* 0000800000001 * DFD

# Newlighthouse Mock AS & A Level

CANDIDATE NAME

CENTRE NUMBER

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**FURTHER MATHEMATICS** **9231/32**

Paper 3 Further Mechanics **May/June 2026**

**1 hour 30 minutes**

You must answer on the question paper.

You will need: List of formulae (MF19)

**INSTRUCTIONS**

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- If additional space is needed, you should use the lined page at the end of this booklet; the question number or numbers must be clearly shown.
- You should use a calculator where appropriate.
- You must show all necessary working clearly; no marks will be given for unsupported answers from a calculator.
- Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place for angles in degrees, unless a different level of accuracy is specified in the question.
- Where a numerical value for the acceleration due to gravity ($g$) is needed, use $10\,\mathrm{m\,s^{-2}}$.

**INFORMATION**

- The total mark for this paper is 50.
- The number of marks for each question or part question is shown in brackets [ ].


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**1** One end of a light elastic string of natural length $a$ and modulus of elasticity $3mg$ is attached to a fixed point $O$ on a rough horizontal surface. The other end of the string is attached to a particle $P$ of mass $m$. The coefficient of friction between $P$ and the surface is $\frac{3}{4}$.

The particle $P$ is pulled away from $O$ until the distance $OP$ is $2a$, and is then released from rest.

Find the total distance moved by $P$ before it first comes to instantaneous rest. [5]

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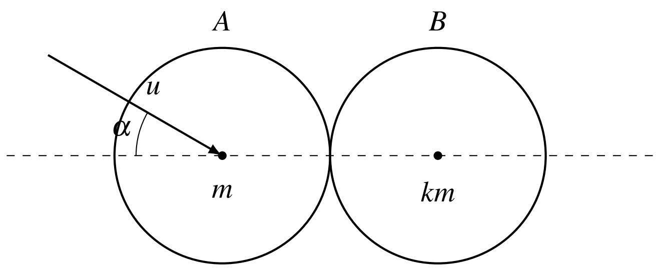
**2** A particle $P$ of mass $m$ is projected with speed $U$ along a horizontal surface. $P$ moves in a straight horizontal line. At time $t$, $P$ has displacement $x$ from its point of projection and its speed is $v$. The only horizontal force acting on $P$ is a resistive force of magnitude $mcv^3$, where $c$ is a positive constant.

**(a)** Find an expression for $v$ in terms of $x$, $c$ and $U$. [3]

**(b)** Find an expression for the time $T$ taken for the speed of $P$ to halve, giving your answer in terms of $c$ and $U$. [3]

**3** Two uniform smooth spheres $A$ and $B$ of equal radii have masses $m$ and $km$ respectively, where $k > 1$. The spheres are moving on a smooth horizontal surface. Sphere $A$ is moving with speed $u$ when it collides with sphere $B$ which is at rest. Immediately before the collision, $A$'s direction of motion makes an angle $\alpha$ with the line of centres (see diagram).




Immediately after the collision, $A$'s direction of motion is perpendicular to its original direction of motion. The coefficient of restitution between the spheres is $e$.

**(a)** Show that $\tan^2 \alpha = \frac{ke-1}{k+1}$. [4]

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**(b)** It is given that $e = 0.5$ and that, immediately after the collision, the kinetic energy of $B$ is equal to the kinetic energy of $A$.

Find the value of $k$ and the exact value of $\alpha$. [3]

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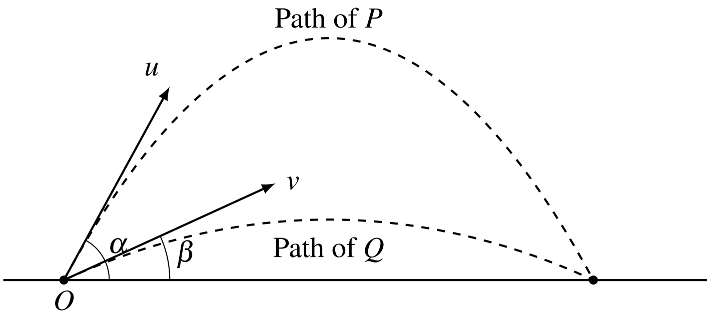
**4** Identical particles $P$ and $Q$ move freely under gravity in the same vertical plane. Particle $P$ is projected from a point $O$ on a horizontal plane with speed $u$ at an angle $\alpha$ above the horizontal.

When $P$ is at its maximum height, $Q$ is projected from $O$ with speed $v$ at an angle $\beta$ above the horizontal. The particles hit the plane at the same point and at the same time.



