OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE UNIT **4729/01**

MATHEMATICS

Mechanics 2

WEDNESDAY 20 JUNE 2007 Afternoon

Time: 1 hour 30 minutes

Additional Materials: Answer Booklet (8 pages)
List of Formulae (MF1)

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the spaces provided on the answer booklet.
- Answer **all** the questions.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question or is clearly appropriate.
- The acceleration due to gravity is denoted by $g\,\mathrm{m\,s^{-2}}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.
- You are permitted to use a graphical calculator in this paper.

INFORMATION FOR CANDIDATES

- 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 72.

ADVICE TO CANDIDATES

- Read each question carefully and make sure you know what you have to do before starting your answer.
- **You are reminded of the need for clear presentation in your answers.**

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

1 A man drags a sack at constant speed in a straight line along horizontal ground by means of a rope attached to the sack. The rope makes an angle of 35° with the horizontal and the tension in the rope is 40 N. Calculate the work done in moving the sack 100 m. [3]

2 Calculate the range on a horizontal plane of a small stone projected from a point on the plane with speed $12\,\mathrm{m\,s^{-1}}$ at an angle of elevation of 27°. [4]

3 A rocket of mass 250 kg is moving in a straight line in space. There is no resistance to motion, and the mass of the rocket is assumed to be constant. With its motor working at a constant rate of 450 kW the rocket's speed increases from $100\,\mathrm{m\,s^{-1}}$ to $150\,\mathrm{m\,s^{-1}}$ in a time t seconds.

(i) Calculate the value of t. [4]

(ii) Calculate the acceleration of the rocket at the instant when its speed is $120\,\mathrm{m\,s^{-1}}$. [4]

4 A ball is projected from a point O on the edge of a vertical cliff. The horizontal and vertically upward components of the initial velocity are $7\,\mathrm{m\,s^{-1}}$ and $21\,\mathrm{m\,s^{-1}}$ respectively. At time t seconds after projection the ball is at the point (x, y) referred to horizontal and vertically upward axes through O. Air resistance may be neglected.

(i) Express x and y in terms of t, and hence show that $y = 3x - \frac{1}{10}x^2$. [5]

The ball hits the sea at a point which is 25 m below the level of O.

(ii) Find the horizontal distance between the cliff and the point where the ball hits the sea. [3]

5 A cyclist and her bicycle have a combined mass of 70 kg. The cyclist ascends a straight hill AB of constant slope, starting from rest at A and reaching a speed of $4\,\mathrm{m\,s^{-1}}$ at B. The level of B is 6 m above the level of A. For the cyclist's motion from A to B, find

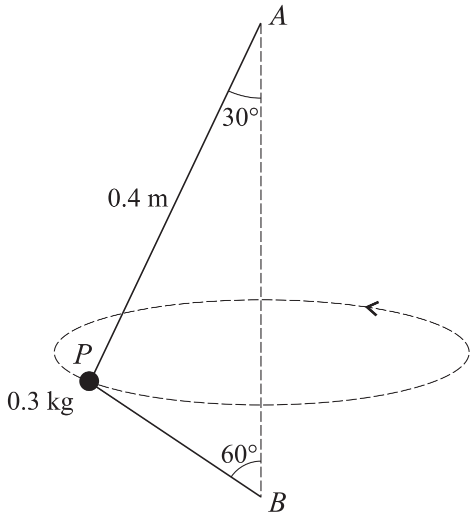
(i) the increase in kinetic energy, [2]

(ii) the increase in gravitational potential energy. [2]

During the ascent the resistance to motion is constant and has magnitude 60 N. The work done by the cyclist in moving from A to B is 8000 J.

(iii) Calculate the distance AB. [4]

6



A particle P of mass 0.3 kg is attached to one end of each of two light inextensible strings. The other end of the longer string is attached to a fixed point A and the other end of the shorter string is attached to a fixed point B, which is vertically below A. AP makes an angle of 30° with the vertical and is 0.4 m long. PB makes an angle of 60° with the vertical. The particle moves in a horizontal circle with constant angular speed and with both strings taut (see diagram). The tension in the string AP is 5 N.

