Elastic Collision

Kinetic Energy Conserved

$$\frac{1}{2}m_1V_{1i}{}^2 + \frac{1}{2}m_2V_{2i}{}^2 = \frac{1}{2}m_1V_{1f}{}^2 + \frac{1}{2}m_2V_{2f}{}^2$$

Momentum Conserved

$$m_1V_{1i} + m_2V_{2i} = m_1V_{1f} + m_2V_{2f}$$

Inelastic Collision

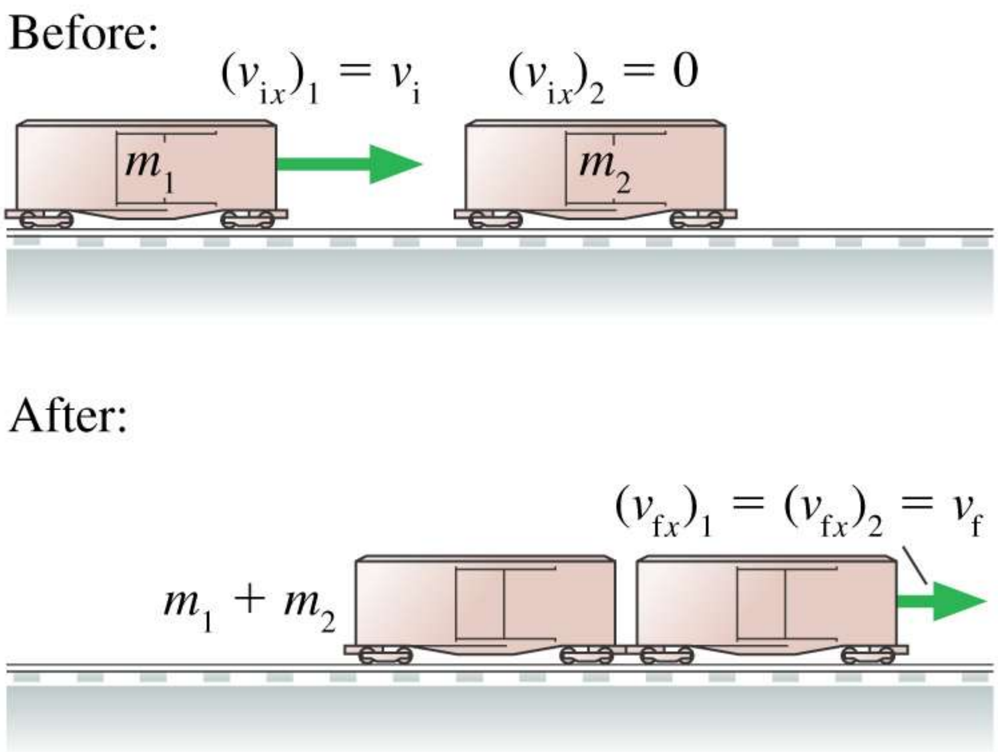
Most collisions are inelastic

Momentum is Conserved

$$m_1V_{1i} + m_2V_{2i} = m_1V_{1f} + m_2V_{2f}$$

Is Kinetic Energy Conserved?

Inelastic Collision



Completely Inelastic Collision (stick together)

$$P_i = m_1V_1 + m_2V_2, \quad P_f = (m_1 + m_2)V_f$$

$$P_i = P_f, \quad V_f = \frac{m_1V_1 + m_2V_2}{(m_1 + m_2)} = V_{com}$$

$$K_i = \frac{1}{2}m_1V_1^2 + \frac{1}{2}m_2V_2^2, \quad K_f = \frac{1}{2}(m_1 + m_2)V_f^{\ 2}$$

