

## Lesson 3

### Further A-Level Mathematics, Mechanics 1 Momentum and Impulse

#### 3.1 Examination Questions

#### 3.2 Example

*M1 Exam question, 14th January 2002, Q1*

A ball of mass  $0.3 \text{ kg}$  is moving vertically downwards with speed  $8 \text{ ms}^{-1}$  when it hits the floor which is smooth and horizontal.

It rebounds vertically from the floor with speed  $6 \text{ ms}^{-1}$ .

Find the magnitude of the impulse exerted by the floor on the ball.

[ 3 marks ]

### 3.3 Exercise

#### Question 1

*M1 Exam question, 20th January 2012, Q1*

A railway truck  $P$ , of mass  $m$  kg, is moving along a straight horizontal track with speed  $15 \text{ ms}^{-1}$ . Truck  $P$  collides with a truck  $Q$  of mass  $3000$  kg, which is at rest on the same track. Immediately after the collision the speed of  $P$  is  $3 \text{ ms}^{-1}$  and the speed of  $Q$  is  $9 \text{ ms}^{-1}$ .

The direction of motion of  $P$  is reversed by the collision.

Modelling the trucks as particles, find

( a ) the magnitude of the impulse exerted by  $P$  on  $Q$

[ 2 marks ]

( b ) the value of  $m$

[ 3 marks ]

## Question 2

*M1 Exam question, 14th January 2002, Q2 (edited)*

A railway truck *A* of mass 1800 kg is moving along a straight horizontal track with speed  $4 \text{ ms}^{-1}$ . It collides directly with a stationary truck *B* of mass 1200 kg on the same track. In the collision, *A* and *B* are coupled and move off together.

(a) find the speed of the trucks immediately after the collision.

[ 3 marks ]

After the collision, the trucks experience a constant resistive force of magnitude  $rR$  newtons. They come to rest 8 s after the collision

(b) Find  $R$  by using the impulse relationship

$$Ft = mv - mu$$

[ 3 marks ]

### Question 3

*M1 Exam question, 18th May 2011, Q2*

Particle  $P$  has mass 3 kg and particle  $Q$  has mass 2 kg. The particles are moving in opposite directions on a smooth horizontal plane when they collide directly. Immediately before the collision,  $P$  has speed  $3 \text{ ms}^{-1}$  and  $Q$  has speed  $2 \text{ ms}^{-1}$ . Immediately after the collision, both particles move in the same direction and the difference in their speeds is  $1 \text{ ms}^{-1}$ .

( a ) Find the speed of each particle after the collision.

[ 5 marks ]

( b ) Find the magnitude of the impulse exerted on  $P$  by  $Q$ .

[ 3 marks ]

**Question 4**

*M1 Exam question, 24th May 2010, Q2*

Particle  $P$  has mass  $m$  kg and particle  $Q$  has mass  $3m$  kg. The particles are moving in opposite directions along a smooth horizontal plane when they collide directly. Immediately before the collision,  $P$  has speed  $4u$  ms<sup>-1</sup> and  $Q$  has speed  $ku$  ms<sup>-1</sup>, where  $k$  is a constant. As a result of the collision the direction of motion of each particle is reversed and the speed of each particle is halved.

( a ) Find the value of  $k$

[ 4 marks ]

( b ) Find, in terms of  $m$  and  $u$ , the magnitude of the impulse exerted on  $P$  by  $Q$ .

[ 3 marks ]

**Question 5**

*M1 Exam question, 18th January 2001, Q5*

Two small balls  $A$  and  $B$  have masses  $0.6\text{ kg}$  and  $0.2\text{ kg}$  respectively. They are moving towards each other in opposite directions on a horizontal table when they collide directly. Immediately before the collision, the speed of  $A$  is  $4.5\text{ ms}^{-1}$  and the speed of  $B$  is speed  $3\text{ ms}^{-1}$ . Immediately after the collision,  $A$  and  $B$  move in the same direction and the speed of  $B$  is twice the speed of  $A$ .

By modelling the balls as particles, find

( a ) the speed of  $B$  immediately after the collision.

[ 4 marks ]

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

[ 3 marks ]

The table is rough. After the collision,  $B$  moves a distance of 2 m on the table before coming to rest

( c ) Find the coefficient of friction between  $B$  and the table.

[ 6 marks ]

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