NEWTON'S LAW OF RESTITUTION

1. A sphere of mass 10kg moving horizontally with speed $8ms^{-1}$ hits a vertical brick wall and rebounds horizontally with speed $5ms^{-1}$. Find :

a) the coefficient of restitution between the sphere and the wall.

[2]

b) the loss in kinetic energy due to the impact

[3]

c) the impulse exerted by the wall on the sphere.

[2]

The sphere goes on to collide and coalesce with a stationary sphere of mass 5kg.

d) Find the speed of the combined mass after collision.

[3]

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2. A particle A of mass 2mkg collides directly with a particle B of mass m kg. Before the impact, both spheres were moving in the same direction, the speed of A was $4ms^{-1}$ and the speed of B was $2ms^{-1}$. The coefficient of restitution between the two spheres is 0.5.

a) Find the velocities of A and B immediately after impact.

[10]

b) Find the impulse exerted on A in the collision.

[2]

c) Find the kinetic energy lost in the collision.

[4]

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3. Two spheres A and B of equal radii and masses m kg and 2m kg respectively are moving in the same direction along a straight line. A has speed ku ms^{-1} (k>1) and B has speed u ms^{-1}. After A hits B, it is brought to rest. The coefficient of restitution between A and B is e.

a) Show that $e = \frac{k+2}{2(k-1)}$.

[7]

b) Deduce that $k \geq 4$.

[2]

After the collision between A and B, the sphere B moves at constant speed until it hits a wall. After rebounding from the wall it again collides with A. Given that k=6 and that the coefficient of restitution between B and the wall is 0.5,

c) find the velocities of A and B after their second collision.

[11]

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4. Two identical spheres A and B of mass m kg collide directly. Before the collision, A is moving with speed 2u ms^{-1} and B with a speed of u ms^{-1} in the opposite direction. After the collision, A's direction of motion is reversed and its speed reduced to u ms^{-1}. Find :

a) The magnitude and direction of the impulse exerted by B on A

[4]

b) The velocity of B after the collision.

[4]

c) The value of e, the coefficient of restitution between the spheres. Comment on your result.

[3]

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5. Three spheres A, B and C of equal radii and masses m, 2m and 4m respectively are at rest in that order on a smooth horizontal table with their centres lying in a horizontal line. An impulse is applied to A and as a result it moves with a constant speed u towards B. The coefficient of restitution between any two spheres is 0.5. Find :

a) the speeds of A and B in terms of u after the first collision

[6]

b) what further collisions took place and the velocities of the three spheres when no further collisions can occur.

[7]

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6. A and B are two identical spheres each of mass m. Initially they are moving in the same direction with speeds u and $\frac{1}{2}$u respectively. A collides with B, and after this collision B goes on to strike a vertical wall. The coefficient of restitution between the two spheres is $\frac{1}{2}$ and between B and the wall is $\frac{1}{7}$.

a) Find the speeds of A and B after their first collision.

[6]

b) Find the speeds of A and B after B has hit the wall for the second time.

[8]

c) Show that there will be a total of three collisions between A and B.

[5]

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7. Two spheres A and B of the same radii have masses 2m kg and m kg respectively. They are moving in the same direction on a straight line on a smooth horizontal table. A has a speed of 3u ms^{-1} and B a speed of ums^{-1}. A and B collide. After the collision, they both continue to move in the same direction and the speed of A is reduced to 2u. Find :

a) the speed of B after the collision

[4]

b) the value of e, the coefficient of restitution between the spheres

[3]

c) the loss in kinetic energy due to the collision

[5]

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8. A white snooker ball, of mass 0.1kg, is initially at rest. A snooker player strikes it with the cue so that it moves in a straight line across a horizontal table with speed 2.5ms^{-1}. The ball and cue are in contact for 0.05 seconds. Calculate :

a) the impulse exerted by the cue on the ball

[2]

b) the magnitude of the force, which may be assumed to be constant, exerted by the cue on the ball.

[2]

The white ball, still moving at 2.5ms^{-1}, collides directly with a black snooker ball of identical size and mass which is at rest. The coefficient of restitution between the two balls in $\frac{3}{4}$. Find :

c) the speed of each ball immediately after the collision

[5]

d) the loss in kinetic energy due to the collision, giving your answer in Joules to three significant figures.

[3]

The white and black balls continue to move at these speeds on the table.

e) Find their distance apart after 0.8 seconds.

[2]

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9. Three identical beads A, B and C each of mass m are threaded in the order A, B, C on a smooth, fixed horizontal wire. The coefficient of restitution in any collision of a pair of beads is e. The bead A is projected with speed $6ms^{-1}$ towards the bead B, which is at rest, and collides with it.

a) Show that the speed of A after the collision is $3(1–e)\ ms^{-1}$ and find, in terms of e, the speed of B.

[5]

The bead B now moves on to collide with C, which is at rest.

b) Find, in terms of e, the speeds of B and C after their collision.

[4]

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10. Two particles, A and B, of mass m and 3m respectively, are placed on a smooth horizontal plane. Particle A is made to move on the plane with speed u so as to collide directly with B, which is at rest. After the collision, B moves with speed ku, where k is a constant.

a) Find the speed of A after the collision.

[2]

b) By using Newton's law of restitution, show that $\frac{1}{4} \leq k \leq \frac{1}{2}$

[4]

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11. Two particles, A and B, of masses m and 2m respectively, moving in opposite directions with speeds 3u and u respectively, collide directly.

a) Given that A is bought to rest, find the coefficient of restitution between the spheres.

[4]

Find also, in terms of m and u,

b) the magnitude of the impulse exerted on A

[1]

c) the kinetic energy lost in the collision.

[4]

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12. Two particles, A and B, of masses m and km respectively, moving in opposite directions with speeds u and ku respectively, collide directly. The coefficient of restitution between A and B is e.

a) Show that the speed of B after the collision is $u(1 – k + e)$ and find, in terms of k, u and e, the speed of A.

[8]

Given that B was bought to rest in the collision,

b) show that $k = 1 + e$

[2]

A collides with a vertical wall and rebounds. The coefficient of restitution between A and the wall is $\frac{1}{2}$.
Given that $e = 0.4$,

c) find the speeds of A and B after their second collision

[5]

d) show that no further collision will occur

[2]
