Chapter 4 Worksheet

Part1: sentence completion

1. Impulse is ___**Force**_____ times __**time**___
2. Momentum is ____**mass**__ __ times __**velocity**__.
3. More inertia implies more__ **mass**___.
4. __**Impulse**__ equals change of momentum.
5. Energy __**before** __equals energy __**after**__. This is the law of __ **conservation of energy**__.
6. Momentum__ **before**__ equals momentum__ **after**__. This is the law of__ **conservation of momentum_.**

Part2: Multiple choices

1. Impulse is **(D)**
   A. A force applied to an object.
   B. The initial force applied to an object.
   C. The initial momentum applied to an object
   D. The change in momentum due to a force being applied to an object during a short period of time.

2. Momentum is **(B)**
   A. Equal to speed times weight.
   B. Equal to mass times velocity.
   C. Another alternative name to force
   D. All of the above is correct.

3. What is the metric (SI) unit of momentum? **(A)**
   A. Kg. m/s.
   B. Newton.
   C. Kg m/s^2
   D. Newton. meter

4. Which of the following statement is correctly expressing the conservation of total momentum of interacting objects? **(C)**
   A. The total momentum always remains the same.
   B. The total momentum remains the same if there are no internal forces.
   C. The total momentum remains the same if there are no external forces.
   D. No one of the above is correct.

5. A 2000 kg car is moving to the right at 30m/sec and collided with a wall and comes to rest at 0.2 sec. The average force the car exerts on the wall is **(D)**
   A. 1.2×10^4 N to the right
   B. 3×10^5 N to the left

C. 6×10^4 N to the right
D. None of the above

6. A 3kg object moves to the right with a speed of 4 m/sec. It collides in a perfectly elastic collision with a 6kg object moving to the left at 2m/sec. What is the total kinetic energy after the collision?**(A)**
A. 72 J
B. 36 J
C. 24 J
D. 0 J

7. How long must a 100 N force act to produce a change in momentum 200 kg.m/sec? **(D)**
A. 0.25 sec
B. 0.50 sec
C. 1.0 sec
D. 2.0 sec

8. Which is a vector quantity? **(D)**
A. Energy
B. Work
C. Power
D. Momentum

9. When the velocity of an object is doubled, its ____________ is also doubled **(C)**
A. Gravitational potential energy
B. Acceleration
C. Momentum
D. Kinetic energy

10. Impulse is related to **(D)**
A. Kinetic energy
B. Change in kinetic energy
C. Momentum
D. Change in momentum

Part 3: True of false

1. The impulse is always in the same directions as the average force. **(A)**
A. True
B. False

2. The momentum of an object remains the same when the net external force acting on it is zero. **(A)**
A. True
B. False

3. If the kinetic energy of an object is zero, then its momentum must not be zero. **(B)**
A. True
B. False

4. A large force always produces a larger impulse on a body than a smaller force. **(B)**
A. True
B. False

5. The kinetic energy is always conserved both in elastic collisions and inelastic collisions. **(B)**
   A. True
   B. False
6. If two particles of different masses have equal kinetic energy they also have equal momentum. **(B)**

   A. True
   B. False

Part3: Exercises

1. An average force of 250 N acts on a ball for 0.05 sec. (a) what is the magnitude of the impulse on the ball? (b) What is the change in the ball's momentum?

   Solution

   $$(a) \because\ J = F \times t \Rightarrow \therefore\ J = (250N) \times (0.05\,\text{sec}) = 12.5N.\text{sec}$$
   $$(b) \because\ J = \Delta p \Rightarrow \therefore\ \Delta p = 12.5\ kg.m/\text{sec}$$

2. What is the momentum of 2000 kg truck traveling with 25m/sec?

   Solution

   $$\because\ p = m \times v \Rightarrow \therefore\ p = (2000kg) \times (25ml\,\text{sec}) = 50{,}000\,kg.m/\text{sec}$$

3. A football of mass 1.5 kg and a speed of 2 m/sec and ping pong ball of mass 0.003kg and a speed of 4 m/sec. Which ball has the larger momentum?

   Solution

   $$\because\ p = m \times v \Rightarrow \therefore\ p(\,football\,) = (1.5kg) \times (2m/\text{sec}) = 3.0kg.m/\text{sec}$$
   $$p(\,ping\ pong) = (0.003kg) \times (4m/\text{sec}) = 0.012kg.m/\text{sec}$$
   $$\therefore\ p(\,footbal\,) > p(\,ping\ pong)$$

4. A force of 100N acts on a ball initially at rest for 0.05 sec. (a) what is the impulse on the ball? (b) What is the final momentum of the ball?

