AQA
Realising potential

TOPIC TEST

A-level
FURTHER MATHS

Momentum and Collisions

Version 1.0

Specification content coverage: MB1, MB2, MB3

In this test you will be assessed on:

- the momentum of an object
- conservation of momentum when two objects collide
- use of Newton's experimental law of restitution in direct collisions
- use of Newton's experimental law of restitution in oblique collisions and with fixed smooth surfaces
- impulse as change in momentum
- elastic and inelastic collisions
- understanding of these concepts in both 1D and 2D

The test comprises two sections. The questions in section A will test you on the basics of the topic. Those in section B require a bit more thinking.

Section A: The basics

1 A car of mass 750 kg is travelling at a speed of 15 m s^{-1}.

Find the magnitude of the direct impulse required to bring the car to rest.

[1 mark]

2 An object of mass 2 kg has a velocity of $(2\mathbf{i} + 3\mathbf{j})$ m s^{-1}.

The object receives an impulse of **I** Ns which changes its velocity to $(5\mathbf{i} - 2\mathbf{j})$ m s^{-1}.

Find **I**.

[2 marks]

3 A toy train engine of mass 0.4 kg moves along a straight horizontal track with a speed of 3 m s^{-1}. It collides with a stationary toy carriage of mass 0.1 kg. Immediately after the collision both the engine and carriage couple together and move with speed v.

Find v.

[2 marks]

4 A smooth sphere *A* of mass 4 kg is moving with velocity $(1.5\mathbf{i} + 2\mathbf{j})$ m s^{-1}.

It collides with a smooth sphere *B* of mass 6 kg moving with velocity $(-\mathbf{i} - 4\,\mathbf{j})$ m s^{-1}.

Immediately after the collision sphere *A* moves with velocity $(-3\mathbf{i} - \mathbf{i})$ m s^{-1}.

Find the velocity of sphere *B* immediately after the collision.

[3 marks]

5 A ball *P* of mass 2 kg is moving at 4 m s^{-1}.

It hits another ball *Q* of mass 3 kg which was moving directly towards *P* with speed 1 m s^{-1}.

The coefficient of restitution between *P* and *Q* is 0.5.

Find the speeds of *P* and *Q* immediately after the collision.

[4 marks]

6 (a) A smooth puck of mass 0.25 kg moves across a smooth horizontal surface with a constant speed of 10 m s^{-1}.

The puck hits a vertical wall and rebounds directly with a speed of v m s^{-1}.

The coefficient of restitution between the puck and the wall is $\frac{3}{5}$

State the value of v.

[1 mark]

6 (b) Hence find the magnitude of the impulse that is exerted by the wall on the puck.

[3 marks]

Section B: A bit more thinking

7 (a) Two small spheres *A* and *B* move directly towards each other on a smooth horizontal table.

Sphere *A* has mass m and moves with speed $2u$.

Sphere *B* has mass $2m$ and moves with speed $4\ u$.

The coefficient of restitution between the spheres is e.

Show that the speed of *B* after the collision is $2u(1-e)$ and find the speed of *A*.

[5 marks]

7 (b) In the case when the collision is perfectly elastic find an expression in terms of m and u for the magnitude of the impulse that sphere *A* exerts on sphere *B*.

[3 marks]

8 (a) In this question take the unit vectors **i** and **j** to lie in the horizontal plane of a rectangular snooker table. The unit vector **i** is perpendicular to the smooth edge, *E*, of the table and the unit vector **j** is parallel to *E*.

A snooker ball has mass 0.2 kg and moves across the horizontal snooker table until it collides with the edge *E*.

Immediately before the collision the ball has a velocity of $(6\mathbf{i} + 8\mathbf{j})$ m s^{-1}

The speed of the ball immediately after the collision is $4\sqrt{5}$ m s^{-1}

Find the coefficient of restitution between the ball and *E*.

[5 marks]

8 (b) Find the impulse received by the ball as a result of the collision.

[3 marks]