Q10.5

A glider of mass m_1 on a frictionless horizontal track is connected to an object of mass m_2 by a massless string. The glider accelerates to the right, the object accelerates downward, and the string rotates the pulley. What is the relationship among T_1 (the tension in the horizontal part of the string), T_2 (the tension in the vertical part of the string), and the weight m_2g of the object?

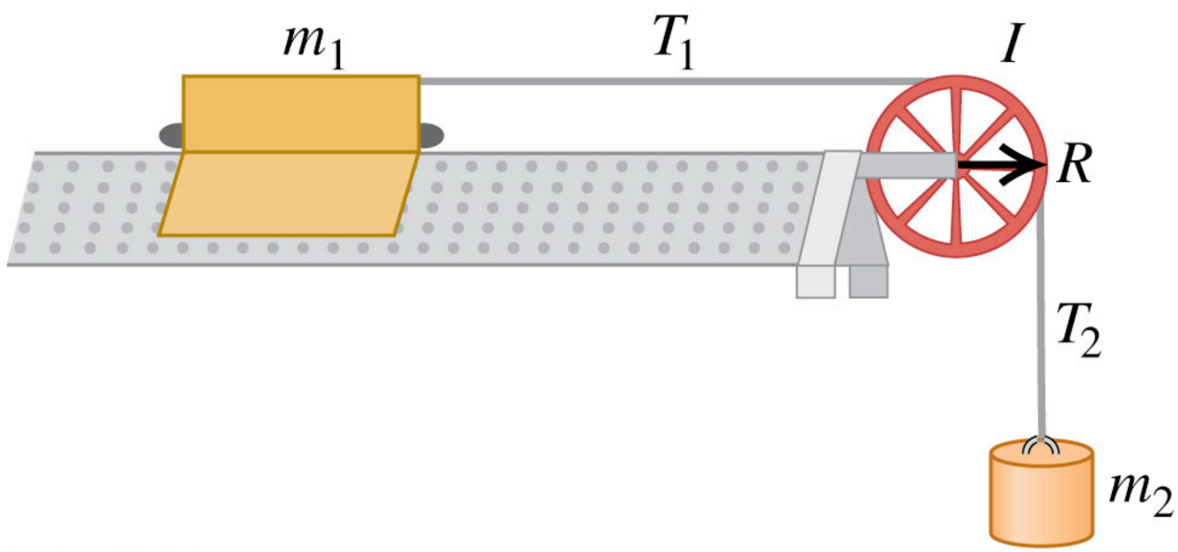
A. $m_2g = T_2 = T_1$

B. $m_2g > T_2 = T_1$

C. $m_2g > T_2 > T_1$

D. $m_2g = T_2 > T_1$

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 10.3-4
Rotational Motion

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