Solution

Note: I forgot to add a value to the force in the initial problem. I correct it and add 1000N

$(a)\ \because J = F \times t \Rightarrow \therefore J = (1000N)\times(0.05\sec) = 50N.\sec$

$(b)\ \because J = \Delta p \Rightarrow \therefore\ p_f - p_i = p_f - 0 = J\ or\ p_f = 50kg.m/\sec$

5. A father ice skater with a mass of 80kg pushes off against his child ice skater whose mass is 45kg. Both skaters were initially at rest. (a) What is the total momentum of both skaters after they push off? (b) If the father skater moves off with speed of 1.5 m/sec, what is the speed of the child?

Solution

(a) Assuming external forces (friction) is zero, therefore the momentum of both father and son is conserved meaning: $p_{before} = p_{father} + p_{son} = p_{after} = (p_{father} + p_{son})$

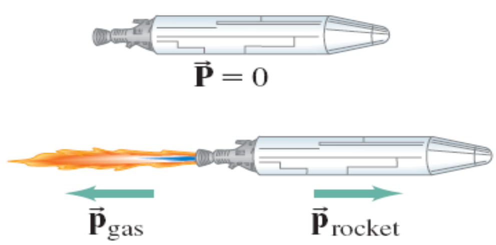
$\because p_{before} = 0 \Rightarrow \therefore\ p_{after} = 0\ also,\ or\ p_{father} + p_{son} = 0 \Rightarrow p_{father} = -p_{son}$

This means that father and son will move with same momentum, but at different directions

(b) $p_{father} = (80kg)\times(1.5m/\sec) = 120kg.m/\sec$

$\therefore\ p_{son} = -120kg.m/\sec$

6. A rocket ship, shown in the drawing below, at rest in space gives a short blast of its engine, firing 50kg of exhaust gas out the back end with an average velocity of 200 m/sec. What is the change in momentum of the rocket during this blast?



Solution

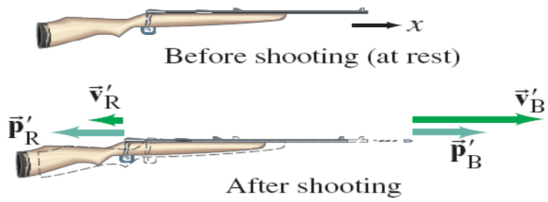
In outer space there is no friction, therefore momentum is conserved.

$\because\ p_{initial} = 0\ \ \therefore\ p_{final} = 0$

$p_{final} = p_{gas} + p_{rocket} = 0\ or \Rightarrow\ p_{gas} = -p_{rocket},\ \Rightarrow\ p_{gas} = (50kg)\times(200m/\sec) = 10{,}000kg.m/\sec$

$\therefore p_{rocket} = -10{,}000kg.m/\sec\ \Rightarrow \Delta p_{rocket} = p_{final} - p_{initial} = p_{final} - 0 = -10{,}000kg.m/\sec$

7. A rifle and a bullet shown in the drawing below. The rifle of mass 1.5 kg fires a bullet of 5g mass. The bullet moves with muzzle velocity v'_B = 500m/sec. (a) what is the momentum of the fired bullet? (b) If the external forces acting on the rifle are ignored, what is its recoil velocity after firing the bullet?



Solution

Momentum is conserved, therefore

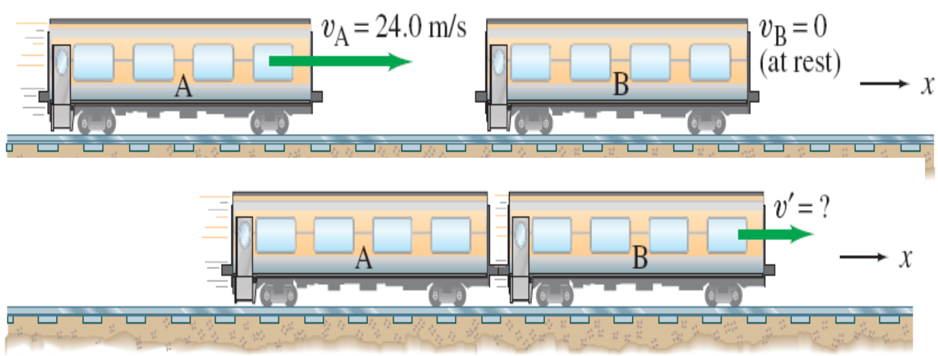
$$(a)\ \ p_{initial} = p_{final},\ or\ \ (p_{bullet} + p_{rifle})_{initial} = (p_{bullet} + p_{rifle})\ \Rightarrow\ 0 = (p_{bullet} + p_{rofle})_{after}$$

