Rotation

Physics Club

November 13, 2014



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Rotation

Angular Quantities

	Translational	Rotational
Displacement	Δχ	$\Delta \theta$
Velocity	v	ω
Acceleration	а	α
Equation $\#1$	$\Delta x = \bar{v}t$	$\Delta heta = ar{\omega} t$
Equation #2	$v = v_0 + at$	$\omega=ar{\omega} t$
Equation #3	$\Delta x = v_0 t + \frac{1}{2} a t^2$	$\Delta\omega = \omega_0 t + \frac{1}{2}\alpha t^2$
Equation #4	$\Delta x = v_0 t - \frac{1}{2} a t^2$	$\Delta \omega = \omega_0 t - \frac{1}{2} \alpha t^2$
Equation $\#5$	$v^2 = v_0^2 + 2a\Delta x$	$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$

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Basic Definitions

Radian

Unit of angular measure. By definition, the angle in radians is equal to the length subtended.

One radian is approximately $180^{\circ}/\pi = 57.30^{\circ}$.

Angular Displacement $\Delta \theta$

$$\Delta s = r \Delta \theta$$

Angular Velocity ω

$$v = r\omega$$

Angular Acceleration lpha

$$a_t = r\alpha$$

$$a_c = \frac{v^2}{r} = r\omega^2$$

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The Right-Hand Rule

Angular quantities are vectors. Angular displacement, angular velocity, and angular acceleration are all vectors.

Use the right-hand rule to find the direction of the angular velocity $\boldsymbol{\omega}$ vector.

The angular acceleration α vector is the same direction if the angular velocity ω is increasing with time, opposite if decreasing.

Rotational Kinetic Energy & Moment of Inertia

Rotational Kinetic Energy K

$$K = \sum \left(\frac{1}{2}m_i v_i\right) = \frac{1}{2}\sum \left(m_i r_i^2 \omega^2\right) = \frac{1}{2}I\omega^2$$

Moment of Inertia I

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

The Parallel-Axis Theorem

$$I = I_{\rm cm} + Mh^2$$

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Newton's Second Law for Rotation

Torque au

$$\tau = rF_t = rF\sin\phi = F\ell$$

Work W

$$\Delta W = F_t r \Delta \theta$$

Newton's Second Law for Rotation

$$\sum \tau_{\mathsf{ext}} = I\alpha$$

Power

$$P = \frac{\Delta W}{\Delta t} = \frac{\tau \Delta \theta}{\Delta t} = \tau \omega$$

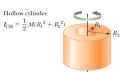
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Moments of Inertia

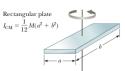
pop or thin lindrical shell MR^2





Solid cylinder or disk $I_{CM} = \frac{1}{2}MR^2$





Long, thin rod with rotation axis through center $I_{\text{CM}} = \frac{1}{12} ML^2$







Solid sphere $I_{CM} = \frac{2}{5}MR^5$



hin spherical nell $c_M = \frac{2}{3}MR^2$



Angular Momentum

Angular Momentum *L*

$$L = I\omega = r \times p$$

Conservation of Angular Momentum

 L_{sys} is constant if the external torque on the system is 0.

Rolling

When rigid objects roll, there are two types of basic rolling: "with slipping" and "without slipping".

$$v_{\sf cm} = R\omega$$