

CANDIDATE
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MATHEMATICS

9709/41

Paper 4 Mechanics 1 **(M1)**

May/June 2019

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

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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.

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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.

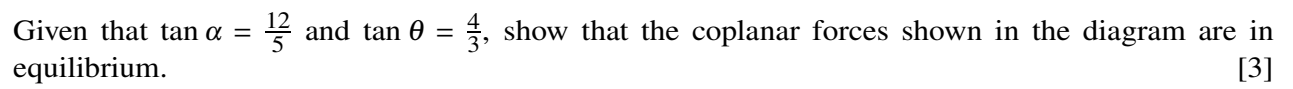
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The total number of marks for this paper is 50.

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



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[illegible]

- 2 A particle P is projected vertically upwards with speed 25 m s^{-1} from a point 3 m above horizontal ground.

(i) Find the time taken for P to reach its greatest height. [2]

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(ii) Find the length of time for which P is higher than 23 m above the ground. [3]

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(iii) P is higher than h m above the ground for 1 second. Find h . [2]

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3 A lorry has mass 12 000 kg.

- (i) The lorry moves at a constant speed of 5 m s^{-1} up a hill inclined at an angle of θ to the horizontal, where $\sin \theta = 0.08$. At this speed, the magnitude of the resistance to motion on the lorry is 1500 N . Show that the power of the lorry's engine is 55.5 kW . [3]

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.

When the speed of the lorry is $v \text{ m s}^{-1}$ the magnitude of the resistance to motion is $kv^2 \text{ N}$, where k is a constant.

- (ii) Show that $k = 60$. [1]

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- (iii)** The lorry now moves at a constant speed on a straight level road. Given that its engine is still working at 55.5 kW, find the lorry's speed. [3]

[illegible]

- 4 A particle of mass 1.3 kg rests on a rough plane inclined at an angle θ to the horizontal, where $\tan \theta = \frac{12}{5}$. The coefficient of friction between the particle and the plane is μ .
- (i) A force of magnitude 20 N parallel to a line of greatest slope of the plane is applied to the particle and the particle is on the point of moving up the plane. Show that $\mu = 1.6$. [4]

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The force of magnitude 20 N is now removed.

(ii) Find the acceleration of the particle.

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(iii) Find the work done against friction during the first 2 s of motion.

[3]

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

$$v = t^2 - 8t + 12 \quad \text{for } 0 \leq t \leq 8.$$

- (i) Find the minimum velocity of P . [3]

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- (ii) Find the total distance travelled by P in the interval $0 \leq t \leq 8$. [7]

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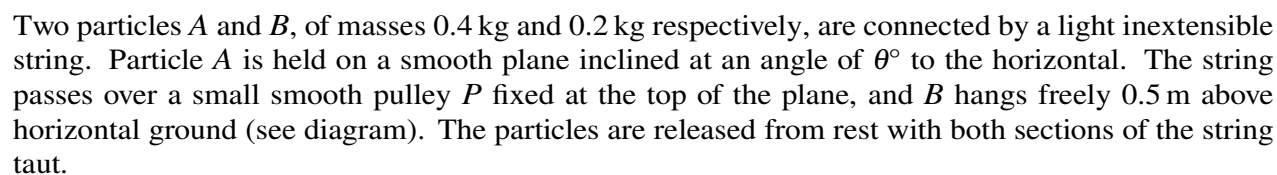
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- [illegible]

- (ii) It is given instead that $\theta = 20$. In the subsequent motion particle A does not reach P and B remains at rest after reaching the ground.

- (a) Find the tension in the string and the acceleration of the system. [4]

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- (b) Find the speed of A at the instant B reaches the ground. [2]

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[Question 6 continues on the next page.]

