A solid disk and a ring roll down an incline. The ring is slower than the disk if

A. $m_{ring} = m_{disk}$, where m is the mass.

B. $r_{ring} = r_{disk}$, where r is the radius.

C. $m_{ring} = m_{disk}$ and $r_{ring} = r_{disk}$.

D. The ring is always slower regardless of the relative values of m and r.

E. None of the above.

Exam #2

- April 7, 5-7pm
- CR 214 (Wed Labs) & CR 222 (Thu Labs)
- Chapters 6-9
- One page single-sided equation sheet allowed.
- **Review session**: Wed, April 6 5-7pm, Enzi 195

Ch 10.5-6
Angular Momentum

PHYS 1210 -- Prof. Jang-Condell

Goals for Chapter 10

- To learn what is meant by torque
- To see how torque affects rotational motion
- To analyze the motion of a body that rotates as it moves through space
- To use work and power to solve problems for rotating bodies
- To study angular momentum and how it changes with time
- To learn why a gyroscope precesses

Linear vs. Rotational Motion

	Linear	**Rotational**	**relation**
position	$\boldsymbol{r}$	$\boldsymbol{\theta}$	$\theta = s/r$
velocity	$\boldsymbol{v}$	$\boldsymbol{\omega}$	$\omega = v/r$
acceleration	$\boldsymbol{a}$	$\boldsymbol{\alpha}$	$\alpha = a/r$
mass	m	I	$I = \sum m_i r_i^2$ $= \int r^2\, dm$

Linear vs. Rotational Motion

	Linear	**Rotational**	**relation**
force	$\sum \boldsymbol{F} = m\boldsymbol{a}$	$\sum \boldsymbol{\tau} = I\boldsymbol{\alpha}$	$\boldsymbol{\tau} = \boldsymbol{r} \times \boldsymbol{F}$
momentum	$\boldsymbol{p} = m\boldsymbol{v}$	$\boldsymbol{L} = I\boldsymbol{\omega}$	$\boldsymbol{L} = \boldsymbol{r} \times \boldsymbol{p}$
kinetic energy	$K = (1/2)mv^2$	$K = (1/2)I\omega^2$	
work	$W = \int \boldsymbol{F} \cdot d\boldsymbol{l}$	$W = \int \boldsymbol{\tau} \cdot d\boldsymbol{\theta}$	

