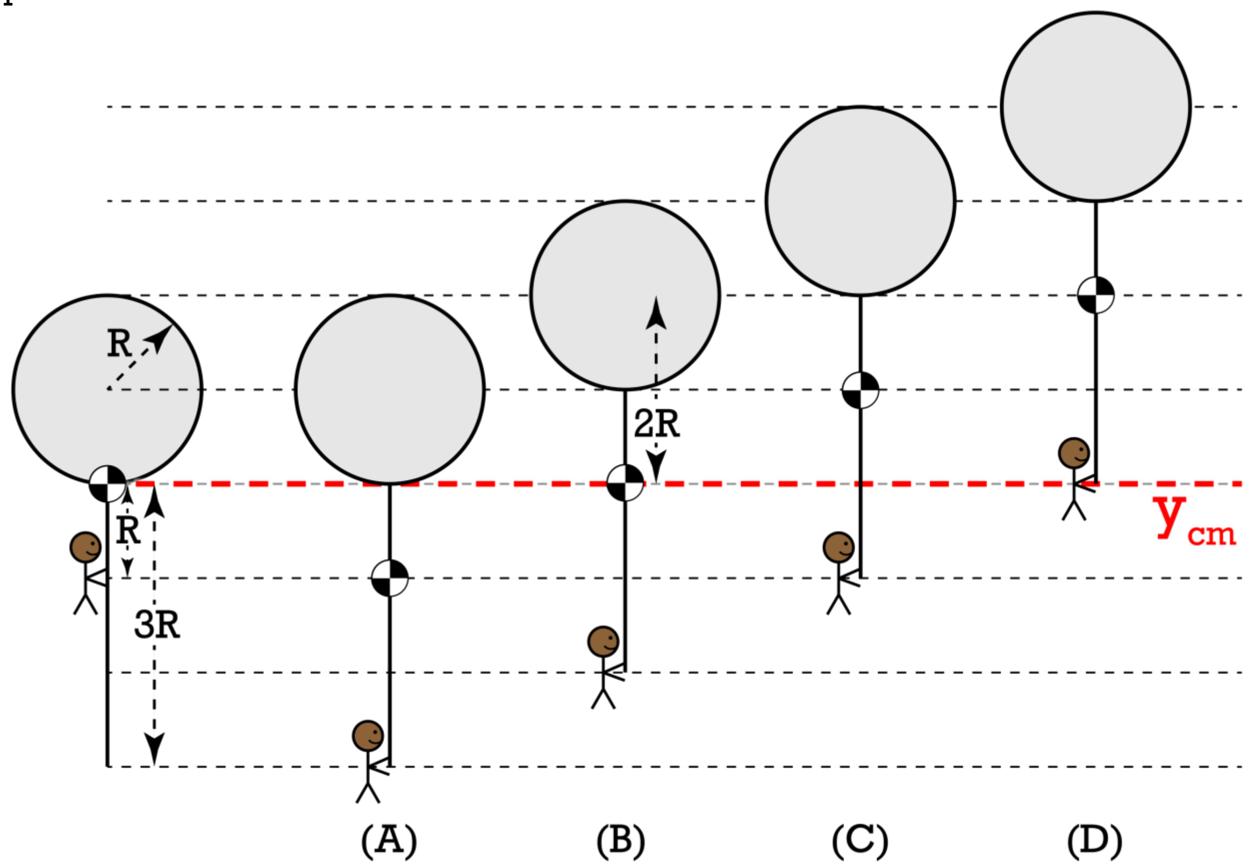
This lesson is a part of my AP Physics 1 Ultimate Review Packet. Please consider signing up for access to the whole Review Packet at www.UltimateReviewpPacket.com!

This is what a typical center of mass problem could look like:

1) A giant, spherical helium balloon with mass M and radius R has a massless rope of length 3R hanging from it. A person with a mass of M is hanging on the rope in perfect equilibrium such that the balloon-person system does not move up or down. If the person starts a distance R from the bottom of the balloon and climbs down to the end of the rope, which figure best illustrates the final position of the balloon and person? Assume there is no wind.



Because the net external force on the balloon-person system is zero, the system will not accelerate, and the center of mass of the system will stay in the same location while the person climbs down to the bottom of the rope.

Because both objects have the same mass, the initial center of mass of the balloon-person system will be directly in the middle between the centers of mass of the two objects. In other words, because the initial distance between the two objects is 2R, the *initial center of mass of the balloon-person system will be half that distance or a distance R from the centers of mass of both objects.*

Again, because both objects have the same mass, the final center of mass of the balloon-person system will again be in the middle between the centers of mass of the two objects. In other words, because the final distance between the two objects is 4R, the final center of mass of the balloon-person system will be half that distance or a distance 2R from the centers of mass of both objects. Therefore, the correct answer is (B).

The center of mass equation is not required for AP Physics 1; however, I often find that the equation helps solidify understanding. So, here is the solution using the equation. Note, I have set the zero y-position to be at the center of mass of the balloon.

$$y_{cm} = \frac{m_b y_b + m_p y_p}{m_b + m_p} \Rightarrow y_{cm_i} = \frac{(M)(0) + (M)(2R)}{M + M} = \frac{2MR}{2M} = R$$

$$\& \ y_{cm_f} = \frac{(M)(0) + (M)(4R)}{M + M} = \frac{4MR}{2M} = 2R$$

Another typical center of mass question involves the standard “frozen, frictionless ice”.

2) While peacefully reading your physics textbook, you are sliding at 3 m/s East on a very large patch of frozen, frictionless ice. In frustration, you decided to throw your physics textbook and give it a speed of 8 m/s North. If your mass is 40 times larger than the mass of your physics textbook, what is the velocity of the center of mass of the you-textbook system after you throw the book?

(A) 0
(B) 3 m/s East
(C) 4 m/s @ 53° South of East
(D) 4 m/s @ 37° South of East

Considering the net external force of the you-textbook system is zero when you throw the book, the acceleration of the system is also zero. Therefore, the you-textbook system has no change in its momentum or velocity when you throw the book. So, the velocity of the center of mass of the you-textbook system is still 3 m/s East after you throw the book. The correct answer is (B).