000kg traveling at 40 ms^{-1} rounds a curve of radius 100m. what is the F_C**
(a) 100 N
(b) 1.6×10^{4}N
(c) 1.6×10^{6}N
(d) 8×10^{4}N

(49) **If the radius of the circular path of a moving body is half without changing speed of rotation then the F_C becomes**
(a) half
(b) doubled
(c) one third
(d) one forth

(50) **The curved flight of fighter planes at high speed requires a large**
(a) gravitational force
(b) centripetal force
(c) frictional force
(d) centrifugal acceleration

(51) **The centripetal force has the same dimension as the**
(a) angular acceleration
(b) centrifugal force
(c) centripetal acceleration
(d) centrifugal acceleration

(52) **The vector form of centripetal force is**
(a) $m\omega\vec{r}$
(b) $-m\vec{r}\omega^2$
(c) $m\omega\vec{r}$
(d) $m\omega\vec{r}^2$

(53) **The centripetal acceleration directed along the radius**
(a) away from the centre of the circle
(b) perpendicular to the centre of the circle
(c) towards the centre of the circle
(d) parallel the centre of the circle

(54) **The dimensions of centripetal force is**
(a) $[MLT^{-2}]$
(b) $[MLT^{-1}]$
(c) $[LT^{-2}]$
(d) $[LT^{-1}]$

(55) **A body is moving in a circle of radius "r" with constant angular speed "ω". It's centripetal acceleration is**
(a) $\frac{\omega}{r}$
(b) $r\omega^2$
(c) $r^2\omega^2$
(d) $\frac{\omega^2}{r^2}$

Topic 5.6:

Moment of Inertia

(56) **Three hoops of same masses are shown in the figure. Which of these have maximum moment of inertia?**

(a) (b) (c) (d) All

(57) **Moment of inertia of rod of length L and mass m is**

(a) $\frac{1}{6}mL$
(b) $\frac{1}{12}mL$
(c) $\frac{1}{6}mL^2$
(d) $\frac{1}{12}mL^2$

(58) **The unit of moment of inertia is**

(a) $kgms^{-1}$
(b) kgm^{-2}
(c) $kg^{-1}m^2$
(d) kgm^2

(59) **The moment of inertia of a body comes in action in**

(a) circular path
(b) curved path
(c) straight line
(d) parallel

(60) **The relation between torque 'τ' and the moment of inertia 'I' is given by**

(a) $\tau = mr^2\alpha$
(b) $\tau = I\alpha$
(c) $\tau = mr\omega^2$
(d) both a and b

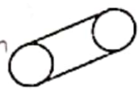
(61) **Moment of inertia of hoop**

(a) $I = \frac{1}{3}mr^2$
(b) $I = mr^2$
(c) $I = \frac{2}{3}mr^2$
(d) $I = I\alpha$

(62) **The dimensions of moment of inertia is**

(a) $[ML^{-1}]$
(b) $[MT^{-2}]$
(c) $[MT^{-1}]$
(d) $[ML^2]$

(63) **Which of the following cylinder requires least torque to be moved if have same mass?**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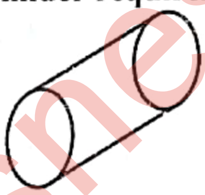
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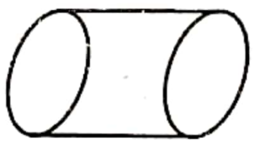

(c)

(d) Can't be predicted

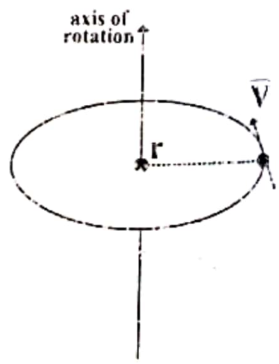
(64) **If two cylinders of equal mass roles, the one with the larger diameter has the**

(a) smaller rotational inertia
(b) larger rotational inertia
(c) zero rotational inertia
(d) none of these

Topic 5.7:

Angular Momentum

(65) **In the figure a body is shown which is rotating along a circular track. If the object is moving with constant angular velocity then.**



(a) Angular moments remains same
(b) Linear momentum changes at every moment
(c) Body rotates yet there is no torque
(d) All