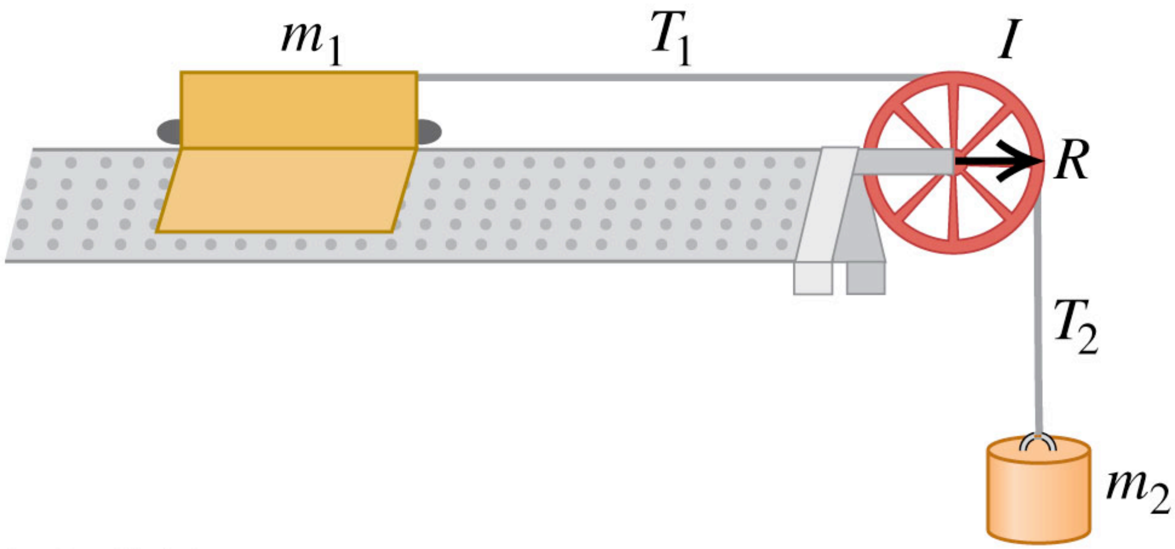
Linear vs. Rotational Motion

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

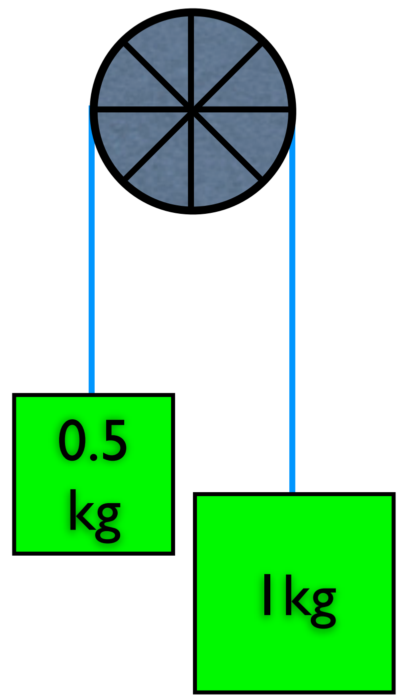
Linear vs. Rotational Motion

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

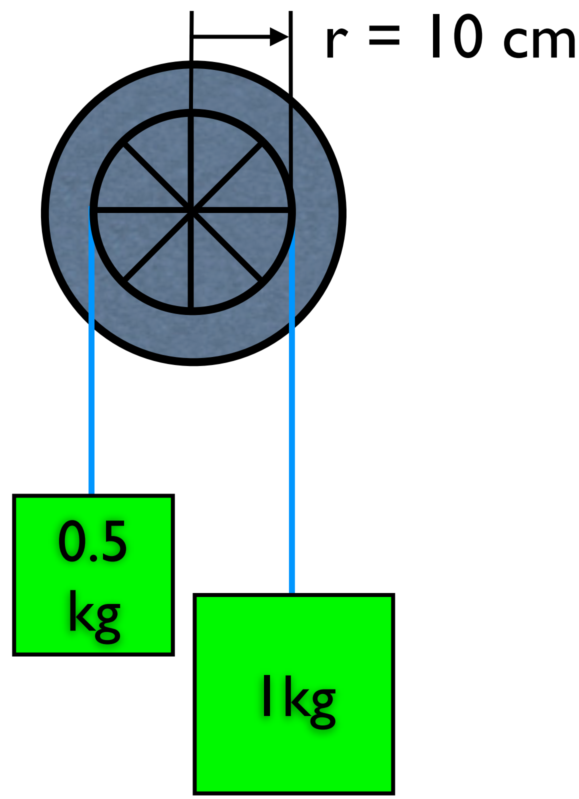
What is the angular acceleration of the pulley?
What is the acceleration of the total system?



The two weights pictured below are attached to a frictionless, massless pulley of radius 10 cm. What is the angular acceleration on the pulley?



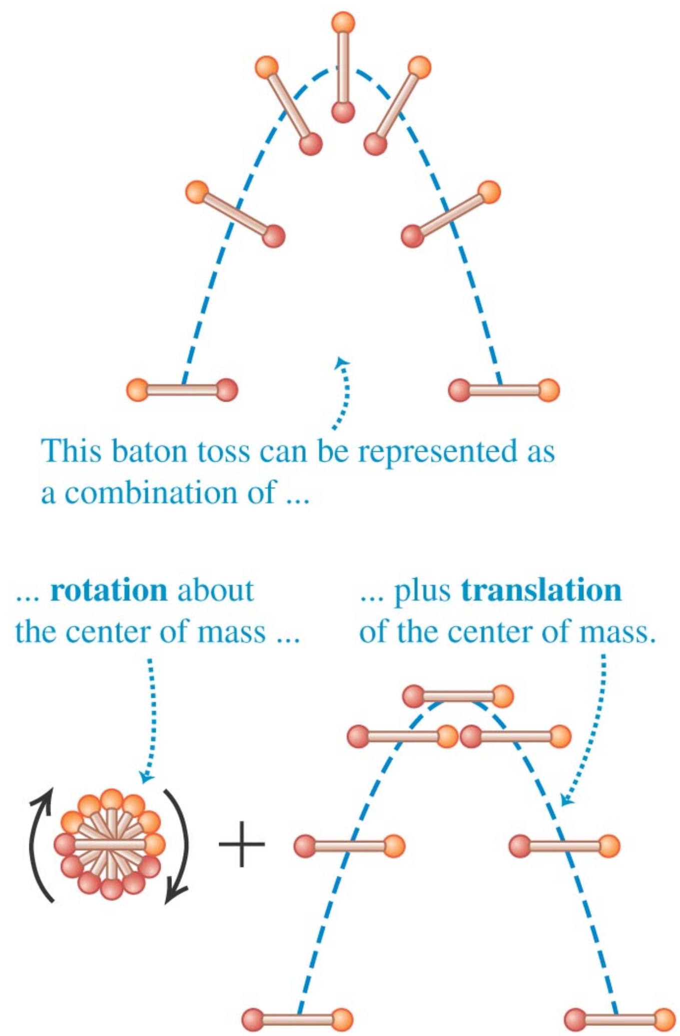
Now suppose that the pulley has some moment of inertia *I*. What is the *linear* acceleration of the weights?



