# Lesson 6 Explosions Solutions

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## Lesson 6 Homework:

1. The gunpowder explosion in a gun results in an expansion of gases that cause a bullet to be propelled forward. The gun in turn "kicks" or "recoils" backwards.

i) The recoil momentum of a gun that kicks is _____ the momentum of the bullet that it fires.

a. more than b. less than c. the same as

ii) The recoil speed of a gun that kicks is _____ the speed of the bullet that it fires.

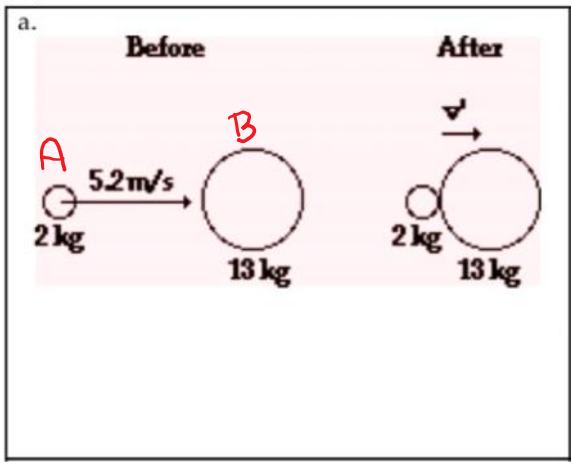
a. more than b. less than c. the same as

$p = m\vec{v}$

2. Determine the missing velocities (labelled v') of the following objects or combination of objects:

$\Sigma \vec{p}_i = \Sigma \vec{p}_f$

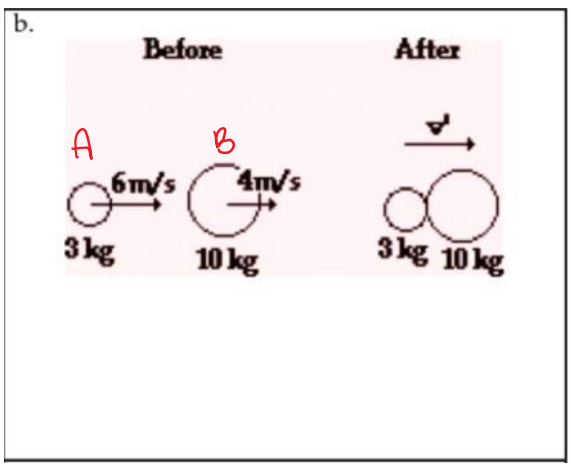
a.




$m_A \vec{v}_{A_i} = (m_A + m_B)\vec{v}_f$

$\vec{v}_f = \frac{m_A \vec{v}_{A_i}}{m_A + m_B} = \frac{2(5.2)}{2+13} = 0.69$ m/s forward

b.



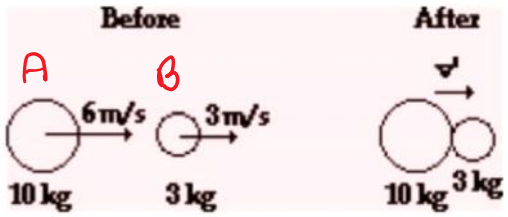

$\frac{m_A \vec{v}_{A_i} + m_B \vec{v}_{B_i} = (m_A + m_B)\vec{v}_f}{m_A + m_B}$

$\vec{v}_f = \frac{3(6) + 10(4)}{3+10} = 4.46$ m/s forward

c.


$m_A \vec{v}_{A_i} + m_B \vec{v}_{B_i} = (m + m)\vec{v}_f$

c.




$$m_A\vec{v}_{A_i} + m_B\vec{v}_{B_i} = (m_A + m_B)\vec{v}_f$$

$$v_f = \frac{10(6) + 3(3)}{13} = 5.3 \text{ m/s forward}$$

Ans: 5.3 m/s right, 4.2 m/s right

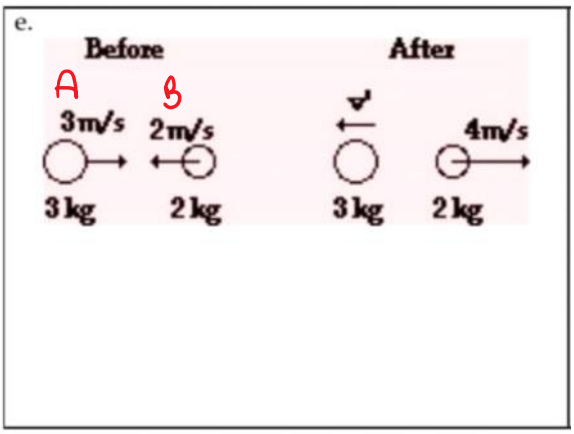
d.