(66) **The rate of change of angular momentum of a body is equal to**

(a) moment of force
(b) the applied force
(c) the applied torque
(d) impulse

(67) **Dimensions of angular momentum are**

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

(68) **The expression for angular momentum is given by**

(a) $\vec{L} = \vec{r} \times \vec{p}$
(b) $\vec{L} = \frac{\vec{r}}{\vec{p}}$
(c) $\vec{L} = \vec{p} \times \vec{r}$
(d) $\vec{L} = \vec{r} \times \vec{v}$

(69) **The direction of angular momentum is**

(a) along the axis of rotation
(b) perpendicular to the radius of circle
(c) perpendicular to the velocity of object
(d) all of these

(70) **The expression for angular momentum is given by**

(a) $L = I\omega$
(b) $L = mr^2\omega$
(c) $L = mvr$
(d) all of these

(71) **The unit of angular momentum is**

(a) $kg\ m^2/s$
(b) Js^{-1}
(c) Js
(d) both a and c

(72) **Which of the following is a vector quantity**

(a) speed
(b) angular momentum
(c) time
(d) mass

(73) **The angular momentum of any body about a fixed point is conserved when the angular acceleration of the body**

(a) go on decreasing
(b) go on increasing
(c) must remain constant
(d) must be zero

(74) **The angular momentum associated with the motion of a body along a circular path is called**

(a) spin angular momentum
(b) orbital angular momentum
(c) tangential angular momentum
(d) linear angular momentum

Topic 5.8:

Law of Conservation of Angular Momentum

(75) **Law of conservation of angular momentum states that if no ________ acts on a system, the total angular momentum of the system remain constant**

(a) external force
(b) external torque
(c) external couple
(d) none of these

(76) **The axis of rotation of an object will not change its orientation unless an ________ causes it to do so.**

(a) external force
(b) external torque
(c) external couple
(d) none of these

(77) **The law of conservation of angular momentum can explain**

(a) the rotational motion of earth
(b) spin motion of diver using divers board
(c) generation of stars in the universe
(d) all of these

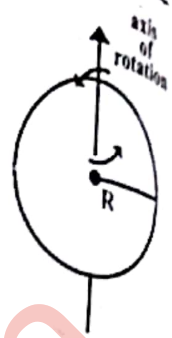
(78) **The diver can move faster when its moment of inertia**

(a) become large
(b) become smaller
(c) become zero
(d) none of these

(79) **Earth moves around the sun according to**

(a) law of conservation of charge
(b) law of conservation of angular momentum
(c) law of conservation of mass
(d) law of conservation of momentum

(80) A sphere is rotating arount its won axis of roation such that its radius Reduces to $\frac{1}{4}$ yet mass remins same. Then the angular velocity becomes



(a) 16 times
(b) 16 times
(c) 4 times
(d) $\frac{1}{4}$ times

Topic 5.9:

Rotational Kinetic Energy

(81) The rotational K.E of any hoop of radius r is given by
(a) $1/2\ I\omega^2$
(b) $1/3\ I\omega$
(c) $1/2\ mr^2$
(d) $2/3\ Ir^2$

(82) The ratio of rotational K.E of hoop to its translational K.E is
(a) 1:2
(b) 2:1
(c) 1:1
(d) 1:4

(83) When a disc of mass m rolling down on an inclined plane then its K.E is
(a) $\frac{1}{2}mv^2$
(b) $\frac{3}{4}mv^2$
(c) $\frac{1}{4}mv^2$
(d) $\frac{2}{5}mv^2$

(84) Speed of hoop at the bottom of inclined plane is
(a) $v=\sqrt{2gh}$
(b) $v=\sqrt{gh}$
(c) $v=\sqrt{\frac{3}{4}gh}$
(d) $v=\sqrt{\frac{4}{3}gh}$

(85) A hoop of radius 1m and mass 2kg rolls down an inclined plane of height 10m its speed on reaching the ground is
(a) 4m/sec
(b) 2m/sec
(c) 10m/sec
(d) $1.5ms^{-1}$

(86) Speed of disc at the bottom of inclined plane is
(a) $v=\sqrt{gh}$
(b) $v=\sqrt{2gh}$
(c) $v=\sqrt{\frac{3}{4}gh}$
(d) $v=\sqrt{\frac{4}{3}gh}$

(87) The rotational K.E of disc is ________ of translational K.E
(a) 1/2 times
(b) two times
(c) same
(d) 1/4 times

(88) When a body of cylindrical shape is rolled down on an inclined plane of height 'h', it contains
(a) only rotational K.E
(b) only translational K.E
(c) both 'a' and 'b'
(d) none of these

