Momentum and Impulse Practice Problems

1. Block A has mass 3 kg and is moving to the right with velocity 10 m/s. It collides with Block B (5 kg) which is stationary. After the collision, Block A is stationary while Block B moves to the right. What is the velocity of Block B after the collision?

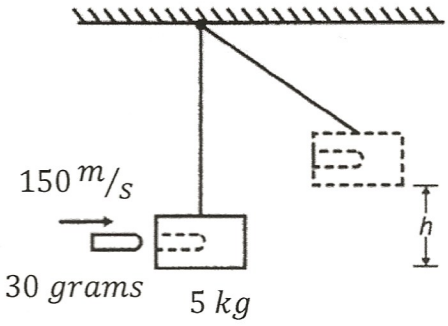
2. Two blocks, one with mass 6 kg and the other with mass 12 kg, collide on the x-axis. The 6 kg block was traveling at +8 m/s before the collision and -2 m/s after the collision. The 12 kg block was traveling at -5 m/s before the collision. What is the speed and direction of the 12 kg block after the collision?

3. An archer shoots an arrow through a block of wood so that the arrow becomes lodged inside the wood. The mass of the arrow and wood are 100 g and 5 kg respectively. If the wood and arrow are moving together at 3.2 m/s after the collision, what was the arrow's speed the moment before it hit the wood block?

4. Jenny and her younger sister, Beth, are standing still in the middle of an ice rink (you can neglect friction). Jenny weighs twice as much as Beth. If Jenny pushes her younger sister forward at 2 m/s, how fast does Jenny move backwards?

5. A boat sits idly in the middle of a lake. The captain throws a 60 kg anchor off the side of the boat with a speed of 3.1 m/s. If the captain's mass is 80 kg and the boat's mass is 200 kg, what is the speed of the boat after he throws the anchor?

6. A bullet moving at 150 m/s strikes a block on a string in a perfectly inelastic collision. The bullet and block have masses of 30 grams and 5 kg respectively. How high will the block-bullet combination go? (Hint: this question also requires conservation of energy)



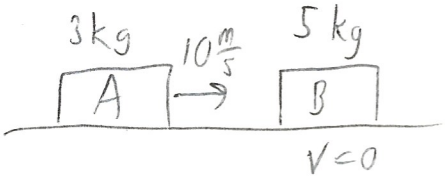
7. A pitcher throws a 90 mph (40 m/s) fast ball. The baseball has a mass of 140 grams. The batter hits the ball back with a speed of 48 m/s. What is the impulse of the bat on the ball? If the ball was in contact with the bat for 20 milliseconds, what was the force of the bat on the ball?

8. Superman flies into a brick wall at a speed of 85 m/s. His mass is 100 kg. As he smashes through the wall, the wall exerts a force of 1,200 N for 0.7 seconds. What is Superman's speed as he emerges on the other side of the wall?

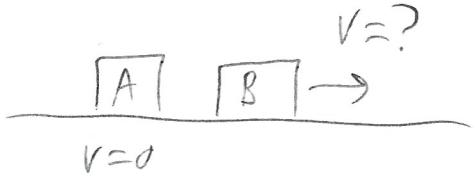
9. A kid drops a bouncy ball from a height of 2 meters, and it bounces back up to a peak height of 1.2 meters. The ball's mass is 1 kg. What is the impulse of the floor on the ball?

1.

Before



After



$p = mv$

$p_i = 3(10) + 5(0)$

$= 30$

$p_f = 3(0) + 5v$

$= 5v$

$p_i = p_f$

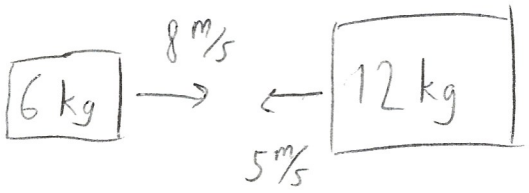
$30 = 5v$

$v = 6 \text{ m/s}$

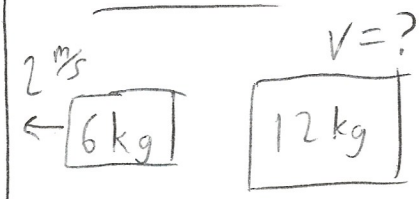
Block B moves +6 m/s (to the right)

2.

