a place of mind

FACULTY OF EDUCATION

Department of
Curriculum and Pedagogy

Physics
Momentum: Collisions

Science and Mathematics Education Research Group

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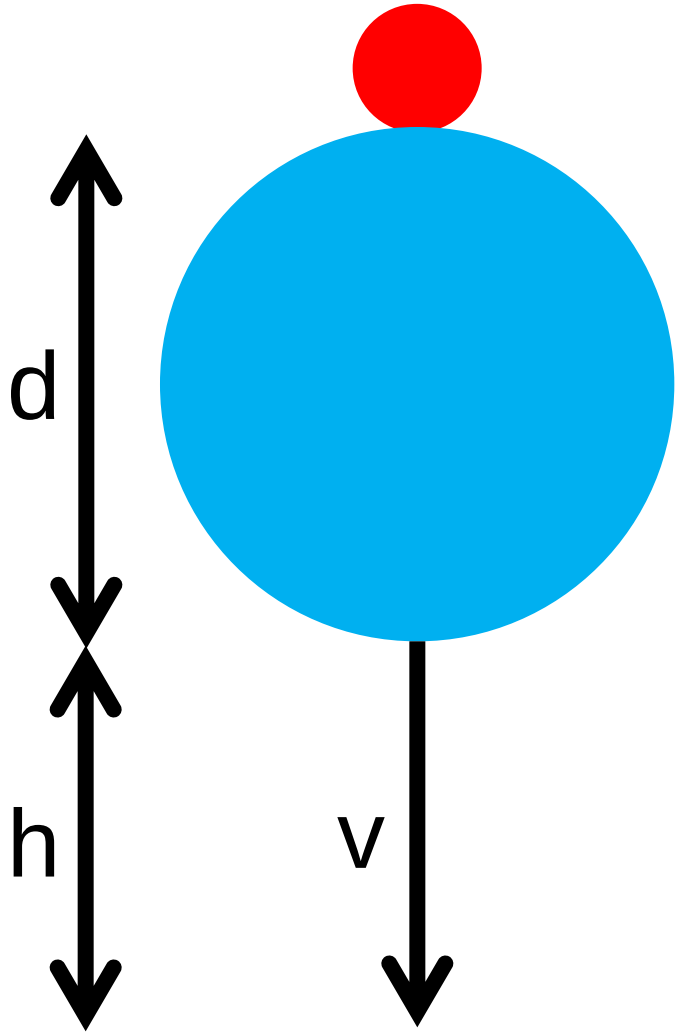
Bouncing Balls



Bouncing Balls I

A completely elastic ball of mass m_1 is bouncing up and down on the floor. If the ball was released from a height of y, what height will the ball return to when it bounces up? Assume the ball is of average mass (~1 kg).

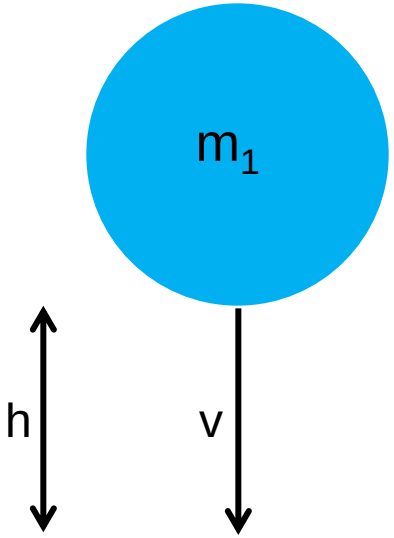
A. 0.5 y

B. 0.7 y

C. 0.9 y

D. y

E. Not enough information



Solution

Answer: D

Justification: The ball has a completely elastic collision with the earth. Since the mass of the earth is much greater than that of the ball, the earth will not move. The ball bounces back with its initial velocity and therefore returns to the same height.

Bouncing Balls II

A completely elastic ball of mass m_1 is at rest. Another ball of mass m_2 is moving directly at it with a velocity of **v**. Assuming that $m_1 >> m_2$, what will be the final velocity of m_2?

