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**MATHEMATICS**

**9709/41**

Paper 4 Mechanics 1 **(M1)**

**May/June 2017**

**1 hour 15 minutes**

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name in the spaces at the top of this page.

Write in dark blue or black pen.

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

Do not use staples, paper clips, glue or correction fluid.

**DO NOT WRITE IN ANY BARCODES.**

Answer **all** the questions.

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

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 **11** printed pages and **1** blank page.



- 1 A particle of mass  $0.6 \text{ kg}$  is dropped from a height of  $8 \text{ m}$  above the ground. The speed of the particle at the instant before hitting the ground is  $10 \text{ m s}^{-1}$ . Find the work done against air resistance. [3]

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.

- 2 A particle of mass  $0.8 \text{ kg}$  is projected with a speed of  $12 \text{ m s}^{-1}$  up a line of greatest slope of a rough plane inclined at an angle of  $10^\circ$  to the horizontal. The coefficient of friction between the particle and the plane is  $0.4$ .

(i) Find the acceleration of the particle.

[4]

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(ii) Find the distance the particle moves up the plane before coming to rest.

[2]

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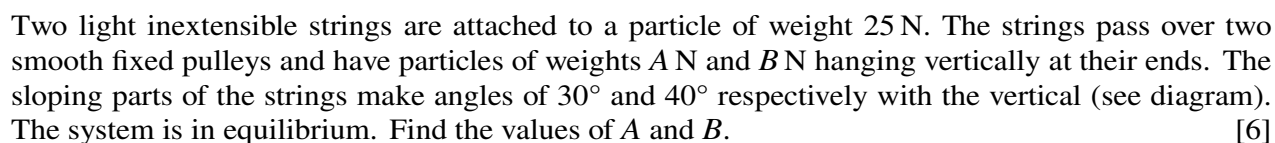
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- 4** A car of mass 800 kg is moving up a hill inclined at  $\theta^\circ$  to the horizontal, where  $\sin \theta = 0.15$ . The initial speed of the car is  $8 \text{ m s}^{-1}$ . Twelve seconds later the car has travelled 120 m up the hill and has speed  $14 \text{ m s}^{-1}$ .

(i) Find the change in the kinetic energy and the change in gravitational potential energy of the car. [3]

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(ii) The engine of the car is working at a constant rate of 32 kW. Find the total work done against the resistive forces during the twelve seconds. [3]

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- 5** A particle  $P$  moves in a straight line  $ABCD$  with constant deceleration. The velocities of  $P$  at  $A$ ,  $B$  and  $C$  are  $20 \text{ m s}^{-1}$ ,  $12 \text{ m s}^{-1}$  and  $6 \text{ m s}^{-1}$  respectively.

(i) Find the ratio of distances  $AB : BC$ .

[4]

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.

- (ii) The particle comes to rest at  $D$ . Given that the distance  $AD$  is 80 m, find the distance  $BC$ . [3]

[illegible]

- 6** A particle  $P$  moves in a straight line passing through a point  $O$ . At time  $t$  s, the velocity of  $P$ ,  $v$  m s<sup>-1</sup>, is given by  $v = qt + rt^2$ , where  $q$  and  $r$  are constants. The particle has velocity 4 m s<sup>-1</sup> when  $t = 1$  and when  $t = 2$ .

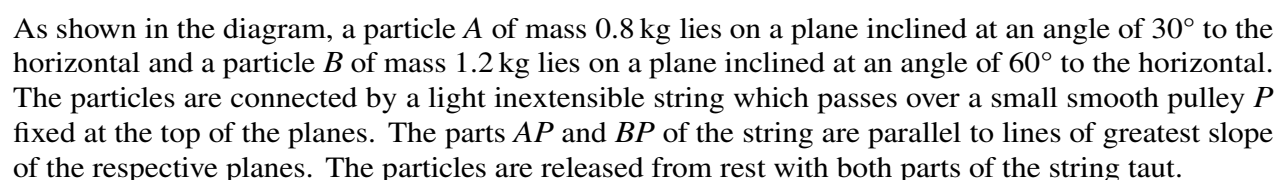
(i) Show that, when  $t = 0.5$ , the acceleration of  $P$  is  $4 \text{ m s}^{-2}$ . [4]

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.