Rigid body rotation about a moving axis

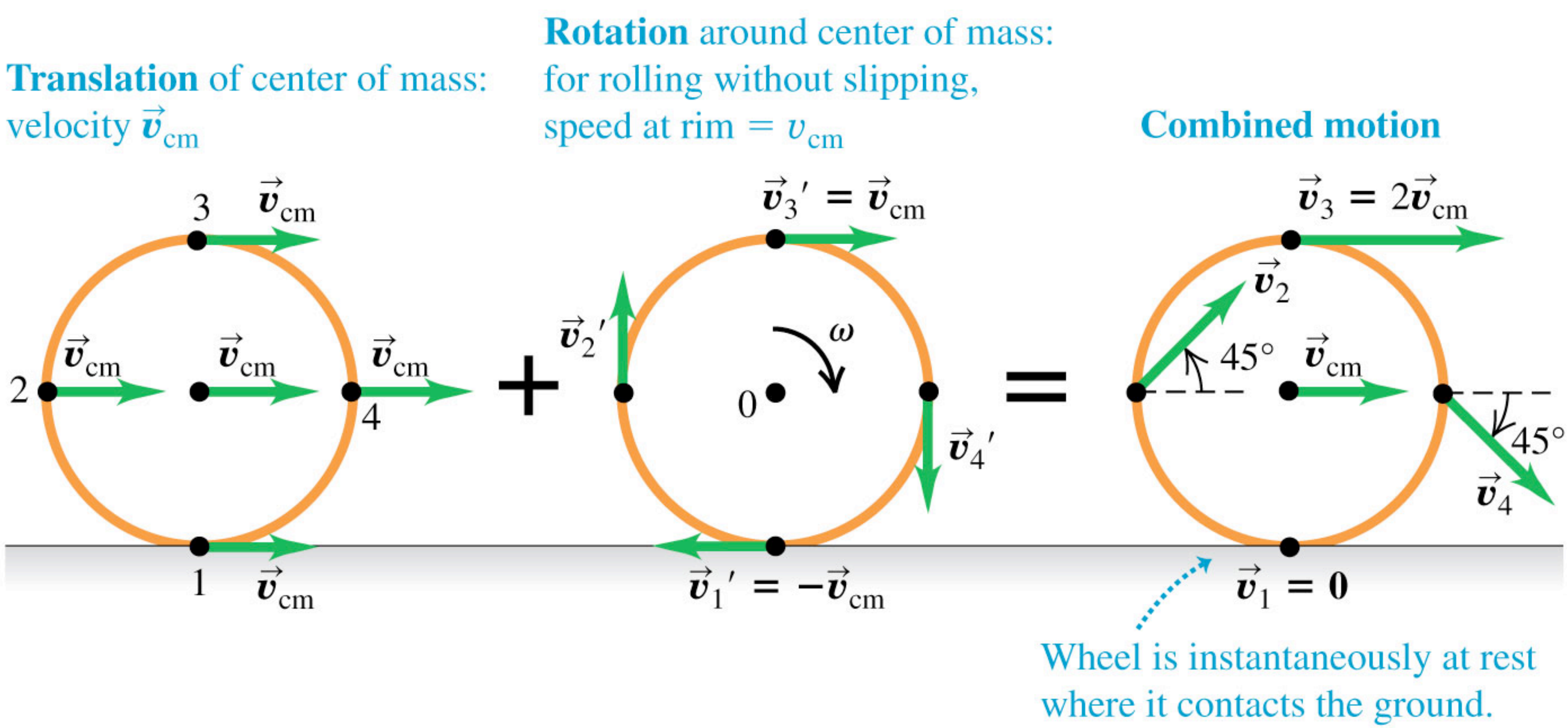
- The motion of a rigid body is a combination of translational motion of the center of mass and rotation about the center of mass (see Figure 10.11 at the right).
- The kinetic energy of a rotating and translating rigid body is

  $K = 1/2\ Mv_{cm}{}^2 + 1/2\ I_{cm}\omega^2$.



Rolling without slipping

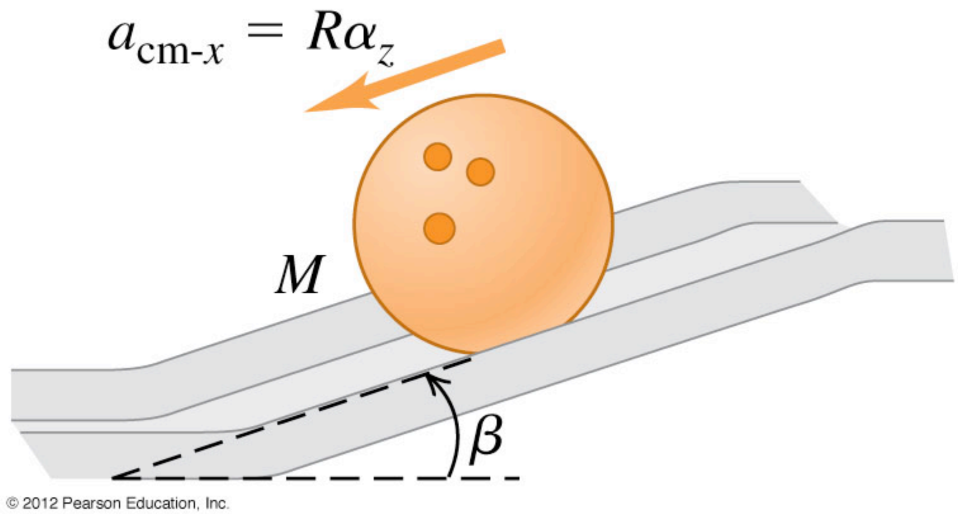
$$v_{\mathrm{cm}} = R\omega$$



Q10.7

A solid bowling ball rolls down a ramp.

