Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

MATHEMATICS **9709/51**

Paper 5 Mechanics 2 **(M2)** **October/November 2014**

1 hour 15 minutes

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

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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.

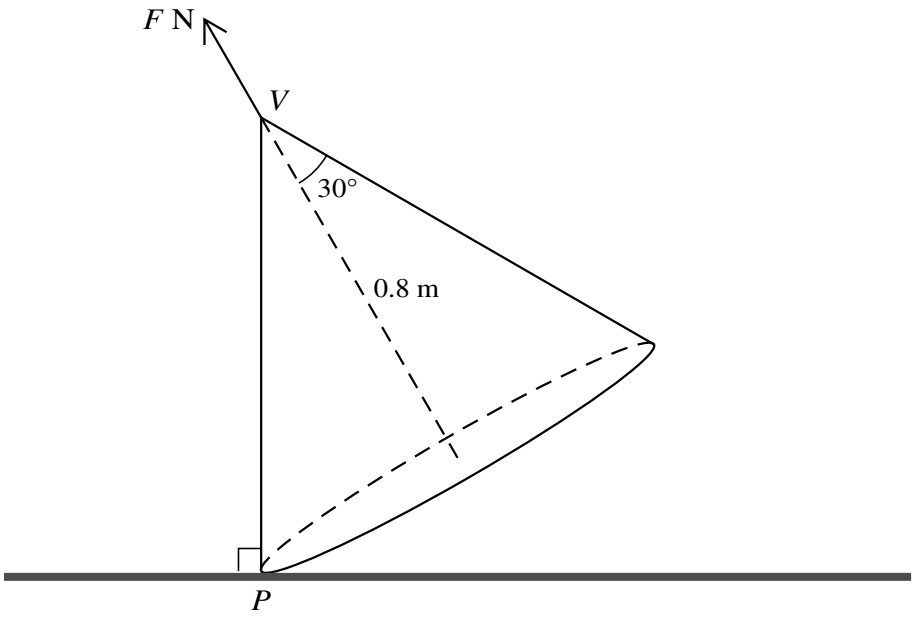
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper is 50.
Questions carrying smaller numbers of marks are printed earlier in the paper, and questions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

This document consists of **4** printed pages.

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1 A particle P is projected with speed V m s^{-1} at an angle of 30° above the horizontal from a point O on horizontal ground. At the instant 2 s after projection, OP makes an angle of 15° above the horizontal. Calculate V. [4]

2



A uniform solid cone with height 0.8 m and semi-vertical angle 30° has weight 20 N. The cone rests in equilibrium with a single point P of its base in contact with a rough horizontal surface, and its vertex V vertically above P. Equilibrium is maintained by a force of magnitude F N acting along the axis of symmetry of the cone and applied to V (see diagram).

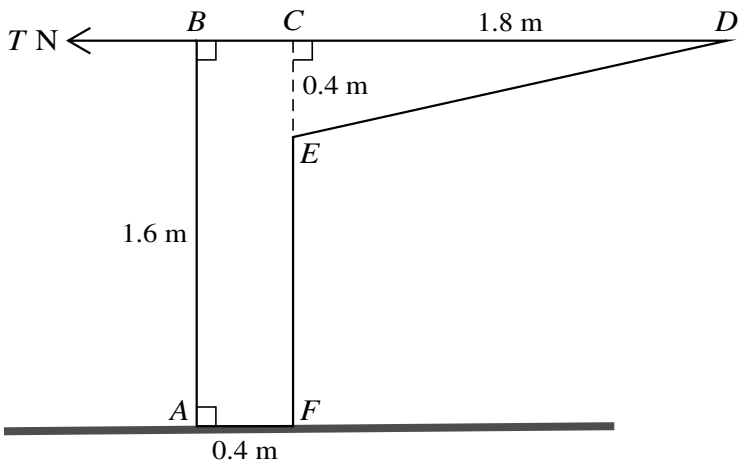
(i) Show that the moment of the weight of the cone about P is 6 N m. [2]

