

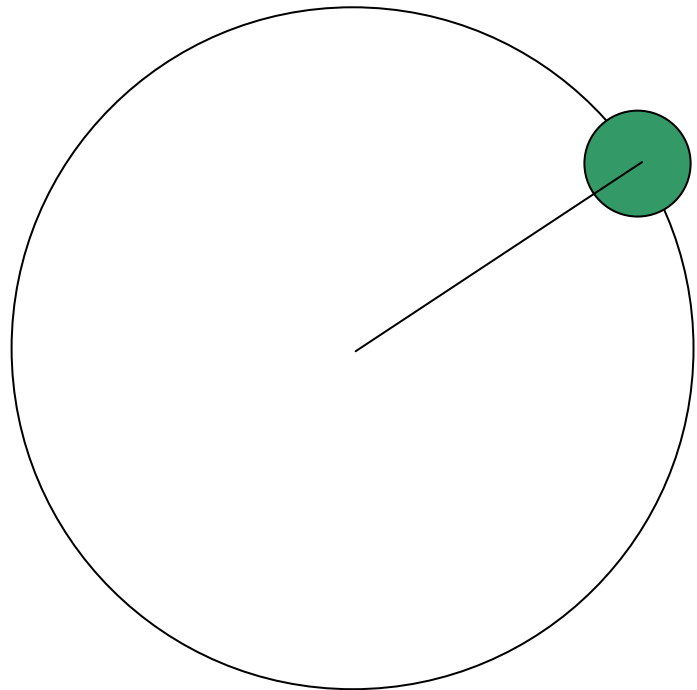
# Physics 105 Class 14

## TORQUE AND ROTATION

### Rotational kinetic energy

Kinetic energy of a point object rotating about a center:

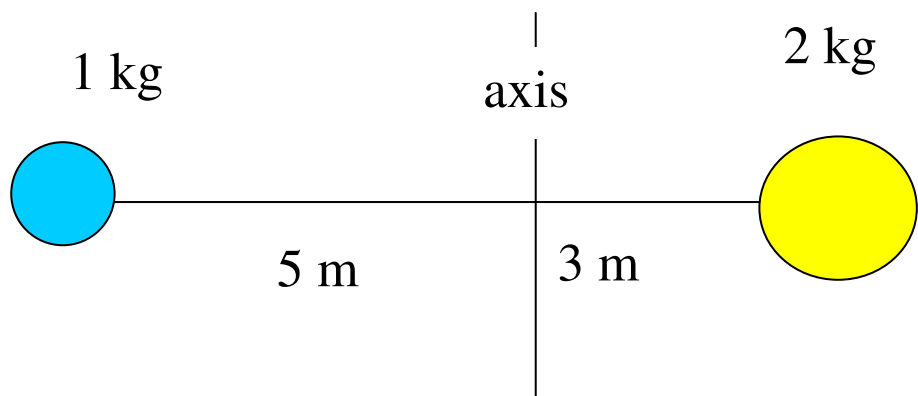
Write in terms of  $\omega$ :



### Moment of inertia:

$$KE_{rot} = \frac{1}{2} I \omega^2$$

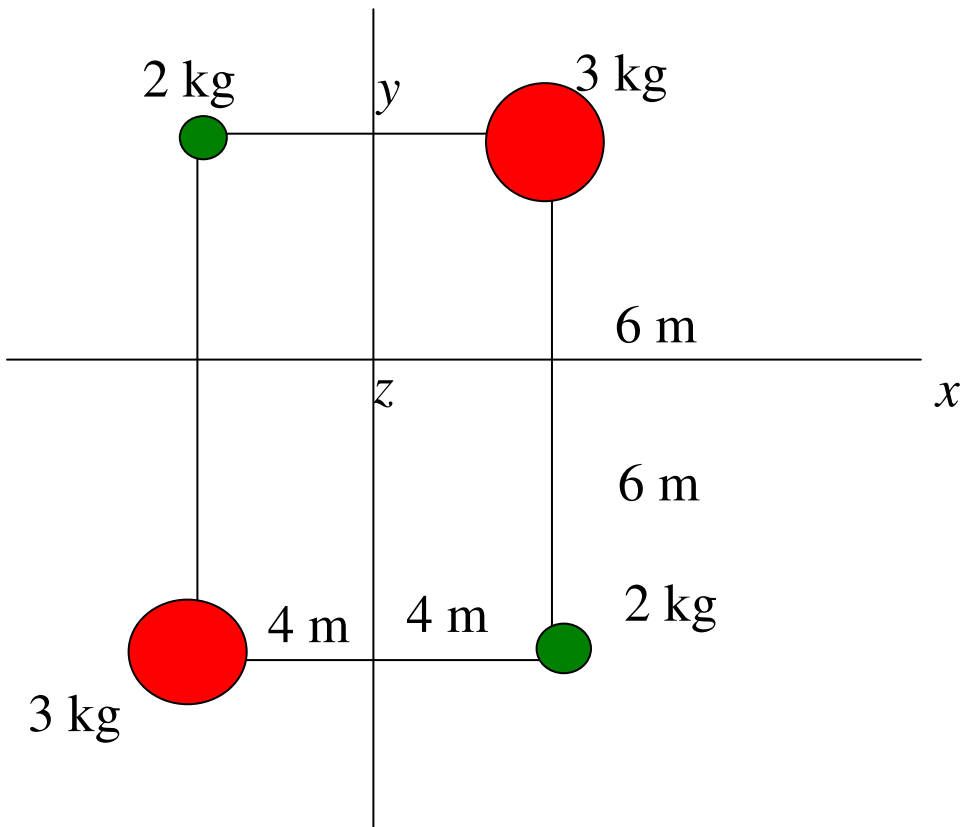
I for two masses on a rod?



