Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

* 8 7 8 7 3 3 5 9 1 6 *

MATHEMATICS **9709/42**

Paper 4 Mechanics **February/March 2020**

1 hour 15 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- If additional space is needed, you should use the lined page at the end of this booklet; the question number or numbers must be clearly shown.
- You should use a calculator where appropriate.
- You must show all necessary working clearly; no marks will be given for unsupported answers from a calculator.
- Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place for angles in degrees, unless a different level of accuracy is specified in the question.
- Where a numerical value for the acceleration due to gravity (g) is needed, use $10\,\mathrm{m\,s^{-2}}$.

INFORMATION

- The total mark for this paper is 50.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **16** pages. Blank pages are indicated.

1 A lorry of mass 16 000 kg is travelling along a straight horizontal road. The engine of the lorry is working at constant power. The work done by the driving force in 10 s is 750 000 J.

(a) Find the power of the lorry's engine. [1]

(b) There is a constant resistance force acting on the lorry of magnitude 2400 N.

Find the acceleration of the lorry at an instant when its speed is $25\,\mathrm{m\,s^{-1}}$. [3]

2 A particle P of mass 0.4 kg is on a rough horizontal floor. The coefficient of friction between P and the floor is μ. A force of magnitude 3 N is applied to P upwards at an angle α above the horizontal, where $\tan\alpha = \frac{3}{4}$. The particle is initially at rest and accelerates at $2\,\mathrm{m\,s^{-2}}$.

(a) Find the time it takes for P to travel a distance of 1.44 m from its starting point. [2]

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(b) Find μ. [4]

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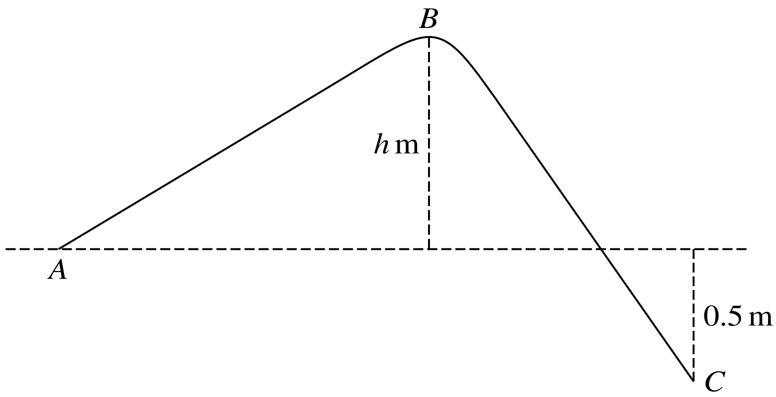

The diagram shows the vertical cross-section of a surface. A, B and C are three points on the cross-section. The level of B is h m above the level of A. The level of C is 0.5 m below the level of A. A particle of mass 0.2 kg is projected up the slope from A with initial speed $5\,\text{m}\,\text{s}^{-1}$. The particle remains in contact with the surface as it travels from A to C.

(a) Given that the particle reaches B with a speed of $3\,\text{m}\,\text{s}^{-1}$ and that there is no resistance force, find h. [3]

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(b) It is given instead that there is a resistance force and that the particle does 3.1 J of work against the resistance force as it travels from A to C.

Find the speed of the particle when it reaches C. [3]

4 A cyclist travels along a straight road with constant acceleration. He passes through points A, B and C. The cyclist takes 2 seconds to travel along each of the sections AB and BC and passes through B with speed $4.5\,\mathrm{m\,s^{-1}}$. The distance AB is $\frac{4}{5}$ of the distance BC.

(a) Find the acceleration of the cyclist. [5]

(b) Find AC. [2]

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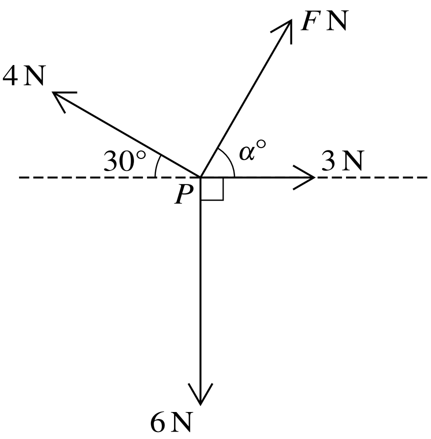

Coplanar forces, of magnitudes F N, 3 N, 6 N and 4 N, act at a point P, as shown in the diagram.