Work and Power

$$W = \int \boldsymbol{\tau} \cdot d\boldsymbol{\theta}$$

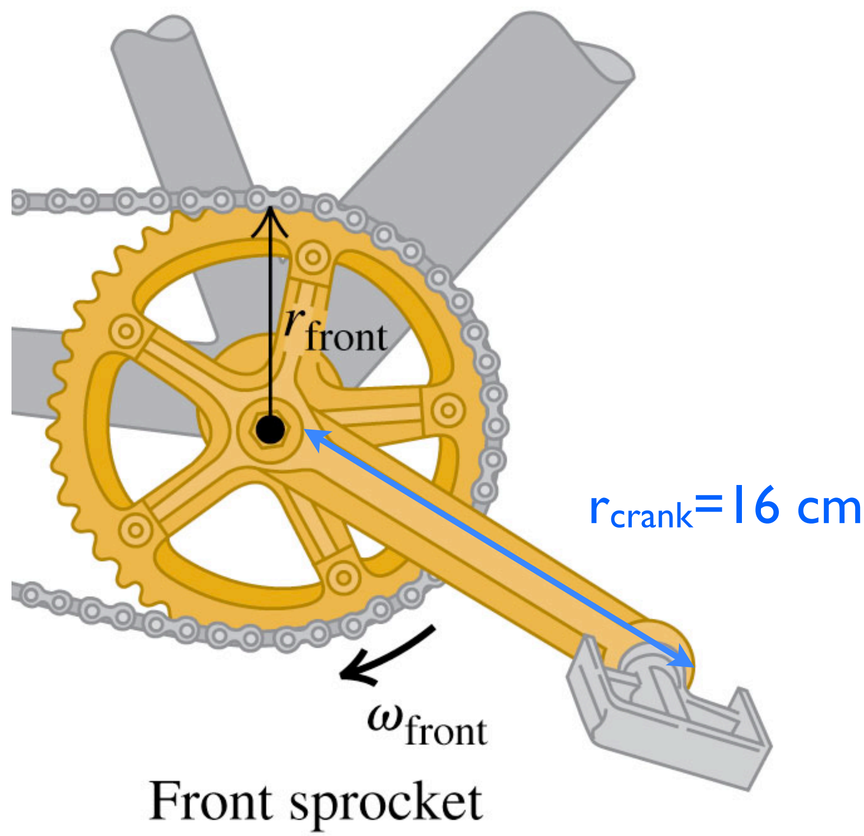
$$P = \tau \cdot \omega$$

Power

While riding your bicycle, you find that you apply a constant force of 50 N while pedaling at a constant rate of 1.50 revolutions per second. The length of the crank is 16.0 cm.

How much work do you apply over half a revolution?

How much power are you applying?



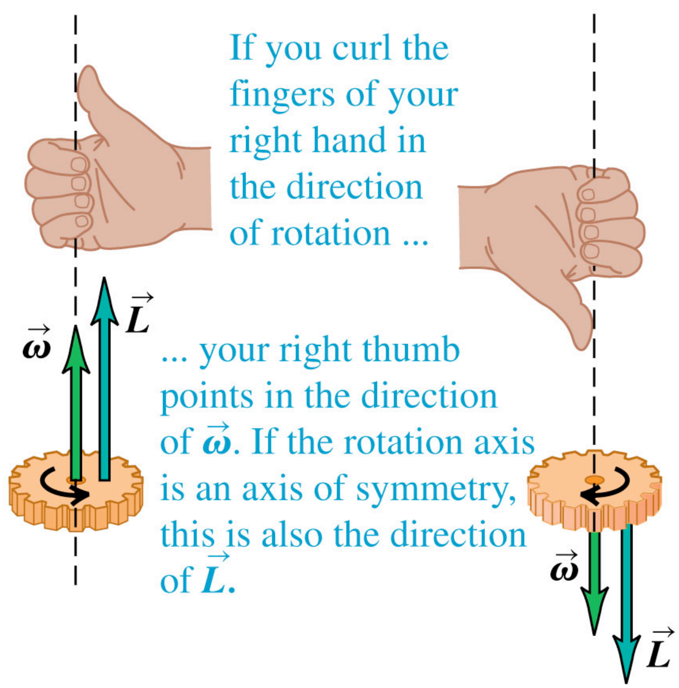
Angular momentum

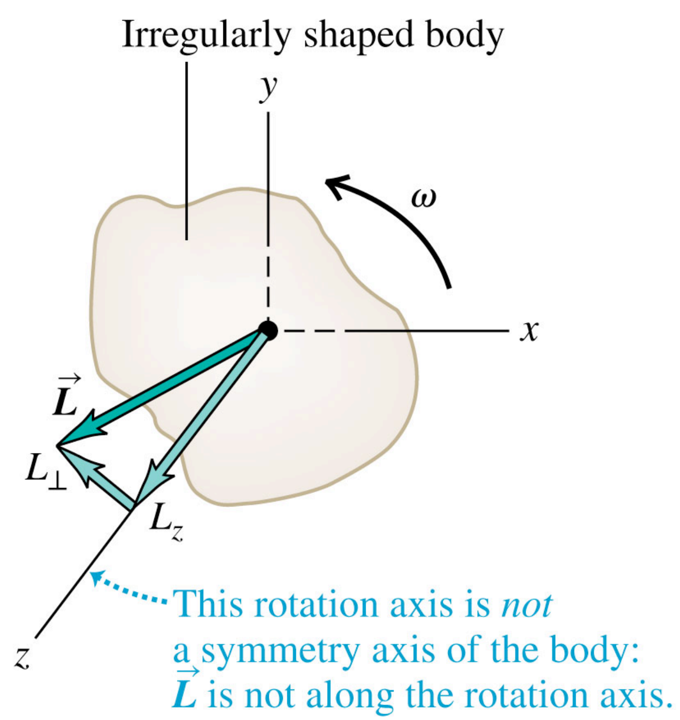
$$\boldsymbol{L} = \boldsymbol{r} \times \boldsymbol{p}$$

