Chapter = 05

Circular Motion

Circular motion: The motion of an object in circular path is called circular motion. For example motion of satellite in orbit around the earth.

What is Angular displacement? State right hand rule.

Angular displacement: The angle subtended at the center of circle by a moving body in given time is called angular displacement. SI unit of angular displacement is radian.

Right hand rule to find the direction of angular displacement: "Rotate the fingers of your right hand through some possible angle then erect thumb will show the direction of angular displacement.

Radian: The angle subtended at the center of circle by an arc whose length is equal to radius of circle is called radian.

Prove that S=rϴ.

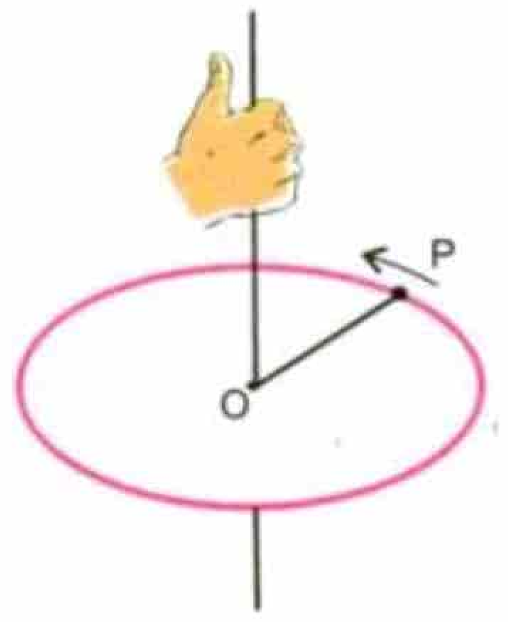
let S is the length of circle of radius r

which makes an angle θ at the center

$$\theta = \frac{\text{arc length}}{\text{radius}} (rad)$$

$$\theta = \frac{S}{r}$$

$$S = r\theta$$



Prove that 1 radian=57.3°

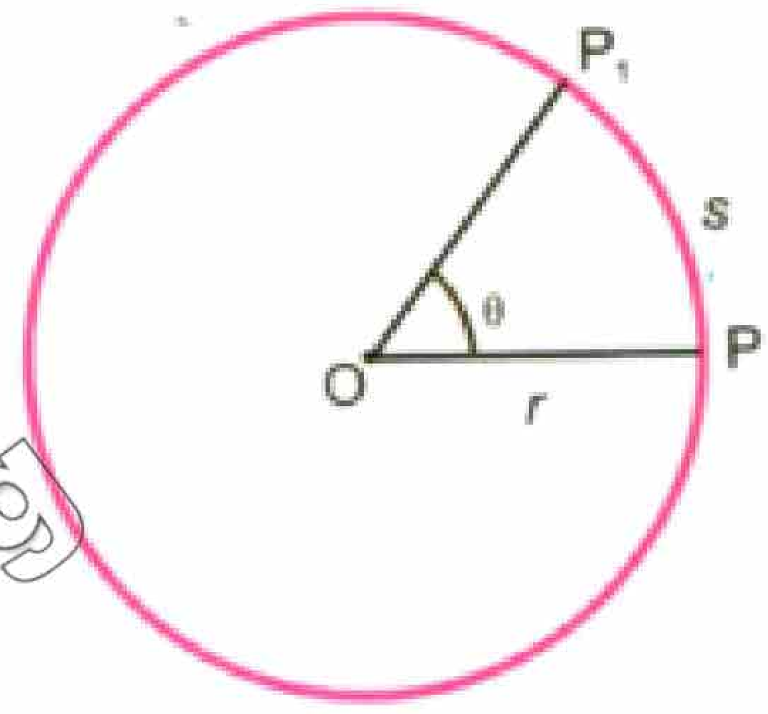
As we know that in one revolution distance covered by a particle is equal to circumference $S = 2\pi r$

$$\theta = \frac{S}{r} = \frac{2\pi r}{r}(\text{rad}) = 2\pi \text{ radian}$$

as angle for circle is $\theta = 360^\circ$ so

$$360^\circ = 2\pi \text{ radian} \Rightarrow 1 \text{ radian} = \frac{360^\circ}{2\pi}$$

$1 \text{ radian} = 57.3^\circ$ which is required result



What is Angular velocity? What is average and instantaneous angular velocity?

Angular velocity: Time rate of change of angular displacement is called angular velocity. Its formula is $\omega = \frac{\Delta\theta}{\Delta t}$.

SI unit is radian/sec. It is vector quantity. Its dimension are $[T^{-1}]$. Its direction is along the axis of rotation.

Average angular velocity: The ratio of total change in angular displacement to total time is called average angular velocity. $<\omega> = \frac{\Delta\theta}{t}$

Instantaneous angular velocity the angular velocity at any instant of time when limiting value approaches to zero is called instantaneous velocity. $\omega = \lim \Delta t \to 0 \frac{\Delta\theta}{\Delta t}$

Define Angular acceleration? what is average and instantaneous angular acceleration?

Definition: The time rate of change of angular velocity is called angular acceleration.

Its formula $\alpha = \frac{\Delta\omega}{\Delta t}$. It is vector quantity and SI unit is rad/sec^2 and $[T^{-2}]$, its direction is along the axis of rotation.

Average angular acceleration: The ratio of total change in angular velocity to the total time interval is called average angular acceleration. $<\alpha> = \frac{\Delta\omega}{t}$.

Instantaneous angular acceleration: The angular acceleration at any instant of time when limiting value approaches to zero is called instantaneous angular acceleration $\alpha = \lim \Delta t \to 0 \frac{\Delta\omega}{\Delta t}$.

Relation b/w linear and angular velocities OR prove that $v = r\omega$

let a point P in rigid body at perpendicular distance r from axis of rotation with linear velocity v,

$\Delta S = r\Delta\theta$

dividing both sides by Δt

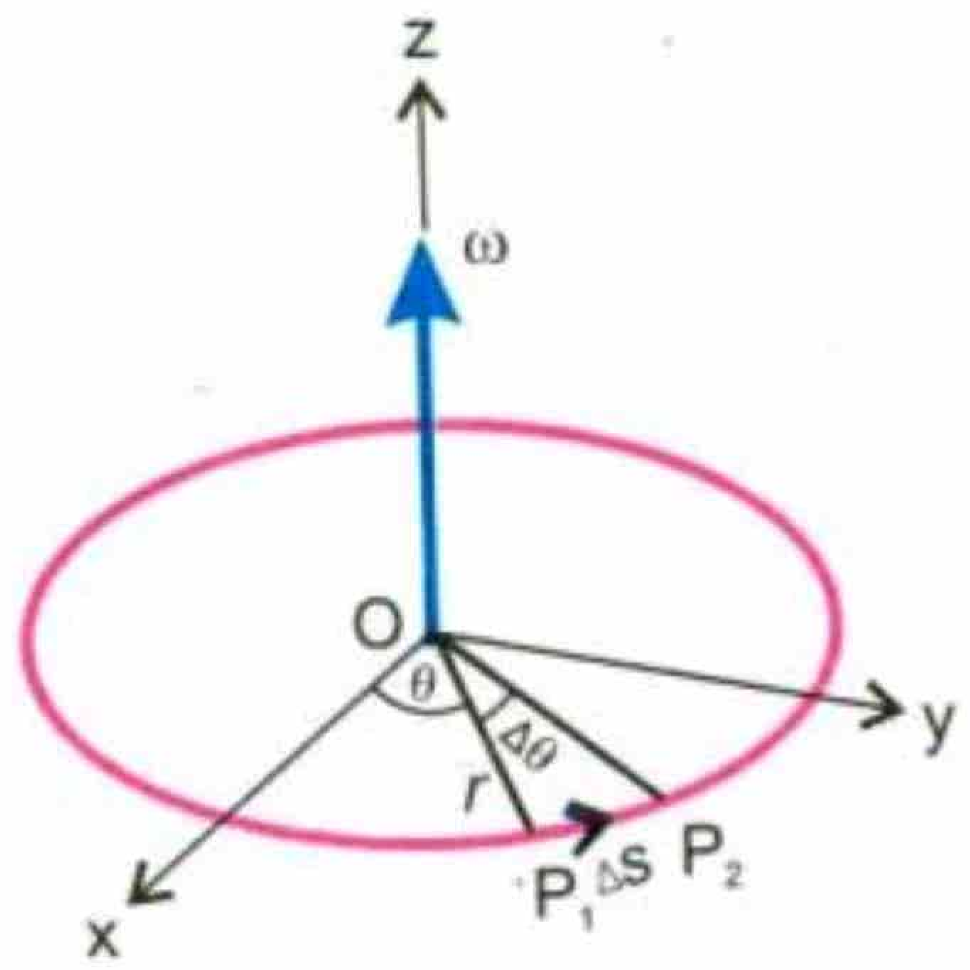
$\frac{\Delta S}{\Delta t} = r\frac{\Delta\theta}{\Delta t}$ taking limit on both sides