(89) When a hoop of mass m rolling down on an inclined plane then its rotational K.E is
(a) $\frac{1}{2}mv^2$
(b) $\frac{3}{4}mv^2$
(c) $\frac{1}{4}mv^2$
(d) $\frac{2}{5}mv^2$

(90) If no energy is lost against friction, then rotational K.E of the disc or hoop on reaching the bottom of inclined plane must be

(a) equal to P.E at top
(b) greater than P.E at top
(c) less than P.E at top
(d) zero

Topic 5.10:

Artificial Satellites

(91) The ratio of critical velocity to the escape velocity

(a) $v_{esc} = \sqrt{\frac{1}{2}}v_o$
(b) $v_{esc} = \sqrt{2}v_o$
(c) $v_o = \sqrt{2}v_{esc}$
(d) $v_{esc} = 2v_o$

(92) As we go below the surface of the earth, the value of g

(a) increases
(b) decreases
(c) remain same
(d) zero

(93) The minimum velocity required to put a satellite in an orbit close to the earth

(a) 9m/sec
(b) 7.9×10^2m/sec
(c) 7.9×10^3 m/sec
(d) 8.9×10^2m/sec

(94) The orbital velocity of satellite is independent of

(a) mass of the earth
(b) orbital radius
(c) mass of satellite
(d) both b and c

(95) The number of satellites in the Global Positioning system are

(a) 23
(b) 34
(c) 19
(d) 24

(96) The close orbiting satellite orbits the Earth at height of

(a) 400km
(b) 430km
(c) 390km
(d) 360km

(97) The minimum velocity necessary to put a satellite into the orbit is called

(a) relative velocity
(b) critical velocity
(c) tangential velocity
(d) terminal velocity

(98) The expression for the time period of low flying satellite put into the orbit is

(a) $T = \frac{2\pi R}{g}$
(b) $T = \frac{2\pi R}{G}$
(c) $T = \frac{2\pi g}{R}$
(d) $T = \frac{2\pi R}{v}$

(99) The critical velocity is the minimum __________ to put the satellite in orbit around the earth

(a) terminal velocity
(b) orbital velocity
(c) relative velocity
(d) escape velocity

(100) The value for the time period of low flying satellite put into the orbit is

(a) 5960 sec
(b) 84 min
(c) 95 min
(d) 6400 sec

Topic 5.11 & 5.12:

Real and Apparent Weight & Weightlessness in Satellite and Gravity Free System

(101) Real weight of the object changes in

(a) Inertial frame (b) Non-inertial frame

(c) Both (d) Remains same

(102) A man in an elevator descending with acceleration will conclude that his weight has

(a) increased (b) decreased

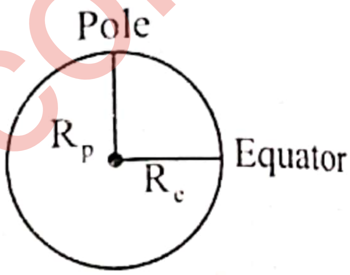
(c) remain same (d) zero

(103) An elevator is moving upward with acceleration 'a' the apparent weight of an object inside the elevator is

(a) mg-ma (b) mg + ma

(c) ma-mg (d)-mg - ma

(104) Earth is shown in which we have shown pole, equator and centre. At which of these points the real weight of anobject is zero?



(a) Pole (b) equetor

(c) Centre (d) Not possible

(105) When the elevator moving down with an acceleration of 9.8ms^{-2} then the weight of a person becomes

(a) remain same (b) 2 times increases

(c) zero (d) half

(106) The apparent weight of the body in spaceship in orbiting the earth is

(a) less than its weight (b) greater than its weight

(c) weightlessness (d) no change

(107) An elevator is moving upward such that brakes are applied on it. The relation for a mass suspended in it regarding its weight will be.

