Physics 101: Lecture 13
Rotational Kinetic Energy and Inertia

- Today's lecture will cover Textbook Section 8.1

Linear and Angular

	Linear	Angular
Displacement	x	θ
Velocity	v	ω
Acceleration	a	α
Inertia	m	I
KE	$\frac{1}{2} m v^2$	Today!
N2L	$F = ma$	
Momentum	$p = mv$	

Energy ACT

- When the bucket reaches the bottom, its potential energy has decreased by an amount mgh. Where has this energy gone?

A) Kinetic Energy of bucket

B) Kinetic Energy of flywheel

C) Both 1 and 2.

Rotational Inertia, I

- Tells how much "work" is required to get object spinning. Just like mass tells you how much "work" is required to get object moving.
  - $K_{tran} = \frac{1}{2} m v^2$ Linear Motion
  - $K_{rot} = \frac{1}{2} I \omega^2$ Rotational Motion

- $I = \Sigma m_i r_i^2$ (units kg m^2)

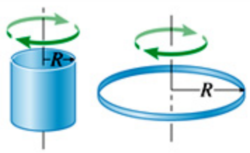
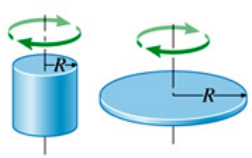
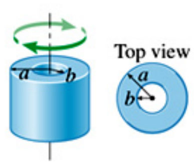
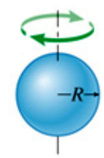
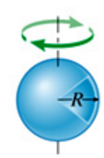
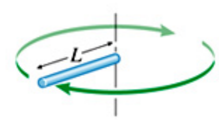
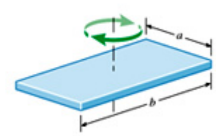
- Note! Rotational Inertia depends on what you are spinning about (basically the r_i in the equation).

Rotational Inertia Table

- For objects with finite number of masses, use $I = \Sigma\, m\, r^2$. For "continuous" objects, use table below.

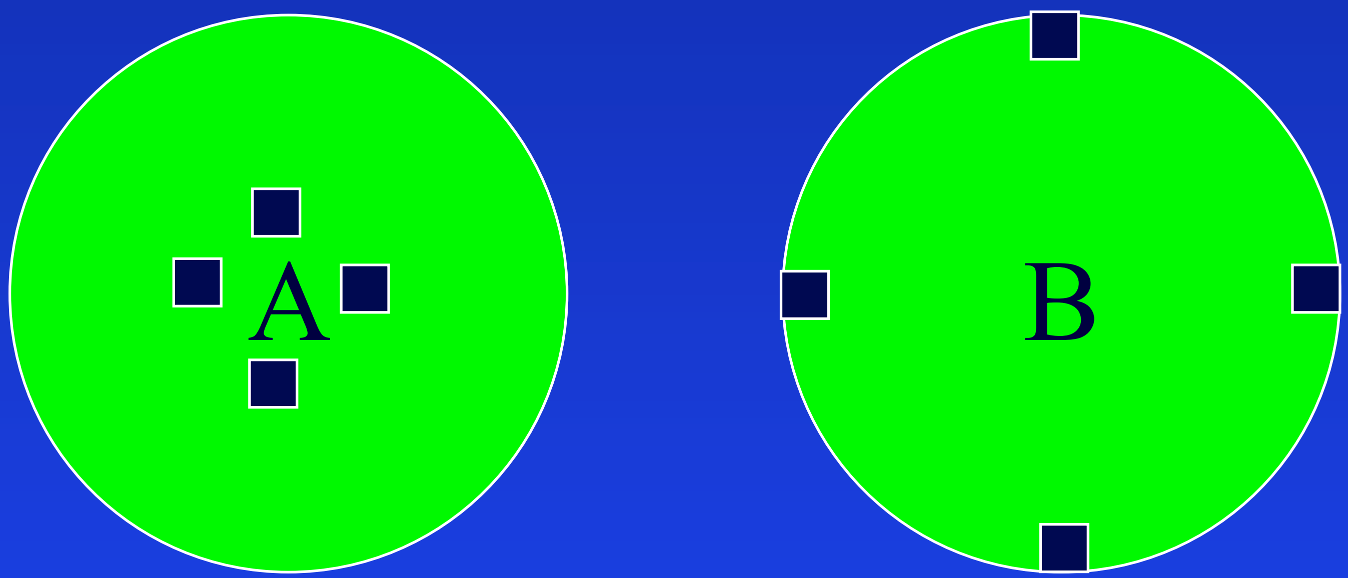
Table 8.1

Rotational Inertia for Uniform Objects with Various Geometrical Shapes

Shape		Axis of Rotation	Rotational Inertia
Thin hollow cylindrical shell (or hoop)		Central axis of cylinder	MR^2
Solid cylinder (or disk)		Central axis of cylinder	$\frac{1}{2}MR^2$
Hollow cylindrical shell or disk		Central axis of cylinder	$\frac{1}{2}M(a^2 + b^2)$
Solid sphere		Through center	$\frac{2}{5}MR^2$
Thin hollow spherical shell		Through center	$\frac{2}{3}MR^2$
Thin rod		Perpendicular to rod through end	$\frac{1}{3}ML^2$
Rectangular plate		Perpendicular to plate through center	$\frac{1}{12}M(a^2 + b^2)$

Merry Go Round

Four kids (mass m) are riding on a (light) merry-go-round rotating with angular velocity ω=3 rad/s. In case A the kids are near the center (r=1.5 m), in case B they are near the edge (r=3 m). Compare the kinetic energy of the kids on the two rides.



