

Ex : A uniform hoop, disk, and sphere, having the same mass M and radius R , are released simultaneously from rest at the top of a frictionless ramp whose length $L=2.5$ m and whose ramp angle is $\theta = 12^\circ$.

a). Which object reaches the bottom first?

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

Object	I_{cm}	% of Energy in	
		Translation	Rotation
Hoop	$1MR^2$	50%	50%
Disk	$1/2MR^2$	67%	33%
Sphere	$2/5MR^2$	71%	29%

The finish order depends on how much of the energy goes into translation of the object.

\Rightarrow **Win : Sphere Place : Disk Show : Hoop**

b). How fast are objects moving at the bottom of the ramp?

For all objects, $U_i = K_f$

$$U_i = Mgh = MgL \sin \theta \qquad K_f = \frac{1}{2}I_{cm}\omega^2 + \frac{1}{2}Mv_{cm}^2$$

$$v_{cm} = \sqrt{\frac{2gL \sin \theta}{1 + I_{cm}/MR^2}}$$

Hoop : $v_{cm} = 2.3$ m/s
 Disk : $v_{cm} = 2.6$ m/s
 Sphere : $v_{cm} = 2.7$ m/s