

**Unit 6****Rotational motion**

- rotational motion is the motion of a given body rotating wrt the fixed axis
- rotation occurs at all scales from the motion of electron in atoms to the motion of entire galaxies ; as do CD,DVD etc
- The study of rotation yields results that apply to a great variety of natural phenomena

:Rotational Kinematics (RK)

RK is the study of effect of rotating rigid body

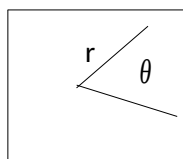
- Rigid body A body having perfectly definite and unchanging shape and size or RK is the study of the most basic angular quantities like
 - ✓ Angular displacement
 - ✓ Angular velocity
 - ✓ Angular acceleration

(a: angular displacement (θ))

- The angle through which a rigid body rotates about a fixed axis
- θ read as theta
- θ depends on arc length and radius of the circle
- θ is measured in radian degree or revolution or cycle but its SI unit is radian

$$\rightarrow 1 \text{ rev} = 360^\circ = 2\pi \text{ rad}$$

- Assume the following figure shows the rotating body around the given circle with the radius r



$$\sin \theta = \frac{s}{r} \text{ for small angle } \theta \approx \sin \theta$$

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

where S is arc length r is radius of the circle

N.B By convention the direction of θ is either clockwise or anticlockwise
 clockwise negative
 anticlockwise positive

By interpreting the above equation we have

$$V_t = r\omega \quad \text{where } V_t \text{ is tangential velocity}$$

$$a_t = r\alpha \quad \text{tangential acceleration}$$

Illustration 1: A flywheel is rotating at 180 rpm and after 20 sec it is running at 120 rpm If the retardation is uniform

- a) How many revolutions will it make and
- b) What time will elapse before it stops

$$\text{Answer } \theta = \frac{w^2 - w_o^2}{2\alpha} \text{ but } t = \frac{w - w_o}{\alpha} = 1 \text{ min}$$

$$\therefore 180\pi \text{ rad} = 90 \text{ rev}$$

Illustration 2: the angel of rotation of a reel of a taps recorder of diameter 1.2 cm is given by $\theta = 1.2t + 0.1t^2$ complete the livear speed and acceleration of a pt on the rim of reel at a) $t=0$ b) $t=30 \text{ sec}$

$$\text{Answer: } w = \frac{d\theta}{dt} = 1.2 \frac{\text{rad}}{\text{s}} \wedge 7.2 \frac{\text{rad}}{\text{s}} \quad a = \frac{dw}{dt} = 0.2 \frac{\text{rad}}{\text{s}^2} \quad 0.72 \frac{\text{cm}}{\text{s}}$$

$$- \quad v = wr = 0.72 \frac{\text{cm}}{\text{s}} = 4.32 \frac{\text{cm}}{\text{s}} \quad a = \alpha r = 1.72 \frac{\text{cm}}{\text{s}^2} \quad 0.72 \frac{\text{cm}}{\text{s}}$$

Illustration3: The angular position of a swining door is described by $\theta = 5 + 10t + 2t^2$ what is the angular speed and acceleration of the door at $t=3 \text{ sec}$?

$$\text{Answer } w = \frac{d\theta}{dt} = 22 \frac{\text{rad}}{\text{s}}$$

$$\alpha = \frac{dw}{dt} = \frac{d^2\theta}{dt^2} = 4 \text{ rad/s}^2$$

:Angular Velocity (w)

- The time rate of change of angular displacement
- W read as omega
- $w = \frac{\Delta\theta}{\Delta t} \wedge \text{its unit is } \frac{\text{rev}}{\text{s}} \vee \frac{\text{rad}}{\text{s}} \vee \frac{\text{rev}}{\text{min}} = \frac{2\pi \text{ rad}}{60 \text{ s}} \vee \frac{1 \text{ rad}}{\text{s}} = 10 \text{ rpm}$

N.B: since its vector the direction is determined by right hand rule direction or pointing of tumb - direction of angular velocity

: direction of w is in the +Ve Z - direction if CCW

Direction of ω is in the -Ve Z-direction if CW

Angular acceleration (α)

- The rate of change of angular velocity

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

 and its SI unit is $\frac{rad}{s^2}$

N.B:- the direction of α is the same as direction of ω when the rotation speed up.