$\lim \Delta t \to 0 \frac{\Delta S}{\Delta t} = \lim \Delta t \to 0\, r\frac{\Delta\theta}{\Delta t}$ ----(1

As $\lim \Delta t \to 0 \frac{\Delta S}{\Delta t} = v, \lim \Delta t \to 0 \frac{\Delta\theta}{\Delta t} = \omega$

put in eq (1

$v = r\omega$ which is required result



Relation b/w angular and linear acceleration. OR prove that $a = r\alpha$

let a point P in rigid body at perpendicular distance r from axis of rotation with with angular acceleration α,

$\Delta v = r\Delta\omega$

dividing both sides by Δt

$\frac{\Delta v}{\Delta t} = r\frac{\Delta\omega}{\Delta t}$ taking limit on both sides

$\lim \Delta t \to 0 \frac{\Delta v}{\Delta t} = \lim \Delta t \to 0\, r\frac{\Delta\omega}{\Delta t}$ ----(1

As $\lim \Delta t \to 0 \frac{\Delta v}{\Delta t} = a, \lim \Delta t \to 0 \frac{\Delta\omega}{\Delta t} = \alpha$

put in eq (1

$a = r\alpha$ which is required result

Write Equations of motion in case of angular motion

Uniform acceleration	Angular velocity
$V_f=V_i+at$	$\omega_f = \omega_i + \alpha t$
$S=V_it+1/2\, at^2$	$\theta = \omega_i + \frac{1}{2}\alpha t^2$
$2as=V_f^2-V_i^2$	$2\alpha\theta = \omega_f^2 - \omega_i^2$

What is Centripetal force and centripetal acceleration? derive their relations.

Centripetal force: The force which move the body in circular path is called centripetal force. For example force acting on Earth around the sun. $F_c=mv^2/r$.

Centripetal acceleration: The acceleration which is produced by centripetal force is called centripetal acceleration. Its formula is $a=v^2/r=w^2r$. It is also called radial acceleration. The direction of centripetal acceleration is along the radius towards the center of circle.

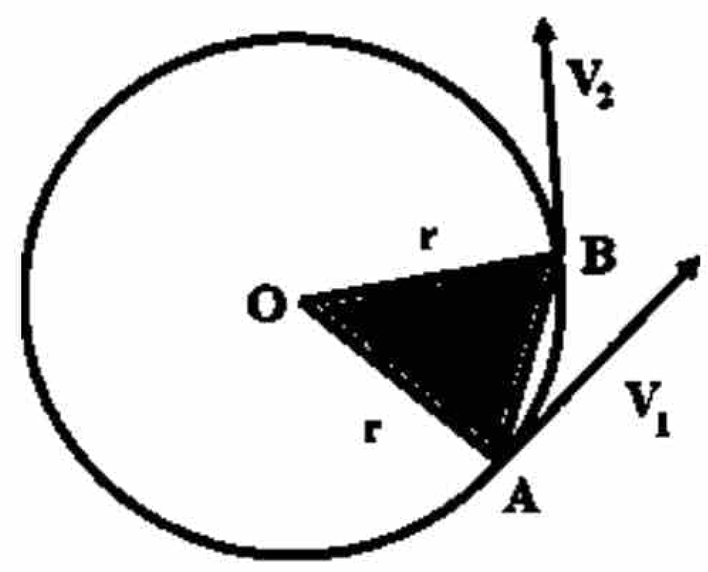
Expression for centripetal acceleration and centripetal force: Let us consider a particle of mass moves from point A to point B with uniform speed v. the velocity of the particle changes its direction but magnitude remains same. This change in velocity is shown in fig produce acceleration whose value

$a = \frac{\Delta V}{\Delta t}$ ---------------------- (1)

Let $\vec{V}_1$ and $\vec{V}_2$ are the velocities at point A and point B so magnitude of both speed are equal. $V_1 = V_2 = |V| = V$. so time taken to travel distance S or AB is Δt which is Δt=S/V put in equation (1)

$a = \frac{\Delta V}{S/V} = \frac{V\Delta V}{S}$---------------------- (2)

For calculation of ΔV we draw a triangle ΔPQR such that PQ is parallel to $\vec{V}_1$ and PR is parallel to $\vec{V}_2$

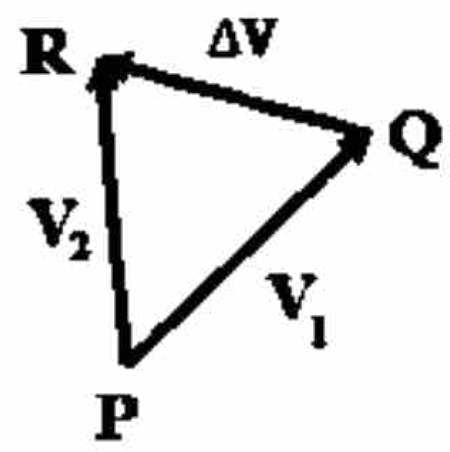


So from isosceles triangle PQR the value of angle $\theta = \frac{QR}{PR} = \frac{\Delta V}{V}$ ----- (i)

Similarly From triangle OAB, the value of angle $\theta = \frac{AB}{r} = \frac{S}{r}$ ---------- (ii)

Comparing both (i) and (ii) we get $\frac{\Delta V}{V} = \frac{S}{r}$ $\Delta V = \frac{SV}{r}$ putting in equation (2)

$a = \frac{V(\frac{SV}{r})}{S} = \frac{V^2}{r}$, this is the formula for centripetal acceleration



Expression for centripetal force: As we know that F=ma, and $a = \frac{V^2}{r}$ putting in formula to get result

$F = \frac{mV^2}{r}$ this is the formula for centripetal force, in case of angular motion V=rω so we get

$F_c = \frac{m(r\omega)^2}{r} = \frac{mr^2\omega^2}{r} = mr\omega^2$, this is centripetal force, its unit is newton and dimension $[MLT^{-2}]$, and it is only force which perform no work.

What is Moment of Inertia? Calculate the torque in terms of moment of inertia on rigid body.

Definition: The product of mass of particle and square of its perpendicular distance from axis of rotation is called moment of inertia. It is scalar and unit is kgm^2. Its formula is $I = mr^2$ and its dimension is $[ML^2]$.

Significance: Moment of inertia plays the same role in angular motion as mass play in linear motion.

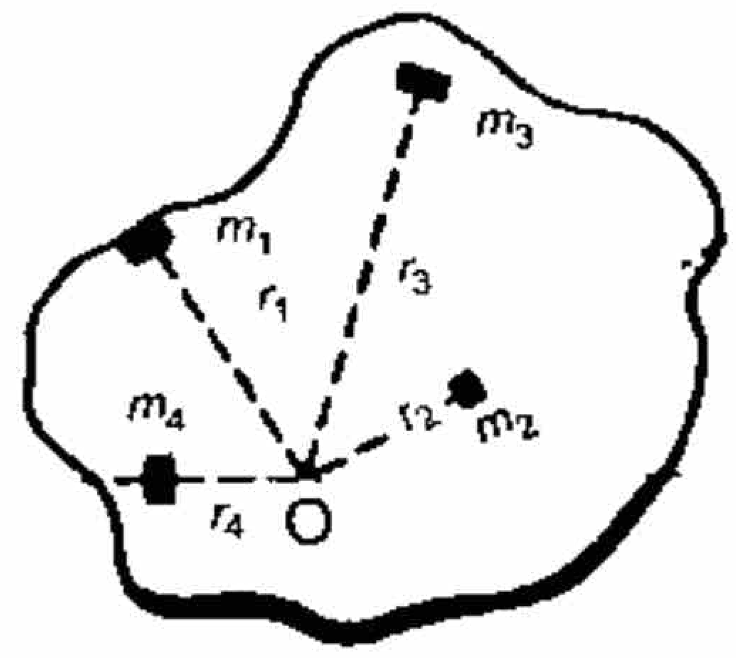
Explanation: consider a mass which is attached to a massless rod which can rotate about a frictionless axis of rotation O. let the system be in horizontal place. A force F acts on the mass perpendicular to rod, F=ma. This force rotates the mass in angular motion a=rα, equation of force

F=mrα multiplying both sides by r, $rF = mr^2\alpha$

As Ʈ= r F, $Ʈ = mr^2\alpha$ as we know that $I = mr^2$

Ʈ=Iα, is the torque acting on a body of mass.

