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MATHEMATICS

9709/41

Paper 4 Mechanics 1 **(M1)**

October/November 2017

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

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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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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 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.

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The total number of marks for this paper is 50.

This document consists of **11** printed pages and **1** blank page.

- 1 A block of mass 3 kg is initially at rest on a smooth horizontal floor. A force of 12 N, acting at an angle of 25° above the horizontal, is applied to the block. Find the distance travelled by the block in the first 5 seconds of its motion. [4]

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- 2 A tractor of mass 3700 kg is travelling along a straight horizontal road at a constant speed of 12 m s^{-1} . The total resistance to motion is 1150 N.

- (i) Find the power output of the tractor's engine. [1]

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The tractor comes to a hill inclined at 4° above the horizontal. The power output is increased to 25 kW and the resistance to motion is unchanged.

- (ii) Find the deceleration of the tractor at the instant it begins to climb the hill. [3]

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- (iii) Find the constant speed that the tractor could maintain on the hill when working at this power. [2]

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- 3** A roller-coaster car (including passengers) has a mass of 840 kg. The roller-coaster ride includes a section where the car climbs a straight ramp of length 8 m inclined at 30° above the horizontal. The car then immediately descends another ramp of length 10 m inclined at 20° below the horizontal. The resistance to motion acting on the car is 640 N throughout the motion.

- (i)** Find the total work done against the resistance force as the car ascends the first ramp and descends the second ramp. [2]

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- (ii)** The speed of the car at the bottom of the first ramp is 14 m s^{-1} . Use an energy method to find the speed of the car when it reaches the bottom of the second ramp. [4]

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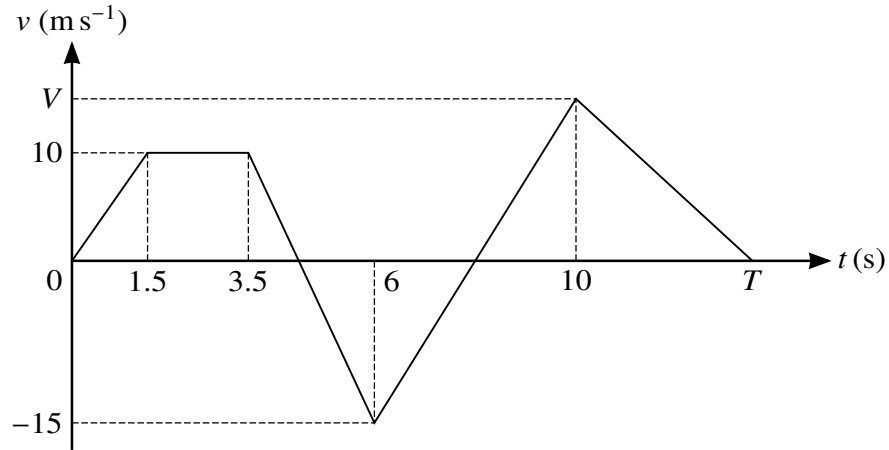
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The diagram shows the velocity-time graph of a particle which moves in a straight line. The graph consists of 5 straight line segments. The particle starts from rest at a point A at time $t = 0$, and initially travels towards point B on the line.

- (i) Show that the acceleration of the particle between $t = 3.5$ and $t = 6$ is -10 m s^{-2} . [1]

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- (ii) The acceleration of the particle between $t = 6$ and $t = 10$ is 7.5 m s^{-2} . When $t = 10$ the velocity of the particle is $V \text{ m s}^{-1}$. Find the value of V . [2]

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- (iii) The particle comes to rest at B at time T s. Given that the total distance travelled by the particle between $t = 0$ and $t = T$ is 100 m, find the value of T . [4]

