2 Two particles A and B, of masses 3.2 kg and 2.4 kg respectively, lie on a smooth horizontal table. A moves towards B with a speed of $v\,\text{m}\,\text{s}^{-1}$ and collides with B, which is moving towards A with a speed of $6\,\text{m}\,\text{s}^{-1}$. In the collision the two particles come to rest.

(a) Find the value of v. [2]

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(b) Find the loss of kinetic energy of the system due to the collision. [2]

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1 A particle B of mass 5 kg is at rest on a smooth horizontal table. A particle A of mass 2.5 kg moves on the table with a speed of $6\,\text{m}\,\text{s}^{-1}$ and collides directly with B. In the collision the two particles coalesce.

(a) Find the speed of the combined particle after the collision. [2]

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(b) Find the loss of kinetic energy of the system due to the collision. [3]

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1 Small smooth spheres A and B, of equal radii and of masses 5 kg and 3 kg respectively, lie on a smooth horizontal plane. Initially B is at rest and A is moving towards B with speed $8.5\,\text{m s}^{-1}$. The spheres collide and after the collision A continues to move in the same direction but with a quarter of the speed of B.

(a) Find the speed of B after the collision. [3]

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(b) Find the loss of kinetic energy of the system due to the collision. [2]

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2 Two small smooth spheres A and B, of equal radii and of masses km kg and m kg respectively, where $k > 1$, are free to move on a smooth horizontal plane. A is moving towards B with speed $6\,\text{m s}^{-1}$ and B is moving towards A with speed $2\,\text{m s}^{-1}$. After the collision A and B coalesce and move with speed $4\,\text{m s}^{-1}$.

(a) Find k. [3]

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(b) Find, in terms of m, the loss of kinetic energy due to the collision. [2]

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2 Small smooth spheres A and B, of equal radii and of masses 6 kg and 2 kg respectively, lie on a smooth horizontal plane. Initially A is moving towards B with speed $5\,\text{m}\,\text{s}^{-1}$ and B is moving towards A with speed $3\,\text{m}\,\text{s}^{-1}$. After the spheres collide, both A and B move in the same direction and the difference in the speeds of the spheres is $2\,\text{m}\,\text{s}^{-1}$.

Find the loss of kinetic energy of the system due to the collision. [5]

4 Two particles P and Q, of masses 6 kg and 2 kg respectively, lie at rest 12.5 m apart on a rough horizontal plane. The coefficient of friction between each particle and the plane is 0.4. Particle P is projected towards Q with speed $20\,\text{m}\,\text{s}^{-1}$.

(a) Show that the speed of P immediately before the collision with Q is $10\sqrt{3}\,\text{m}\,\text{s}^{-1}$. [3]

In the collision P and Q coalesce to form particle R.

(b) Find the loss of kinetic energy due to the collision. [4]

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The coefficient of friction between R and the plane is 0.4.

(c) Find the distance travelled by particle R before coming to rest. [2]

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4 Two small smooth spheres A and B, of equal radii and of masses 4 kg and m kg respectively, lie on a smooth horizontal plane. Initially, sphere B is at rest and A is moving towards B with speed $6\,\text{m}\,\text{s}^{-1}$. After the collision A moves with speed $1.5\,\text{m}\,\text{s}^{-1}$ and B moves with speed $3\,\text{m}\,\text{s}^{-1}$.

Find the two possible values of the loss of kinetic energy due to the collision. [6]

4 Two particles, A and B, of masses 3 kg and 6 kg respectively, lie on a smooth horizontal plane. Initially, B is at rest and A is moving towards B with speed $8\,\text{m}\,\text{s}^{-1}$. After A and B collide, A moves with speed $2\,\text{m}\,\text{s}^{-1}$.

Find the greater of the two possible total losses of kinetic energy due to the collision. [6]

4 Small smooth spheres A and B, of equal radii and of masses 4 kg and 2 kg respectively, lie on a smooth horizontal plane. Initially B is at rest and A is moving towards B with speed $10\,\text{m}\,\text{s}^{-1}$. After the spheres collide A continues to move in the same direction but with half the speed of B.

(a) Find the speed of B after the collision. [2]

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A third small smooth sphere C, of mass 1 kg and with the same radius as A and B, is at rest on the plane. B now collides directly with C. After this collision B continues to move in the same direction but with one third the speed of C.

