

L15_Rotational Kinematics and Moment of Inertia

✓ SP-check

Rotational Kinematics

Formulas

- Note the comparisons between linear motion (translation motion) and angular motion

<u>Linear</u>	<u>Angular</u>
$d = vt$	$\theta = \omega t$
$v_F = v_0 + at$	$\omega_F = \omega_0 + \alpha t$
$v_F^2 = v_0^2 + 2ad$	$\omega_F^2 = \omega_0^2 + 2\alpha\theta$
$d = v_0t + \frac{1}{2}at^2$	$\theta = \omega_0t + \frac{1}{2}\alpha t^2$
$d = \frac{1}{2}(v_0 + v_F)t$	$\theta = \frac{1}{2}(\omega_0 + \omega_F)t$

屏幕截图 2025-05-01 145839.png

- Related linear parameters to angular ones

$$d = \theta R$$

$$v = \omega R$$

$$a = \alpha R$$

屏幕截图 2025-05-01 150334.png

3. Direction:

Define the Direction of Positive Rotation



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Rotational Energy

- Derivation

Moment of Inertia

$$I \equiv \sum m_i r_i^2$$

$$K_{system} = \frac{1}{2} \left(\sum m_i r_i^2 \right) \omega^2$$

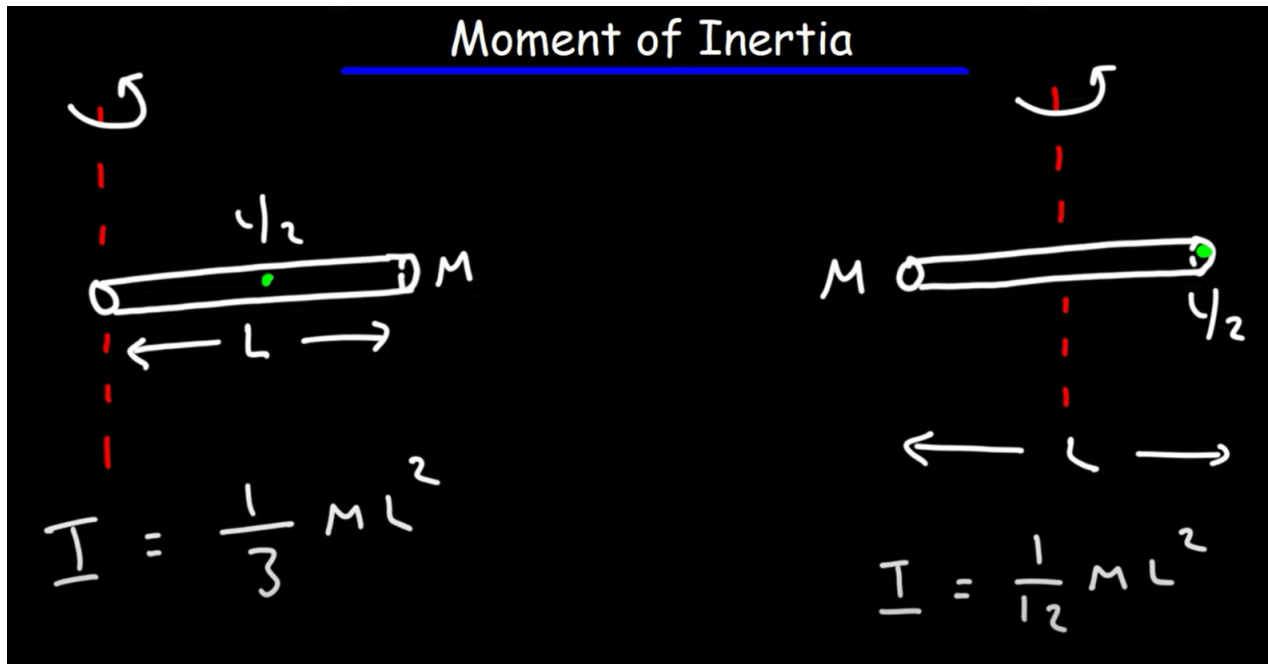
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- $E_{rot} = \frac{1}{2} m v^2 = \frac{1}{2} m (\omega r)^2 = \frac{1}{2} m r^2 (\omega)^2 = \frac{1}{2} I \omega^2$
- Note that the definition of I is different for different object

Moment of inertia

Slender Rod

1. Special cases



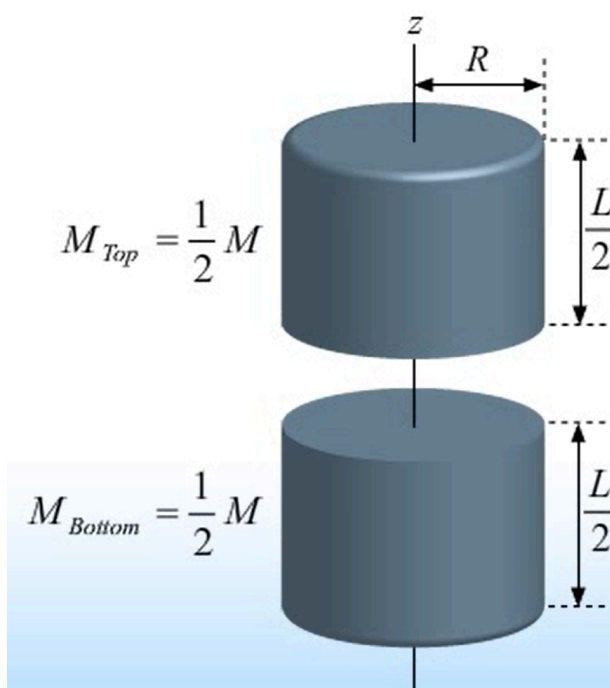
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2. Here h is the distance from the axis to the left and L is the length of the rod

$$I = \frac{M}{3} [L^2 - 3Lh + 3h^2]$$

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Disk/Solid Cylinder/Puck



Solid Cylinder of Mass M

Moment of Inertia about
the Axis of Symmetry

$$I_z = \frac{1}{2} M R^2$$

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•

$$I = \frac{1}{2}mR^2$$

Hoop/Block

•

$$I = mR^2$$

Sphere

$$I = \frac{2}{5}mR^2$$

Shell

Cylindrical Shell

$$I = MR^2$$



Spherical Shell

$$I = \frac{2}{3}MR^2$$

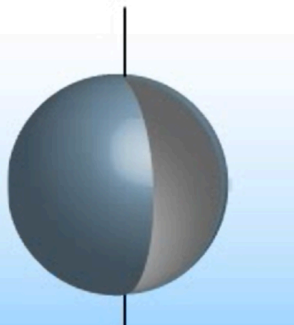


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System

- Add every component's moment of inertia up