Lesson 6 Explosions

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Physics 11 Unit 6 Momentum Name:

Lesson 6 Explosions

Ex 1) A 0.060 kg rifle bullet leaves the muzzle with a velocity of 6.0×10^2 m/s. If the 3.0 kg rifle is held very loosely, with what velocity will it recoil?

B

R

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

$$0 = m_B \vec{v}_B + m_R \vec{v}_R$$

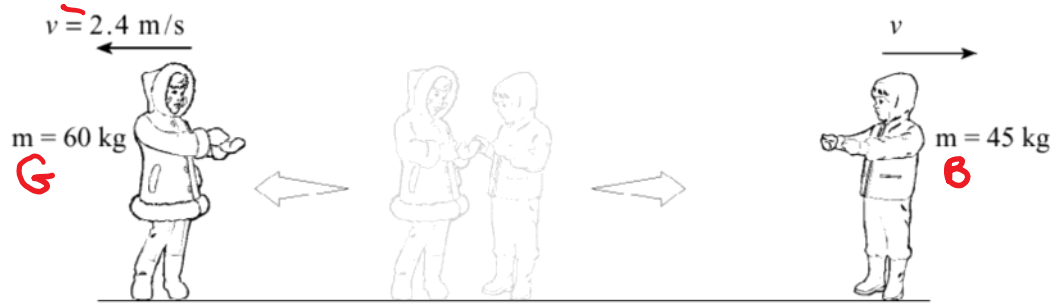
$$-m_B v_B = m_R \vec{v}_R$$

$$\vec{v}_R = \frac{-m_B v_B}{m_R} = \frac{-(.06)(600)}{3} = -12 \text{ m/s}$$

Ex 2) Spencer is sitting in a canoe, floating on the water next to a dock. He decides to stand up and step out of the canoe, and onto the dock. Why does Spencer get wet?

Initial p of canoe and Spencer is zero.
If Spencer has momentum to the left, canoe must have momentum to the right.

Ex. 3) A 45 kg boy and a 60 kg girl are standing in the middle of a frozen pond. The boy gives the girl a push as shown, and she moves off with a speed of 2.4 m/s.



a) What velocity does the boy move off with? (ignore friction)

$\Sigma \vec{p}_i = \Sigma \vec{p}_f \rightarrow \quad 0 = m_G \vec{v}_G + m_B \vec{v}_B$

$-m_G \vec{v}_G = m_B \vec{v}_B \rightarrow \quad \vec{v}_B = \frac{-m_G v_G}{m_B} = \frac{-60(-2.4)}{45} = 3.2 \text{ m/s}$

b) What is the impulse of the boy?

$\Delta \vec{p} = m\vec{v}_f - m\vec{v}_i$

$\Delta \vec{p} = m_B \vec{v}_B = 45(3.2) = 144 \text{ kg m/s}$

c) What is the impulse of the girl?

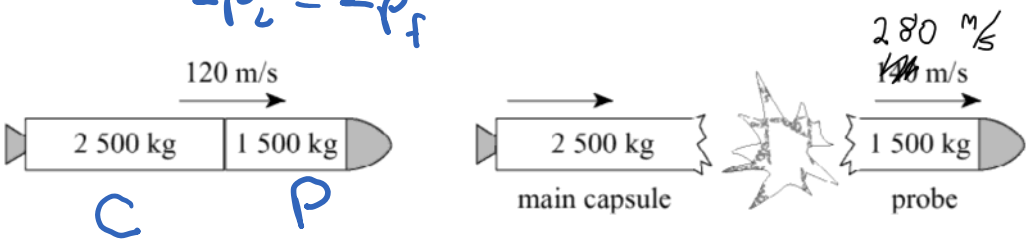
$\Delta \vec{p}_G = -144 \text{ kg m/s}$

d) If the push lasted for 0.25 s, with what average force did the boy push the girl?

$\Delta \vec{p} = \vec{F} \Delta t \rightarrow \quad \vec{F} = \frac{\Delta \vec{p}}{t} = \frac{144}{.25} = \boxed{576 \text{ N}}$

Ex 4) A 4000 kg space capsule consists of a 2500 kg main capsule and a 1500 kg probe. The space vehicle is travelling at 120 m/s when an explosion occurs between the capsule and the probe. After the explosion, the probe moves forward at 280 m/s.

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



a) What is the new speed of the main capsule after the explosion?

$(m_c + m_p)\vec{v}_i = m_c\vec{v}_c + m_p\vec{v}_p$

$\vec{v}_c = \dfrac{(m_c + m_p)\vec{v}_i - m_p\vec{v}_p}{m_c} = \dfrac{(4000)(120) - 1500(280)}{2500}$

$v_c = 24 \text{ m/s}$

b) What is the magnitude of the impulse given to the probe?