Which of the following forces exerts a torque on the bowling ball about its center?



F. the weight of the ball

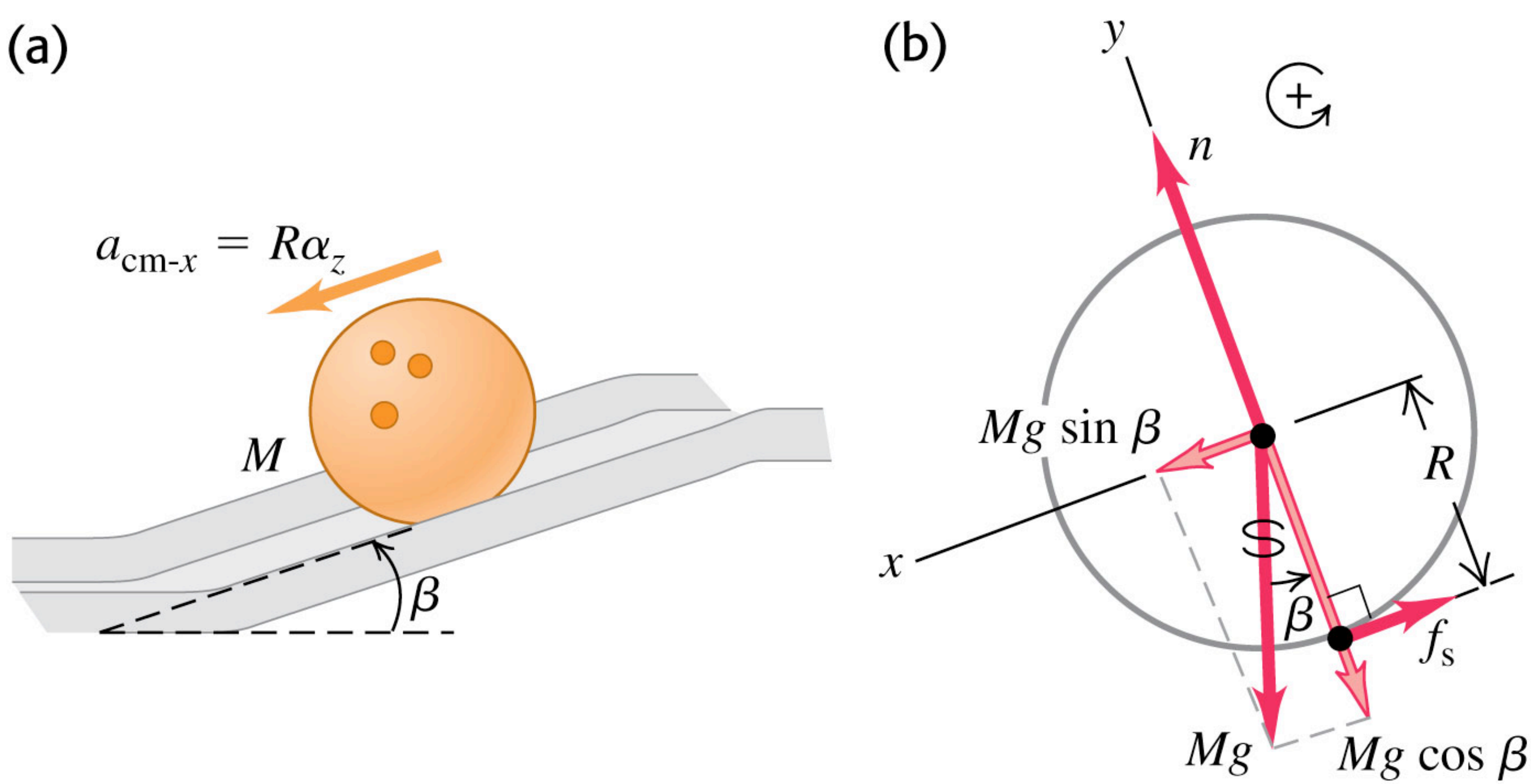
G. the normal force exerted by the ramp

H. the friction force exerted by the ramp

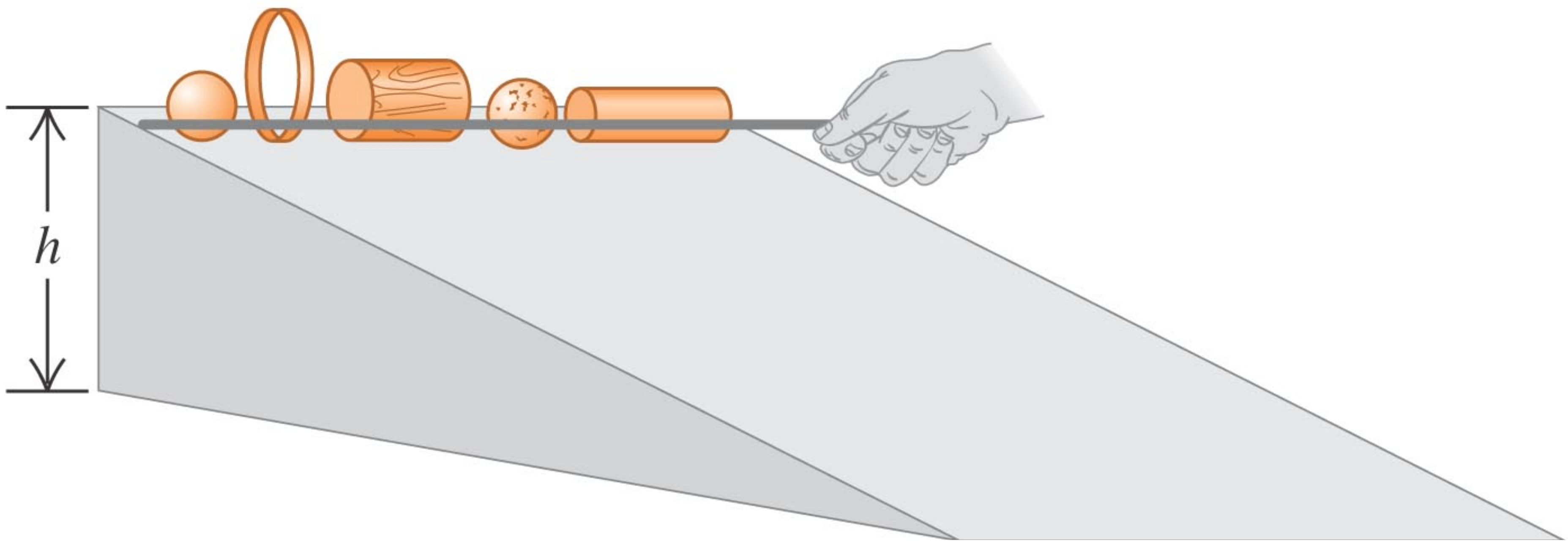
I. more than one of the above

J. The answer depends on whether the ball rolls without slipping.

Acceleration of a rolling sphere



The ramp race



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

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

