

Cambridge International AS & A Level

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MATHEMATICS

9709/41

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.
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- 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 ms^{-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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- 1 A car starts from rest and accelerates at 2 m s^{-2} for 10 s. It then travels at a constant speed for 30 s. The car then uniformly decelerates to rest over a period of 20 s.

(a) Sketch a velocity-time graph for the motion of the car.

[2]



(b) Find the total distance travelled by the car.

[2]

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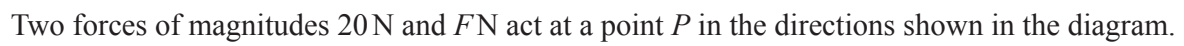
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- [illegible]

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- This image shows a full page of white paper with horizontal dashed lines, typical of primary school handwriting practice paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

- 3** A train of mass 180 000 kg ascends a straight hill of length 1.5 km, inclined at an angle of 1.5° to the horizontal. As it ascends the hill, the total work done to overcome the resistance to motion is 12 000 kJ and the speed of the train decreases from 45 ms^{-1} to 40 ms^{-1} .

Find the work done by the engine of the train as it ascends the hill, giving your answer in kJ. [4]

This image shows a full page of white paper with horizontal dotted lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings on the page.

- 4 A car of mass 1700 kg is pulling a trailer of mass 300 kg along a straight horizontal road. The car and trailer are connected by a light inextensible cable which is parallel to the road. There are constant resistances to motion of 400 N on the car and 150 N on the trailer. The power of the car's engine is $14\,000\text{ W}$.

Find the acceleration of the car and the tension in the cable when the speed is 20 ms^{-1} . [6]

This image shows a single page of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

- 5 A straight slope of length 60 m is inclined at an angle of 12° to the horizontal. A bobsled starts at the top of the slope with a speed of 5 m s^{-1} . The bobsled slides directly down the slope.
- (a) It is given that there is no resistance to the bobsled's motion.

Find its speed when it reaches the bottom of the slope.

[3]

[illegible]

- (b)** It is given instead that the coefficient of friction between the bobsled and the slope is 0.03 .

Find the time that it takes for the bobsled to reach the bottom of the slope.

[5]

This image shows a full page of a handwriting practice worksheet. It consists of multiple sets of three horizontal dashed lines, providing a guide for letter height and placement. The lines are evenly spaced across the entire page, leaving ample room for practicing various letters and words. There is no text or other markings on the page.

- (a)** Show that $k = 10$. [5]

[illegible]

- (b) (i) Verify that $v = 0$ when $t = 1$ and $t = 16$. [1]

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- (ii) Find the distance travelled by the particle in the first 16 s. [5]

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7 A particle P of mass 0.2 kg is projected vertically upwards from horizontal ground with speed 25 ms^{-1} .

(a) Show that the speed of P when it reaches 20 m above the ground is 15 ms^{-1} . [2]

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When P reaches 20 m above the ground it collides with a second particle Q of mass 0.1 kg which is moving downwards at 20 ms^{-1} . P is brought to instantaneous rest in the collision.

(b) Find the velocity of Q immediately after the collision. [2]

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MATHEMATICS

9709/42

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.
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- 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 ms^{-2} .

INFORMATION

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- The number of marks for each question or part question is shown in brackets [].

This document has **12** pages.

- 1 A cyclist and bicycle have a total mass of 72 kg. The cyclist rides along a horizontal road against a total resistance force of 28 N.

Find the total work done by the cyclist to increase his speed from 8 ms^{-1} to 16 ms^{-1} while travelling a distance of 100 metres. [3]

This image shows a full page of white paper with horizontal dotted lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings on the page.

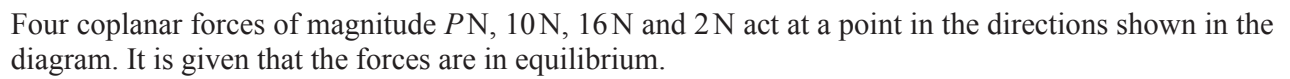
- 2** A particle P moves in a straight line. At time t s after leaving a point O on the line, P has velocity v ms⁻¹, where $v = 44t - 6t^2 - 36$.

- (a)** Find the set of values of t for which the acceleration of the particle is positive. [2]

[illegible]

- (b)** Find the two values of t at which P returns to O . [3]

[illegible]



[6]

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

- 4 A car has mass 1400 kg. When the speed of the car is $v \text{ ms}^{-1}$ the magnitude of the resistance to motion is $kv^2 \text{ N}$ where k is a constant.

(a) The car moves at a constant speed of 24 ms^{-1} up a hill inclined at an angle of α to the horizontal where $\sin \alpha = 0.12$. At this speed the magnitude of the resistance to motion is 480 N.

(i) Find the value of k . [1]

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(ii) Find the power of the car's engine. [3]

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(b) The car now moves at a constant speed on a straight level road.