- (c) Use an energy method to find the total distance A moves up the plane before coming to instantaneous rest. [5]

[illegible]

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MATHEMATICS

9709/42

Paper 4 Mechanics 1 **(M1)**

May/June 2019

1 hour 15 minutes

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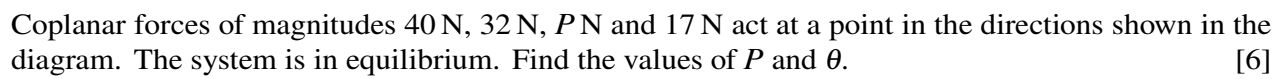
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The total number of marks for this paper is 50.

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[illegible]

- 2** A car moves in a straight line with initial speed $u \text{ m s}^{-1}$ and constant acceleration $a \text{ m s}^{-2}$. The car takes 5 s to travel the first 80 m and it takes 8 s to travel the first 160 m. Find a and u . [6]

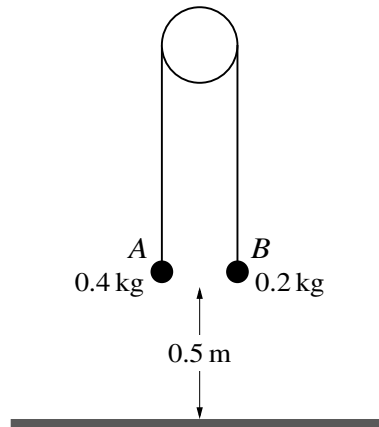
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- 3** A particle of mass 13 kg is on a rough plane inclined at an angle of θ to the horizontal, where $\tan \theta = \frac{5}{12}$. The coefficient of friction between the particle and the plane is 0.3. A force of magnitude T N, acting parallel to a line of greatest slope, moves the particle a distance of 2.5 m up the plane at a constant speed. Find the work done by this force. [5]

[illegible]

- 4 A constant resistance to motion of magnitude 350 N acts on a car of mass 1250 kg. The engine of the car exerts a constant driving force of 1200 N. The car travels along a road inclined at an angle of θ to the horizontal, where $\sin \theta = 0.05$. Find the speed of the car when it has moved 100 m from rest in each of the following cases.
- The car is moving up the hill.
 - The car is moving down the hill.
- [7]

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.



Two particles A and B , of masses 0.4 kg and 0.2 kg respectively, are connected by a light inextensible string which passes over a fixed smooth pulley. Both A and B are 0.5 m above the ground. The particles hang vertically (see diagram). The particles are released from rest. In the subsequent motion B does not reach the pulley and A remains at rest after reaching the ground.

- (i) For the motion before A reaches the ground, show that the magnitude of the acceleration of each particle is $\frac{10}{3} \text{ m s}^{-2}$ and find the tension in the string. [4]

This image shows a single sheet 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.

This image shows a full page of white paper with horizontal dashed lines, typical of primary school writing paper. 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 has mass 1000 kg. When the car is travelling at a steady speed of $v \text{ m s}^{-1}$, where $v > 2$, the resistance to motion of the car is $(Av + B) \text{ N}$, where A and B are constants. The car can travel along a horizontal road at a steady speed of 18 m s^{-1} when its engine is working at 36 kW. The car can travel up a hill inclined at an angle of θ to the horizontal, where $\sin \theta = 0.05$, at a steady speed of 12 m s^{-1} when its engine is working at 21 kW. Find A and B . [7]

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- 7 Particles P and Q leave a fixed point A at the same time and travel in the same straight line. The velocity of P after t seconds is $6t(t - 3) \text{ m s}^{-1}$ and the velocity of Q after t seconds is $(10 - 2t) \text{ m s}^{-1}$.