Moment of inertia of rigid body:



Consider a rigid body made up of n small pieces of masses $m_1, m_2, m_3 \ldots m_n$

Magnitude of torque acting on m_1 $Ʈ_1 = m_1 r_1^2 \alpha_1$

Magnitude of torque acting on m_2 $Ʈ_2 = m_2 r_2^2 \alpha_2$

Magnitude of torque acting on m_n $Ʈ_n = m_n r_n^2 \alpha_n$

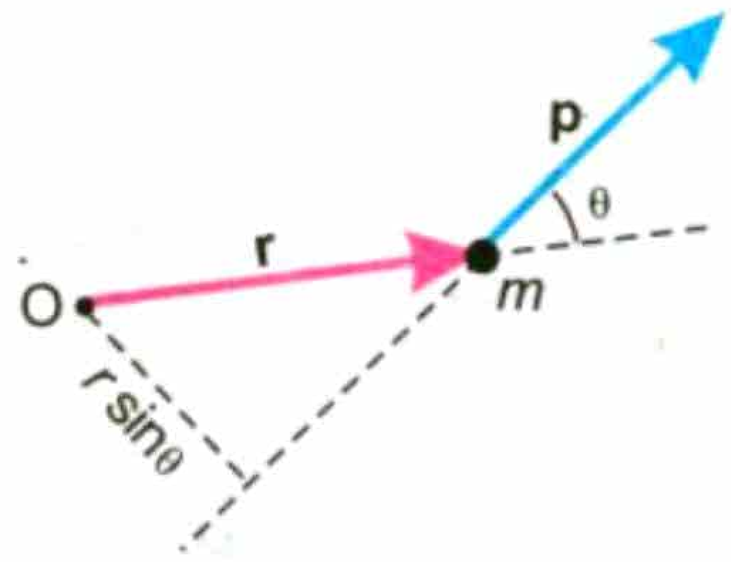
Total torque $Ʈ = Ʈ_1 + Ʈ_2 + \ldots\ldots\ldots + Ʈ_n = m_1 r_1^2 \alpha_1 + m_2 r_2^2 \alpha_2 + \ldots\ldots\ldots + m_n r_n^2 \alpha_n = (m_1 r_1^2 + m_2 r_2^2 + \ldots + m_n r_n^2)\alpha = I\alpha$

Thin rod $= I = \frac{1}{12} mL^2$, Thin Ring or Hoop $= I = mr^2$, solid cylinder $= I = \frac{1}{2} mr^2$, sphere $= I = \frac{2}{5} mr^2$

What is Angular momentum? Prove that L=Iω.

Definition: The cross product of position vector **r** about axis of rotation and linear momentum **P** of rotating body is called angular momentum. Its SI unit is kgm^2/s or Js , whose dimension are $[ML^2T^{-1}]$.

Explanation: Consider a body mass m moving with v and linear momentum relative to origin then angular momentum



$$\text{As we know taht } \vec{L} = \vec{r} * \vec{P} = rP\sin\theta\,\hat{r}$$

$$\text{put } P = mv \text{ and } \theta = 90^o$$

$$L = r(mv)\sin 90^o = mvr$$

$$\text{as we know that } v = r\omega$$

$$L = m(\omega r)r = mr^2\omega = I\omega$$

The direction of angular momentum is perpendicular to plane containing $\vec{r}$ and $\vec{P}$.

Angular momentum of rigid body: Consider rigid body rotating body about a fixed axis through center of mass m as shown in fig, each particle rotates about the same axis in circle with same angular velocity ω.

Magnitude of angular momentum acting on m_1 $L_1= m_1r_1^2\omega_1$

Magnitude of angular momentum acting on m_2 $L_2= m_2r_2^2\omega_2$

Magnitude of angular momentum acting on m_n $L_n= m_nr_n^2\omega_n$

Total $L= L_1+ L_2+\ldots\ldots\ldots + L_n = m_1r_1^2\omega_1 + m_2r_2^2\omega_2 +\ldots\ldots\ldots + m_nr_n^2\omega_n = (m_1r_1^2 + m_2r_2^2 +\ldots + m_nr_n^2)\omega= I\omega$

Spin angular momentum: Angular momentum of spinning body is called spin angular momentum L_s.

Orbital angular momentum: Angular momentum of orbiting in circular path is called orbital angular momentum.

Point object: Such an object whose radius is larger as compared to size of the body is called point object.

State and explain Law of conservation of angular momentum.

Statement: If no external torque acts on a system, total angular momentum remains constant. $I_1\omega_1 = I_2\omega_2$

Explanation: This law has great importance for Earth as it moves around the sun. No other sizable torque is experience the Earth, because the major force acting on it is the pull of the sun, the Earth's axis of rotation, therefore, remains fixed in one direction with reference to the universe around us.

Other examples: (1) a man diving from diving board (2) Diving (3) Gymnastics (4) Ice-skating.

What is Rotational Kinetic Energy? calculate rotational kinetic energy and speed for disc and hoop.

Definition: The energy possessed by a body due to its rotation about an axis is called rotational kinetic energy. **OR** the kinetic energy of rotating or spinning body is called rotational kinetic energy.

Derivation: To derive the relation for rotational kinetic energy, consider a piece of mass dividing into (m_1, m_2,m_n) from a distance (r_1,r_2,r_3,….r_n), also we know v=rω then

K.E= $\frac{1}{2}mv^2=\frac{1}{2}m(r\omega)^2=\frac{1}{2}mr^2\omega^2$,

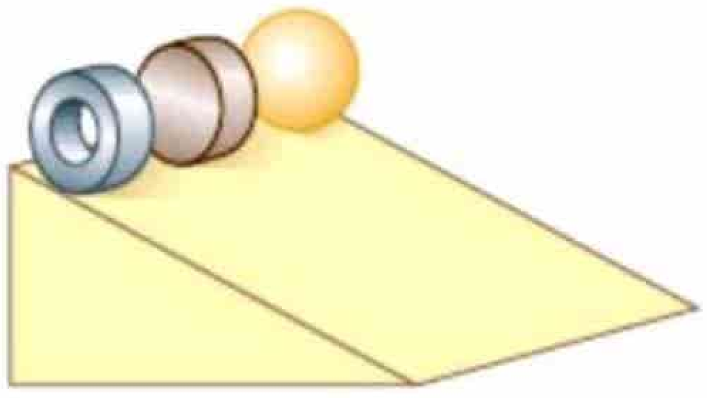
for each part its sum will be

K.E rot=$\frac{1}{2}m_1r_1^2\omega_1^2 + \frac{1}{2}m_2r_2^2\omega_2^2 +\ldots\ldots\ldots+ \frac{1}{2}m_nr_n^2\omega_n^2 = \frac{1}{2}(m_1r_1^2 + m_2r_2^2 +\ldots+ m_nr_n^2)\omega^2$

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

Uses: It is used by fly wheel which are compulsory parts of many engines. A fly wheel stores energy b/w the power strokes of piston.

Rotational kinetic energy of a disc	**Rotational kinetic energy of hoop**
We know that $K.E_{rot}= \frac{1}{2} I\omega^2$	We know that $K.E_{rot}= \frac{1}{2} I\omega^2$
For a disc $I= \frac{1}{2} mr^2$ as we know v=rω	For a hoop $I= mr^2$ as we know v=rω
$K.E_{rot}= \frac{1}{2}(\frac{1}{2}mr^2)\omega^2= \frac{1}{4}m(r^2\omega^2)= \frac{1}{4}m(r\omega)^2= \frac{1}{4}mv^2$	$K.E_{rot}= \frac{1}{2}(mr^2)\omega^2= \frac{1}{2}m(r^2\omega^2)= \frac{1}{2}m(r\omega)^2= \frac{1}{2}mv^2$

Velocity of a disc	Velocity of hoop
Consider a disc starts moving down an inclined place of height h, its motion consists of both rotational and translational motion as shown in fig $P.E = K.E_{tran} + K.E_{rot}$ $mgh = \frac{1}{2}mv^2 + \frac{1}{4}mv^2$ for disk $K.E_{rot} = \frac{1}{4}mv^2$ $mgh = \frac{2mv^2 + mv^2}{4} = \frac{3mv^2}{4}$ $v^2 = \frac{4gh}{3}$ $v = \sqrt{\frac{4gh}{3}}$ 	Consider a hoop starts moving down an inclined place of height h, its motion consists of both rotational and translational motion as shown in fig $P.E = K.E_{tran} + K.E_{rot}$ $mgh = \frac{1}{2}mv^2 + \frac{1}{2}mv^2$ for disk $K.E_{rot} = \frac{1}{2}mv^2$ $mgh = \frac{mv^2 + mv^2}{2} = \frac{2mv^2}{2} = mv^2$ $v^2 = gh$ $v = \sqrt{gh}$ conclusion: it is concluded from both equations that $D_{isc} > V_{hoop}$

What is Artificial satellite? Derive the formula for speed and time period of artificial satellite.

Satellite: The objects which orbits around the Sun are called satellites.

Artificial satellite: The man-made objects that orbit around the Earth is called artificial satellite. They are put into orbits by rockets and era held in orbits by gravitational pull of Earth. The low flying satellites have acceleration 9.8 ms^{-2} towards the center of Earth.