$$\therefore\ \ p_{bullet} = -p_{rifle}\ \ \ after\ \ \ firing$$

$$\therefore\ \ p_{bullet} = (0.005kg)\times(500m/\sec) = 2.5kg.m/\sec$$

$$(b)\ \ p_{rifle} = 2.5kg.m/\sec = (1.5kg)\times(v_R^{'})\ \Rightarrow \therefore\ \ v_R^{'} = 1.7m/\sec$$

8. Consider the collision of train cars shown below as a perfectly inelastic collision. Find the velocity of the coupled cars after collision. Assume a 10,000 kg mass of each car



Solution

Because the collision is inelastic, therefore the total momentum is conserved, but the total KE is not.

$$p_{initial} = p_{final}\ \Rightarrow\ (p_A + p_B)_{initial} = (10{,}000kg)(24m/\sec) + 0 = 24{,}0000kg.m/\sec$$

$$p_{final} = (m_1 + m_2)\times v' = (2\times 10{,}000kg)\times v' = 24{,}0000kg.m/\sec$$

$$\therefore v' = \frac{24{,}0000kg.m/\sec}{20{,}000kg} = 12m/\sec$$

Part4: Challenge exercises

1. A bullet is fired into a block of wood sitting on a block of ice. The bullet has an initial velocity of 350m/sec and a mass of 50g. The wooden block has a mass of 2 kg and is initially ate rest. The bullet remains inside the wooden block after collision. (a) Assuming the momentum is conserved; find the velocity of wood and bullet after the collision. (b) What is the magnitude of the impulse that acts on the block of wood?

Solution

Friction between block and ice is ignored, therefore, momentum is conserved. This is an example of completely inelastic

$$p_{initial} = p_{final} \quad \Rightarrow \therefore \; p_{bullet} + p_{wood} = (m_{bullet} + m_{wood})V$$

$$(0.050kg)(350m/\sec) + 0 = (0.050kg + 2kg)V \Rightarrow V = \frac{17.5kg.m/\sec}{2.05kg} = 8.54m/\sec$$

2. A 2000 kg car is traveling north with speed of 30 m/sec collides head on with a 4000kg truck traveling south with speed of 20 m/sec. The car and truck stick together after the collision.

(a) What is the total momentum of the system of car and truck before collision?
(b) What is the velocity of both just after the collision?
(c) What is the total kinetic energies of the system before collision?
(d) What is the total kinetic energies just after the collision?
(e) Is the collision elastic or inelastic? Explain

Solution

This kind of collision is completely inelastic. Momentum is conserved.

$$(a)\; p_{before} = (2000kg)(30m/\sec) + (4000kg)(-20m/\sec) = (60{,}000 - 80{,}000) = -20{,}000kg.m/\sec \; south$$

$$(b)\; p_{fter} = (m_{car} + m_{truck})V = p_{before} = -20{,}000kg.m/\sec \Rightarrow V = \frac{-20{,}000kg.m/\sec}{6000kg} = -3.33m/\sec \; south$$

$$(c)\; KE_{before} = \frac{1}{2}m_{car}v_{car}^2 + \frac{1}{2}m_{truck}v_{truck}^2 = \frac{1}{2}(2000kg)(900m^2/\sec^2) + \frac{1}{2}(4000kg)(400m^2/\sec^2)$$

$$\therefore KE_{before} = 1.7\times10^6\,Joule$$

$$(d)\; KE_{after} = \frac{1}{2}(m_{car} + m_{truck})V^2 = \frac{1}{2}(6000kg)(-3.33m/\sec)^2 = 3.333\times10^4\,Joule$$

$$(e)\; because \;\; KE_{before} \neq KE_{after} \Rightarrow \therefore \; collision \; is \; not \; elastic$$

Part 5: learning from vision

1. What can you tell from just looking at this drawing?

Solution

Impulse provided by the nail changes the momentum of the hammer.
The hammer has initial momentum and its final momentum equals zero.