(a) Given that $\alpha = 60$, and that the resultant of the four forces is in the direction of the 3 N force, find F. [3]

(b) Given instead that the four forces are in equilibrium, find the values of F and α. [5]

6 On a straight horizontal test track, driverless vehicles (with no passengers) are being tested. A car of mass 1600 kg is towing a trailer of mass 700 kg along the track. The brakes are applied, resulting in a deceleration of 12 m s^{-2}. The braking force acts on the car only. In addition to the braking force there are constant resistance forces of 600 N on the car and of 200 N on the trailer.

(a) Find the magnitude of the force in the tow-bar. [2]

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(b) Find the braking force. [2]

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(c) At the instant when the brakes are applied, the car has speed $22\,\text{m}\,\text{s}^{-1}$. At this instant the car is 17.5 m away from a stationary van, which is directly in front of the car.

Show that the car hits the van at a speed of $8\,\text{m}\,\text{s}^{-1}$. [2]

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(d) After the collision, the van starts to move with speed $5\,\text{m}\,\text{s}^{-1}$ and the car and trailer continue moving in the same direction with speed $2\,\text{m}\,\text{s}^{-1}$.

Find the mass of the van. [3]

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7 A particle moves in a straight line through the point O. The displacement of the particle from O at time t s is s m, where

$$s = t^2 - 3t + 2 \qquad \text{for } 0 \leqslant t \leqslant 6,$$

$$s = \frac{24}{t} - \frac{t^2}{4} + 25 \quad \text{for } t \geqslant 6.$$

(a) Find the value of t when the particle is instantaneously at rest during the first 6 seconds of its motion. [2]

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At $t = 6$, the particle hits a barrier at a point P and rebounds.

(b) Find the velocity with which the particle arrives at P and also the velocity with which the particle leaves P. [3]

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

Additional Page

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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

9303616557

MATHEMATICS **9709/42**

Paper 4 Mechanics **February/March 2021**

1 hour 15 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
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INFORMATION

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This document has **16** pages. Any blank pages are indicated.

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1 Two particles P and Q of masses 0.2 kg and 0.3 kg respectively are free to move in a horizontal straight line on a smooth horizontal plane. P is projected towards Q with speed $0.5\,\mathrm{m\,s^{-1}}$. At the same instant Q is projected towards P with speed $1\,\mathrm{m\,s^{-1}}$. Q comes to rest in the resulting collision.

Find the speed of P after the collision. [3]

2 A car of mass 1400 kg is travelling at constant speed up a straight hill inclined at α to the horizontal, where $\sin\alpha = 0.1$. There is a constant resistance force of magnitude 600 N. The power of the car's engine is 22 500 W.

(a) Show that the speed of the car is $11.25\,\mathrm{m\,s^{-1}}$. [3]

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The car, moving with speed $11.25\,\mathrm{m\,s^{-1}}$, comes to a section of the hill which is inclined at 2° to the horizontal.

(b) Given that the power and resistance force do not change, find the initial acceleration of the car up this section of the hill. [3]

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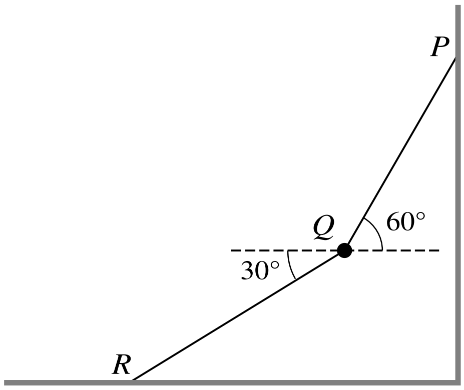

A particle Q of mass 0.2 kg is held in equilibrium by two light inextensible strings PQ and QR. P is a fixed point on a vertical wall and R is a fixed point on a horizontal floor. The angles which strings PQ and QR make with the horizontal are 60° and 30° respectively (see diagram).