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

M. m_{ring} = m_{disk} and r_{ring} = r_{disk}.

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

Q10.6

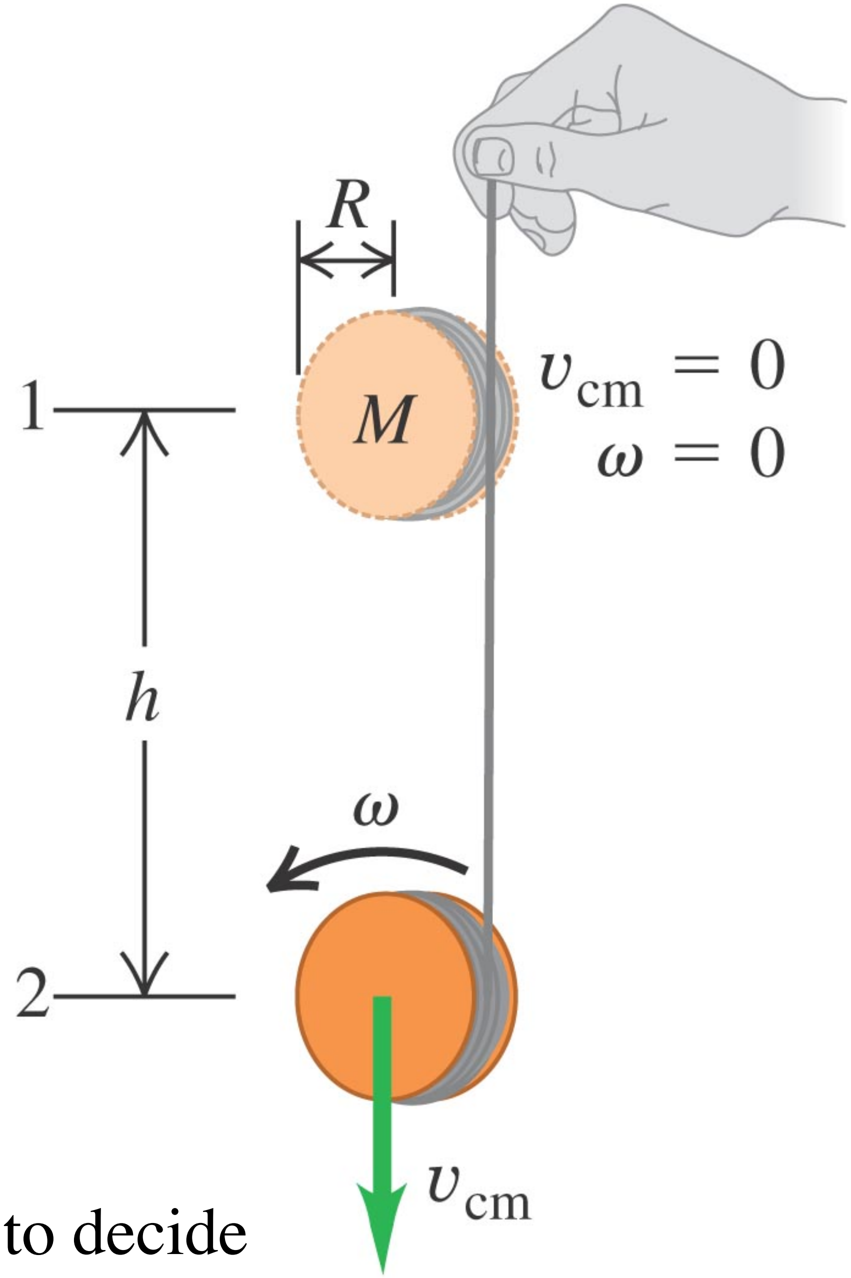
A lightweight string is wrapped several times around the rim of a small disk. If the free end of the string is held in place and the disk is released from rest, the string unwinds and the disk descends. How does the tension in the string (T) compare to the weight of the disk (w)?

