UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

MATHEMATICS **9709/41**

Paper 4 Mechanics 1 **(M1)** **October/November 2013**

1 hour 15 minutes

Additional Materials: Answer Booklet/Paper
Graph Paper
List of Formulae (MF9)

8725173182

READ THESE INSTRUCTIONS FIRST

If you have been given an Answer Booklet, follow the instructions on the front cover of the Booklet.
Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

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.
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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.
Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.

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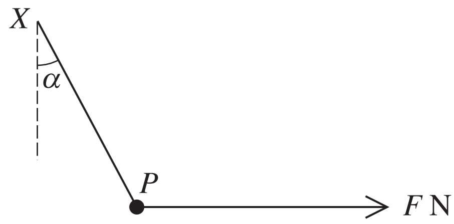
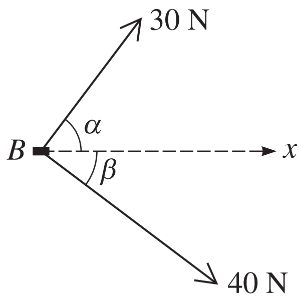
International Examinations

1



A particle P of mass 0.3 kg is attached to one end of a light inextensible string. The other end of the string is attached to a fixed point X. A horizontal force of magnitude F N is applied to the particle, which is in equilibrium when the string is at an angle α to the vertical, where $\tan\alpha = \frac{8}{15}$ (see diagram). Find the tension in the string and the value of F. [4]

2



A block B lies on a rough horizontal plane. Horizontal forces of magnitudes 30 N and 40 N, making angles of α and β respectively with the x-direction, act on B as shown in the diagram, and B is moving in the x-direction with constant speed. It is given that $\cos\alpha = 0.6$ and $\cos\beta = 0.8$.

(i) Find the total work done by the forces shown in the diagram when B has moved a distance of 20 m. [2]

(ii) Given that the coefficient of friction between the block and the plane is $\frac{5}{8}$, find the weight of the block. [3]

3 A cyclist exerts a constant driving force of magnitude F N while moving up a straight hill inclined at an angle α to the horizontal, where $\sin\alpha = \frac{36}{325}$. A constant resistance to motion of 32 N acts on the cyclist. The total weight of the cyclist and his bicycle is 780 N. The cyclist's acceleration is $-0.2\,\mathrm{m\,s^{-2}}$.

(i) Find the value of F. [4]

The cyclist's speed is $7\,\mathrm{m\,s^{-1}}$ at the bottom of the hill.

(ii) Find how far up the hill the cyclist travels before coming to rest. [2]

4 Particles P and Q are moving in a straight line on a rough horizontal plane. The frictional forces are the only horizontal forces acting on the particles.

(i) Find the deceleration of each of the particles given that the coefficient of friction between P and the plane is 0.2, and between Q and the plane is 0.25. [2]

At a certain instant, P passes through the point A and Q passes through the point B. The distance AB is 5 m. The velocities of P and Q at A and B are $8\,\mathrm{m\,s^{-1}}$ and $3\,\mathrm{m\,s^{-1}}$, respectively, both in the direction AB.

(ii) Find the speeds of P and Q immediately before they collide. [5]

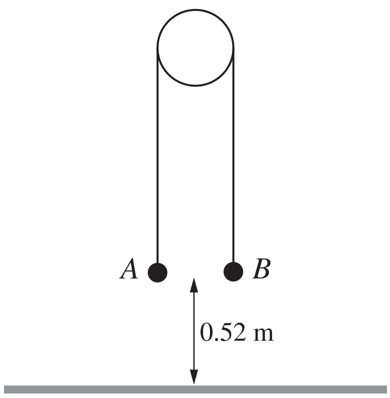
5 A lorry of mass 15 000 kg climbs from the bottom to the top of a straight hill, of length 1440 m, at a constant speed of $15\,\mathrm{m\,s^{-1}}$. The top of the hill is 16 m above the level of the bottom of the hill. The resistance to motion is constant and equal to 1800 N.

(i) Find the work done by the driving force. [4]

On reaching the top of the hill the lorry continues on a straight horizontal road and passes through a point P with speed $24\,\mathrm{m\,s^{-1}}$. The resistance to motion is constant and is now equal to 1600 N. The work done by the lorry's engine from the top of the hill to the point P is 5030 kJ.

