



## Cambridge International AS & A Level

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**MATHEMATICS**

**9709/43**

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  $10 \text{ m s}^{-2}$ .

### 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 particle is projected vertically upwards from horizontal ground with a speed of  $u \text{ m s}^{-1}$ . The particle has height  $s \text{ m}$  above the ground at times 3 seconds and 4 seconds after projection.

Find the value of  $u$  and the value of  $s$ .

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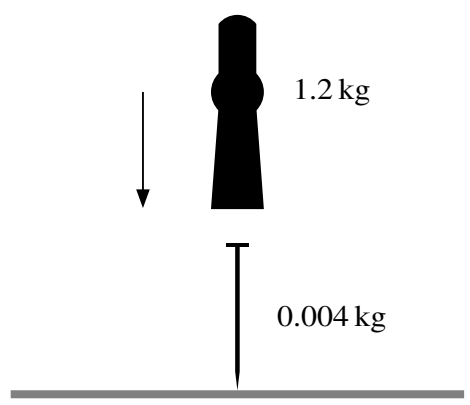
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A machine for driving a nail into a block of wood causes a hammerhead to drop vertically onto the top of a nail. The mass of the hammerhead is 1.2 kg and the mass of the nail is 0.004 kg (see diagram). The hammerhead hits the nail with speed  $v \text{ m s}^{-1}$  and remains in contact with the nail after the impact. The combined hammerhead and nail move immediately after the impact with speed  $40 \text{ m s}^{-1}$ .

(a) Calculate  $v$ , giving your answer as an exact fraction. [2]

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(b) The nail is driven 4 cm into the wood.  
Find the constant force resisting the motion. [3]

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## 4

- 3 A block of mass 8 kg slides down a rough plane inclined at  $30^\circ$  to the horizontal, starting from rest. The coefficient of friction between the block and the plane is  $\mu$ . The block accelerates uniformly down the plane at  $2.4 \text{ m s}^{-2}$ .

(a) Draw a diagram showing the forces acting on the block. [1]

(b) Find the value of  $\mu$ . [4]

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(c) Find the speed of the block after it has moved 3 m down the plane. [1]

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4 A car has mass 1600 kg.

- (a) The car is moving along a straight horizontal road at a constant speed of  $24 \text{ m s}^{-1}$  and is subject to a constant resistance of magnitude 480 N.

Find, in kW, the rate at which the engine of the car is working. [2]

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The car now moves down a hill inclined at an angle of  $\theta$  to the horizontal, where  $\sin \theta = 0.09$ . The engine of the car is working at a constant rate of 12 kW. The speed of the car is  $24 \text{ m s}^{-1}$  at the top of the hill. Ten seconds later the car has travelled 280 m down the hill and has speed  $32 \text{ m s}^{-1}$ .

- (b) Given that the resistance is not constant, use an energy method to find the total work done against the resistance during the ten seconds. [5]

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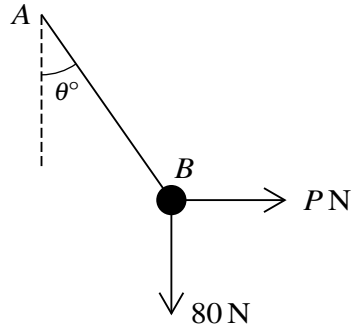
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A light string  $AB$  is fixed at  $A$  and has a particle of weight  $80$  N attached at  $B$ . A horizontal force of magnitude  $P$  N is applied at  $B$  such that the string makes an angle  $\theta^\circ$  to the vertical (see diagram).

(a) It is given that  $P = 32$  and the system is in equilibrium.

Find the tension in the string and the value of  $\theta$ .

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(b) It is given instead that the tension in the string is 120N and that the particle attached at  $B$  still has weight 80N.

Find the value of  $P$  and the value of  $\theta$ . [4]

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## 8

6 A particle moves in a straight line. At time  $t$  s, the acceleration,  $a$  m s $^{-2}$ , of the particle is given by  $a = 36 - 6t$ . The velocity of the particle is 27 m s $^{-1}$  when  $t = 2$ .

(a) Find the values of  $t$  when the particle is at instantaneous rest.

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(b) Find the total distance the particle travels during the first 12 seconds.

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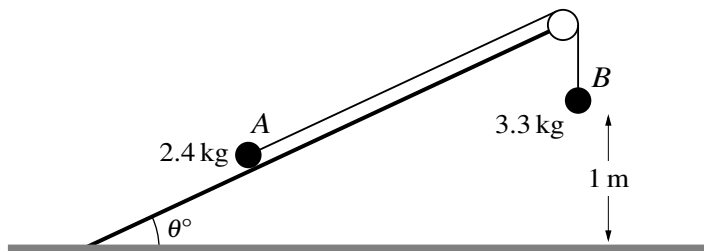
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Particles  $A$  and  $B$ , of masses  $2.4 \text{ kg}$  and  $3.3 \text{ kg}$  respectively, are connected by a light inextensible string that passes over a smooth pulley which is fixed to the top of a rough plane. The plane makes an angle of  $\theta^\circ$  with horizontal ground. Particle  $A$  is on the plane and the section of the string between  $A$  and the pulley is parallel to a line of greatest slope of the plane. Particle  $B$  hangs vertically below the pulley and is  $1 \text{ m}$  above the ground (see diagram). The coefficient of friction between the plane and  $A$  is  $\mu$ .

- (a) It is given that  $\theta = 30$  and the system is in equilibrium with  $A$  on the point of moving directly up the plane.

Show that  $\mu = 1.01$  correct to 3 significant figures. [5]

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(b) It is given instead that  $\theta = 20$  and  $\mu = 1.01$ . The system is released from rest with the string taut.

Find the total distance travelled by  $A$  before coming to instantaneous rest. You may assume that  $A$  does not reach the pulley and that  $B$  remains at rest after it hits the ground. [8]

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