ABRHS PHYSICS (H) NAME: KEY

1D Momentum Problems

1. A 1.5 kg gun can fire a 0.005 kg bullet with a speed of 500 m/s. What is the "recoil speed" of the gun?

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

$m_1 = 1.5$ kg

$m_2 = 0.005$ kg

$v_{1i} = v_{2i} = 0$ m/s

$v_{2f} = 500$ m/s

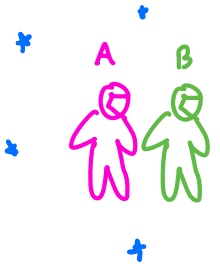
$0 = m_1 v_{1f} + m_2 v_{2f}$

$0 = (1.5) v_{1f} + (.005)(500)$

$v_{1f} = -1.67$ m/s

oops! so speed is 1.67 m/s!

2. Two astronauts are floating in space. One of them pushes the other, sending astronaut A to the left at 0.5 m/s and astronaut B to the right at 0.75 m/s. What is the ratio of their masses?



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

$0 = m_A(-0.5) + m_B(0.75)$

$\frac{m_A}{m_B} = 1.5$ (so ratio is $\frac{m_A}{m_B} = \frac{3}{2}$)

3. A 70 kg person is at rest in a 40 kg canoe by a dock. In a horrible attempt to get out of the canoe, the person tries to jump forward, sending the canoe backward. If the relative speed of the person with respect to the canoe is 4 m/s, what is the speed of the person with respect to the dock?

$m_p = 70$ kg

$m_c = 40$ kg

Dock Reference Frame:

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

$0 = (70)v_{pd} + (40)v_{cd}$

$0 = 70v_{pd} + 40(v_{pd} - 4)$

$0 = 70v_{pd} + 40v_{pd} - 160$

$110 v_{pd} = 160$

$v_{pd} = 1.46$ m/s

could have said $v_{cp} = -4$ m/s

$v_{pc} = 4$ m/s

pay attention!

& $v_{pc} = v_{pd} + v_{dc}$

$4 = v_{pd} - v_{cd} \rightarrow v_{cd} = v_{pd} - 4$

4. A 7 kg object is sliding along a frictionless surface with an initial velocity of 5 m/s. For some reason, it explodes into 2 pieces. A 4 kg piece of it is now only sliding with a velocity of 3 m/s. What is the velocity of the other piece after the explosion?

initial: 7 kg → 5 m/s

final: 4 kg → 3 m/s; 3 kg → v = ?

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

$(7)(5) = (4)(3) + (3)v$

$35 = 12 + 3v$

$3v = 23$

$v = 7.67$ m/s

1D Momentum Problems

5. A 1500 kg car rear-ends a 2000 kg car at a stop sign. Immediately after the collision, the two cars have a speed of 13 m/s. (They then skid to a stop, but that is not part of this problem.) How fast was the 1500 kg car moving just before the collision?

$m_1 = 1500$ kg
$m_2 = 2000$ kg
$v_{1f} = v_{2f} = 13$ m/s
$v_{2i} = 0$ m/s

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

$(1500)v_{1i} = (1500)(13) + (2000)(13) = 45{,}500$

$v_{1i} = 30.3$ m/s

6. Maya and Miguel are on the bumper cars and have a head-on collision. Maya (total mass 300 kg) is traveling to the right at 5 m/s. Miguel (250 kg) is traveling to the left at 3 m/s. After the collision, Maya is only traveling at 1 m/s, but still to the right. What is the final velocity of Miguel?

$m_1 = 300$ kg
$v_{1i} = 5$ m/s
$m_2 = 250$ kg
$v_{2i} = -3$ m/s
$v_{1f} = 1$ m/s

$\Sigma p_i = \Sigma p_f$

$(300)(5) + (250)(-3) = (300)(1) + 250v_{2f}$

$750 = 300 + 250v_{2f}$

$v_{2f} = 1.8$ m/s

7. A stream of 40 gram bullets, fired horizontally with a speed of 1000 meters per second, strikes a 10 kg wooden block that is free to move on a horizontal frictionless tabletop. What is the speed of the block after it has absorbed 15 bullets?

