Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER				

5490161887

MATHEMATICS **9709/51**

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 $10\,\text{m}\,\text{s}^{-2}$.
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.

This document consists of **15** printed pages and **1** blank page.

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1 A small ball B is projected with speed $30\,\mathrm{m\,s^{-1}}$ at an angle of $60°$ to the horizontal from a point on horizontal ground. Find the time after projection when the speed of B is $25\,\mathrm{m\,s^{-1}}$ for the second time. [4]

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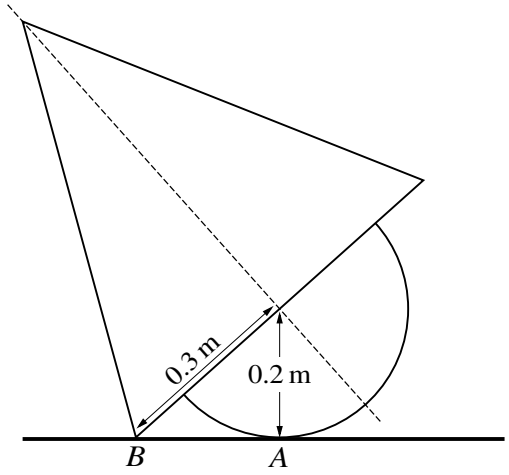

A uniform object is made by attaching the base of a solid hemisphere to the base of a solid cone so that the object has an axis of symmetry. The base of the cone has radius 0.3 m, and the hemisphere has radius 0.2 m. The object is placed on a horizontal plane with a point A on the curved surface of the hemisphere and a point B on the circumference of the cone in contact with the plane (see diagram).

(i) Given that the object is on the point of toppling about B, find the distance of the centre of mass of the object from the base of the cone. [3]

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(ii) Given instead that the object is on the point of toppling about A, calculate the height of the cone. [3]

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

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3 A particle P of mass 0.4 kg is attached to a fixed point O by a light elastic string of natural length 0.5 m and modulus of elasticity 20 N. The particle P is released from rest at O.

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

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(ii) Find the distance below O of the point at which P comes to instantaneous rest. [3]

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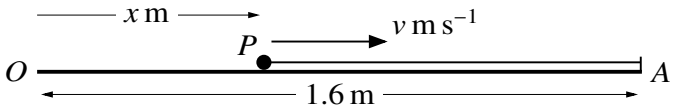

A particle P of mass 0.5 kg is projected along a smooth horizontal surface towards a fixed point A. Initially P is at a point O on the surface, and after projection, P has a displacement from O of x m and velocity $v\,\mathrm{m\,s^{-1}}$. The particle P is connected to A by a light elastic string of natural length 0.8 m and modulus of elasticity 16 N. The distance OA is 1.6 m (see diagram). The motion of P is resisted by a force of magnitude $24x^2$ N.

(i) Show that $v\dfrac{\mathrm{d}v}{\mathrm{d}x} = 32 - 40x - 48x^2$ while P is in motion and the string is stretched. [3]

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The maximum value of v is 4.5.

(ii) Find the initial value of v. [5]

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5 A particle P of mass 0.1 kg is attached to one end of a light inextensible string of length 0.5 m. The other end of the string is attached to a fixed point A. The particle P moves in a circle which has its centre O on a smooth horizontal surface 0.3 m below A. The tension in the string has magnitude T N and the magnitude of the force exerted on P by the surface is R N.

(i) Given that the speed of P is $1.5\,\mathrm{m\,s^{-1}}$, calculate T and R. [4]

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(ii) Given instead that $T = R$, calculate the angular speed of P. [4]

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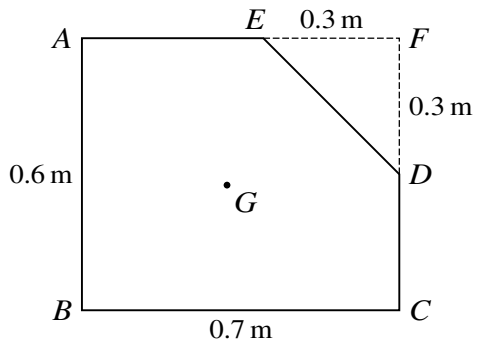

Fig. 1

Fig. 1 shows the cross-section $ABCDE$ through the centre of mass G of a uniform prism. The cross-section consists of a rectangle $ABCF$ from which a triangle DEF has been removed; $AB = 0.6$ m, $BC = 0.7$ m and $DF = EF = 0.3$ m.

(i) Show that the distance of G from BC is 0.276 m, and find the distance of G from AB. [5]

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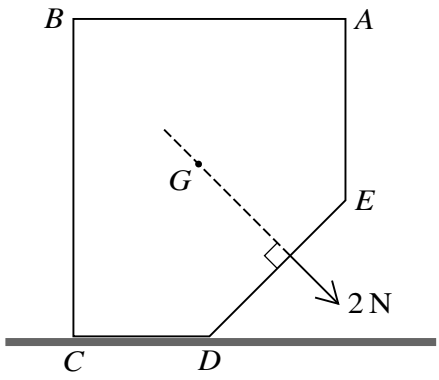

Fig. 2

The prism is placed with CD on a rough horizontal surface. A force of magnitude 2 N acting in the plane of the cross-section is applied to the prism. The line of action of the force passes through G and is perpendicular to DE (see Fig. 2). The prism is on the point of toppling about the edge through D.

(ii) Calculate the weight of the prism. [3]

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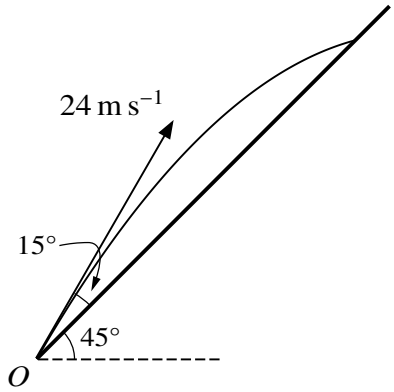

A small object is projected with speed 24 m s^{-1} from a point O at the foot of a plane inclined at 45° to the horizontal. The angle of projection of the object is 15° above a line of greatest slope of the plane (see diagram). At time t s after projection, the horizontal and vertically upwards displacements of the object from O are x m and y m respectively.

(i) Express x and y in terms of t, and hence find the value of t for the instant when the object strikes the plane. [4]

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(ii) Express the vertical height of the object above the plane in terms of t and hence find the greatest vertical height of the object above the plane. [5]

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Additional Page

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