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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

5509202066

MATHEMATICS **9709/42**

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.

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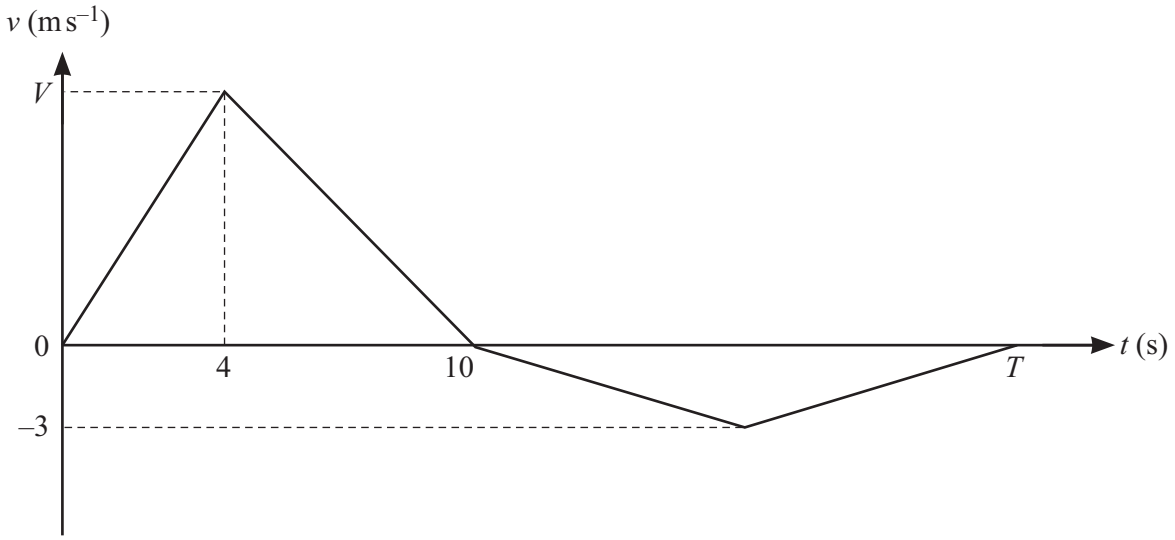
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The velocity of a particle moving in a straight line at time t seconds after leaving a fixed point O is $v\,\text{m s}^{-1}$. The diagram shows a velocity-time graph which models the motion of the particle from $t = 0$ to $t = T$. The graph consists of four straight line segments. The particle accelerates from rest to a speed of $V\,\text{m s}^{-1}$ over a period of 4 s, and then decelerates at $\frac{5}{3}\,\text{m s}^{-2}$ to instantaneous rest over a period of 6 s. The particle then travels back towards O, reaching a maximum speed of $3\,\text{m s}^{-1}$ before coming to rest at time $t = T$.

(a) Find the value of V. [2]

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(b) Given that the total distance travelled by the particle from $t = 0$ to $t = T$ is 68 m, find the value of T. [3]

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2 A block of mass 20 kg is held at rest at the top of a plane inclined at 30° to the horizontal. The block is projected with speed $5\,m\,s^{-1}$ down a line of greatest slope of the plane. There is a resistance force acting on the block. As the block moves 2 m down the plane from its point of projection, the work done against this resistance force is 50 J.

Find the speed of the block when it has moved 2 m down the plane. [4]

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3 A cyclist is riding along a straight horizontal road. The total mass of the cyclist and his bicycle is 90 kg. The power exerted by the cyclist is 250 W. At an instant when the cyclist's speed is $5\,m\,s^{-1}$, his acceleration is $0.1\,m\,s^{-2}$.

(a) Find the value of the constant resistance to motion acting on the cyclist. [3]

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The cyclist comes to the bottom of a hill inclined at 2° to the horizontal.

