Announcements

1. Opening Convocation – Thursday, Oct 10th
   -- 6 PM in Wait Chapel

2. 2002 Nobel Prize in Physics:

   http://www.nobel.se/physics/laureates/2002/public.html

3. Mid-term grades

4. Online quizes

5. Today's lecture – angular momentum (Chapter 11)
   -- stability and equilibrium (Chapter 12)

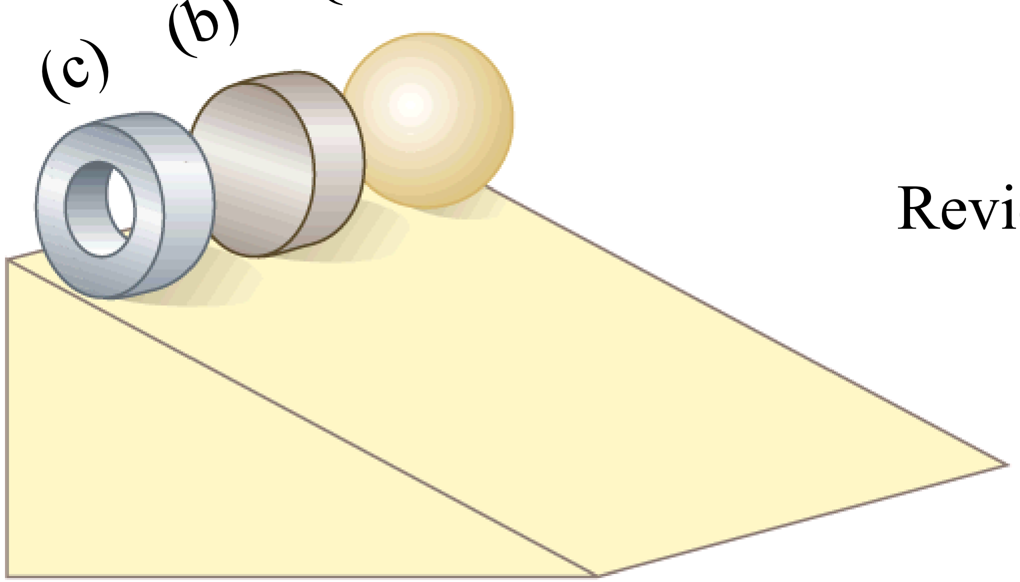
The Prize is awarded with one half jointly to:

Raymond Davis Jr, Department of Physics and Astronomy, University of Pennsylvania, Philadelphia, USA, and Masatoshi Koshiba, International Center for Elementary Particle Physics, University of Tokyo, Japan, “for pioneering contributions to astrophysics, in particular for the detection of cosmic neutrinos”, and the second half to Riccardo Giacconi, Associated Universities, Inc., Washington, DC, USA, “for pioneering contributions to astrophysics, which have led to the discovery of cosmic X-ray sources”.

Conservation of momentum lead to the discovery of the neutrino!

neutron → proton + electron + (anti-neutrino)

$^{37}Cl \rightarrow {}^{37}Ar + e^- + \bar{\nu}$



Review

$I_a = 2/5\ MR^2$

$I_b = 1/2\ MR^2$

$I_c = MR^2$

Three objects of uniform density – a solid sphere (a), a solid cylinder (b), and a hollow cylinder (c) -- are placed at the top of an incline. If they all are released from rest at the same elevation and roll without slipping, which object reaches the bottom first?

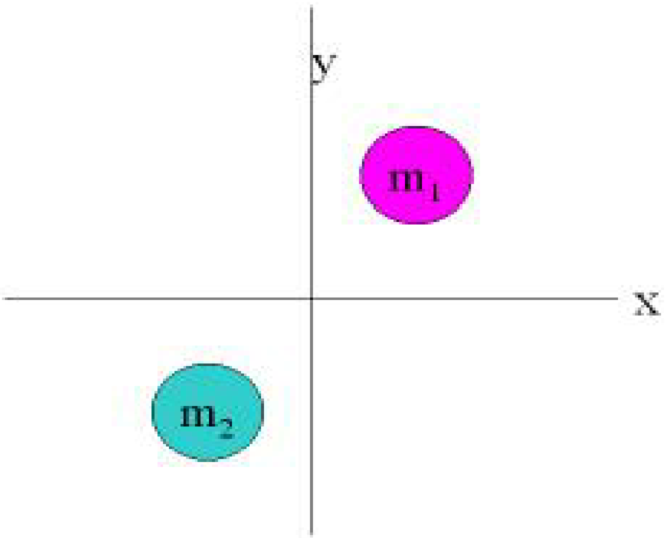
$K_{rot} = ½\ I\ \omega^2$ ➔ For fixed ω, (c) has the largest K_{rot}

