Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

MATHEMATICS **9709/41**

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 **12** pages.

[Turn over

1 A block of mass 12 kg is being pulled by a rope up a rough plane. The plane is inclined at an angle of 20° above the horizontal. The rope pulling the block is parallel to a line of greatest slope of the plane. The coefficient of friction between the block and the plane is 0.4. The acceleration of the block is $2\,\text{m}\,\text{s}^{-2}$.

Find the tension in the rope. [4]

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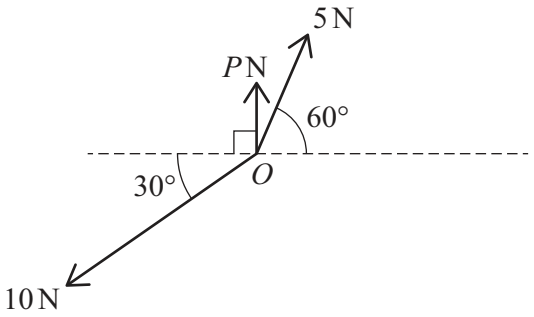

Three coplanar forces of magnitudes P N, 5 N and 10 N act at a point O, as shown in the diagram. The resultant of the three forces has magnitude Q N and acts in a direction perpendicular to the force of magnitude P N.

Find the value of P and the value of Q. [4]

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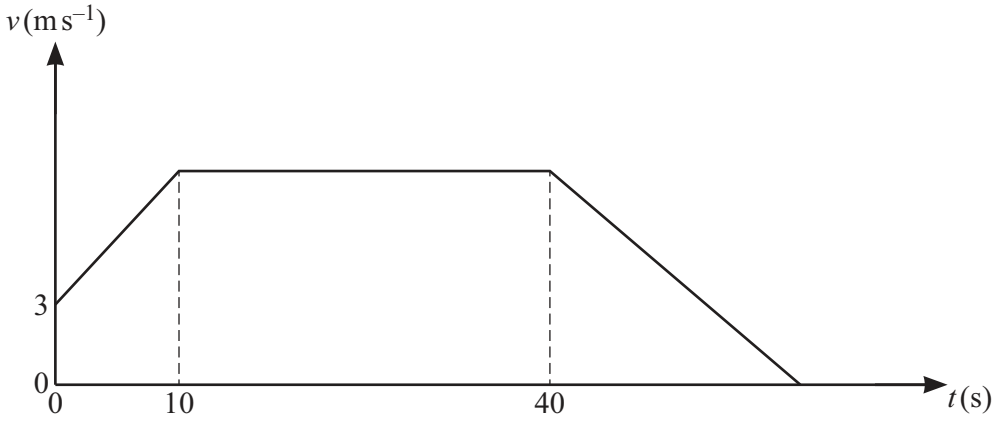

The diagram shows the velocity-time graph of the motion of a cyclist. The graph consists of three straight line segments. The cyclist passes a point O with speed $3\,\text{m s}^{-1}$ and then accelerates for 10 s with constant acceleration $0.5\,\text{m s}^{-2}$. He then travels at constant speed for 30 s before decelerating, coming to rest at point P, covering a distance of 80 m whilst decelerating.

(a) Find the total time taken for the journey from O to P. [3]

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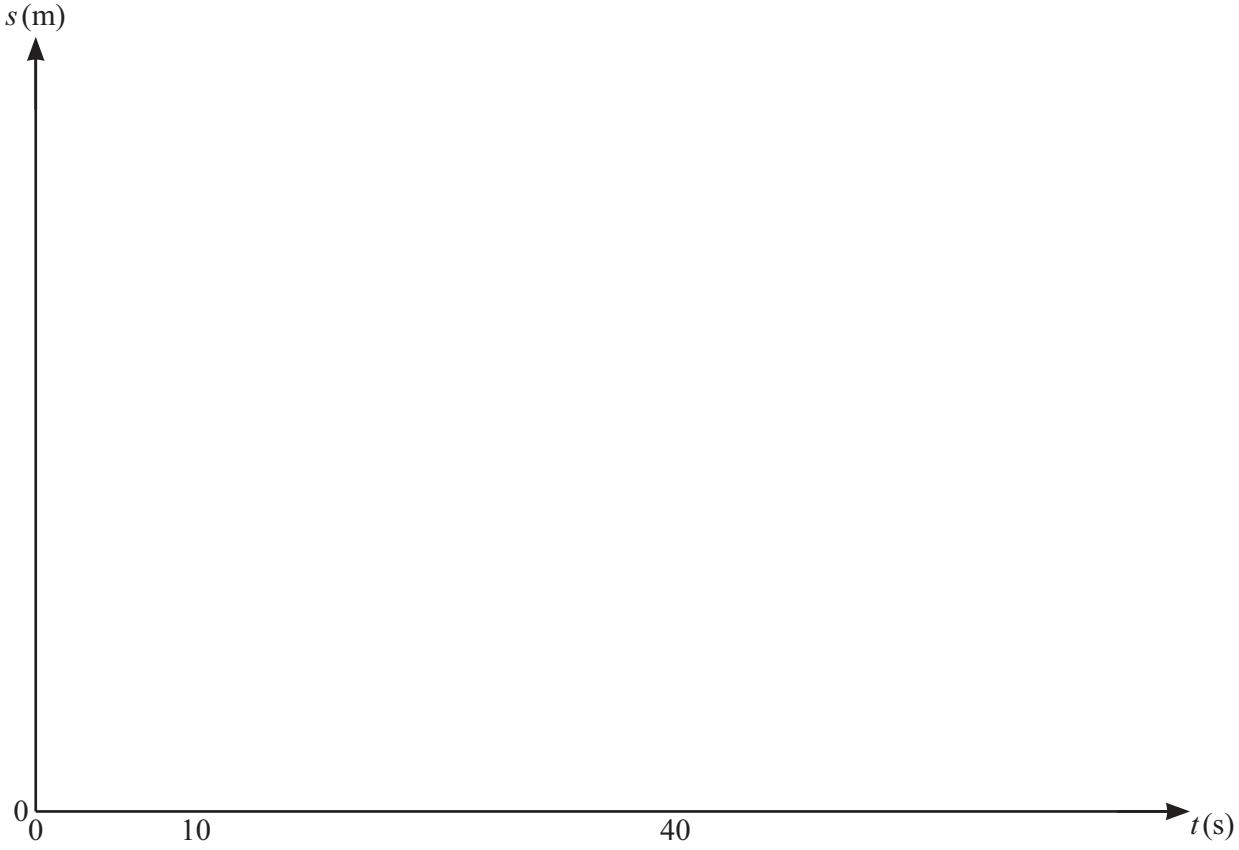
(b) On the given axes, sketch a displacement-time graph for the cyclist's journey from O to P, showing on your graph the distances travelled after 10 s and 40 s. [4]



