Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

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 [ ].

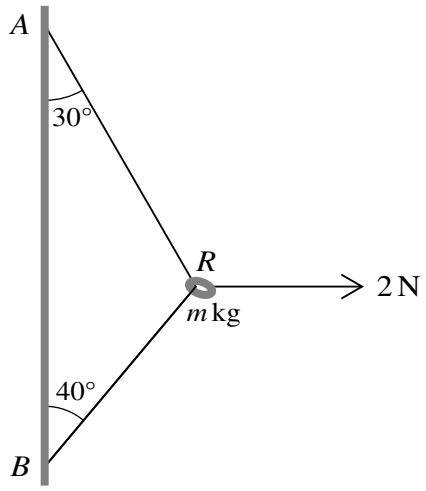
This document has **12** pages.

[Turn over

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]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

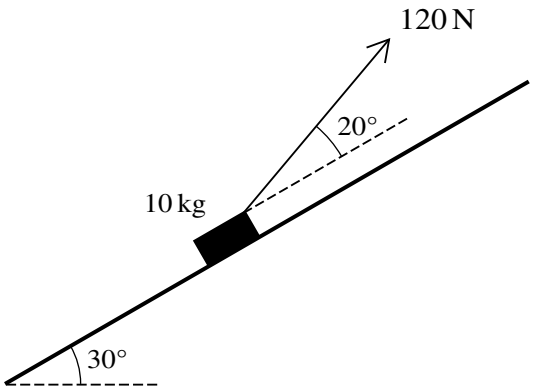
.....

.....

.....

.....

3



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]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

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]

.....

.....

.....

.....

.....

.....

.....

.....

(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]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

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]

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]

(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]

.....

.....

.....

.....

.....

.....

.....

.....

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]

.....

.....

.....

(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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....