

CANDIDATE
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MATHEMATICS

9709/41

Paper 4 Mechanics 1 **(M1)**

May/June 2018

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

READ THESE INSTRUCTIONS FIRST

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Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

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DO NOT WRITE IN ANY BARCODES.

Answer **all** the questions in the space provided. If additional space is required, you should use the lined page at the end of this booklet. The question number(s) must be clearly shown.

Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.

Where a numerical value for the acceleration due to gravity is needed, use 10 m s^{-2} .

The use of an electronic calculator is expected, where appropriate.

You are reminded of the need for clear presentation in your answers.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [] at the end of each question or part question.

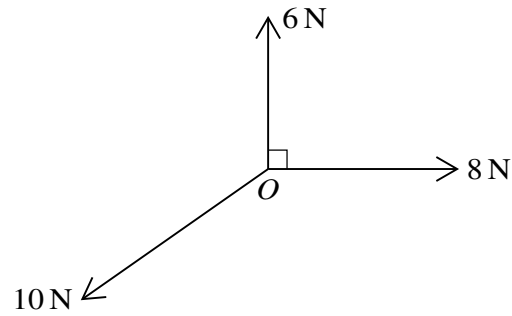
The total number of marks for this paper is 50.

This document consists of **14** printed pages and **2** blank pages.



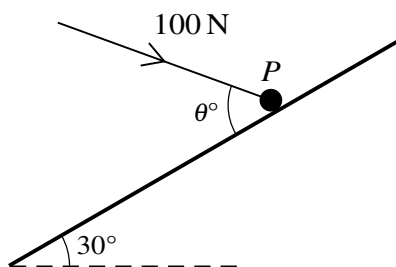
- 1** A particle P is projected vertically upwards with speed 24 m s^{-1} from a point 5 m above ground level. Find the time from projection until P reaches the ground. [3]

This image shows a full page of primary-ruled paper. It consists of approximately 20 horizontal dashed lines spaced evenly down the page, providing a guide for handwriting practice. The background is white, and there are no margins or other markings present.



The diagram shows three coplanar forces acting at the point O . The magnitudes of the forces are 6 N, 8 N and 10 N. The angle between the 6 N force and the 8 N force is 90° . The forces are in equilibrium. Find the other angles between the forces. [4]

[illegible]



(i) Given that P is in equilibrium, show that $\theta = 66.4$, correct to 1 decimal place, and find the normal reaction between the plane and P . [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.

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(ii) Given instead that $\theta = 30$, find the acceleration of P .

[2]

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- 4 A particle P moves in a straight line starting from a point O . At time t s after leaving O , the displacement s m from O is given by $s = t^3 - 4t^2 + 4t$ and the velocity is $v \text{ m s}^{-1}$.

(i) Find an expression for v in terms of t . [2]

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(ii) Find the two values of t for which P is at instantaneous rest. [2]

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(iii) Find the minimum velocity of P .

[3]

[illegible]

- 5 A sprinter runs a race of 200 m. His total time for running the race is 20 s. He starts from rest and accelerates uniformly for 6 s, reaching a speed of 12 m s^{-1} . He maintains this speed for the next 10 s, before decelerating uniformly to cross the finishing line with speed $V \text{ m s}^{-1}$.

- (i) Find the distance travelled by the sprinter in the first 16 s of the race. Hence sketch a displacement-time graph for the 20 s of the sprinter's race. [6]