(i) Sketch, on the same axes, velocity-time graphs for P and Q for $0 \leq t \leq 5$. [3]

(ii) Verify that P and Q meet after 5 seconds. [4]

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(iii) Find the greatest distance between P and Q for $0 \leq t \leq 5$. [4]

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MATHEMATICS

9709/43

Paper 4 Mechanics 1 **(M1)**

May/June 2019

1 hour 15 minutes

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- 1 A bus moves in a straight line between two bus stops. The bus starts from rest and accelerates at 2.1 m s^{-2} for 5 s. The bus then travels for 24 s at constant speed and finally slows down, with a constant deceleration, stopping in a further 6 s. Sketch a velocity-time graph for the motion and hence find the distance between the two bus stops. [5]

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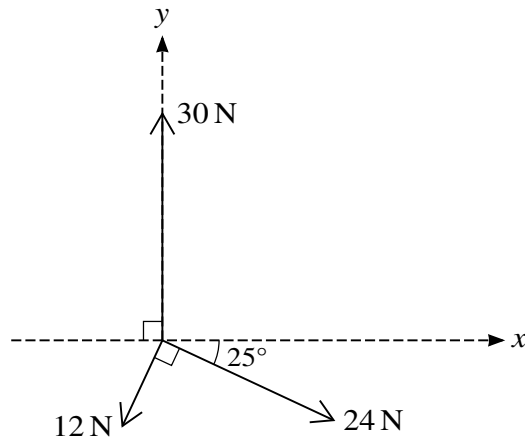
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Coplanar forces of magnitudes 12 N, 24 N and 30 N act at a point in the directions shown in the diagram.

- (i) Find the components of the resultant of the three forces in the x -direction and in the y -direction. [4]

Component in x -direction.....

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Component in y -direction.....

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- (ii) Hence find the direction of the resultant. [2]

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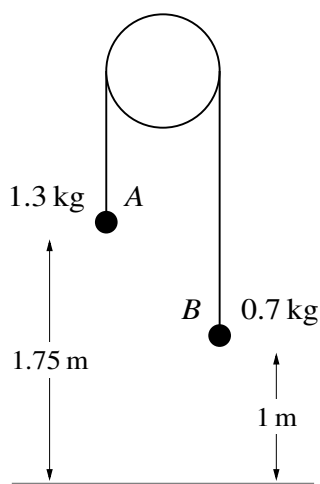
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- 3** A car of mass 1400 kg is travelling up a hill inclined at an angle of 4° to the horizontal. There is a constant resistance to motion of magnitude 1550 N acting on the car.
- (i)** Given that the engine of the car is working at 30 kW, find the speed of the car at an instant when its acceleration is 0.4 m s^{-2} . [4]

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- (ii)** The greatest possible constant speed at which the car can travel up the hill is 40 m s^{-1} . Find the maximum possible power of the engine. [3]

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Two particles A and B , of masses 1.3 kg and 0.7 kg respectively, are connected by a light inextensible string which passes over a smooth fixed pulley. Particle A is 1.75 m above the floor and particle B is 1 m above the floor (see diagram). The system is released from rest with the string taut, and the particles move vertically. When the particles are at the same height the string breaks.

- (i) Show that, before the string breaks, the magnitude of the acceleration of each particle is 3 m s^{-2} and find the tension in the string. [4]

[illegible]

- (ii)** Find the difference in the times that it takes the particles to hit the ground.

[6]

[illegible]

- 5 A particle of mass 18 kg is on a plane inclined at an angle of 30° to the horizontal. The particle is projected up a line of greatest slope of the plane with a speed of 20 m s^{-1} .

- (i) Given that the plane is smooth, use an energy method to find the distance the particle moves up the plane before coming to instantaneous rest. [4]

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- (ii) Given instead that the plane is rough and the coefficient of friction between the particle and the plane is 0.25, find the speed of the particle as it returns to its starting point. [8]

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- 6** A particle P moves in a straight line. The acceleration $a \text{ m s}^{-2}$ of P at time $t \text{ s}$ is given by $a = 6t - 12$. The displacement of P from a fixed point O on the line is $s \text{ m}$. It is given that $s = 5$ when $t = 1$ and $s = 1$ when $t = 3$.

(i) Show that $s = t^3 - 6t^2 + pt + q$, where p and q are constants to be found. [4]

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 practice. There are no margins, text, or other markings on the page.

(ii) Find the values of t when P is at instantaneous rest.

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

[4]

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