- the direction of α is apposite to the direction of ω when the rotation is lows down.

The equation of rotational Kinematics

- The equation of motion is the same as the equation of UAM with its interchangeable physical quantities
- Interchangeable quantities:

S	$\longrightarrow$	θ
V	$\longrightarrow$	$\omega \vee \omega_0$
a	$\longrightarrow$	α

linear equation

rotational equation

$$V = u + at$$

$$\omega = \omega_0 + \alpha t$$

$$S = \left(\frac{v+u}{2} \right) t$$

$$\theta = \left(\frac{\omega + \omega_0}{2} \right) t$$

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

$$\theta = \omega_0 t + \frac{1}{2} \alpha t^2$$

$$V^2 = U^2 + 2as$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

Rotational Dynamics (RD)

RD : is the study of cause of rotating body is the study of

- torque
- KE rotation
- W rotation

- power rotation and angular momentum

(a) Torque : -Twisting or turning effect of force

- The cross product of force and displacement

$$\vec{\tau} = \vec{r} \times \vec{F}$$

= (perpendicular distance)X (force); perpendicular distance to the force is called **lever arm** or $|\tau| = rF \sin \theta$, where $|\tau|$ is magnitude of torque

N.B: The direction of $\vec{\tau}$ is determined by using right hand rule the pointing of thumb= direction of torque.

Illustration 1: force $\vec{F} = 2\hat{i} - 3\hat{k}$ acts on a body with a position vector

$$\vec{r} = (0.5\hat{j} - 2\hat{k})\text{m}$$

what torque acts on the body? a) about the origin
b) about a point with coordinate

(2,0,-3/m?

answer $\tau = r \times f$

$$= (-1.5\hat{i} - 4\hat{j} - \hat{k})\text{Nm}$$

$$\text{b): } \tau = r \times f = \begin{vmatrix} -20.51 \\ 20-3 \end{vmatrix}$$

$$= (-1.5\hat{i} - 4\hat{j} - \hat{k})\text{Nm}$$

Illustration 2: force $\vec{f} = (-8\hat{i} + 6\hat{j})\text{N}$ acts on a particle with position vector $\vec{r} =$

$$(3\hat{i} + 4\hat{j})\text{m}$$

what are a) torque on the particle

b)The angle between the position and force vector

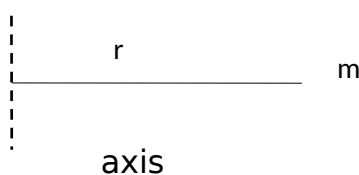
answer : $\tau = r \times f = 50 \text{ K Nm}$

$$\text{b) } \sin \theta = \frac{|r \times f|}{rf} = 90^\circ$$

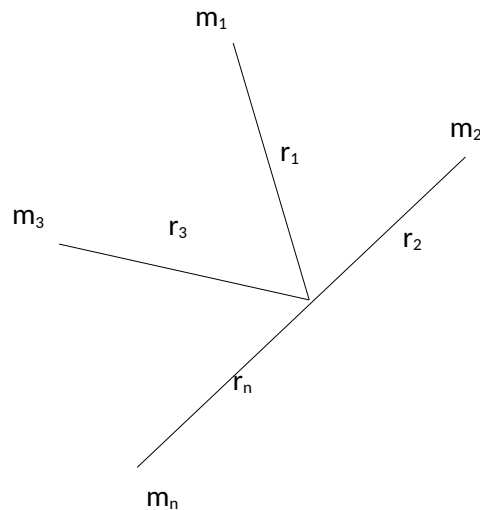
moment of inertia (I)

- : is rotational mass
- : is the measure of the resistance of a body to change in its rotational motion
- : depends on the mass of the body and its distribution of that mass about the axis of rotation
- Its unit is kgm^2