(a) mg+ma (b) mg-ma

(c) mg (d) Zero

(108) The system in which no force is required to hold an object falling in the frame of reference of the space craft or satellite is called

(a) orbital system (b) gravitational system

(c) virtual system (d) gravity free system

(109) Generally the weight of an object is measured by a

(a) ordinary balance (b) spring balance

(c) both 'a' and 'b' (d) none of these

(110) When a person rides in an elevator then its apparent weight may

(a) Increase (b) Decrease

(c) Remains same (d) All

(111) A man weighs 1000 N is in a stationary lift. What will be it's weight if the lift starts moving up with an acceleration 10 m/s^2

(a) 2000 N (b) 3000 N

(c) 1500 N (d) 1000 N

Topic 5.13:

Orbital Velocity

(112) The expression for orbital velocity is given by

(a) $v=\sqrt{\frac{gM}{R}}$ (b) $v=\sqrt{\frac{GM}{gh}}$

(c) $v=\sqrt{\frac{gM}{G}}$ (d) $v=\sqrt{\frac{GM}{r}}$

(113) The mass of the satellite is unimportant in describing the

(a) earth's orbit (b) satellite's orbit

(c) earth's radius (d) earth's gravity

Topic 5.14:

Artificial Gravity

(114) To create artificial gravity in a satellite, the satellite is given a frequency

(a) $f=2\pi\sqrt{g/R}$ (b) $f=\frac{1}{2\pi}\sqrt{g/R}$

(c) $f=\frac{1}{2\pi}\sqrt{R/g}$ (d) $2\pi\sqrt{R/g}$

(115) The unit of frequency

(a) s^{-1} (b) $m^{-1}s$

(c) ms (d) s^{-2}

Topic 5.15:

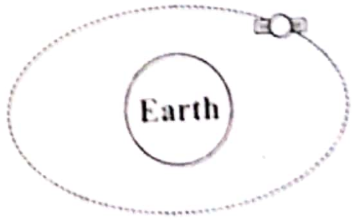
Geostationary Orbits

(116) One geostationary satellite covers

(a) 60° longitude (b) 120° longitude

(c) 120° latitude (d) 90° longitude

(117) A geo-statonary satellite is shown in the diagram such that its motion is synchrozied with the motion of earth. Which of the following is true?



(a) It has same angular velocity as earth has

(b) It has same time period to complete rotation as that of earth

(c) It has same orbital velocity as a point on earth has

(d) Both A and B

(118) The expression for the orbital radius is

(a) $r=\left(\frac{gMT^2}{2\pi^2}\right)^{\frac{1}{2}}$ (b) $r=\left(\frac{gMT^2}{2\pi^2}\right)^{\frac{1}{3}}$

(c) $r=\left(\frac{GMT^2}{4\pi^2}\right)^{\frac{1}{3}}$ (d) $r=\left(\frac{GMT^2}{4r\pi^2}\right)^{\frac{1}{3}}$

(119) The radius of geo-stationary orbit from the centre of earth

(a) 4.24×10^3 km (b) 4.2×10^4 km

(c) 3.6×10^4 km (d) 2.42×10^4 km

Topic 5.16:

Communication Satellites

(120) The minimum number of geo-stationary satellites use to send telecommunication signals to all parts of earth are

(a) 2 (b) 3
(c) 5 (d) 4

(121) The number of Earth stations which transmit signals to satellites and receive signals via satellite from other countries are

(a) 200 (b) 400
(c) 300 (d) 240

(122) 1 GHz =

(a) 10^9 Hz (b) 10^3 Hz
(c) 10^{12} Hz (d) 10^6 Hz

(123) The communication satellite INTELSAT-VI

(a) provides facility of three T.V channels
(b) operates at microwave frequency 4,6,11 and 14 GHz
(c) has capability of 30,000 two-way telephone circuits
(d) all of above

(124) The largest satellite system has been managed by

(a) 120 countries (b) 126 countries
(c) 160 countries (d) 140 countries

(125) The communication satellite INTELSAT-VI can be used as

(a) for navigational purpose only (b) for world wide communication only
(c) for weather monitoring (d) all of these

Topic 5.17:

Newton's and Einstein's view of Gravitation

(126) According to Einstein, light from star is deflected as it passes close to the sun on its way to earth through an angle of

(a) 1.745 sec (b) 10^0
(c) 2^0 (d) 1^0

(127) According to __________ the gravitation is the intrinsic property of matter

(a) Einstein (b) Joule
(c) Newton (d) Pascal

(128) Which theory of gravitation is better

(a) Newton (b) Compton
(c) Einstein (d) Rydberg

(129) According to Einstein's theory, space time is

(a) parabolic (b) curved
(c) elliptic (d) circular

(130) Einstein's theory also says that gravity follows

(a) Newton's law (b) inverse square law
(c) Pascal's law (d) none of these

(131) The gravity of a sun could be used to

(a) bend the light from stars (b) diverge the light from stars
(c) scatter the light from stars (d) polarize the light from stars