$$\boldsymbol{L} = I\boldsymbol{\omega}$$

Angular momentum

- The angular momentum of a rigid body rotating about a symmetry axis is parallel to the angular velocity and is given by $\vec{L} = I\vec{\omega}$. (See Figures 10.26 and 10.27 below).
- For any system of particles $\Sigma\vec{\tau} = d\vec{L}/dt$.
- For a rigid body rotating about the z-axis $\Sigma\tau_z = I\alpha_z$.

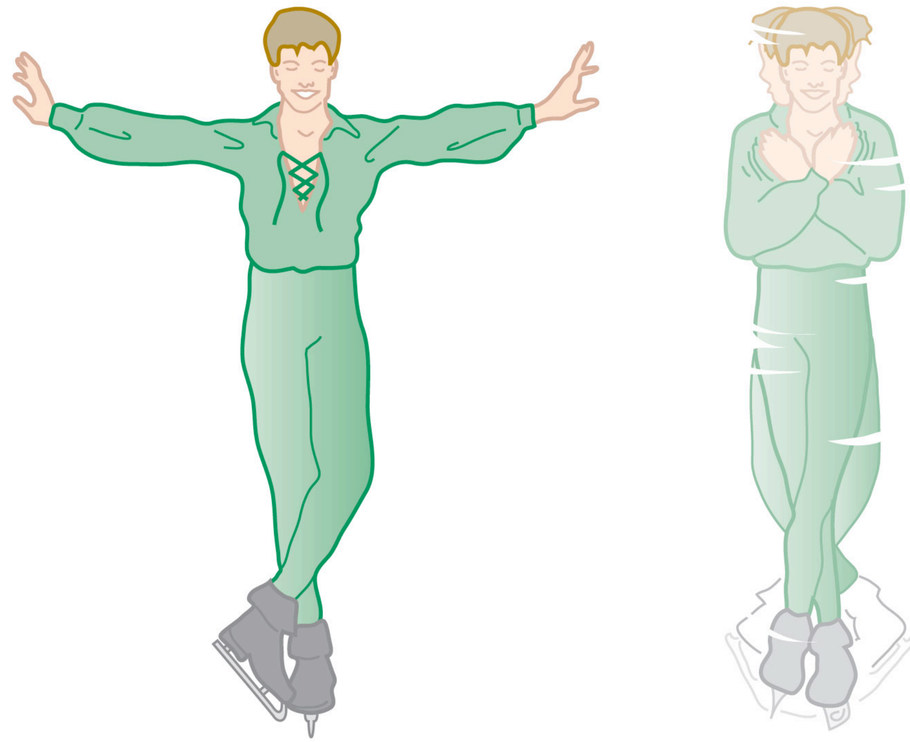




Angular Momentum Conservation

Q10.11

A spinning figure skater pulls his arms in as he rotates on the ice. As he pulls his arms in, what happens to his angular momentum L and kinetic energy K?



