Lesson 5 More C of M Solutions

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Lesson 5 Homework:

1. A 50 kg object initially traveling at 30 m/s North is decelerated to 10 m/s North during a time interval of 5 ms (milliseconds). $t = 5 \times 10^{-3}$ s $= .005$ s

a) What is the initial linear momentum of the object? $\vec{p}_i = m\vec{v}_i = 50(30) = 1500$ kg m/s @ N

b) What is final momentum of the object? $\vec{p}_f = m\vec{v}_f = 50(10) = 500$ kg m/s @ N

c) What is the impulse exerted on the object?

$\Delta\vec{p} = \vec{p}_f - \vec{p}_i = 500 - 1500 = -1000$ kg m/s or 1000 kg m/s @ South

d) What is the average force exerted on the object?

$\Delta\vec{p} = Ft \rightarrow \vec{F} = \frac{\Delta\vec{p}}{t} = \frac{1000}{.005} = 200{,}000$ N @ South

e) If the deceleration had occurred over a time interval of 5 sec, what would be the average force exerted on the object?

$\vec{F} = \frac{\Delta\vec{p}}{t} = \frac{1000}{5} = 200$ N @ South

f) How far does the object travel during the 5 ms deceleration?

$d = ?$ $t = .005$ $v_i = 30$ $v_f = 10$

$d = \frac{(v_i + v_f)}{2} t = \frac{(30 + 10)(.005)}{2} = \boxed{0.10 \text{ m}}$

2. An 100 (A) kg object traveling at 50 m/s collides inelastically with a 25 (B) kg object initially at rest. What is the speed of the objects following the collision?

(40. m/s)

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

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

$\vec{v}_f = \frac{m_A v_{Ai}}{m_A + m_B} = \frac{100(50)}{100 + 25} = 40.$ m/s

3. A metal sphere with a mass of ~~95~~ g (A: .095 kg) rolls along a frictionless surface at + 20.0 m/s due north and strikes a stationary sphere having a mass of ~~300~~ g (B = .3 kg). The first sphere stops completely. At what velocity (**magnitude and direction**) does the second sphere move away after impact?

(6.33 m/s North)

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

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

$$\vec{v}_{B_f} = \frac{m_A \vec{v}_{A_i}}{m_B} = \frac{.095(20)}{.3} = {}^{+}6.33 \text{ m/s @ North}$$

A = .025 kg

4. An arrow of mass ~~25~~ g traveling at 80.0 m/s due south is shot into a stationary target hanging from a rope. The target has a mass of 2.4 kg and the arrow sticks into the target. (a) Is this collision elastic or inelastic? (b) Calculate the velocity (**magnitude and direction**) of the target with the arrow immediately after the arrow strikes. (ans: inelastic, 0.825 m/s South)

a) inelastic

b) $\Sigma \vec{p}_i = \Sigma \vec{p}_f \rightarrow m_A \vec{v}_{A_i} = (m_A + m_B)\vec{v}_f$

$$v_f = \frac{m_A v_{A_i}}{m_A + m_B} = \frac{(.025)(80)}{.025 + 2.4} = 0.825 \text{ m/s @ South}$$

A = .045 kg

5. An arrow of mass ~~45~~ g traveling north is shot into a target hanging from a rope. The target has a mass of 1.2 kg and the arrow sticks into the target. After the impact, both masses move off due north at 5.6 m/s. Calculate the incoming velocity (**magnitude and direction**) of the arrow before impact. (155 m/s north)

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

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

$$\vec{v}_{A_i} = \frac{(m_A + m_B)\vec{v}_f}{m_A} = \frac{(.045 + 1.2)(5.6)}{.045} = 155 \text{ m/s @ North}$$

6. A 2.50 kg ball moving at 7.50 m/s is caught by a 70.0 kg man while the man is standing on ice. How fast will the man / ball combination be moving after the ball is caught by the man? (0.26 m/s)

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

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

$$\vec{v}_f = \frac{m_A v_{A_i}}{m_A + m_B} = \frac{2.5(7.5)}{2.5+70} = 0.259 \text{ m/s}$$

7. A 1200 kg car traveling North at 20.0 m/s collides with a 1400 kg car traveling South at 22.0 m/s. The two cars collide and entangle. What is the resulting velocity of the wreckage? (2.6 m/s South)

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

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

$$v_f = \frac{m_A \vec{v}_{A_i} + m_B \vec{v}_{B_i}}{m_A + m_B} = \frac{(1200)(20) + 1400(-22)}{1200 + 1400} = 2.6 \text{ m/s @ South}$$

8. A 5.00 kg ball hits a 75.0 kg man standing at rest on ice. The man catches the ball. How fast does the ball need to be moving in order to send the man off at a speed of 3.00 m/s? (48 m/s)

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

$$\vec{v}_{A_i} = \frac{(m_A + m_B)\vec{v}_f}{m_A} = \frac{(5+75)(3)}{5} = 48 \text{ m/s}$$

9. A 1.50 x 10^3 kg car traveling at 39 m/s South collides with a 1.20 x 10^3 kg car traveling North at 10 m/s. The heavier car continues to move South after the collision, but slows to 15 m/s. How fast is the lighter car moving after the collision? (20 m/s South)

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

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

$$\vec{v}_{B_f} = \frac{m_A \vec{v}_{A_i} + m_B \vec{v}_{B_i} - m_A \vec{v}_{A_f}}{m_B} = \frac{(1500)(-39) + (1200)(10) - 1500(-15)}{1200}$$

$$\boxed{\vec{v}_{B_f} = -20 \text{ m/s @ South}}$$

10. A 109 kg running back is trying to score a touchdown. Just before the goal line he is moving South at 8.5 m/s. He collides head-on and sticks together with a 159 kg defensive player moving towards him at 5.9 m/s North.

a) Will the running back score a touchdown? Justify your answer with calculations. (Ans: No, the running back won't score --his final velocity is 0.043 m/s backwards)

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

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

$$v_f = \frac{m_A \vec{v}_{A_i} + m_B v_{B_i}}{(m_A + m_B)} = \frac{(109)(-8.5) + 159(5.9)}{109 + 159} = .043 \text{ m/s North}$$

No, the running back doesn't score, since he got pushed backwards.

b) How fast (magnitude and direction) does the running back's initial velocity need to be if he wants to keep moving forwards after the collision with a velocity of 0.20 m/s South? (ans: 9.1 m/s South)

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

$$v_{A_i} = \frac{(m_A + m_B)\vec{v}_f - m_B \vec{v}_{B_i}}{m_A} = \frac{(109+159)(-.2) - 159(5.9)}{109}$$

$$\vec{v}_{A_i} = -9.1 \text{ m/s} = \boxed{9.1 \text{ m/s @ South}}$$