➔ For fixed K_{rot}, (a) has the largest ω

$$K_{tot} = K_{CM} + K_{rot}$$

Online Quiz for Lecture 17

Calculating the moment of inertia -- Oct. 9, 2002

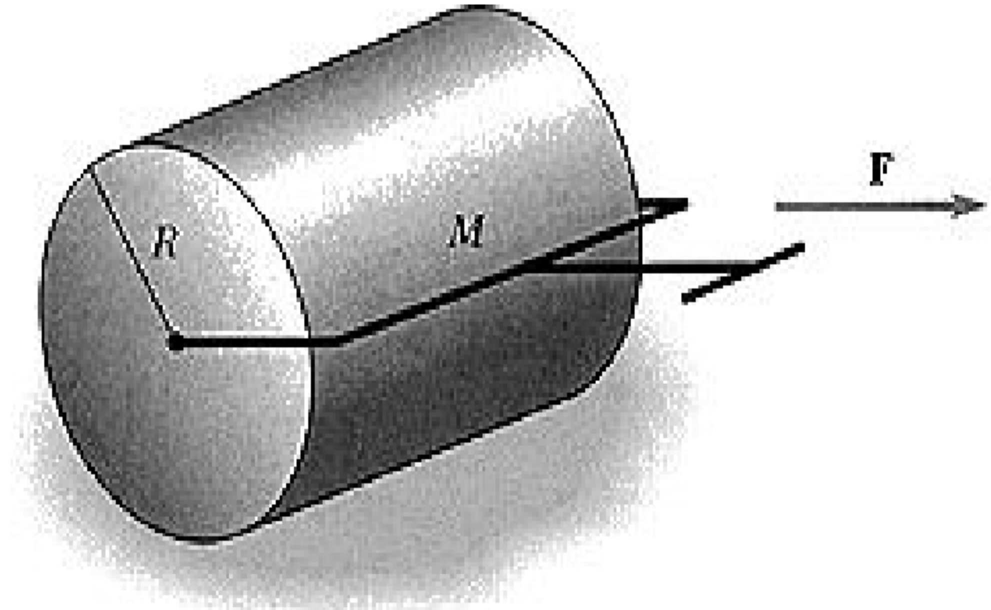


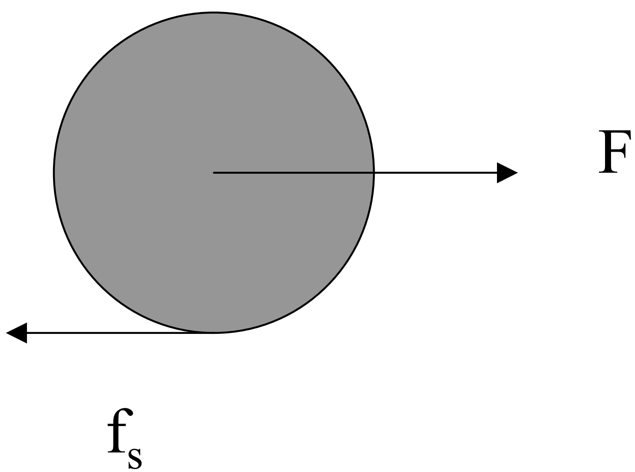
Consider the two masses shown in the figure. Assume that they are held rigidly by massless supports with $\mathbf{r_1}$=0.1 m **i**+ 0.1 m **j** for mass 1 and $\mathbf{r_2}$=-0.1 m **i**- 0.1 m **j** for mass 2. Suppose that each mass is 1 kg.

1. What is the moment of inertia (in units of kg m^2) for rotating about the x axis? (a) 0.01 (b) 0.02 (c) 0.04 (d) 0.08
2. What is the moment of inertia (in units of kg m^2) for rotating about the y axis? (a) 0.01 (b) 0.02 (c) 0.04 (d) 0.08
3. What is the moment of inertia (in units of kg m^2) for rotating about the z axis (which is perpendicular to the plane of the figure)? (a) 0.01 (b) 0.02 (c) 0.04 (d) 0.08

Newton's law for torque:

$$\boldsymbol{\tau}_{total} = I\frac{d\boldsymbol{\omega}}{dt} = I\boldsymbol{\alpha}$$



