

## 4D Successive Collisions

1. Three spheres A, B and C have masses 1kg, 2kg and 3kg respectively. They are moving along the same straight horizontal plane with A following B, which is following C. The initial velocities of A, B and C are  $7\text{ms}^{-1}$ ,  $3\text{ms}^{-1}$  and  $1\text{ms}^{-1}$  in the direction ABC. Sphere A collides with sphere B then sphere B collides with sphere C. The coefficient of restitution between A and B is  $\frac{1}{2}$  and between B and C is  $\frac{1}{4}$ .
  - a) Find the velocities of the 3 spheres after both collisions have taken place

- b) Explain how you know that there will be a further collision between A and B

2. A uniform smooth sphere P of mass  $3m$  is moving in a straight line with speed  $u$  on a smooth horizontal table. Another uniform smooth sphere Q of mass  $m$  and having the same radius as P, is moving with speed  $2u$  in the opposite direction of P. P and Q collide directly, and their speeds after the collision are  $v$  and  $w$  respectively. The coefficient of restitution between P and Q is  $e$ .
- a) Find expressions for  $v$  and  $w$  in terms of  $u$  and  $e$ .

- b) Show that, if the direction of motion of P is changed by the collision, then  $e > \frac{1}{3}$

Following the collision with P, the sphere Q then collides with and rebounds from a vertical wall. The coefficient of restitution between Q and the wall is  $e'$

- c) Given that  $e = \frac{5}{9}$  and that P and Q collide again in the subsequent motion, show that  $e' > \frac{1}{9}$

3. A tennis ball, which may be modelled as a particle, is dropped from rest at a height of 90cm onto a smooth horizontal plane. The coefficient of restitution between the ball and the plane is 0.5. Assume there is no air resistance and the ball falls freely under gravity at a right angle to the plane.
- a) Find the height to which the ball rebounds after the first bounce

b) Find the height to which the ball bounces after the second bounce

c) Find the total distance travelled by the ball before it comes to rest