

Cambridge International AS & A Level

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MATHEMATICS

9709/42

Paper 4 Mechanics

February/March 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 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 **16** pages. Any blank pages are indicated.

- 1** A crate of mass 200 kg is being pulled at constant speed along horizontal ground by a horizontal rope attached to a winch. The winch is working at a constant rate of 4.5 kW and there is a constant resistance to the motion of the crate of magnitude 600 N.

(a) Find the time that it takes for the crate to move a distance of 15 m. [2]

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The rope breaks after the crate has moved 15 m.

(b) Find the time taken, after the rope breaks, for the crate to come to rest. [3]

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2 A particle P is projected vertically upwards from horizontal ground with speed 15 m s^{-1} .

(a) Find the speed of P when it is 10 m above the ground. [2]

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At the same instant that P is projected, a second particle Q is dropped from a height of 18 m above the ground in the same vertical line as P .

(b) Find the height above the ground at which the two particles collide. [3]

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- 3** A particle moves in a straight line starting from rest from a point O . The acceleration of the particle at time t s after leaving O is $a \text{ m s}^{-2}$, where $a = 4t^{\frac{1}{2}}$.

(a) Find the speed of the particle when $t = 9$. [2]

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(b) Find the time after leaving O at which the speed (in metres per second) and the distance travelled (in metres) are numerically equal. [3]

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- 4** A toy railway locomotive of mass 0.8 kg is towing a truck of mass 0.4 kg on a straight horizontal track at a constant speed of 2 m s^{-1} . There is a constant resistance force of magnitude 0.2 N on the locomotive, but no resistance force on the truck. There is a light rigid horizontal coupling connecting the locomotive and the truck.

(a) State the tension in the coupling. [1]

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(b) Find the power produced by the locomotive's engine. [1]

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The power produced by the locomotive's engine is now changed to 1.2 W .

(c) Find the magnitude of the tension in the coupling at the instant that the locomotive begins to accelerate. [5]

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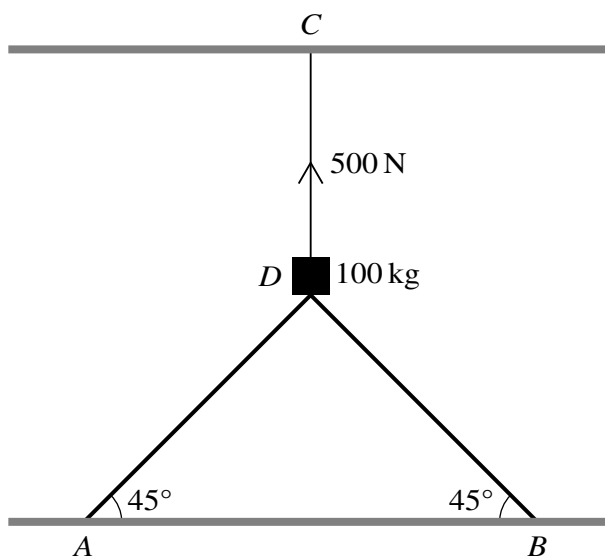
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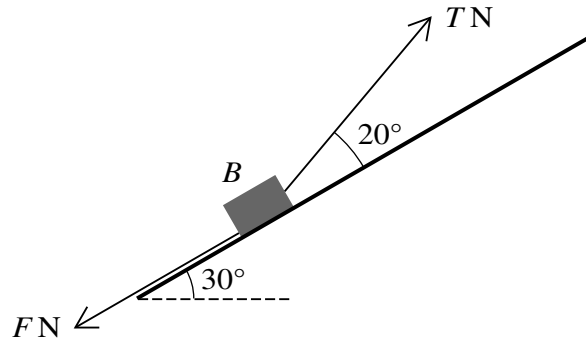
The diagram shows a block D of mass 100 kg supported by two sloping struts AD and BD , each attached at an angle of 45° to fixed points A and B respectively on a horizontal floor. The block is also held in place by a vertical rope CD attached to a fixed point C on a horizontal ceiling. The tension in the rope CD is 500 N and the block rests in equilibrium.

- (a) Find the magnitude of the force in each of the struts AD and BD . [3]

[illegible]

- [illegible]

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A block B , of mass 2 kg , lies on a rough inclined plane sloping at 30° to the horizontal. A light rope, inclined at an angle of 20° above a line of greatest slope, is attached to B . The tension in the rope is $T\text{ N}$. There is a friction force of $F\text{ N}$ acting on B (see diagram). The coefficient of friction between B and the plane is μ .

(a) It is given that $F = 5$ and that the acceleration of B up the plane is 1.2 m s^{-2} .

(i) Find the value of T .

[3]

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(ii) Find the value of μ .

[3]

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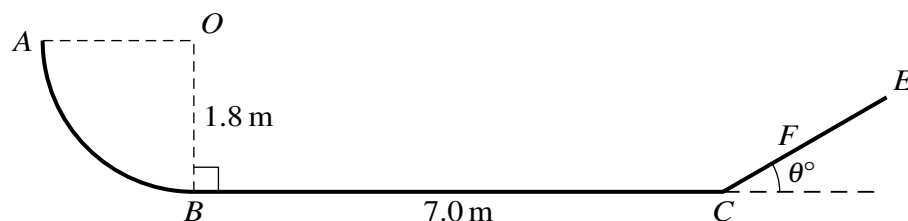
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- (b)** It is given instead that $\mu = 0.8$ and $T = 15$.

Determine whether B will move up the plane.

[3]

[illegible]



The diagram shows a smooth track which lies in a vertical plane. The section AB is a quarter circle of radius 1.8 m with centre O . The section BC is a horizontal straight line of length 7.0 m and OB is perpendicular to BC . The section CFE is a straight line inclined at an angle of θ° above the horizontal.

A particle P of mass 0.5 kg is released from rest at A . Particle P collides with a particle Q of mass 0.1 kg which is at rest at B . Immediately after the collision, the speed of P is 4 ms^{-1} in the direction BC . You should assume that P is moving horizontally when it collides with Q .

- (a) Show that the speed of Q immediately after the collision is 10 ms^{-1} . [4]

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, which is otherwise blank white space.

When Q reaches C , it collides with a particle R of mass 0.4 kg which is at rest at C . The two particles coalesce. The combined particle comes instantaneously to rest at F . You should assume that there is no instantaneous change in speed as the combined particle leaves C , nor when it passes through C again as it returns down the slope.

- (b) Given that the distance CF is 0.4 m , find the value of θ . [4]

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[Question 7 continues on the next page.]

[5]

[illegible]

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