Q. $T = w$

R. $T > w$

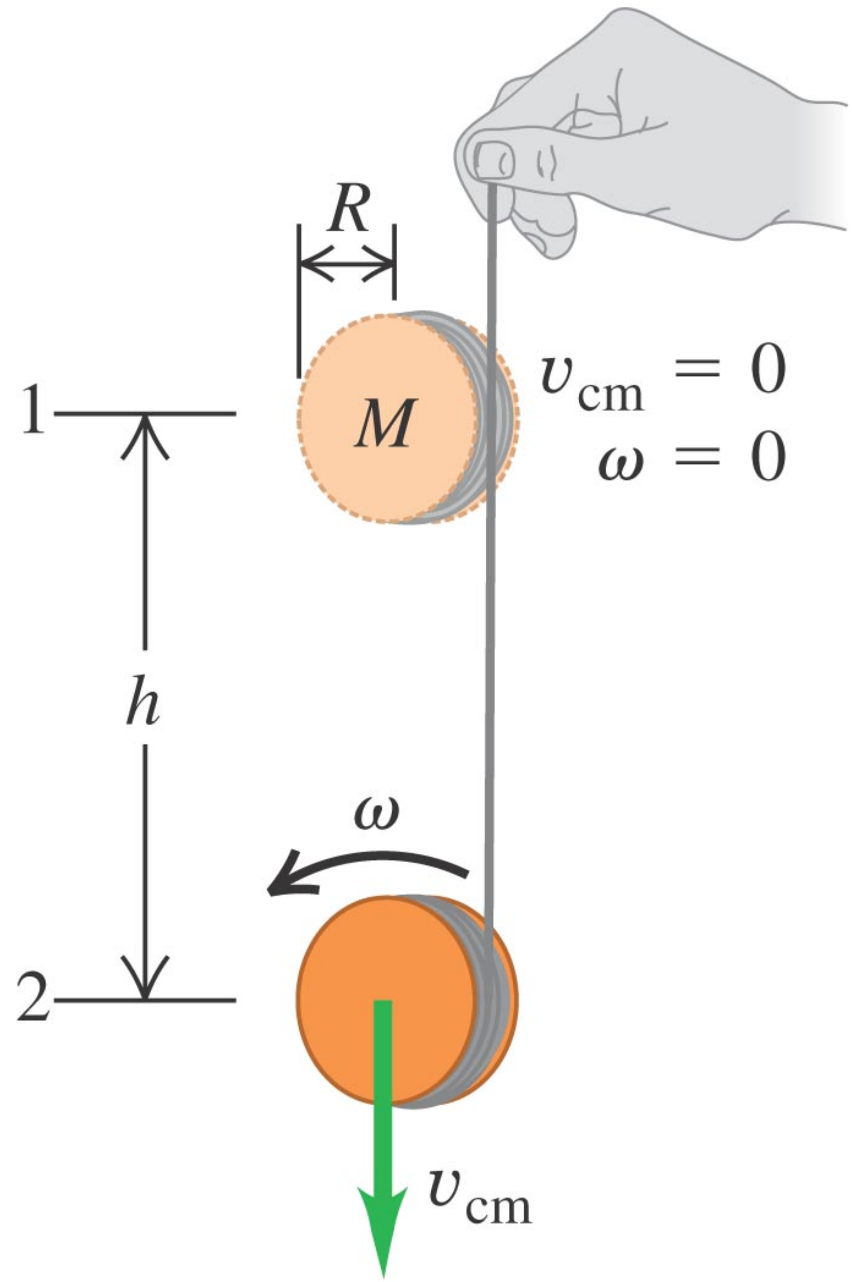
S. $T < w$

T. not enough information given to decide



A yo-yo

- What is the speed of the yo-yo after it has dropped a height *h*?
- What is the acceleration?