$$K_i - K_f = \frac{m_1m_2}{2(m_1 + m_2)}(V_1 - V_2)^2 > 0$$

$$\Rightarrow \boxed{K_f < K_i}$$

Inelastic Collision

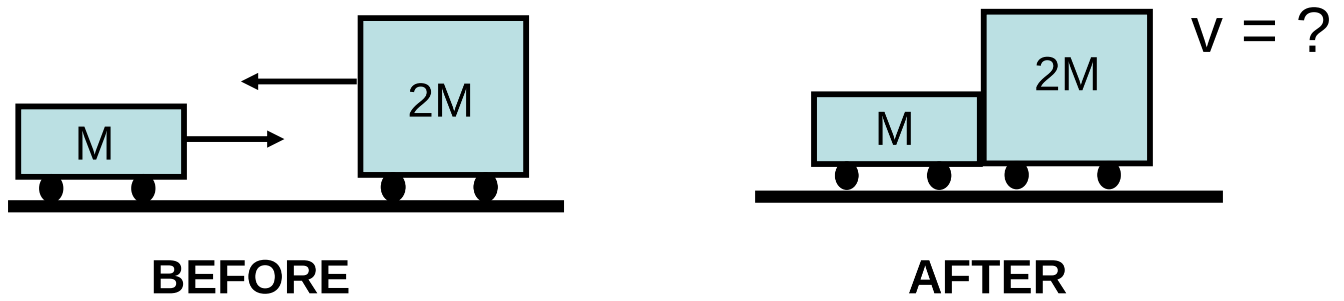
Kinetic Energy is NOT Conserved

$$\frac{1}{2}m_1V_{1i}^{\ 2}+\frac{1}{2}m_2V_{2i}^{\ 2}>\frac{1}{2}(m_1+m_2)V_f^{\ 2}$$

Momentum Conserved

$$m_1V_{1i}+m_2V_{2i}=m_1V_{1f}+m_2V_{2f}$$

A car with a mass M is moving toward another car with a mass 2 M on a frictionless surface. Both cars have a speed of 10 m/s. Subsequently, they collide and stick together. What is the final velocity of the two car system?



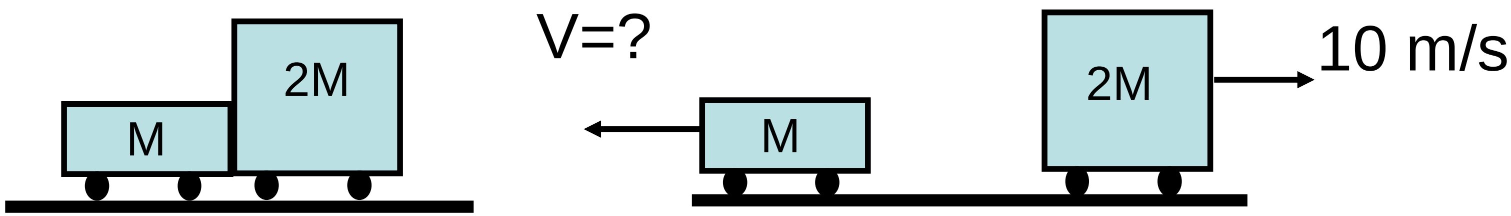
1. 0 m/s
2. +3.3 m/s
3. -3.3 m/s
4. +5.0 m/s
5. -5.0 m/s
6. +10 m/s
7. -10 m/s
8. None of the above

+x

$$M \times 10 + (-10 \times 2M) = (M + 2M) V_f$$

$$V_f = \frac{-10M}{3M} = -3.33 \text{ m/s}$$

Two cars initially at rest on a frictionless surface are blown apart by an explosion. The one with twice the mass ends up moving to the right at 10 meters/second. The less massive car ends up moving to the left at what speed?