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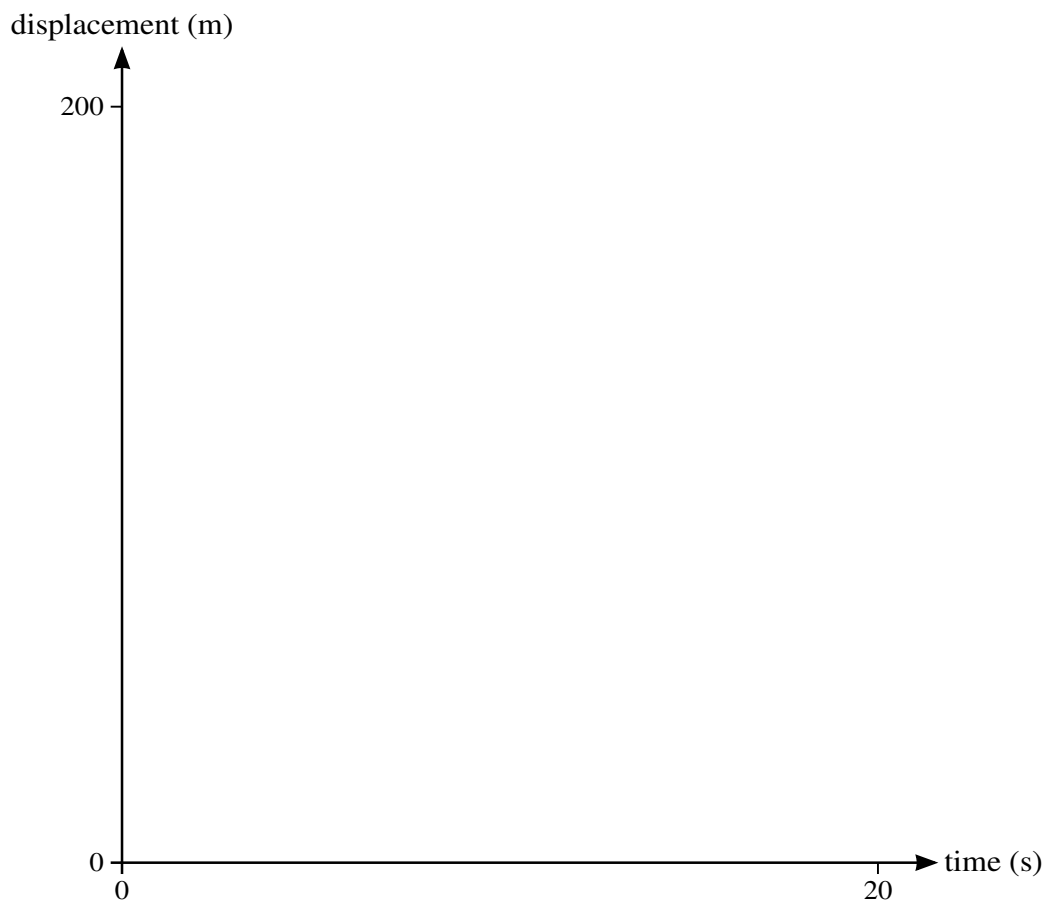
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[Turn over

6 A car has mass 1250 kg.

- (i) The car is moving along a straight level road at a constant speed of 36 m s^{-1} and is subject to a constant resistance of magnitude 850 N. Find, in kW, the rate at which the engine of the car is working. [2]

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- (ii) The car travels at a constant speed up a hill and is subject to the same resistance as in part (i). The hill is inclined at an angle of θ° to the horizontal, where $\sin \theta^\circ = 0.1$, and the engine is working at 63 kW. Find the speed of the car. [3]

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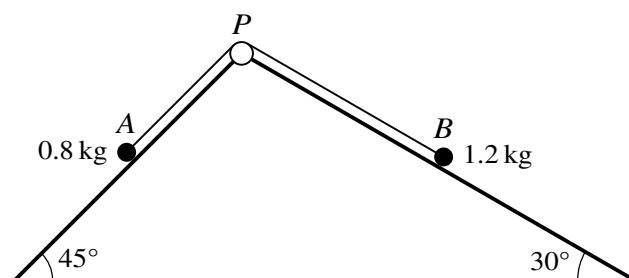
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- (iii) The car descends the same hill with the engine of the car working at a constant rate of 20 kW. The resistance is not constant. The initial speed of the car is 20 m s^{-1} . Eight seconds later the car has speed 24 m s^{-1} and has moved 176 m down the hill. Use an energy method to find the total work done against the resistance during the eight seconds. [5]

This image shows a full page of a handwriting practice worksheet. It consists of approximately 20 horizontal rows. Each row is defined by two parallel dotted lines, creating a series of uniform gaps for writing. The lines are evenly spaced and extend across the entire width of the page, providing a guide for letter height and placement. There is no text or other markings on the page.