(ii) Find the values of  $t$  when  $P$  is at instantaneous rest. [2]

[illegible]

**[Turn over**



- [illegible]

[illegible]

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**MATHEMATICS**

**9709/42**

Paper 4 Mechanics 1 (**M1**)

**May/June 2017**

**1 hour 15 minutes**

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

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

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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- 1 One end of a light inextensible string is attached to a block. The string makes an angle of  $\theta^\circ$  with the horizontal. The tension in the string is 20 N. The string pulls the block along a horizontal surface at a constant speed of  $1.5 \text{ m s}^{-1}$  for 12 s. The work done by the tension in the string is 50 J. Find  $\theta$ . [3]

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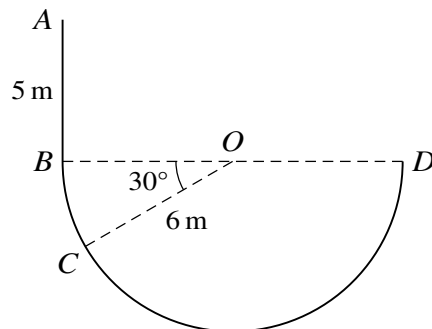
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The diagram shows a wire  $ABCD$  consisting of a straight part  $AB$  of length 5 m and a part  $BCD$  in the shape of a semicircle of radius 6 m and centre  $O$ . The diameter  $BD$  of the semicircle is horizontal and  $AB$  is vertical. A small ring is threaded onto the wire and slides along the wire. The ring starts from rest at  $A$ . The part  $AB$  of the wire is rough, and the ring accelerates at a constant rate of  $2.5 \text{ m s}^{-2}$  between  $A$  and  $B$ .

- (i) Show that the speed of the ring as it reaches  $B$  is  $5 \text{ m s}^{-1}$ . [1]

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The part  $BCD$  of the wire is smooth. The mass of the ring is  $0.2 \text{ kg}$ .

- (ii) (a) Find the speed of the ring at  $C$ , where angle  $BOC = 30^\circ$ . [4]

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- (b) Find the greatest speed of the ring. [2]

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- 3** A particle  $A$  moves in a straight line with constant speed  $10 \text{ m s}^{-1}$ . Two seconds after  $A$  passes a point  $O$  on the line, a particle  $B$  passes through  $O$ , moving along the line in the same direction as  $A$ . Particle  $B$  has speed  $16 \text{ m s}^{-1}$  at  $O$  and has a constant deceleration of  $2 \text{ m s}^{-2}$ .

- (i) Find expressions, in terms of  $t$ , for the displacement from  $O$  of each particle  $t$  s after  $B$  passes through  $O$ . [3]

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- (ii) Find the distance between the particles when  $B$  comes to instantaneous rest. [3]

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**(iii)** Find the minimum distance between the particles.

[3]

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.

- 4** A car of mass 1200 kg is moving on a straight road against a constant force of 850 N resisting the motion.

(i) On a part of the road that is horizontal, the car moves with a constant speed of  $42 \text{ m s}^{-1}$ .

- (a) Calculate, in kW, the power developed by the engine of the car. [2]

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- (b) Given that this power is suddenly increased by 6 kW, find the instantaneous acceleration of the car. [3]

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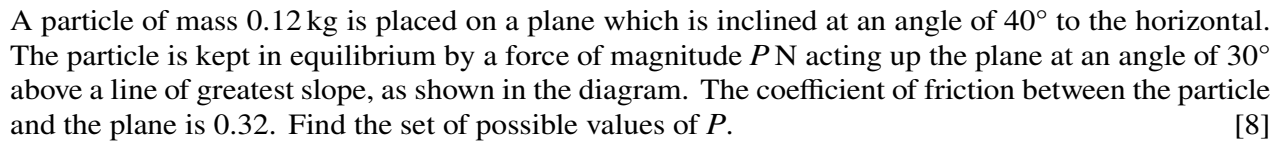
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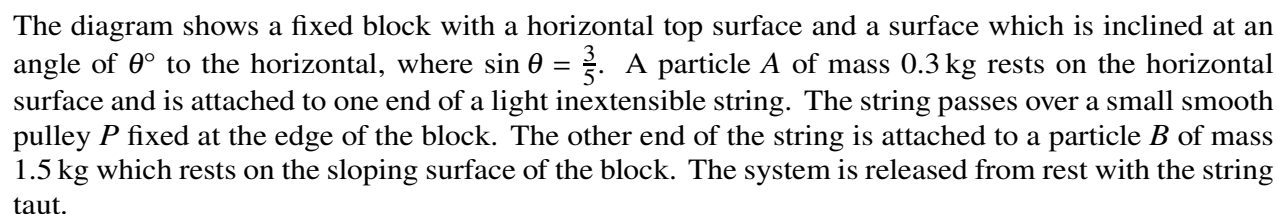
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- (ii) On a part of the road that is inclined at  $\theta^\circ$  to the horizontal, the car moves up the hill at a constant speed of  $24 \text{ m s}^{-1}$ , with the engine working at  $80 \text{ kW}$ . Find  $\theta$ . [4]

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.

[illegible]





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- 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, leaving ample room for writing practice. There is no text or other markings on the page.