BEFORE **AFTER**

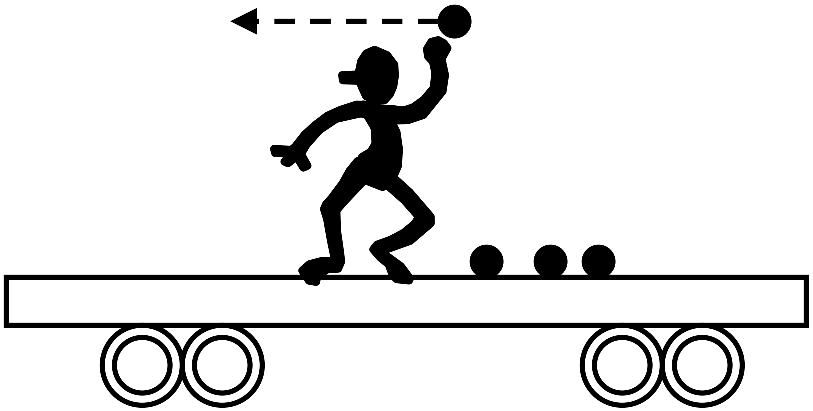
1. 5 m/s
2. 7 m/s
3. 10 m/s
4. 14 m/s
5. 15 m/s
6. 20 m/s
7. 25 m/s

$$0 = 2M \times 10 + M \times V_m$$

$$V_m = \frac{-2M \times 10}{M} = -20 \text{ m/s}$$

Suppose you are on a cart initially at rest that rides on a frictionless track. If you throw a ball off the cart towards the left, will the cart be put into motion?