Mathematical : $I = mr^2$



- For a no of mass system then I becomes:



$$I = I_1 + I_2 + I_3 + I_n$$

$$I = m_1 r_1^2 + m_2 r_2^2 + \dots + m_n r_n^2$$

N.B: I depends on the shape, mass distribution and Orientation of axis of rotation

⇒ even if m and r is same but I is d/t for

- ✓ Cylinder
- ✓ Solid sphere (through the center and tangent)
- ✓ Hollow sphere
- ✓ Disc

Illustration 1: what is the moment of inertia of a sphere through an axis $\frac{1}{5}$ of its radius

Answer :- $I = I_{cm} + MD^2$

$$= \frac{2}{5}MR^2 + M\left(\frac{1}{5}R\right)^2$$

$$= \frac{11}{25}MR^2$$

Illustration 2: The moment of inertia of a uniform solid sphere mass M and radius R about on axis passing through its center is given by $I = \frac{2}{5}MR^2$. What is the moment of inertia of the sphere about an axis passing through its edge

Answer $I_p = I_{cm} + Md^2$

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

$$I_p = \frac{7}{5}MR^2$$

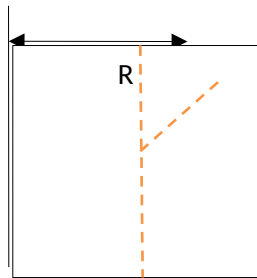


Illustration 1: The four particles are connected by rigid rods of negligible mass, the origin is at the center of the rectangle. If the system rotates about the Z-axis with the angular speed of 6 rad/s calculate

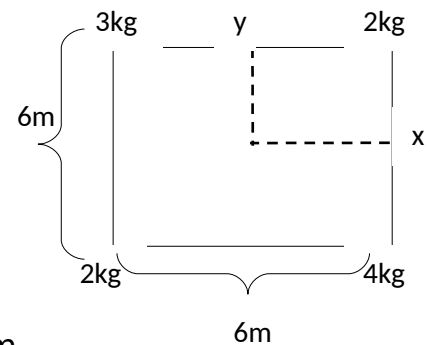
(a): I of the system

(b): KE of the system

Answer $I_2 = m_1$

$$I = r^2(m_1 + m_2 + m_3 + m_4) \text{ but } r = \sqrt{6^2 + 4^2}$$

$$= 3.6m$$



$$I = (3.6m)^2(2+3+2+4)$$

$$= 143 \text{ kgm}^2$$

b) KE $\frac{1}{2}I\omega^2 = \frac{143}{2}(6^2) = 2574 \text{ J}$

rotational kinetic energy (KE_{rot})

- The energy possessed due to its rotational motion, since a rotating body consists of mass in motion
- Depends on moment of inertia and angular speed
- The greater I the greater KE_{rot}

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

$$KE_{rot} = \frac{1}{2}I\omega^2 = \frac{1}{2}\frac{I^2}{r^2}(\omega r)^2$$

$KE_1 = \frac{1}{2}I\omega^2$

- Since have energy transfer this resulted or yields amount of work done rotational work done (W_{rot})
- The product of the torque and angular displacement

Mathematically $W=FS$ or $W=Fs$

$Wr = \tau\theta$

$$Wr = \frac{\tau}{r}s$$

$$= \frac{\tau}{r}(\theta)$$

$Wr = \tau\theta$

But $\tau = I \propto \theta \rightarrow Wr$ rotational

workdone

$$Wr = I \propto \theta$$

Therefore by energy transfer

$$Wr = \Delta KE_r$$

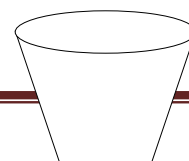
$$I \propto \theta = \frac{1}{2}I(\omega^2 - \omega_o^2) = \tau\theta$$