F. L and K both increase.

G. L stays the same; K increases.

H. L increases; K stays the same.

I. L and K both stay the same.

Demo 1

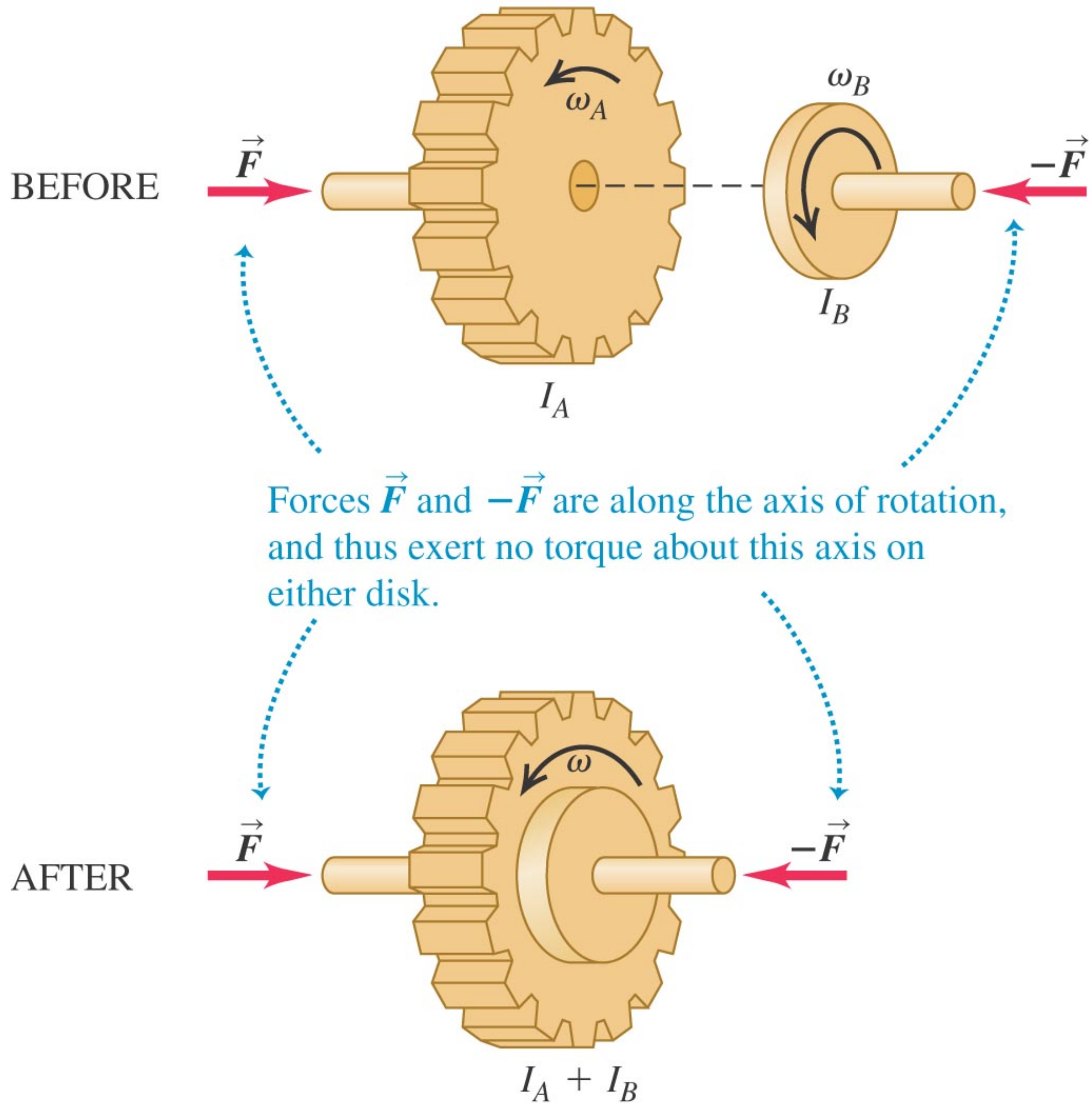
A girl moves quickly to the center of a spinning merry-go-round, traveling along the radius of the merry-go-round. Which of the following statements are true?

1. The angular speed of the system decreases.
2. The angular speed of the system increases.
3. The angular speed of the system remains constant.
4. The moment of inertia of the system decreases.
5. The moment of inertia of the system increases.
6. The moment of inertia of the system remains constant.
7. The kinetic energy of the system decreases.
8. The kinetic energy of the system increases.
9. The kinetic energy of the system remains constant.