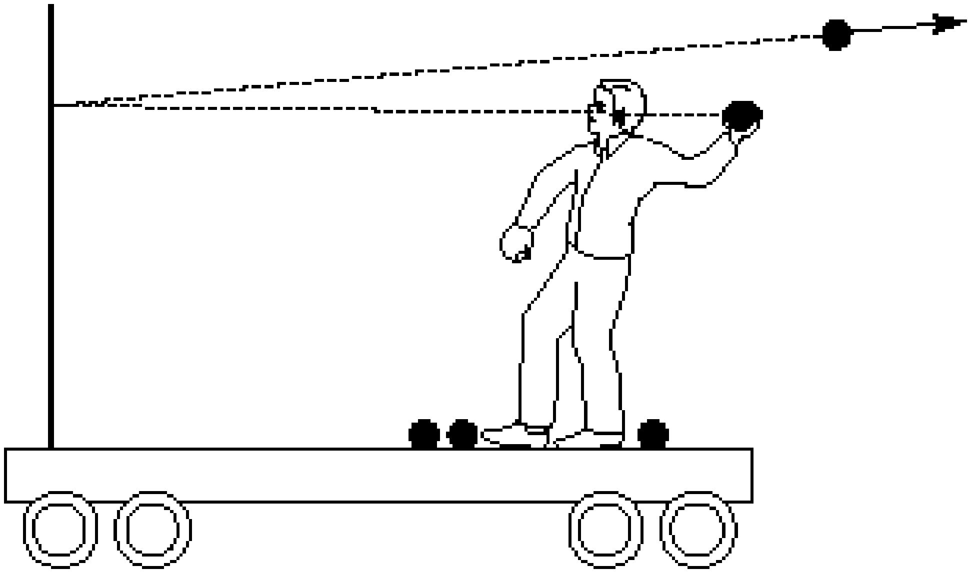
Left



Right

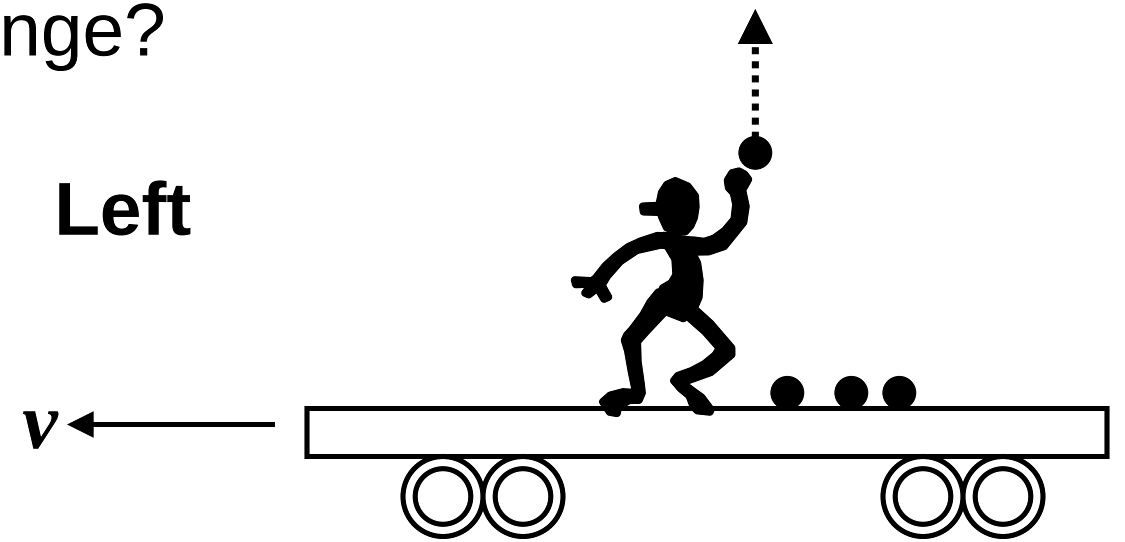
1. Yes, and it moves to the right.
2. Yes, and it moves to the left.
3. No, it remains in place.

Suppose you are on a cart which is initially at rest that rides on a frictionless track. You throw a ball at a vertical surface that is firmly attached to the cart. If the ball bounces straight back as shown in the picture, will the cart be put into motion after the ball bounces back from the surface?



1. Yes, and it moves to the right.
2. Yes, and it moves to the left.
3. No, it remains in place.

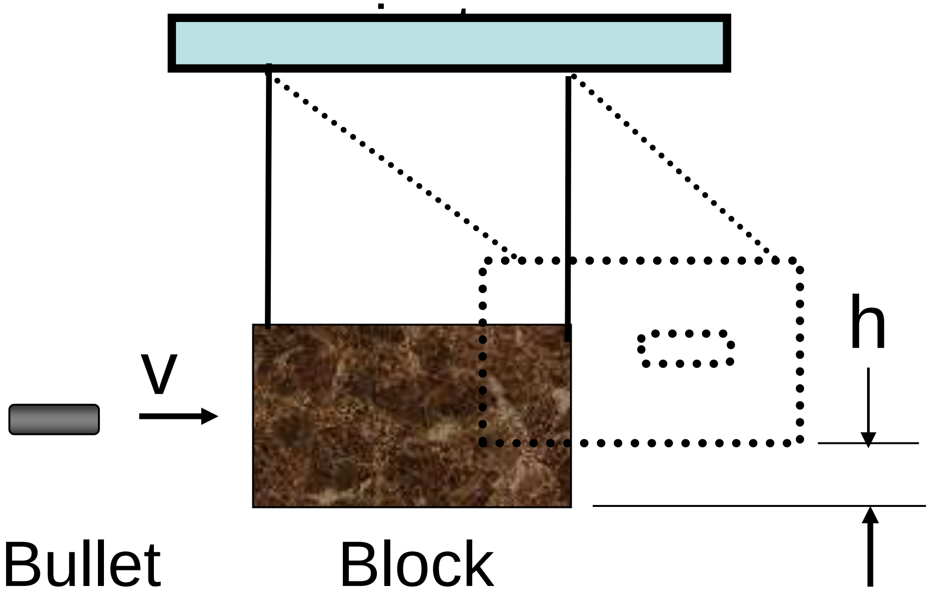
Suppose you are on a cart that is moving at a constant speed v toward the left on a frictionless track. If you throw a massive ball straight up (from your perspective), how will the speed of the cart change?



1. Increase
2. Decrease
3. Will not change
4. You need to know how fast you throw the ball

A 20 gram bullet with an initial velocity v is shot into a 5 kg wood block attached to a pivot with massless strings. After the collision, the block swings upward to a maximum height h = 0.2m above its initial position. What was the initial velocity of the bullet?