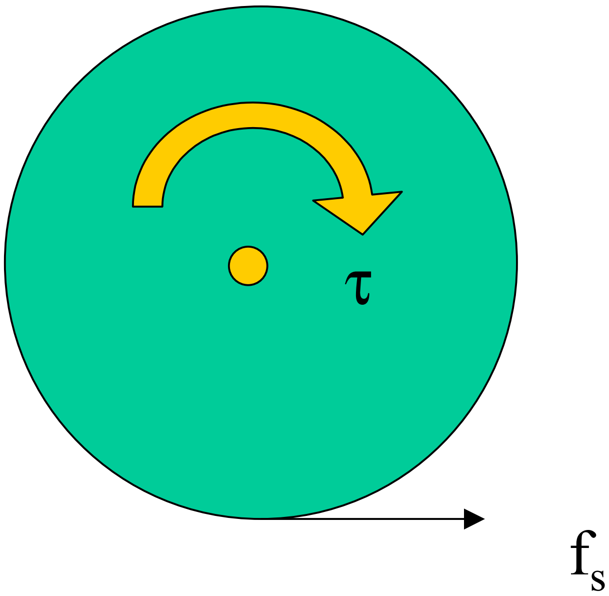


$F - f_s = M\, a_{CM}$

$Rf_s = I\,\alpha = I\, a_{CM}/R$

$$f_s = \mathbf{F}\left(\frac{I/(MR^2)}{1 + I/(MR^2)}\right)$$

Bicycle or automobile wheel:



$$f_s = Ma_{CM}$$

$$\tau - Rf_s = I\alpha = Ia_{CM} / R$$

$$f_s = \frac{\tau/R}{\left(1 + I/MR^2\right)}$$

Torque and angular momentum

Define angular momentum: $\mathbf{L} \equiv \mathbf{r} \times \mathbf{p}$

For composite object: $L = I\omega$

Newton's law for torque:

$$\boldsymbol{\tau}_{total} = I\frac{d\boldsymbol{\omega}}{dt} = \frac{d\mathbf{L}}{dt}$$

➔ If $\boldsymbol{\tau}_{\text{total}} = 0$ then $\mathbf{L}$ = constant

In the absence of a net torque on a system,
angular momentum is conserved.

Peer instruction question

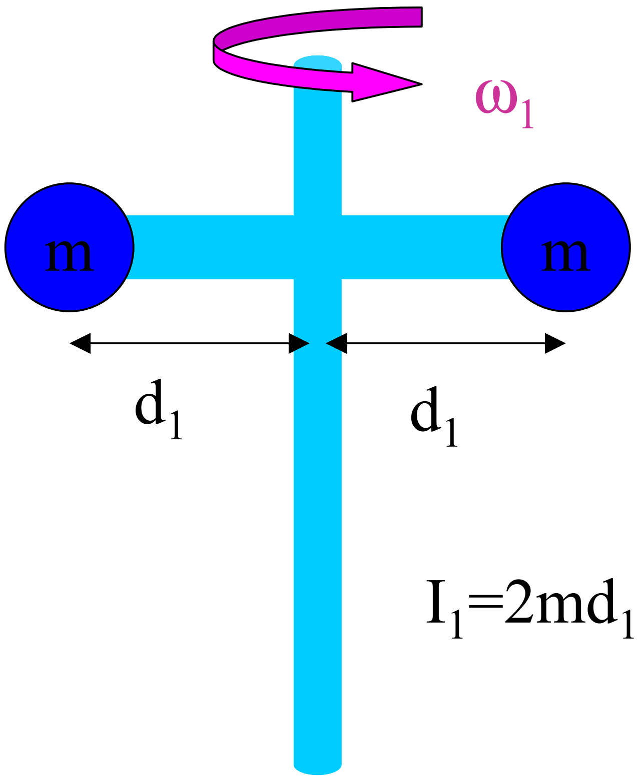
A student sits on a rotatable stool holding a spinning bicycle wheel with angular momentum $\mathbf{L}_i$. What happens when the wheel is inverted?

(a) The student will remain at rest.

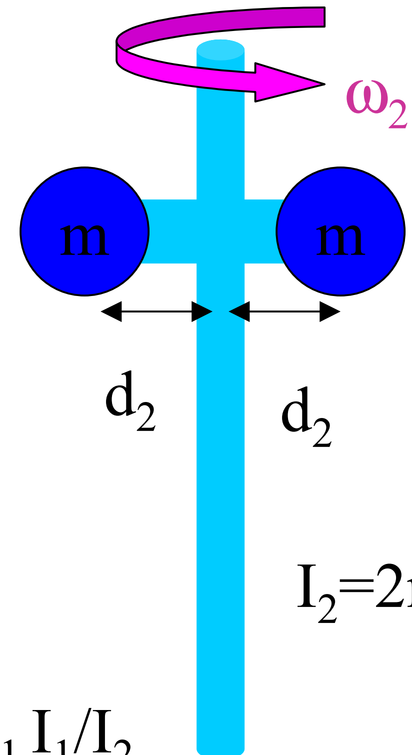
(b) The student will rotate counterclockwise.

