FM1 (Year 1) – Coefficient Of Restitution With Multiple Collisions Exam Questions (Edexcel)

Q1.

Three identical particles P, Q and R, each of mass m, lie in a straight line on a smooth horizontal plane with Q between P and R. Particles P and Q are projected directly towards each other with speeds $4u$ and $2u$ respectively, and at the same time particle R is projected along the line away from Q with speed $3u$. The coefficient of restitution between each pair of particles is e. After the collision between P and Q there is a collision between Q and R.

(a) Show that $e > \frac{2}{3}$

(7)

It is given that $e = \frac{3}{4}$

(b) Show that there will not be a further collision between P and Q.

(6)

(Total for question = 13 marks)

(Q04 6678/01, June 2015)

Q2.

Three particles P, Q and R lie at rest in a straight line on a smooth horizontal table with Q between P and R. The particles P, Q and R have masses $2m$, $3m$ and $4m$ respectively. Particle P is projected towards Q with speed u and collides directly with it. The coefficient of restitution between each pair of particles is e.

(a) Show that the speed of Q immediately after the collision with P is $\frac{2}{5}(1 + e)u$.

(6)

After the collision between P and Q there is a direct collision between Q and R.

Given that $e = \frac{3}{4}$, find

(b) (i) the speed of Q after this collision,

(ii) the speed of R after this collision.

(6)

Immediately after the collision between Q and R, the rate of increase of the distance between P and R is V.

(c) Find V in terms of u.

(3)

(Total 15 marks)

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(Q03 6678/01, June 2013)

Q3.

A particle A of mass m is moving with speed u on a smooth horizontal floor when it collides directly with another particle B, of mass $3m$, which is at rest on the floor. The coefficient of restitution between the particles is e. The direction of motion of A is reversed by the collision.

(a) Find, in terms of e and u,

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

(ii) the speed of B immediately after the collision.

(7)

After being struck by A the particle B collides directly with another particle C, of mass $4m$, which is at rest on the floor. The coefficient of restitution between B and C is $2e$. Given that the direction of motion of B is reversed by this collision,

(b) find the range of possible values of e,

(6)

(c) determine whether there will be a second collision between A and B.

(3)

(Total 16 marks)

(Q04 6678/01, Jan 2013)

Q4.

Three identical particles, A, B and C, lie at rest in a straight line on a smooth horizontal table with B between A and C. The mass of each particle is m. Particle A is projected towards B with speed u and collides directly with B. The coefficient of restitution between each pair of particles is $\frac{2}{3}$.

(a) Find, in terms of u,

(i) the speed of A after this collision,
(ii) the speed of B after this collision.

(7)

(b) Show that the kinetic energy lost in this collision is $\frac{5}{36}mu^2$

(4)

After the collision between A and B, particle B collides directly with C.

(c) Find, in terms of u, the speed of C immediately after this collision between B and C.

(4)

(Total 15 marks)

(Q02 6678/01, Jan 2012)

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Q5.

Two small spheres P and Q of equal radius have masses m and $5m$ respectively. They lie on a smooth horizontal table. Sphere P is moving with speed u when it collides directly with sphere Q which is at rest. The coefficient of restitution between the spheres is e, where $e > \frac{1}{5}$.

(a) (i) Show that the speed of P immediately after the collision is $\frac{u}{6}(5e - 1)$.

(ii) Find an expression for the speed of Q immediately after the collision, giving your answer in the form λu, where λ is in terms of e.

(6)

Three small spheres A, B and C of equal radius lie at rest in a straight line on a smooth horizontal table, with B between A and C. The spheres A and C each have mass $5m$, and the mass of B is m. Sphere B is projected towards C with speed u. The coefficient of restitution between each pair of spheres is $\frac{4}{5}$.

(b) Show that, after B and C have collided, there is a collision between B and A.

(3)

(c) Determine whether, after B and A have collided, there is a further collision between B and C.

(4)

(Total 13 marks)

(Q04 6678/01, June 2007)

Q6.

A particle P of mass $3m$ is moving in a straight line with speed $2u$ on a smooth horizontal table. It collides directly with another particle Q of mass $2m$ which is moving with speed u in the opposite direction to P. The coefficient of restitution between P and Q is e.

(a) Show that the speed of Q immediately after the collision is $\frac{1}{5}(9e + 4)u$.

(5)

The speed of P immediately after the collision is $\frac{1}{2}u$.