The diagram shows a triangular block with sloping faces inclined to the horizontal at 45° and 30° . Particle A of mass 0.8 kg lies on the face inclined at 45° and particle B of mass 1.2 kg lies on the face inclined at 30° . The particles are connected by a light inextensible string which passes over a small smooth pulley P fixed at the top of the faces. The parts AP and BP of the string are parallel to lines of greatest slope of the respective faces. The particles are released from rest with both parts of the string taut. In the subsequent motion neither particle reaches the pulley and neither particle reaches the bottom of a face.

- (i) Given that both faces are smooth, find the speed of A after each particle has travelled a distance of 0.4 m. [6]

[illegible]

- (ii)** It is given instead that both faces are rough. The coefficient of friction between each particle and a face of the block is μ . Find the value of μ for which the system is in limiting equilibrium. [6]

This image shows a full page of white paper with horizontal dotted lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting or typing. There are no margins, text, or other markings on the page.

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MATHEMATICS

9709/42

Paper 4 Mechanics 1 **(M1)**

May/June 2018

1 hour 15 minutes

Candidates answer on the Question Paper.

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This document consists of **13** printed pages and **3** blank pages.

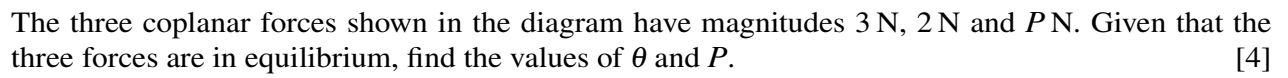
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- 1** A man has mass 80 kg. He runs along a horizontal road against a constant resistance force of magnitude P N. The total work done by the man in increasing his speed from 4 m s^{-1} to 5.5 m s^{-1} while running a distance of 60 metres is 1200 J. Find the value of P . [4]

This image shows a full page of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page, typical of notebook or legal stationery. There are no margins, text, or other markings on the page.

- 2** A train of mass 240 000 kg travels up a slope inclined at an angle of 4° to the horizontal. There is a constant resistance of magnitude 18 000 N acting on the train. At an instant when the speed of the train is 15 m s^{-1} its deceleration is 0.2 m s^{-2} . Find the power of the engine of the train. [4]

[illegible]

[illegible]

- 4 A particle P moves in a straight line $ABCD$ with constant acceleration. The distances AB and BC are 100 m and 148 m respectively. The particle takes 4 s to travel from A to B and also takes 4 s to travel from B to C .

(i) Show that the acceleration of P is 3 m s^{-2} and find the speed of P at A . [6]

[illegible]

- (ii) P reaches D with a speed of 61 m s^{-1} . Find the distance CD . [3]

- 5 A particle of mass 20 kg is on a rough plane inclined at an angle of 60° to the horizontal. Equilibrium is maintained by a force of magnitude P N acting on the particle, in a direction parallel to a line of greatest slope of the plane. The greatest possible value of P is twice the least possible value of P . Find the value of the coefficient of friction between the particle and the plane. [7]

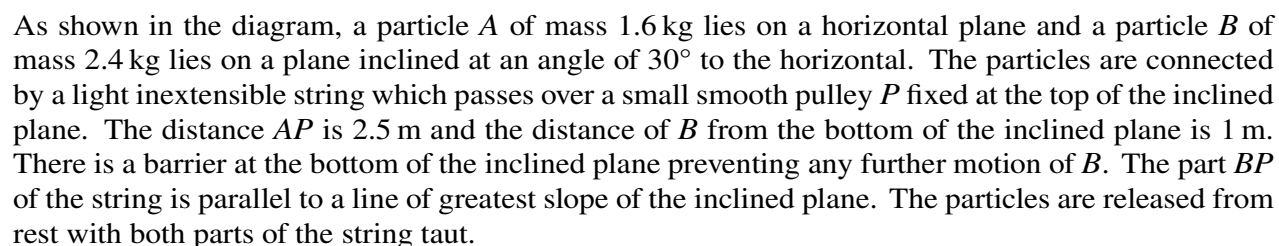
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- 6** A particle P moves in a straight line passing through a point O . At time t s, the acceleration, a m s⁻², of P is given by $a = 6 - 0.24t$. The particle comes to instantaneous rest at time $t = 20$.