MULTIPLE CHOICE QUESTIONS

(From Past Papers 2012-2017)
(Federal Board)

(1) **The expression for spinning frequency to create artificial gravity in satellite is ____** **(FDR 2012)**

(a) $f=\frac{1}{2\pi}\sqrt{g/R}$ (b) $f=2\pi\sqrt{g/R}$

(c) $f=\frac{1}{2\pi}\sqrt{R/g}$ (d) $f=2\pi\sqrt{R/g}$

(2) **A gramophone record turntable accelerates from rest to an angular velocity of 45.0 rev min^{-1} in 1.60s. The average angular acceleration is ____** **(FDR 2012)**

(a) 19.5 rads^{-2} (b) 2.95 rads^{-2}

(c) 2.95revs^{-2} (d) None of these

(3) **The height of a geostationary satellite above the equator is ____** **(FDR 2014)**

(a) $6.4\times10^{6}m$ (b) $3.4\times10^{7}m$

(c) $3.4\times10^{-7}m$ (d) $6\times10^{6}m$

(4) **The expression for orbital speed of artificial satellite is ____** **(FDR 2014)**

(a) $v=\sqrt{\frac{GM}{r}}$ (b) $v=\frac{\sqrt{GM}}{r}$

(c) $v=\frac{GM}{r}$ (d) $v=\sqrt{\frac{GM}{2r}}$

(5) **45 rev/min = ____ rad/s** **(FDR 2015)**

(a) 90 π (b) 4.71

(c) 0.75 (d) 90

(6) **For a geo stationary satellite the orbital radius measured from the centre of the earth is** **(FDR 2015)**

(a) 36000 km (b) 42300 km

(c) 64000 km (d) 72000 km

(7) **A hoop of mass 'm' rolls down an inclined plane of height 'h', reaches the bottom with linear velocity 'v' and angular velocity 'ω'. If friction is ignored, what is the total energy of the hoop at the bottom of inclined plane?** **(FDR 2016)**

(a) $\frac{3}{4}mv^2$ (b) mv^2

(c) $\frac{1}{4}mv^2$ (d) $\frac{1}{2}mv^2$

(8) **In dryer, water is pushed out of wet clothes due to:** **(FDR 2017)**

(a) Abundance of centripetal force (b) Lack of centripetal force

(c) Friction (d) Retarding force

(9) **A stone of mass 16 kg is attached to a string 144 m long and is whirled in a horizontal circle. The maximum tension the spring can withstand is 16 N. the maximum velocity of revolution that can be given to the stone without breaking it, will be:** **(FDR 2017)**

(a) 20ms^{-1} (b) 16ms^{-1}

(c) 14ms^{-1} (d) 12ms^{-1}

ANSWER KEYS

(Topical Multiple Choice Questions)

1	c	21	d	41	c	61	b	81	a	101	d	121	a
2	c	22	c	42	d	62	d	82	c	102	b	122	a
3	b	23	d	43	a	63	a	83	c	103	b	123	d
4	b	24	b	44	b	64	b	84	b	104	c	124	b
5	a	25	b	45	d	65	d	85	c	105	c	125	d
6	b	26	b	46	c	66	c	86	d	106	c	126	a
7	d	27	c	47	a	67	c	87	a	107	b	127	c
8	d	28	a	48	b	68	a	88	c	108	d	128	c
9	a	29	c	49	a	69	d	89	a	109	b	129	b
10	c	30	b	50	b	70	d	90	a	110	d	130	b
11	b	31	a	51	b	71	d	91	b	111	a	131	a
12	d	32	b	52	b	72	b	92	b	112	d		
13	c	33	b	53	c	73	c	93	c	113	b		
14	d	34	a	54	a	74	b	94	c	114	b		
15	d	35	a	55	b	75	b	95	d	115	a		
16	d	36	b	56	c	76	b	96	a	116	b		
17	b	37	d	57	d	77	d	97	b	117	d		
18	d	38	a	58	d	78	b	98	d	118	c		
19	d	39	a	59	a	79	b	99	b	119	b		
20	d	40	c	60	d	80	b	100	b	120	b		

SHORT QUESTIONS

(From Textbook Exercise)

5.1 Explain the difference between tangential velocity and the angular velocity. If one of these is given for a wheel of known radius, how will you find the other?