Critical velocity for artificial satellite: "The minimum velocity required to put the satellite into orbit around Earth"

Formula for critical velocity: consider a satellite moving in a circle of radius R having centripetal force which is supplied by gravitational force.

$$\text{Centripetal force} = \frac{mv^2}{R} \text{ --------(1)} \quad \text{Gravitational force} = mg \text{ -----------------(2)}$$

$$\text{comparing both equations} \quad \frac{mv^2}{R} = mg \Rightarrow v^2 = gR$$

$$v = \sqrt{gR} \quad \Rightarrow v = \sqrt{9.8*6.4*10^6} = 7.9*10^3 \text{ m/s} = 7.9 \text{ km/s}$$, this is the numerical value of critical velocity.

Time period: "The time required by the satellite to complete one revolution around the Earth is called Time period".

$$\text{As we } S = vt \quad \Rightarrow t = \frac{S}{v} = \frac{2\pi\pi}{v} = \frac{2*3.14*6.4*10^6}{7.9*10^3} = 5060\text{sec} \approx 84 \text{ min}$$

If the satellite moves at height h from surface the earth, thus higher the satellite, the slower will be the required speed and longer it will take to complete one revolution around the earth. Closest orbiting satellite the Earth at a height of 400Km.

Global positioning system: There are twenty four satellites close orbiting satellites form the global positioning system. With help of this system, an airline pilot, sailor or any other person can now use a pocket size instrument or mobile phone to find his position on the Earth's surface to within 10m accuracy.

What is Real and apparent weight? Discuss its different cases.

Real weight: The gravitational pull of Earth on object is called real weight,
Apparent weight: Weight is generally measured by spring balance and the readings of spring balance is called apparent weight.
Apparent weight of an object in a lift: Consider the apparent weight of an object mass m suspended by a string and spring balance in a lift, the tension T in the string can be measured with help of spring balance.
Case 01: When the lift at rest or moving with uniform velocity: In this case, acceleration is zero as net force is zero on the object, if W is the gravitational force (Real weight) and T is tension (apparent weight) then using Newton's law

$T + (-W) = ma \qquad \Rightarrow T - W = m(0) \qquad a = 0 \text{ so}$

$T = W, \quad \text{Result : Apparent weight of an object is equal to real weight}$

Case 02: When the lift is moving upward with acceleration a: In this case upward force T is greater than real weight W then net force acting on the body will be T + (-W)= ma

$T - W = ma \qquad \Rightarrow T = W + ma$, Result : Apparent weight of object is increased by an amount ma than actual weight.

Case 03: When the lift is moving downward with acceleration a: In this case real weight W is greater than real apparent weight T then net force acting on the body will be W + (-T)= ma

$-T + W = ma \qquad \Rightarrow T = W - ma$, Result : Apparent weight of object is decreased by an amount ma than actual weight.

Case 04: When the lift is falling freely: When the lift is falling freely then a=g
T=W-ma= W-mg=mg-mg=0 as W=mg, ma=mg in this case apparent weight is zero.
Weightlessness: When the apparent weight of object is zero than this condition is called weightlessness.

Write a note on Weightlessness in satellite and gravity free system.

Weightlessness: When a satellite is falling freely in space under the action of force of attraction of Earth, then this state is called weightlessness.
Explanation:

- An Earth's satellite is freely falling object.
- To explain this if the projectile is thrown continuously at larger speeds then during its free fall to the Earth, the curvature of the path decrease with increasing horizontal speeds.
- If object is through fast enough parallel to the Earth, the curvature of its path will match the curvature of the Earth and space ship simply circle round the Earth.
- Its free fall acceleration is simply g.
- In fact the space ship is falling towards the center of Earth at all times but due to spherical shape of Earth, it never strikes the surface of Earth.

Gravity free system: When a satellite is moving under weightlessness then no force is required to hold it, such a system is called gravity free system.

What is Orbital velocity? Derive its formula.

Definition: The velocity of satellite with which it revolves around the Earth is called orbital velocity.

Formula: $v = \sqrt{\frac{Gm}{r}}$ Where r=R+h

Formula derivation: Let us consider a satellite of mass m moving with orbital velocity v around the Earth of mass.

If r is the radius of orbit then centripetal force $F = \frac{mv^2}{r} ------(1)$

It is provided by gravitational force b/w Earth and satellite $F = G\frac{Mm}{r^2} -----(2)$

equating (1) and (2) $\frac{mv^2}{r} = G\frac{Mm}{r^2} \qquad \Rightarrow v^2 = \frac{GM}{r}$

$v = \sqrt{\frac{GM}{r}}$, G = Gravitation constant, M = mass of Earth, r = R + h, R = radius of Earth, h = height of orbit from equator

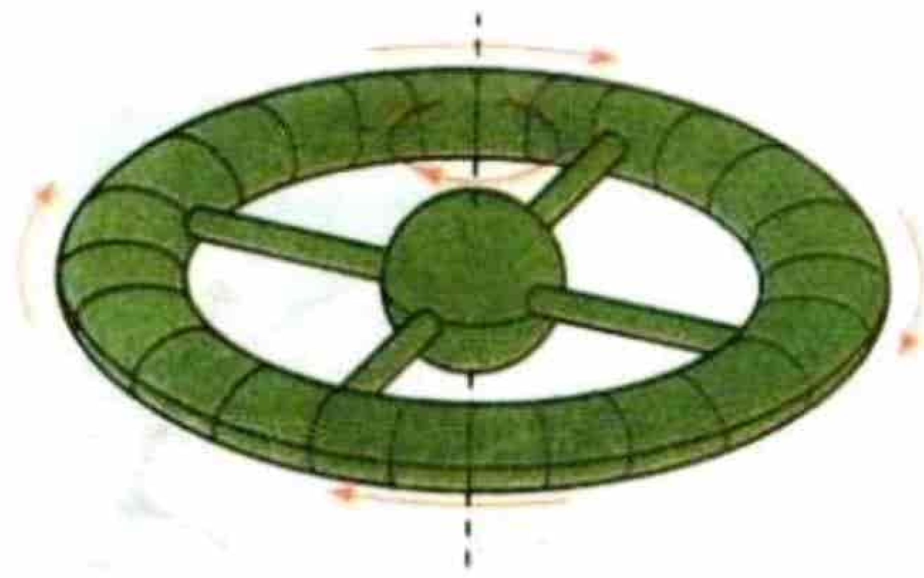
What is Artificial Gravity? Derive the expression for frequency of spaceship.

Artificial Gravity: The gravity produced in an orbiting satellite by spinning it around its own axis is called artificial gravity. Formula for frequency of spaceship for artificial gravity is $f = \frac{1}{2\pi}\sqrt{\frac{g}{R}}$.

Need of artificial gravity: If the spaceship is to stay in orbit for longer times, then weightlessness creates many problems for astronauts present in spaceship, to overcome this problem, artificially gravity is created.

How it produced: Artificial gravity is produced by rotating the spaceship around its own axis, the astronauts then pressed the outer rim and exert a force on the floor of spaceship in much as same way as on the Earth.

Expression for Frequency: Let us consider a spacecraft having radius R which rotates around its axis with angular speed ω, linear speed v=Rω. As force of gravity provides the centripetal acceleration so in this case a=g.



$$a_c = \frac{v^2}{R} = \frac{(R\omega)^2}{R} = \frac{R^2\omega^2}{R}$$

$$a_c = R\omega^2 ----------------(1)$$

$$as \text{ Angular frequency is } \omega = \frac{2\pi}{T} \text{ puttingin (1)}$$

$$a_c = R\left(\frac{2\pi}{T}\right)^2 = \frac{4\pi^2 R}{T^2} = 4\pi^2 R(\frac{1}{T^2}) \qquad \text{As } f = \frac{1}{T} \Rightarrow f^2 = \frac{1}{T^2}$$

$$a_c = 4\pi^2 R(f^2)$$

$$f^2 = \frac{1}{4\pi^2}\frac{a_c}{R} = \frac{1}{4\pi^2}\frac{g}{R} \qquad \text{As } a_c = g \text{ so}$$

$$f = \frac{1}{4\pi^2}\frac{g}{R}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{R}}, \text{ This is the formula for frequency of spaceship required to provide artificial gravity}$$

What is Geostationary Orbit? write its uses and derive the formula for radius of geostationary orbit.

Geo stationary orbit: The orbit in which the period of rotation of satellite is equal to period of rotation of Earth about its axis is called geo stationary orbit. A geostationary satellite orbits the Earth once per day(24h) over the equator.

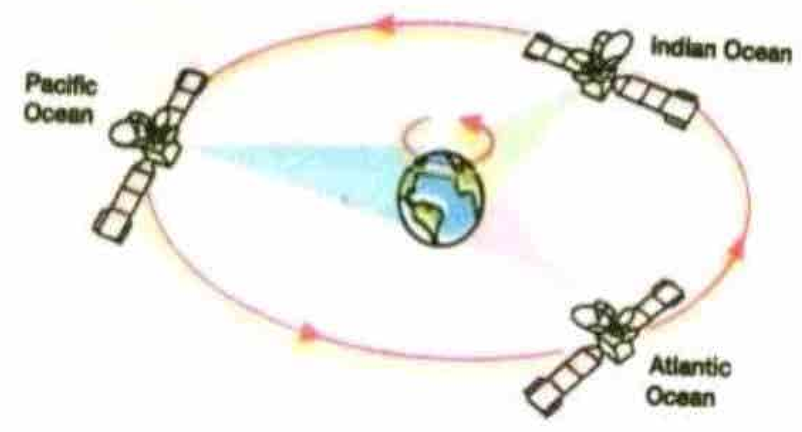
Uses of Geostationary orbit: There are following uses of geostationary orbit

Such satellite are used in communication system, weather observation and other military uses.