Work and Power

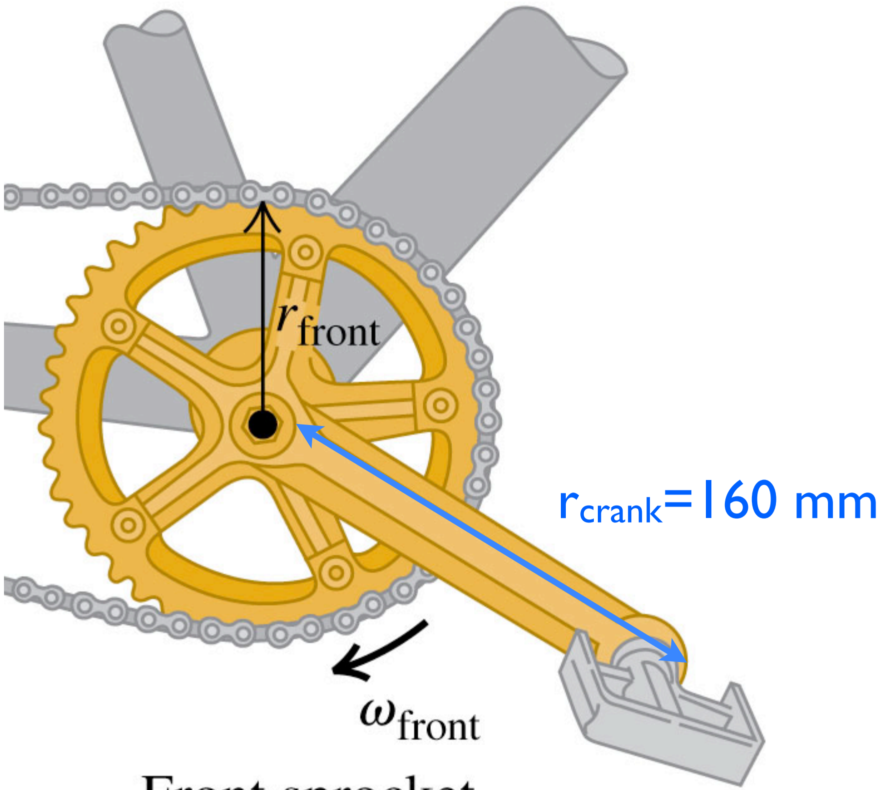
$$W = \int \boldsymbol{\tau} \cdot d\boldsymbol{\theta}$$

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

Power

You are out riding your bicycle, and find that you are applying a constant force of 50 N while pedaling at a constant rate of 1.5 revolutions per second. The length of the crank is 160 mm. How much power are you applying?

