

Class 11 Physics • Chapter 6

Kinematics of Rotational Motion

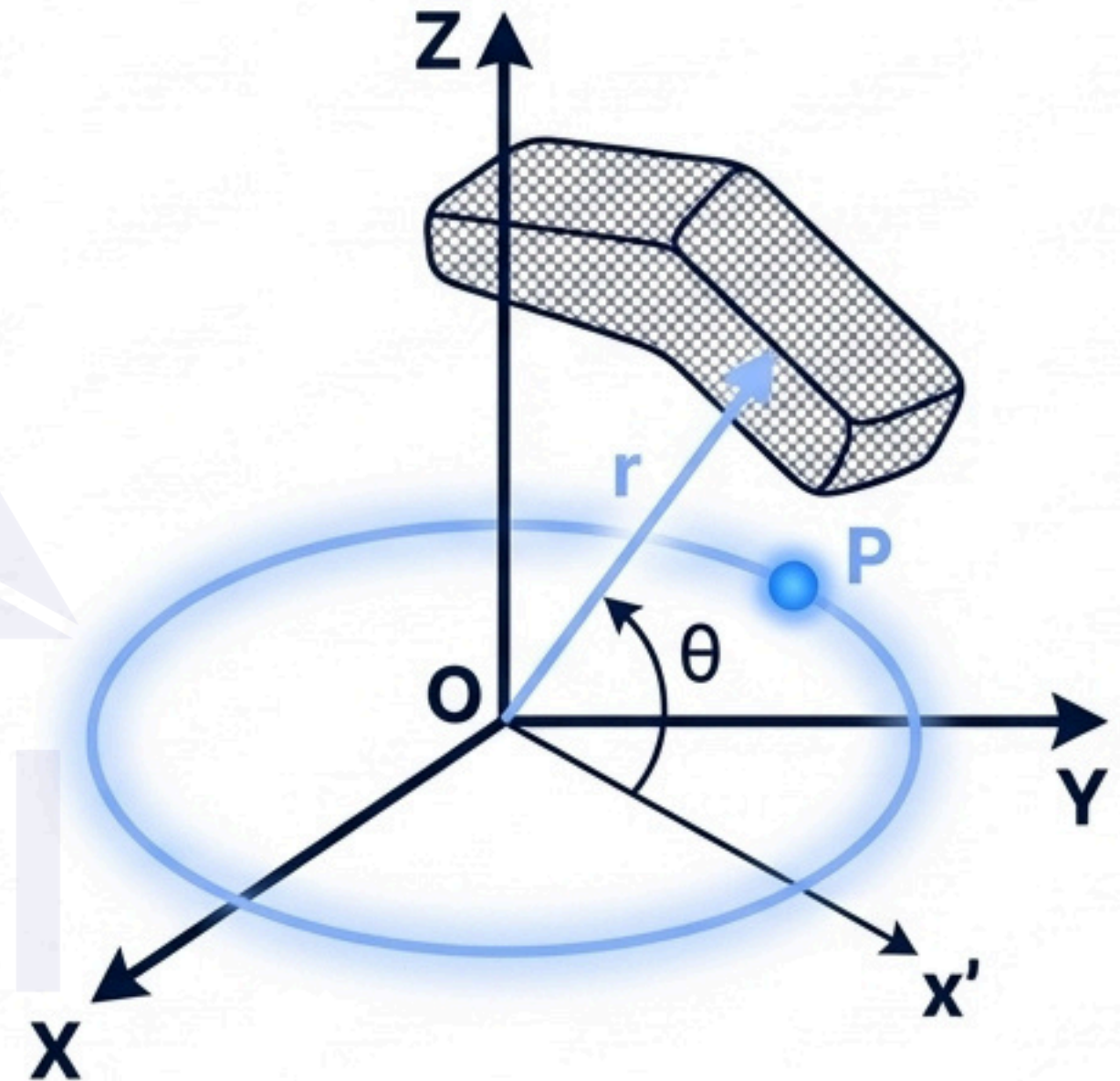
About a Fixed Axis (Section 6.10)



Defining the Setup: Fixed-Axis Rotation

Fixed-axis rotation requires only one degree of freedom—a single independent variable to describe the entire system's motion.

- ✓ The axis of rotation (e.g., Z-axis) remains completely stationary.
- ✓ Every particle moves in a perfect circle within a plane perpendicular to the axis (the X-Y plane).
- ✓ The position of the entire rigid body is specified by a single angular displacement (θ) from a fixed reference line.



The Variables of Rotation



θ

Angular Displacement

The angle through which the body rotates from a fixed reference direction. Maps the position in the circular plane.

ω

Angular Velocity

The time rate of change of angular displacement.
(Treated as a scalar because the axis is fixed).

$$\omega = \frac{d\theta}{dt}$$

α

Angular Acceleration

The time rate of change of angular velocity.

$$\alpha = \frac{d\omega}{dt}$$

Kinematic Equations

For uniform (constant) angular acceleration ($\alpha = \text{constant}$)

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

Initial position at $t = 0$

Initial velocity at $t = 0$

$$\theta = \theta_0 + \omega_0 t + \frac{1}{2} \alpha t^2$$

$$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$$

The Kinematics Analogy



Rotational motion perfectly mirrors linear motion.

Translational Motion (Linear)

$$x$$

$$v = dx/dt$$

$$a = dv/dt$$

$$v = v_0 + at$$

$$x = x_0 + v_0t + \frac{1}{2}at^2$$

$$v^2 = v_0^2 + 2a(x - x_0)$$

Rotational Motion (Fixed Axis)

$$\theta$$

$$\omega = d\theta/dt$$

$$\alpha = d\omega/dt$$

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

$$\theta = \theta_0 + \omega_0t + \frac{1}{2}\alpha t^2$$

$$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$$



Quick Recap

1 Fixed Axis Simplification

Rotation about a fixed axis requires only one degree of freedom. Vector directions remain constant, simplifying the math to scalars.

2 The Big Three

Angular displacement (θ), angular velocity (ω), and angular acceleration (α) completely define the kinematic state of the rigid body.

3 Constant Acceleration

When α is uniform, three standard kinematic equations can be reliably used to predict future rotational states.

4 The Analogy

Every linear kinematic formula has an exact rotational twin. Swap Latin letters for Greek ($x \rightarrow \theta$, $v \rightarrow \omega$, $a \rightarrow \alpha$).