Momentum

Cambridge International AS & A Level - Mathematics 9709
Paper 4: Mechanics - Exam-style question bank

Original Steps to Conquer practice questions in the style of recent 9709 Paper 4 examinations - not past Cambridge questions. Marks are shown in brackets [ ]. Give non-exact answers to 3 significant figures (1 d.p. for angles) and show full working.

Questions

1 A particle of mass 2 kg moving at 5 m s^{-1} collides with a particle of mass 3 kg moving at 1 m s^{-1} in the same direction. They coalesce. Find their common speed. [4]

2 A particle of mass 1 kg moving at 6 m s^{-1} collides head-on with a particle of mass 2 kg moving at 3 m s^{-1} in the opposite direction. The particles coalesce. Find their common velocity. [4]

3 An object at rest explodes into two parts of masses 4 kg and 2 kg. The 4 kg part moves at 3 m s^{-1} in one direction. Find the velocity of the 2 kg part. [4]

4 A particle of mass 2 kg moving at 5 m s^{-1} collides with a stationary particle of mass 3 kg. After the collision the 2 kg particle moves backwards at 1 m s^{-1}. Find the velocity of the 3 kg particle. [5]

5 A car of mass 1000 kg travelling at 20 m s^{-1} collides with a stationary van of mass 1500 kg. The vehicles coalesce. Find their common speed immediately after the collision. [4]

6 A bullet of mass 0.02 kg moving at 400 m s^{-1} embeds itself in a block of mass 1.98 kg at rest. Find the speed of the block and bullet immediately after impact. [5]

7 A particle of mass 0.5 kg moving at 10 m s^{-1} catches up and coalesces with a particle of mass 0.3 kg moving at 4 m s^{-1} in the same direction. Find the common speed. [5]

8 A particle of mass 4 kg moving at 2 m s^{-1} collides with a particle of mass 1 kg moving at 10 m s^{-1} in the opposite direction. They coalesce. Find their velocity after collision. [5]

9 A particle of mass m kg moving at 6 m s^{-1} coalesces with a stationary particle of mass $2m$ kg. Find the common speed in terms of no unknown constants. [4]

10 Two particles of masses 3 kg and 5 kg move in the same straight line with velocities u m s^{-1} and 2 m s^{-1} respectively. They coalesce and move with speed 5 m s^{-1}. Find u. [4]

Worked solutions

Full methods with final answers. Other valid methods may also earn full marks.

1 Momentum before collision $= 2(5) + 3(1) = 13$.

Combined mass $= 5$ kg.

By conservation of momentum, $5v = 13$.

$v = 2.6$ m s^{-1}.

2 Take the direction of the 1 kg particle as positive.

Initial momentum $= 1(6) + 2(-3) = 0$.

After coalescence, total mass is 3 kg, so $3v = 0$.

$v = 0$.

3 Initial momentum is zero.

Taking the direction of the 4 kg part as positive, $4(3) + 2v = 0$.

$v = -6$ m s^{-1}.

The 2 kg part moves at 6 m s^{-1} in the opposite direction.

4 Initial momentum $= 2(5) = 10$.

Final momentum $= 2(-1) + 3v = -2 + 3v$.

Conservation of momentum gives $10 = -2 + 3v$.

$v = 4$ m s^{-1}.

5 Initial momentum $= 1000(20) = 20000$.

Combined mass $= 2500$ kg.

$2500v = 20000$, so $v = 8$ m s^{-1}.

6 Initial momentum $= 0.02(400) = 8$.

Combined mass $= 0.02 + 1.98 = 2.00$ kg.

$2v = 8$, so $v = 4$ m s^{-1}.

7 Initial momentum $= 0.5(10) + 0.3(4) = 6.2$.

Combined mass $= 0.8$ kg.

$0.8v = 6.2$.

$v = 7.75$ m s^{-1}.

8 Take the direction of the 4 kg particle as positive.

Initial momentum $= 4(2) + 1(-10) = -2$.

Combined mass $= 5$ kg.

$5v = -2$, so $v = -0.4$ m s^{-1}.

They move at 0.4 m s^{-1} in the original direction of the 1 kg particle.

9 Initial momentum $= 6m$.

Combined mass $= 3m$.

$3mv = 6m$, so $v = 2$ m s^{-1}.

10 Conservation of momentum gives $3u + 5(2) = (3 + 5)(5)$.

$3u + 10 = 40$.

$u = 10$ m s^{-1}.