Calculate

(i) the tension in the string PB, [3]

(ii) the angular speed of P, [3]

(iii) the kinetic energy of P. [3]

7 Two small spheres A and B, with masses 0.3 kg and m kg respectively, lie at rest on a smooth horizontal surface. A is projected directly towards B with speed $6\,\text{m s}^{-1}$ and hits B. The direction of motion of A is reversed in the collision. The speeds of A and B after the collision are $1\,\text{m s}^{-1}$ and $3\,\text{m s}^{-1}$ respectively. The coefficient of restitution between A and B is e.

(i) Show that $m = 0.7$. [2]

(ii) Find e. [2]

B continues to move at $3\,\text{m s}^{-1}$ and strikes a vertical wall at right angles. The coefficient of restitution between B and the wall is f.

(iii) Find the range of values of f for which there will be a second collision between A and B. [2]

(iv) Find, in terms of f, the magnitude of the impulse that the wall exerts on B. [3]

(v) Given that $f = \frac{3}{4}$, calculate the final speeds of A and B, correct to 1 decimal place. [7]

[Question 8 is printed overleaf.]

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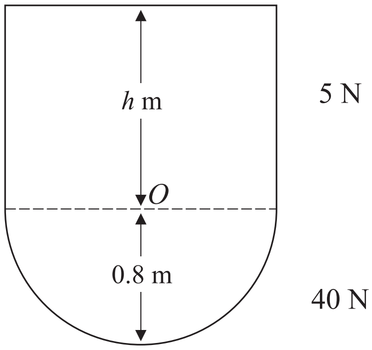

Fig. 1

An object consists of a uniform solid hemisphere of weight 40 N and a uniform solid cylinder of weight 5 N. The cylinder has height h m. The solids have the same base radius 0.8 m and are joined so that the hemisphere's plane face coincides with one of the cylinder's faces. The centre of the common face is the point O (see Fig. 1). The centre of mass of the object lies inside the hemisphere and is at a distance of 0.2 m from O.

(i) Show that $h = 1.2$. [6]

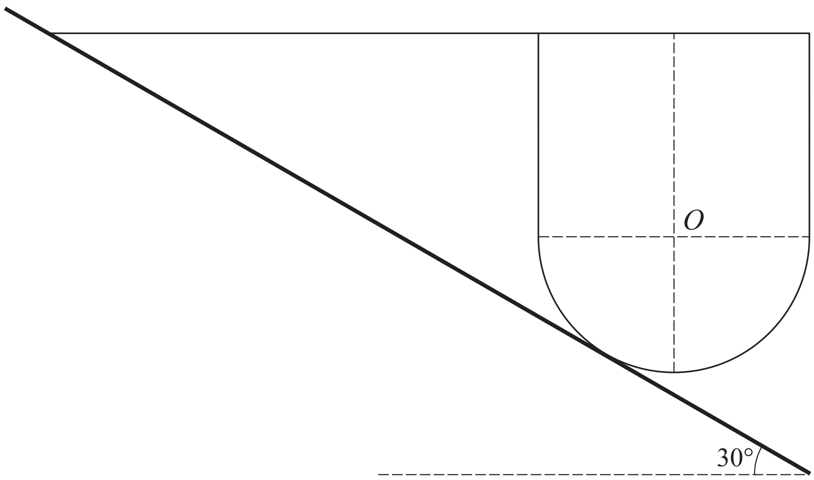

Fig. 2

One end of a light inextensible string is attached to a point on the circumference of the upper face of the cylinder. The string is horizontal and its other end is tied to a fixed point on a rough plane. The object rests in equilibrium on the plane with its axis of symmetry vertical. The plane makes an angle of 30° with the horizontal (see Fig. 2). The tension in the string is T N and the frictional force acting on the object is F N.

(ii) By taking moments about O, express F in terms of T. [4]

(iii) Find another equation connecting T and F. Hence calculate the tension and the frictional force. [6]