Rotational power: -the rate at which rotational work is done

$$p = \frac{W}{t} = \frac{\tau\theta}{t} = \tau\omega$$

Illustration 1: A constant torque of 25 Nm is applied to a grind stone whose of inertia is 0.13 kgm^2 , negligible friction, find the angular speed after the grindstone has made 15 revolutions.

$$R = 0.6 \text{ m} \quad M = 5 \text{ kg}$$



Answer $\tau\theta = \frac{1}{2}I\omega^2 = \frac{1}{2}I\omega_o^2$

$$\omega^2 = \frac{2\tau\theta}{I} = 190 \frac{\text{rad}}{\text{s}}$$



Illustration 2: determine the angular speed of the pool after the 3kg bucket has fallen 4m starting from rest

Answer $KE_r = GPE$

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

$$\frac{1}{2} \left(\frac{1}{2}Mr^2\omega^2 \right) = mgh$$

- $\omega = 16 \text{ rad/s}$

Illustration 3: A 240 N sphere 0.2m in radius rolls without slipping 6m down in ramp that is inclined at 37° with the horizontal. What is the angular speed of the sphere at the bottom of the slope if it starts from rest by conserve of energy

$$ME_1 = ME_f$$

$$\rightarrow mghi = KE_p + KE_{rot}$$

$$mgh \sin\theta = \frac{1}{2}mr^2\omega^2 + I\omega^2, I = \frac{2}{5}mR^2$$

$$mgh \sin\theta = \frac{1}{2}mr^2\omega^2 + \frac{1}{2} \left(\frac{2}{5}MR^2 \right) \omega^2$$

$$\omega^2 = \frac{2gb \sin\theta}{\frac{7}{5}R^2} = \omega = 36 \text{ rad/s}$$

Angular momentum

Angular momentum is:

- ❖ A vector quantity whose direction is in the direction of the velocity
- ❖ The product of moment of inertia and angular velocity
- ❖ The mathematical expression starts from the expression of linear momentum

Mathematically

$$P = mv \quad \text{or} \quad P = mv$$

$$L = I\omega \quad P = \frac{I}{r^2} \omega r$$

$$Pr = I\omega \text{ but } Pr = \dot{L}$$

$$L = I\omega \text{ where}$$

L angular momentum

$$\dot{L} = \vec{r} \times \vec{p} = I \vec{\omega}$$

I moment of inertia

W angular velocity

: If the net torque

Exerted on the body during a given time interval is given by

$$\tau = \frac{\Delta L}{\Delta t}$$

$$\Delta L = \tau \Delta t$$

ΔL is called angular impulse or $I_{tot} = \sum I_i = I_1 + I_2 + \dots + I_n$ angular momentum of q system of particle

Conservation of angular momentum

States that:

. angular momentum doesn't change with time

. or the total angular momentum is constant in the absence of net torque

$$\tau_{net} = 0$$

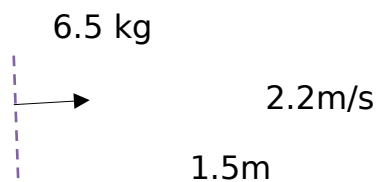
$$\frac{\Delta \vec{L}}{\Delta t} = 0 \Rightarrow \Delta L = 0 \Rightarrow \sum L_i = \sum L_f \Rightarrow I_i \omega_i = I_f \omega_f$$

Eg1: two bodies moving as shown below, what is their total angular momentum about pt O?

$$\text{Answer } L = L_{AC} + L_C$$

$$= (2.8)(3.6)(3.1) - 1.5(6.5)(2.2)$$

$$= 9.8 \text{ kgm}^2/\text{s}$$



$$=9.8 \text{ Ns}$$

$$3.6 \frac{m}{s}$$

$$\text{-----} 2.8m$$

$$3.1kg$$

Illustration 2: A 1.5kg particle moves in the xy plane with velocity $V =$

$$(4.2\hat{i} - 3.6\hat{j}) \frac{m}{s} \text{ what is the angular momentum when its position vector is } r =$$

