Conservation of Momentum (From OCR 4728)

Q1, (Jun 2005, Q3)

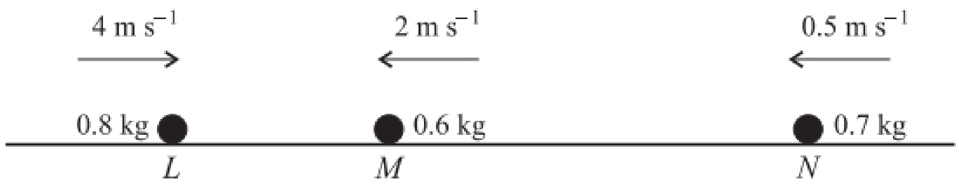
Two small spheres P and Q have masses 0.1 kg and 0.2 kg respectively. The spheres are moving directly towards each other on a horizontal plane and collide. Immediately before the collision P has speed 4 m s^{-1} and Q has speed 3 m s^{-1}. Immediately after the collision the spheres move away from each other, P with speed $u\text{ m s}^{-1}$ and Q with speed $(3.5 - u)\text{ m s}^{-1}$.

(i) Find the value of u. [4]

After the collision the spheres both move with deceleration of magnitude 5 m s^{-2} until they come to rest on the plane.

(ii) Find the distance PQ when both P and Q are at rest. [4]

Q2, (Jan 2007, Q4)



Three uniform spheres L, M and N have masses 0.8 kg, 0.6 kg and 0.7 kg respectively. The spheres are moving in a straight line on a smooth horizontal table, with M between L and N. The sphere L is moving towards M with speed 4 m s^{-1} and the spheres M and N are moving towards L with speeds 2 m s^{-1} and 0.5 m s^{-1} respectively (see diagram).

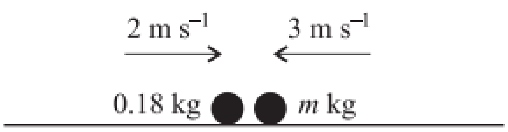
(i) L collides with M. As a result of this collision the direction of motion of M is reversed, and its speed remains 2 m s^{-1}. Find the speed of L after the collision. [4]

(ii) M then collides with N.

(a) Find the total momentum of M and N in the direction of M's motion before this collision takes place, and deduce that the direction of motion of N is reversed as a result of this collision. [4]

(b) Given that M is at rest immediately after this collision, find the speed of N immediately after this collision. [2]

Q3, (Jun 2007, Q4)



Two particles of masses 0.18 kg and m kg move on a smooth horizontal plane. They are moving towards each other in the same straight line when they collide. Immediately before the impact the speeds of the particles are 2 m s^{-1} and 3 m s^{-1} respectively (see diagram).

(i) Given that the particles are brought to rest by the impact, find m. [3]

(ii) Given instead that the particles move with equal speeds of 1.5 m s^{-1} after the impact, find

(a) the value of m, assuming that the particles move in opposite directions after the impact, [3]

(b) the two possible values of m, assuming that the particles coalesce. [4]

Q4, (Jun 2009, Q5)

(i)

Fig. 1

A particle P of mass 0.5 kg is projected with speed 6 m s^{-1} on a smooth horizontal surface towards a stationary particle Q of mass m kg (see Fig. 1). After the particles collide, P has speed $v \text{ m s}^{-1}$ in its original direction of motion, and Q has speed 1 m s^{-1} more than P. Show that $v(m+0.5) = -m+3$. **[3]**

(ii)

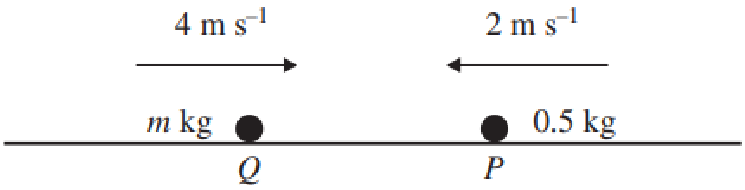


Fig. 2

Q and P are now projected towards each other with speeds 4 m s^{-1} and 2 m s^{-1} respectively (see Fig. 2). Immediately after the collision the speed of Q is $v \text{ m s}^{-1}$ with its direction of motion unchanged and P has speed 1 m s^{-1} more than Q. Find another relationship between m and v in the form $v(m+0.5) = am + b$, where a and b are constants. **[4]**

(iii) By solving these two simultaneous equations show that $m = 0.9$, and hence find v. **[4]**

Q5, (Jan 2012, Q1)

Particles P and Q, of masses 0.3 kg and 0.5 kg respectively, are moving in the same direction along the same straight line on a smooth horizontal surface. P is moving with speed 2.2 m s^{-1} and Q is moving with speed 0.8 m s^{-1} immediately before they collide. In the collision, the speed of P is reduced by 50% and its direction of motion is unchanged.

(i) Calculate the speed of Q immediately after the collision. **[4]**

(ii) Find the distance PQ at the instant 3 seconds after the collision. **[2]**

Q6, (Jun 2010, Q2)

Two particles P and Q are moving in opposite directions in the same straight line on a smooth horizontal surface when they collide. P has mass 0.4 kg and speed 3 m s^{-1}. Q has mass 0.6 kg and speed 1.5 m s^{-1}. Immediately after the collision, the speed of P is 0.1 m s^{-1}.