Find the tensions in the two strings. [5]

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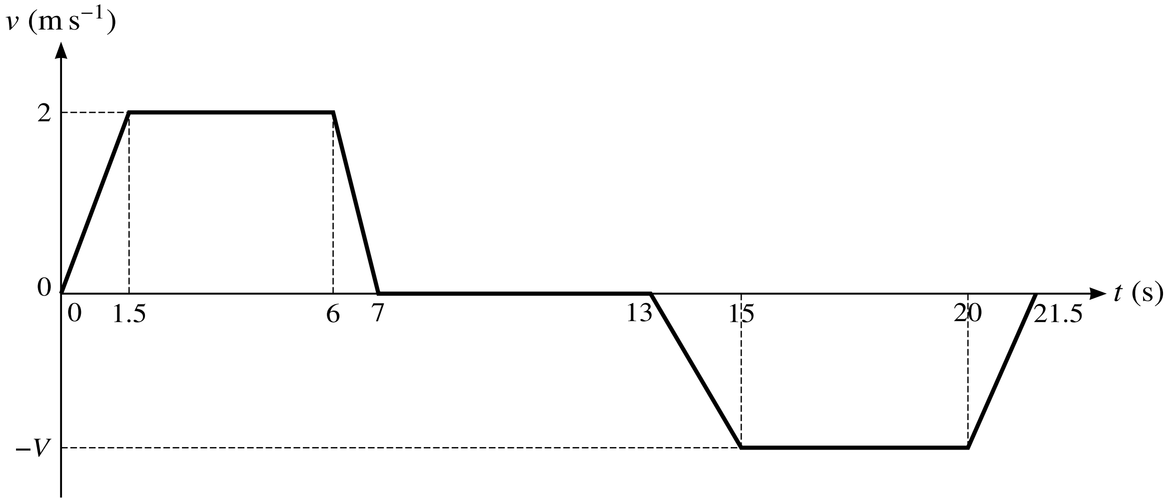

An elevator moves vertically, supported by a cable. The diagram shows a velocity-time graph which models the motion of the elevator. The graph consists of 7 straight line segments.

The elevator accelerates upwards from rest to a speed of $2\,\text{m}\,\text{s}^{-1}$ over a period of 1.5 s and then travels at this speed for 4.5 s, before decelerating to rest over a period of 1 s.

The elevator then remains at rest for 6 s, before accelerating to a speed of $V\,\text{m}\,\text{s}^{-1}$ downwards over a period of 2 s. The elevator travels at this speed for a period of 5 s, before decelerating to rest over a period of 1.5 s.

(a) Find the acceleration of the elevator during the first 1.5 s. [1]

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(b) Given that the elevator starts and finishes its journey on the ground floor, find V. [2]

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(c) The combined weight of the elevator and passengers on its upward journey is 1500 kg. Assuming that there is no resistance to motion, find the tension in the elevator cable on its upward journey when the elevator is decelerating. [3]

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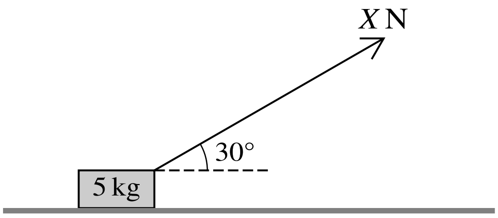

A block of mass 5 kg is being pulled along a rough horizontal floor by a force of magnitude X N acting at 30° above the horizontal (see diagram). The block starts from rest and travels 2 m in the first 5 s of its motion.

(a) Find the acceleration of the block. [2]

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(b) Given that the coefficient of friction between the block and the floor is 0.4, find X. [4]

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The block is now placed on a part of the floor where the coefficient of friction between the block and the floor has a different value. The value of X is changed to 25, and the block is now in limiting equilibrium.

(c) Find the value of the coefficient of friction between the block and this part of the floor. [3]

6 A particle moves in a straight line. It starts from rest from a fixed point O on the line. Its velocity at time t s after leaving O is $v\,\mathrm{m\,s^{-1}}$, where $v = t^2 - 8t^{\frac{3}{2}} + 10t$.

(a) Find the displacement of the particle from O when $t = 1$. [4]

(b) Show that the minimum velocity of the particle is $-125\,\mathrm{m\,s^{-1}}$. [7]

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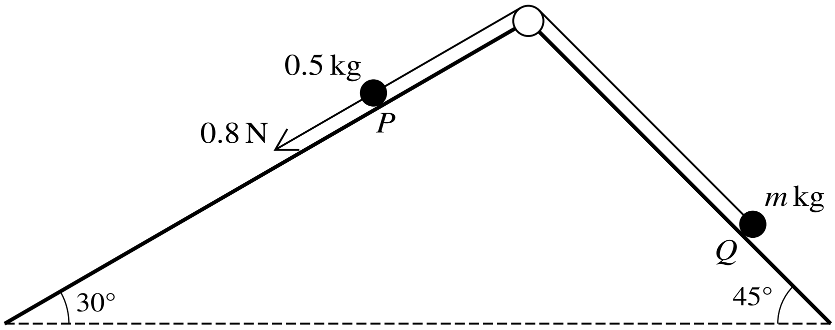