$$(15\hat{i} + 2.2\hat{j}) m$$

$$\text{Ans: } L = m (r \times v)$$

$$= 22 \text{ kgm}^2/s$$

Illustration 3: an object with a mass of $m = 3kg$ is attached to the free end of light string wound around a pulley of radius $R = 0.5m$ and moment of inertia

$$I = 0.75 \frac{kgm^2}{5} \text{ the pulley is free to rotate in a vertical plane about a fixed}$$

frictionless axis passing through its center. The suspended object is released from rest at 3.6 above the floor. What is the $\vec{L}$ of the pulley at the time when the object strikes the floor (2007)

$$\text{Ans } mgh = \frac{1}{2} mu^2 + \frac{1}{2} I \omega^2 \text{ but } v = r\omega \text{ then } \omega = 12 \text{ rad/s}$$

$$\therefore L = I\omega = 9 \text{ kgm}^2/s$$

Illustration 4: An artificial satellite is placed in to a elliptical orbit about the earth. If its speed is $8450m/s$ at a distance of $8.37 \times 10^6 m$ from the center of the earth. What will be its speed at a distance of $25.1 \times 10^6 m$ from the earth's center?

$$\text{Ans } I_1 \omega_1 = I_2 \omega_2 \text{ but } \omega = \frac{v}{r}$$

$$\therefore V_2 = \frac{r_1 V_1}{r_2} = 2820 \frac{m}{s}$$

Unit 7

Equilibrium

- Equilibrium is: condition in which the of motion of a body doesn't change : The body is said to be in equilibrium if $F_{net}=0$

$$\tau_{net}=0$$

- Classification (1) static equilibrium (2) dynamic equilibrium

. occurs when a body is at rest moving at a steady

occurs when a body is

velocity and there is

$$F_{net}=0 \quad \tau_{net}=0$$

- **Conditions of equilibrium**

First condition

2nd condition

- States $F_{net}=0$
- Called translation equilibrium
- $\sum F=0 \rightarrow \sum F_x=0, \sum F_y=0 \sum F_z=0$
- $\sum \tau=0 \sum \tau_c=\sum \tau_{Ac}$

$$\text{Since } \sum \vec{F} = \sum F_x \hat{i} + \sum F_y \hat{j} + \sum F_z \hat{k}$$

$$\text{since } \sum \tau = \sum \tau_c + \sum \tau_{Ac}$$

- $\vec{P}$ is constant
- Another way of Newton's 1st law
- $\vec{L}$ is constant
- A body doesn't rotate

. The two conditions are independent each other

e.g couple force – produce rotation

- no translational motion

e.g car steering wheel

Illustration 1: Traffic lights weighing 250N are suspended from a cable as shown find the tension T in the string if $\theta_1=\theta_2=30^\circ$

$$\text{ans } \sum F_y=0$$

$$T \sin 30 + T \sin 30 = 250$$

$$\Rightarrow T = 250 \text{ N}$$

Illustration 2: In a tower crane a 30 tone of load is suspended determine the mass of the country weight which is usually layer of concrete slabs (1tonne= 100kg)

$$\text{Ans :- } \sum \tau_c = 0$$

$$5W - 10(3 \times 10^5) = 0 \quad W = 60 \text{ tonne}$$

Illustration 3: A 100 kg box is pushed a constant speed up a smooth 30° incline plane shown below what horizontal force F is required?

Ans : $\sum F_y = 0$

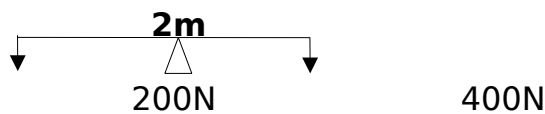
$$\Rightarrow F = 577.35 \text{ N}$$

Illustration 4: A see saw of length 4m pivoted at its center rest in a horizontal position A body of mass 20 kg sits on one end. How far from the center should his sister of mass 40 kg sit if the see saw is balanced?

