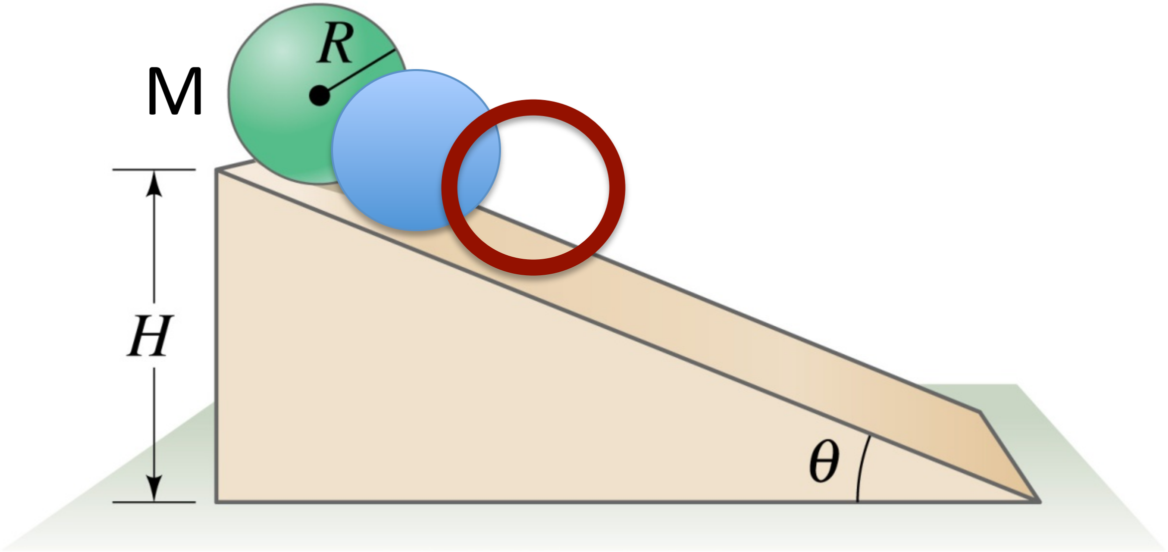
Clicker Question

Room Frequency BA



$$KE_{tot} = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2$$

$$I_{sphere} = \frac{2}{5}MR^2$$

$$I_{hoop} = MR^2$$

$$I_{disk} = \frac{1}{2}MR^2$$

A sphere, a disk, and a hoop all have the same mass *M* and the same radius *R*. They are released simultaneously from the top of the ramp and freely roll down.

Which object will reach the bottom of the ramp first?

A) Sphere B) Disk C) Hoop D) All the same.

Spring 2014

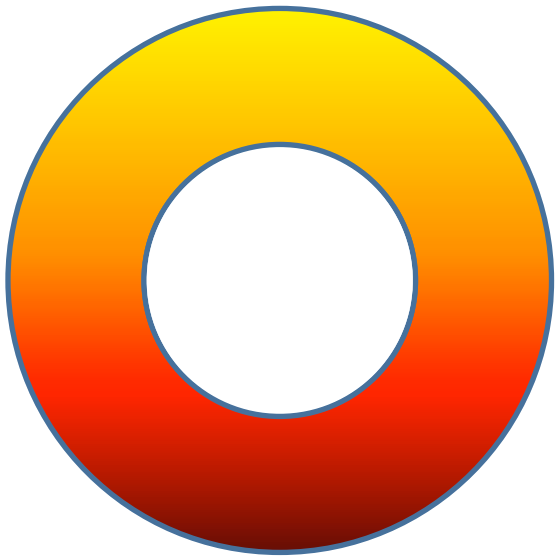
PHYS-2010

Lecture 35

Announcements

- Finish Giancoli **Chapter 8,** start Chapter 9.
- CAPA # 12 and taxes due next Tuesday, April 15.
- No written Homework due today.
- Next written Homework due next Friday, April 18.
- **Midterm Exam 3** results and solution will be posted on D2L tonight.

Rotational Kinetic Energy



Does this object have translational kinetic energy?

No, zero net translational velocity of the object.

However, there is motion of each piece of the object and thus there must be kinetic energy.

