OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MATHEMATICS 4728

Mechanics 1

Friday **21 JANUARY 2005** Afternoon 1 hour 30 minutes

Additional materials:
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 $g\,\text{m s}^{-2}$. 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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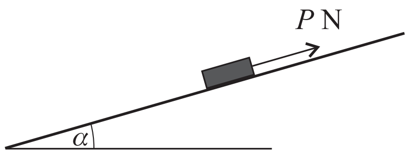
1



A box of weight 100 N rests in equilibrium on a plane inclined at an angle α to the horizontal. It is given that $\sin \alpha = 0.28$ and $\cos \alpha = 0.96$. A force of magnitude P N acts on the box parallel to the plane in the upwards direction (see diagram). The coefficient of friction between the box and the plane is 0.25.

(i) Find the magnitude of the normal force acting on the box. [2]

(ii) Given that the equilibrium is limiting, show that the magnitude of the frictional force acting on the box is 24 N. [1]

(iii) Find the value of P for which the box is on the point of slipping

(a) down the plane,

(b) up the plane.

[3]

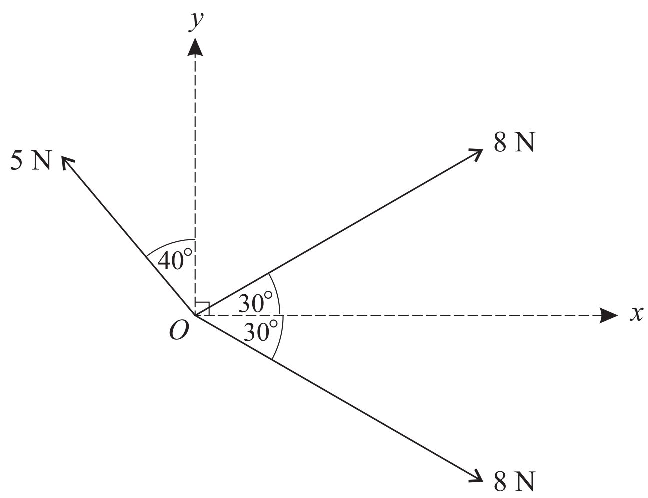
2

Three small uniform spheres A, B and C have masses 0.4 kg, 1.2 kg and m kg respectively. The spheres move in the same straight line on a smooth horizontal table, with B between A and C. Sphere A is moving towards B with speed 6 m s^{-1}, B is moving towards A with speed 2 m s^{-1} and C is moving towards B with speed 4 m s^{-1} (see diagram). Spheres A and B collide. After this collision B moves with speed 1 m s^{-1} towards C.

(i) Find the speed with which A moves after the collision and state the direction of motion of A. [5]

(ii) Spheres B and C now collide and move away from each other with speeds 0.5 m s^{-1} and 2 m s^{-1} respectively. Find the value of m. [3]

3



Three coplanar forces of magnitudes 5 N, 8 N and 8 N act at the origin O of rectangular coordinate axes. The directions of the forces are as shown in the diagram.

(i) Find the component of the resultant of the three forces in

(a) the x-direction,

(b) the y-direction. [5]

(ii) Find the magnitude and direction of the resultant. [4]

4 A particle moves in a straight line. Its velocity t s after leaving a fixed point on the line is $v\,\mathrm{m\,s^{-1}}$, where $v = t + 0.1t^2$. Find

(i) an expression for the acceleration of the particle at time t, [2]

(ii) the distance travelled by the particle from time $t = 0$ until the instant when its acceleration is $2.8\,\mathrm{m\,s^{-2}}$. [7]

5 Two particles A and B are projected vertically upwards from horizontal ground at the same instant. The speeds of projection of A and B are $7\,\mathrm{m\,s^{-1}}$ and $10.5\,\mathrm{m\,s^{-1}}$ respectively.

(i) Write down expressions for the heights above the ground of A and B at time t seconds after projection. [1]

(ii) Hence find a simplified expression for the difference in the heights of A and B at time t seconds after projection. [1]

(iii) Find the difference in the heights of A and B when A is at its maximum height. [3]

At the instant when B is 3.5 m above A, find

(iv) whether A is moving upwards or downwards, [3]

(v) the height of A above the ground. [2]