Given that its engine is working at 54 kW, find this speed. [3]

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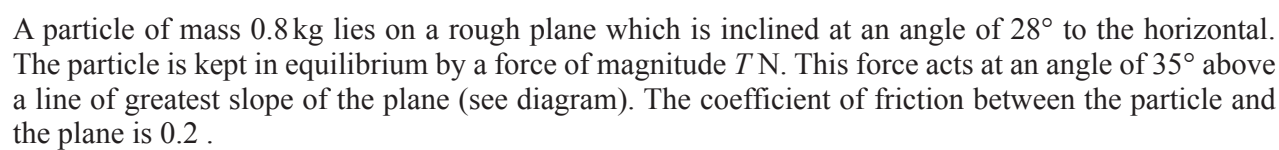
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[8]

[illegible]

- 6 Three particles A , B and C of masses 5 kg, 1 kg and 2 kg respectively lie at rest in that order on a straight smooth horizontal track XYZ . Initially A is at X , B is at Y and C is at Z . Particle A is projected towards B with a speed of 6 ms^{-1} and at the same instant C is projected towards B with a speed of $v \text{ ms}^{-1}$. In the subsequent motion, A collides and coalesces with B to form particle D . Particle D then collides and coalesces with C to form particle E and E moves towards Z .

- (a)** Show that after the second collision the speed of E is $\frac{15-v}{4} \text{ m s}^{-1}$. [3]

[illegible]

- (b)** The total loss of kinetic energy of the system due to the two collisions is 63 J.

Use the result from **(a)** to show that $v = 3$. [3]

This image shows a full page of white paper with ten horizontal dashed lines, typical of primary-ruled notebook paper. The lines are evenly spaced and extend across the entire width of the page. There is no handwriting or other markings on the paper.

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(c) It is given that the distance XY is 36 m and the distance YZ is 98 m.

(i) Find the time between the two collisions. [4]

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(ii) Find the time between the instant that A is projected from X and the instant that E reaches Z . [1]

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- (b)** Use an energy method to find the speed of the particles at the instant when they are at the same vertical height. [5]

This image shows a full page of a worksheet designed for handwriting practice. It features approximately 20 horizontal dashed lines spaced evenly across the page, providing a guide for letter height and placement. The background is plain white, and there are no other markings or text present.

This image shows a full page of white paper with horizontal dotted lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting or typing. There are no margins, text, or other markings on the page.

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**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

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INFORMATION

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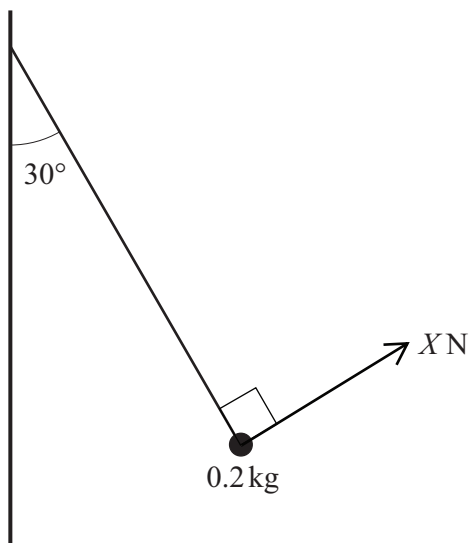
This document has **12** pages.

[3]

[illegible]



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 $X\text{ N}$, 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]

This image shows a full page of handwriting practice paper. It features 15 evenly spaced horizontal dashed lines across the entire width of the page, providing a guide for letter height and placement. The background is plain white, and there are no margins or additional markings.

[4]

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page. There are no margins, text, or other markings on the paper.

[2]

This image shows a blank sheet of white paper with ten horizontal dashed lines, typical of primary-ruled notebook paper. The lines are evenly spaced and extend across the width of the page. There is no handwriting or other markings on the paper.



- 4 A particle travels in a straight line. The velocity of the particle at time t s after leaving a point O is $v \text{ m s}^{-1}$, 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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- Find the acceleration of the trailer and the driving force of the van's engine. [4]

[illegible]



5

- [illegible]

- [illegible]



- 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 m s^{-1} , her acceleration is 0.1 m 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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(c) Given that the speed of the cyclist at the top of the hill is 7.5 m s^{-1} , find her speed at the bottom of the hill. [6]

This image shows a full page of white paper with horizontal dashed lines, typical of primary-ruled notebook paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.



7



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 .

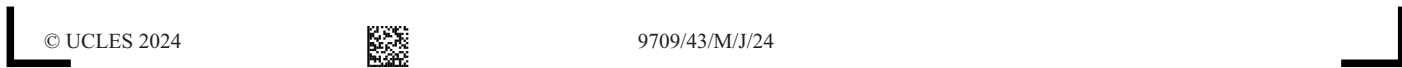
- (a)** It is given that $\mu = 0.1$.

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

This image shows a full page of white paper with horizontal dashed lines, typical of primary-ruled notebook paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.



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

[illegible]

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