Physics 121 – October 26, 2009

This Week:

- Finish reading Chapter 11 – Angular Momentum
- Homework problems due **Today**
  Chap 10, # 17, 19, 23, 25, 33, 34, 35, 40
- MP Assignment #8 (Rotation) to be completed **Today** by 11 pm.
- Homework problems due **Friday, Oct 30**
  Chap 11, # 23, 27, 28, 46, 47, 51
- MP Assignment #9 (more rotation) to be completed by **Sunday, Nov 1** at 11 pm.

Recall from last week:

Linear and Angular Quantities Compared

This table summarizes the analogies between linear and rotational quantities, along with quantitative relations that link rotational and linear quantities. Many of these relations require that angles be measured in radians, and most require explicit specification of a rotation axis.

Linear Quantity or Equation	Angular Quantity or Equation	Relation Between Linear and Angular Quantities
Position x	Angular position θ	
Speed $v = dx/dt$	Angular speed $\omega = d\theta/dt$	$v = \omega r$
Acceleration a	Angular acceleration α	$a_t = \alpha r$
Mass m	Rotational inertia I	$I = \int r^2\, dm$
Force F	Torque τ	$\tau = rF \sin\theta$
Kinetic energy $K_{trans} = \frac{1}{2}mv^2$	Kinetic energy $K_{rot} = \frac{1}{2}I\omega^2$	
Newton's second law (constant mass or rotational inertia):		
$F = ma$	$\tau = I\alpha$	

Cases and Uses

Constant angular acceleration: When angular acceleration is constant, equations analogous to those of Chapter 2 apply.

Equations for Constant Linear Acceleration		Equations for Constant Angular Acceleration	
$\overline{v} = \frac{1}{2}(v_0 + v)$	(2.8)	$\overline{\omega} = \frac{1}{2}(\omega_0 + \omega)$	(10.6)
$v = v_0 + at$	(2.7)	$\omega = \omega_0 + \alpha t$	(10.7)
$x = x_0 + v_0 t + \frac{1}{2}at^2$	(2.10)	$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$	(10.8)
$v^2 = v_0^2 + 2a(x - x_0)$	(2.11)	$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$	(10.9)

Rolling motion: When an object of radius R rolls without slipping, the point in contact with the ground is instantaneously at rest. In this case the object's translational and rotational speeds are related by $v = \omega R$. The object's kinetic energy is shared among translational kinetic energy $\frac{1}{2}mv^2$ and rotational kinetic energy $\frac{1}{2}I\omega^2$, with the division between these forms dependent on the rotational inertia.

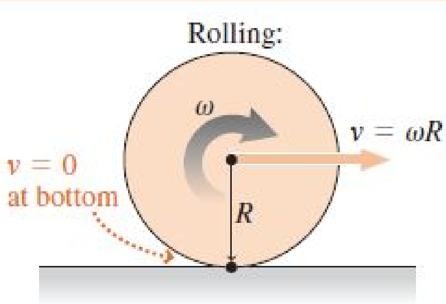
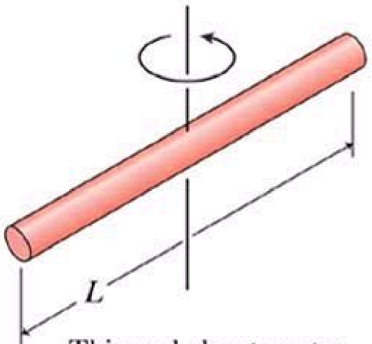
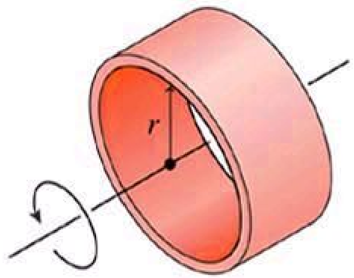