(i) Given that P and Q are moving in the same direction after the collision, find the speed of Q. **[4]**

(ii) Given instead that P and Q are moving in opposite directions after the collision, find the distance between them 3 s after the collision. **[5]**

Q7, (Jun 2012, Q7)

The diagram shows two particles P and Q, of masses 0.2 kg and 0.3 kg respectively, which move on a horizontal surface in the same direction along a straight line. A stationary particle R of mass 1.5 kg also lies on this line. P and Q collide and coalesce to form a combined particle C. Immediately before this collision P has velocity 4 m s^{-1} and Q has velocity 2.5 m s^{-1}.

(i) Calculate the velocity of C immediately after this collision. **[3]**

At time t s after this collision the velocity $v\text{ m s}^{-1}$ of C is given by $v = V_0 - 3t^2$ for $0 < t \leqslant 0.3$. C strikes R when $t = 0.3$.

(ii) (a) State the value of V_0. **[1]**

(b) Calculate the distance C moves before it strikes R. **[4]**

(c) Find the acceleration of C immediately before it strikes R. **[3]**

Immediately after C strikes R, the particles have equal speeds but move in opposite directions.

(iii) Find the speed of C immediately after it strikes R. **[4]**

Q8, (Jan 2013, Q6)

Particle P of mass 0.3 kg and particle Q of mass 0.2 kg are 3.6 m apart on a smooth horizontal surface. P and Q are simultaneously projected directly towards each other along a straight line. Before the particles collide P has speed 4 m s^{-1} and Q has speed 5 m s^{-1}.

(i) Given that the particles coalesce in the collision, calculate their common speed after they collide. **[3]**

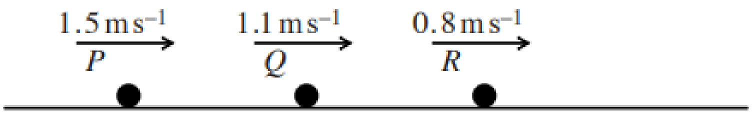
(ii) It is given instead that one particle is at rest immediately after the collision.

(a) State which particle is in motion after the collision and find the speed of this particle. **[4]**

(b) Find the time taken after the collision for the moving particle to return to its initial position. **[4]**

(c) On a single diagram sketch the (t, v) graphs for the two particles, with $t = 0$ as the instant of their initial projection. **[4]**

Q9, (Jun 2013, Q1)



Three particles P, Q and R have masses 0.1 kg, 0.3 kg and 0.6 kg respectively. The particles travel along the same straight line on a smooth horizontal table and have velocities 1.5 m s^{-1}, 1.1 m s^{-1} and 0.8 m s^{-1} respectively (see diagram). P collides with Q and then Q collides with R. In the second collision Q and R coalesce and subsequently move with a velocity of 1 m s^{-1}.

(i) Find the speed of Q immediately before the second collision. **[3]**

(ii) Calculate the change in momentum of P in the first collision. **[3]**

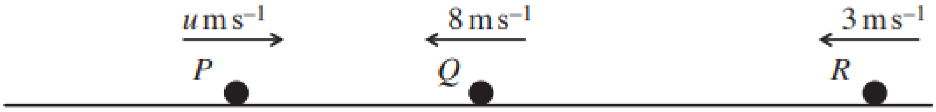
Q10, (Jun 2014, Q4)

Particles P and Q are moving towards each other with constant speeds $4\,\mathrm{m\,s^{-1}}$ and $2\,\mathrm{m\,s^{-1}}$ along the same straight line on a smooth horizontal surface (see diagram). P has mass 0.2 kg and Q has mass 0.3 kg. The two particles collide.

(i) Show that Q must change its direction of motion in the collision. **[3]**

(ii) Given that P and Q move with equal speed after the collision, calculate both possible values for their speed after they collide. **[5]**

Q11, (Jun 2015, Q2)



Three particles P, Q and R with masses 0.4 kg, 0.3 kg and m kg are moving along the same straight line on a smooth horizontal surface. P and Q are moving towards each other with speeds $u\,\mathrm{m\,s^{-1}}$ and $8\,\mathrm{m\,s^{-1}}$ respectively. R has speed $3\,\mathrm{m\,s^{-1}}$ and is moving in the same direction as Q (see diagram).

(i) Immediately after the collision between P and Q their directions of motion have been reversed, but their speeds are unchanged. Calculate u. **[4]**

The next collision is between Q and R. After the collision between Q and R, particle Q is at rest and R has speed $9\,\mathrm{m\,s^{-1}}$.

(ii) Calculate m. **[4]**

Q12, (Jun 2016, Q4)

Four particles A, B, C and D are on the same straight line on a smooth horizontal table. A has speed $6\,\mathrm{m\,s^{-1}}$ and is moving towards B. The speed of B is $2\,\mathrm{m\,s^{-1}}$ and B is moving towards A. The particle C is moving with speed $5\,\mathrm{m\,s^{-1}}$ away from B and towards D, which is stationary (see diagram). The first collision is between A and B which have masses 0.8 kg and 0.2 kg respectively.

(i) After the particles collide A has speed $4\,\mathrm{m\,s^{-1}}$ in its original direction of motion. Calculate the speed of B after the collision. **[4]**

The second collision is between C and D which have masses 0.3 kg and 0.1 kg respectively.

(ii) The particles coalesce when they collide. Find the speed of the combined particle after this collision. **[3]**

The third collision is between B and the combined particle, after which no further collisions occur.

(iii) Calculate the greatest possible speed of the combined particle after the third collision. **[4]**