$m_1 = .04$ kg
$v_{1i} = 1000$ m/s
$m_2 = 10$ kg

bullets stuck in wood

$\Sigma p_i = \Sigma p_f$

$15(.04)(1000) = [10 + (15)(.04)]v_f$

15 bullets

$600 = (10.6)v_f$

$v_f = 56.6$ m/s

8. A 0.5 kg ball is traveling with a speed of 7 m/s when it collides with a 0.4 kg ball traveling in the opposite direction with a speed of 3 m/s. After the collision, the first ball (0.5 kg) is traveling with a speed of 1 m/s, in the same direction that it was before.
   a. What is the speed and direction of the second ball after the collision?

$m_1 = 0.5$ kg
$v_{1i} = 7$ m/s
$m_2 = 0.4$ kg
$v_{2i} = -3$ m/s
$v_{1f} = 1$ m/s

$\Sigma p_i = \Sigma p_f$

$(.5)(7) + (.4)(-3) = (.5)(1) + (.4)v_{2f}$

$3.5 - 1.2 = .5 + .4v_{2f}$

$.4v_{2f} = 1.8$

$v_{2f} = 4.5$ m/s

1D Momentum Problems

b. Which ball experienced the greater change in momentum? change in velocity? impulse?

$|\Delta p|$ must be the same! The smaller mass will have greater Δv

$|J|$ must be the same!

c. If the collision lasted for 0.25 seconds, what was the force on the second ball?

$m_2 = 0.4$ kg
$v_{2i} = -3$ m/s
$v_{2f} = 4.5$ m/s

Find Δp first:

$\Delta \vec{p} = m_2 v_{2f} - m_2 v_{2i}$
$= (.4)(4.5) - (.4)(-3)$
$\Delta \vec{p} = 3.0$

So $J = Ft$ & $J = \Delta p$

$3.0 = \bar{F}(.25)$

$\bar{F} = 12$ N

9. A ball of mass 0.25 kg has a one-dimensional elastic collision with a ball of mass 0.35 kg. After the collision the smaller ball has a velocity of 6.5 m/s and the larger ball has a velocity of 9 m/s. What was the velocity of each ball before the collision?

You can either use the blobs or start with conservation of p & K.

$m_1 = 0.25$ kg
$v_{1i} = ?$
$v_{1f} = 6.5$ m/s

$m_2 = 0.35$ kg
$v_{2i} = ?$
$v_{2f} = 9$ m/s

$$v_{1f} = \frac{m_1 - m_2}{m_1 + m_2} v_{1i} + \frac{2m_2}{m_1 + m_2} v_{2i}$$

$$6.5 = \frac{(.25 - .35)}{.25 + .35} v_{1i} + \frac{2(.35)}{.25 + .35} v_{2i}$$

$3.9 = -.1 v_{1i} + .7 v_{2i}$

$$v_{2f} = \frac{2m_1}{m_1 + m_2} v_{1i} + \frac{m_2 - m_1}{m_1 + m_2} v_{2i}$$

$$9 = \frac{2(.25)}{.6} v_{1i} + \frac{.35 - .25}{.6} v_{2i}$$

$5.4 = .5 v_{1i} + .1 v_{2i}$

$\times 5 \rightarrow 19.5 = -.5 v_{1i} + 3.5 v_{2i}$

add together

$24.9 = 0 + 3.6 v_{2i}$

$v_{2i} = 6.92$ m/s

So $3.9 = -.1 v_{1i} + .7(6.92)$

$-.1 v_{1i} = -.942$

$v_{1i} = 9.42$ m/s

Answers:

1. 1.7 m/s *2. A:B = 3:2* *3. 1.46 m/s* *4. 7.7 m/s* *5. a) 30.3 m/s*

6) 1.8 m/s *7) 56.6 m/s* *8. a) 4.5 m/s* *b) same, 0.4 kg, same* *c) (-) 12 N*

9) 9.5 & 6.9 m/s