

1 A snooker player strikes the white ball, which begins at rest, directly with her cue so that the cue makes contact with the ball to apply a simple, constant, forward force of 5 N for a time of 0.4 seconds.

- a Calculate the impulse exerted on the ball by the cue, and state the units of this value.

**(2 marks)**

A snooker player says that if you divide the impulse on the ball by the cue by the mass of the ball, you will get the initial speed of the ball, regardless of the force applied to the ball or the length of time it was applied for.

- b Using  $F = ma$  and  $v = u + at$  as a starting point, prove that the snooker player is correct.

**(3 marks)**

The ball moves across the table, in a straight line in the direction in which it was struck, at  $8 \text{ m s}^{-1}$ .

- c Find the mass of the ball and state its momentum in  $\text{kg m s}^{-1}$ .

**(2 marks)**

2 In a game of marbles, two glass spheres, one of mass 20 g and the other of mass 50 g, are projected towards each other along the same line, travelling with constant speeds  $0.5 \text{ m s}^{-1}$  and  $0.6 \text{ m s}^{-1}$  respectively, so that they collide head-on. Immediately after the collision the speed of the heavier marble is halved, but its direction of motion is unchanged.

- a Find the speed and the direction of travel of the lighter marble immediately after the collision.

**(4 marks)**

- b Find the magnitude of the impulse given by the heavier marble to the lighter marble in the collision.

**(2 marks)**

- c State one modelling assumption that has been made in your solution to this problem.

**(1 mark)**

3 Two toy cars are connected by a light inextensible string which is 10 cm long. The cars are not the same. One has mass  $m \text{ kg}$  and the other is 25 g heavier. Initially both toys are stationary and the connecting string is completely slack. The lighter car is propelled away from the heavier car in a straight line, on a smooth surface, at a constant speed of  $0.8 \text{ m s}^{-1}$ . As soon as the string becomes taut,

the heavier car is jerked forward along the same line of motion so that it moves at a constant speed of  $v \text{ m s}^{-1}$ . At this same instant the impulse of the string on the lighter car brings it to instantaneous rest.

- a** Express  $v$  in terms of  $m$ . **(4 marks)**

As soon as the heavier car begins to move it experiences a constant resistant force to its motion of  $20 \text{ N}$  so that it quickly comes to rest.

- b** Given that the heavier car stops the instant before it collides with the lighter car, find an inequality for  $m$ , the mass of the lighter car. Give your answer correct to 3 significant figures.

**(4 marks)**

- 4 A ball of mass 100 g is thrown vertically upwards with initial speed of  $7 \text{ m s}^{-1}$  so that it collides with an apple hanging from a tree. The apple has a mass of 250 g and hangs 1.8 m above the point from which the ball was thrown. During the collision the ball remains in contact with the apple for 0.8 seconds then, due to the collision, changes its direction and has an immediate downward speed of  $1 \text{ m s}^{-1}$ . The apple will break from the tree and fall freely to the ground if it is struck with a force of more than 0.5 N.
- a Deduce whether the ball thrown as described above will dislodge the apple from the tree.  
(4 marks)

Immediately after the collision the apple will move a distance  $x$  cm vertically upwards due to the impulse given to the apple by the ball, before falling back again due to gravity.

- b Find  $x$  to 2 significant figures.  
(4 marks)