Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

MATHEMATICS **9709/45**

Paper 4 Mechanics **May/June 2025**

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

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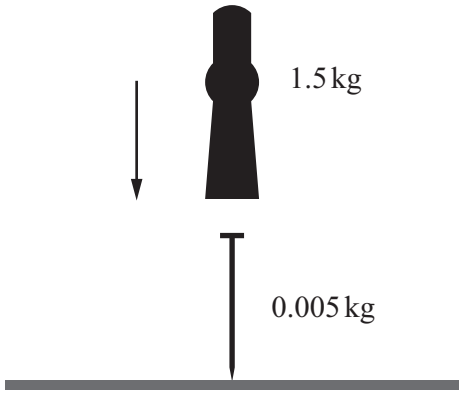
1 A box of mass 25 kg is pulled 12 m up a rough plane inclined at an angle of 8° to the horizontal. The box moves up a line of greatest slope against a frictional force of 50 N. The force pulling the box is parallel to the line of greatest slope. The box starts from rest and has speed 2.4 m s^{-1} at the end of the 12 m.

Find the work done by the pulling force. [4]



A machine for driving a nail into a block of wood causes a hammerhead to drop vertically onto the top of the nail. The mass of the hammerhead is 1.5 kg and the mass of the nail is 0.005 kg (see diagram). The hammerhead hits the nail with speed $32\,m\,s^{-1}$ and remains in contact with the nail after the impact.

(a) Calculate the speed with which the combined hammerhead and nail move immediately after the impact. Give your answer correct to 3 decimal places. [2]

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There is a constant force resisting the motion of magnitude 25 000 N.

(b) Calculate the distance the nail is driven into the wood. [3]

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3 A train travels 4.8 km between two stations, A and B. The train starts from rest at A and accelerates at a constant rate until it reaches a speed of $30\,m\,s^{-1}$. It then travels at this constant speed for T seconds, before decelerating at a constant rate, coming to rest at B. The total time for the journey is 180 s.

Find the value of T and hence find the distance moved by the train while travelling at the constant speed of $30\,m\,s^{-1}$. [5]

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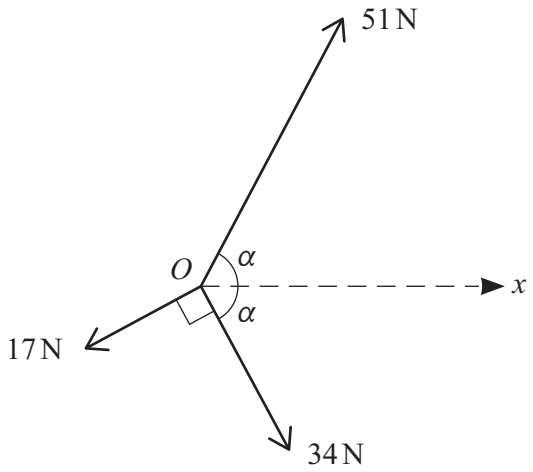

Coplanar forces of magnitudes 17 N, 51 N and 34 N act at a point O in the directions shown in the diagram, where $\tan \alpha = \frac{15}{8}$.

(a) Find the magnitude and direction of the resultant of the three forces. [6]

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The force of magnitude 51 N is replaced by a force of magnitude P N acting in the same direction. The resultant of the three forces now acts in the positive x-direction.

(b) Find the value of P. [2]

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5 A car of mass 1500 kg is travelling along a straight horizontal road.

(a) It is given that there is a constant resistance to motion. The engine of the car is working at 24 kW while the car is travelling at a constant speed of 32 m s^{-1}. The power is now increased to 28 kW.

Find the acceleration of the car at the instant it is travelling at a speed of 36 m s^{-1}. [4]

(b) It is given instead that the resistance to the motion of the car is $(340 + 4v)$ N when the speed of the car is $v\,\text{m s}^{-1}$.

When the engine is working at 20 kW, the car is travelling at constant speed.

Find this constant speed. [3]

6 A particle P moves in a straight line starting from a point O. At time t s after leaving O, the velocity, $v\,\text{m s}^{-1}$, of P is given by $v = (15 - 2t)^2$.

(a) Find the values of t when the velocity of P is $100\,\text{m s}^{-1}$. [2]

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(b) Show that there is a particular value of t for which the velocity and acceleration of the particle are both zero. [3]

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(c) Find the displacement of P from O at the time that the velocity and acceleration of the particle are both zero. [4]

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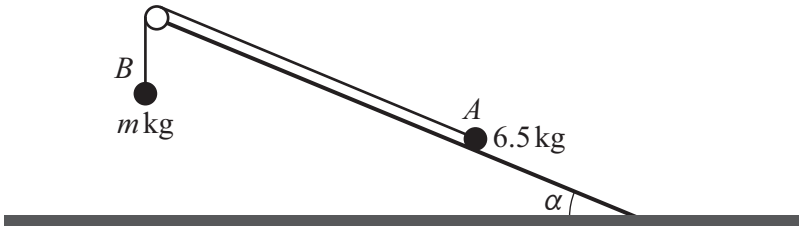

Two particles A and B of masses 6.5 kg and m kg respectively are connected by a light inextensible string that passes over a smooth pulley. The pulley is fixed at the top of a rough slope which is at an angle of α to the horizontal ground, where $\tan\alpha = \frac{5}{12}$. A is on the rough slope and B hangs below the pulley (see diagram). The coefficient of friction between the slope and A is 0.4.

(a) Given that the system is in equilibrium, find the set of possible values of m. [7]

(b) It is given instead that $m = 12$ and the particles are released from rest with the string taut.

Use an energy method to find the speed of the particles when each particle has moved 0.6 m. You may assume that this occurs before A reaches the pulley or B reaches the ground. [5]

Additional page

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

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