SYSTEM OF PARTICLES AND ROTATIONAL MOTION

DYNAMICS OF ROTATIONAL MOTION ABOUT A FIXED AXIS

Rigid bodies undergo translational as well as rotational motion. So, in such cases, both the linear and the angular velocity need to be analyzed. To simplify these problems, we define the translational and rotational motion of the body separately. In this article, we will discuss the dynamics of an object's rotational motion about a fixed axis.

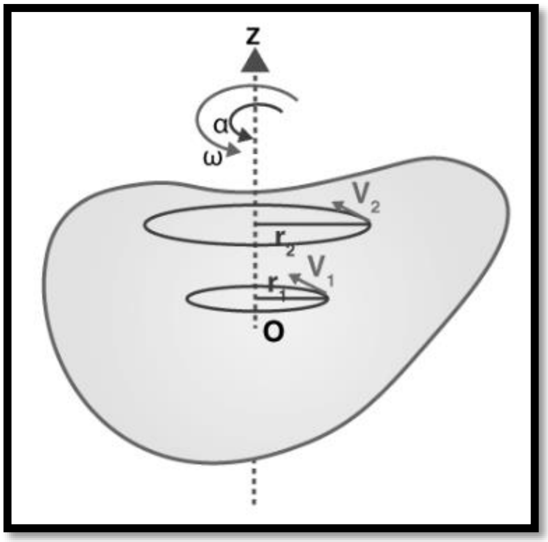
Rotational Motion

Rotational motion can be defined as the motion of an object around a circular path, in a fixed orbit."

The dynamics for rotational motion are completely analogous to linear or translational dynamics. Many of the equations for mechanics of rotating objects are similar to the motion equations for linear motion. In rotational motion, only rigid bodies are considered. A rigid body is an object with a mass that holds a rigid shape.

Rotational Motion About a Fixed Axis

The figure below shows a rotating body that has a point with zero velocity about which the object undergoes rotational motion. This point can be on the body or at any point away from it. Since the axis of rotation is fixed, we consider only those components of the torques applied to the object that is along this axis, as only these components cause rotation in the body. The perpendicular component of the torque will tend to turn the axis of rotation for the object from its position.



This results in the emergence of some necessary forces of constraint, which finally tends to cancel the effect of these perpendicular components, thus restricting the movement of the axis from its fixed position, rendering its position to be maintained. Since the perpendicular components cause no effect, these components are not considered during the calculation. For any rigid body undergoing a rotational motion about a fixed axis, we need to consider only the forces that lie in planes perpendicular to the axis.

Parallel position vectors not considered

Forces that are parallel to the axis will give torques perpendicular to the axis and need not be taken into account. Also, only the components of the position vector that are perpendicular to the axis are considered. Components of position vectors along the axis result in torques perpendicular to the axis and thus are not to be taken into account.

Rotational Motion Examples

Examples of Rotation about a fixed point

Ceiling fan rotation, rotation of the minute hand and the hour hand in the clock, and the opening and closing of the door are some of the examples of rotation about a fixed point.

Examples of Rotation about an axis of rotation

Rotation about an axis of rotation includes translational as well as rotational motion. The best example of rotation about an axis of rotation is pushing a ball from an inclined plane. The ball reaches the bottom of the inclined plane through translational motion while the motion of the ball is happening as it is rotating about its axis, which is rotational motion.

Another example of rotation about an axis of rotation is the earth's motion. The earth rotates about its axis every day, and it also rotates around the sun once every year. This is a classic example of translational motion as well as rotational motion.

Rotational Motion Dynamics

Moment of Inertia

The moment of inertia measures the object's resistance to the change in its rotation. The moment inertia is symbolized as I and is measured in kilogram metre^2 (kg m^2.) The moment of inertia is given by the following equations:

$I = Mr^2$, where m is the particle's mass, and r is the distance from the axis of rotation.

The moment of inertia depends on the particle's mass; the larger the mass, the greater the moment of inertia.

Following is the table for a moment of inertia for symmetric bodies:

Symmetric body	Moment of inertia
Ring with a symmetric axis	$I = mR^2$
Cylinder or disc with a symmetric axis	$I = \frac{1}{2}mR^2$
Uniform sphere	$I = \frac{2}{5}mR^2$
Rod with the axis through the end	$I = \frac{1}{3}ml^2$
Rod with the axis at the centre	$I = \frac{1}{12}ml^2$