- (ii) It is given instead that the block is rough. The coefficient of friction between  $A$  and the block is  $\mu$  and the coefficient of friction between  $B$  and the block is also  $\mu$ . In the first 3 seconds of the motion,  $A$  does not reach  $P$  and  $B$  does not reach the bottom of the sloping surface. The speed of the particles after 3 s is  $5 \text{ m s}^{-1}$ . Find the acceleration of particle  $A$  and the value of  $\mu$ . [9]

[illegible]

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**MATHEMATICS**

**9709/43**

Paper 4 Mechanics 1 **(M1)**

**May/June 2017**

**1 hour 15 minutes**

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

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The total number of marks for this paper is 50.

This document consists of **12** printed pages.



- 1** A man pushes a wheelbarrow of mass 25 kg along a horizontal road with a constant force of magnitude 35 N at an angle of  $20^\circ$  below the horizontal. There is a constant resistance to motion of 15 N. The wheelbarrow moves a distance of 12 m from rest.

(i) Find the work done by the man.

[2]

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(ii) Find the speed attained by the wheelbarrow after 12 m.

[3]

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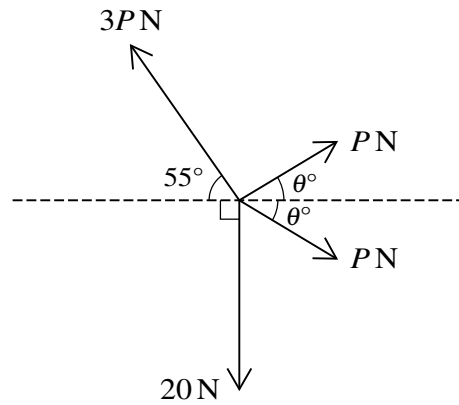
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The four coplanar forces shown in the diagram are in equilibrium. Find the values of  $P$  and  $\theta$ . [5]

This image shows a full page of white paper with horizontal dashed lines, typical of primary-ruled notebook 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.

- 3 A train travels between two stations,  $A$  and  $B$ . The train starts from rest at  $A$  and accelerates at a constant rate for  $T$  s until it reaches a speed of  $25 \text{ m s}^{-1}$ . It then travels at this constant speed before decelerating at a constant rate, coming to rest at  $B$ . The magnitude of the train's deceleration is twice the magnitude of its acceleration. The total time taken for the journey is 180 s.

(i) Sketch the velocity-time graph for the train's journey from  $A$  to  $B$ .

[1]



- (ii) Find an expression, in terms of  $T$ , for the length of time for which the train is travelling with constant speed.

[2]

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- (iii) The distance from  $A$  to  $B$  is 3300 m. Find how far the train travels while it is decelerating.

[3]

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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 velocity,  $v \text{ m s}^{-1}$ , of  $P$  is given by  $v = (2t - 5)^3$ .

(i) Find the values of  $t$  when the acceleration of  $P$  is  $54 \text{ m s}^{-2}$ . [3]

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(ii) Find an expression for the displacement of  $P$  from  $O$  at time  $t$  s. [3]

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- 5 A particle is projected vertically upwards from a point  $O$  with a speed of  $12 \text{ m s}^{-1}$ . Two seconds later a second particle is projected vertically upwards from  $O$  with a speed of  $20 \text{ m s}^{-1}$ . At time  $t \text{ s}$  after the second particle is projected, the two particles collide.

(i) Find  $t$ .

[5]

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(ii) Hence find the height above  $O$  at which the particles collide.

[1]

**6** A car of mass 1200 kg is travelling along a horizontal road.

**(i)** It is given that there is a constant resistance to motion.

- (a)** The engine of the car is working at 16 kW while the car is travelling at a constant speed of  $40 \text{ m s}^{-1}$ . Find the resistance to motion. [2]

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- (b)** The power is now increased to 22.5 kW. Find the acceleration of the car at the instant it is travelling at a speed of  $45 \text{ m s}^{-1}$ . [3]

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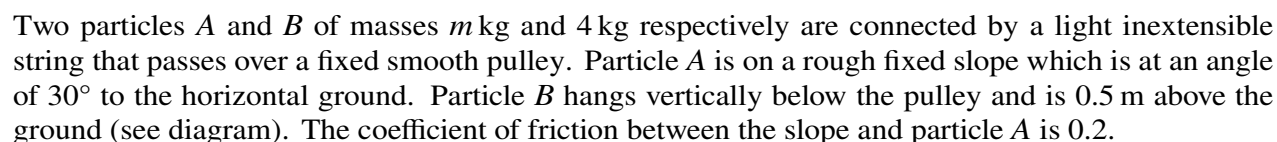
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- (ii) It is given instead that the resistance to motion of the car is  $(590 + 2v)$  N when the speed of the car is  $v \text{ m s}^{-1}$ . The car travels at a constant speed with the engine working at 16 kW. Find this speed. [3]

[illegible]



- [illegible]

- (ii) In the case where  $m = 3$ , 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. [8]

[illegible]

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