Momentum Unit: Review Solutions

Answer the questions to the best of your ability in the spaces provided on the question sheets. If you run out of room for an answer, continue on the back of the page.

Name and section: _____

Date: _____

1. (5 points) If the statement is false, change the statement to make it true.

   (a) **True** **False** If a bigger football player and a smaller football player were to have the same momentum, the larger player must be going ~~faster~~ **slower** than the smaller player.
   False

   (b) **True** **False** A helmet works by increasing the amount of time that the "melon" is in an impact and therefore decreasing the force of the impact.
   True

   (c) **True** **False** Newton's cradle is an example of a ~~in~~elastic collision.
   False

   (d) **True** **False** Given a system of two equal mass, if one of the masses is initially in motion and the masses collide inelastically, the final velocity will be ~~the same as~~ **half** the initial velocity of the moving mass.
   False

   (e) **True** **False** I **REALLY** would like a mark for this question.
   False

2. (5 points) Multiple choice. Pick the best answer.

   (a) A 5 kg object is accelerating uniformly with 0.5 m/s^2 from rest for 10 s. Find the change of momentum of the object.
   √ **25 kg m/s** ◯ 32 kg m/s ◯ 30 kg m/s ◯ 18 kg m/s

   (b) Which of the following quantity represent(s) the unit of momentum?

   1. N /m
   2. N s
   3. N/s
   4. kg m/s

   ◯ (1) and (2) √ **(2) and (4)** ◯ (1) and (3) ◯ none of the above

(c) Which statement is CORRECT?

1. The impulse equation results from Newton's 1st law.
2. Conservation of momentum is a result of Newton's 3rd Law
3. In an elastic collision, the masses will be stuck together after the collision

◯ Only (1) √ **Only (2)** ◯ Only (3) ◯ All options are correct.

(d) Which of the following is/are CORRECT for an inelastic collision?

1. Two identical masses are moving towards each other at the same speed and are having a head on collision. After collision, the two masses will stick together and become stationary according to the conservation of momentum.
2. Two identical masses A and B, A is moving with uniform velocity **u** and B is stationary. After the collision, A will become stationary while B will move with uniform velocity **u** because of the conservation of momentum.
3. Two identical masses A and B, A is moving with uniform velocity **u** and B is moving with -0.5 **u**. After the collision, A and B stick together and move with **u** because of conservation of momentum.

√ **(1) only** ◯ (2) only ◯ (3) only ◯ (1) and (3) only

(e) In a car accident, car A of 1 000 kg is hit by car B of 1 580 kg. Car A is initially at rest. From the tire tracks on the road, police found that the speed of car A and B after the collision is 10 m/s and 8 m/s respectively. Find the speed of car B before the collision. (Assume it is valid to use conservation of momentum here.)

◯ 16.97 m/s √ **14.32 m/s** ◯ 20.58 m/s ◯ 26.44 m/s

Long Answer Remember to box your final answer in each question. Show all of your work for full marks. No marks will be given for answers only.

Momentum and Impulse

3. (2 points) What is the momentum of a 3 kg object moving at 5 m/s?

Solution:

$$\begin{aligned}\mathbf{p} &= m\mathbf{v} \\ &= (3\text{kg})(5\text{m/s}) \\ &= 15\text{kg m/s}\end{aligned}$$

The momentum is 20 kg m/s (sig figs)

4. (3 points) What is the change in momentum of a 33 kg object accelerating from 30 m/s to 12 m/s?

Solution:

$$\begin{aligned}\Delta\mathbf{p} &= m\Delta\mathbf{v} \\ &= m(\mathbf{v}_f - \mathbf{v}_i) \\ &= (33\text{kg})(12\text{m/s} - 30\text{m/s}) \\ &= -600\text{kg m/s}\end{aligned}$$

The change in momentum is -600 kg m/s

5. (3 points) How much force is exerted on a 4 kg object accelerating from 10 m/s to 12 m/s in 2.5 seconds?

Solution:

$$\begin{aligned}\mathbf{F}_{net}\Delta t &= m\Delta\mathbf{v} \\ \mathbf{F}_{net} &= \frac{m(\mathbf{v}_f - \mathbf{v}_i)}{\Delta t} \\ &= \frac{4\text{kg}(12\text{m/s} - 10\text{m/s})}{2.5\text{s}} \\ &= 3\text{N}\end{aligned}$$

The force is 3N.

6. (3 points) How much time is needed to accelerate a 13 kg object from 20 m/s to 12 m/s if there is a force of -2.5 N?

