# Momentum 2

Q1.

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]

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

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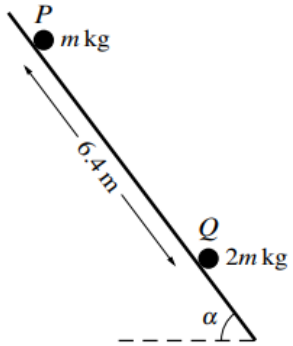
Q2.




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 $\alpha$ 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]

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

**(c)** The particles coalesce on impact.

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

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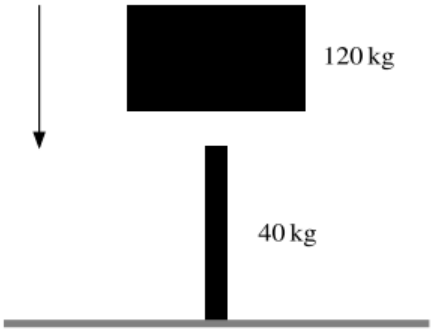
# Momentum 2

Q3.




A metal post is driven vertically into the ground by dropping a heavy object onto it from above. The mass of the object is 120 kg and the mass of the post is 40 kg (see diagram). The object hits the post with speed $8\,\text{m}\,\text{s}^{-1}$ and remains in contact with it after the impact.

**(a)** Calculate the speed with which the combined post and object moves immediately after the impact. [2]

**(b)** There is a constant force resisting the motion of magnitude 4800 N.

Calculate the distance the post is driven into the ground. [3]

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Q4

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 $\mu$. 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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# Momentum 2

Q5.

Two particles $A$ and $B$, of masses 0.4 kg and 0.2 kg respectively, are moving down the same line of greatest slope of a smooth plane. The plane is inclined at 30° to the horizontal, and $A$ is higher up the plane than $B$. When the particles collide, the speeds of $A$ and $B$ are $3\,\text{m s}^{-1}$ and $2\,\text{m s}^{-1}$ respectively. In the collision between the particles, the speed of $A$ is reduced to $2.5\,\text{m s}^{-1}$.

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

After the collision, when $B$ has moved 1.6 m down the plane from the point of collision, it hits a barrier and returns back up the same line of greatest slope. $B$ hits the barrier 0.4 s after the collision, and when it hits the barrier, its speed is reduced by 90%. The two particles collide again 0.44 s after their previous collision, and they then coalesce on impact.

**(b)** Show that the speed of $B$ immediately after it hits the barrier is $0.5\,\text{m s}^{-1}$. Hence find the speed of the combined particle immediately after the second collision between $A$ and $B$. [7]

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Q6.

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]

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

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Q7.

Two particles $P$ and $Q$, of masses 0.3 kg and 0.2 kg respectively, are at rest on a smooth horizontal plane. $P$ is projected at a speed of $4\,\text{m s}^{-1}$ directly towards $Q$. After $P$ and $Q$ collide, $Q$ begins to move with a speed of $3\,\text{m s}^{-1}$.

**(a)** Find the speed of $P$ after the collision. [2]

After the collision, $Q$ moves directly towards a third particle $R$, of mass $m$ kg, which is at rest on the plane. The two particles $Q$ and $R$ coalesce on impact and move with a speed of $2\,\text{m s}^{-1}$.

**(b)** Find $m$. [2]

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# Momentum 2

Q8.

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 $5\,\text{m s}^{-1}$ and $B$ is moving towards $A$ with speed $3\,\text{m s}^{-1}$. After the spheres collide, both $A$ and $B$ move in the same direction and the difference in the speeds of the spheres is $2\,\text{m s}^{-1}$.

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

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Q9.

Three particles $A$, $B$ and $C$ of masses 0.3 kg, 0.4 kg and $m$ kg respectively lie at rest in a straight line on a smooth horizontal plane. The distance between $B$ and $C$ is 2.1 m. $A$ is projected directly towards $B$ with speed $2\,\text{m s}^{-1}$. After $A$ collides with $B$ the speed of $A$ is reduced to $0.6\,\text{m s}^{-1}$, still moving in the same direction.

**(a)** Show that the speed of $B$ after the collision is $1.05\,\text{m s}^{-1}$. [2]

After the collision between $A$ and $B$, $B$ moves directly towards $C$. Particle $B$ now collides with $C$. After this collision, the two particles coalesce and have a combined speed of $0.5\,\text{m s}^{-1}$.

**(b)** Find $m$. [2]

**(c)** Find the time that it takes, from the instant when $B$ and $C$ collide, until $A$ collides with the combined particle. [5]

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