Mechanics II – QUESTION BANK 14
Momentum

SOLUTIONS

1. An object of 1200 g is moving with 14 m/s. Find its momentum.

$P = m \cdot V \Rightarrow P = 1200 \cdot 14 = 16800\ kg\frac{m}{s}$

2. What is the unit of momentum? What is the meaning of impulse?

Momentum $\Rightarrow P = mV$

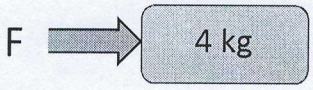
$P = kg\frac{m}{s}$

Impulse : change in momentum $= \Delta p$

Impulse is also calculated by

$Impulse = F \cdot \Delta t$

3. A force of 15 N acts on the object below for 3 seconds. Calculate the impulse caused by the force.

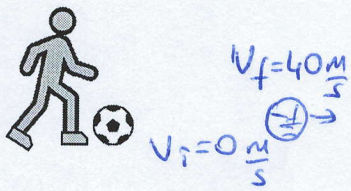


$F = 15\ N \quad \Delta t = 3\ s$

$I = F \cdot \Delta t \Rightarrow$ Impulse $= I = 15\ N \cdot 3\ s = 45\ Ns$

4. A ball 450 g is at rest, when a player kicks the ball it reaches to 40 m/s in 0.6 ms.
   a. Calculate the impulse on the ball.
   b. Calculate the avarage force acting on the ball.

$V_f = 40\ m/s \quad V_i = 0$



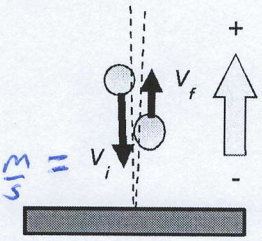
a) Impulse: $F \cdot \Delta t = \Delta p \quad \Delta p = m\Delta V = m(V_f - V_i)$

$\Delta p = 450 \cdot 10^{-3}\ kg\ (40-0)\frac{m}{s} = 18\ kg\frac{m}{s}$

b) $I = F \cdot \Delta t = \Delta p \quad F = \frac{\Delta p}{\Delta t} = \frac{18\ kg\,m/s}{0{,}6 \cdot 10^{-3}\ s} = 30000\ kg\frac{m}{s^2} = 30000\ N = 3 \cdot 10^4\ N$

$\Delta t = 0.6\ ms = 0.6 \times 10^{-3}\ s$

5. A 500 g ball strikes the plate with a speed of 10 m/s and rebounds with a speed of 8 m/s.
   a. What is the initial momentum of the ball?
   b. What is the final momentum of the ball?
   c. Calculate the change in momentum.



$-10\frac{m}{s} = V_i \qquad V_f = +8\frac{m}{s}$

a) $P_i = mV_i \Rightarrow P_i = 500g \cdot (-10\frac{m}{s})$

$= 0{,}5\ kg \cdot (-10\frac{m}{s})$

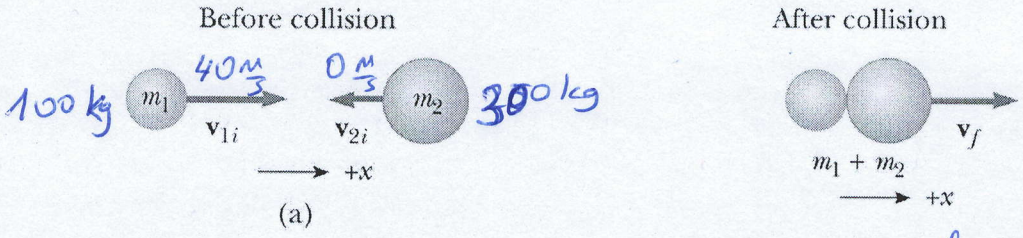
$= -5\ kg\frac{m}{s}$

b) $P_f = mV_f \quad P_f = 500g \cdot (+8\frac{m}{s}) =$

$= 0{,}5\ kg \cdot 8\frac{m}{s} = 4\ kg\frac{m}{s}$

c) $\Delta p = P_f - P_i = 4\ kg\frac{m}{s} - (-5\ kg\frac{m}{s}) = 9\ kg\frac{m}{s}$

6. The mass of the first object is 100 kg and the second object 300 kg. The initial velocity of the first objects is 40 m/s and the second object is 0. After perfectly inelastic collision two objects stick to each other and move together as in the figure below. What is the final velocity of the system?



The total momentum of the system before the collision is equal to the total momentum of the system after the collision.

$$P_{total\ before} = P_{total\ after}$$

$$P_{1i} + P_{2i} = P_{total}$$

$$m_1 v_{1i} + m_2 v_{2i} = (m_1 + m_2) v_f$$

$$100 \cdot 40 + 300 \cdot 0 = (100 + 300) v_f \Rightarrow \frac{4000}{400} = \frac{400 v_f}{400} \quad v_f = 10 \frac{m}{s}$$

$$4000\ kg\frac{m}{s} = 400\ v_f$$

7. The mass of the first object is 50 kg and the second object 200 kg. The initial velocity of the first objects is 40 m/s and the second object is – 20 m/s. These two objects collide elastically.

   a. Calculate the total momentum of the system before collision.
   b. Calculate the total kinetic energy of the system before collision.
   c. What is the momentum of the system after collision?
   d. What is the total kinetic energy of the system after collision?

50 kg 200 kg

a) $P_{total} = P_{1i} + P_{2i} = m_1 v_{1i} + m_2 v_{2i} = 50 \cdot 40 + 200 \cdot (-20)$

$= 2000 - 4000 = -2000 \frac{kg\,m}{s}$

b) $KE_{total} = KE_{1i} + KE_{2i} = \frac{1}{2} m_1 v_{1i}^2 + \frac{1}{2} m_2 v_{2i}^2$

$= \frac{1}{2} 50 \cdot (40)^2 + \frac{1}{2} 200 \cdot (-20)^2 = 25 \cdot (1600) + 100 (400)$

$= 80000\ J = 8 \cdot 10^4\ J$

c) Before and after collision the total momentum is conserved (the same). $P_{total\ initial} = P_{total\ after} = -2000\ kg\frac{m}{s}$

d) For elastic collisions, the kinetic energy is also conserved,

$KE_{total\ initial} = KE_{total\ final} = 8 \cdot 10^4\ J$