TABLE 10.2 Rotational Inertias

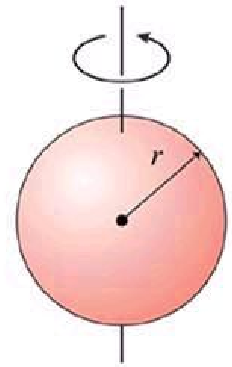


Thin rod about center
$I = \frac{1}{12}ML^2$

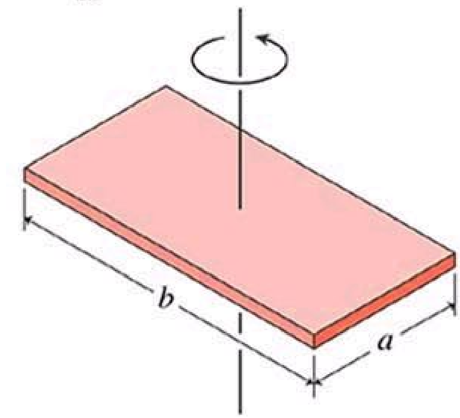


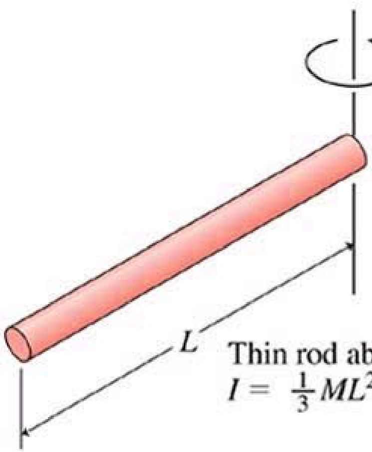
Thin ring or hollow cylinder about its axis
$I = MR^2$

Solid sphere about diameter
$I = \frac{2}{5}MR^2$

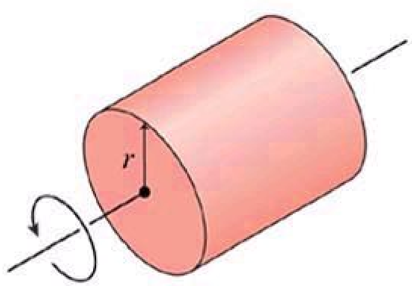


Flat plate about perpendicular axis
$I = \frac{1}{12}M(a^2 + b^2)$



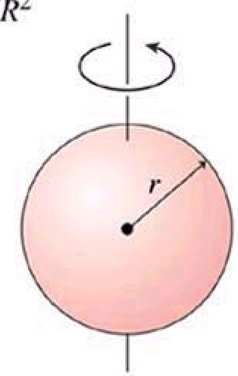


Thin rod about end
$I = \frac{1}{3}ML^2$

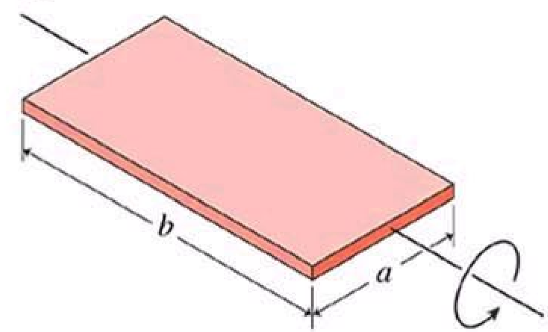


Disk or solid cylinder about its axis
$I = \frac{1}{2}MR^2$

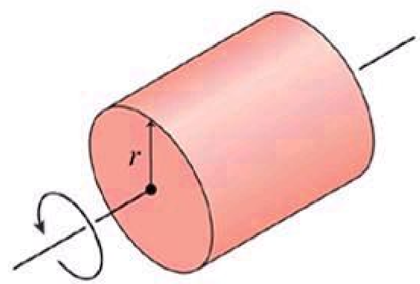
Hollow spherical shell about diameter
$I = \frac{2}{3}MR^2$