Text your answer to 22333



Front sprocket

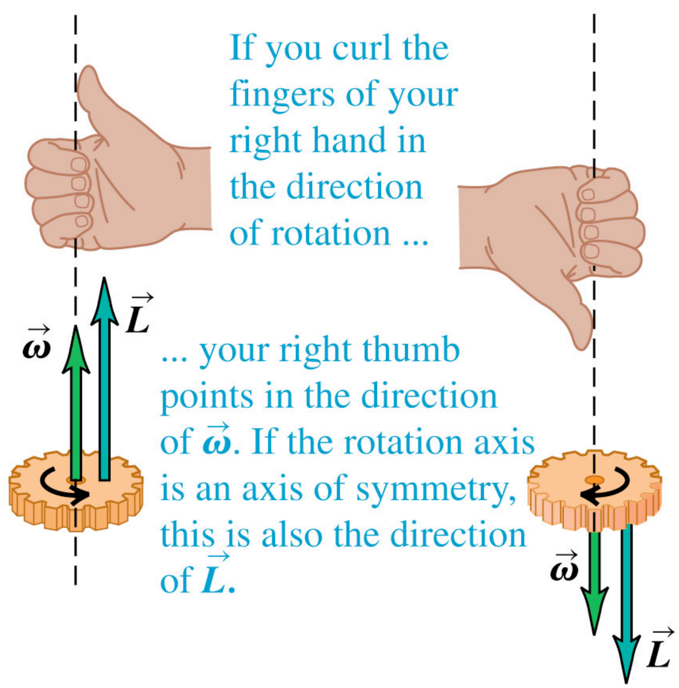
Angular momentum

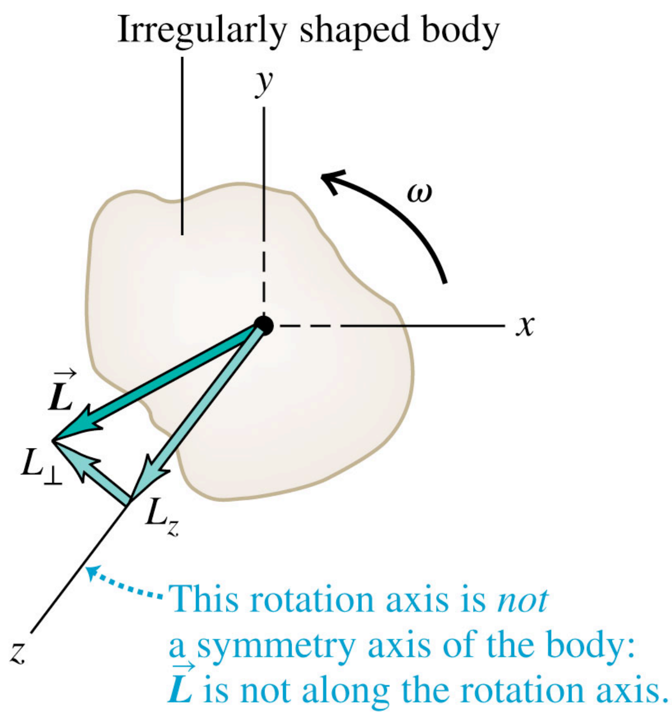
$$\boldsymbol{L} = \boldsymbol{r} \times \boldsymbol{p}$$

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

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 $\Sigma\tau_z = I\alpha_z$.
-

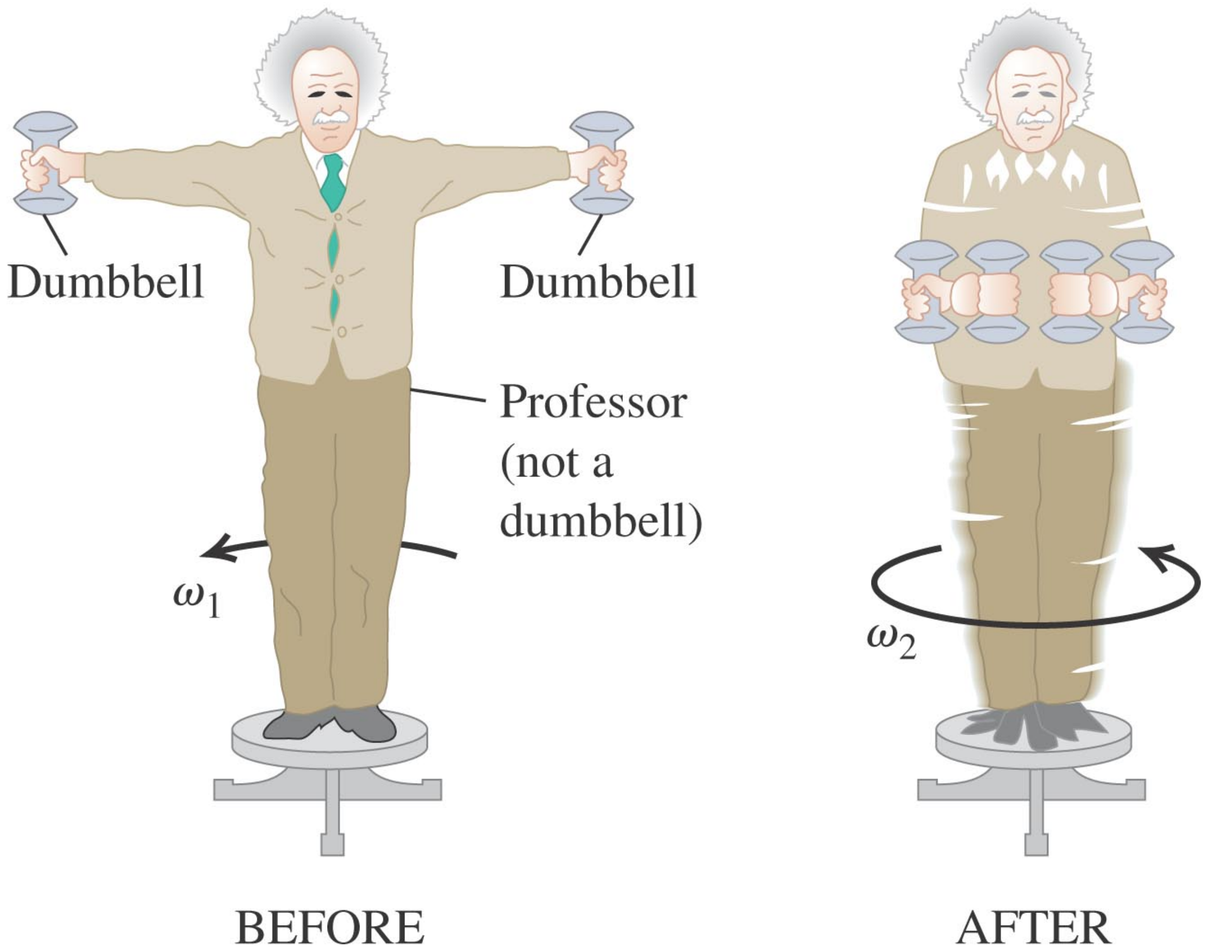




Angular Momentum Conservation

Conservation of angular momentum

- When the net external torque acting on a system is zero, the total angular momentum of the system is constant (conserved).



Demo 1