Two particles P and Q of masses 0.5 kg and m kg respectively are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the top of two inclined planes. The particles are initially at rest with P on a smooth plane inclined at 30° to the horizontal and Q on a plane inclined at 45° to the horizontal. The string is taut and the particles can move on lines of greatest slope of the two planes. A force of magnitude 0.8 N is applied to P acting down the plane, causing P to move down the plane (see diagram).

(a) It is given that $m = 0.3$, and that the plane on which Q rests is smooth.

Find the tension in the string. [5]

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(b) It is given instead that the plane on which Q rests is rough, and that after each particle has moved a distance of 1 m, their speed is $0.6\,\mathrm{m\,s^{-1}}$. The work done against friction in this part of the motion is 0.5 J.

Use an energy method to find the value of m. [5]

Additional Page

If you use the following lined page to complete the answer(s) to any question(s), the question number(s) must be clearly shown.

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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

4968591686

MATHEMATICS **9709/42**

Paper 4 Mechanics **October/November 2020**

1 hour 15 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
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INFORMATION

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This document has **16** pages. Blank pages are indicated.

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1 Two particles P and Q, of masses 0.2 kg and 0.5 kg respectively, are at rest on a smooth horizontal plane. P is projected towards Q with speed $2\,\mathrm{m\,s^{-1}}$.

(a) Write down the momentum of P. [1]

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(b) After the collision P continues to move in the same direction with speed $0.3\,\mathrm{m\,s^{-1}}$.

Find the speed of Q after the collision. [2]

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2 A car of mass 1800 kg is travelling along a straight horizontal road. The power of the car's engine is constant. There is a constant resistance to motion of 650 N.

(a) Find the power of the car's engine, given that the car's acceleration is $0.5\,\mathrm{m\,s^{-2}}$ when its speed is $20\,\mathrm{m\,s^{-1}}$. [3]

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(b) Find the steady speed which the car can maintain with the engine working at this power. [2]

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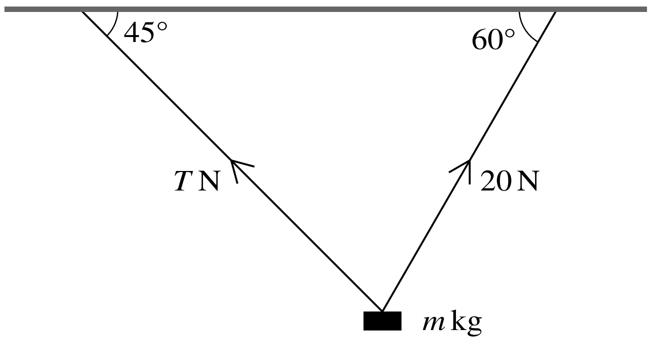

A block of mass m kg is held in equilibrium below a horizontal ceiling by two strings, as shown in the diagram. One of the strings is inclined at 45° to the horizontal and the tension in this string is T N. The other string is inclined at 60° to the horizontal and the tension in this string is 20 N.

Find T and m. [5]

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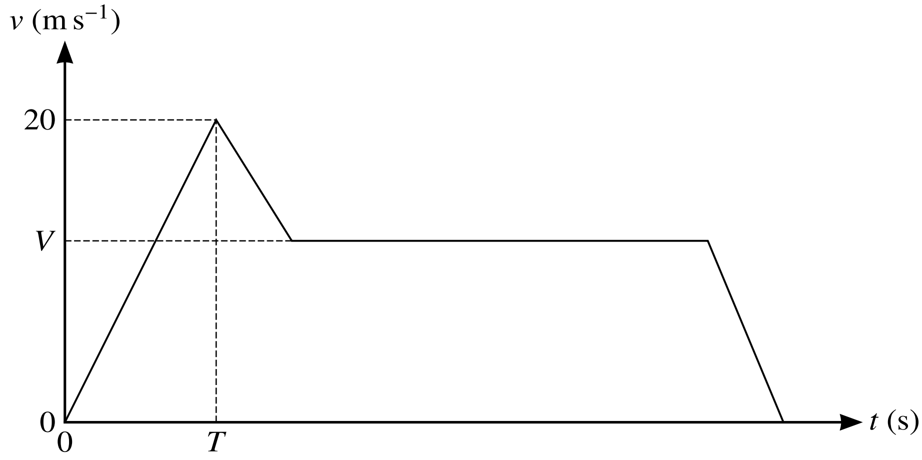