(ii) Find the distance from the top of the hill to the point P. [3]

6



Particles A and B, of masses 0.3 kg and 0.7 kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley. A is held at rest and B hangs freely, with both straight parts of the string vertical and both particles at a height of 0.52 m above the floor (see diagram). A is released and both particles start to move.

(i) Find the tension in the string. [4]

When both particles are moving with speed $1.6\,\mathrm{m\,s^{-1}}$ the string breaks.

(ii) Find the time taken, from the instant that the string breaks, for A to reach the floor. [5]

[Question 7 is printed on the next page.]

7 A particle P starts from rest at a point O and moves in a straight line. P has acceleration $0.6t\,\mathrm{m\,s^{-2}}$ at time t seconds after leaving O, until $t = 10$.

(i) Find the velocity and displacement from O of P when $t = 10$. [5]

After $t = 10$, P has acceleration $-0.4t\,\mathrm{m\,s^{-2}}$ until it comes to rest at a point A.

(ii) Find the distance OA. [7]

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MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **October/November 2013**

1 hour 15 minutes

Additional Materials: Answer Booklet/Paper
Graph Paper
List of Formulae (MF9)

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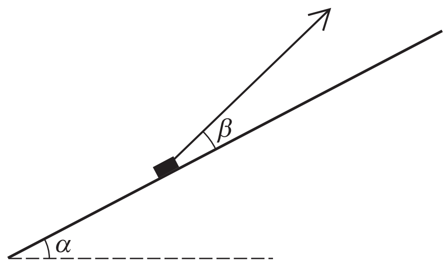


A small block of weight 5.1 N rests on a smooth plane inclined at an angle α to the horizontal, where $\sin\alpha = \frac{8}{17}$. The block is held in equilibrium by means of a light inextensible string. The string makes an angle β above the line of greatest slope on which the block rests, where $\sin\beta = \frac{7}{25}$ (see diagram). Find the tension in the string. [3]

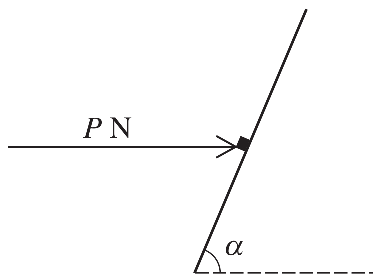
2 A box of mass 25 kg is pulled in a straight line along a horizontal floor. The box starts from rest at a point A and has a speed of $3\,\mathrm{m\,s^{-1}}$ when it reaches a point B. The distance AB is 15 m. The pulling force has magnitude 220 N and acts at an angle of $\alpha°$ above the horizontal. The work done against the resistance to motion acting on the box, as the box moves from A to B, is 3000 J. Find the value of α. [5]

3 The resistance to motion acting on a runner of mass 70 kg is kv N, where $v\,\mathrm{m\,s^{-1}}$ is the runner's speed and k is a constant. The greatest power the runner can exert is 100 W. The runner's greatest steady speed on horizontal ground is $4\,\mathrm{m\,s^{-1}}$.

(i) Show that $k = 6.25$. [2]

(ii) Find the greatest steady speed of the runner while running uphill on a straight path inclined at an angle α to the horizontal, where $\sin\alpha = 0.05$. [4]

4



A rough plane is inclined at an angle α to the horizontal, where $\tan\alpha = 2.4$. A small block of mass 0.6 kg is held at rest on the plane by a horizontal force of magnitude P N. This force acts in a vertical plane through a line of greatest slope (see diagram). The coefficient of friction between the block and the plane is 0.4. The block is on the point of slipping down the plane. By resolving forces parallel to and perpendicular to the inclined plane, or otherwise, find the value of P. [8]

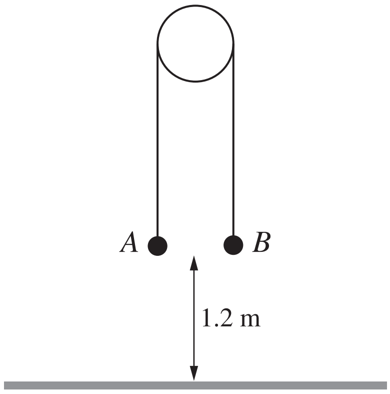
5 A particle P moves in a straight line. P starts from rest at O and travels to A where it comes to rest, taking 50 seconds. The speed of P at time t seconds after leaving O is $v\,\mathrm{m\,s^{-1}}$, where v is defined as follows.

