

↻ Last Lecture

- ↻ Pendulums and Kinetic Energy of rotation

↻ Today

- ↻ Energy and Momentum of rotation

↻ Important Concepts

- ↻ Equations for angular motion are mostly identical to those for linear motion with the names of the variables changed.
- ↻ Kinetic energy of rotation adds a new term to the same energy equation, it does not add a new equation.
- ↻ Momentum of rotation gives an additional equation

8.01L IAP 2006

1/18/2006

Important Reminders

- ↻ Contact your tutor about session scheduling
- ↻ Mastering Physics due today at 10pm.
- ↻ Pset due this Friday at 11am.

8.01L IAP 2006

1/18/2006

Torque Checklist

↻ Make a careful drawing showing **where** forces act

- ↻ Clearly indicate what axis you are using
- ↻ Clearly indicate whether CW or CCW is positive

↻ For each force:

- ↻ If force acts at axis or points to or away from axis, $\tau=0$
- ↻ Draw (imaginary) line from axis to point force acts. If distance and angle are clear from the geometry $\tau=Fr\sin(\theta)$
- ↻ Draw (imaginary) line parallel to the force. If distance from axis measured perpendicular to this line (lever arm) is clear, then the torque is the force times this distance

↻ Don't forget CW versus CCW, is the torque + or -

8.01L IAP 2006

1/18/2006

Kinetic Energy with Rotation

- ↻ Adds a new term not a new equation!
- ↻ Rotation around any fixed pivot: $KE = \frac{1}{2} I_{pivot} \omega^2$
- ↻ Moving and rotating: $KE = \frac{1}{2} I_{CM} \omega^2 + \frac{1}{2} M_{Tot} v_{CM}^2$

8.01L IAP 2006

1/18/2006

Everything you need to know for Linear & Rotational Dynamics

- $\Sigma \vec{F} = M\vec{a}$
- $\Sigma \vec{\tau} = I\vec{\alpha}$
 - This is true for **any fixed** axis and for an axis through the center of mass, even if the object moves or accelerates.
- Rolling **without** slipping: $v = R\omega$ $a = R\alpha$ $f \neq \mu N$
 - Friction does NOT do work!
- Rolling **with** slipping: $v \neq R\omega$ $a \neq R\alpha$ $f = \mu N$
 - Friction does work, usually negative.
 - Rarely solvable without using force and torque equations!

8.01L IAP 2006

1/18/2006

Kinematics Variables

- | | |
|--------------------|---------------------------------|
| → Position x | → Angle θ |
| → Velocity v | → Angular velocity ω |
| → Acceleration a | → Angular acceleration α |
| → Force F | → Torque τ |
| → Mass M | → Moment of Inertia I |
| → Momentum p | → Angular Momentum \times |

$$\omega = \frac{d\theta}{dt} \quad \alpha = \frac{d\omega}{dt} = \frac{d^2\theta}{dt^2}$$

8.01L IAP 2006

1/18/2006

Kinematics Variables

- | | |
|--------------------|---------------------------------|
| → Position x | → Angle θ |
| → Velocity v | → Angular velocity ω |
| → Acceleration a | → Angular acceleration α |
| → Force F | → Torque τ |
| → Mass M | → Moment of Inertia I |
| → Momentum p | → Angular Momentum L |

$$\omega = \frac{d\theta}{dt} \quad \alpha = \frac{d\omega}{dt} = \frac{d^2\theta}{dt^2}$$

8.01L IAP 2006

1/18/2006

Angular Momentum

- Conserved when external torques are zero or when you look over a very short period of time.
 - True for any fixed axis and for the center of mass
- Formula we will use is simple: $\vec{L} = I\vec{\omega}$
 - Vector nature (CW or CCW) is still important
- Point particle: $\vec{L} = \vec{r} \times \vec{p}$
- Conservation of angular momentum is a separate equation from conservation of linear momentum
- Angular impulse: $\vec{\tau} = \frac{d\vec{L}}{dt} \quad \Delta\vec{L} = \int \vec{\tau} dt$

8.01L IAP 2006

1/18/2006