Cambridge Assessment International Education

# Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER



**MATHEMATICS** **9709/41**

Paper 4 Mechanics **October/November 2024**

**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.

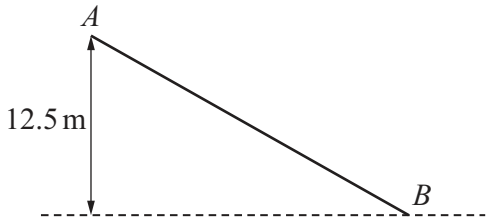



**[Turn over**

**1** Two particles, of masses 1.8 kg and 1.2 kg, are connected by a light inextensible string that passes over a fixed smooth pulley. The particles hang vertically. The system is released from rest.

Find the magnitude of the acceleration of the particles and find the tension in the string. [4]

2




A particle of mass 7.5 kg, starting from rest at $A$, slides down an inclined plane $AB$. The point $B$ is 12.5 metres vertically below the level of $A$, as shown in the diagram.

**(a)** Given that the plane is smooth, use an energy method to find the speed of the particle at $B$. [2]

.....

.....

.....

.....

.....

.....

**(b)** It is given instead that the plane is rough and the particle reaches $B$ with a speed of $8\,\text{m}\,\text{s}^{-1}$. The plane is 25 m long and the constant frictional force has magnitude $F$ N.

Find the value of $F$. [3]

.....

.....

.....

.....

.....

.....

.....

.....

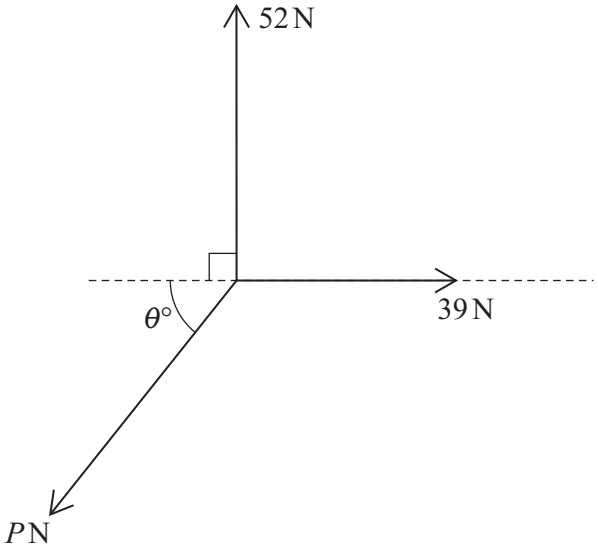
.....

.....

.....

.....

3




Coplanar forces of magnitudes 52 N, 39 N and $P$ N act at a point in the directions shown in the diagram. The system is in equilibrium.

Find the values of $P$ and $\theta$. [4]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

**4** A bus travels between two stops, $A$ and $B$. The bus starts from rest at $A$ and accelerates at a constant rate of $a\,\text{m s}^{-2}$ until it reaches a speed of $16\,\text{m s}^{-1}$. It then travels at this constant speed before decelerating at a constant rate of $0.75a\,\text{m s}^{-2}$, coming to rest at $B$. The total time for the journey is 240 s.

**(a)** Sketch the velocity-time graph for the bus's journey from $A$ to $B$. [1]


**(b)** Find an expression, in terms of $a$, for the length of time that the bus is travelling with constant speed. [2]

.....

.....

.....

.....

.....

.....

**(c)** Given that the distance from $A$ to $B$ is 3000 m, find the value of $a$. [3]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

**5** A particle, $A$, is projected vertically upwards from a point $O$ with a speed of $80\,\text{m}\,\text{s}^{-1}$. One second later a second particle, $B$, with the same mass as $A$, is projected vertically upwards from $O$ with a speed of $100\,\text{m}\,\text{s}^{-1}$. At time $T$ s after the first particle is projected, the two particles collide and coalesce to form a particle $C$.

**(a)** Show that $T = 3.5$ . [4]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

**(b)** Find the height above $O$ at which the particles collide. [1]

.....

.....

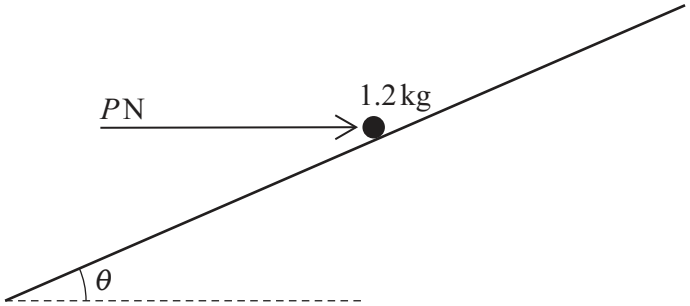
.....

.....

.....

**(c)** Find the time from $A$ being projected until $C$ returns to $O$. [5]

6




A particle of mass 1.2 kg is placed on a rough plane which is inclined at an angle $\theta$ to the horizontal, where $\sin\theta = \frac{7}{25}$. The particle is kept in equilibrium by a horizontal force of magnitude $P$ N acting in a vertical plane containing a line of greatest slope (see diagram). The coefficient of friction between the particle and the plane is 0.15 .

Find the least possible value of $P$. [6]

**7** A car has mass 1200 kg. When the car is travelling at a speed of $v\,\text{m s}^{-1}$, there is a resistive force of magnitude $kv$ N. The maximum power of the car's engine is 92.16 kW.

**(a)** The car travels along a straight level road.

**(i)** The car has a greatest possible constant speed of $48\,\text{m s}^{-1}$.

Show that $k = 40$. [1]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

**(ii)** At an instant when its speed is $45\,\text{m s}^{-1}$, find the greatest possible acceleration of the car. [3]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

**(b)** The car now travels at a constant speed up a hill inclined at an angle of $\sin^{-1}0.15$ to the horizontal.

Find the greatest possible speed of the car going up the hill. [4]

**8** A particle $P$ moves in a straight line, passing through a point $O$ with velocity $4.2\,\text{m s}^{-1}$. At time $t$ s after $P$ passes $O$, the acceleration, $a\,\text{m s}^{-2}$, of $P$ is given by $a = 0.6t - 2.7$.

Find the distance $P$ travels between the times at which it is at instantaneous rest. [7]

**Additional page**

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

**BLANK PAGE**

**BLANK PAGE**