Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

MATHEMATICS **9709/53**

Paper 5 Mechanics 2 **(M2)** **October/November 2015**

1 hour 15 minutes

Additional Materials: Answer Booklet/Paper
Graph Paper
List of Formulae (MF9)

* 9 5 4 5 8 5 7 4 2 5 *

READ THESE INSTRUCTIONS FIRST

If you have been given an Answer Booklet, follow the instructions on the front cover of the Booklet.
Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** the questions.
Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.
Where a numerical value for the acceleration due to gravity is needed, use $10\,\text{m}\,\text{s}^{-2}$.
The use of an electronic calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper is 50.
Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.

This document consists of **3** printed pages and **1** blank page.

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1 A particle is projected with speed $25\,\text{m s}^{-1}$ at an angle of $50°$ above the horizontal. Calculate the time after projection when the particle has speed $18\,\text{m s}^{-1}$ and is rising. [4]

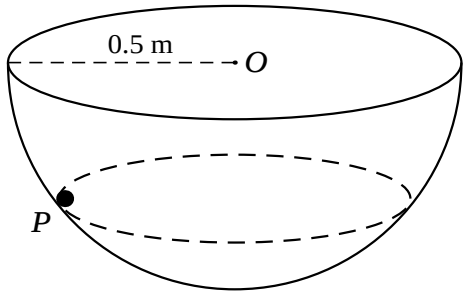
2 One end of a light inextensible string of length 0.5 m is attached to a fixed point $\boldsymbol{A}$. A particle $\boldsymbol{P}$ of mass 0.2 kg is attached to the other end of the string. $\boldsymbol{P}$ moves with constant speed in a horizontal circle with centre $\boldsymbol{O}$ which is 0.4 m vertically below $\boldsymbol{A}$.

(i) Show that the tension in the string is 2.5 N. [2]

(ii) Find the speed of $\boldsymbol{P}$. [3]

3 A particle $\boldsymbol{P}$ is projected with speed $\boldsymbol{V}\,\text{m s}^{-1}$ at an angle of $\theta°$ above the horizontal from a point $\boldsymbol{O}$ on horizontal ground. At the instant 4 s after projection the particle passes through the point $\boldsymbol{A}$, where $\boldsymbol{OA} = 40$ m and the line $\boldsymbol{OA}$ makes an angle of $30°$ with the horizontal. Calculate $\boldsymbol{V}$ and θ. [5]

4



A particle $\boldsymbol{P}$ of mass 0.4 kg moves with constant speed in a horizontal circle on the smooth inner surface of a fixed hollow hemisphere with centre $\boldsymbol{O}$ and radius 0.5 m (see diagram).

(i) Given that the speed of the particle is $4\,\text{m s}^{-1}$ and its angular speed is $10\,\text{rad s}^{-1}$, calculate the angle between $\boldsymbol{OP}$ and the vertical. [2]

(ii) Given instead that the magnitude of the force exerted on $\boldsymbol{P}$ by the hemisphere is 6 N, calculate

(a) the angle between $\boldsymbol{OP}$ and the vertical, [2]

(b) the angular speed of $\boldsymbol{P}$. [3]

5 A particle $\boldsymbol{P}$ of mass 0.5 kg is projected vertically upwards from a point on a horizontal surface. A resisting force of magnitude $0.02\boldsymbol{v}^2$ N acts on $\boldsymbol{P}$, where $\boldsymbol{v}\,\text{m s}^{-1}$ is the upward velocity of $\boldsymbol{P}$ when it is a height of $\boldsymbol{x}$ m above the surface. The initial speed of $\boldsymbol{P}$ is $8\,\text{m s}^{-1}$.

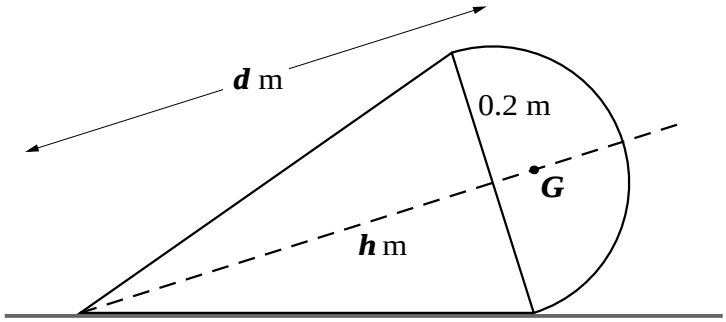
(i) Show that, while $\boldsymbol{P}$ is moving upwards, $\boldsymbol{v}\dfrac{\text{d}\boldsymbol{v}}{\text{d}\boldsymbol{x}} = -10 - 0.04\boldsymbol{v}^2$. [2]

(ii) Find the greatest height of $\boldsymbol{P}$ above the surface. [3]

(iii) Find the speed of $\boldsymbol{P}$ immediately before it strikes the surface after descending. [4]

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6



An object is formed by joining a hemispherical shell of radius 0.2 m and a solid cone with base radius 0.2 m and height h m along their circumferences. The centre of mass, G, of the object is d m from the vertex of the cone on the axis of symmetry of the object. The object rests in equilibrium on a horizontal plane, with the curved surface of the cone in contact with the plane (see diagram). The object is on the point of toppling.

(i) Show that $d = h + \frac{0.04}{h}$. [3]

(ii) It is given that the cone is uniform and of weight 4 N, and that the hemispherical shell is uniform and of weight W N. Given also that $h = 0.8$, find W. [6]

7 A particle P of mass M kg is attached to one end of a light elastic string of natural length 0.8 m and modulus of elasticity 12.5 N. The other end of the string is attached to a fixed point A. The particle is released from rest at A and falls vertically until it comes to instantaneous rest at the point B. The greatest speed of P during its descent is $4.4\ \text{m s}^{-1}$ when the extension of the string is e m.

(i) Show that $e = 0.64M$. [2]

(ii) Find a second equation in e and M, and hence find M. [6]

(iii) Calculate the distance AB. [3]

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