Have an
Irrational Day
3.14

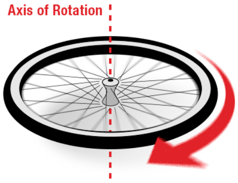
Announcements and Upcoming Events

PRACTICE	Unit 12 Problems (1-17)
LABS	Correct Paper Car Crash Lab
TESTS	Unit 12 Test Tuesday (3/26/19)

Rolling Motion and the Moment of Inertia

Learning Target

12.2	I can describe, interpret, and solve problems involving rolling motion and the moment of inertia.



UNIT 12 REVIEW

Key Concepts

- Angular position and its changes are measured in radians. One complete revolution is 2π rad.
- Angular velocity is given by the following equation.

$$\omega = \frac{\Delta\theta}{\Delta t}$$

- Angular acceleration is given by the following equation.

$$\alpha = \frac{\Delta\omega}{\Delta t}$$

- For a rotating, rigid object, the angular displacement, velocity, and acceleration can be related to the linear displacement, velocity, and acceleration for any point on the object.

$$d = r\theta \qquad v = r\omega \qquad a = r\alpha$$

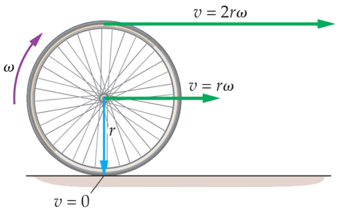
UNIT 12 REVIEW

Key Concepts

Linear Equation (a = constant)	Angular Equation (α = constant)
$v = v_0 + at$	$\omega = \omega_0 + \alpha t$
$x = x_0 + v_0 t + \frac{1}{2}at^2$	$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$
$v^2 = v_0^2 + 2a(x - x_0)$	$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$

UNIT 12 REVIEW

Key Concepts



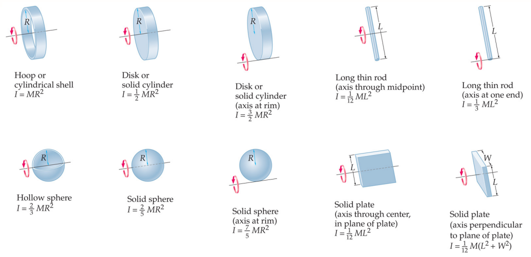
In a wheel that rolls without slipping, the point in contact with the ground is instantaneously at rest. The center of the wheel moves forward with the speed $v = r\omega$, and the top of the wheel moves forward with twice that speed, $v = 2r\omega$.

UNIT 12 REVIEW

Key Concepts

- The moment of inertia of an object depends on the way the object's mass is distributed about the rotational axis. For a point object:

$$I = mr^2$$



Hoop or cylindrical shell $I = MR^2$

Disk or solid cylinder $I = \frac{1}{2}MR^2$

Disk or solid cylinder (axis at rim) $I = \frac{3}{2}MR^2$

Long thin rod (axis through midpoint) $I = \frac{1}{12}ML^2$

Long thin rod (axis at one end) $I = \frac{1}{3}ML^2$

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

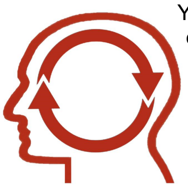
Solid sphere $I = \frac{2}{5}MR^2$

Solid sphere (axis at rim) $I = \frac{7}{5}MR^2$

Solid plate (axis through center, in plane of plate) $I = \frac{1}{12}ML^2$

Solid plate (axis perpendicular to plane of plate) $I = \frac{1}{12}M(L^2 + W^2)$

UNIT 12 IN CLASS PROBLEMS



Retrieval Practice
[Practice Testing]

You learned that an object's motion can be described using big picture concepts of kinetic energy and momentum.

12. In one minute, write down at least 3 things that you remember about kinetic energy and at least 3 things you remember about momentum.

Rotational Kinetic Energy

The rotational kinetic energy of an object is one-half the product of its moment of inertia and the square of its angular speed.

$$K = \frac{1}{2} I \omega^2$$

Rotational Kinetic Energy

Vector of [✓ Scalar]?

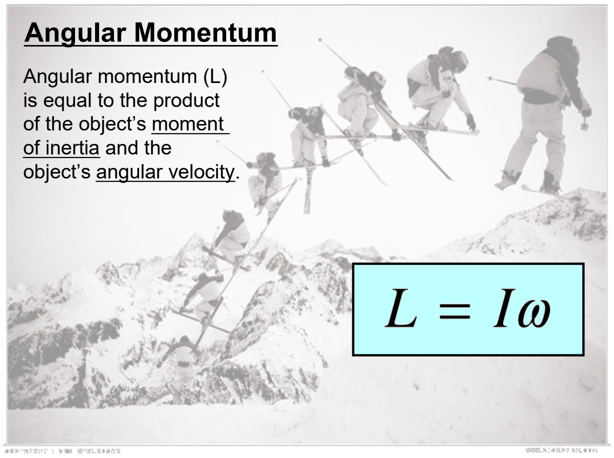
$$K = \frac{1}{2} I \omega^2$$

Units? J

Relationship?