(b) Given that the power and resistance to motion are unchanged, find the steady speed which the cyclist could maintain when riding up the hill. [2]

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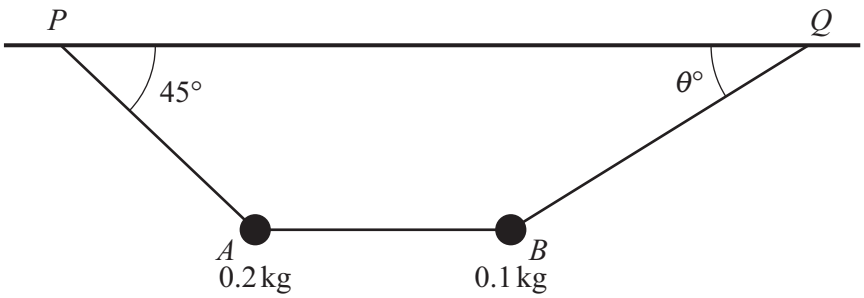
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The diagram shows two particles, A and B, of masses 0.2 kg and 0.1 kg respectively. The particles are suspended below a horizontal ceiling by two strings, AP and BQ, attached to fixed points P and Q on the ceiling. The particles are connected by a horizontal string, AB. Angle $APQ = 45°$ and $BQP = \theta°$. Each string is light and inextensible. The particles are in equilibrium.

(a) Find the value of the tension in the string AB. [2]

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(b) Find the value of θ and the tension in the string BQ. [4]

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5 Two particles, P and Q, of masses $2m$ kg and m kg respectively, are held at rest in the same vertical line. The heights of P and Q above horizontal ground are 1 m and 2 m respectively. P is projected vertically upwards with speed $2\,\text{m}\,\text{s}^{-1}$. At the same instant, Q is released from rest.

(a) Find the speed of each particle immediately before they collide. [4]

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(b) It is given that immediately after the collision the downward speed of Q is $3.5\,\text{m}\,\text{s}^{-1}$.

Find the speed of P at the instant that it reaches the ground. [5]

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6 A particle, P, travels in a straight line, starting from a point O with velocity $6\,\text{m}\,\text{s}^{-1}$. The acceleration of P at time t s after leaving O is $a\,\text{m}\,\text{s}^{-2}$, where

$$a = -1.5t^{\frac{1}{2}} \qquad \text{for } 0 \leqslant t \leqslant 1,$$

$$a = 1.5t^{\frac{1}{2}} - 3t^{-\frac{1}{2}} \qquad \text{for } t > 1.$$

(a) Find the velocity of P at $t = 1$. [3]

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(b) Given that there is no change in the velocity of P when $t = 1$, find an expression for the velocity of P for $t > 1$. [3]

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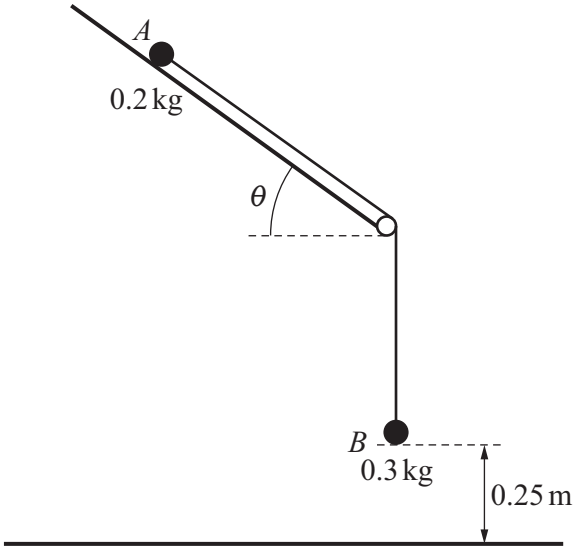
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(c) Given that the velocity of P is positive for $t \leqslant 4$, find the total distance travelled between $t = 0$ and $t = 4$. [4]

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Two particles, A and B, of masses 0.2 kg and 0.3 kg respectively, are attached to the ends of a light inextensible string. The string passes over a small fixed smooth pulley which is attached to the bottom of a rough plane inclined at an angle θ to the horizontal where $\sin\theta = 0.6$. Particle A lies on the plane, and particle B hangs vertically below the pulley, 0.25 m above horizontal ground. The string between A and the pulley is parallel to a line of greatest slope of the plane (see diagram). The coefficient of friction between A and the plane is 1.125 . Particle A is released from rest.

(a) Find the tension in the string and the magnitude of the acceleration of the particles. [7]

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(b) When B reaches the ground, it comes to rest.

Find the total distance that A travels down the plane from when it is released until it comes to rest. You may assume that A does not reach the pulley. [4]

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