(i) Find the value of t at which the particle is again at instantaneous rest. [5]

[illegible]

[illegible]



- [illegible]

- (ii) It is given instead that the horizontal plane is rough and that the coefficient of friction between A and the horizontal plane is 0.2. The inclined plane is smooth. Find the total distance travelled by A. [9]

[illegible]

[illegible]

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MATHEMATICS

9709/43

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May/June 2018

1 hour 15 minutes

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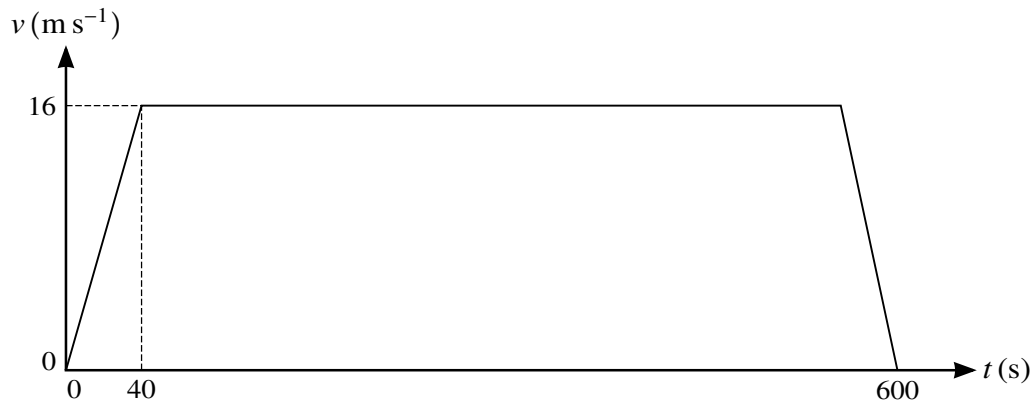
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The diagram shows the velocity-time graph for a train which travels from rest at one station to rest at the next station. The graph consists of three straight line segments. The distance between the two stations is 9040 m.

- (i) Find the acceleration of the train during the first 40 s. [1]

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- (ii) Find the length of time for which the train is travelling at constant speed. [2]

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- (iii) Find the distance travelled by the train while it is decelerating. [2]

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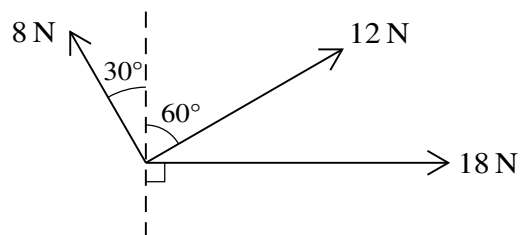
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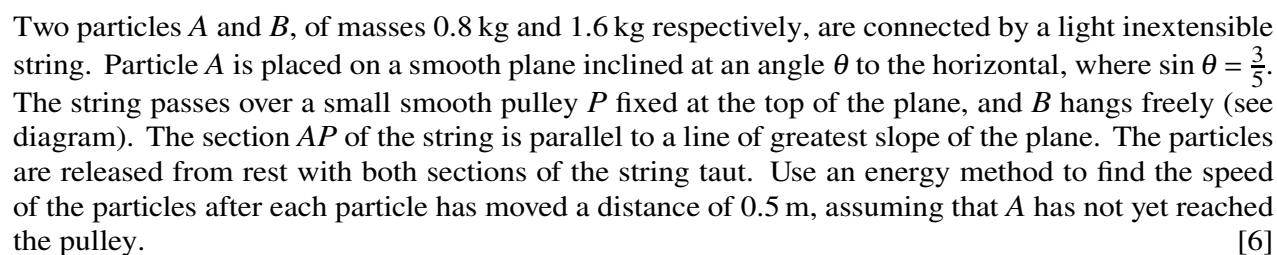
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- 2** A small ball is projected vertically downwards with speed 5 m s^{-1} from a point A at a height of 7.2 m above horizontal ground. The ball hits the ground with speed $V \text{ m s}^{-1}$ and rebounds vertically upwards with speed $\frac{1}{2}V \text{ m s}^{-1}$. The highest point the ball reaches after rebounding is B . Find V and hence find the total time taken for the ball to reach the ground from A and rebound to B . [5]

