Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

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1079248266

MATHEMATICS **9709/42**

Paper 4 Mechanics **October/November 2023**

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

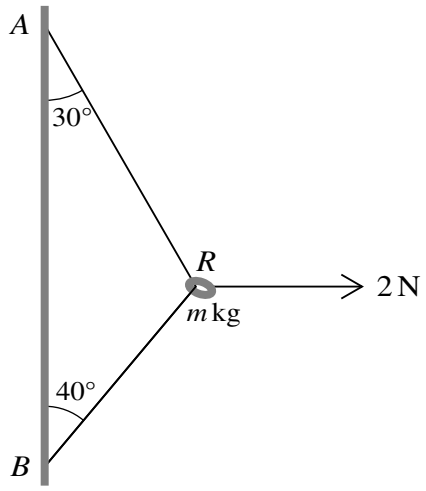
- The total mark for this paper is 50.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **12** pages.

1 A block of mass 15 kg slides down a line of greatest slope of an inclined plane. The top of the plane is at a vertical height of 1.6 m above the level of the bottom of the plane. The speed of the block at the top of the plane is $2\,m\,s^{-1}$ and the speed of the block at the bottom of the plane is $4\,m\,s^{-1}$.

Find the work done against the resistance to motion of the block. [4]

2



The diagram shows a smooth ring R, of mass m kg, threaded on a light inextensible string. A horizontal force of magnitude 2 N acts on R. The ends of the string are attached to fixed points A and B on a vertical wall. The part AR of the string makes an angle of 30° with the vertical, the part BR makes an angle of 40° with the vertical and the string is taut. The ring is in equilibrium.

Find the tension in the string and find the value of m. [5]

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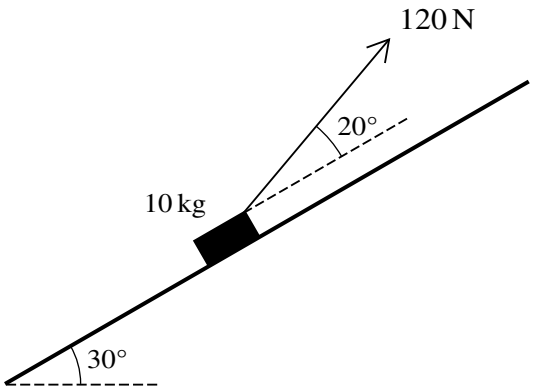

A block of mass 10 kg is at rest on a rough plane inclined at an angle of 30° to the horizontal. A force of 120 N is applied to the block at an angle of 20° above a line of greatest slope (see diagram). There is a force resisting the motion of the block and 200 J of work is done against this force when the block has moved a distance of 5 m up the plane from rest.

Find the speed of the block when it has moved a distance of 5 m up the plane from rest. [5]

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4 A particle P of mass 0.2 kg lies at rest on a rough horizontal plane. A horizontal force of 1.2 N is applied to P.

(a) Given that P is in limiting equilibrium, find the coefficient of friction between P and the plane. [3]

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(b) Given instead that the coefficient of friction between P and the plane is 0.3, find the distance travelled by P in the third second of its motion. [4]

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5 A particle A of mass 0.5 kg is projected vertically upwards from horizontal ground with speed 25 m s^{-1}.

(a) Find the speed of A when it reaches a height of 20 m above the ground. [2]

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When A reaches a height of 20 m, it collides with a particle B of mass 0.3 kg which is moving downwards in the same vertical line as A with speed 32.5 m s^{-1}. In the collision between the two particles, B is brought to instantaneous rest.

(b) Show that the velocity of A immediately after the collision is 4.5 m s^{-1} downwards. [2]

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(c) Find the time interval between A and B reaching the ground. You should assume that A does not bounce when it reaches the ground. [4]

6 A railway engine of mass 120 000 kg is towing a coach of mass 60 000 kg up a straight track inclined at an angle of α to the horizontal where $\sin \alpha = 0.02$. There is a light rigid coupling, parallel to the track, connecting the engine and coach. The driving force produced by the engine is 125 000 N and there are constant resistances to motion of 22 000 N on the engine and 13 000 N on the coach.

(a) Find the acceleration of the engine and find the tension in the coupling. [5]

At an instant when the engine is travelling at $30\,\text{m}\,\text{s}^{-1}$, it comes to a section of track inclined upwards at an angle β to the horizontal. The power produced by the engine is now 4 500 000 W and, as a result, the engine maintains a constant speed.

(b) Assuming that the resistance forces remain unchanged, find the value of β. [4]

7 A particle X travels in a straight line. The velocity of X at time t s after leaving a fixed point O is denoted by v m s^{-1}, where

$$v = -0.1t^3 + 1.8t^2 - 6t + 5.6.$$

The acceleration of X is zero at $t = p$ and $t = q$, where $p < q$.

(a) Find the value of p and the value of q. [4]

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It is given that the velocity of X is zero at $t = 14$.

(b) Find the velocities of X at $t = p$ and at $t = q$, and hence sketch the velocity-time graph for the motion of X for $0 \leqslant t \leqslant 15$. [3]

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(c) Find the total distance travelled by X between $t = 0$ and $t = 15$. [5]

Additional Page

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

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