Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

8496452985

MATHEMATICS **9709/52**

Paper 5 Mechanics 2 **(M2)** **October/November 2018**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name in the spaces at the top of this page.
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 in the space provided. If additional space is required, you should use the lined page at the end of this booklet. The question number(s) must be clearly shown.
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 $10\,\mathrm{m\,s^{-2}}$.
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.

This document consists of **14** printed pages and **2** blank pages.

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CAMBRIDGE International Examinations

[Turn over

1 A small ball B is projected with speed $38\,\mathrm{m\,s^{-1}}$ at an angle of $30°$ to the horizontal from a point on horizontal ground. Find the speed of B when the path of B makes an angle of $20°$ above the horizontal. [3]

2 A uniform solid object is made by attaching a cone to a cylinder so that the circumferences of the base of the cone and a plane face of the cylinder coincide. The cone and the cylinder each have radius 0.3 m and height 0.4 m.

(i) Calculate the distance of the centre of mass of the object from the vertex of the cone. [4]

[The volume of a cone is $\frac{1}{3}\pi r^2 h$.]

The object has weight W N and is placed with its plane circular face on a rough horizontal surface. A force of magnitude kW N acting at 30° to the upward vertical is applied to the vertex of the cone. The object does not slip.

(ii) Find the greatest possible value of k for which the object does not topple. [3]

3 A particle P of mass 0.4 kg is projected horizontally along a smooth horizontal plane from a point O. After projection the velocity of P is $v\,\mathrm{m\,s^{-1}}$ and its displacement from O is x m. A force of magnitude $8x$ N directed away from O acts on P and a force of magnitude $(2e^{-x} + 4)$ N opposes the motion of P. One end of a light elastic string of natural length 0.5 m is attached to O and the other end of the string is attached to P.

(i) Show that $v\dfrac{dv}{dx} = 20x - 10 - 5e^{-x}$ before the elastic string becomes taut. [2]

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(ii) Given that the initial velocity of P is $6\,\mathrm{m\,s^{-1}}$, find v when the string first becomes taut. [3]

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When the string is taut, the acceleration of P is proportional to e^{-x}.

(iii) Find the modulus of elasticity of the string. [2]

4 A small object is projected horizontally with speed $V \text{ m s}^{-1}$ from a point O above horizontal ground. At time t s after projection, the horizontal and vertically upwards displacements of the object from O are x m and y m respectively.

(i) Express x and y in terms of t and hence show that the equation of the path of the object is $y = -\dfrac{5x^2}{V^2}$. [3]

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The object passes through points with coordinates $(a, -a)$ and $(a^2, -16a)$, where a is a positive constant.

(ii) Find the value of a. [3]

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(iii) Given that the object strikes the ground at the point where $x = 5a$, find the height of O above the ground . [2]

5 A particle P of mass 0.7 kg is attached to a fixed point O by a light elastic string of natural length 0.6 m and modulus of elasticity 15 N. The particle P is projected vertically downwards from the point A, 0.8 m vertically below O. The initial speed of P is $2\,\mathrm{m\,s^{-1}}$.

(i) Find the distance below A of the point at which P comes to instantaneous rest. [4]

(ii) Find the greatest speed of P in the motion. [4]

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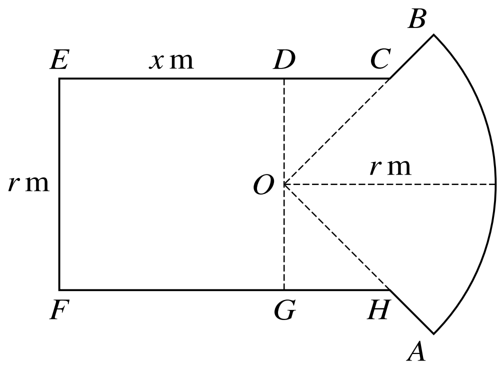

The diagram shows a uniform lamina $ABCDEFGH$. The lamina consists of a quarter-circle OAB of radius r m, a rectangle $DEFG$ and two isosceles right-angled triangles COD and GOH. The rectangle has $DG = EF = r$ m and $DE = FG = x$ m.

(i) Given that the centre of mass of the lamina is at O, express x in terms of r. [6]

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(ii) Given instead that the rectangle $DEFG$ is a square with edges of length r m, state with a reason whether the centre of mass of the lamina lies within the square or the quarter-circle. [1]

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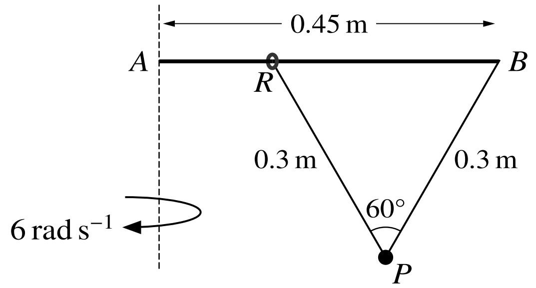

A rough horizontal rod AB of length 0.45 m rotates with constant angular velocity $6\,\text{rad}\,\text{s}^{-1}$ about a vertical axis through A. A small ring R of mass 0.2 kg can slide on the rod. A particle P of mass 0.1 kg is attached to the mid-point of a light inextensible string of length 0.6 m. One end of the string is attached to R and the other end of the string is attached to B, with angle $RPB = 60°$ (see diagram). R and P move in horizontal circles as the system rotates. R is in limiting equilibrium.

(i) Show that the tension in the portion PR of the string is 1.66 N, correct to 3 significant figures. [5]

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(ii) Find the coefficient of friction between the ring and the rod. [5]

Additional Page

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