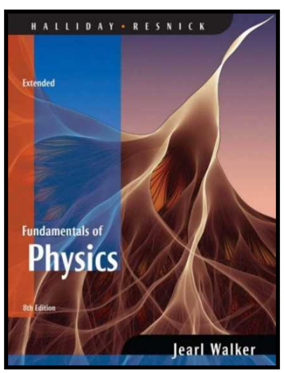
University Physics II

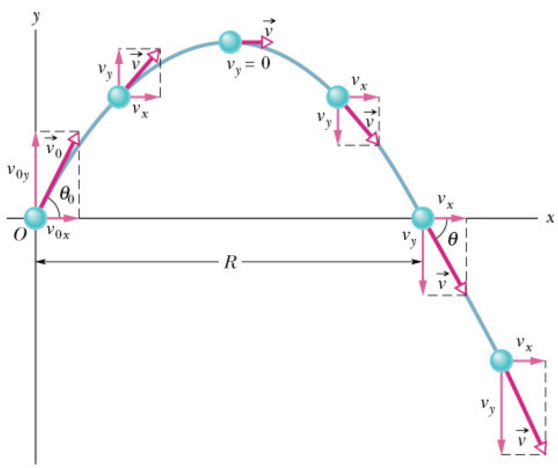


Week 3 : Day 3

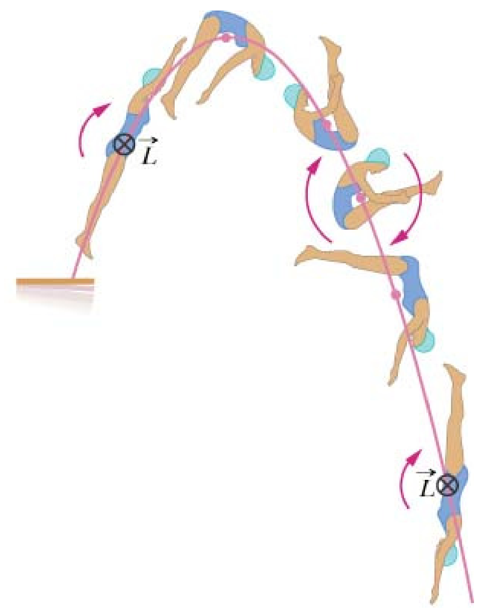
Outline

- **Translational and Rotational Motion**
  - Linear and rotational variables and equations
- **Aspects of Rolling Motion**
  - Two terms for energy
  - Two terms for angular momentum
- **Angular momentum applications**
  - Rotating platform
  - The Simple pendulum
  - The ballistic pendulum
- **Activity – Angular Momentum Problems**

Comparison of Translational and Rotational Motion



Translational Motion		Rotational Motion
x	$\leftrightarrow$	θ
v	$\leftrightarrow$	ω
a	$\leftrightarrow$	α
p	$\leftrightarrow$	ℓ
$K = \frac{mv^2}{2}$	$\leftrightarrow$	$K = \frac{I\omega^2}{2}$
m	$\leftrightarrow$	I
$F = ma$	$\leftrightarrow$	$\tau = I\alpha$
F	$\leftrightarrow$	τ
$P = Fv$	$\leftrightarrow$	$P = \tau\omega$
$\vec{F}_{net} = \frac{d\vec{p}}{dt}$	$\leftrightarrow$	$\vec{\tau}_{net} = \frac{d\vec{\ell}}{dt}$
$p = mv$	$\leftrightarrow$	$L = I\omega$



Aspects of Rolling Motion

- **Two terms for Energy**
  - One translational
  - One Rotational

$$\Rightarrow K = \underbrace{\frac{1}{2}mv^2}_{Translational} + \underbrace{\frac{1}{2}I\omega^2}_{Rotational}$$

- **Two terms for Angular Momentum**
  - One translational
  - One rotational

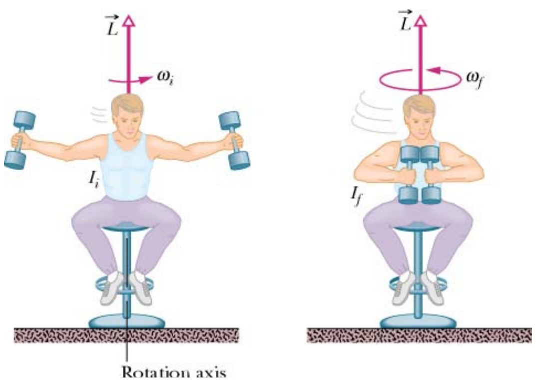
$$\Rightarrow \vec{L} = \underbrace{\vec{r}\times\vec{p}}_{Translational} + \underbrace{I\vec{\omega}}_{Rotational}$$

Angular Momentum - Application

- **Rotating Platform**
  - Pure rotation
    - *Energy **not** conserved*

$$\Rightarrow K_i \neq K_f$$

  - Use conservation of angular momentum:



