

FM1 – Mechanics Chapter 4

Exam Questions: Successive Direct Collisions

Q1.

A particle P of mass m kg is moving with speed 6 m s^{-1} in a straight line on a smooth horizontal floor.

The particle strikes a fixed smooth vertical wall at right angles and rebounds.

The kinetic energy lost in the impact is 64 J.

The coefficient of restitution between P and the wall is $\frac{1}{3}$.

(a) Show that $m = 4$. (6)

After rebounding from the wall, P collides directly with a particle Q which is moving towards P with speed 3 m s^{-1} .

The mass of Q is 2 kg and the coefficient of restitution between P and Q is $\frac{1}{3}$.

(b) Show that there will be a second collision between P and the wall.

(7)
(Total 13 marks)

Q2.

A small ball of mass 0.1 kg is dropped from a point which is 2.4 m above a horizontal floor.

The ball falls freely under gravity, strikes the floor and bounces to a height of 0.6 m above the floor.

The ball is modelled as a particle.

(a) Show that the coefficient of restitution between the ball and the floor is 0.5 (6)

(b) Find the height reached by the ball above the floor after it bounces on the floor for the second time.

(3)

(c) By considering your answer to (b), describe the subsequent motion of the ball.

(1)

(Total for question = 10 marks)

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)

(Total 13 marks)

Q4.

Three particles, P , Q and R , are at rest on a smooth horizontal plane.

The particles lie along a straight line with Q between P and R .

The particles Q and R have masses m and km respectively, where k is a constant.

Particle Q is projected towards R with speed u and the particles collide directly.

The coefficient of restitution between each pair of particles is e .

(a) Find, in terms of e , the range of values of k for which there is a second collision.

(9)

Given that the mass of P is km and that there is a second collision,

(b) write down, in terms of u , k and e , the speed of Q after this second collision.

(1)

(Total for question = 10 marks)

Q5.

A particle P of mass $3m$ is moving in a straight line on a smooth horizontal floor.

A particle Q of mass $5m$ is moving in the opposite direction to P along the same straight line.

The particles collide directly.

Immediately before the collision, the speed of P is $2u$ and the speed of Q is u .

The coefficient of restitution between P and Q is e .

(a) Show that the speed of Q immediately after the collision is $\frac{u}{8}(9e + 1)$ (6)

(b) Find the range of values of e for which the direction of motion of P is not changed as a result of the collision. (2)

When P and Q collide they are at a distance d from a smooth fixed vertical wall, which is perpendicular to their direction of motion.

After the collision with P , particle Q collides directly with the wall and rebounds so that there is a second collision between P and Q .

This second collision takes place at a distance x from the wall.

Given that $e = \frac{1}{18}$ and the coefficient of restitution between Q and the wall is $\frac{1}{3}$

(c) find x in terms of d . (6)

(Total for question = 14 marks)

Q6.

Two particles A and B , of masses $3m$ and $4m$ respectively, lie at rest on a smooth horizontal surface.

Particle B lies between A and a smooth vertical wall which is perpendicular to the line joining A and B .

Particle B is projected with speed $5u$ in a direction perpendicular to the wall and collides with the wall. The coefficient of restitution between B and the wall is $\frac{3}{5}$.

(a) Find the magnitude of the impulse received by B in the collision with the wall.

(3)

After the collision with the wall, B rebounds from the wall and collides directly with A . The coefficient of restitution between A and B is e .

(b) Show that, immediately after they collide, A and B are both moving in the same direction.

(7)

The kinetic energy of B immediately after it collides with A is one quarter of the kinetic energy of B immediately before it collides with A .

(c) Find the value of e .

(4)

(Total for question = 14 marks)