The diagram shows a velocity-time graph which models the motion of a car. The graph consists of four straight line segments. The car accelerates at a constant rate of $2\,\mathrm{m\,s^{-2}}$ from rest to a speed of $20\,\mathrm{m\,s^{-1}}$ over a period of T s. It then decelerates at a constant rate for 5 seconds before travelling at a constant speed of $V\,\mathrm{m\,s^{-1}}$ for 27.5 s. The car then decelerates to rest at a constant rate over a period of 5 s.

(a) Find T. [1]

(b) Given that the distance travelled up to the point at which the car begins to move with constant speed is one third of the total distance travelled, find V. [4]

5 A particle is projected vertically upwards with speed $40\,\mathrm{m\,s^{-1}}$ alongside a building of height h m.

(a) Given that the particle is above the level of the top of the building for 4 s, find h. [4]

(b) One second after the first particle is projected, a second particle is projected vertically upwards from the top of the building with speed $20\,\mathrm{m\,s^{-1}}$.

Denoting the time after projection of the first particle by t s, find the value of t for which the two particles are at the same height above the ground. [4]

6 A block of mass 5 kg is placed on a plane inclined at 30° to the horizontal. The coefficient of friction between the block and the plane is μ.

(a)

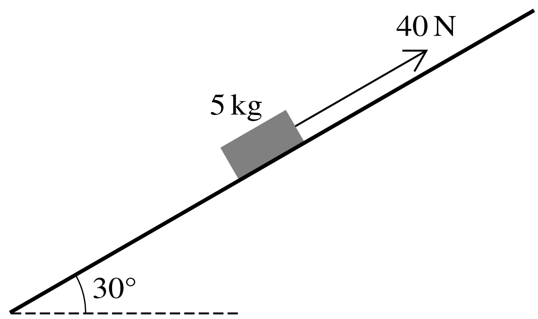

Fig. 6.1

When a force of magnitude 40 N is applied to the block, acting up the plane parallel to a line of greatest slope, the block begins to slide up the plane (see Fig. 6.1).

Show that $\mu < \frac{1}{5}\sqrt{3}$. [4]

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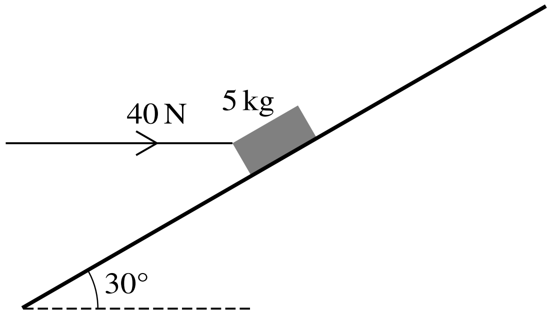

Fig. 6.2

When a force of magnitude 40 N is applied horizontally, in a vertical plane containing a line of greatest slope, the block does not move (see Fig. 6.2).

Show that, correct to 3 decimal places, the least possible value of μ is 0.152. [4]

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7 A particle P moves in a straight line, starting from a point O with velocity $1.72\,\mathrm{m\,s^{-1}}$. The acceleration $a\,\mathrm{m\,s^{-2}}$ of the particle, t s after leaving O, is given by $a = 0.1t^{\frac{3}{2}}$.

(a) Find the value of t when the velocity of P is $3\,\mathrm{m\,s^{-1}}$. [4]

(b) Find the displacement of P from O when $t = 2$, giving your answer correct to 2 decimal places. [3]