(b) Show that there is another collision between A and B. [3]

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(c) *A* and *B* coalesce during this collision.

Find the total loss of kinetic energy in the system due to the three collisions. [5]

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6 Three particles A, B and C of masses 5 kg, 1 kg and 2 kg respectively lie at rest in that order on a straight smooth horizontal track XYZ. Initially A is at X, B is at Y and C is at Z. Particle A is projected towards B with a speed of $6\,\text{m s}^{-1}$ and at the same instant C is projected towards B with a speed of $v\,\text{m s}^{-1}$. In the subsequent motion, A collides and coalesces with B to form particle D. Particle D then collides and coalesces with C to form particle E and E moves towards Z.

(a) Show that after the second collision the speed of E is $\frac{15-v}{4}\,\text{m s}^{-1}$. [3]

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(b) The total loss of kinetic energy of the system due to the two collisions is 63 J.

Use the result from **(a)** to show that $v = 3$. [3]

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(c) It is given that the distance XY is 36 m and the distance YZ is 98 m.

(i) Find the time between the two collisions. [4]

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(ii) Find the time between the instant that A is projected from X and the instant that E reaches Z. [1]

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7 A bead, A, of mass 0.1 kg is threaded on a long straight rigid wire which is inclined at $\sin^{-1}\left(\frac{7}{25}\right)$ to the horizontal. A is released from rest and moves down the wire. The coefficient of friction between A and the wire is μ. When A has travelled 0.45 m down the wire, its speed is $0.6\,\text{m}\,\text{s}^{-1}$.

(a) Show that $\mu = 0.25$. [6]

Another bead, B, of mass 0.5 kg is also threaded on the wire. At the point where A has travelled 0.45 m down the wire, it hits B which is instantaneously at rest on the wire. A is brought to instantaneous rest in the collision. The coefficient of friction between B and the wire is 0.275.

(b) Find the time from when the collision occurs until A collides with B again. [6]

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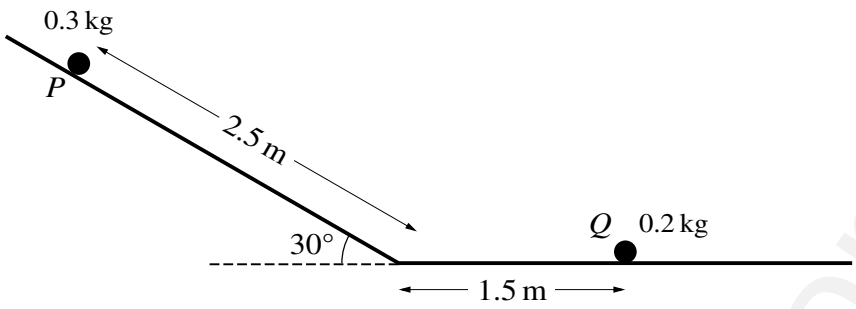

A particle P of mass 0.3 kg, lying on a smooth plane inclined at 30° to the horizontal, is released from rest. P slides down the plane for a distance of 2.5 m and then reaches a horizontal plane. There is no change in speed when P reaches the horizontal plane. A particle Q of mass 0.2 kg lies at rest on the horizontal plane 1.5 m from the end of the inclined plane (see diagram). P collides directly with Q.

(a) It is given that the horizontal plane is smooth and that, after the collision, P continues moving in the same direction, with speed $2\,\text{m}\,\text{s}^{-1}$.

Find the speed of Q after the collision. [5]

(b) It is given instead that the horizontal plane is rough and that when P and Q collide, they coalesce and move with speed $1.2\,\text{m}\,\text{s}^{-1}$.