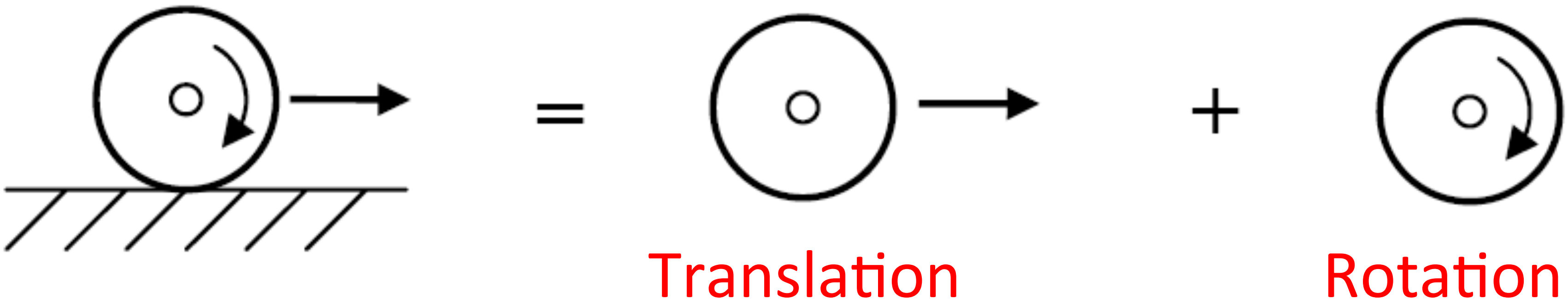
Each piece of the donut has a velocity v = ω r.

$$KE_{tot} = \Sigma \left(\tfrac{1}{2} mv^2\right)_i = \tfrac{1}{2} \Sigma \left[m_i (\omega r_i)^2\right] = \tfrac{1}{2} \underbrace{\left[\Sigma (m_i r_i^2)\right]}_{I} \omega^2$$

$$KE = \tfrac{1}{2} I \omega^2$$

Rotational KE

Rolling Kinetic Energy



KE (total) = KE (translation) + KE (rotation)

$$KE_{total} = \frac{1}{2} mv^2 + \frac{1}{2} I \omega^2$$

Both pieces in units of Joules.

* ***Rolling without slipping means $v = \omega r$.***

One revolution $\Delta\theta = 2\pi$ leads to displacement of $2\pi r$

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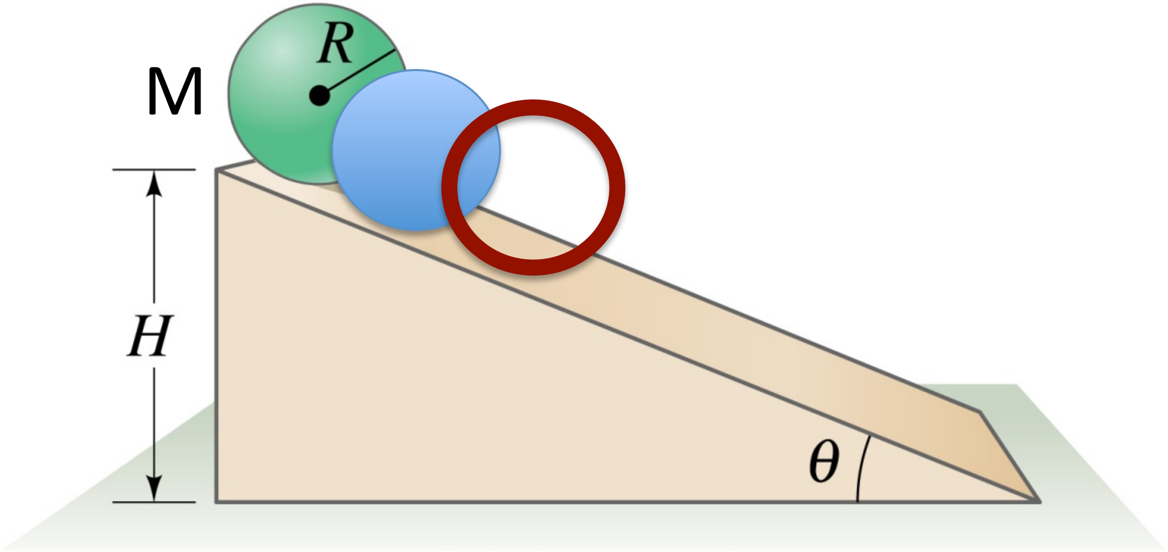