6

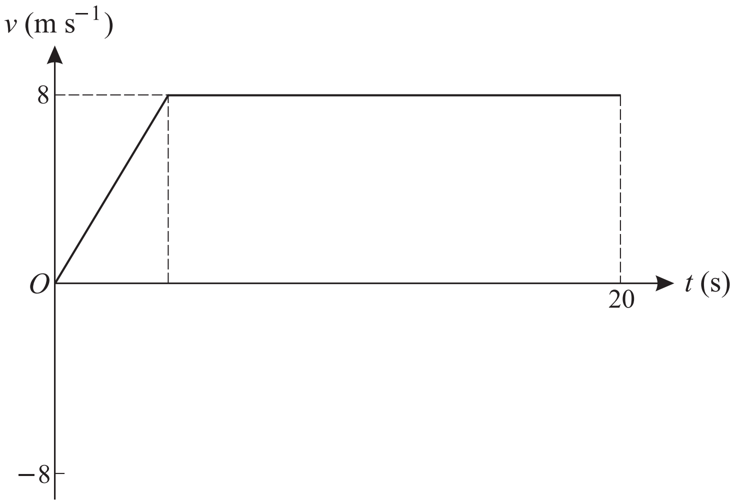


Fig. 1

A cyclist P travels along a straight road starting from rest at A and accelerating at $2\,\mathrm{m\,s^{-2}}$ up to a speed of $8\,\mathrm{m\,s^{-1}}$. He continues at a constant speed of $8\,\mathrm{m\,s^{-1}}$, passing through the point B 20 s after leaving A. Fig. 1 shows the (t, v) graph of P's journey for $0 \leqslant t \leqslant 20$. Find

(i) the time for which P is accelerating, [2]

(ii) the distance AB. [3]

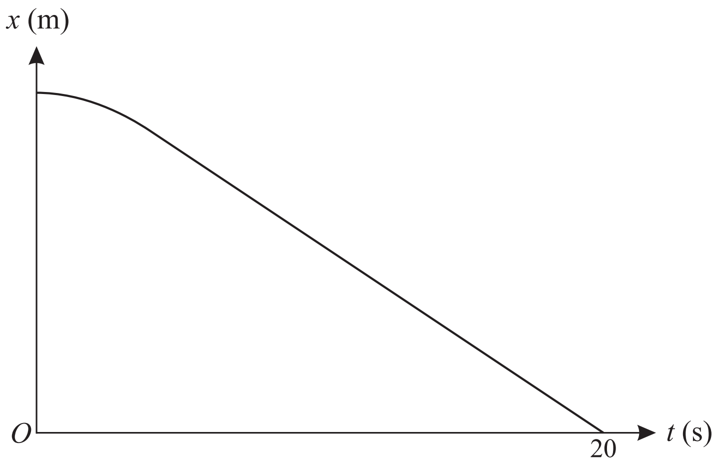


Fig. 2

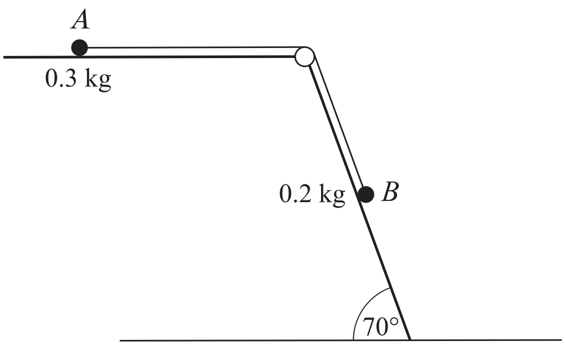
Another cyclist Q travels along the same straight road in the opposite direction. She starts at rest from B at the same instant that P leaves A. Cyclist Q accelerates at $2\,\mathrm{m\,s^{-2}}$ up to a speed of $8\,\mathrm{m\,s^{-1}}$ and continues at a constant speed of $8\,\mathrm{m\,s^{-1}}$, passing through the point A 20 s after leaving B. Fig. 2 shows the (t, x) graph of Q's journey for $0 \leqslant t \leqslant 20$, where x is the displacement of Q from A towards B.

(iii) Sketch a copy of Fig. 1 and add to your copy a sketch of the (t, v) graph of Q's journey for $0 \leqslant t \leqslant 20$. [2]

(iv) Sketch a copy of Fig. 2 and add to your copy a sketch of the (t, x) graph of P's journey for $0 \leqslant t \leqslant 20$. [3]

(v) Find the value t at the instant that P and Q pass each other. [3]

7



The upper edge of a smooth plane inclined at 70° to the horizontal is joined to an edge of a rough horizontal table. Particles *A* and *B*, of masses 0.3 kg and 0.2 kg respectively, are attached to the ends of a light inextensible string. The string passes over a smooth pulley which is fixed at the top of the smooth inclined plane. Particle *A* is held in contact with the rough horizontal table and particle *B* is in contact with the smooth inclined plane with the string taut (see diagram). The coefficient of friction between *A* and the horizontal table is 0.4. Particle *A* is released from rest and the system starts to move.

(i) Find the acceleration of *A* and the tension in the string. [8]

The string breaks when the speed of the particles is $1.5\,\mathrm{m\,s^{-1}}$.

(ii) Assuming *A* does not reach the pulley, find the distance travelled by *A* after the string breaks. [3]

(iii) Assuming *B* does not reach the ground before *A* stops, find the distance travelled by *B* from the time the string breaks to the time that *A* stops. [6]

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