Find the coefficient of friction between P and the horizontal plane. [5]

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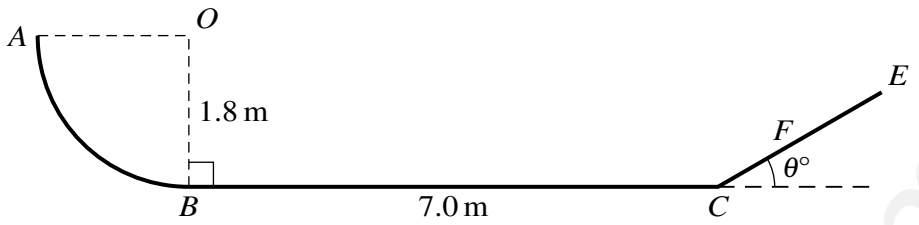

The diagram shows a smooth track which lies in a vertical plane. The section AB is a quarter circle of radius 1.8 m with centre O. The section BC is a horizontal straight line of length 7.0 m and OB is perpendicular to BC. The section CFE is a straight line inclined at an angle of $\theta°$ above the horizontal.

A particle P of mass 0.5 kg is released from rest at A. Particle P collides with a particle Q of mass 0.1 kg which is at rest at B. Immediately after the collision, the speed of P is $4\,\text{m s}^{-1}$ in the direction BC. You should assume that P is moving horizontally when it collides with Q.

(a) Show that the speed of Q immediately after the collision is $10\,\text{m s}^{-1}$. [4]

When Q reaches C, it collides with a particle R of mass 0.4 kg which is at rest at C. The two particles coalesce. The combined particle comes instantaneously to rest at F. You should assume that there is no instantaneous change in speed as the combined particle leaves C, nor when it passes through C again as it returns down the slope.

(b) Given that the distance CF is 0.4 m, find the value of θ. [4]

[Question 7 continues on the next page.]

(c) Find the distance from B at which P collides with the combined particle. [5]

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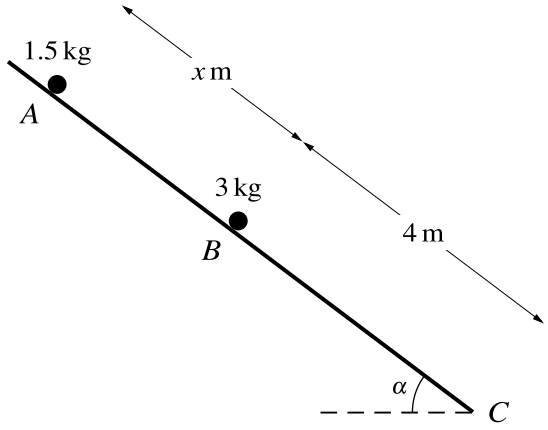

Particles of masses 1.5 kg and 3 kg lie on a plane which is inclined at an angle of α to the horizontal, where $\tan\alpha = \frac{3}{4}$. The section of the plane from A to B is smooth and the section of the plane from B to C is rough. The 1.5 kg particle is held at rest at A and the 3 kg particle is in limiting equilibrium at B. The distance AB is x m and the distance BC is 4 m (see diagram).

(a) Show that the coefficient of friction between the particle at B and the plane is 0.75. [3]

The 1.5 kg particle is released from rest. In the subsequent motion the two particles collide and coalesce. The time taken for the combined particle to travel from B to C is 2 s. The coefficient of friction between the combined particle and the plane is still 0.75.

(b) Find x. [6]

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(c) Find the total loss of energy of the particles from the time the 1.5 kg particle is released until the combined particle reaches C. [3]

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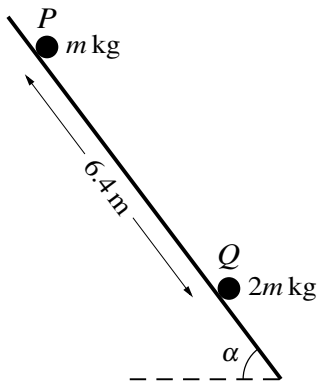

Particles P and Q have masses m kg and $2m$ kg respectively. The particles are initially held at rest 6.4 m apart on the same line of greatest slope of a rough plane inclined at an angle α to the horizontal, where $\sin\alpha = 0.8$ (see diagram). Particle P is released from rest and slides down the line of greatest slope. Simultaneously, particle Q is projected up the same line of greatest slope at a speed of $10\,\text{m s}^{-1}$. The coefficient of friction between each particle and the plane is 0.6.

(a) Show that the acceleration of Q up the plane is $-11.6\,\text{m s}^{-2}$. [4]

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(b) Find the time for which the particles are in motion before they collide. [5]

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(c) The particles coalesce on impact.

Find the speed of the combined particle immediately after the impact. [4]

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