$$I = \sum m_i r_i^2$$

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$$I = \sum m_i r_i^2$$



Calculate  $I_x$

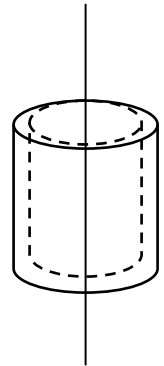
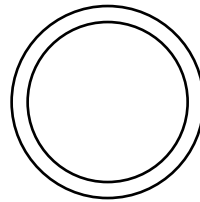
Which has the largest  $I$ : for axis  $x$ ,  $y$ , or  $z$ ?

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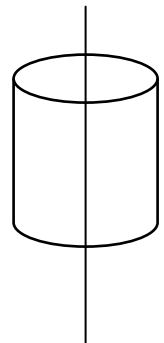
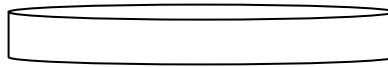
## Extended objects

Which object has the highest  $I$  (if the same  $M$  and  $R$ )? The one with the mass farthest from the axis!

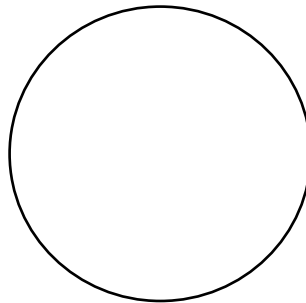
Hoop/cylindrical shell



Solid disk/cylinder



Solid sphere



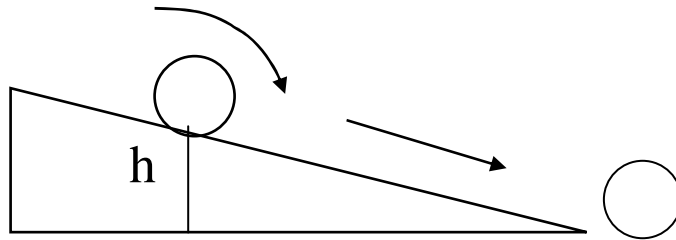
Which kind of object is moving the **fastest** at bottom of an incline (and wins!)?

**Sphere, disk or hoop?** \_\_\_\_\_

Does it depend on  $M$ ,  $R$ ? \_\_\_\_\_

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An object with moment of inertia  $I$  rolls down a height  $h$  without slipping. Using energy conservation to find the speed at bottom.



**P3.** If they continue on, which would go the farthest up a hill on the other side?

- a) hoop
- b) solid disk
- c) solid sphere
- d) all the same height at the end

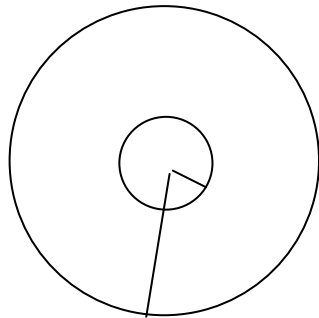
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### Newton's second law for rotation

$$\sum \tau = I\alpha \quad \text{and} \quad \sum \vec{F} = m\vec{a}_{cm}$$

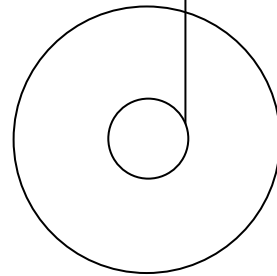
Yo-yo: Find  $\alpha$  when it unrolls

FBD



Mass  $m$

2  $r$ 's:  $R_{\text{string}}$   $R_{\text{disc}}$



Moment of inertia (neglect the small axle):