A) $K_A > K_B$ B) $K_A = K_B$ C) $K_A < K_B$

Contest!

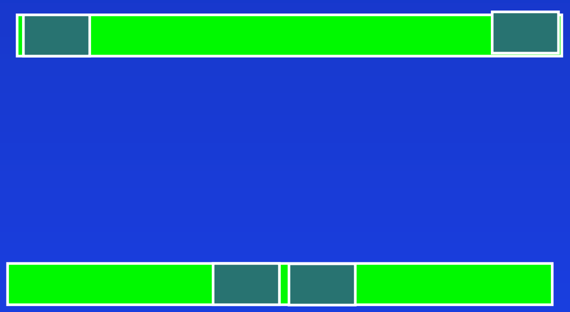
Inertia Rods

Two batons have equal mass and length.
Which will be "easier" to spin

A) Mass on ends

B) Same

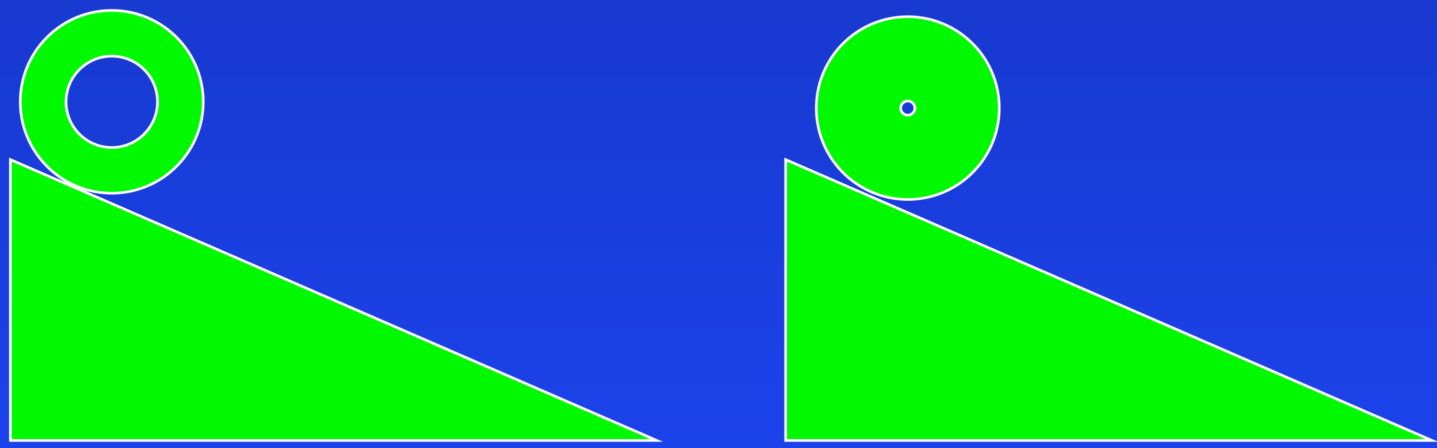
C) Mass in center



Rolling Race
(Hoop vs Cylinder)

A hoop and a cylinder of equal mass roll down a ramp with height h. Which has greater KE at bottom?