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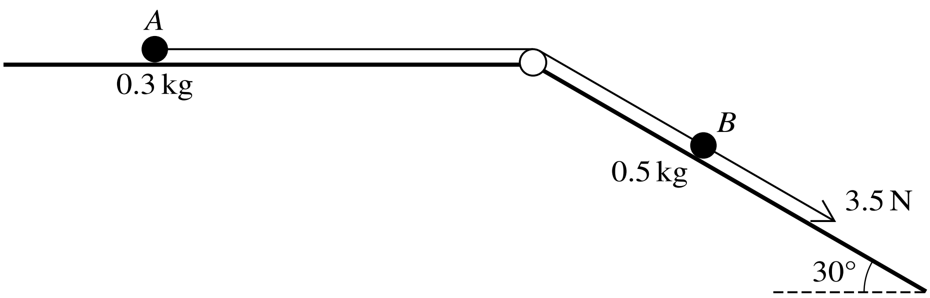

Two particles A and B, of masses 0.3 kg and 0.5 kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to a horizontal plane and to the top of an inclined plane. The particles are initially at rest with A on the horizontal plane and B on the inclined plane, which makes an angle of 30° with the horizontal. The string is taut and B can move on a line of greatest slope of the inclined plane. A force of magnitude 3.5 N is applied to B acting down the plane (see diagram).

(a) Given that both planes are smooth, find the tension in the string and the acceleration of B. [5]

(b) It is given instead that the two planes are rough. When each particle has moved a distance of 0.6 m from rest, the total amount of work done against friction is 1.1 J.

Use an energy method to find the speed of B when it has moved this distance down the plane. [You should assume that the string is sufficiently long so that A does not hit the pulley when it moves 0.6 m.] [4]

Additional Page

If you use the following lined page to complete the answer(s) to any question(s), the question number(s) must be clearly shown.

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

MATHEMATICS **9709/04**

Paper 4 Mechanics 1 **(M1)**

May/June 2003

1 hour 15 minutes

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

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 on both sides of the paper.
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.
Where a numerical value for the acceleration due to gravity is needed, use $10\,\mathrm{m\,s^{-2}}$.
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.
The use of an electronic calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

This document consists of **4** printed pages.

UNIVERSITY of CAMBRIDGE
Local Examinations Syndicate

[Turn over

1 A crate of mass 800 kg is lifted vertically, at constant speed, by the cable of a crane. Find

(i) the tension in the cable, [1]

(ii) the power applied to the crate in increasing the height by 20 m in 50 s. [3]

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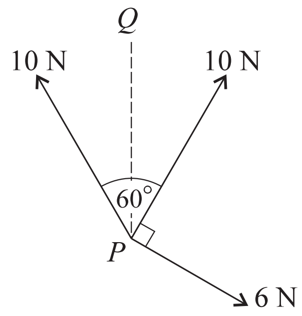

Three coplanar forces of magnitudes 10 N, 10 N and 6 N act at a point P in the directions shown in the diagram. PQ is the bisector of the angle between the two forces of magnitude 10 N.

(i) Find the component of the resultant of the three forces

(a) in the direction of PQ, [2]

(b) in the direction perpendicular to PQ. [1]

(ii) Find the magnitude of the resultant of the three forces. [2]

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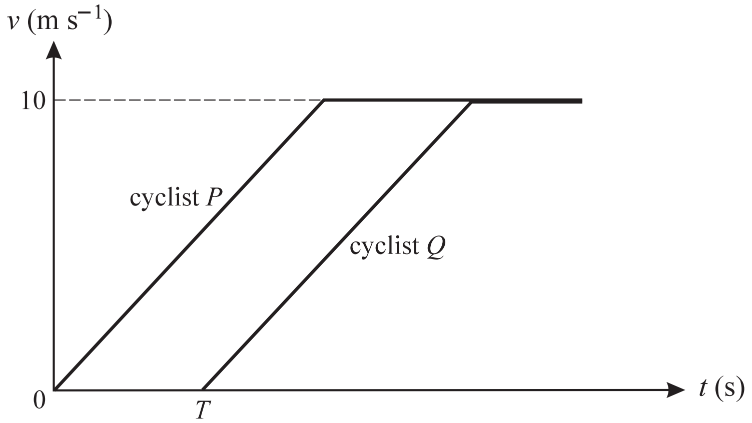

The diagram shows the velocity-time graphs for the motion of two cyclists P and Q, who travel in the same direction along a straight path. Both cyclists start from rest at the same point O and both accelerate at $2\,\text{m}\,\text{s}^{-2}$ up to a speed of $10\,\text{m}\,\text{s}^{-1}$. Both then continue at a constant speed of $10\,\text{m}\,\text{s}^{-1}$. Q starts his journey T seconds after P.