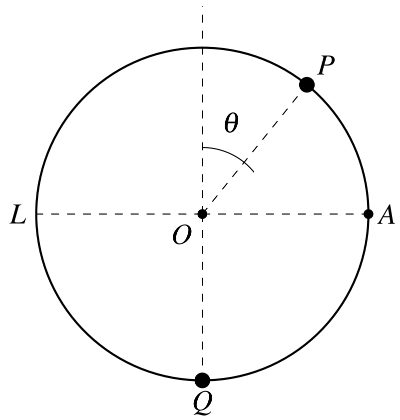

**(a)** Show that $\tan\beta = \frac{1}{4}\tan\alpha$. [4]

**(b)** Find an expression for $\frac{v^2}{u^2}$ in terms of $\alpha$. [2]

**(c)** It is given further that the initial kinetic energy of $Q$ is equal to the initial kinetic energy of $P$.

Find the value of $\tan \alpha$. [2]

**5** Two identical beads, $P$ and $Q$, each of mass $m$, are threaded on a fixed smooth circular wire of radius $a$ and centre $O$ in a vertical plane. Bead $Q$ is initially at rest at the lowest point $B$. The beads are sufficiently small that they can be treated as particles colliding exactly at $B$.




**(a)** In the first case, $P$ is released from rest at the point $A$ on the right side of the wire, where $OA$ is horizontal. At $B$, $P$ collides with $Q$. The coefficient of restitution between the beads is $e = \frac{\sqrt{2}}{2}$.

Find the exact height above $B$ reached by $Q$ in its subsequent motion, and deduce whether $Q$ reaches the point on the left side of the wire level with $O$. [4]

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**(b)** In a second case, $P$ is released from rest at a point $C$ on the upper right side of the wire, where $OC$ makes an angle $\theta$ with the upward vertical. At $B$, $P$ again collides with $Q$. The coefficient of restitution is now $e = \frac{1}{2}$.

After the collision, $Q$ exactly reaches the point on the left side of the wire level with $O$ before coming to instantaneous rest. Find the exact value of $\cos\theta$. [4]

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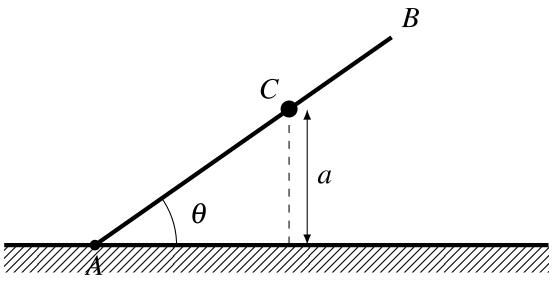


A uniform rod $AB$ of length $2a$ and weight $W$ rests in equilibrium. The end $A$ rests on a rough horizontal plane. The rod rests against a fixed smooth horizontal peg $C$. The point $C$ is at a vertical height $a$ above the plane. The rod lies in a vertical plane perpendicular to the peg. The rod makes an angle $\theta$ with the horizontal, where $0 < \theta < \frac{\pi}{2}$.

**(a)** Show that the normal reaction exerted by the peg on the rod is $W \sin\theta \cos\theta$. [3]

**(b)** Find an expression for the coefficient of friction $\mu$ between the rod and the plane, given that the rod is on the point of slipping. [3]

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**(c)** It is given that $\theta = 45^\circ$ and a particle of weight $kW$ is now attached to the rod at $B$. The rod is again on the point of slipping. Find the exact value of $k$ given that $\mu = 1$. [3]

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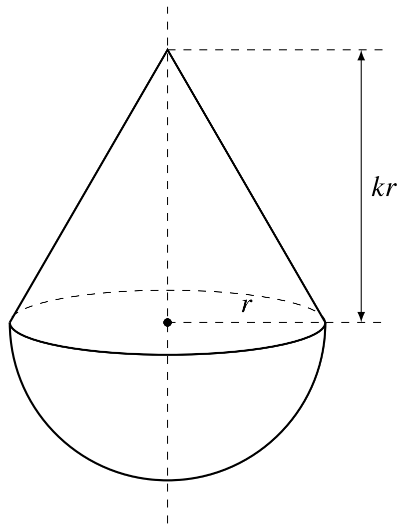
**7** An object is formed by attaching the circular base of a uniform solid cone, of radius $r$ and height $kr$, to the flat face of a uniform solid hemisphere of radius $r$. Both the cone and the hemisphere are made from the same material. The axes of symmetry of the cone and hemisphere coincide (see diagram).




**(a)** Show that the distance of the centre of mass of the object from the common flat face is $\frac{r(k^2-3)}{4(k+2)}$, taking the direction towards the vertex of the cone as positive. [3]

**(b)** The object is placed with its flat circular face in contact with a rough plane which is inclined at an angle $\theta$ to the horizontal. The plane is sufficiently rough to prevent sliding. The object is on the point of toppling. Given that $\tan\theta = \frac{10}{3}$, find the value of $k$. [2]

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**(c)** In a different case, the object is placed with its curved hemispherical surface on a horizontal plane. It is observed that the object can rest in equilibrium with **any** point of the spherical surface in contact with the plane.

Deduce the exact value of $k$. [2]

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