Ans $\sum \tau_{\text{pivot}} = 0$

$$-400 \times 1 + 200(2) = 0$$

$$\Rightarrow x = 1 \text{ m}$$



Unit 8

Properties of bulk matter

- It is the study of feature of
 - solid
 - liquid and {huge substance}
 - gaseous substance
- property of solid substance:
 - . Elastic behavior
 - Elasticity behavior of solid material or substance
 - Elasticity is the property of a body to retain its original shapes Or size after the removal of a deforming force
 - The deformation can be:

. elastic deformation . a body regains its original Shape when the force that Caused the deformation is Removed	. plastic deformation . A body do not regain its original shape after the that caused deformation removed
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N.B:- material are elastic until a certain limit called elastic limit

. material become plastic beyond the elastic limit or the material is permanently deformed

. elastic limit depends on internal structure of the material

Eg:- steel lower elastic limit than rubber (band)

Hook's law:- states that "the force applied to material is directly proportional to its extension up to the elastic limit".

❖ With is its elastic limit stress is directly proportional to the strain."

Stress Strain relation

Stress:- force resistance per unit area called tensile stress

Stran:- change in length per unit length called tense stran mathematically

tensile stress $= \frac{F}{A}$ tensile strain $= \frac{X}{L}$ X-extension

L- original length

. the force F acts 1r to A

Young's Modulus (Y)

- Is the ratio longitudinal stress to the longitudinal strain up to the materials elastic limit.

Mathematically:

- Consider a wire of length L and cross sectional area of A If a force F is applied normal to the cross section and produces a change in length the wire by X1 then

$$\text{Young's modulus} = \frac{\text{longtudinal stress}}{\text{longtudical stran}}$$

$$Y = \frac{F/A}{X/L} = \frac{FL}{AX}$$

N.B:- strain is unit less and dimensionless

. unit of Y is N/m^2

. if Y is large relatively the material is un stretched

e.g $Y_{\text{steel}} > Y_{\text{rubber}}$

$2 \times 10^{11} \text{ pa} > 5 \times 10^8 \text{ pa}$

Illustration 1: A metal wire 75 cm long and 1.5 mm in diameter stretches 0.4 mm when a load of 10kg is hung on its end find

- a) The strees b) the strain c) the young's modulus of the wire

$$\text{Ans :- stress} = \frac{F}{A} = \frac{mg}{Ad^2/4} = 5.7 \times 10^7$$

$$\text{Strain} = \frac{X}{L} = \frac{0.4}{750} = 5.3 \times 10^{-4}$$

$$Y = \frac{\text{stress}}{\text{strain}} = 107 \text{ Ra}$$

Reference Grade 11 physics test book and extreme book series

Questions

1. A rigid body is rotating around the circular path of radius with angular velocity of P and angular acceleration Q express its net acceleration interims .e.g P_1 q and
 2. Find the a) position b) angular velocity c) the angular acceleration of the rotation of $t=3$ sec of a rigid body governed by the equation: $\theta(t) = 3t^2 + 4$
 3. Find the moment of inertia of a rod through an axis $\frac{1}{4}$ th from one end
 4. A wheel of radius 0.2m is mounted on a frictionless horizontal axle. A massless cord is wrapped around the wheel and attached to a 2kg box that slides on a frictionless surface include at angle $\theta = 20^\circ$ with the horizontal. The box accelerate down the surface at 2 m/s^2 . What is the rotational inertia of the wheel about the axle?
 5. The force $F = (-3\hat{i} - 10\hat{j} - k) \text{ N}$ acts on a particle with position vector $r = (\hat{i} + \hat{j}) \text{ m}$ what are a) the torque on the particle about the origin, in unit vector notation b) the angle between $\vec{r} \wedge \vec{F}$?
 6. The rigid body consists of 3 particles connected by mass less rods it is to be rotated about an axis perpendicular to its plane through point P. if $M=0.4 \text{ kg}$ $a=30 \text{ cm}$ & $b=50 \text{ cm}$. find the moment of inertia of the system wrt Pt P
 7. The angle of rotation of a reel of a tape recorder of diameter 1.5 cm is given by $\theta = -2t + 3t^2$ compute a) the linear speed b) the angular acceleration c) the tangential (linear) acceleration d) the total or resultant acceleration
- I. Choose the correct answer from the alternatives and write the letter on the space provided.**
1. A sphere rolling on a horizontal surface gradually slows down and stops the frictional force has the tendency to

