# Impulse and momentum – 2023 AS Mathematics 9709

**1.** Nov/2023/Paper_9709/41/No.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 $20\,\text{m s}^{-1}$.

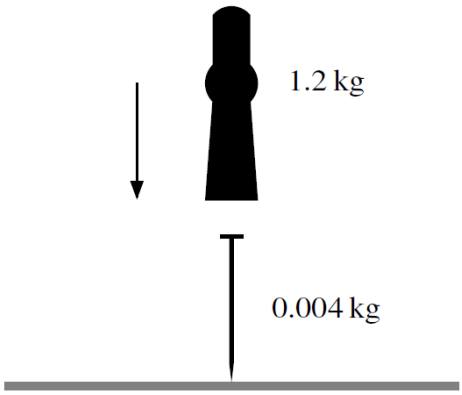
**(a)** Show that the speed of $P$ immediately before the collision with $Q$ is $10\sqrt{3}\,\text{m s}^{-1}$. [3]

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

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

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]




A machine for driving a nail into a block of wood causes a hammerhead to drop vertically onto the top of a nail. The mass of the hammerhead is 1.2 kg and the mass of the nail is 0.004 kg (see diagram). The hammerhead hits the nail with speed $v\,\text{m}\,\text{s}^{-1}$ and remains in contact with the nail after the impact. The combined hammerhead and nail move immediately after the impact with speed $40\,\text{m}\,\text{s}^{-1}$.

**(a)** Calculate $v$, giving your answer as an exact fraction. [2]

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**(b)** The nail is driven 4 cm into the wood.

Find the constant force resisting the motion. [3]

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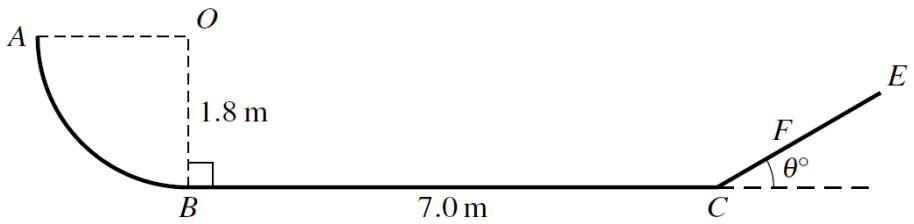
**3.** March/2023/Paper_9709/42/No.7




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 $\theta$. [4]



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