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$$\sum \tau = I\alpha$$

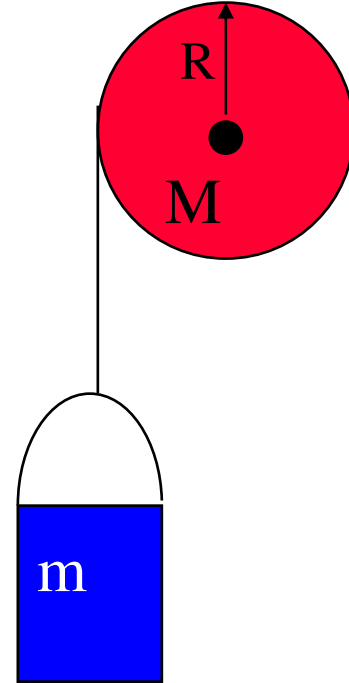
$$\sum \vec{F} = m\vec{a}_{cm}$$

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### Falling mass and solid disc flywheel

**P4.** Write  $\sum \tau = I\alpha$  for the flywheel.

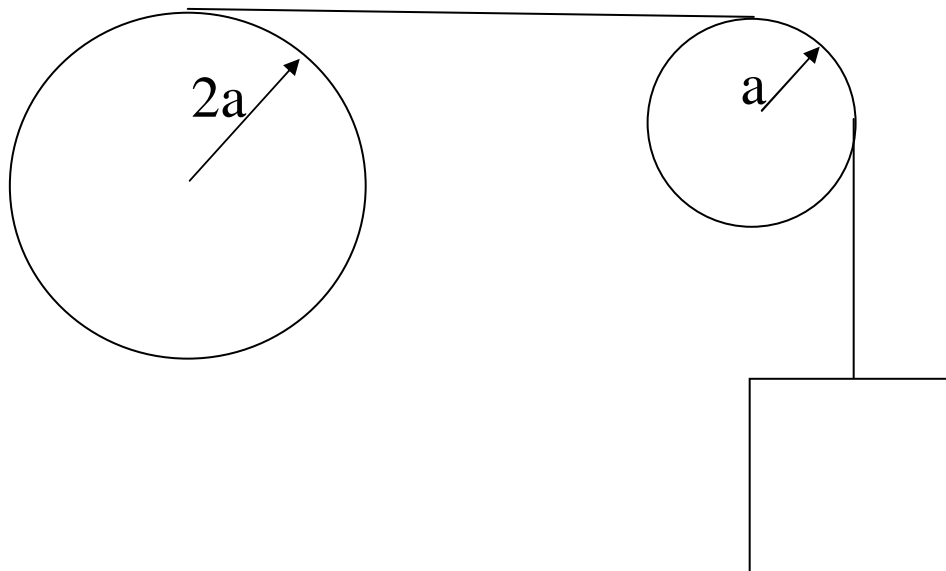
**P5.** Write  $\sum \vec{F} = m\vec{a}_{cm}$  for the bucket.



Find  $\alpha$  and  $a$ .

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The large disk has a rope wrapped around its edge. The rope passes over a second disk, and turns it with no slipping. The disks both have the same mass, but one has twice the radius.



**P7.** As the mass falls, the disk with the largest  $\omega$  is:

1. the large disk
2. the small disk
3. neither; same

**P8.** The disk with the largest kinetic energy is:

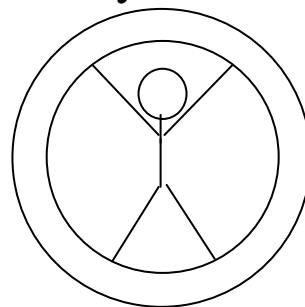
1. the large disk
2. the small disk
3. neither; same

(hint: look at how  $I$  and  $\omega$  may vary)

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**P9.** Mary and Fred are rolling a large tire down a hill. Mary says it will go faster if Fred gets inside the tire as shown and rolls down with it. Fred disagrees. What do you think?

1. It will go faster
2. It will go slower
3. It will take the same time



**P10.** A string pulls horizontally on a pedal as shown. The front wheel does not slip on the ground. The tricycle will move

- a) forward
- b) backward

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### **HOMEWORK HINTS:**