Expression for orbital radius of Geo stationary orbit: As we know that the orbital speed necessary for the circular orbit is given as $v = \sqrt{\frac{GM}{r}}$ ------------(1), r is the distance of satellite from Earth, M= Mass of earth

This speed must equal to speed s $v = \frac{S}{T} = \frac{2\pi r}{T}$ -----------(2), t is the period of revolution of satellite

Equating both equation $\frac{2\pi r}{T} = \sqrt{\frac{GM}{r}}$, squaring both sides



$\frac{4\pi^2 r^2}{T^2} = \frac{GM}{r} \quad \Rightarrow r^3 = \frac{GMT^2}{4\pi^2}$, Taking cube root on both sides

$r = \left(\frac{GMT^2}{4\pi^2}\right)^{1/3}$, This is the formula for orbital radius of geostationary satellite

$$r = \left(\frac{6.67*10-11*6*1024*(86400)^2}{4(3.14)^2}\right)^{1/3} = 4.23*10^4\,km$$

The height above the equator comes out to be 36000 km.

What is Communication satellite? Explain.

Definition: Such a satellite which is used for worldwide communication is called communication satellite.

- A communication system can be set up by placing many geostationary satellites in orbit over different point on surface of Earth.
- One such satellite covers 120° of longitude, so whole populated Earth surface covered 03 correctly position satellites.
- Solar cells provides the energy to amplify and retransmit the signal
- About 200 Earth stations transmit and receive signals via satellite from other countries

Why Microwaves are used in communication satellite?: Micro waves are used in communication satellite because they travel in straight line and can pass easily through atmosphere of the earth.

What is INTELSAT?: INTELSAT mean international satellite organization. It is managed by 126 countries. It works at the microwaves frequencies 4, 6, 11, 14 GHz and capacity of 30000 two way telephone calls plus 3 tv channels.1 GHz=10^9 Hz.

Describe Newton and Einstein views of gravitation.

Newton views about gravitation: "Gravitation is the intrinsic property of matter and gave law of gravitation which is

Law of gravitation: "Every particle of matter attract every particle with a force that is directly proportional the product of their masses and inversely proportional to the square of distance b/w them", $F=Gm_1m_2/r^2$.

Einstein Views about gravitation: According to Einstein gravity is due to the curvature of space and time, to observe this we take example of thin rubber sheet, if a heavy weight is hung from it, it curves.

According to Einstein bodies and light rays move along

Geodesics: Such path which is equailent to straight line in plane geometry is called geodesics.

What is Differences b/w Einstein and Newton views about gravitation?

Newton views	Einstein views
Newton discovered inverse square law but give no explanation of it	Einstein theory gives a physical picture of how gravity works
According to Newton gravitation is due to force b/w masses.	According to Einstein gravity is due to the curvature of space and time

Why Einstein theory of gravity is better than Newton theory of gravitation?: It is better than Newton theory because it gives explanation of inverse square law of gravitation and deflection of light must bend light due to gravity by definite amount. So Einstein theory about gravity is better than Einstein theory.

Chapter = 05

Exercise Short Questions

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 (v)** "The linear velocity, along the direction of the tangent at any point on that curve which is followed by the moving particle".
Angular velocity (ω): "The rate of change of angular displacement of a particle moving along a curved path". Both are related as: $\mathbf{v} = r\,\omega$
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
The force needed to move a body around a circular path". Mathematically, $F = mv^2 / r = mr\omega^2$.Its direction is towards the center of the circle. Fc is furnished for an object moving in a circular path (of constant radius). For m & r constant, $F \propto \omega^2$,
3. What is meant by moment of inertia? Explain the significance.
The product of mass of particle and square of its perpendicular distance from axis of rotation is called moment of inertia. $I=mr^2$
I plays the same role in angular motion as that of mass in linear motion.
4. What is meant by angular momentum? Explain the law of conservation of angular momentum.
The cross product of position vector and linear momentum". Mathematically, $\mathbf{L} = \mathbf{r} \times \mathbf{p}$
"If no external torque acts on a system, the total angular momentum of the system remains constant". Mathematically, $T_{total} = L_1 + L_2 + \ldots = \text{constant}$.
5. Show that orbital angular momentum Lo = mvr.

$$\text{As we know taht } \vec{L} = \vec{r} * \vec{P} = rP\sin\theta\,\hat{r}$$

$$\text{put } P = mv \text{ and } \theta = 90^o$$

$$L = r(mv)\sin 90^o = mvr$$

$$Lo = mvr$$

6. Describe what should be the minimum velocity, for a satellite, to orbit close to the Earth around it.
The minimum velocity needed to orbit a satellite close to earth is called critical velocity. Its formula is
$v = \sqrt{gR}$ Its value is 7.9 km/sec
7. State the direction of the following vectors in simple situations; angular momentum and angular velocity.
The direction of angular velocity and angular momentum is along the axis of rotation stated by right hand rule " Grasp the axis of rotation in your right hand then erect thumb show the direction of angular velocity and moment and curled fingers show the direction of rotation".
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.
An object is given certain tangential velocity for orbiting the earth. It is like freely falling due to force of gravity. It will follow curved path due to two forces. The curvature of its path will match the curvature of the earth. Its centripetal acceleration equals its acceleration due to gravity; i.e. a = g, so T = mg – mg = 0. Hence it appears weightless.
9. When mud flies off the tyre of a moving bicycle, in what direction does it fly? Explain.
Ans. The mud will fly in a direction tangent to the wheel. When mud separates from the tyre, centripetal force is ceased from the mud particles
10. A disc and a hoop start moving down from the top of an inclined plane at the sametime. Which one will be moving faster on reaching the bottom?
Disc will be moving faster on reaching the ground

Because $v = \sqrt{\dfrac{4gh}{3}}$ For disc $v = \sqrt{gh}$ for hoop

$V_{disc} = \sqrt{\dfrac{4}{3}}\,gh = 1.15V_{hoop}$ so $V_{disc} > V_{hoop}$

11. Why does a diver change his body positions before diving in the pool?
To increase angular velocity, the diver changes his body positions. L = I ω = mr^2 ω for smaller r, ω will be greater. The diver closed his legs and arms to make smaller r so that his angular velocity increases to make more somersaults. $I_1\omega_1 = I_2\omega_2$.

12 A student holds two dumb-bells without stretched arms while sitting on a turntable. He is given a push until he is rotating at certain angular velocity. The student then pulls the dumbbell towards his chest. What will be the effect on rate of rotation?
His rate of rotation will increase, due to smaller r, the distance from the axis of the distribution of mass m. L = I ω = mr^2 ω When he pulls the dumbbells towards his chest, his moment of inertia decreases and he spins faster.

13 Explain how much minimum number of geo-stationary satellites are required for global coverage of T.V.
Three correctly positioned satellites are sufficient for global coverage of TV transmission. As one such satellite covers 120° of longitude.

Numerical problems

5.1: A tiny laser beam is directed from the Earth to the Moon. If beam is to have a diameter of 2.50 m at the Moon, how small must divergence angle be for the beam? The distance of Moon from the Earth is $3.8\times10^8 m$.

$$\text{Given Data}: S = 2.5\text{ m}, r = 3.8*10^8\text{ m}, \theta = ?$$

$$\theta = \frac{S}{r} = \frac{2.5}{3.8*10^8} = 6.6*10^{-9}\,rad$$

5.2: A gramophone record turntable accelerates from rest to an angular velocity of 45.0 rev min^{-1} in 1.60s. What is its average angular acceleration?

$$\text{Given data}: \omega i = 0, \omega_f = 45\text{ rev/min} = 45*2\pi\pi/6 = 1.5\pi\text{ rad/sec}, t = 1.60\text{ sec}, \alpha = ?$$

$$\alpha = \frac{\omega_f - \omega i}{t} = \frac{1.5\pi - 0}{1.6} = 2.95\text{rad s}^{-2}$$

5.3: A body of moment of inertia $I = 0.80\,kg\,m^2$ about a fixed axis, rotates with a constant angular velocity $100\ rad\ s^{-1}$. Calculate its angular momentum L and the torque to sustain this motion.

$$\text{Given Data}: I = 0.80\text{ kgm}^2, \omega = 100\text{ rads}^{-1}, \alpha = 0, L = ?\ \tau = ?$$

$$L = I\omega = 0.80*100 = 80\text{Js},\ \tau = I\alpha = I(0) = 0$$

5.4: Consider the rotating cylinder shown in fig. 5.26. Suppose that m=5.0 kg, F=0.60 N and r=0.20 m. Calculate (a) the torque acting on the cylinder, (b) the angular acceleration of the cylinder. (Moment of inertia of cylinder$=\frac{1}{2}mr^2$).

$$\text{Given data}: m = 5\text{kg}, F = 060\text{ N}, r = 0.2\text{ m}, \theta = 90^\circ, \tau = ?,\ \alpha = 0$$

$$\tau = rF\sin\theta = 0.2*0.6*\sin 90^\circ = 0.12\text{Nm},\quad I = 1/2mr^2 = 1/2*5(0.2)^2 = 0.1\text{kgm}^2$$

$$\text{As}\tau = I\alpha \Rightarrow \alpha = \frac{\tau}{I} = \frac{0.12}{0.1} = 1.2\text{rads}^{-2}$$

5.5: Calculate the angular momentum of a star of mass $2.0\times10^{30}kg$ and radius $7.0\times10^{5}km$. If it makes one complete rotation about its axis once in 20 days, what is its kinetic energy?

