AQA
Realising potential

TOPIC TEST

AS and A-level FURTHER MATHS

Momentum and collisions

Specification content coverage: MB1, MB2, MB3

In this test you will be assessed on:

- using conservation of momentum for linear motion and where velocities are given as one or two dimensional vectors
- using the coefficient of restitution and Newton's Experimental Law for direct collisions and impacts
- understanding of impulse and its relation to momentum.

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 Particle A of mass 5 kg, is moving with speed 3 m s^{-1}.

It collides directly with particle B of mass 2 kg, which is moving with speed 4 m s^{-1} towards A. After the collision, the particles coalesce.

Find the speed of the combined particle after impact.

Circle the correct answer.

0.4 m s^{-1} 1.0 m s^{-1} 1.4 m s^{-1} 4.6 m s^{-1}

[1 mark]

2 A particle of mass 0.2 kg is moving with velocity $(2\mathbf{i} + 5\mathbf{j})$ m s^{-1} when it strikes a fixed vertical wall. It rebounds with velocity $(-3\mathbf{i} + 7\mathbf{j})$ m s^{-1}.

Find the impulse exerted on the particle by the wall.

[2 marks]

3 A smooth sphere A is travelling along a horizontal surface with speed 6 m s^{-1} when it collides with a smooth sphere B of equal mass, moving towards A with speed 3 m s^{-1}.

After the collision A's direction is unchanged and the speed of A is 1 m s^{-1}.

Find the coefficient of restitution between A and B.

[4 marks]

4 A small smooth ball strikes a smooth vertical wall at right angles. Its kinetic energy after impact is one third of its initial kinetic energy.

Find the coefficient of restitution between the ball and the wall.

[2 marks]

5 Three **perfectly elastic** particles A, B and C with masses 3 kg, 2 kg and 1 kg respectively lie at rest, in a straight line on a horizontal surface with B between A and C.

Particle A is projected with speed 5 m s^{-1} and collides directly with particle B. Then particle B collides with particle C.

5 (a) Find the speeds of A, B and C following the collision with B and C.

[6 marks]

5 (b) Identify whether there will be a third collision.

[1 mark]

Section B: A bit more thinking

6 A force acts on a particle of mass 5 kg for 4 seconds causing it to change velocity from $(2\mathbf{i} - \mathbf{j})$ m s^{-1} to $(5\mathbf{i} - 3\mathbf{j})$ m s^{-1}.

Find the magnitude and direction of the force.

[4 marks]

7 **In this question use g = 10 m s^{-2}.**

A pile driver of mass 1500 kg drops from a height of 2.5 m onto a pile of mass 500 kg, which is lying on the ground.

After the impact, the pile and pile driver move together into the ground. The resistance of the ground is 50 kN.

By modelling the pile and pile driver as a particle, find the distance moved into the ground.

[5 marks]

8 A particle is dropped from a height of 1 m above a smooth horizontal plane. The coefficient of restitution between the particle and the plane is e.

(a) Find, in terms of e, the height reached by the particle following the second impact with the ground.

[4 marks]

8 (b) Show that the total distance travelled by the particle before coming to rest is $\frac{1+e^2}{1-e^2}$

[3 marks]