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- 5 A particle starts from a point O and moves in a straight line. The velocity of the particle at time t s after leaving O is $v \text{ m s}^{-1}$, where

$$v = 1.5 + 0.4t \quad \text{for } 0 \leq t \leq 5,$$

$$v = \frac{100}{t^2} - 0.1t \quad \text{for } t \geq 5.$$

- (i) Find the acceleration of the particle during the first 5 seconds of motion. [1]

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- (ii) Find the value of t when the particle is instantaneously at rest. [2]

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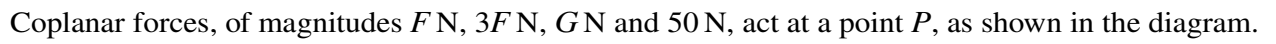
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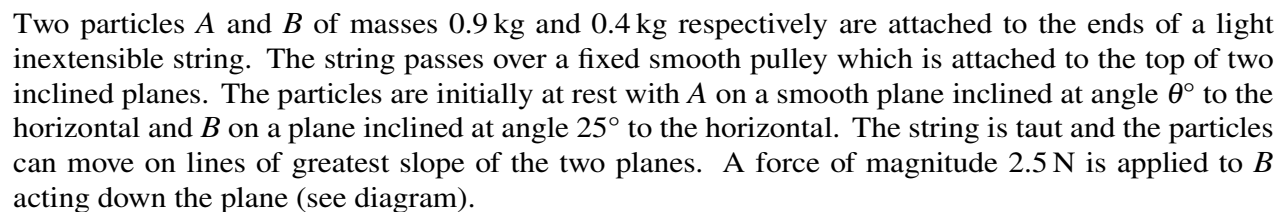
- (iii) Find the total distance travelled by the particle in the first 10 seconds of motion. [5]

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.



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

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- [illegible]

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MATHEMATICS

9709/42

Paper 4 Mechanics 1 (M1)

October/November 2017

1 hour 15 minutes

Candidates answer on the Question Paper.

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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.

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- 1 A particle of mass 0.2 kg is resting in equilibrium on a rough plane inclined at 20° to the horizontal.
- (i) Show that the friction force acting on the particle is 0.684 N, correct to 3 significant figures. [1]

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The coefficient of friction between the particle and the plane is 0.6. A force of magnitude 0.9 N is applied to the particle down a line of greatest slope of the plane. The particle accelerates down the plane.

- (ii) Find this acceleration. [4]

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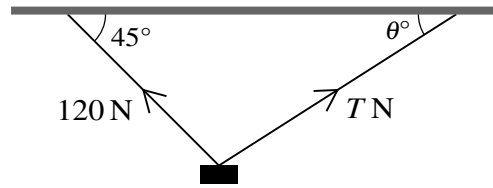
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A block of mass 15 kg hangs in equilibrium below a horizontal ceiling attached to two strings as shown in the diagram. One of the strings is inclined at 45° to the horizontal and the tension in this string is 120 N. The other string is inclined at θ° to the horizontal and the tension in this string is T N. Find the values of T and θ . [6]

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.

- 3** A car travels along a straight road with constant acceleration. It passes through points A , B and C . The car passes point A with velocity 14 m s^{-1} . The two sections AB and BC are of equal length. The times taken to travel along AB and BC are 5 s and 3 s respectively.

- (i) Write down an expression for the distance AB in terms of the acceleration of the car. Write down a similar expression for the distance AC . Hence show that the acceleration of the car is 4 m s^{-2} . [4]

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- (ii) Find the speed of the car as it passes point C. [2]

[illegible]

- 4** A particle P is projected vertically upwards from horizontal ground with speed 12 m s^{-1} .

(i) Find the time taken for P to return to the ground. [2]

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The time in seconds after P is projected is denoted by t . When $t = 1$, a second particle Q is projected vertically upwards with speed 10 m s^{-1} from a point which is 5 m above the ground. Particles P and Q move in different vertical lines.

(ii) Find the set of values of t for which the two particles are moving in the same direction. [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.