This image shows a full page of a worksheet designed for handwriting practice. It features 20 evenly spaced, horizontal dashed lines across the entire width of the page. The background is plain white, and there are no margins, text, or other markings present.



This image shows a full page of white paper with horizontal dashed lines, typical of primary school handwriting practice paper. The lines are evenly spaced and run across the entire width of the page. There are no margins, text, or other markings present.

[illegible]

- 5 A particle of mass 3 kg is on a rough plane inclined at an angle of 20° to the horizontal. A force of magnitude P N acting parallel to a line of greatest slope of the plane is used to keep the particle in equilibrium. The coefficient of friction between the particle and the plane is 0.35. Show that the least possible value of P is 0.394, correct to 3 significant figures, and find the greatest possible value of P . [6]

This image shows a single page of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

- 6** A car of mass 1400 kg travelling at a speed of $v \text{ m s}^{-1}$ experiences a resistive force of magnitude $40v \text{ N}$. The greatest possible constant speed of the car along a straight level road is 56 m s^{-1} .

(i) Find, in kW, the greatest possible power of the car's engine. [2]

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(ii) Find the greatest possible acceleration of the car at an instant when its speed on a straight level road is 32 m s^{-1} . [3]

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- (iii)** The car travels down a hill inclined at an angle of θ° to the horizontal at a constant speed of 50 m s^{-1} . The power of the car's engine is 60 kW . Find the value of θ . [4]

[illegible]

- 7 A particle P moves in a straight line starting from a point O . The velocity $v \text{ m s}^{-1}$ of P at time $t \text{ s}$ is given by

$$v = 12t - 4t^2 \quad \text{for } 0 \leq t \leq 2,$$

$$v = 16 - 4t \quad \text{for } 2 \leq t \leq 4.$$

- (i) Find the maximum velocity of P during the first 2 s. [3]

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- (ii) Determine, with justification, whether there is any instantaneous change in the acceleration of P when $t = 2$. [2]

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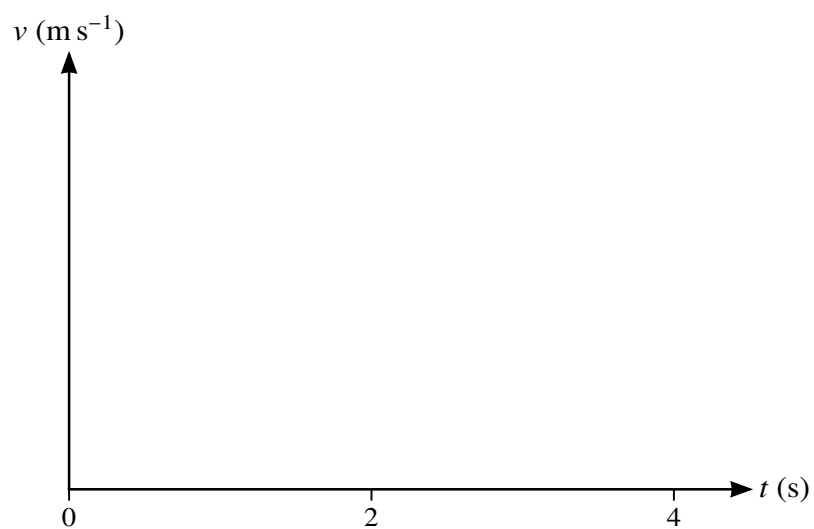
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- (iii) Sketch the velocity-time graph for $0 \leq t \leq 4$.

[3]



- (iv) Find the distance travelled by P in the interval $0 \leq t \leq 4$.

[5]

[illegible]

[illegible]

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