1. 31 m/s.
2. 44 m/s.
3. 248 m/s.
4. 497 m/s.
5. 994 m/s
6. None of the above.



$(\cancel{m+M})gh = \frac{1}{2}(\cancel{m+M})v_f^2$

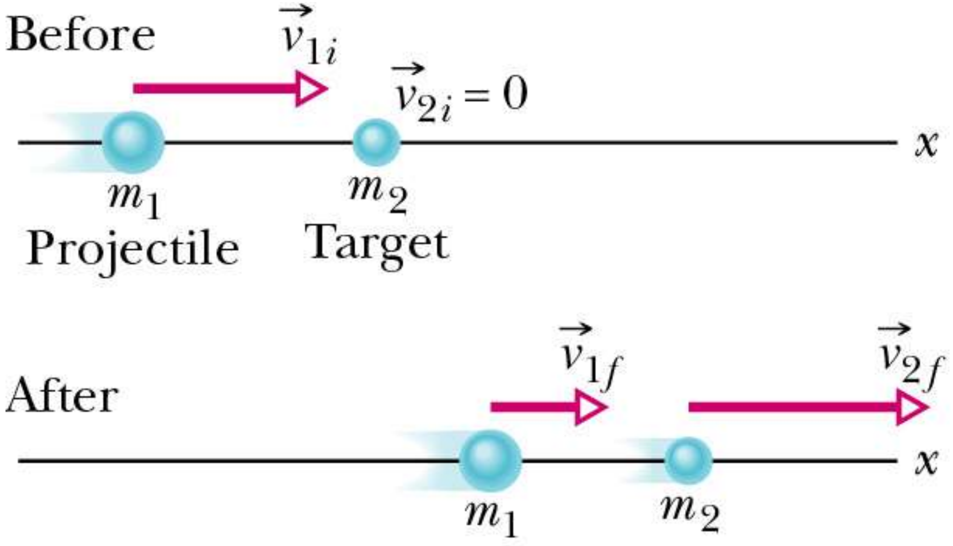
$v_f = \sqrt{2gh} = 1.98$

$m_1 V_{1i} + m_2 V_{2i} = m_1 V_{1f} + m_2 V_{2f}$

$.02 V_{1i} = 5 V_{2f}$

$V_{1i} = 250 V_{2f}$

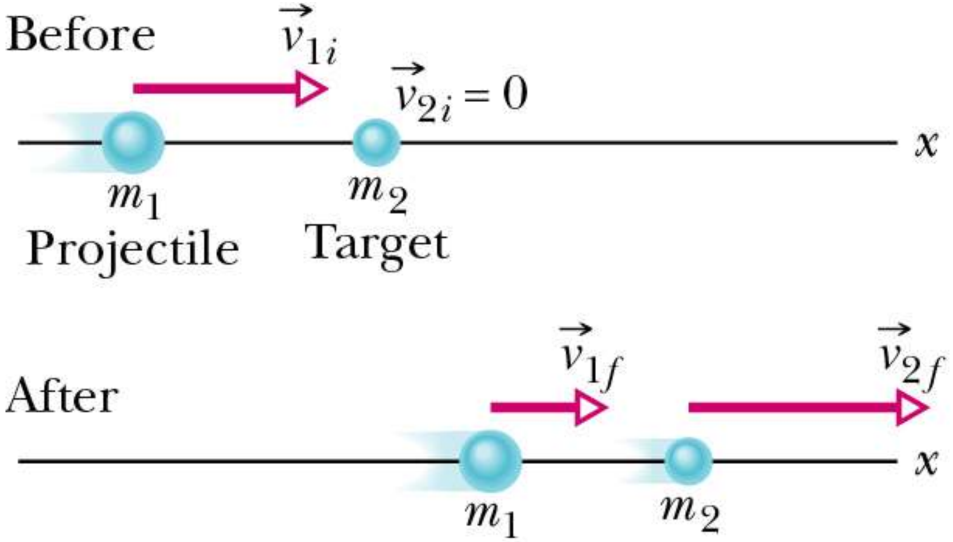
$V_{1i} = 250(1.98) = 495$



$$V_{2i} = 0$$

$$\frac{1}{2}m_1V_{1i}{}^2 + \frac{1}{2}m_2V_{2i}{}^2 = \frac{1}{2}m_1V_{1f}{}^2 + \frac{1}{2}m_2V_{2f}{}^2$$

$$m_1V_{1i} + m_2V_{2i} = m_1V_{1f} + m_2V_{2f}$$

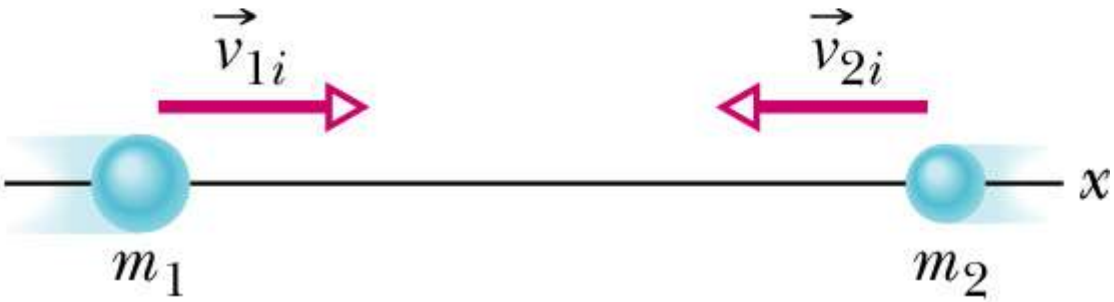


$$V_{2i} = 0$$

$$V_{1f} = \frac{m_1 - m_2}{m_1 + m_2} V_{1i}$$