$\omega \rightarrow$ Quad.

$I = m\underline{\underline{r}}^2$



Angular Momentum

Angular momentum (L) is equal to the product of the object's moment of inertia and the object's angular velocity.

$$L = I\omega$$

Angular Momentum

[✓ Vector] of Scalar?

$$L = I\omega$$

Units? $kg \cdot m^2 \times \frac{rad}{s} = \boxed{\frac{kg \cdot m^2}{s}}$

Relationship?

Direct Prop.

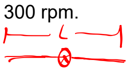
UNIT 12 IN CLASS PROBLEMS

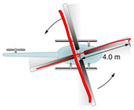
13. A typical small rescue helicopter has four blades, each is 4.00 m long and has a mass of 50.0 kg. The blades can be approximated as thin rods that rotate about one end of an axis perpendicular to their length. The helicopter has a total loaded mass of 1000 kg. Calculate the rotational kinetic energy in the blades when they rotate at 300 rpm.

14. Find the angular momentum of a 0.13 kg Frisbee (considered to be a uniform disk of radius 7.5 cm) spinning with an angular speed of 1.15 rad/s.

UNIT 12 IN CLASS PROBLEMS

13. A typical small rescue helicopter has four blades, each is 4.00 m long and has a mass of 50.0 kg. The blades can be approximated as thin rods that rotate about one end of an axis perpendicular to their length. The helicopter has a total loaded mass of 1000 kg. Calculate the rotational kinetic energy in the blades when they rotate at 300 rpm.





$m = 100 \text{ kg}$

$L = 8 \text{ m}$

$I = \frac{1}{12} mL^2$

$m = 50 \text{ kg}$

$L = 4 \text{ m}$

$I = \frac{1}{3} mL^2$

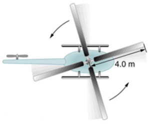
$$\omega = \frac{300 \cancel{\text{rev}}}{\cancel{\text{min}}} \times \frac{2\pi \text{ rad}}{1 \cancel{\text{rev}}} \times \frac{1 \cancel{\text{min}}}{60 \text{ s}}$$

UNIT 12 IN CLASS PROBLEMS

13. A typical small rescue helicopter has four blades, each is 4.00 m long and has a mass of 50.0 kg. The blades can be approximated as thin rods that rotate about one end of an axis perpendicular to their length. The helicopter has a total loaded mass of 1000.0 kg. Calculate the rotational kinetic energy in the blades when they rotate at 300.0 rpm.

$\omega = 31.4 \text{ rad/s}$

$I_{total} = 1070 \text{ kg·m}^2$



$K = ½ I \omega^2$

$K = ½ (1070 \text{ kg·m}^2) (31.4 \text{ rad/s})^2$

$K = 5.27 \times 10^5 \text{ J}$

UNIT 12 IN CLASS PROBLEMS

14. Find the angular momentum of a 0.13 kg Frisbee (considered to be a uniform disk of radius 7.5 cm) spinning with an angular speed of 1.15 rad/s.

$r = 0.075 \text{ m}$

$L = I\omega$

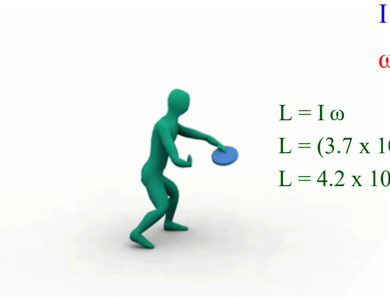
$I = \frac{1}{2} mr^2$

UNIT 12 IN CLASS PROBLEMS

14. Find the angular momentum of a 0.13 kg Frisbee (considered to be a uniform disk of radius 7.5 cm) spinning with an angular speed of 1.15 rad/s.

$I = 3.7 \times 10^{-4} \text{ kg·m}^2$

$\omega = 1.15 \text{ rad/s}$



$L = I \omega$

$L = (3.7 \times 10^{-4} \text{ kg·m}^2)(1.15 \text{ rad/s})$

$L = 4.2 \times 10^{-4} \text{ kg·m}^2/\text{s}$

PRACTICE

PROBLEMS

(10-17)