$\Delta \vec{p}_p = m_p\vec{v}_f - m_p\vec{v}_i = (1500)(280) - 1500(120) = 240000 \text{ kg m/s}$

c) What is the magnitude of the impulse given to the capsule?

$\Delta \vec{p}_c = -240{,}000 \text{ kg m/s}$

Ex. 5) Mountain climbers use nylon safety ropes due to their tendency to stretch considerably under stress. Use principles of physics to explain why.

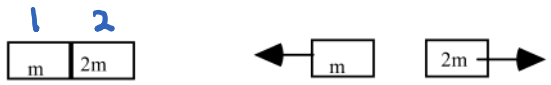
stretch → Δt increases

$\Delta \vec{p} = \vec{F}\Delta t$ as $t \uparrow$, $F \downarrow$

Ex. 6) Why does conservation of momentum explain why it is so difficult for firefighters to hold hoses that are ejecting large amounts of water at a high speed?

Forward momentum of the H2O means firefighters experience backward momentum

Ex. 7) The diagram below shows two pop cans of unequal mass, initially at rest. An explosive charge is detonated between them and the cans fly apart.



before = at rest after =exploding apart

a) What can be said about their velocities after the explosion?

lighter can will be going twice as fast as the heavier can

b) Using principles of physics, explain your answer

$0 = m_1 v_1 + m_2 v_2$

$v_1 = \frac{-m_2 v_2}{m_1} = \frac{-(2m) v_2}{m} = -2v_2$

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

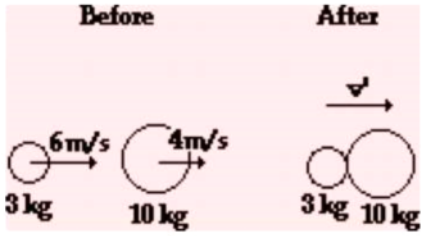
ii) The recoil speed of a gun that kicks is _____ the speed of the bullet that it fires.

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

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

a.

b.



Ans: (0.693 m/s right, 4.46 m/s right)

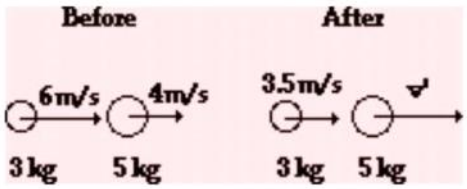
c.

d.

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

e.

f.



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

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)

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)

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)

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)

7. A 0.30 g (← that's grams!) fly moving at 1.5 m/s is trapped by a spider's web. The fly comes to rest in a time of 0.40 s. Calculate the magnitude of:

a) the change in momentum of the fly; (-4.5×10^{-4} kg m/s)

b) the average force exerted by the web on the fly. (-1.13×10^{-3} N)

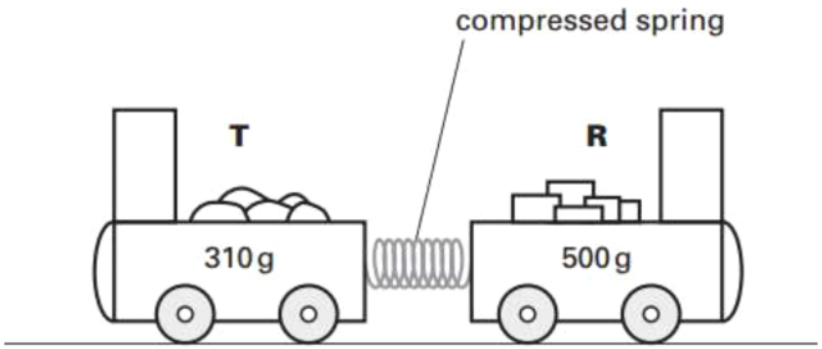
8. A 850 kg cannon fires a 20 kg shell at a velocity of 180 m/s.

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)

9. The diagram shows two toy trains T and R held in place on a level track against the force exerted by the compressed spring.



When the trains are released, R moves to the right at a speed of 3.8 m/s. The spring takes 0.25 s to uncoil to its natural length. Calculate:

a) the velocity of train T; (6.13 m/s left)

b) the average force exerted by the spring on each train. (7.6 N)

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)

11. When a stationary uranium nucleus undergoes fission, it breaks into two unequal chunks that fly apart. What can you conclude about the momentum of each chunk? What can you conclude about the speed of each chunk?

(ans: the momentum of each chunk must be the same, since the initial momentum of the nucleus was zero, but the speeds will be different, since each chunk has a different mass)

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 μ=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;)

13. A 5.00 kg mass is launched upwards at 8.00 m/s. It hits and sticks to a stationary 4.00 kg block which is held 2.00 m above the ground

a) how fast is the 5 kg mass moving just before the impact? (4.98 m/s)

b) how fast are the two masses moving together after the crash? (2.77 m/s)

c) how high does the combined mass go? (0.39 m higher; 2.39m in total)