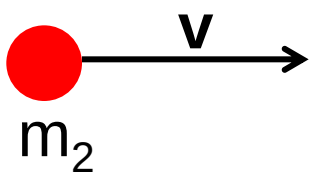
A. 0

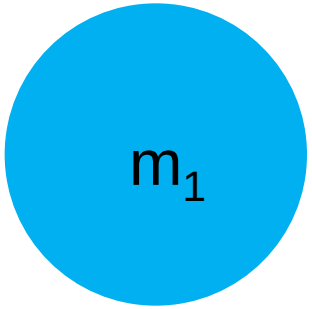
B. 0.5**v**

C. **v**

D. 2**v**

E. **-v**





Solution

Answer: C

Justification: The ball with mass m_1 is greatly resistant to moving because of its heavy mass, so when the lighter ball bounces off of it, the heavy ball will barely move at all. In order for momentum to be conserved, m_2 will move with the same speed v, but in the opposite direction. Therefore, its velocity will be **–v**.

Bouncing Balls III

A completely elastic ball of mass m_1 is moving toward another ball of mass m_2 with a velocity of -**v**. The other ball is also moving at it with a velocity of **v**. Assuming that $m_1 >> m_2$, what will be the final velocity of m_2?

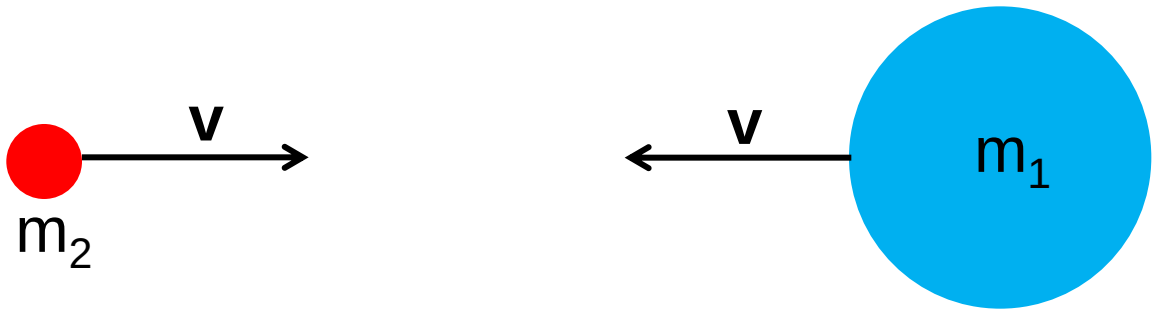
A. 0.5**v**

B. **v**

C. 2**v**

D. 3**v**

E. -**v**



Solution

Answer: D

Justification: From the reference frame of the heavier ball, it is at rest and the smaller ball is travelling at it with a velocity of 2**v**. Since the heavier ball is much heavier than the lighter ball, the lighter ball bounces off the heavier ball with a velocity of 2**v** relative to the heavier ball. The heavier ball is travelling at **v**, so the lighter ball bounces off with 2**v**+**v**=3**v**.

Bouncing Balls IV

A. 1h+d

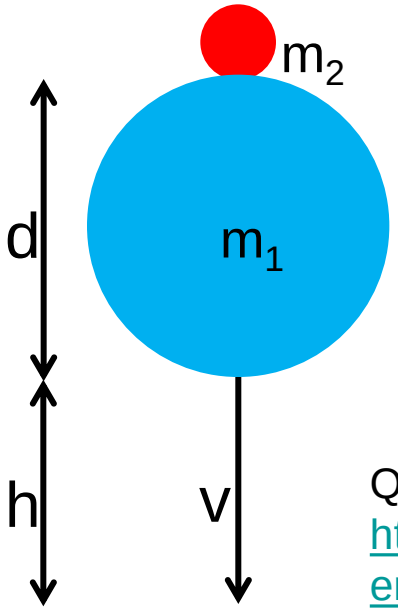
B. 4h+d

C. 9h+d

D. 16h+d

E. Not enough information

A completely elastic ball of mass m_1 and diameter d has a ball of mass m_2 on top of it. Both balls fall simultaneously to the ground from a distance d and bounce back up. How high does the lighter ball bounce if $m_1 >> m_2$?



Question adapted from http://www.physics.harvard.edu/academics/undergrad/probweek/prob1.pdf

Solution

Answer: D

Justification: When the heavier ball hits the ground, it bounces back with a speed of v. At this moment in time, the lighter ball is still falling downward with a speed of v (it fell from h+d to d, so it is travelling with the same speed as the heavier ball, which fell from h to 0). As we saw in question 3, from the reference frame of the heavier ball it comes and bounces back with a speed of 2v, so it has a final speed of 3v from an external observer's perspective. We know that $v=\sqrt{(2gh)}$, so $3v=\sqrt{(2g(9h))}$, which means that 3v allows the ball to bounce up 9h. The lighter ball bounced from the top of the heavier ball, so it will bounce up to 9h+d above the ground.