Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER | | | | | |

CANDIDATE NUMBER | | | | |

7756958613

MATHEMATICS **9709/41**

Paper 4 Mechanics **May/June 2022**

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 **16** pages. Any blank pages are indicated.

1 A car starts from rest and moves in a straight line with constant acceleration for a distance of 200 m, reaching a speed of 25 m s^{-1}. The car then travels at this speed for 400 m, before decelerating uniformly to rest over a period of 5 s.

(a) Find the time for which the car is accelerating. [2]

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(b) Sketch the velocity–time graph for the motion of the car, showing the key points. [2]

(c) Find the average speed of the car during its motion. [2]

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2 Two particles P and Q, of masses 0.5 kg and 0.3 kg respectively, are connected by a light inextensible string. The string is taut and P is vertically above Q. A force of magnitude 10 N is applied to P vertically upwards.

Find the acceleration of the particles and the tension in the string connecting them. [5]

3 A crate of mass 300 kg is at rest on rough horizontal ground. The coefficient of friction between the crate and the ground is 0.5. A force of magnitude X N, acting at an angle α above the horizontal, is applied to the crate, where $\sin \alpha = 0.28$.

Find the greatest value of X for which the crate remains at rest. [5]

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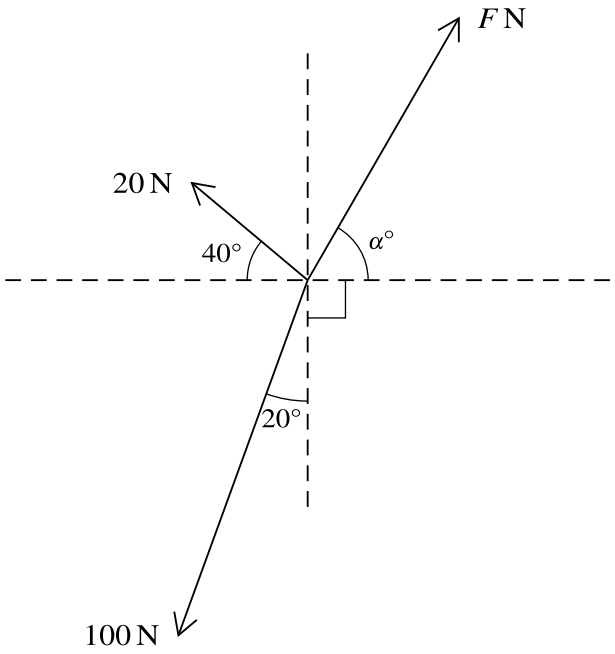

Three coplanar forces of magnitudes 20 N, 100 N and F N act at a point. The directions of these forces are shown in the diagram.

Given that the three forces are in equilibrium, find F and α. [6]

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5 Two racing cars A and B are at rest alongside each other at a point O on a straight horizontal test track. The mass of A is 1200 kg. The engine of A produces a constant driving force of 4500 N. When A arrives at a point P its speed is $25\,\text{m}\,\text{s}^{-1}$. The distance OP is d m. The work done against the resistance force experienced by A between O and P is 75 000 J.

(a) Show that $d = 100$. [3]

Car B starts off at the same instant as car A. The two cars arrive at P simultaneously and with the same speed. The engine of B produces a driving force of 3200 N and the car experiences a constant resistance to motion of 1200 N.

(b) Find the mass of B. [3]

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(c) Find the steady speed which B can maintain when its engine is working at the same rate as it is at P. [3]

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6 A particle starts from a point O and moves in a straight line. The velocity $v\,\text{m s}^{-1}$ of the particle at time t s after leaving O is given by

$$v = k(3t^2 - 2t^3),$$

where k is a constant.

(a) Verify that the particle returns to O when $t = 2$. [4]

(b) It is given that the acceleration of the particle is $-13.5\,\text{m s}^{-2}$ for the positive value of t at which $v = 0$.

Find k and hence find the total distance travelled in the first two seconds of motion. [6]

7 Two particles A and B, of masses 0.4 kg and 0.2 kg respectively, are moving down the same line of greatest slope of a smooth plane. The plane is inclined at 30° to the horizontal, and A is higher up the plane than B. When the particles collide, the speeds of A and B are $3\,\text{m s}^{-1}$ and $2\,\text{m s}^{-1}$ respectively. In the collision between the particles, the speed of A is reduced to $2.5\,\text{m s}^{-1}$.

(a) Find the speed of B immediately after the collision. [2]

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After the collision, when B has moved 1.6 m down the plane from the point of collision, it hits a barrier and returns back up the same line of greatest slope. B hits the barrier 0.4 s after the collision, and when it hits the barrier, its speed is reduced by 90%. The two particles collide again 0.44 s after their previous collision, and they then coalesce on impact.

(b) Show that the speed of B immediately after it hits the barrier is $0.5\,\text{m s}^{-1}$. Hence find the speed of the combined particle immediately after the second collision between A and B. [7]

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Additional Page

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