$$V_{2f} = \frac{2m_1}{m_1 + m_2} V_{1i}$$

Moving Target



$$\frac{1}{2}m_1V_{1i}^{\ 2}+\frac{1}{2}m_2V_{2i}^{\ 2}=\frac{1}{2}m_1V_{1f}^{\ 2}+\frac{1}{2}m_2V_{2f}^{\ 2}$$

$$m_1V_{1i}+m_2V_{2i}=m_1V_{1f}+m_2V_{2f}$$

$$V_{1i}-V_{2i}=-(V_{1f}-V_{2f})$$

$$V_{1f}=\frac{m_1-m_2}{m_1+m_2}V_{1i}+\frac{2m_2}{m_1+m_2}V_{2i}$$

$$V_{2f}=\frac{2m_1}{m_1+m_2}V_{1i}+\frac{m_2-m_1}{m_1+m_2}V_{2i}$$

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$$1.\quad Equal\ masses:\ if\ \ m_1 = m_2$$

$$\underline{V_{1f} = 0,\quad V_{2f} = V_{1i}}$$

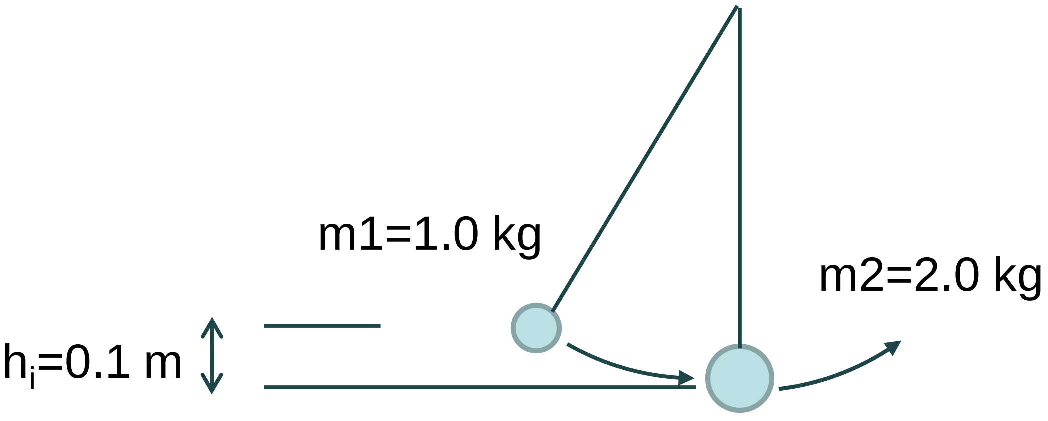
$$2.\quad A\, massive\, t\arg et: if\ \ m_1 << m_2$$