Before



After



right = positive
left = negative

$p_i = 6(8) - 12(5)$

$= 48 - 60$

$= -12$

$p_f = -6(2) + 12v$

$= -12 + 12v$

$p_i = p_f$

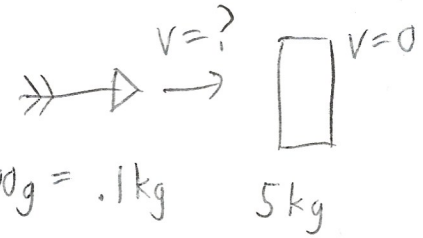
$-12 = -12 + 12v$

$0 = 12v$

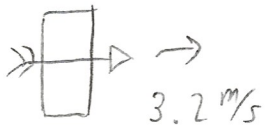
$v = 0 \text{ m/s}$

The 12 kg block is not moving

3. **Before**



After



stick together
↓
perfectly inelastic collision
↓
V_f is the same for both

$p_i = .1v + 5(0)$

$p_f = (.1+5)(3.2)$

↖ Add masses together

$p_i = p_f$

$.1v = (.1+5)(3.2)$

$.1v = 16.32$

$v = 163.2\ m/s$ ← Arrow's initial speed

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4. **Before**

Let Beth's mass be m

↑ let Jenny's mass be 2m

$p_i = 0$

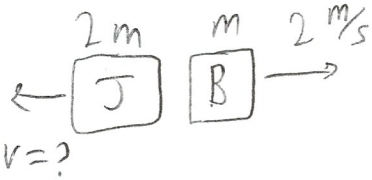
$p_i = p_f$

$0 = 2mv + 2m$

$-2m \quad -2m$

$-2m = 2mv$

After



$p_f = (2m)(v) + (m)(2)$

$-2m = 2mv$

$-2 = 2v$

$v = -1\ m/s$ ← negative means left

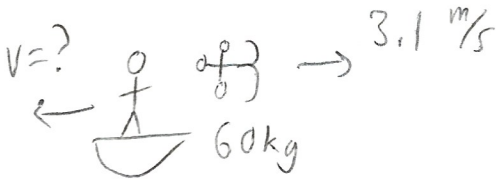
Jenny moves backwards at 1 m/s

5.

Before

$p_i = 0$

After



$p_f = (80+200)(v) + 60(3.1)$

$= 280v + 186$

$p_i = p_f$

$0 = 280v + 186$

$-186 \quad -186$

$-186 = 280v$

$v = -.664 \text{ m/s}$

↖ negative means left

The boat's speed is .664 m/s

↑ speed (direction doesn't matter)

6. Part 1: conservation of momentum

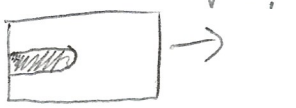
Before

30 grams = .03 kg

$p_i = .03(150) + 5(0)$

$= 4.5$

After



mass = .03 + 5

$p_f = (.03+5)v$

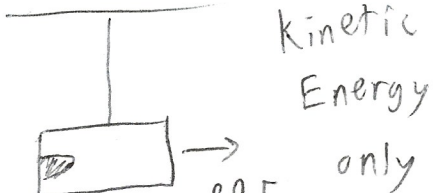
perfectly inelastic collision

$p_i = p_f$

$4.5 = 5.03v$ $\quad v = .895$ m/s

Part 2: conservation of energy

Initial



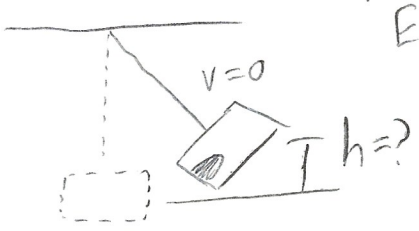
kinetic Energy only

5.03 kg

$E_{tot,i} = \frac{1}{2}(5.03)(.895)^2$

$= 2.013$

Final



Potential Energy only

$E_{tot,i} = E_{tot,f}$

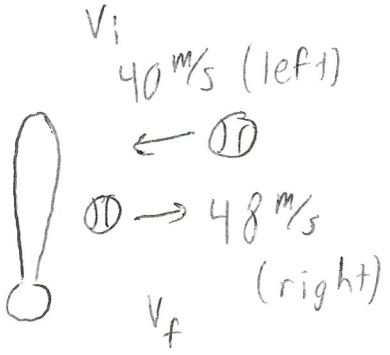
$E_{tot,f} = mgh = 5.03(9.8)h$

$= 49.3h$

$2.013 = 49.3h$

$h = .041$ meters

7.