Given Data : $m = 2*10^{30}$ kg, $r = 7*10^{5}$ km $= 7*10^{5}*10^{3}$ m $= 7*10^{8}$ m,

$T = 20$ days $= 20*24*60*60 = 1.728*10^{6}$ sec   Angular momentum = L = ?, K.E = ?

$$L = I\omega = \frac{2}{5}mr^2\frac{2\pi}{T} = \frac{2}{5}(2*10^{30})(7*10^{8})^2\frac{2*3.14}{1.728*10^{6}} = 1.42*10^{42}Js$$

$$K.E = \frac{1}{2}I\omega^2 = \frac{1}{2}\frac{2}{5}mr^2(\frac{2\pi}{T})^2 = \frac{1}{5}(2*10^{30})(7*10^{8})^2\left(\frac{2*3.14}{1.728*10^{6}}\right)^2 = 2.5*10^{36}J$$

5.6: A 1000 kg car travelling with a speed of 144km h^{-1} round a curve of radius 100m. Find the necessary centripetal force.

Given Data : m = 1000kg, v = 144 km/h = 144*1000/3600 = 40 m/s, r = 100 m, F_c = ?

$$F_c = \frac{mv^2}{r} = \frac{(1000)(40)^2}{100} = 16000N = 1.6*10^4N$$

5.7: What is the least speed at which an aeroplane can execute a vertical loop of 1.0km radius so that there will be no tendency for the pilot to fall down at the highest point?

Given Data : R = 1000m, v = ? g = 9.8 ms^{-2}

$$v = \sqrt{gR} = \sqrt{9.8*1000} = 99m/s$$

5.8: The Moon orbits the Earth so that the same side always faces the Earth. Determine the ratio of its spin angular momentum (about its own axis) and its orbital angular momentum. (In this case, treat the Moon as a particle orbiting the Earth). Distance between the Earth and the Moon is $3.85\times10^{8}m$. Radius of the Moon is $1.74\times10^{6}m$.

Given data : Radius of moon = $r_m = 1.74*10^{6}$ m, Distance b/w Earth and moon = $r = 3.85*10^{8}$ m

$$\frac{Ls}{Lo} = \frac{\frac{2}{5}mr^2{}_m\omega^2}{mr^2\omega^2} = \frac{2r^2{}_m}{5r^2} = \frac{2(1.74*10^{6})^2}{5(3.85*10^{8})^2} = 8.17*10^{-6}$$

5.9: The Earth rotates on its once a day. Suppose, by some process the Earth contracts so that its radius is only half as large as at present. How fast will it be rotating then? (For sphere $I = \frac{2}{5}MR^2$).

Given Data : $T_1 = 1$ day = 24 hour, T_2 = ? if radius of earth becomes half of present.

Using law of conservation of angular momentum $I_1\omega_1 = I_2\omega_2 \Rightarrow \frac{2}{5}mR_1{}^2*\frac{2\pi}{T_1} = \frac{2}{5}mR_2{}^2*\frac{2\pi}{T_2}$

$$R_1{}^2*\frac{1}{T_1} = (R_1/2)^2*\frac{1}{T_2} \Rightarrow \frac{R_1{}^2}{T_1} = \frac{R_1{}^2}{4T_2} \Rightarrow 4T_2 = T_1 \Rightarrow T_2 = \frac{T_1}{4} = \frac{24}{4} = 6\text{ hour}$$

5.10: What should be the orbiting speed to launch a satellite in a circular orbit 900 km above the surface of the Earth? (Take mass of the Earth as 6.0×10^{24} and its radius as 6400 km).

Given Data : M = 6*1024 kg, R = 6400Km, h = 900km, r = 600 + 900 = 7300Km, v = ?

$$v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{6.673*10^{-11}*6*10^{24}}{7300*10^{3}}} = 7.4*10^{3}m/s = 7.4Km/s$$

Chapter = 05

Multiple choice questions

1) As the wheel turns through an angle, it lays out a ----distance S=rɵ

Circular	**Tangential**	Linear	Angular

2) Which are needed for turn that taken so quickly that friction alone cannot provide energy for centripetal force

Banked tracked	Linear track	Circular track	None

3) Curved flight at high speed requires a --- centripetal force that make the stunt dangerous even if the air planes are not so close

Small	**Large**	Zero	Maximum

4) Two cylinders of equal mass, which mass has greater rotational inertia?

Smaller diameter	**Larger diameter**	Both have equal diameter	None

5) As the sphere rolls to the bottom of inclided surface, its gravitational potential energy is changed to

Kinetic energy of rotation	Kinetic energy of translation	**Both A&B**	None

6) As the wheel rolls, it has

Translational K.E	Rotational K.E	**Both A&B**	None

7) Global positioning system tracked immediately the ---when switch on mobile phone

Time	**Location**	Both A&B	None

8) Your apparent weight differ from your true weight when the velocity elevator changes

At the start	At the end	**Both A&B**	None

9) Which satellite is first human satellite of Earth

Bruce McCandless	Hawaii	Island	None

10) When Hawaii island stepped into space the first human satellite

1987	1985	**1984**	1986

11) First human satellite was above the height of Hawaii island

100 km	200 km	300 km	400 km

12) Bruce McCandless have speed

290 km/h	29000 km/h	2900 km/h	29 km/h

13) The surface of rotating spaceship pushes on an object with which it is in contact provides—to keep object moving on a circular path

Linear force	**Centripetal force**	Angular motion	None

14) 1GHz=?

10^6 Hz	**10^9 Hz**	10^{12} Hz	10^{15} Hz

15) Which can bend light

Mass	**Gravity**	Acceleration	All of these

16) --- could be used to focus light from stars

Gravity of star	Mass of star	Radius of star	Atmosphere of star

17) Coasting rotating system slows down as water drip into beaker in order to conserve?

Momentum	**Angular momentum**	Mass	Torque

Previous all Punjab board exams solved MCQs

	Questions	Option A	Option B	Option C	Option D
1)	SI unit for angular displacement is	Meter	Degree	Revolution	**Radian**
2)	A satellite moving around the earth makes	**Inertial frame of reference**	Non inertial frame of reference	Both A&B	None of these
3)	The angular velocity of minute hand of a clock is	2π rad/s	π rad/sec	π/60 rad/s	**π/1800 rad/s**

$$\omega = \frac{\theta}{t} = \frac{2\pi \text{ rad}}{3600 \text{ sec}} = \frac{\pi}{1800} rad/\sec$$

4)	The period of revolution for geostationary satellite is	84 sec	84 min	84 hour	**24 hour or 1 day**
5)	The force which do not work on the body on which it acts is	Elastic force	Frictional force	Gravitational force	**Centripetal force**
6)	The angular momentum L is given by	**mxW**	**rxP**	Mv	None of these
7)	Minimum number of geostationary satellite to cover whole of the world	2	**3**	4	5
8)	When a body moves in circle then angle between linear and angular velocity	**90°**	0°	180°	45°
9)	One geostationary satellite coves the longitude of	90°	**120°**	180°	45°
10)	The light from stars can be focused by their	Mass	Distance	Radius	**Gravity**
11)	If angular velocity of rotating body in circle is doubled then moment of inertia	**Remains same**	Becomes half	Becomes double	Becomes four times
12)	Rotational kinetic energy for disc is given by	**¼ mv^2**	½ mv^2	1/3 mv^2	1/5mv^2
13)	Largest satellite system is managed by the countries	24	**126**	200	3
14)	If a gymnastic sitting on stool with his arms stretched out lowers his arms	Angular speed decreases	**Angular speed increases**	Both inertial and non-inertia	Neither inertia nor non inertial
15)	SI unit of angular velocity is	m/s	Radian	**Radian/sec**	Joule second
16)	Angular speed of daily rotation of earth is given by	2π	π	4π	**$7.3*10^5$ rad/sec**

$$\theta = wt, w = \frac{\theta}{t} = \frac{2\pi rad}{1day} = \frac{2\pi}{86400\sec} rad = 7.3*10^5 rad/s$$