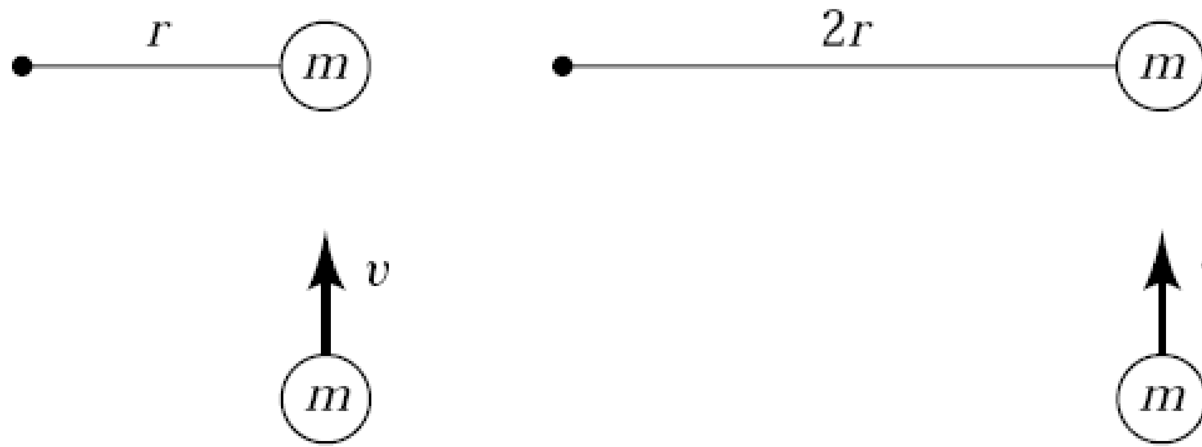
Text all answers that apply to 22333

A rotational "collision"

- Follow Example 10.11 using Figure 10.30 at the right.

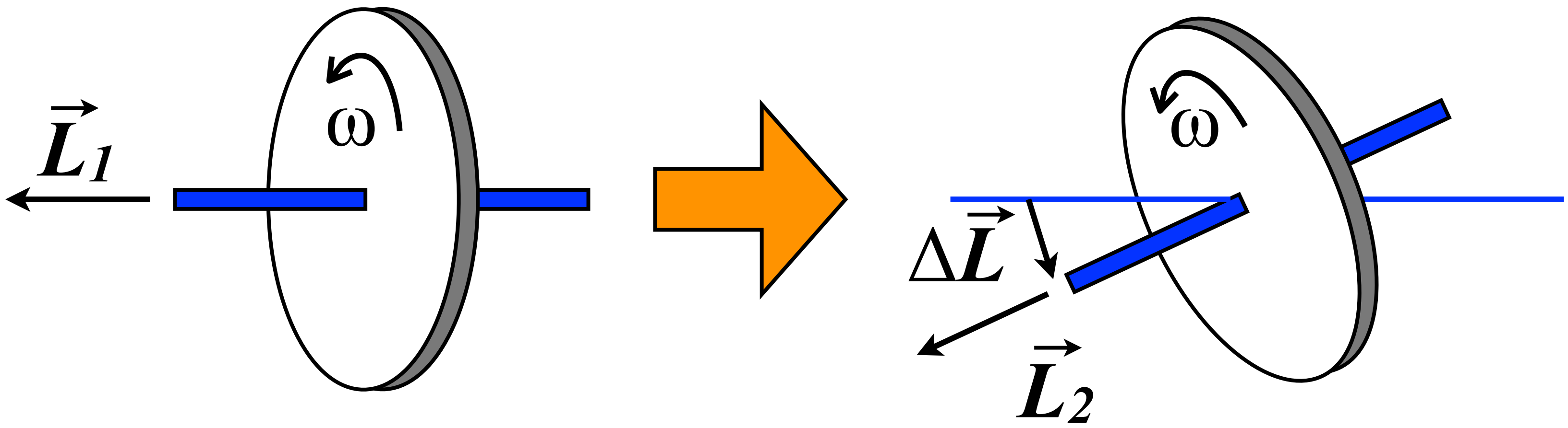


Consider the situation shown at left below. A puck of mass m, moving at speed v hits an identical puck which is fastened to a pole using a string of length r. After the collision, the puck attached to the string revolves around the pole. Suppose we now lengthen the string by a factor 2, as shown on the right, and repeat the experiment. Compared to the angular speed in the first situation, the new angular speed is