$$\begin{aligned} \text{For } 0 \leqslant t \leqslant 5, &\quad v = t - 0.1t^2, \\ \text{for } 5 \leqslant t \leqslant 45, &\quad v \text{ is constant}, \\ \text{for } 45 \leqslant t \leqslant 50, &\quad v = 9t - 0.1t^2 - 200. \end{aligned}$$

(i) Find the distance travelled by P in the first 5 seconds. [3]

(ii) Find the total distance from O to A, and deduce the average speed of P for the whole journey from O to A. [6]

6



Particles A of mass 0.4 kg and B of mass 1.6 kg are attached to the ends of a light inextensible string which passes over a fixed smooth pulley. A is held at rest and B hangs freely, with both straight parts of the string vertical and both particles at a height of 1.2 m above the floor (see diagram). A is released and both particles start to move.

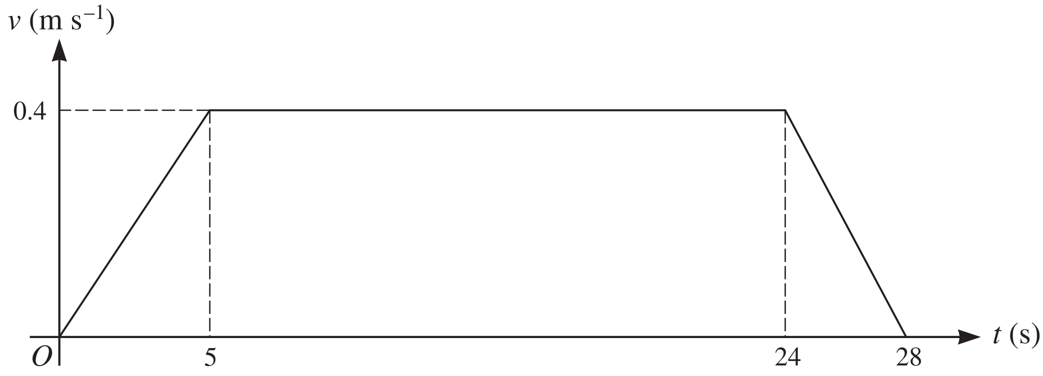
(i) Find the work done on B by the tension in the string, as B moves to the floor. [5]

When particle B reaches the floor it remains at rest. Particle A continues to move upwards.

(ii) Find the greatest height above the floor reached by particle A. [4]

[Question 7 is printed on the next page.]

7



An elevator is pulled vertically upwards by a cable. The velocity-time graph for the motion is shown above. Find

(i) the distance travelled by the elevator, [2]

(ii) the acceleration during the first stage and the deceleration during the third stage. [2]

The mass of the elevator is 800 kg and there is a box of mass 100 kg on the floor of the elevator.

(iii) Find the tension in the cable in each of the three stages of the motion. [3]

(iv) Find the greatest and least values of the magnitude of the force exerted on the box by the floor of the elevator. [3]

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MATHEMATICS **9709/43**

Paper 4 Mechanics 1 **(M1)** **October/November 2013**

1 hour 15 minutes

Additional Materials: Answer Booklet/Paper
Graph Paper
List of Formulae (MF9)

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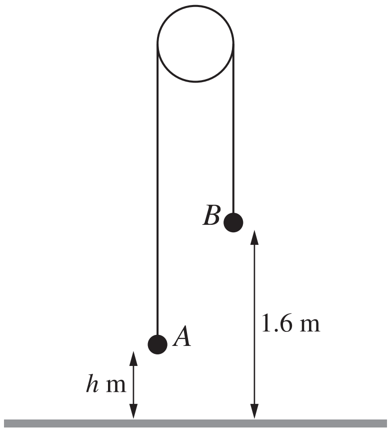
1 A particle moves up a line of greatest slope of a rough plane inclined at an angle α to the horizontal, where $\sin \alpha = 0.28$. The coefficient of friction between the particle and the plane is $\frac{1}{3}$.