17)	When torque acting on a system is zero then which of the following quantity remains same	Linear momentum	Force	**Angular momentum**	Impulse
18)	Centripetal force performs work	Maximum	**Zero**	Minimum	Negative
19)	A diver spin faster by reducing its	Torque	Angular momentum	**Moment of inertia**	Inertia
20)	Linear acceleration is	r times linear acceleration	**r times angular acceleration**	r times speed	None of these
21)	When happened to moment of inertia of thin rod if its length is doubled ?	1/12 ML^2	**1/3ML^2**	2/5 ML^2	ML^2
22)	The expression for spinning frequency to create artificial gravity in satellite is given by	$f = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$	$f = \frac{1}{2\pi}\sqrt{\frac{g}{R}}$	$f = \frac{1}{2\pi}\sqrt{\frac{m}{R}}$	None of these
23)	As the wheel turns out, it cover	Radial distance	**Tangential distance**	Circular distance	Straight distance
24)	SI unit of rotational kinetic energy is	Rad/Sec	Js	**J**	Kgm2
25)	20 N centripetal force move a body circle of radius 1m, work done by it	10 J	50 J	**0 J**	100 J
26)	The SI unit of angular momentum is	**JS**	Ns	Joule	Newton
27)	Which theory is better about gravitation?	**Einstein**	Newton	Plank	Michelson
28)	The direction of angular velocity is given by	Left hand rule	Head to tail rule	**Right hand rule**	General rule
29)	Dimension of angular momentum is	$[MLT^{-1}]$	**$[ML^{-2}T^{-1}]$**	$ML^2T]$	None of these
30)	The dimension of angular acceleration	$[T^{-1}]$	**$[T^{-2}]$**	$[LT^{-2}]$	$[LT^{-1}]$
31)	A man standing in an elevator is acted upon	One force	**Two force**	Three forces	Four forces

32)	The time period of artificial satellite is given by	T=1/f	$T=\frac{2\pi R}{v}$	$T=\sqrt{GM/R}$	$v=\sqrt{gR}$
33)	If a body is at rest or moving with uniform angular velocity then torque will be	**Zero**	Minimum	Maximum	None of these
34)	A man of weight w is standing on an elevator which is ascending with acceleration a the apparent weight of the man	**W+ma**	W-ma	W	Ma
35)	Rotational kinetic energy of a hoop moving down frictionless inclined plane with velocity v	**½ mv^2**	¼ mv^2	¾ mv^2	Mv^2
36)	Rotational kinetic energy K.Erot=?	**½ mr^2w^2**	½ mr^2w	½ mrw	1/2mrw^2
37)	The weight of man in an elevator moving with acceleration g will be	Half	Double	Four times	**Zero**
38)	According to Einstein space time is	Linear	**Curved**	Circular	Elliptical
39)	Rotational inertia of two equal masses cylinder but one has larger diameter will be	Lesser	**Larger**	Same	None of these
40)	A ball tied to the end of a string is swing in vertical circle under the action of gravity tension in string when ball is maximum height	Equal to centripetal force	**Zero**	Equal to weight of ball	Maximum
41)	A body of mass 8kg moves along a circle of radius 4m with constant speed of 8m/s , the centripetal force on the body is	48N	8N	**128N**	72N
	Put m=8kg, r=4m, v=8 m/s in formula of centripetal force $F_c=mv^2/r$				
42)	Two cylinder of same mass but different diameter are	Same I	**I is larger for larger diameter**	I is smaller for larger diameter	Depends upon angular velocity
43)	The angle subtended at the centre by circumference of the circle whose arc length is equal to radius	Π radian	3	2π radian	**Radian**
44)	The minimum velocity necessary to put a satellite into orbit is	7.1 Km/s	7.3 Km/s	**7.9Km/s**	8.9 Km/s
45)	Angular acceleration is produced by	Momentum	**Torque**	Pressure	Power
46)	SI unit of angular momentum are JS they can also be expressed as	Kgm/s	**Kgm^2/S**	Kgm^2s^{-2}	$Kgm^{-2}s^{-1}$
47)	A particle is moving in circle with constant speed, the direction of centripetal force will be	Along the tangent	**Along radius towards centre**	Along radius away from the centre	Changing with the motion
48)	A 100 kg man is standing in an elevator, which accidently falls freely. What will be the weight of the person in the freely falling elevator (take g=10 m/s2)	1000 N	500 N	10 N	**Zero** Due to free fall weightlessness condition occur so apparent will be equal to zero
49)	The weight of man in an elevator descending with an acceleration 4.9m/s² will	Twice	**Half**	Zero	Unchanged
50)	Which is unimportant in describing the satellite orbit	Distance from earth centre	Gravitation constant	**Mass of satellite**	Mass of earth
51)	1 revolution is equal to	57.3°	180°	**360°**	90°
52)	Which is larger for a hoop of mass M and radius R that is rolling without	Translational kinetic energy	Rotational kinetic energy	**Both are same**	Answer depends upon the radius

	slipping, its translational or rotational kinetic energy?				
53)	The direction of angular momentum of a body moving in a circle is	Along the tangent	**Perpendicular to the plane of circle**	Radially outward	Radially inward
54).	The counter part of force for rotational motion is called	Linear momentum	Angular momentum	Angular acceleration	**The torque**
55)	A man in an elevator descending with an acceleration will conclude that his weight has	Increased	**Decreased**	Reduced to zero	Not changed
56)	Moment of inertia of 100 kg sphere of radius 50cm will be	**10 kgm^2**	5 kgm^2	500kgm^2	2.5 kgm^2
	$I=2/5\ mr^2=2/5*100(50/100)^2=2/5*(100)*(1/4)=10kgm^2$				
57)	The apparent weight of a man in an ascending lift moving with acceleration "a"	**Increase**	Decrease	Remains constant	Becomes zero
58)	A body rotates with constant angular velocity of 100 rad/sec about a vertical axis, the required torque to sustain motion	**Zero Nm**	10 Nm	100 Nm	50 Nm
59)	The ratio of moment of inertia of disc and hoop is	¼	**2/4=1:2**	¾	4/4
	$I_{disc}=1/2\ mr^2$ $I_{hoop}=mr^2$ dividing to get the result				
60)	The velocity of stone whirled in a circle increase from 10 rev/min to 20 rev/min it has	Centripetal acceleration	**Centrifugal acceleration**	Tangential acceleration	No acceleration
61)	Velocity of hoop V_h and velocity of sphere Vs are related by	V_h>Vs	**V_h<Vs**	V_h=Vs	V_h=2Vs
62)	Ratio of moment of inertia of two objects 'A' and 'B' is 2:3. Which one of the following is the ratio of torques of 'A' and 'B' respectively, if both are being rotated with constant angular acceleration?	3:4	3:2	**2:3** Torque=Iα For constant α torque is proportional to I. so same ratio occur	4:3
63)	A wheel of radius 50cm having angular speed of 5 rad/sec will linear speed in m/s is	1.5	**2.5**	3.5	4.5
	As r=50cm=50/100=0.5m V=rw=0.5*5=2.5				
64)	When a diver change his position during jumping, which of the following quantities remains constant?	Moment of inertia	**Angular momentum**	Angular velocity	Linear momentum
65)	A body is moving in a circle under centripetal force F, if its linear velocity and radius both are made twice, the centripetal force will be	Fs	Fs/2	**$2F_s$**	4Fs
	As centripetal force is directly proportional to square of velocity and inversely to radius				
66)	The angular displacement of one revolution is equal to	1 radian	π/2 radian	Π radian	**2π radian**
67)	INTELSAT operates at microwaves frequencies of	4,6,8 and 10 Hz	4,6,8,10 MHz	4,6,8,12 Hz	**4,8,11,14 GHz**
68)	When a body is whirled in a horizontal circle by means of a string, the centripetal force is supplied by	Mass of body	Velocity of body	**Tension in string**	Centripetal acceleration
69)	If a car moves with uniform speed of 2m/s in a circle of radius 0.4m its angular speed is	4 rad/sec	**5 rad/sec**	1.6 rad/sec	2.8 rad/sec

