OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MATHEMATICS 4728

Mechanics 1

Tuesday **10 JANUARY 2006** Afternoon 1 hour 30 minutes

Additional materials:
8 page answer booklet
Graph paper
List of Formulae (MF1)

TIME 1 hour 30 minutes

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.
- Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.
- **You are reminded of the need for clear presentation in your answers.**

This question paper consists of 5 printed pages and 3 blank pages.

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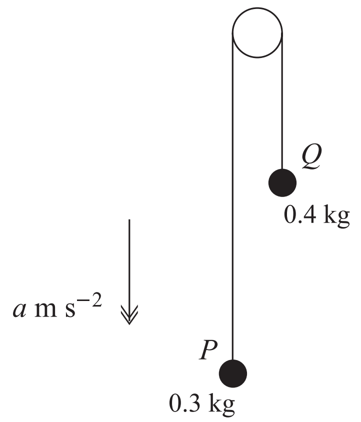
1



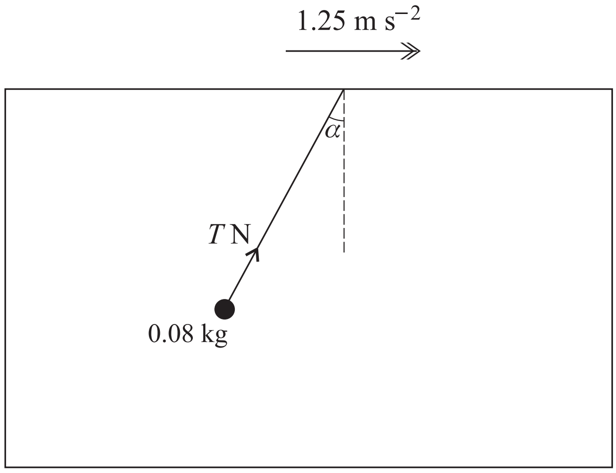
Particles P and Q, of masses 0.3 kg and 0.4 kg respectively, are attached to the ends of a light inextensible string. The string passes over a smooth fixed pulley. The system is in motion with the string taut and with each of the particles moving vertically. The downward acceleration of P is a m s^{-2} (see diagram).

(i) Show that $a = -1.4$. [4]

Initially P and Q are at the same horizontal level. P's initial velocity is vertically downwards and has magnitude 2.8 m s^{-1}.

(ii) Assuming that P does not reach the floor and that Q does not reach the pulley, find the time taken for P to return to its initial position. [3]

2



An object of mass 0.08 kg is attached to one end of a light inextensible string. The other end of the string is attached to the underside of the roof inside a furniture van. The van is moving horizontally with constant acceleration 1.25 m s^{-2}. The string makes a constant angle α with the downward vertical and the tension in the string is T N (see diagram).

(i) By applying Newton's second law horizontally to the object, find the value of $T \sin \alpha$. [2]

(ii) Find the value of T. [5]

3 A motorcyclist starts from rest at a point O and travels in a straight line. His velocity after t seconds is $v\,\mathrm{m\,s^{-1}}$, for $0 \leqslant t \leqslant T$, where $v = 7.2t - 0.45t^2$. The motorcyclist's acceleration is zero when $t = T$.

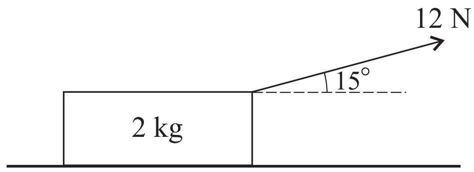
(i) Find the value of T. [4]

(ii) Show that $v = 28.8$ when $t = T$. [1]

For $t \geqslant T$ the motorcyclist travels in the same direction as before, but with constant speed $28.8\,\mathrm{m\,s^{-1}}$.

(iii) Find the displacement of the motorcyclist from O when $t = 31$. [6]

4



A block of mass 2 kg is at rest on a rough horizontal plane, acted on by a force of magnitude 12 N at an angle of 15° upwards from the horizontal (see diagram).

(i) Find the frictional component of the contact force exerted on the block by the plane. [2]

(ii) Show that the normal component of the contact force exerted on the block by the plane has magnitude 16.5 N, correct to 3 significant figures. [2]

It is given that the block is on the point of sliding.

(iii) Find the coefficient of friction between the block and the plane. [2]

The force of magnitude 12 N is now replaced by a horizontal force of magnitude 20 N. The block starts to move.