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Demonstration

Clicker Question

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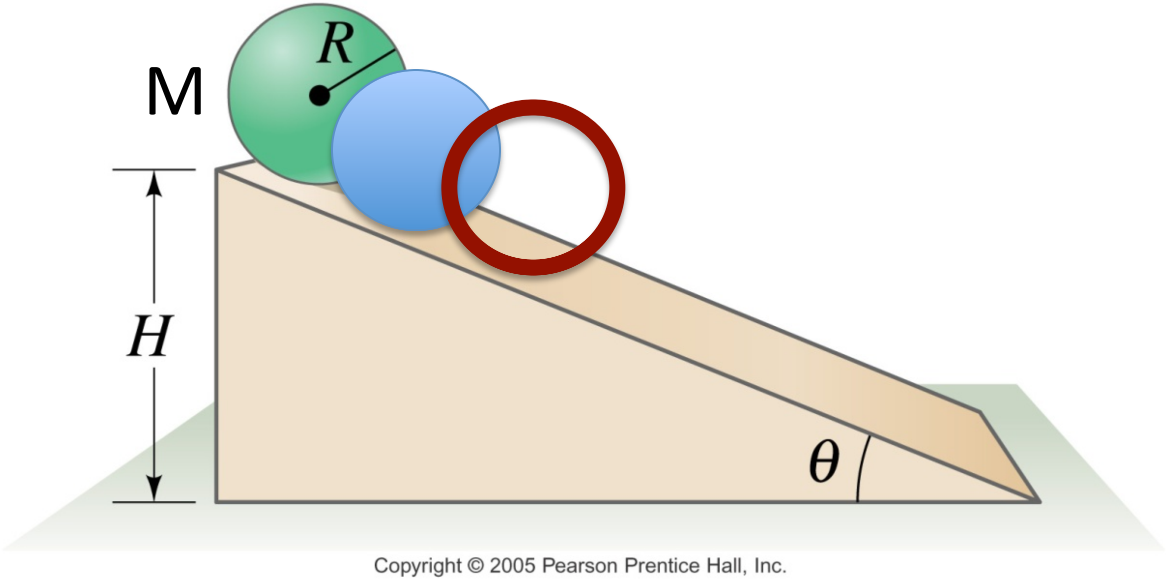

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Which object has the largest total kinetic energy at the bottom of the ramp?

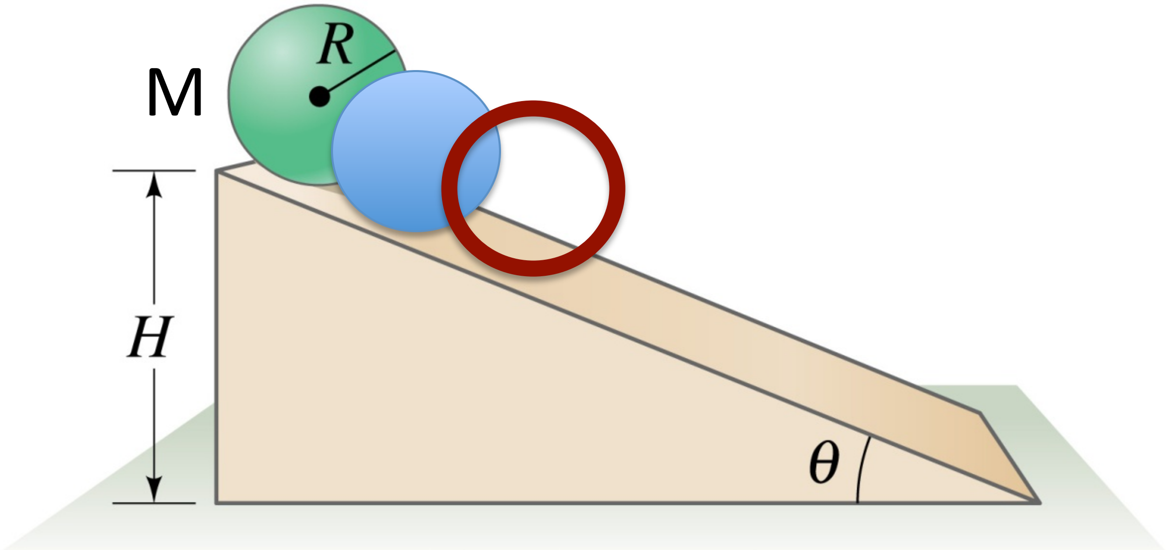
A) Sphere B) Disk C) Hoop D) All the same.

$$KE_i + PE_i = KE_f + PE_f$$

$$0 + MgH = KE_f + 0$$

$$KE_f = MgH$$

All have the same total KE.



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$$I_{disk} = \frac{1}{2}MR^2$$