Ans:

TANGENTIAL VELOCITY	ANGUALR VELOCITY
• Velocity of a body along the tangent is known as tangential velocity of linear velocity.	• Angular velocity of a body is the rate of change of angular displacement.
• Its unit is m/s	• Its unit is radian/sec
• Its direction is along tangent	• Its direction is along the axis of rotation.
• $v_t = \frac{\Delta d}{\Delta t}, v = r\omega$	• $\omega = \frac{\Delta\theta}{\Delta t} \omega = \frac{v}{r}$

If one of them is given for a wheel of known radius, then other can be calculated using the relation $v = r\omega$

5.2 Explain what is meant by centripetal force and why it must be furnished to an object if the object is to follow a circular path?

Ans: Definition

"The force needed to bend the normally straight path of the particle into a circular path is called centripetal force"

Centripetal Force only changes the direction of motion

When a force acts perpendicular to the direction of motion of a body then that force changes only the direction of motion of the body. When a body moves in a circular path then at every instant its direction of motion changes. It means that a force always acts perpendicular to the direction of motion which keeps the body moving in the circular path. This force is called centripetal force. If we stop applying the centripetal force, body will move on the straight path. Hence it must be furnished so that direction of motion of body changes continuously due to which straight path bends into circular path.

5.3 What is meant by moment of inertia? Explain its significance.

Ans: DEFINITION:

"The rotational analogous of linear mass is called moment of inertia"

It is denoted by I.

SIGNIFICANCE:

It plays same role in angular motion which inertia plays in linear motion. It resists angular / circular motion as inertia resists linear motion.

It may be noted that moment of inertia depends not only on mass m but also on r^2.

5.4 What is meant by angular momentum? Explain the law of conservation of angular momentum.

Ans: Angular Momentum:

The moment of linear momentum of a body about a point is called angular momentum. OR

The cross product of position vector $\vec{r}$ and linear momentum $\vec{P}$ of an object is called angular momentum. It is denoted by $\vec{L}$.

Mathematically, $\vec{L} = \vec{r} \times \vec{p}$

Law of conservation of angular momentum:
It states that if no external torque acts on a system, the total angular momentum of the system remains constant.

$\vec{L}_{Total} = \vec{L}_1 + \vec{L}_2 + \text{-----------} = \text{constant}$

$I_1\omega_1 = I_2\omega_2 = \text{constant}$ (For an isolated system)

5.5 **Show that orbital angular momentum $L_0 = mvr$**

Ans: **Proof**

Consider a boy of mass m is moving in a circular path of radius r with speed V, the angular momentum of the body is given by

$$\vec{L}_o = \vec{r} \times \vec{P}$$

The magnitude of angular momentum is given by

$$L_o = rp\sin\theta$$

$$(\because \theta = 90^0)$$

$$L_o = rp\sin 90^0$$

$$L_o = rp \qquad (\because \sin 90^0 = 1)$$

As, $p = mv$

So,

$$L_0 = rmv$$

Hence, Proved, $L_0 = mvr$

5.6 **Describe what should be the minimum velocity, for a satellite, to orbit close to the Earth around it.**

Ans: **Definition:**

"The minimum velocity necessary to put the satellite into an orbit close to the surface of Earth is called critical velocity."

It is given by the relation.

$v = \sqrt{gR} = \sqrt{9.8 \times 6.4 \times 10^6}$

$v = 7.9 \times 10^3 m\sec^{-1}$

So, $v = 7.9kms^{-1}$

5.7 **State the direction of the following vectors in simple situation; angular momentum and angular velocity.**

Ans: The direction of angular momentum and angular velocity is determined by right hand rule.

For Angular Momentum:

- We know that:

$$\vec{L} = \vec{r} \times \vec{p}$$

- This shows that the direction of angular momentum is perpendicular to the plane containing $\vec{r}$ and $\vec{p}$.
- In case of circular motion, angular momentum is perpendicular to the plane of circle and is along axis of rotation.

For Angular velocity:

The direction of angular velocity is perpendicular to the plane of the circle and is along the axis of rotation.

5.8 Explain why an object, orbiting the Earth, is said to be freely falling. Use your explanation to point out why objects appear weightless under certain circumstances.

Ans: When an object is orbiting around the Earth, force of gravity provides the necessary centripetal force, as no force is holding that object. Therefore, it is freely falling frame of reference. The curvature of path of the object and the Earth prevent it from falling on the surface of Earth.