K. twice as high
L. the same
M. half as much
N. none of the above

Demo 2

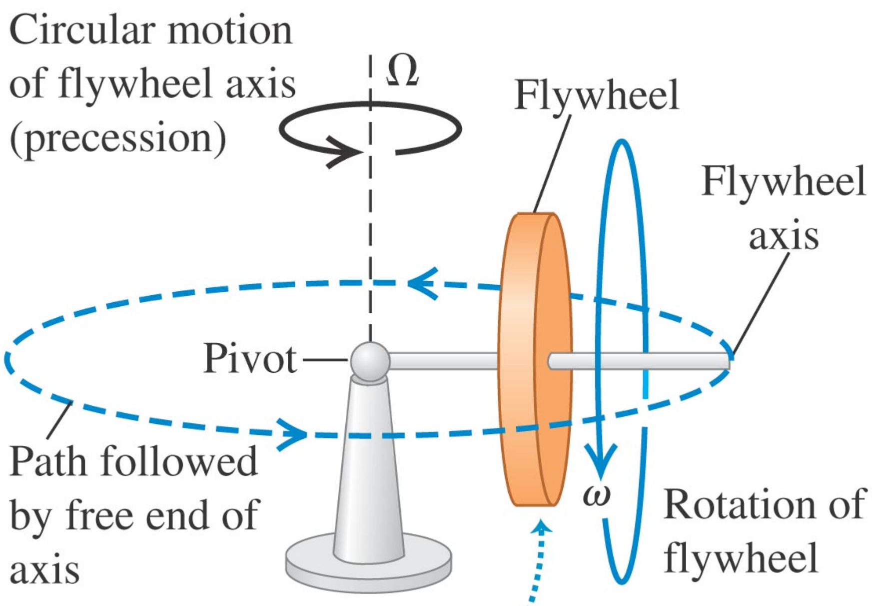


Conservation of angular momentum:
Person holding axle gains -$\Delta\vec{L}$ in angular momentum, rotates counter clockwise

Torque: Need to apply a torque of $\vec{\tau}=\Delta\vec{L}/\Delta t$ to get axle to move. Equal and opposite reaction to axle holder of $\vec{\tau}=-\Delta\vec{L}/\Delta t$, results in CCW rotation

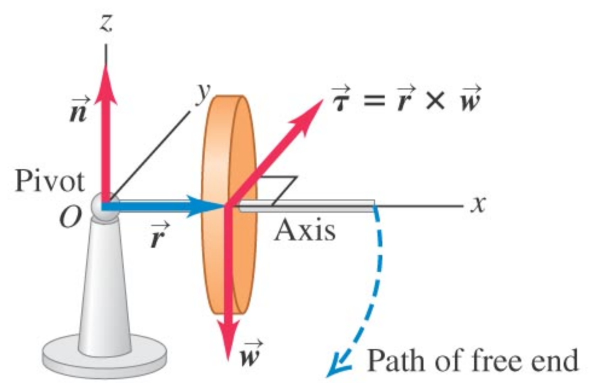
Gyroscopes and precession

- For a gyroscope, the axis of rotation changes direction. The motion of this axis is called *precession*.



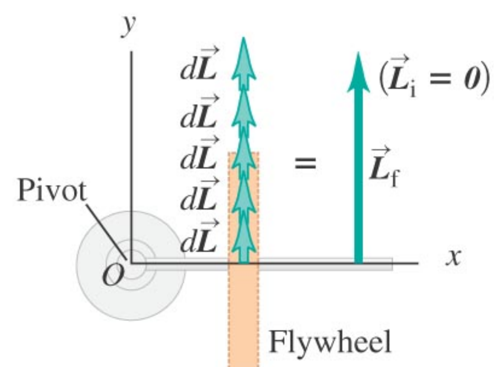
When the flywheel and its axis are stationary, they will fall to the table surface. When the flywheel spins, it and its axis "float" in the air while moving in a circle about the pivot.

