CAMBRIDGE
International Education

Cambridge International AS & A Level

MATHEMATICS **9709/04**

Paper 4 Mechanics **For examination from 2027**

SPECIMEN PAPER **1 hour 15 minutes**

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You must answer on the printed answer booklet.

You will need: Printed answer booklet
List of formulae (MF19)

INSTRUCTIONS

- Answer **all** questions.
- Write your answers on the printed answer booklet. Follow the instructions on the front cover of the answer booklet.
- You should use a calculator where appropriate.
- You must show all necessary working clearly; no marks will be given for unsupported answers from a calculator.
- Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place for angles in degrees, unless a different level of accuracy is specified in the question.
- Where a numerical value for the acceleration due to gravity (g) is needed, use $10\,\text{m}\,\text{s}^{-2}$.

INFORMATION

- The total mark for this paper is 50.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **4** pages. Any blank pages are indicated.

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1 A particle P is projected vertically upwards with speed $20\,\text{m s}^{-1}$ from a point on the ground.

(a) Find the greatest height above the ground reached by P. [2]

(b) Find the total time from projection until P returns to the ground. [2]

2 A constant resistance of magnitude 1350 N acts on a car of mass 1200 kg.

(a) The car is moving along a straight horizontal road at a constant speed of $32\,\text{m s}^{-1}$.

Find, in kW, the rate at which the engine of the car is working. [2]

(b) The car travels at a constant speed down a hill inclined at an angle of θ to the horizontal, where $\sin\theta = \frac{1}{20}$, with the engine working at 31.5 kW.

Find the speed of the car. [3]

3 Three small smooth spheres A, B and C of equal radii and of masses 4 kg, 2 kg and 3 kg respectively, lie in that order in a straight line on a smooth horizontal plane. Initially, B and C are at rest and A is moving directly towards B with speed $6\,\text{m s}^{-1}$. After the collison with B, sphere A continues to move in the same direction but with speed $2\,\text{m s}^{-1}$.

(a) Find the speed of B after this collison. [2]

(b) Sphere B collides with C. In this collison these two spheres coalesce to form an object D.

(i) Find the speed of D after this collision. [2]

(ii) Show that the total loss of kinetic energy in the system due to the two collisions is 38.4 J. [2]

4 A block of mass 20 kg is on a rough plane inclined at an angle of 30° to the horizontal. A force of magnitude 25 N, acting at an angle of 20° above a line of greatest slope of the plane, is used to prevent the block from sliding down the plane. The coefficient of friction between the block and the plane is μ.

(a) Draw a diagram to show all the forces acting on the block. [1]

(b) Find the least possible value of μ block to prevent the block from sliding down the plane. [5]

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5 A car of mass 1200 kg is pulling a trailer of mass 800 kg up a hill inclined at an angle of $\sin^{-1}(0.1)$ to the horizontal. The car and the trailer are connected by a light rigid tow-bar which is parallel to the hill. The driving force of the car's engine is 2500 N and the resistances to the car and trailer are 300 N and 100 N respectively.

(a) Find the acceleration of the system and the tension in the tow-bar. [4]

(b) When the car and trailer are travelling at a speed of $30\,\text{m s}^{-1}$, the driving force becomes zero.

Find the time, in seconds, before the system comes to rest and the force in the tow-bar during this time. [5]

6 A particle P moves in a straight line. The velocity $v\,\text{m s}^{-1}$ at time t s is given by

$$\begin{aligned} v &= 5t(t-2) && \text{for } 0 \leqslant t \leqslant 4, \\ v &= k && \text{for } 4 \leqslant t \leqslant 14, \\ v &= 68 - 2t && \text{for } 14 \leqslant t \leqslant 20, \end{aligned}$$

where k is a constant.

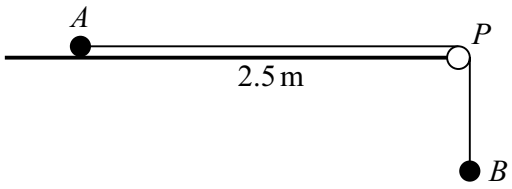
(a) Find k. [1]

(b) Sketch the velocity–time graph for $0 \leqslant t \leqslant 20$. [3]

(c) Find the set of values of t for which the acceleration of P is positive. [2]

(d) Find the total distance travelled by P in the interval $0 \leqslant t \leqslant 20$. [5]

7



Two particles A and B, of masses 0.8 kg and 0.2 kg respectively, are connected by a light inextensible string. Particle A is placed on a horizontal surface. The string passes over a small smooth pulley P fixed at the edge of the surface, and B hangs freely. The horizontal section of the string, AP, is of length 2.5 m (see diagram). The particles are released from rest with both sections of the string taut.

(a) Given that the surface is smooth, find the time taken for A to reach the pulley. [5]

(b) It is given instead that the surface is rough and that the speed of A immediately before it reaches the pulley is $v\,\text{m s}^{-1}$. The work done against friction as A moves from rest to the pulley is 2 J.

Use an energy method to find v. [4]

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