(i) Show that the acceleration of the particle is $-6\,\mathrm{m\,s^{-2}}$. [3]

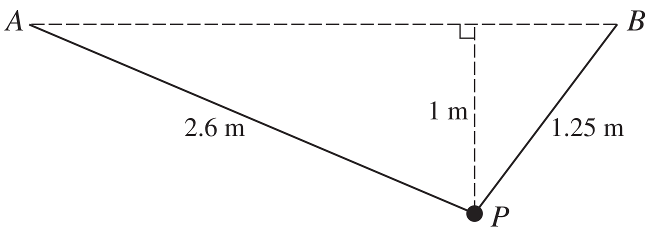
(ii) Given that the particle's initial speed is $5.4\,\mathrm{m\,s^{-1}}$, find the distance that the particle travels up the plane. [2]

2



Particle A of mass 0.2 kg and particle B of mass 0.6 kg are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley. B is held at rest at a height of 1.6 m above the floor. A hangs freely at a height of h m above the floor. Both straight parts of the string are vertical (see diagram). B is released and both particles start to move. When B reaches the floor it remains at rest, but A continues to move vertically upwards until it reaches a height of 3 m above the floor. Find the speed of B immediately before it hits the floor, and hence find the value of h. [6]

3



A particle P of mass 1.05 kg is attached to one end of each of two light inextensible strings, of lengths 2.6 m and 1.25 m. The other ends of the strings are attached to fixed points A and B, which are at the same horizontal level. P hangs in equilibrium at a point 1 m below the level of A and B (see diagram). Find the tensions in the strings. [6]

4 A box of mass 30 kg is at rest on a rough plane inclined at an angle α to the horizontal, where $\sin\alpha = 0.1$, acted on by a force of magnitude 40 N. The force acts upwards and parallel to a line of greatest slope of the plane. The box is on the point of slipping up the plane.

(i) Find the coefficient of friction between the box and the plane. [5]

The force of magnitude 40 N is removed.

(ii) Determine, giving a reason, whether or not the box remains in equilibrium. [2]

5 A car travels in a straight line from A to B, a distance of 12 km, taking 552 seconds. The car starts from rest at A and accelerates for T_1 s at $0.3\,\text{m s}^{-2}$, reaching a speed of $V\,\text{m s}^{-1}$. The car then continues to move at $V\,\text{m s}^{-1}$ for T_2 s. It then decelerates for T_3 s at $1\,\text{m s}^{-2}$, coming to rest at B.

(i) Sketch the velocity-time graph for the motion and express T_1 and T_3 in terms of V. [3]

(ii) Express the total distance travelled in terms of V and show that $13V^2 - 3312V + 72\,000 = 0$. Hence find the value of V. [5]

6 A lorry of mass 12 500 kg travels along a road from A to C passing through a point B. The resistance to motion of the lorry is 4800 N for the whole journey from A to C.

(i) The section AB of the road is straight and horizontal. On this section of the road the power of the lorry's engine is constant and equal to 144 kW. The speed of the lorry at A is $16\,\text{m s}^{-1}$ and its acceleration at B is $0.096\,\text{m s}^{-2}$. Find the acceleration of the lorry at A and show that its speed at B is $24\,\text{m s}^{-1}$. [3]

(ii) The section BC of the road has length 500 m, is straight and inclined upwards towards C. On this section of the road the lorry's driving force is constant and equal to 5800 N. The speed of the lorry at C is $16\,\text{m s}^{-1}$. Find the height of C above the level of AB. [5]

7 A vehicle starts from rest at a point O and moves in a straight line. Its speed $v\,\text{m s}^{-1}$ at time t seconds after leaving O is defined as follows.

$$\text{For } 0 \leqslant t \leqslant 60, \quad v = k_1 t - 0.005t^2,$$
$$\text{for } t \geqslant 60, \quad v = \frac{k_2}{\sqrt{t}}.$$

The distance travelled by the vehicle during the first 60 s is 540 m.

(i) Find the value of the constant k_1 and show that $k_2 = 12\sqrt{(60)}$. [5]

(ii) Find an expression in terms of t for the total distance travelled when $t \geqslant 60$. [2]

(iii) Find the speed of the vehicle when it has travelled a total distance of 1260 m. [3]

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