- A cyclist is riding up a straight hill inclined at an angle α to the horizontal, where $\sin \alpha = 0.04$. The total mass of the bicycle and rider is 80 kg. The cyclist is riding at a constant speed of 4 m s^{-1} . There is a force resisting the motion. The work done by the cyclist against this resistance force over a distance of 25 m is 600 J.

(i) Find the power output of the cyclist.

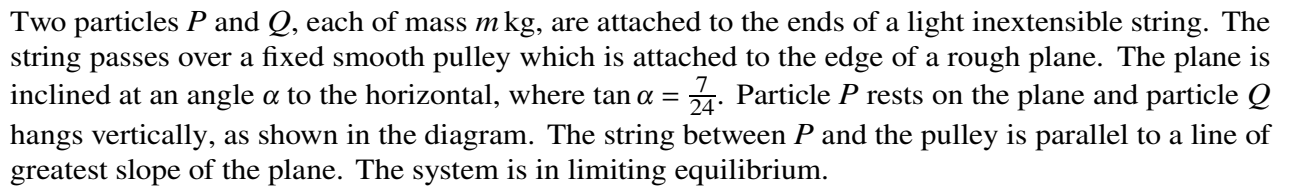
[4]

[illegible]

The cyclist reaches the top of the hill, where the road becomes horizontal, with speed 4 m s^{-1} . The cyclist continues to work at the same rate on the horizontal part of the road.

- (ii) Find the speed of the cyclist 10 seconds after reaching the top of the hill, given that the work done by the cyclist during this period against the resistance force is 1200 J. [4]

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- [illegible]

A force of magnitude 10 N is applied to P , acting up a line of greatest slope of the plane, and P accelerates at 2.5 m s^{-2} .

(ii) Find the value of m .

[5]

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- 7 A particle starts from rest and moves in a straight line. The velocity of the particle at time t s after the start is $v \text{ m s}^{-1}$, where

$$v = -0.01t^3 + 0.22t^2 - 0.4t.$$

- (i) Find the two positive values of t for which the particle is instantaneously at rest. [2]

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- (ii) Find the time at which the acceleration of the particle is greatest. [3]

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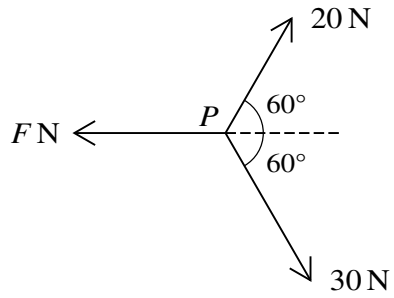
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Three coplanar forces of magnitudes F N, 20 N and 30 N act at a point P , as shown in the diagram. The resultant of the three forces acts in a direction perpendicular to the force of magnitude F N. Find the value of F . [3]

[illegible]

- 2 A lorry of mass 7850 kg travels on a straight hill which is inclined at an angle of 3° to the horizontal. There is a constant resistance to motion of 1480 N.

(i) Find the power of the lorry's engine when the lorry is going up the hill at a constant speed of 10 m s^{-1} . [3]

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(ii) Find the power of the lorry's engine at an instant when the lorry is going down the hill at a speed of 15 m s^{-1} with an acceleration of 0.8 m s^{-2} . [3]

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- 3 A particle is released from rest and slides down a line of greatest slope of a rough plane which is inclined at 25° 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 travelled by the particle in the first 3 s after it is released.

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- 4 Two particles A and B have masses 0.35 kg and 0.45 kg respectively. The particles are attached to the ends of a light inextensible string which passes over a small fixed smooth pulley which is 1 m above horizontal ground. Initially particle A is held at rest on the ground vertically below the pulley, with the string taut. Particle B hangs vertically below the pulley at a height of 0.64 m above the ground. Particle A is released.