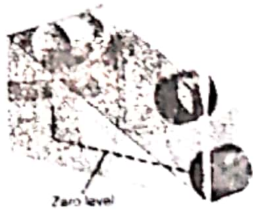
In a freely falling frame of reference, the frame of reference and the objects inside the frame of reference are falling at the same rate i.e. same acceleration $a = g$, therefore they appear to be weightless.

5.9 When mud flies off the tyre of a moving bicycle, in what direction does it fly? Explain.

Ans: When tyre of bicycle moves, then initially mud rotates with the tyre. The adhesive force between mud and the tyre provides necessary centripetal force to rotate the mud along with tyre. When speed of tyre increases, more centripetal force is required by mud to rotate with tyre. Since, adhesive force is not enough to provide necessary centripetal force. Therefore, the mud flies off the tyre in a direction of tangent to the circular path.

5.10 A disc and hoop start moving down from the top of an inclined plane at the same time. Which one will be moving faster on reaching the bottom?

Ans: When a disc and a hoop start moving down from the top of the inclined plane, then the speed of disc is greater than the speed of hoop on reaching the ground because moment of inertia of disc is lesser than that of hoop.



For DISC

$$v = \sqrt{\frac{4}{3}gh}$$

For HOOP

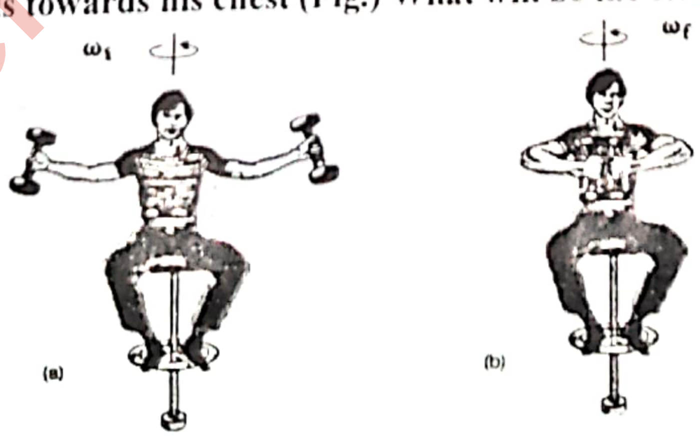
$$v = \sqrt{gh}$$

This shows that the speed of disc is greater than that of hoop

5.11 Why does a diver change his body positions before and after diving in the pool?

Ans: When a diver jumps off the diving board, he has small angular velocity about the horizontal axis through his centre of gravity. When he draws his legs and arms close to his body, his moment of inertia decreases and to conserve angular momentum, his angular velocity increases and he spins faster. This enables the diver to take extra somersaults.

5.12 A student holds two dumb-bells with stretched arms while sitting on a turn table. He is given a push until he is rotating at certain angular velocity. The student pulls the dumb-bells towards his chest (Fig.) What will be the effect on rate of rotation?



Ans: When the student pulls the dum–bells towards his chest, his moment of inertia decreases and to conserve angular momentum, his angular velocity increases and he spins faster.

13 **Explain how many minimum number of geo-stationary satellites are required for global coverage of T.V transmission.**

Ans: To cover the whole earth, three properly positioned geo stationary satellites are required. Each satellite covers an angle of 120^0 longitude and three satellites will be covering complete angle of 360^0.

SHORT QUESTIONS

(From past papers 2012-2017)

(Federal Board)

(1) Why does a diver change his body positions before and after diving in the pool? **(FDR 2012)**

(2) A disc and a hoop start moving down from the top of an inclined plane at the same time which one will be moving faster on reaching the bottom? **(FDR 2012)**

(3) Relate how orbital speed of a sate satellite depends on its radius. **(FDR 2013)**

(4) Define radian. **(FDR 2013)**

(5) State the direction of the following vectors in simple situation. **(FDR 2013)**

a. Angular momentum

b. Angular velocity

(6) What is Einstein's view of gravitation? **(FDR 2014)**

(7) Briefly describe gravity free system. **(FDR 2015)**

(8) Why does a diver change his body positions before and after diving in the pool? Explain **(FDR 2016)**

(9) A disc and hoop start moving down form the top of an inclined plane at the same time. Which one will be moving faster on reaching the bottom and Why? (Justify your answer by using mathematical equations) **(FDR 2017)**

(10) What is the least speed at which an aero plane can execute a vertical loop of 1 km radius so that there will be no tendency for the pilot to fail at the highest point. **(FDR 2017)**