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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.


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**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]

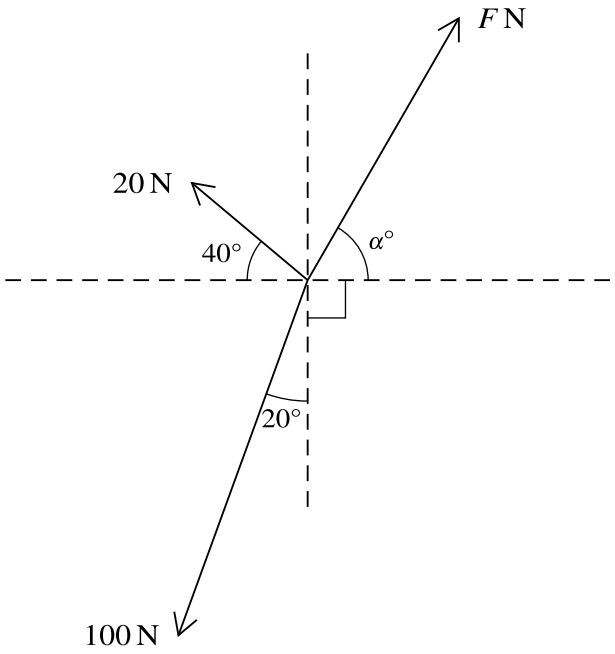
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**3** A crate of mass 300 kg is at rest on rough horizontal ground. The coefficient of friction between the crate and the ground is 0.5. A force of magnitude $X$ N, acting at an angle $\alpha$ above the horizontal, is applied to the crate, where $\sin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

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

**4**




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 $\alpha$. [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]

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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]

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**(b)** It is given that the acceleration of the particle is $-13.5\,\text{m}\,\text{s}^{-2}$ 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]

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**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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**13**

## Additional Page

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