(i) Find the speed of A at the instant that B reaches the ground. [5]

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(ii) Assuming that B does not bounce after it reaches the ground, find the total distance travelled by A between the instant that B reaches the ground and the instant when the string becomes taut again. [2]

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- 5** A particle starts from a fixed origin with velocity 0.4 m s^{-1} and moves in a straight line. The acceleration $a \text{ m s}^{-2}$ of the particle $t \text{ s}$ after it leaves the origin is given by $a = k(3t^2 - 12t + 2)$, where k is a constant. When $t = 1$, the velocity of P is 0.1 m s^{-1} .

(i) Show that the value of k is 0.1.

[5]

[illegible]

- (ii) Find an expression for the displacement of the particle from the origin in terms of t . [2]

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- (iii) Hence verify that the particle is again at the origin at $t = 2$. [1]

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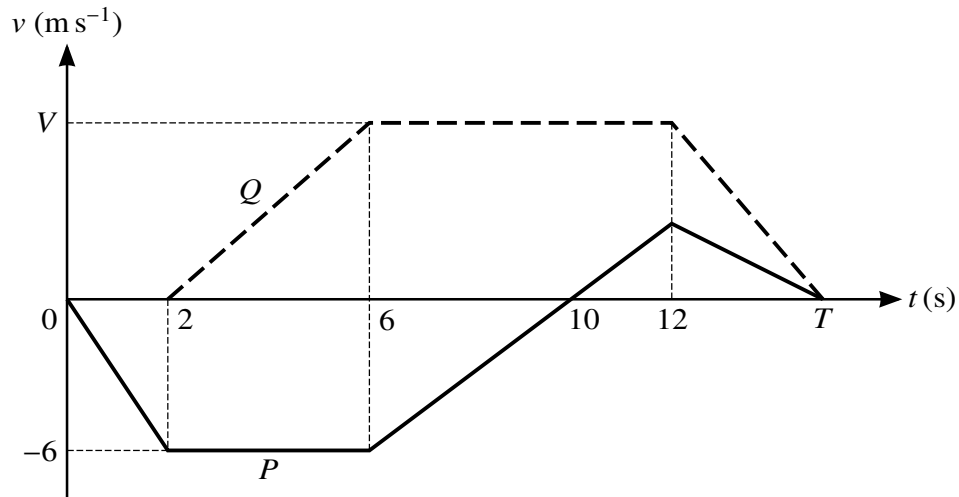
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The diagram shows the velocity-time graphs for two particles, P and Q , which are moving in the same straight line. The graph for P consists of four straight line segments. The graph for Q consists of three straight line segments. Both particles start from the same initial position O on the line. Q starts 2 seconds after P and both particles come to rest at time $t = T$. The greatest velocity of Q is $V \text{ m s}^{-1}$.

- (i) Find the displacement of P from O at $t = 10$. [1]

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- (ii) Find the velocity of P at $t = 12$. [2]

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- (iii) Given that the total distance covered by P during the T seconds of its motion is 49.5 m, find the value of T . [3]

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- (iv) Given also that the acceleration of Q from $t = 2$ to $t = 6$ is 1.75 m s^{-2} , find the value of V and hence find the distance between the two particles when they both come to rest at $t = T$. [3]

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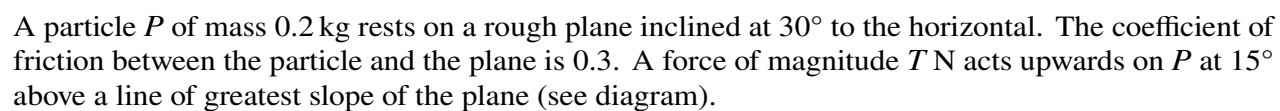
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- [illegible]

The force of magnitude T N is now removed. A new force of magnitude 0.25 N acts on P up the plane, parallel to a line of greatest slope of the plane. Starting from rest, P slides down the plane. After moving a distance of 3 m, P passes through the point A .

- (ii) Use an energy method to find the speed of P at A . [5]

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