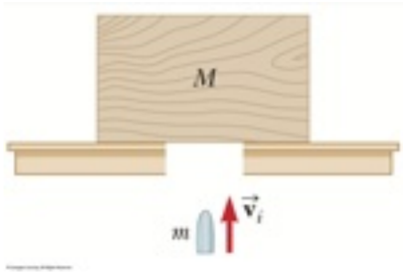
PHY 110 Spring 2018 Quiz 8 Solution



1. In the figure to the left, a bullet (m = 20 g) is fired vertically into a stationary block (M = 1 kg). The bullet sticks in the block, and the bullet/block system rises a maximum height of 21 cm. What was the initial velocity of the bullet?

a) 103.5 m/s b) 105.7 m/s c) 107.1 m/s d) 109.8 m/s

From conservation of momentum, we have $mv = (m+M)V$, *or* $V = \frac{mv}{m+M}$. *From conservation of energy after the collision, we have* $\frac{1}{2}(m+M)V^2 = (m+M)gh$, *or* $V = \sqrt{2gh}$. *Setting the two expressions for V equal and solving for v, we get* $v = \frac{m+M}{m}\sqrt{2gh} = \frac{1.02}{.02}\sqrt{2(9.81)(0.21)} = 103.52\frac{m}{s}$

2. A block slides horizontally off a table and falls to the floor. Which of the statements below are true for the block's flight? Circle all that apply. Ignore air resistance.

a) The block's linear momentum is conserved.
b) The block's total mechanical energy (kinetic + potential) is conserved.
c) The block's horizontal momentum is conserved, but not its vertical momentum.
d) The block's vertical momentum is conserved, but not its horizontal momentum.
e) There are no conserved quantities during the block's flight.

The block's linear momentum is not conserved during the flight because an external force (gravity) acts. But gravity is a conservative force, so the total mechanical energy of the block is conserved. And since gravity doesn't act in the horizontal direction, the block's horizontal momentum is conserved.

3. A ball (m = 0.2 kg) hits the floor with a speed of 2 m/s and rebounds with a speed of 1.4 m/s. If the ball's contact with the floor lasts 0.07 s, what was the average force exerted by the floor on the ball during the bounce?

a) 9.7 N b) 12.4 N c) 15.5 N d) 18.3 N

Let positive be upward. Then $\Delta p = p_f - p_i = 0.2(1.4) - 0.2(-2) = 0.68\,kg\frac{m}{s}$. *But since* $\Delta p = F_{avg}\Delta t$, *we have* $F_{avg} = \frac{\Delta p}{\Delta t} = \frac{0.68}{0.07} = 9.71\,N$.

4. A 1 kg object is located at the origin. A 2 kg object is located at coordinates (x = 0, y = 1 m), and a 3 kg object is located at coordinates (x = 2 m, y = 0). What is the x-coordinate of the center of mass of these three objects?

a) 0.50 m b) 0.67 m **c) 1.0 m** d) 1.3 m

$$x_{cm} = \frac{\sum x_i m_i}{\sum m_i} = \frac{0(1)+0(2)+2(3)}{1+2+3} = 1m$$

5. Two children are seated on a frozen lake (no friction) holding hands. Their brother gives them a push so that they have a velocity of 1 m/s across the lake. The smaller of the two (m = 20 kg) gives the larger one (M = 35 kg) a push back towards their brother so that the two children separate and the larger child's speed is cut in half. What is the speed of the smaller child after this push?

a) 1.22 m/s b) 1.44 m/s c) 1.66 m/s **d) 1.88 m/s**

Let positive be in the direction the children are initially moving. Since a push between the children is an internal force, which doesn't affect total linear momentum of the system, conservation of momentum gives

$$(m+M)v_i = mv_f + MV_f$$
$$(20+35)(1) = 20v_f + (35)(0.5)$$
$$v_f = 1.875\frac{m}{s}$$

$$K = \frac{1}{2}mv^2 \quad W_{net} = \Delta K \quad E = K + U \quad U_{spring} = \frac{1}{2}kx^2 \quad U_g = mgh \quad W_{nc} = E_f - E_i \quad W_f = -fd$$

$$a_{radial} = \frac{v^2}{r} \quad \vec{p} = m\vec{v} \quad \vec{I} = \int \vec{F}\,dt = \Delta\vec{p} \quad \vec{r}_{cm} = \frac{\int \vec{r}\,dm}{\int dm} \ or \ \frac{\sum \vec{r}_i m_i}{\sum m_i}$$