(c) The student will rotate clockwise.

Other examples of conservation of angular momentum



$I_1=2md_1^{\,2}$

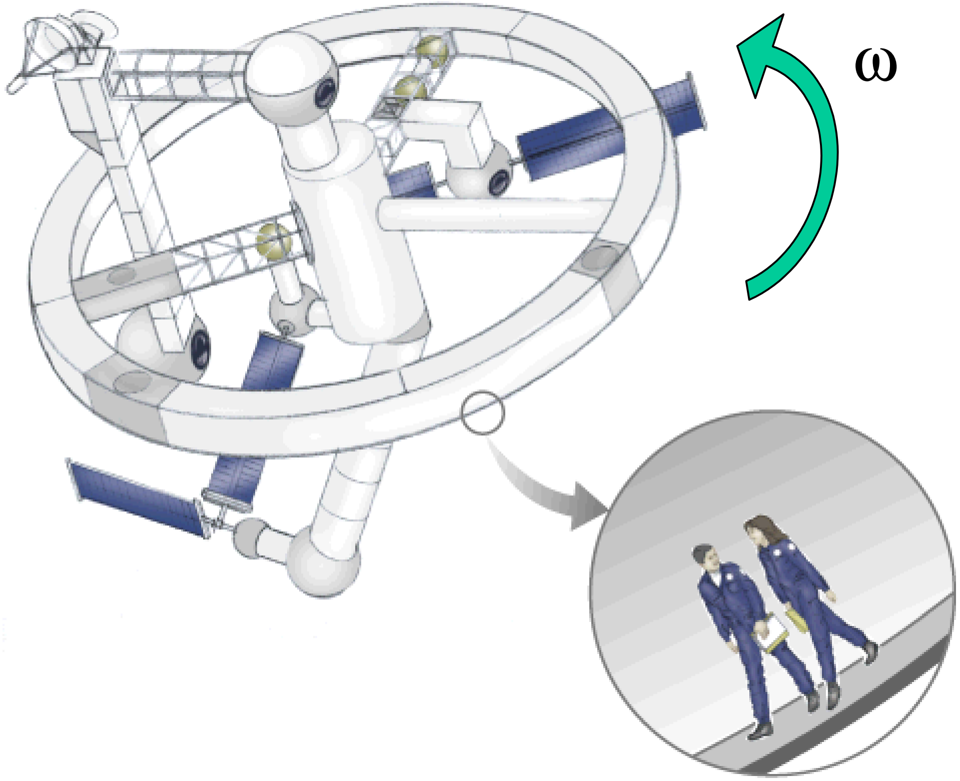


$I_2=2md_2^{\,2}$

$$I_1\omega_1=I_2\omega_2 \rightarrow \omega_2=\omega_1\, I_1/I_2$$

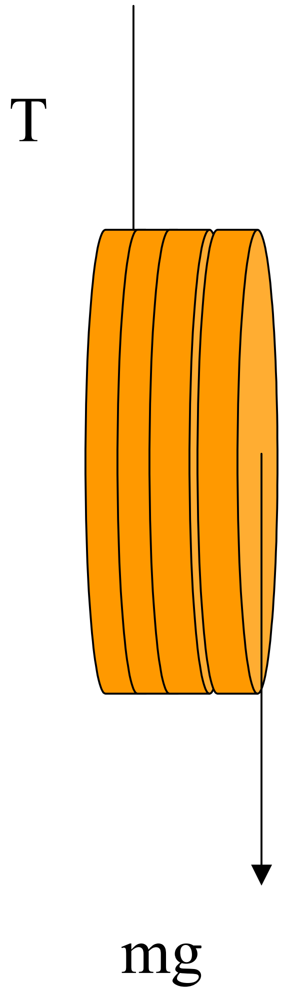
What about centripetal acceleration?

Serway, Physics for Scientists and Engineers, 5/e
Problem 11.40



$a_r = v^2/R = \omega^2 R$

Harcourt, Inc.



$T - mg = -ma_{CM}$

$RT = I\alpha = Ia_{CM}/R$

$$a_{CM} = \frac{g}{\left(1 + I/mR^2\right)}$$