"Initial" "Final"

$$\vec{L}_i = \vec{L}_f$$

$$I_i \omega_i \hat{k} = I_f \omega_f \hat{k}$$

$$\Rightarrow \omega_f = \frac{I_i}{I_f} \omega_i$$

Angular Momentum - Application

- **Recall the simple pendulum**
  - What is the angular momentum about the pivot?
    - *Pure rotation so* L *given by…*

$$L = I\omega = \left(mR^2\right)\omega$$

    - *Angular velocity is given by…*

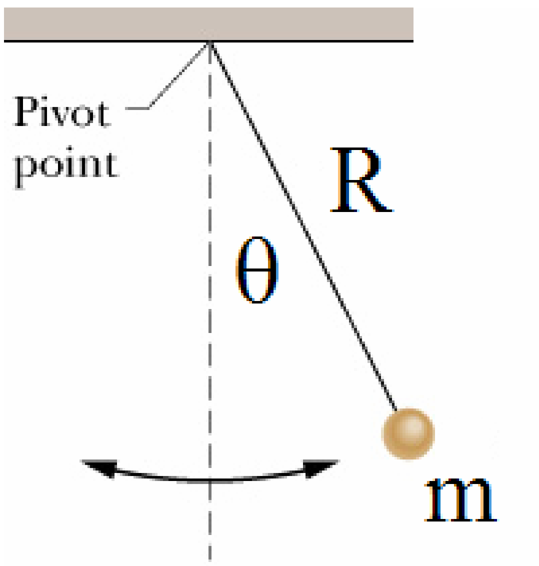
$$\omega = {2\pi}/{T}$$

    - *Period of motion is given by…*

$$T = 2\pi\sqrt{R/g}$$

  - Angular momentum a constant:

$$L = mR^2 \frac{2\pi}{2\pi\sqrt{R/g}} = m\sqrt{gR^3}$$

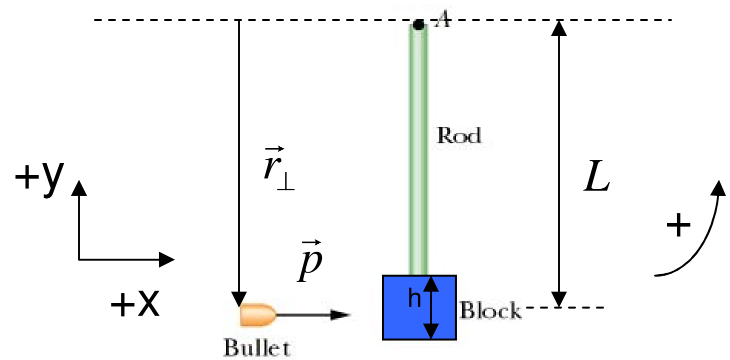


RIT

Angular Momentum - Application

- **Consider the ballistic pendulum**
  - Again energy not conserved
  - Use angular momentum

Ballistic Pendulum



$$\vec{L} = \vec{r} \times \vec{p} + I\vec{\omega}$$

$$\vec{L}_i = \vec{L}_f$$

$$\vec{r} \times \vec{p} = I\vec{\omega}$$

$$\Downarrow$$

$$\left(-L\hat{j}\right) \times m_{bullet} v_{bullet} \hat{i} = \left[\left(m_{bullet} + m_{Block}\right)L^2 + \tfrac{1}{3} m_{rod}\left(L - \tfrac{h}{2}\right)^2\right]\left(+\omega\hat{k}\right)$$

$$\Rightarrow v_{bullet} = +\frac{\left[m_{bullet} + m_{Block} + \frac{1}{3}\left(1 - \frac{h}{2L}\right)^2 m_{rod}\right]}{m_{bullet}} \omega L$$

*Energy conservation can be used after the collision to find height of resulting pendulum motion…

Activity – Angular Momentum Problems

- Conceptual Warm-up: **Imagine you're standing on one of the rotating platforms as in a previous activity, holding the weights with your arms outstretched. You suddenly drop the weights without changing the position of your arms in any way. Your angular velocity will**
  - increase
  - remain the same
  - decrease
  - suddenly stop
  - suddenly reverse direction

  Explain the correct answer using correct physics principles.

- Work problems 2, 4, 6

Your Name (**Print**): ____________________ Date: ________
Group Members: ____________________
____________________ Group: ________

Angular Momentum Problems

1) Conceptual Warm-up: Imagine you're standing on one of the rotating platforms as in a previous activity, holding the weights with your arms outstretched. You suddenly drop the weights without changing the position of your arms in any way. Your angular velocity will

- o increase
- o remain the same
- o decrease
- o suddenly stop
- o suddenly reverse direction

Explain the correct answer using correct physics principles.

2) {HRW8 11.P.043} A student sits on a platform that is rotating without friction with an angular speed of 1.20 rev/s; his arms are outstretched and he holds a weight in each hand. The rotational inertia of the system consisting of the student, weights, and platform about the central vertical axis of the platform is 6.00 kg·m^2. If by moving the weights the student decreases the rotational inertia of the system to 2.00 kg·m^2, what are

a) the resulting angular speed of the platform and
b) the ratio of the new kinetic energy of the system to the original kinetic energy?
c) If the kinetic energy decreased, where did it go? If the kinetic energy increased, where did it come from?

3) {HRW8 11.P.047} Two disks are mounted (like a merry-go-round) on low-friction bearings on the same axle and can be brought together so they couple and rotate as one unit. The first disk, with rotational inertia 3.30 kg·m^2 about its central axis, is set spinning counterclockwise at 450 rpm (rev/min). The second disk with rotational inertia 6.60 kg·m^2 about its central axis is set spinning counterclockwise at 900 rpm. They then couple together.

a) What is their angular speed after coupling?

If instead the second disk is set spinning clockwise at 900 rpm, what are their

b) angular speed and
c) direction of rotation after they couple together?