Impulse

$J = p_f - p_i$

140 grams = .14 kg

$p = mv$

$J = .14(48) - .14(-40)$

negative because it's moving left

$J = 12.32 \text{ kg } \frac{m}{s}$

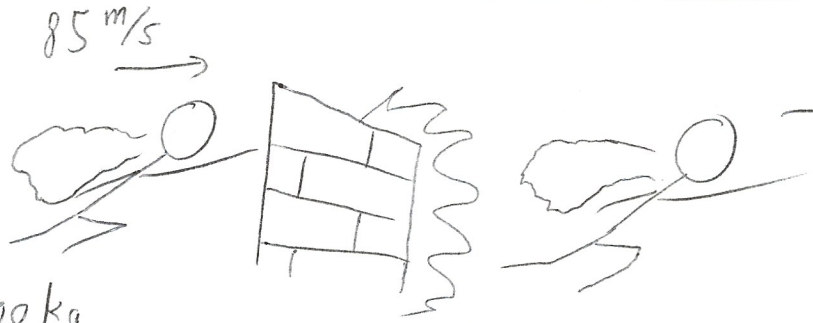
Impulse of bat on ball

$J = F \cdot t$ $\quad 12.32 = F(.02)$ $\quad F = 616 \text{ N}$

20 ms = .02 seconds

Force of bat on ball

8.



$p_f = 100(v)$

F = 1200 left (negative)

t = .7

$p_i = 100(85)$

$p_f - p_i = F \cdot t$

$100v - 100(85) = -1200(.7)$

$100v - 8500 = -840$

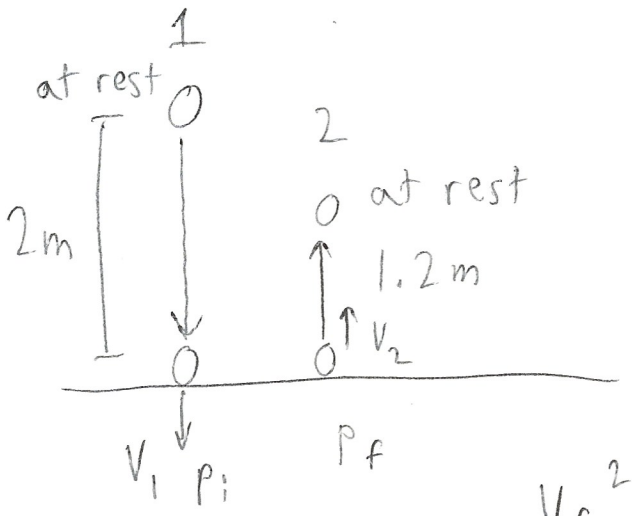
$+8500 \quad +8500$

$100v = 7660$

$v = 76.6 \text{ m/s}$

After he flies through the wall

9.



We use the heights to find the velocities

mass = 1 kg

	1	2
V_i	0	V_2
V_f	V_1	0
a	-9.8	-9.8
t		
Δy	-2	1.2

negative because moving downward

don't need time of flight

$V_f^2 = V_i^2 + 2a\Delta y$

$V_1^2 = 0^2 + 2(-9.8)(-2)$

$V_1^2 = 39.2$

$V_1 = 6.26$ downward (negative)

$0^2 = V_2^2 + 2(-9.8)(1.2)$

$0 = V_2^2 - 23.52$

$23.52 = V_2^2$ $\quad V_2 = 4.85\ m/s$

$J = p_f - p_i$

$p_f = 1 \cdot V_2 = 1(4.85) = 4.85$

$p_i = 1 \cdot V_1 = 1(-6.26) = -6.26$

$J = 4.85 - (-6.26)$

$= 11.11\ kg\ m/s$ ← impulse of floor on ball