(a) Nonrotating flywheel falls



When the flywheel is not rotating, its weight creates a torque around the pivot, causing it to fall along a circular path until its axis rests on the table surface.

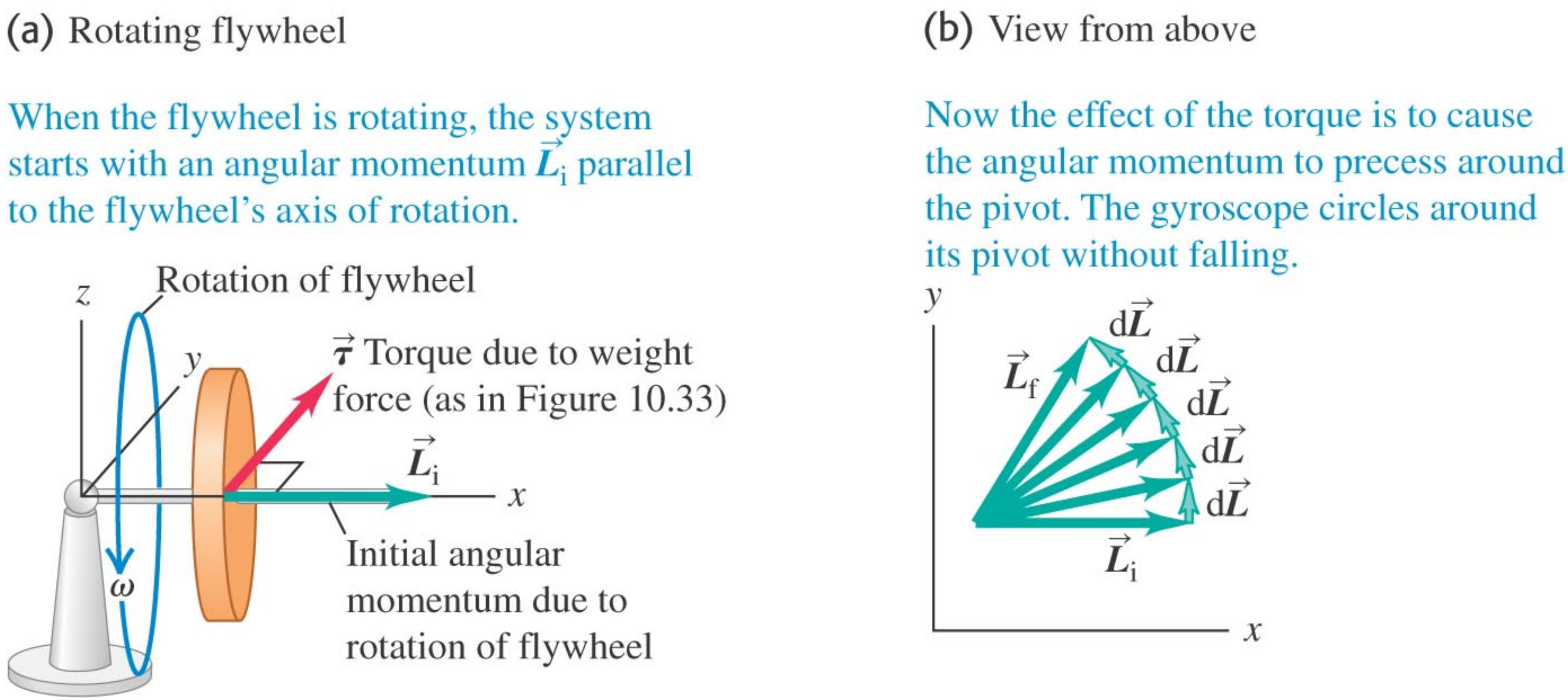
(b) View from above as flywheel falls



In falling, the flywheel rotates about the pivot and thus acquires an angular momentum $\vec{L}$. The *direction* of $\vec{L}$ stays constant.

A rotating flywheel

- Figure 10.34 below shows a spinning flywheel. The magnitude of the angular momentum stays the same, but its direction changes continuously.



A precessing gyroscopic

- Follow Example 10.13 using Figure 10.36.