Solution:

$$\begin{aligned}\mathbf{F}_{net}\Delta t &= m\Delta\mathbf{v} \\ \Delta t &= \frac{m(\mathbf{v}_f - \mathbf{v}_i)}{\mathbf{F}_{net}} \\ &= \frac{15\text{kg}(12\text{m/s} - 20\text{m/s})}{-2.5\text{N}} \\ &= 42\text{s}\end{aligned}$$

The time needed is 42 s.

Conservation of Momentum

7. (5 points) A hockey puck mass with 0.17 kg, moving at 35.0 m/s, strikes a rubber octopus thrown on the ice by a fan. The octopus has a mass of 0.265 kg and is initially at rest. The puck and octopus slide off together. Find their velocity.

Solution: Let m_1 be the hockey puck and m_2 be the octopus.

$$\begin{aligned} m_1\mathbf{v}_{1,i} + \cancel{m_2\mathbf{v}_{2,i}} &= (m_1 + m_2)\mathbf{v}_f \\ \mathbf{v}_f &= \frac{m_1\mathbf{v}_{1,i}}{(m_1 + m_2)} \\ &= \frac{(0.17\text{kg})(35.0\text{m/s})}{(0.17\text{kg} + 0.265\text{kg})} \\ &= 14\text{m/s} \end{aligned}$$

The final velocity is 14 m/s

8. (5 points) A 50.0 kg woman, riding on a 10.0 kg cart, is moving east at 5.0 m/s. The woman jumps off the cart and hits the ground at 7.0 m/s eastward, relative to the ground. Calculate the velocity of the cart after she jumps off.

Solution: Let m_1 be the woman and m_2 be the cart.

$$\begin{aligned} (m_1 + m_2)\mathbf{v}_i &= m_1\mathbf{v}_{1,f} + m_2\mathbf{v}_{2,f} \\ \mathbf{v}_{2,f} &= \frac{(m_1 + m_2)\mathbf{v}_{1,i} - m_1\mathbf{v}_{1,f}}{m_2} \\ &= \frac{(50.0\text{kg} + 10.0\text{kg})(5.0\text{m/s}) - (50.0\text{kg})(7.0\text{m/s})}{10.0\text{kg}} \\ &= -5.0\text{m/s} \end{aligned}$$

The final velocity of the cart is -5.0 m/s

9. (5 points) Two students on roller skates stand face-to-face then push each other away. One student has a mass of 90.0 kg, the other 60.0 kg. If the lighter student has a velocity of 2 m/s just after their hands lose contact, find the velocity of the other student.

Solution: Let m_1 be the lighter student and m_2 be the other student.

$$\begin{aligned}
\cancel{(m_1 + m_2)\mathbf{v}_i} &= m_1\mathbf{v}_{1,f} + m_2\mathbf{v}_{2,f} \\
\mathbf{v}_{2,f} &= -\frac{m_1\mathbf{v}_{1,f}}{m_2} \\
&= -\frac{(60.0\text{kg})(2\text{m/s})}{90.0\text{kg}} \\
&= -1\text{m/s}
\end{aligned}$$

The final velocity of the other student is -1 m/s

10. (5 points) A 4 kg medicine ball is thrown at 15 m/s east and hits a 55 kg boy who is on his stationary skateboard. If the medicine ball bounces off the boy with a speed of 4 m/s west, how fast will the boy and skateboard be going after the collision?

Solution: Let m_1 be the ball and m_2 be the boy and skateboard.

$$\begin{aligned}
m_1\mathbf{v}_{1,i} + \cancel{m_2\mathbf{v}_{2,i}} &= m_1\mathbf{v}_{1,f} + m_2\mathbf{v}_{2,f} \\
\mathbf{v}_{2,f} &= \frac{m_1\mathbf{v}_{1,i} - m_1\mathbf{v}_{1,f}}{m_2} \\
&= \frac{(m_1(\mathbf{v}_{1,i} - \mathbf{v}_{1,f})}{m_2} \\
&= -\frac{(4\text{kg})\left[15\text{m/s} - (-4\text{m/s})\right]}{55\text{kg}} \\
&= 1\text{m/s}
\end{aligned}$$

The final velocity of the boy and skateboard is 1 m/s [east]

Question	Points	Score
1	5	
2	5	
3	2	
4	3	
5	3	
6	3	
7	5	
8	5	
9	5	
10	5	
Total:	41	