$$V_{1f} \approx -V_{1i},\quad V_{2f} \approx (\frac{2m_1}{m_2})V_{1i}$$

$$3.\quad A\, massive\ projectile: if\ \ m_1 >> m_2$$

$$V_{1f} \approx V_{1i},\quad V_{2f} \approx 2V_{1i}$$

Find the maximum vertical displacements that ball 1 and 2 will reach after the elastic collision.



$$V_{1f} = \frac{m_1 - m_2}{m_1 + m_2} V_{1i} + \frac{2m_2}{m_1 + m_2} V_{2i}$$

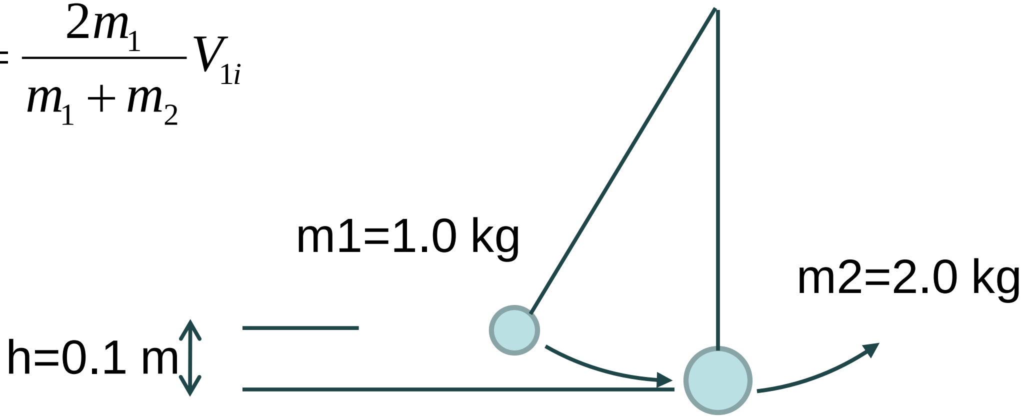
$$V_{2f} = \frac{2m_1}{m_1 + m_2} V_{1i} + \frac{m_2 - m_1}{m_1 + m_2} V_{2i}$$

Find the maximum vertical displacements that ball 1 and 2 will reach after the elastic collision.

$$V_{1f} = \frac{m_1 - m_2}{m_1 + m_2} V_{1i} \qquad V_{2f} = \frac{2m_1}{m_1 + m_2} V_{1i}$$

$$\frac{1}{2} m_1 V_{1i}^2 = m_1 g h$$

$$V_{1i} = \sqrt{2gh} = 1.41\,(m/s)$$



$$V_{1f} = \frac{1-2}{3} 1.41 = -0.47\ m/s \qquad V_{2f} = \frac{2 \times 1}{3} 1.41 = 0.94\ m/s$$

$$\frac{1}{2} m_1 V_{1f}^2 = m_1 g h_1 \qquad \frac{1}{2} m_2 V_{2f}^2 = m_2 g h_2$$

$$h_1 = \frac{V_{1f}^2}{2g} = 0.011\, m \qquad h_2 = \frac{V_{2f}^2}{2g} = 0.044\, m$$