$$KE_i + PE_i = KE_f + PE_f$$

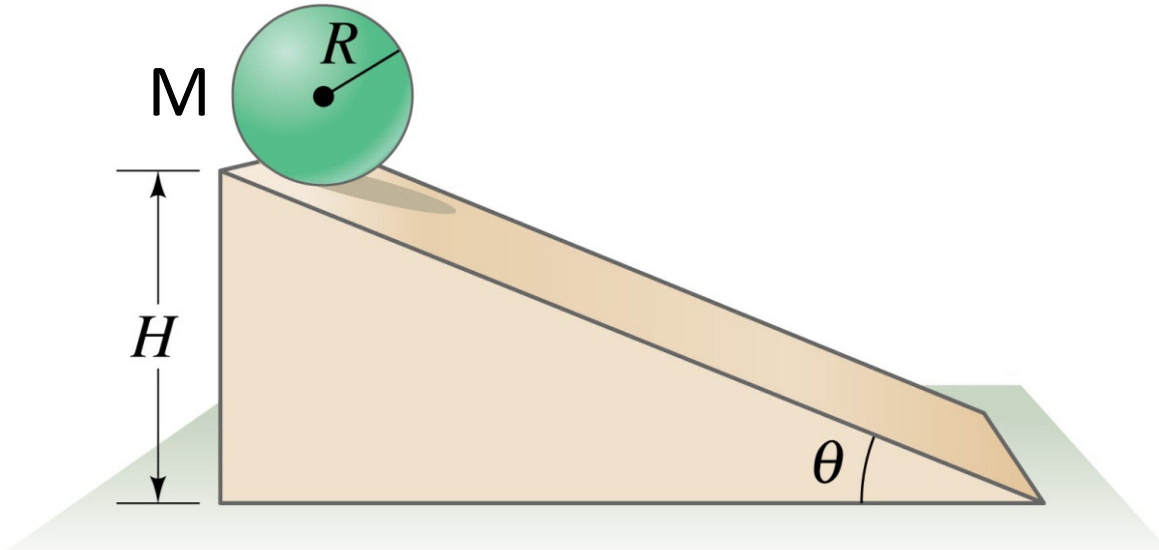
$$0 + MgH = \left(\frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2\right) + 0$$

v = ω R → ω = v/R

$$MgH = \left(\frac{1}{2}Mv^2 + \frac{1}{2}I\frac{v^2}{R^2}\right)$$

$$MgH = \frac{1}{2}v^2\left(M + \frac{I}{R^2}\right)$$

$$v = R\sqrt{\frac{2MgH}{I + MR^2}}$$



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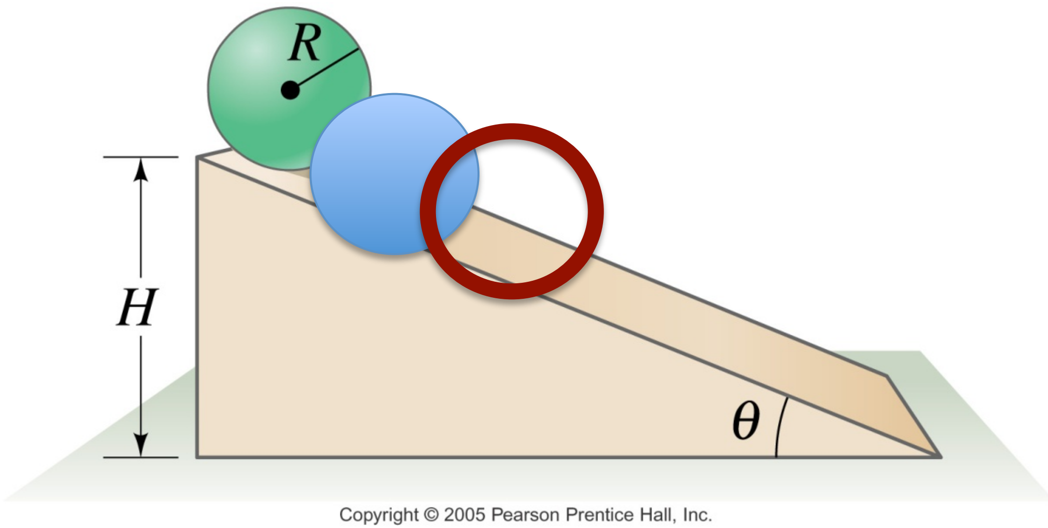
$$v = R\sqrt{\frac{2MgH}{I + MR^2}}$$

$$v = \sqrt{\frac{2gH}{(I/MR^2) + 1}}$$

Sphere

$$v = R\sqrt{\frac{2MgH}{\frac{2}{5}MR^2 + MR^2}} = \sqrt{\frac{10}{7}gH}$$

Who wins the race to the bottom...... sphere, disk, hoop?



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$$v = \sqrt{\frac{2gH}{(I/MR^2)+1}}$$

<u>Sphere:</u> $v = \sqrt{\frac{10}{7}gH}$

<u>Disk:</u> $v_{disk} = \sqrt{\frac{4}{3}gH}$

<u>Hoop:</u> $v_{hoop} = \sqrt{gH}$

Object with smallest moment of inertia will have largest translational velocity and will travel reach bottom first.

What about an object just sliding down (not rolling) with no friction?

Demonstration