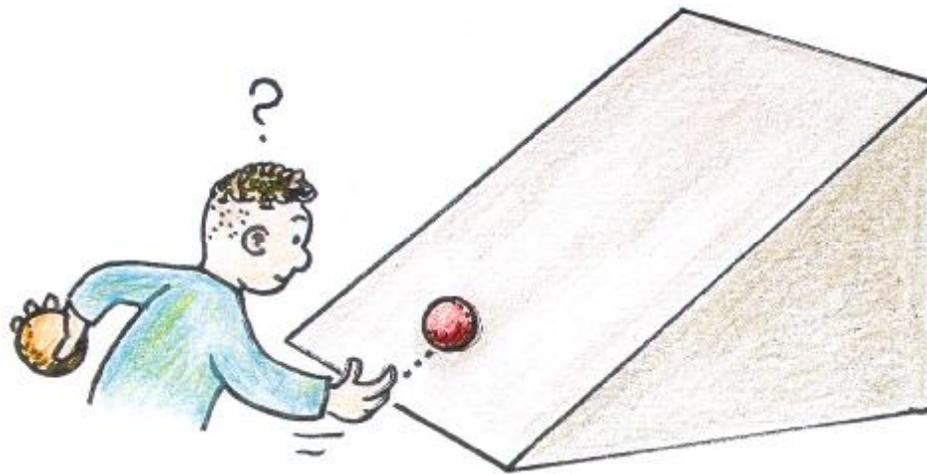


## NEXT-TIME QUESTION

Two balls of equal mass at the bottom of an incline are rolled upward without slipping at the same initial velocity. One ball is solid and the other is a thin-walled hollow ball. Which rolls higher up the incline before coming to a stop?

- a) The hollow ball.
- b) The solid ball.
- c) Both will roll to the same height.
- d) Depends on the relative diameters of the balls.

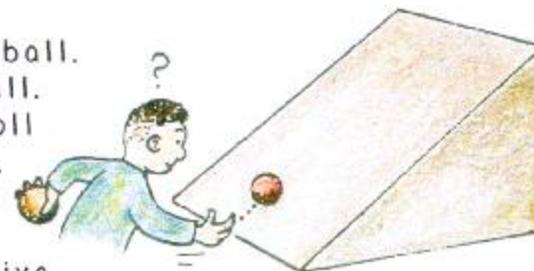


thank to Dave Kagan

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Answer: a

The balls are initially rolled up the incline with kinetic energy of two kinds—translational and rotational. Although their initial translational KEs are the same, the hollow ball begins with more rotational KE due to its greater rotational inertia (a thin-walled hollow ball has most of its mass far from its center, with a relatively large rotational inertia  $\frac{2}{3}mR^2$ —on the other hand, a solid ball with more of its mass near its center has a smaller rotational inertia  $\frac{2}{5}mR^2$ ). So the hollow ball has more total KE at the base of the incline, which means it must have more PE at the top. The hollow ball indeed goes higher.

**A ball with more rotational inertia out-rolls a lower-inertia ball. Hence the hollow ball rolls farther up the incline before coming to a stop.**



Does mass make a difference? No. As with the mass of a pendulum bob, or the mass of a freely-falling object, mass makes no difference. Sent rolling up an incline with equal speeds, any hollow ball will out-roll any solid ball. Diameter doesn't make a difference. A tennis ball will roll farther up than a bowling ball or a marble.

If you instead release both balls from a rest position at the top of an incline, the hollow ball "out-rests" the solid ball, is slower to gain speed, and lags behind the solid ball. The solid ball gets to the bottom first. Inertia is a resistance to *change*.



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