(b) Show that $e = \frac{1}{4}$.

(4)

The collision between P and Q takes place at the point A. After the collision Q hits a smooth fixed vertical wall which is at right-angles to the direction of motion of Q. The distance from A to the wall is d.

(c) Show that P is a distance $\frac{3}{5}d$ from the wall at the instant when Q hits the wall.

(4)

Particle Q rebounds from the wall and moves so as to collide directly with particle P at the point B. Given that the coefficient of restitution between Q and the wall is $\frac{3}{5}$,

(d) find, in terms of d, the distance of the point B from the wall.

(4)

(Total 17 marks)

(Q04 6678/01, Jan 2009)

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Q7.

Particles A, B and C of masses $4m$, $3m$ and m respectively, lie at rest in a straight line on a smooth horizontal plane with B between A and C. Particles A and B are projected towards each other with speeds u m s^{-1} and u m s^{-1} respectively, and collide directly.

As a result of the collision, A is brought to rest and B rebounds with speed kv m s^{-1}. The coefficient of restitution between A and B is $\frac{3}{4}$.

(a) Show that $u = 3v$.

(6)

(b) Find the value of k.

(2)

Immediately after the collision between A and B, particle C is projected with speed $2v$ m s^{-1} towards B so that B and C collide directly.

(c) Show that there is no further collision between A and B.

(4)

(Total 12 marks)

(Q04 6678/01, June 2009)

Q8.

A small ball A of mass $3m$ is moving with speed u in a straight line on a smooth horizontal table. The ball collides directly with another small ball B of mass m moving with speed u towards A along the same straight line. The coefficient of restitution between A and B is $\frac{1}{2}$. The balls have the same radius and can be modelled as particles.

(a) Find

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

(ii) the speed of B immediately after the collision.

(7)

After the collision B hits a smooth vertical wall which is perpendicular to the direction of motion of B. The coefficient of restitution between B and the wall is $\frac{2}{5}$.

(b) Find the speed of B immediately after hitting the wall.

(2)

The first collision between A and B occurred at a distance $4a$ from the wall. The balls collide again T seconds after the first collision.

(c) Show that $T = \frac{112a}{15u}$.

(6)

(Total 15 marks)

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(Q04 6678/01, June 2010)

Q9.

Two particles A and B, of mass $2m$ and $3m$ respectively, are initially at rest on a smooth horizontal surface. Particle A is projected with speed $3u$ towards B. Particle A collides directly with particle B. The coefficient of restitution between A and B is $\frac{3}{4}$

(a) Find

(i) the speed of A immediately after the collision,
(ii) the speed of B immediately after the collision.

(7)

After the collision B hits a fixed smooth vertical wall and rebounds. The wall is perpendicular to the direction of motion of B. The coefficient of restitution between B and the wall is e. The magnitude of the impulse received by B when it hits the wall is $\frac{27}{4}mu$.

(b) Find the value of e.

(3)

(c) Determine whether there is a further collision between A and B after B rebounds from the wall.

(2)

(Total for question = 12 marks)

(Q03 6678/01, June 2016)

Q10.

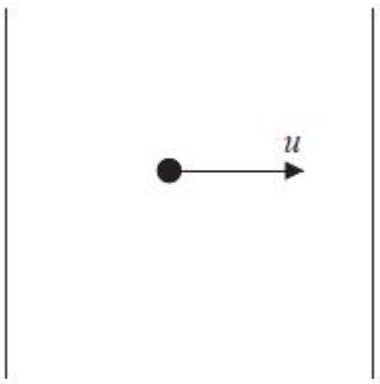

Figure 2

A particle of mass em is at rest on a smooth horizontal plane between two smooth fixed parallel vertical walls, as shown in the plan view in Figure 2. The particle is projected along the plane with speed u towards one of the walls and strikes the wall at right angles. The coefficient of restitution between the particle and each wall is e and air resistance is modelled as being negligible.

Using the model,

(a) find, in terms of m, u and e, an expression for the total loss in the kinetic energy of the particle as a result of the first two impacts.

(3)

Given that e can vary such that $0 < e < 1$ and using the model,

(b) find the value of e for which the total loss in the kinetic energy of the particle as a result of the first two impacts is a maximum,

(4)

(c) describe the subsequent motion of the particle.

(2)

(Total for question = 9 marks)

(Q02 8FM0/25, Oct 2021)

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