$$m_A\vec{v}_{A_i} + m_B\vec{v}_{B_i} = m_A\vec{v}_{A_f} + m_B\vec{v}_{B_f}$$

$$\vec{v}_{A_f} = \frac{m_A v_{A_i} + m_B v_{B_i} - m_B\vec{v}_{B_f}}{m_A}$$

$$\vec{v}_{A_f} = \frac{10(6) + 3(3) - 3(9)}{10} = 4.2 \text{ m/s forward}$$

e.




$$m_A\vec{v}_{A_i} + m_B\vec{v}_{B_i} = m_A\vec{v}_{A_f} + m_B\vec{v}_{B_f}$$

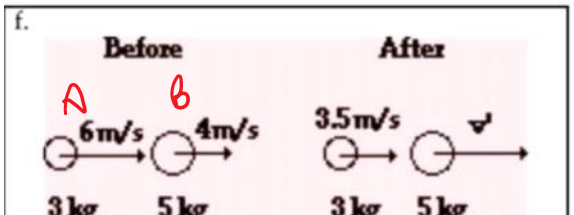
$$\vec{v}_{A_f} = \frac{m_A\vec{v}_{A_i} + m_B\vec{v}_{B_i} - m_B\vec{v}_{B_f}}{m_A}$$

$$\vec{v}_{A_f} = \frac{(3)(3) + 2(-2) - 2(4)}{3} = -1$$

$= 1.0$ m/s backward

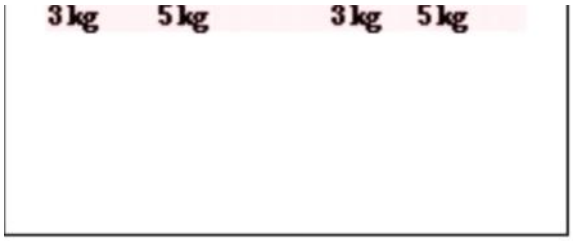
Ans: 1.0 m/s to the left, 5.5 m/s right

f.




$$m_A\vec{v}_{A_i} + m_B\vec{v}_{B_i} = m_A\vec{v}_{A_f} + m_B\vec{v}_{B_f}$$

$$\vec{v}_{A_f} = \frac{m_A\vec{v}_{A_i} + m_B\vec{v}_{B_i} - m_A\vec{v}_{A_f}}{\quad}$$




$$\vec{v}_{Bf} = \frac{m_A\vec{v}_{Ac} + m_B\vec{v}_{Bc} - m_A\vec{v}_{Af}}{m_B}$$

$$\vec{v}_{Bf} = \frac{(3)6 + 5(4) - 3(3.5)}{5} = 5.5 \text{ m/s forward}$$

3. Two boys, Ted and Larry, initially at rest, push each other apart on a frictionless surface. Ted has a mass of 40 kg and Larry has a mass of 60 kg. After the boys push each other apart, Ted has a speed of 6 m/s. What is the final speed of Larry? (4 m/s)

$$\Sigma\vec{p}_i = \Sigma\vec{p}_f$$

$$0 = m_T\vec{v}_T + m_L\vec{v}_L$$

$$v_L = \frac{-m_T v_T}{m_L} = \frac{-40(6)}{60} = -4 = 4 \text{ m/s}$$

4. Robbie has a mass of 79 kg. He is balancing on a floating raft that has a mass of 24 kg. If Robbie dives north at 2.4 m/s, what is the final velocity of the raft? (7.9 m/s South)

$$0 = m_A\vec{v}_A + m_B\vec{v}_B$$

$$v_B = \frac{-m_A\vec{v}_A}{m_B} = \frac{-79(2.4)}{24} = -7.9 = 7.9 \text{ m/s @ South}$$

5. A 38 kg bomb explodes into two pieces. A 12 kg piece flies off at 145 m/s due west. What is the velocity of the other piece? (66.9 m/s east)

$$m_B = 38 - 12 = 26 \text{ kg}$$

$$0 = m_A v_A + m_B v_B$$

$$v_B = \frac{-m_A v_A}{m_B} = \frac{-12(-145)}{26} = 66.9 \text{ m/s @ East}$$

6. A 91 kg running back is sprinting due east at 9.7 m/s. How fast must a 132 kg

6 A 91 kg running back is sprinting due east at 9.7 m/s. How fast must a 132 kg linebacker be running in order to tackle the running back? Assume the collision is head on, and the linebacker holds on to the running back for the whole tackle.