(ii) Hence find F. [2]

3 One end of a light elastic string of natural length 1.6 m and modulus of elasticity 28 N is attached to a fixed point O. The other end of the string is attached to a particle P of mass 0.35 kg which hangs in equilibrium vertically below O. The particle P is projected vertically upwards from the equilibrium position with speed 1.8 m s^{-1}. Calculate the speed of P at the instant the string first becomes slack. [5]

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4



ABCDEF is the cross-section through the centre of mass of a uniform solid prism. *ABCF* is a rectangle in which $AB = CF = 1.6$ m, and $BC = AF = 0.4$ m. *CDE* is a triangle in which $CD = 1.8$ m, $CE = 0.4$ m, and angle $DCE = 90°$. The prism stands on a rough horizontal surface. A horizontal force of magnitude T N acts at B in the direction CB (see diagram). The prism is in equilibrium.

(i) Show that the distance of the centre of mass of the prism from AB is 0.488 m. [4]

(ii) Given that the weight of the prism is 100 N, find the greatest and least possible values of T. [3]

5 The equation of the trajectory of a small ball B projected from a fixed point O is

$$y = -0.05x^2,$$

where x and y are, respectively, the displacements in metres of B from O in the horizontal and vertically upwards directions.

(i) Show that B is projected horizontally, and find its speed of projection. [3]

(ii) Find the value of y when the direction of motion of B is 60° below the horizontal, and find the corresponding speed of B. [6]

6 O, A and B are three points in a straight line on a smooth horizontal surface. A particle P of mass 0.6 kg moves along the line. At time t s the particle has displacement x m from O and speed v m s^{-1}. The only horizontal force acting on P has magnitude $0.4v^{\frac{1}{2}}$ N and acts in the direction OA. Initially the particle is at A, where $x = 1$ and $v = 1$.

(i) Show that $3v^{\frac{1}{2}}\dfrac{\mathrm{d}v}{\mathrm{d}x} = 2$. [2]

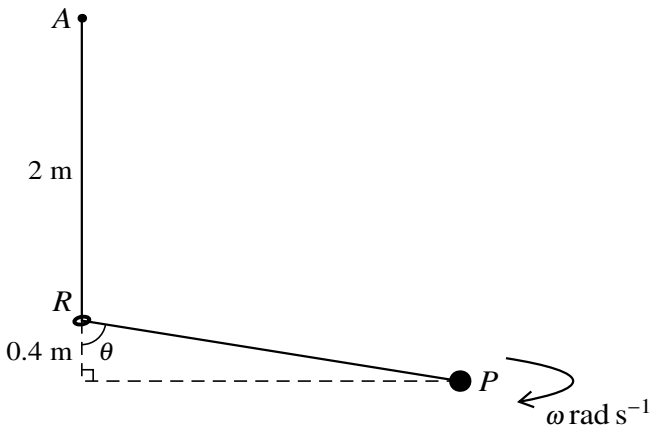
(ii) Express v in terms of x. [4]

(iii) Given that $AB = 7$ m, find the value of t when P passes through B. [3]

[Question 7 is printed on the next page.]

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7



One end of a light elastic string with modulus of elasticity 15 N is attached to a fixed point A which is 2 m vertically above a fixed small smooth ring R. The string has natural length 2 m and it passes through R. The other end of the string is attached to a particle P of mass m kg which moves with constant angular speed ω rad s^{-1} in a horizontal circle which has its centre 0.4 m vertically below the ring. PR makes an acute angle θ with the vertical (see diagram).

(i) Show that the tension in the string is $\dfrac{3}{\cos\theta}$ N and hence find the value of m. [4]

(ii) Show that the value of ω does not depend on θ. [4]

It is given that for one value of θ the elastic potential energy stored in the string is twice the kinetic energy of P.

(iii) Find this value of θ. [4]

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