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4 A lorry of mass 18 000 kg is travelling along a straight road.

(a) On a horizontal section of the road, the power of the lorry's engine is constant. There is a constant resistance to motion of 1600 N.

(i) The steady speed which the lorry can maintain with the engine working at power P W is $30\,\text{m}\,\text{s}^{-1}$.

Find the value of P. [1]

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(ii) At an instant when the speed of the lorry is $16\,\text{m}\,\text{s}^{-1}$, its engine is working at a power of 40 kW.

Find the acceleration of the lorry at this instant. [2]

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(b) When the lorry has reached a speed of $20\,\text{m}\,\text{s}^{-1}$, it begins to ascend a section of road inclined at an angle $\alpha°$ to the horizontal. The engine now works at a power of 120 kW. There is no change in the lorry's speed as it ascends the hill. The constant resistance to motion remains 1600 N.

Find the value of α. [3]

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5 When a particle P of mass m kg has speed $u\,\text{m s}^{-1}$, its momentum is 4 N s and its kinetic energy is 16 J.

(a) Find the value of m and the value of u. [3]

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P is now projected on a smooth horizontal surface with speed $v\,\text{m s}^{-1}$ directly towards a particle Q of mass 1.25 kg which is stationary. After P and Q collide, the velocity of P is $w\,\text{m s}^{-1}$ and the velocity of Q is $2w\,\text{m s}^{-1}$. The loss of kinetic energy in the collision is 25 J.

(b) Find the value of v and the value of w. [4]

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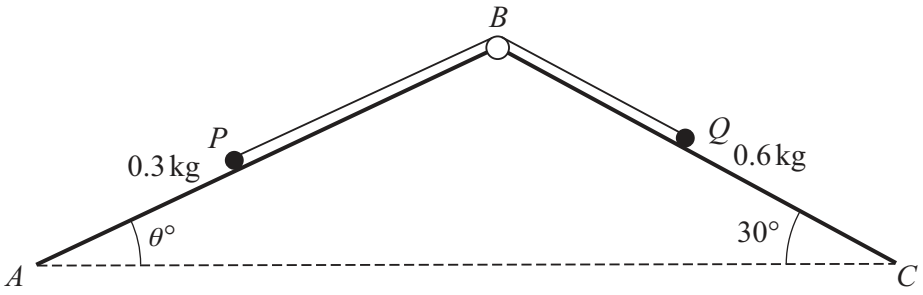

Two particles, P and Q, of masses 0.3 kg and 0.6 kg respectively, are attached to the ends of a light inextensible string. The string passes over a smooth pulley fixed at a point B where the inclined planes AB and BC meet. P lies on the smooth plane AB which is inclined at an angle $\theta°$ to the horizontal where $\sin\theta° = 0.4$. Q lies on the plane BC which is inclined at 30° to the horizontal. The string is taut and the particles can move on lines of greatest slope of the two planes (see diagram). The particles are released from rest.

(a) It is given that the plane BC is smooth.

Find the tension in the string and the acceleration of Q. [5]

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(b) It is given instead that the plane BC is rough. The work done against the frictional force when Q moves 2 m down the plane is 1.8 J. You should assume that P does **not** reach the pulley and that Q does **not** reach C.

Use an energy method to find the speed of Q when it has moved 2 m down the plane. [4]

7 A particle X moves along a straight track, starting from a point O at time $t = 0$. The displacement of X from O at time t s is s m, where $s = 3t^{\frac{3}{2}} - 6t$.

(a) Find the time at which X is instantaneously at rest, and hence find the total distance travelled by X between $t = 0$ and $t = 16$. [6]

A second particle Y moves along another straight track, starting from a point P at time $t = 0$. The acceleration of Y at time t s is $a\,\text{m s}^{-2}$, where $a = 0.8 - 0.6t$. The velocity of Y when it leaves P is $7.5\,\text{m s}^{-1}$.

(b) When the velocity of Y is $-9.6\,\text{m s}^{-1}$, show that the displacement of X from O is equal to the displacement of Y from P. [7]

Additional page

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