(i) Show in a sketch of the diagram the region whose area represents the displacement of P, from O, at the instant when Q starts. [1]

Given that P has travelled 16 m at the instant when Q starts, find

(ii) the value of T, [3]

(iii) the distance between P and Q when Q's speed reaches $10\,\text{m}\,\text{s}^{-1}$. [2]

4 A particle moves in a straight line. Its displacement t seconds after leaving the fixed point O is x metres, where $x = \frac{1}{2}t^2 + \frac{1}{30}t^3$. Find

(i) the speed of the particle when $t = 10$, [3]

(ii) the value of t for which the acceleration of the particle is twice its initial acceleration. [3]

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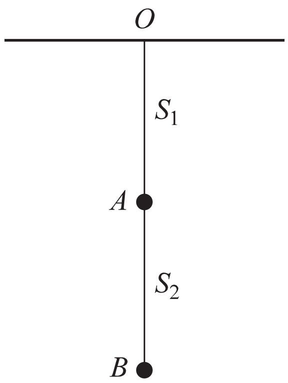


S_1 and S_2 are light inextensible strings, and A and B are particles each of mass 0.2 kg. Particle A is suspended from a fixed point O by the string S_1, and particle B is suspended from A by the string S_2. The particles hang in equilibrium as shown in the diagram.

(i) Find the tensions in S_1 and S_2. [3]

The string S_1 is cut and the particles fall. The air resistance acting on A is 0.4 N and the air resistance acting on B is 0.2 N.

(ii) Find the acceleration of the particles and the tension in S_2. [5]

6 A small block of mass 0.15 kg moves on a horizontal surface. The coefficient of friction between the block and the surface is 0.025.

(i) Find the frictional force acting on the block. [2]

(ii) Show that the deceleration of the block is $0.25\ \mathrm{m\,s^{-2}}$. [2]

The block is struck from a point A on the surface and, 4 s later, it hits a boundary board at a point B. The initial speed of the block is $5.5\ \mathrm{m\,s^{-1}}$.

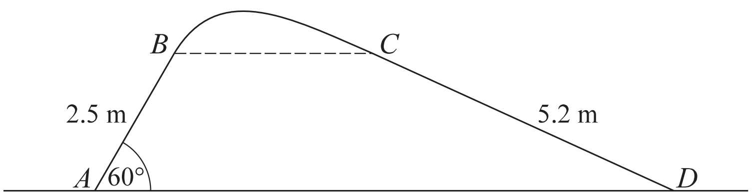
(iii) Find the distance AB. [2]

The block rebounds from the board with a speed of $3.5\ \mathrm{m\,s^{-1}}$ and moves along the line BA. Find

(iv) the speed with which the block passes through A, [2]

(v) the total distance moved by the block, from the instant when it was struck at A until the instant when it comes to rest. [2]

7



The diagram shows a vertical cross-section $ABCD$ of a surface. The parts AB and CD are straight and have lengths 2.5 m and 5.2 m respectively. AD is horizontal, and AB is inclined at 60° to the horizontal. The points B and C are at the same height above AD. The parts of the surface containing AB and BC are smooth. A particle P is given a velocity of $8\,\text{m}\,\text{s}^{-1}$ at A, in the direction AB, and it subsequently reaches D. The particle does not lose contact with the surface during this motion.

(i) Find the speed of P at B. [4]

(ii) Show that the maximum height of the cross-section, above AD, is less than 3.2 m. [2]

(iii) State briefly why P's speed at C is the same as its speed at B. [1]

(iv) The frictional force acting on the particle as it travels from C to D is 1.4 N. Given that the mass of P is 0.4 kg, find the speed with which P reaches D. [4]

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

MATHEMATICS **9709/04**

Paper 4 Mechanics 1 **(M1)**

May/June 2004

1 hour 15 minutes

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

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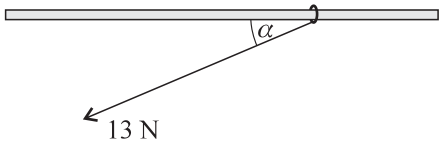
[Turn over

1



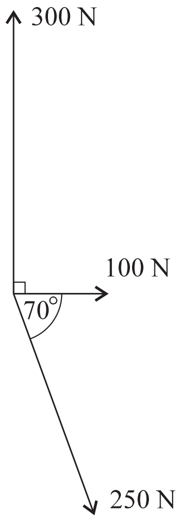
A ring of mass 1.1 kg is threaded on a fixed rough horizontal rod. A light string is attached to the ring and the string is pulled with a force of magnitude 13 N at an angle α below the horizontal, where $\tan\alpha = \frac{5}{12}$ (see diagram). The ring is in equilibrium.

