FM1 Chapter 1 – Momentum and Impulse

Starter Question

Three particles A, B and C are at rest on a smooth horizontal table. The mass of A is 4 kg, the mass of B is 3 kg and the mass of C is 3 kg. The particle A is given an impulse to the right of magnitude 10 N s^{-1}. The particle A moves towards and collides directly with the particle B. Immediately after the collision, the particle A moves to the right at 2 m s^{-1} and the particle B then moves towards the particle C.

(a) Write down the initial speed of the particle A after receiving the impulse. **(1)**

(b) Find the speed of B after its collision with A. **(3)**

After the collision with A, the particle B collides directly with the particle C. Immediately after that collision, the particle C moves with a speed of 1 m s^{-1}.

(c) Calculate the speed and direction of motion of B after its collision with C. **(4)**

(d) Does the particle B collide with the particle A again? Justify your answer. **(2)**

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Bronze Questions

Two particles A and B have mass 0.4 kg and 0.3 kg respectively. They are moving in opposite directions on a smooth horizontal table and collide directly. Immediately before the collision, the speed of A is 6 m s^{-1} and the speed of B is 2 m s^{-1}. As a result of the collision, the direction of motion of B is reversed and its speed immediately after the collision is 3 m s^{-1}. Find

(a) the speed of A immediately after the collision, stating clearly whether the direction of motion of A is changed by the collision,

(4)

(b) the magnitude of the impulse exerted on B in the collision, stating clearly the units in which your answer is given.

(3)

(Total 7 marks)

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A particle P of mass 1.5 kg is moving along a straight horizontal line with speed 3 m s^{-1}. Another particle Q of mass 2.5 kg is moving, in the opposite direction, along the same straight line with speed 4 m s^{-1}. The particles collide. Immediately after the collision the direction of motion of P is reversed and its speed is 2.5 m s^{-1}.

(a) Calculate the speed of Q immediately after the impact.

(3)

(b) State whether or not the direction of motion of Q is changed by the collision.

(1)

(c) Calculate the magnitude of the impulse exerted by Q on P, giving the units of your answer.

(3)
(Total 7 marks)

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Silver Questions

Two small steel balls A and B have mass 0.6 kg and 0.2 kg respectively. They are moving towards each other in opposite directions on a smooth horizontal table when they collide directly. Immediately before the collision, the speed of A is 8 m s^{-1} and the speed of B is 2 m s^{-1}. Immediately after the collision, the direction of motion of A is unchanged and the speed of B is twice the speed of A. Find

(a) the speed of A immediately after the collision,

(5)

(b) the magnitude of the impulse exerted on B in the collision.

(3)
(Total 8 marks)

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A particle A of mass 2 kg is moving along a straight horizontal line with speed 12 m s^{-1}. Another particle B of mass m kg is moving along the same straight line, in the opposite direction to A, with speed 8 m s^{-1}. The particles collide. The direction of motion of A is unchanged by the collision. Immediately after the collision, A is moving with speed 3 m s^{-1} and B is moving with speed 4 m s^{-1}. Find

(a) the magnitude of the impulse exerted by B on A in the collision,

(2)

(b) the value of m.

(4)
(Total 6 marks)

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Gold Questions

A stone S is sliding on ice. The stone is moving along a straight horizontal line ABC, where $AB = 24$ m and $AC = 30$ m. The stone is subject to a constant resistance to motion of magnitude 0.3 N. At A the speed of S is 20 m s^{-1}, and at B the speed of S is 16 m s^{-1}. Calculate

(a) the deceleration of S,

(2)

(b) the speed of S at C.

(3)

(c) Show that the mass of S is 0.1 kg.

(2)

At C, the stone S hits a vertical wall, rebounds from the wall and then slides back along the line CA. The magnitude of the impulse of the wall on S is 2.4 Ns and the stone continues to move against a constant resistance of 0.3 N.

(d) Calculate the time between the instant that S rebounds from the wall and the instant that S comes to rest.

(6)
(Total 13 marks)

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A particle P of mass 2 kg is moving with speed u m s^{-1} in a straight line on a smooth horizontal plane. The particle P collides directly with a particle Q of mass 4 kg which is at rest on the same horizontal plane. Immediately after the collision, P and Q are moving in opposite directions and the speed of P is one-third the speed of Q.

(a) Show that the speed of P immediately after the collision is $\frac{1}{5}u$ m s^{-1}.

(4)

After the collision P continues to move in the same straight line and is brought to rest by a constant resistive force of magnitude 10 N. The distance between the point of collision and the point where P comes to rest is 1.6 m.

(b) Calculate the value of u.

(5)
(Total 9 marks)

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Challenge Question

A tennis ball of mass 0.2 kg is moving with velocity $(-10\mathbf{i})$ m s^{-1} when it is struck by a tennis racket. Immediately after being struck, the ball has velocity $(15\mathbf{i} + 15\mathbf{j})$ m s^{-1}. Find

(a) the magnitude of the impulse exerted by the racket on the ball,

(4)

(b) the angle, to the nearest degree, between the vector **i** and the impulse exerted by the racket,

(2)

(c) the kinetic energy gained by the ball as a result of being struck.

(2)

(Total 8 marks)