Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

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0123456789

MATHEMATICS **9709/04**

Paper 4 Mechanics **For examination from 2020**

SPECIMEN PAPER **1 hour 15 minutes**

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- If additional space is needed, you should use the lined page at the end of this booklet; the question number or numbers must be clearly shown.
- 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 **14** pages. Blank pages are indicated.

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

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

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

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

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

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

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

Find the speed of the car. [3]

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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 towards *B* with speed $6\,\text{m}\,\text{s}^{-1}$. After the collison with *B*, sphere *A* continues to move in the same direction but with speed $2\,\text{m}\,\text{s}^{-1}$.

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

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

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

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

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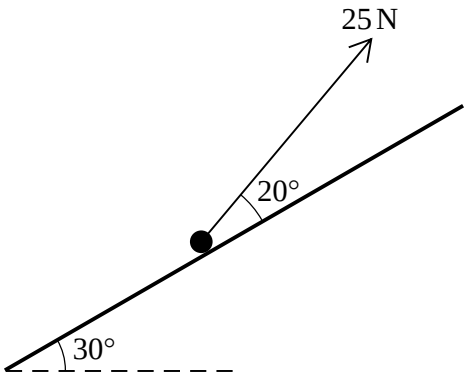
4 A particle of mass 20 kg is on a rough plane inclined at an angle of 30° to the horizontal. A force of magnitude 25 N, acting at an angle of 20° above a line of greatest slope of the plane, is used to prevent the particle from sliding down the plane. The coefficient of friction between the particle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

(a) Complete the diagram below to show all the forces acting on the particle. [1]



(b) Find the least possible value of μ. [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 road. 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 $30\,m\,s^{-1}$, 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]

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

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(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]

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

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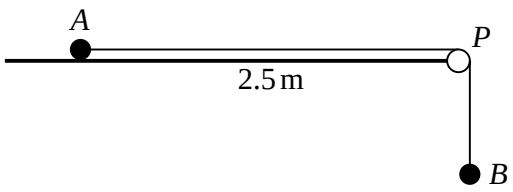

Two particles A and B, of masses 0.8 kg and 0.2 kg respectively, are connected by a light inextensible string. Particle A is placed on a horizontal surface. The string passes over a small smooth pulley P fixed at the edge of the surface, and B hangs freely. The horizontal section of the string, AP, is 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]

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

Use an energy method to find v. [4]

Additional page

If you use the following lined page to complete the answer(s) to any question(s), the question number(s) must be clearly shown.

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