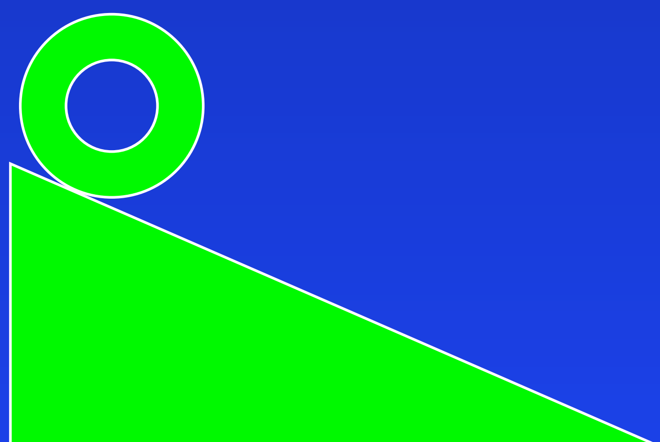
A) Hoop B) Same C) Cylinder

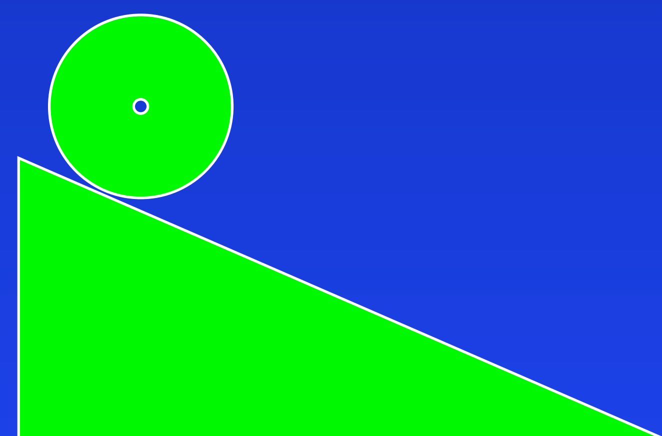


Preflight Rolling Race (Hoop vs Cylinder)

A hoop and a cylinder of equal mass roll down a ramp with height h. Which gets to the bottom of the ramp first?

A) Hoop B) Same C) Cylinder





Main Ideas

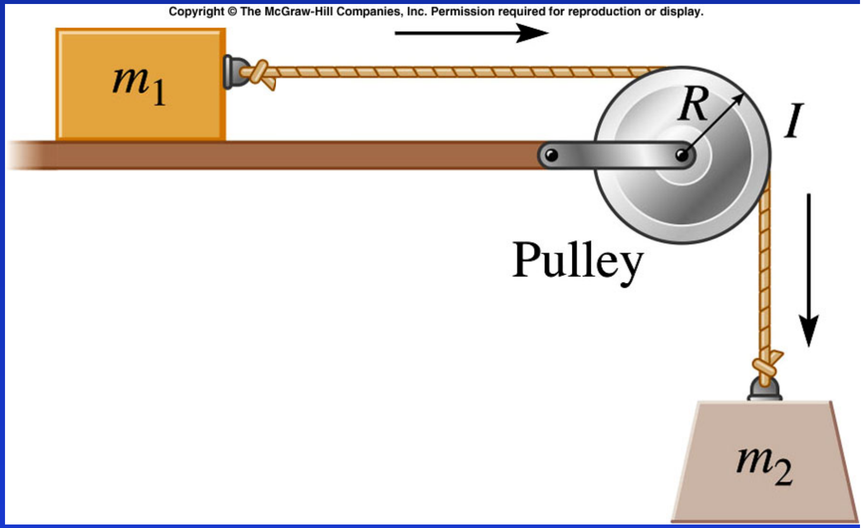
- Rotating objects have kinetic energy
  - ➡ $KE = \frac{1}{2} I \omega^2$

- Moment of Inertia $I = \Sigma mr^2$
  - ➡ Depends on Mass
  - ➡ Depends on axis of rotation

- Energy is conserved but need to include rotational energy too $K_{rot} = \frac{1}{2} I \omega^2$

Massless Pulley Example

Consider the two masses connected by a pulley as shown. Use conservation of energy to calculate the speed of the blocks after m_2 has dropped a distance h. Assume the pulley is massless.



Massive Pulley Act

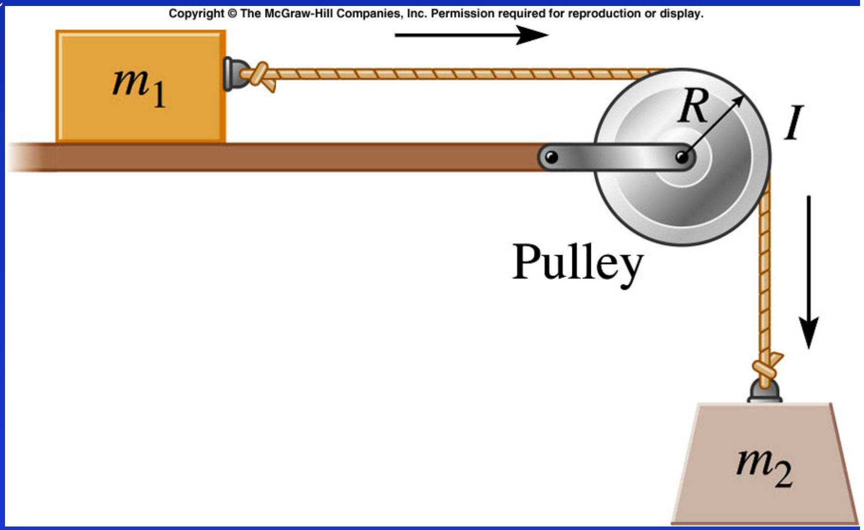
Consider the two masses connected by a pulley as shown. If the pulley is massive, after m2 drops a distance h, the blocks will be moving

A) faster than

B) the same speed as

C) slower than

if it was a massless pulley



Summary

- Rotational Kinetic Energy $K_{rot} = \frac{1}{2} I \omega^2$
- Rotational Inertia $I = \Sigma\, m_i r_i^2$
- Energy Still Conserved!