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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

MATHEMATICS **9709/43**

Paper 4 Mechanics **May/June 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 **12** pages.

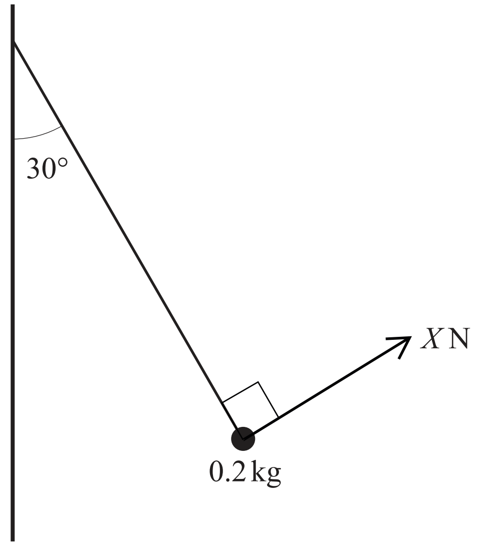
DC (PQ/CT) 329257/3

1 Two particles P and Q of masses 0.2 kg and 0.5 kg respectively are at rest on a smooth horizontal plane. Particle P is projected with a speed $6\,\text{m}\,\text{s}^{-1}$ directly towards Q. After P and Q collide, P moves with a speed of $1\,\text{m}\,\text{s}^{-1}$.

Find the two possible speeds of Q after the collision. [3]

DO NOT WRITE IN THIS MARGIN

2



A particle of mass 0.2 kg is attached to one end of a light inextensible string. The other end of the string is attached to a fixed point on a vertical wall. The particle is held in equilibrium by a force of magnitude X N, perpendicular to the string, with the string taut and making an angle of 30° with the wall (see diagram).

Find the tension in the string and the value of X. [3]

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3 A car travels along a straight road with constant acceleration $a\,\text{m}\,\text{s}^{-2}$, where $a > 0$. The car passes through points A, B and C in that order. The speed of the car at A is $u\,\text{m}\,\text{s}^{-1}$ in the direction AB. The distance BC is twice the distance AB. The car takes 8 seconds to travel from A to B and 10 seconds to travel from B to C.

(a) Find u in terms of a. [4]

(b) Find the speed of the car at C in terms of a. [2]

4 A particle travels in a straight line. The velocity of the particle at time t s after leaving a point O is $v\,\mathrm{m\,s^{-1}}$, where

$$v = kt^2 - 4t + 3.$$

The distance travelled by the particle in the first 2 s of its motion is 6 m. You may assume that $v > 0$ in the first 2 s of its motion.

(a) Find the value of k. [4]

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(b) Find the value of the minimum velocity of the particle. You do **not** need to show that this velocity is a minimum. [3]

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5 A van of mass 4500 kg is towing a trailer of mass 750 kg down a straight hill inclined at an angle of θ to the horizontal where $\sin\theta = 0.05$. The van and the trailer are connected by a light rigid tow-bar which is parallel to the road. There are constant resistance forces of 2500 N on the van and 300 N on the trailer.

(a) It is given that the tension in the tow-bar is 450 N.

Find the acceleration of the trailer and the driving force of the van's engine. [4]

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On another occasion, the van and trailer ascend a straight hill inclined at an angle of α to the horizontal where $\sin\alpha = 0.09$. The driving force of the van's engine is now 9100 N, and the speed of the van at the bottom of the hill is $20\,\text{m}\,\text{s}^{-1}$. The resistances to motion are unchanged.

(b) **(i)** Find the acceleration of the van and the tension in the tow-bar. [5]

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(ii) Find the speed of the van when it has travelled a distance of 375 m up the hill. [2]

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6 A cyclist is travelling along a straight horizontal road. The total mass of the cyclist and her bicycle is 80 kg. There is a constant resistance force of magnitude 32 N to the cyclist's motion. At an instant when she is travelling at $7\,\text{m}\,\text{s}^{-1}$, her acceleration is $0.1\,\text{m}\,\text{s}^{-2}$.

(a) Find the power output of the cyclist. [3]

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(b) Find the steady speed that the cyclist can maintain if her power output and the resistance force are both unchanged. [2]

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The cyclist later descends a straight hill of length 32.2 m, inclined at an angle of $\sin^{-1}\left(\frac{1}{20}\right)$ to the horizontal. Her power output is now 120 W, and the resistance force now has variable magnitude such that the work done against this force in descending the hill is 1128 J. The time taken to descend the hill is 4 s.

(c) Given that the speed of the cyclist at the top of the hill is $7.5\,\text{m}\,\text{s}^{-1}$, find her speed at the bottom of the hill. [6]

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The diagram shows a track *ABCD* which lies in a vertical plane. The section *AB* is a straight line inclined at an angle of 30° to the horizontal and is smooth. The section *BC* is a horizontal straight line and is rough. The section *CD* is a straight line inclined at an angle of 30° to the horizontal and is rough. The lengths *AB*, *BC* and *CD* are each 2 m.

A particle is released from rest at *A*. The coefficient of friction between the particle and both *BC* and *CD* is μ. There is no change in the speed of the particle when it passes through either of the points *B* or *C*.

(a) It is given that $\mu = 0.1$.

Find the distance which the particle has moved up the section *CD* when its speed is $1\,\text{m}\,\text{s}^{-1}$. [5]

(b) It is given instead that with a different value of μ the particle travels 1 m up the track from C before it comes instantaneously to rest.

Find the value of μ and the speed of the particle at the instant that it passes C for the second time. [4]

Additional page

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