- A. decrease the angular velocity speed
 B. increase the linear speed
 C. increase the angular speed
 D) increase the linear momentum
2. the direction of the angular velocity vector is along
 A. tangent to the circular path
 B) the inward radius
 C) the axis of rotation
 D) the outward radius
3. Two solid sphere are made of the same material. The ratio of their radius is 1:3 the ratio of their moment of inertia about their respective radius is
 A. 1:4
 B) 1:2
 C) 1:243
 D) 1:420
4. The rotation of a rigid body a sa function of time is given by $(2t^2-1)rad$ what is the angular speed of this body at $t=1$ sec?
 A. 4 rad/s
 B) 1 rad/s
 C) 31 rad/s
 D) 8 rad/s
5. A sphere of radius 1m rotating at on angular speed of 2 rad/s about an axis accelerates suddenly at $1rad/s^2$. What is the net acceleration of a particle on the surface of the sphere at $t=1$ sec?
 A. $2.5m/s^2$
 B) $4.1m/s^2$
 C) $1rad/s^2$
 D) $2rad/s^2$
6. What is the angular speed of an rotating from rest at $3rad/s^2$ if its total displacement is 6 radians?
 A) 18 rad/s
 B) 3 rad/s
 C) 6 rad/s
 D) 9 rad/s
7. A wheel of radius 2 cm acceleration from rest at $4rad/s^2$. What is the tangential and resultant acceleration of a point on the rim of a wheel at $t=5$ sec 1y?
 A) $(4,10)\frac{m}{s^2}$
 B) $(80,20)\frac{m}{s^2}$
 C) $(8,20)\frac{m}{s^2}$
 D) $(0.8,80)\frac{m}{s^2}$
8. 1 rev/min is the some as
 B) $\frac{2\pi}{60} \frac{rad}{s}$
 B) 1 rad/s
 C) $\frac{\pi rad}{s}$
 D) 1 rev/s
9. Of the following one is correct rotational motion. Which one is it?
 A) The direction of α is parallel to the direction of W when the rotation is speed up
 B) The direction of α is parallel to the direction of W when the rotation is slows down
 C) The direction of α is anti parallel to the direction of W when the rotation is speed up
 D) All are incorrect

10. The force $F = (\hat{i} - 5\hat{k}) N$ acts on a body with a position vector $\vec{r} = (\hat{j} - 2\hat{k}) m$ the torque acts on a body about the origin is
 A) $(\hat{i} + \hat{j} - 7\hat{k}) Nm$ B) $(-5\hat{i} + 2\hat{j} - \hat{k}) Nm$
 C) $(\hat{i} - \hat{j} - 3\hat{k}) Nm$ D) $(-\hat{i} - \hat{j} - \hat{k}) Nm$
11. Force $F = (\hat{i} + \hat{k}) N$ acts on a particle with position vector $\vec{r} = \hat{i} (2\hat{i} + 3\hat{k}) m$ what is the angle formed between the position and the force vector?
 A) 90° B) 79° C) 63° D) 72°
12. What is the moment of inertia of a sphere through an axis one third of its radius.
 A) $\frac{7}{5} MR^2$ B) $\frac{1}{2} MR^2$ C) $\frac{11}{15} MR^2$ D) $\frac{2}{5} MR^2$
13. The measure of the resistance of a body to change in its rotational mass is said to be.
 A) Kinetic energy B) torque C) moment inertia D) force
14. Of the following one effects the moment of inertia of the body. which one is it.
 A) Shape of the body B) mass distribution
 C) orientation of the axis of rotation D) all are correct
15. The motion of a given body rotating with respect to the fixed axis called
 A) Rotational motion B) translational motion
 C) momentum D) vibratory motion