Flat plate about central axis
$I = \frac{1}{12}Ma^2$



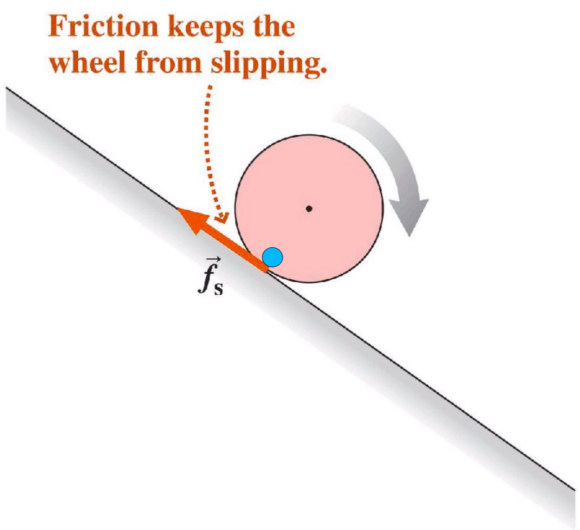
Iclicker: A solid cylinder made of lead has the same mass and same length as a solid cylinder made of aluminum. The rotational inertia of the lead cylinder compared to the aluminum one is:



Disk or solid cylinder about its axis
$I = \frac{1}{2} MR^2$

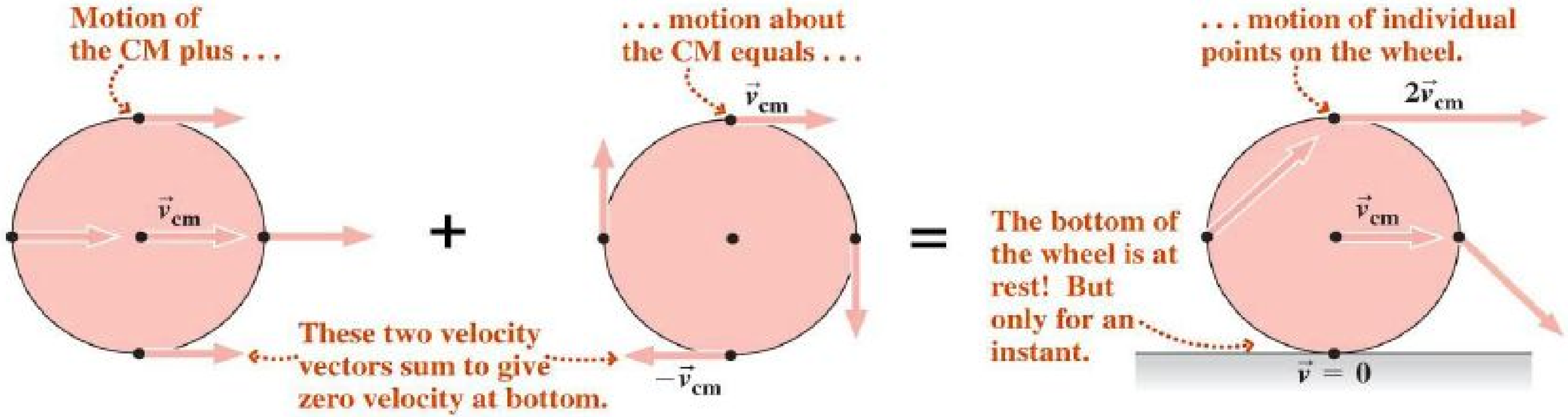
A. greater
B. less
C. same
D. unknown unless both radii are specified exactly

Iclicker: A wheel of radius 0.5 m rolls without slipping down a sloped track as shown below. Friction (f_s) keeps the wheel from slipping. The center-of-mass velocity of the wheel is 2 m/s in a direction parallel to the track. What is the magnitude of the instantaneous velocity of the point on the wheel that is in contact with the track?



A. zero
B. 2 m/s
C. 6 m/s
D. unknown unless ω is given

Rolling motion



Key points:

$v_{cm} = \omega R$ in ground reference frame

$v_{tang} = \omega R$ in wheel reference frame

$v = 0$ for contact point in ground reference frame

$K_{total} = 1/2 M v_{cm}^2 + 1/2 I \omega^2$