(iv) Find the acceleration of the block. [5]

5 A man drives a car on a horizontal straight road. At $t = 0$, where the time t is in seconds, the car runs out of petrol. At this instant the car is moving at $12\,\mathrm{m\,s^{-1}}$. The car decelerates uniformly, coming to rest when $t = 8$. The man then walks back along the road at $0.7\,\mathrm{m\,s^{-1}}$ until he reaches a petrol station a distance of 420 m from his car. After his arrival at the petrol station it takes him 250 s to obtain a can of petrol. He is then given a lift back to his car on a motorcycle. The motorcycle starts from rest and accelerates uniformly until its speed is $20\,\mathrm{m\,s^{-1}}$; it then decelerates uniformly, coming to rest at the stationary car at time $t = T$.

(i) Sketch the shape of the (t, v) graph for the man for $0 \leqslant t \leqslant T$. [Your sketch need not be drawn to scale; numerical values need not be shown.] [5]

(ii) Find the deceleration of the car for $0 < t < 8$. [2]

(iii) Find the value of T. [4]

6

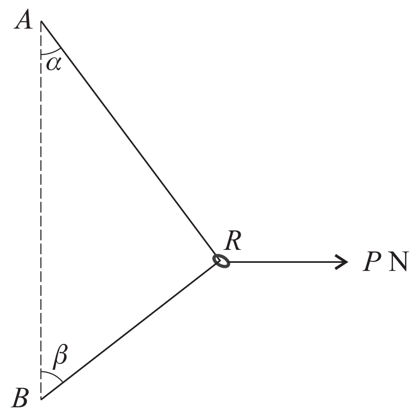


Fig. 1

A smooth ring R of weight W N is threaded on a light inextensible string. The ends of the string are attached to fixed points A and B, where A is vertically above B. A horizontal force of magnitude P N acts on R. The system is in equilibrium with the string taut; AR makes an angle α with the downward vertical and BR makes an angle β with the upward vertical (see Fig. 1).

(i) By considering the vertical components of the forces acting on R, show that $\alpha < \beta$. [3]

(ii)

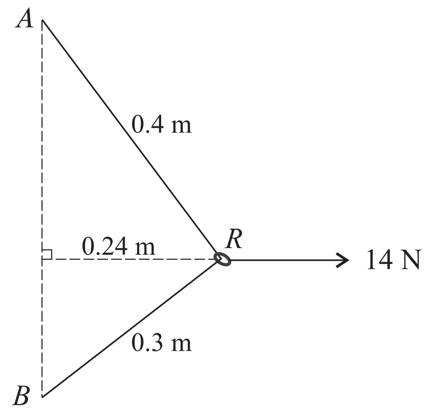


Fig. 2

It is given that when $P = 14$, $AR = 0.4$ m, $BR = 0.3$ m and the distance of R from the vertical line AB is 0.24 m (see Fig. 2). Find

(a) the tension in the string, [3]

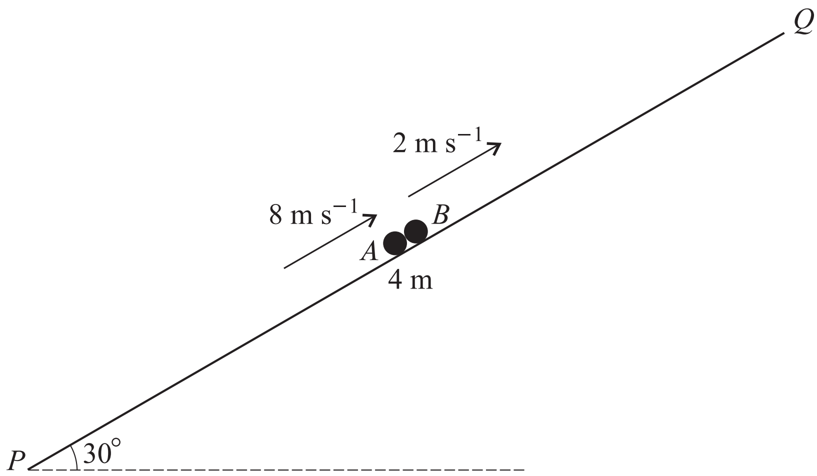
(b) the value of W. [3]

(iii) For the case when $P = 0$,

(a) describe the position of R, [1]

(b) state the tension in the string. [1]

7



PQ is a line of greatest slope, of length 4 m, on a smooth plane inclined at 30° to the horizontal. Particles A and B, of masses 0.15 kg and 0.5 kg respectively, move along PQ with A below B. The particles are both moving upwards, A with speed $8\,\text{m s}^{-1}$ and B with speed $2\,\text{m s}^{-1}$, when they collide at the mid-point of PQ (see diagram). Particle A is instantaneously at rest immediately after the collision.

(i) Show that B does not reach Q in the subsequent motion. [8]

(ii) Find the time interval between the instant of A's arrival at P and the instant of B's arrival at P. [6]

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