(6.69 m/s west)

$$m_A\vec{v}_{Ai} + m_B\vec{v}_{Bi} = (m_A + m_B)\vec{v}_f$$

$$m_A\vec{v}_{Ai} + m_B\vec{v}_{Bi} = 0 \rightarrow \vec{v}_{Bi} = \frac{-m_A\vec{v}_{Ai}}{m_B}$$

$$\vec{v}_{Bi} = \frac{-91(9.7)}{132} = -6.69 = 6.69 \text{ m/s @ West}$$

8 A 850 kg cannon fires a 20 kg shell at a velocity of 180 m/s.

a) Calculate the final momentum of the shell. (3600 kg m/s)

b) What is the magnitude of the momentum of the cannon immediately after the shell is fired? (You may assume that the cannon is initially at rest.) (-3600 kg m/s)

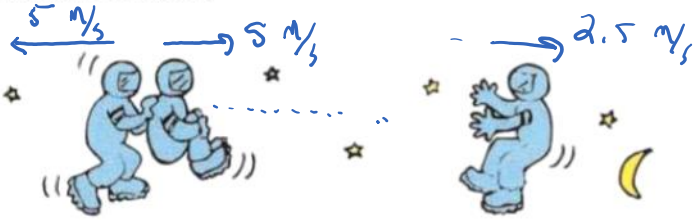
c) Calculate the recoil velocity of the cannon. (-4.24 m/s)

a) $\vec{p}_f = m\vec{v}_f = (20)(180) = 3600 \text{ kg m/s}$

b) $p_{cannon} = -3600 \text{ kg m/s}$

c) $-3600 = m_c\vec{v}_c \Rightarrow \vec{v}_c = \frac{-3600}{850} = -4.24 \text{ m/s}$

10 Suppose that there are three astronauts outside a spaceship and that they decide to play catch. All the astronauts weigh the same on Earth and are equally strong. The first astronaut throws the second one toward the third one and the game begins. Describe the motion of the astronauts as the game proceeds. How long will the game last?




(Only 1 throw. Call the astronauts A, B, and C (where B is being thrown). After one throw, A is moving backwards too fast for the C to throw B hard enough to reach A)

Nasty questions:

12. A 1200. kg car moving at 35 kph runs into and sticks to a parked 1000. kg car. The collision takes 0.15 seconds and after the crash the cars wheels lock and they skid to a stop on the $\mu$=0.40 road. Find:

a) the final speed of both cars immediately after the collision

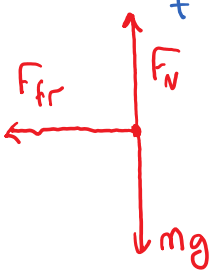
b) the distance travelled before skidding to a stop

c) the impact force on both cars (5.3m/s; 3.6m; 35kN= 35000 N; )

a) $m_A\vec{v}_{A_i} = (m_A + m_B)\vec{v}_f$

$\vec{v}_f = \frac{m_A v_{A_i}}{m_A + m_B} = \frac{1200(9.72)}{1200+1000} = 5.30$ m/s

b) $d = ?$ $v_f = 0$ $v_i = 5.30$ $a = -\mu g$




$F_{fr} = ma \rightarrow \mu F_N = ma \rightarrow \mu mg = ma \quad a = \mu g$

$d = \frac{v_f^2 - v_i^2}{2a} = \frac{0^2 - (5.30)^2}{2(-\mu g)} = 3.6$ m

c) $F_{car\ B} \Rightarrow \Delta\vec{p} = Ft$

$m_B\vec{v}_{B_f} - m_B\vec{v}_{B_i} = Ft \rightarrow F = \frac{m_B\vec{v}_{B_f}}{t}$ ($\vec{v}_{B_i} = 0$)

$F = \frac{(1000)(5.30)}{0.15} = 35000$ N