2.6 BASICS OF ROTATIONAL MOTION

Motion of bodies rotating about a given axis, like wheels, blades of a fan and a chair cannot be analyzed by treating them as a point mass or particle. At a given instant of time, different parts of the body being at different distances from the axis of rotation, have different velocities and accelerations. However the analysis is highly simplified if the body is assumed to be "rigid".

What is a rigid body ?

A body is said to be rigid if its shape and size do not change when ordinary forces are applied to it.

Example : A stone, an iron piece, a wooden block.

Translatory and rotational motion :

A rigid body may have translatory or rotational or both kinds of motion.

In the translatory motion of a body every particle in the body moves with the same speed in the same direction.

In the rotational motion of a body every particle in the body describes a circle with its centre in the axis of rotation.

In general, motion of a body may be neither purely translatory nor purely rotational.

Activity 1 :

a) Make a point (mark) on the rim of a moving bicycle wheel.
b) Note your observation.
c) Does the motion is purely translational or purely rotational?

Examples for rotational motion :

1) Rotation of the earth about its axis.
2) Rotation of a spinning top.
3) Merry go round of a giant wheel.
4) Rotation of blades of a fan.

Activity 2 :

a) Write down some more examples for rotational motion, that you observe.
b) Discuss and make a list.

Definitions:

1) **Angular displacement :** The angle swept by the radius vector in a given time is called the angular displacement of the particle.

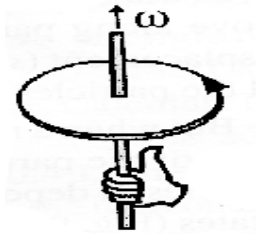
- Angular displacement is a vector quantity.
- The SI unit of angular displacement is radian (rad).
- The angular displacement is taken as positive if the rotation of the body is anticlockwise. It is taken as negative if the rotation is clockwise.

2) **Angular Velocity :** The rate of change of angular displacement is called angular velocity. It is denoted by ω.

Angular velocity $\omega = \dfrac{angular\ displacement}{time\ taken} = \dfrac{\theta}{t}$

- Angular velocity is a vector quantity.
- The SI unit is $\dfrac{radian}{second}$ (rad s^{-1})
- Its direction is given by right hand thumb rule.

Statement : If the fingers of right hand are clasped in the direction of rotation of the body, then the outstretched thumb points in the direction of the angular velocity.



Angular acceleration : The rate of change of angular velocity is called angular acceleration.

Let ω_1 be the angular velocity at some instant of time, and ω_2 at some other instant, then angular acceleration = $\alpha = \frac{\omega_2 - \omega_1}{t}$

- It's a vector quantity.
- The SI unit is $\frac{\text{radian}}{\text{second}^2}$
- Its direction is same as that of angular velocity.

In rotational motion,

1) "The angular displacement has the same significance as the linear displacement in linear motion".
2) Angular velocity (ω) and angular acceleration (α) are of the same significance as the linear velocity (v) and the linear acceleration (a).
3) It can be easily proved that, $V = r\omega$ and $a = r\alpha$

   Where r –> radius of circular path along which the body is moving

   V –> linear velocity and a –> Linear acceleration.

   Equations of rotational motion and linear motion can be compared as follows

1	Equations of motion with constant acceleration	$v = u+at$ $s = ut+\frac{1}{2}at^2$ $v^2 = u^2+2aS$	$\omega = \omega_0 + \alpha t$ $\theta = \omega_0 t + \frac{1}{2}(\alpha t^2)$ $\omega^2 - \omega_0^2 = 2\alpha\theta$
2.	Displacement	S	θ
3.	Velocity	$V= \frac{S}{t}$	$\omega = \frac{\theta}{t}$
4.	Acceleration	$a= \frac{v}{t}$	$\alpha = \frac{\omega}{t}$
5.	Momentum	$p = mv$	$L = I\omega$
6.	Force	$F=ma$	$\tau = I\alpha$
7.	Impulse	$Ft = mv - mu$	$\tau t = I\omega - I\omega_o$
8.	Work done	$W = FS$	$W = \tau\theta$
9.	Kinetic energy	$\frac{1}{2}mv^2$	$\frac{1}{2}I\omega^2$

Questions :

1. What is a rigid body ?
2. When the motion of a body is said to be rotational ?
3. Give two examples for rotational motion.
4. Define (1) Angular displacement (ii) Angular Velocity
5. When does the angular displacement is taken positive ?
6. Mention SI unit of angular velocity.
7. How do you give the direction of angular velocity ?
8. What is angular acceleration ?
9. Mention SI unit of angular acceleration.
10. State right hand thumb rule.

Answers

2.6 Basics of Rotational Motion Answers

1) A body is said to be rigid if its shape and size do not change when ordinary forces are applied to it .
2) The motion of a body is said to be rotational if every particle in the body describes a circle with its center in the axis of rotation .
3) 1.Rotation of the earth about its axis .
   2.Rotation of blades of a fan .
4) 1.The angle swept by the radius vector in a given time is called the angular displacement of the particle .
   2.The rate of change of angular displacement is called angular velocity.
5) The angular displacement is taken as positive if the rotation of the body is anti clock wise.
6) SI unit of angular velocity is rad.s-1 .
7) By right hand thumb rule .
8) The rate of change of angular velocity is called angular acceleration .
9) SI unit of angular acceleration is rad.s-2.
10) If the fingers of right hand are clasped in the direction of rotation of the body, then the out stretched thumb points in the direction of the angular velocity .