



Cambridge International AS & A Level

CANDIDATE NAME



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MATHEMATICS

9709/41

Paper 4 Mechanics

October/November 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.
- 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 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.





- 1 Two particles, of masses 1.8 kg and 1.2 kg, are connected by a light inextensible string that passes over a fixed smooth pulley. The particles hang vertically. The system is released from rest.

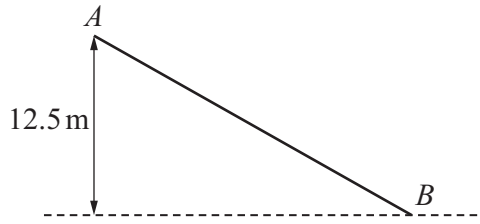
Find the magnitude of the acceleration of the particles and find the tension in the string. [4]

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A particle of mass 7.5 kg, starting from rest at *A*, slides down an inclined plane *AB*. The point *B* is 12.5 metres vertically below the level of *A*, as shown in the diagram.

- (a) Given that the plane is smooth, use an energy method to find the speed of the particle at *B*. [2]

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- (b) It is given instead that the plane is rough and the particle reaches *B* with a speed of 8 m s^{-1} . The plane is 25 m long and the constant frictional force has magnitude $F \text{ N}$.

Find the value of F . [3]

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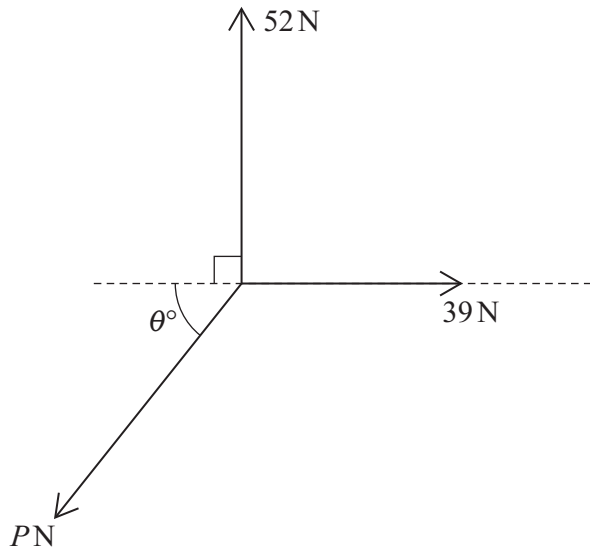
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Coplanar forces of magnitudes 52 N, 39 N and P N act at a point in the directions shown in the diagram. The system is in equilibrium.

Find the values of P and θ . [4]

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4 A bus travels between two stops, *A* and *B*. The bus starts from rest at *A* and accelerates at a constant rate of $a \text{ m s}^{-2}$ until it reaches a speed of 16 m s^{-1} . It then travels at this constant speed before decelerating at a constant rate of $0.75a \text{ m s}^{-2}$, coming to rest at *B*. The total time for the journey is 240 s.

(a) Sketch the velocity-time graph for the bus’s journey from *A* to *B*. [1]



(b) Find an expression, in terms of *a*, for the length of time that the bus is travelling with constant speed. [2]

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(c) Given that the distance from *A* to *B* is 3000 m, find the value of *a*. [3]

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5 A particle, A , is projected vertically upwards from a point O with a speed of 80 m s^{-1} . One second later a second particle, B , with the same mass as A , is projected vertically upwards from O with a speed of 100 m s^{-1} . At time $T \text{ s}$ after the first particle is projected, the two particles collide and coalesce to form a particle C .

(a) Show that $T = 3.5$. [4]

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(b) Find the height above O at which the particles collide. [1]

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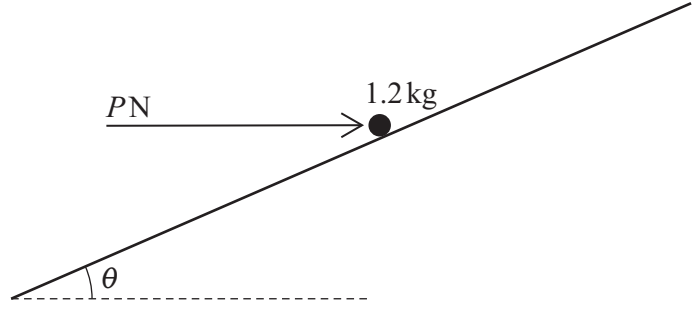
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A particle of mass 1.2 kg is placed on a rough plane which is inclined at an angle θ to the horizontal, where $\sin \theta = \frac{7}{25}$. The particle is kept in equilibrium by a horizontal force of magnitude P N acting in a vertical plane containing a line of greatest slope (see diagram). The coefficient of friction between the particle and the plane is 0.15 .

Find the least possible value of P .

[6]

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7 A car has mass 1200 kg. When the car is travelling at a speed of $v \text{ m s}^{-1}$, there is a resistive force of magnitude $k v \text{ N}$. The maximum power of the car's engine is 92.16 kW.

(a) The car travels along a straight level road.

(i) The car has a greatest possible constant speed of 48 m s^{-1} .

Show that $k = 40$.

[1]

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(ii) At an instant when its speed is 45 m s^{-1} , find the greatest possible acceleration of the car. [3]

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(b) The car now travels at a constant speed up a hill inclined at an angle of $\sin^{-1}0.15$ to the horizontal.

Find the greatest possible speed of the car going up the hill. [4]

A series of horizontal dotted lines are provided for the student to write their solution to the problem.

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8 A particle P moves in a straight line, passing through a point O with velocity 4.2 m s^{-1} . At time t s after P passes O , the acceleration, $a \text{ m s}^{-2}$, of P is given by $a = 0.6t - 2.7$.

Find the distance P travels between the times at which it is at instantaneous rest. [7]

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Additional page

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