	V=rw w=v/r= 2/0.4=5				
70)	Weight of a 60kg man in moving elevator(downward) with constant acceleration g/2(g=10 m/s²)	Zero	**300N**	600N	200N
	T=w-ma=mg-mg/2=mg/2=60*10/2=600/2=300 N				
71)	The ratio of orbital velocity to escape velocity is	1	1/2	$1/\sqrt{2}$	$\sqrt{2}$
	as $V_{esc} = \sqrt{\frac{2GM}{R}}$ and $V_o = \sqrt{\frac{GM}{R}}$ dividing both eq to get the result				
72)	One radian is equal to	**1/2π rev**	Π rev	π/2revolution	360 rev
	1 rev=2π radian. 1radian=above result				
73)	If m=100kg, r=50cm then moment of inertia	**25kgm²**	50 kgm²	500kgm²	5000 kgm²
	As m=100kg, r=50cm=50/100=0.5m I=mr²= 100*0.5²=100*0.025=25				
74)	36° is equal to	π/8	π/6	**π/5**	π/12
	To convert into radian multiply by π/180, 36*π/180=π/5				
75)	Centripetal acceleration is also called	Tangential Acceleration	**Radial Acceleration**	Angular Acceleration	Rotational Acceleration
76)	Weight of a body at the center of earth is	Maximum	Minimum	**Zero**	Infinite
77)	Satellite are the objects that orbit around the	Moon	Sun	**Earth**	Star
78)	A body moves in a circle with increasing angular velocity, at time't'= 6s the angular velocity is 27rad/s... What is the radius of circle where linear velocity is 81cm/s	6cm	7cm	9cm	**3cm** V=rw r=v/w 81/27=3
79)	A wheel of radius 1 m covers an angular displacement of 180°. Its linear displacement is	3.14 m	6.28 m	**π rad** 180=π rad S=rө	0.157 m
80)	If linear velocity and radius are both made to half of a body moving around a circle, the centripetal force becomes	F	$\frac{F}{2}$	$\frac{F}{4}$	2F
	As Centripetal force is directly to square of velocity and inversely to radius so, Fc=m(v/2)²/(r/2)=1/2(mv²/r)=F/2				
81)	A man of mass 5kg is falling freely, the force acting on it will be	5 N	9.8 N	19.6 N	**Zero**
82)	A disc at rest without slipping, rolls down a hill of height (3 x9.8) m. What is its speed in m/sec when it reaches at the bottom?	11.4	22.8	**19.6**	9.8
	applydisc formula $= v\sqrt{\frac{4gh}{3}} = \sqrt{\frac{4g*(3*9.8)}{3}} = \sqrt{4*9.8*9.8} = 19.6$				
83)	A body is having weight 20 N, when the elevator is descended with a =0.1 ms-2, then the value of tension 'T' is:	196 N	1.98 N	**19.8 N**	2 N
	$w = mg = 20, m = 2kg,, soT = w - ma = 20 - 2*0.1 = 20 - 0.2 = 19.8N$				
84)	Si unit of angular momentum is given by	J/S²	**Js**	J/S	Jm
85)	1 rev/min is equal to	$\frac{\pi}{6}rads^{-1}$	$\frac{\pi}{15}rads^{-1}$	$\frac{\pi}{20}rads^{-1}$	**$\frac{\pi}{30}rads^{-1}$**
	1rev=2π rad, 1min=60sec, w=2π rad/60sec= π/30 rad/sec				

86)	Which one of the following is not directed along the axis of rotation?	Angular acceleration	Angular momentum	**Centripetal acceleration**	Angular displacement
87)	If a body revolves under centripetal force, its angular acceleration is	Non zero	Variable	**Zero**	Increasing
88)	A wheel of diameter 1m makes 60 rev/min. the linear speed of point in m/s	π	2π	π/2	3π
$d = 1m, r = d/2 = 1/2 = 0.5m,\ w = 60 * 2\pi\ rad/60sec = 2 \Rightarrow \pi v = rw = 0.5 * 2\pi = \pi$					
89)	The diver spins faster when moment of inertia becomes	Greater	**Smaller**	Constant	None of these
90)	Direction of angular acceleration is always along	X-axis	**Axis of rotation**	Y axis	Z axis
91)	A body starting from rest attains angular acceleration of 5 rad/s^2 in 2 sec, find angular velocity	14 rad/s	**10 rad/s**	3 rad/s	2 rad/s
$\alpha = \Delta\omega / t \Rightarrow \Delta\omega = \alpha * t = 5 * 2 = 10$					
92)	The angular version of F=ma is	$\tau = Iw$	**$\tau = I\alpha$**	$I = \tau\alpha$	$F = mv/t$
93)	In angular motion, the centripetal force Fc is	mr^2w	mr^2w^2	**mrw^2**	r^2w^2
94)	When a lift is accelerated upward, the apparent weight of an object in it will be	Equal to its real weight	Zero	Less than its real weight	**Greater than its real weight**
95)	All points on a rigid body rotating about a fixed axis do not have same	**Speed**	Angular speed	Angular acceleration	Angular displacement
96)	Radian is a unit of angular displacement which can also be measured in degrees. How many radians are equal to one degree?	$\frac{180}{\pi}$	$\frac{2\pi}{180}$	**$\frac{\pi}{180}$**	$\frac{\pi}{57.3}$
$2\pi\ rad = 360°, 1° = \frac{2\pi}{360} = \frac{\pi}{180}$					
97)	Linear velocity or tangential velocity of any particle moving in a circular path of radius 2 m with angular velocity 8 $rads^{-1}$ will be:	**$16\ ms^{-1}$**	$10\ ms^{-1}$	$4\ ms^{-1}$	$6\ ms^{-1}$
V=rw=2*8=16 m/s					
98)	Moment of inertia of a solid sphere is	½ M^2r	Mr^2	**2/5 Mr^2**	Mr
99)	Two cylinders of equal mass are made from same material. The one with the larger diameter accelerates ___________ the other under the action of same torque	**Faster than**	Equal to.	Slower than	None of these.
Acceleration is related to diameter of mass as acceleration is more for more diameter					
100)	The value of 2 radian	57.3°	180°	**114.6°**	90°
1radian=57.3°, 2radian=2*57.3°=114.6°					
101)	Close orbiting satellite orbit the earth at a height of	**400 Km**	4000Km	400m	400cm
102)	In rotational motion, torque is equal to the rate of change of	**angular momentum**	Angular velocity	Linear momentum	Angular acceleration
As force is equal to rate of change of momentum so its analogues is					
103)	An elevator is moving upwards with constant velocity of 'v'. What is a weight of a person of a mass 'm' inside the elevator during upward motion?	mg + mv	mg — mv	**mg** as T=W+ma a is zero so T=W=mg	zero
104)	An object of mass 'm' is suspended in an elevator moving downward with acceleration equal to acceleration due to gravity. What is the apparent weight of object?	**Zero** Due to free fall weightlessness	mg	2mg	mg/2

105)	Speed of moon around the Earth is	**1000 m/s**	1100 m/s	1200 m/s	1300 m/s
106)	The ratio of velocity of disc to velocity of hoop is	$\frac{2}{\sqrt{3}}$	$\frac{4}{\sqrt{3}}$	$\frac{2}{3}$	**$\frac{\sqrt{4}}{3}$**
107)	In dryer, water is pushed out of wet clothes due to	Retarding force	Abundance of centripetal force	**Lack of centripetal force**	Friction
108)	Due to some mechanical fault, a lift falls freely from the top of a multistory building. Which of the followings is the apparent weight of a man inside the lift, if mass of man is 80 kg while value of 'g' is 10 ms^{-2}?	**Zero** Due to free fall weightlessness condition occur so apparent will be equal to zero	mg	2mg	mg/2
109)	The relation between escape velocity and orbital velocity is	Vesc=1/2 Vo	$Vesc = \sqrt{2}Vo$	Vesc=Vo	Vesc=2Vo
as $Vesc = \sqrt{\frac{2GM}{R}}$ and $Vo = \sqrt{\frac{GM}{R}}$ dividing both eq to get the result					
110)	The law of gravitation was introduced by	Huygen	Boyle	**Newton**	Pascal
111)	Angular momentum of rigid body	I^2w	Iw^2	**Iw**	I^2w^2
112)	If the body is rotating with uniform angular velocity, then its torque is	**Zero**	Maximum	Clockwise	Remains the same
When uniform angular velocity then angular acceleration is zero so torque=Iα=0					
113)	A man in a lift moving upward with constant velocity will conclude that his weight has	Increased	Decreased	Reduced to zero	**Not changed**
114)	One degree is equal to	$\frac{2\pi}{260} rad$	$\frac{2\pi}{180} rad$	**$\frac{\pi}{180} rad$**	$\frac{\pi}{360} rad$
As 2π radian=360°, 1°=2π/360 r= π/180					
115)	The apparent weight of man moving upward with acceleration g is	mg	**2mg**	Zero	½ mg
116)	The rate of change of angular momentum is equal to	Applied force	**Applied torque**	Acceleration	Momentum
117)	A body of mass 2kg is suspended from the ceiling of an elevator moving up with an acceleration g, its apparent weight in elevator is	0	**39.2 N**	9.8 N	19.6 N
T=W+ mg=mg + mg=2mg=2*2*9.8=39.2 N					
118)	Height of geostationary satellite from Earth surface	42300 Km	900 km	**36000 km**	400 km
119)	What is torque 'τ' in a circular motion?	$\tau = mr^2\pi$	$\tau = mr\alpha$	**$\tau = mr^2\alpha$**	$\tau = mr^2/\alpha$
120)	If $\omega = 60 \text{ rev min}^{-1}$ is equal to	π rad/sec	2π rad/sec	$\frac{1}{\pi}$ rad/sec	$\frac{2}{\pi}$ rad/sec
As 1rev=2π rad, 1min=60sec, w=60*2π rad/60sec= 2π rad/sec					