Section 1: Introduction to impulse and momentum

Section test

1. The velocity of a particle of mass 5 kg increases from 5 ms^{-1} to 8 ms^{-1}. Find the change in momentum of the particle.

2. A particle of mass 4 kg lies on a smooth horizontal surface. A force of 5 N acts on the particle for 6 seconds. What is its speed after this time?

3. A body of mass 5 kg is moving west with a velocity of 7 ms^{-1}. A force of 10 N acts on the particle for t seconds. After this time the body has a velocity of 13 ms^{-1}, still in a westerly direction. Find the value of t.

4. A body of mass 4 kg, initially at rest on a smooth horizontal surface, is subject to a force of $5\mathbf{i} + 12\mathbf{j}$ N for 2 seconds. Find the final speed of the particle.

5. A body of mass 6 kg is initially moving with a constant velocity of $9\mathbf{i}$ ms^{-1}. A force of $a\mathbf{i}$ N acts on the mass for 9 seconds. After this time the velocity of the mass is $-3\mathbf{i}$ ms^{-1}. Find the value of a.

6. A bullet of mass 25 g is fired from a gun of mass 2.5 kg. The bullet leaves the gun with a speed of 500 ms^{-1}.
   Find the initial recoil speed of the gun.
   Find the increase in the kinetic energy of the system.

7. A particle A of mass 300 g lies at rest on a smooth horizontal surface. A second particle B of mass 200 g is fired at A with a velocity of 6 ms^{-1} and collides with it directly. After the collision B is stationary. What is the velocity of A after the collision?

8. Three balls, A, B and C, are all moving in the same direction along a straight groove. A is moving towards B and B is moving towards C. A and C each have a mass of 500 g and B has a mass of 1 kg. Initially the masses A, B and C are moving with speeds of 7 ms^{-1}, 3 ms^{-1} and 3 ms^{-1} respectively.

   After A has collided with B, B has a speed of 5 ms^{-1} in the same direction as before. Find the speed of A after the collision.

   After B has collided with C, B has a speed of 4 ms^{-1} in the same direction as before. Find the speed of C after this collision.

MEI FM Momentum 1 section test solutions

Solutions to section test

1) Change in momentum $= m(v-u)$
$= 5(8-5)$
$= 15$ Ns

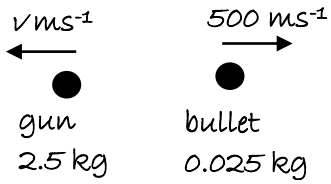
2) Impulse = change in momentum
$Ft = m(v-u)$
$5 \times 6 = 4(v-0)$
$30 = 4v$
$v = 7.5$
The speed after this time is 7.5 ms^{-1}.

3) Impulse = change in momentum
$Ft = m(v-u)$
$10t = 5(13-7)$
$10t = 30$
$t = 3$

4) Impulse = change in momentum
$Ft = m(v-u)$
$2(5\underline{i} + 12\underline{j}) = 4(v-0)$
$v = \frac{1}{2}(5\underline{i} + 12\underline{j})$
$|v| = \frac{1}{2}\sqrt{5^2 + 12^2} = 6.5$
The final speed of the particle is 6.5 ms^{-1}.

5) Impulse = change in momentum
$Ft = m(v-u)$
$a\underline{i} \times 9 = 6(-3\underline{i} - 9\underline{i})$
$9a\underline{i} = -72\underline{i}$
$a = -8$

6) Initially gun and bullet have speed zero.
After firing:



By conservation of momentum: $0 = -2.5v + 0.025 \times 500$

$2.5v = 12.5$

$v = 5$

The recoil speed of the gun is 5 ms^{-1}.

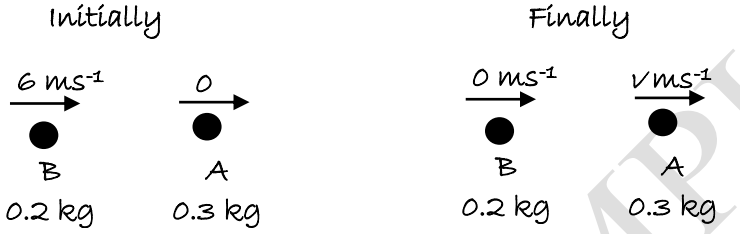
Initial K.E. of system is zero.

K.E. after firing $= \frac{1}{2} \times 2.5 \times 5^2 + \frac{1}{2} \times 0.025 \times 500^2$

$= 3156.25$ J

The increase in kinetic energy = 3156 J (4 s.f.)

7)



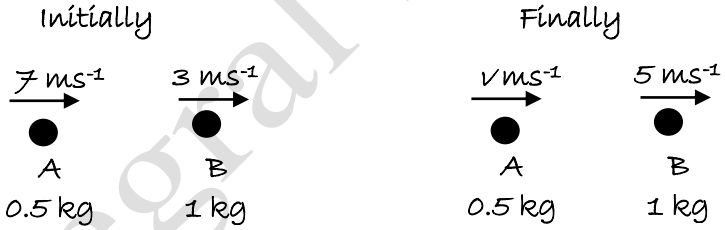
By conservation of momentum: $0.2 \times 6 + 0 = 0 + 0.3v$

$1.2 = 0.3v$

$v = 4$

The velocity of A after the collision is 4 ms^{-1}.

8)



By conservation of momentum:

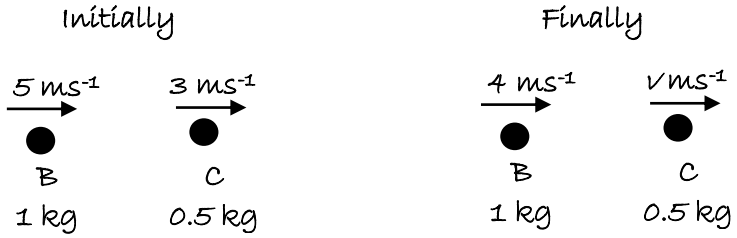
$(0.5 \times 7) + (1 \times 3) = 0.5v + (1 \times 5)$

$3.5 + 3 = 0.5v + 5$

$0.5v = 1.5$

$v = 3$

The speed of A after the collision is 3 ms^{-1}.



MEI FM Momentum 1 section test solutions

By conservation of momentum:

$$(1\times 5)+(0.5\times 3)=(1\times 4)+0.5v$$

$$5+1.5=4+0.5v$$

$$0.5v=2.5$$

$$v=5$$

The speed of C is $5\ \text{ms}^{-1}$.