(i) Find the frictional component of the contact force on the ring. [2]

(ii) Find the normal component of the contact force on the ring. [2]

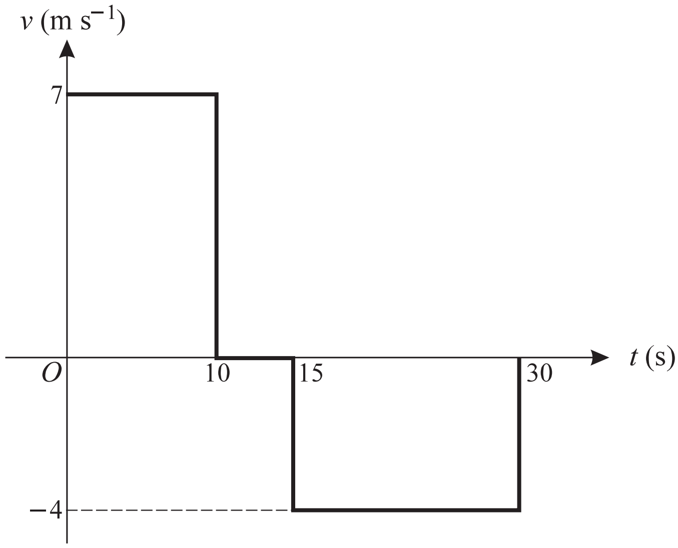
(iii) Given that the equilibrium of the ring is limiting, find the coefficient of friction between the ring and the rod. [1]

2



Coplanar forces of magnitudes 250 N, 100 N and 300 N act at a point in the directions shown in the diagram. The resultant of the three forces has magnitude R N, and acts at an angle $\alpha°$ anticlockwise from the force of magnitude 100 N. Find R and α. [6]

3



A boy runs from a point A to a point C. He pauses at C and then walks back towards A until reaching the point B, where he stops. The diagram shows the graph of v against t, where $v\,\mathrm{m\,s^{-1}}$ is the boy's velocity at time t seconds after leaving A. The boy runs and walks in the same straight line throughout.

(i) Find the distances AC and AB. [3]

(ii) Sketch the graph of x against t, where x metres is the boy's displacement from A. Show clearly the values of t and x when the boy arrives at C, when he leaves C, and when he arrives at B. [3]

4 The top of an inclined plane is at a height of 0.7 m above the bottom. A block of mass 0.2 kg is released from rest at the top of the plane and slides a distance of 2.5 m to the bottom. Find the kinetic energy of the block when it reaches the bottom of the plane in each of the following cases:

(i) the plane is smooth, [2]

(ii) the coefficient of friction between the plane and the block is 0.15. [5]

5 A particle P moves in a straight line that passes through the origin O. The velocity of P at time t seconds is $v\,\mathrm{m\,s^{-1}}$, where $v = 20t - t^3$. At time $t = 0$ the particle is at rest at a point whose displacement from O is -36 m.

(i) Find an expression for the displacement of P from O in terms of t. [3]

(ii) Find the displacement of P from O when $t = 4$. [1]

(iii) Find the values of t for which the particle is at O. [3]

6 A car of mass 1200 kg travels along a horizontal straight road. The power of the car's engine is 20 kW. The resistance to the car's motion is 400 N.

(i) Find the speed of the car at an instant when its acceleration is $0.5\,\text{m}\,\text{s}^{-2}$. [4]

(ii) Show that the maximum possible speed of the car is $50\,\text{m}\,\text{s}^{-1}$. [2]

The work done by the car's engine as the car travels from a point A to a point B is 1500 kJ.

(iii) Given that the car is travelling at its maximum possible speed between A and B, find the time taken to travel from A to B. [2]

7 A particle P_1 is projected vertically upwards, from horizontal ground, with a speed of $30\,\text{m}\,\text{s}^{-1}$. At the same instant another particle P_2 is projected vertically upwards from the top of a tower of height 25 m, with a speed of $10\,\text{m}\,\text{s}^{-1}$. Find

(i) the time for which P_1 is higher than the top of the tower, [3]

(ii) the velocities of the particles at the instant when the particles are at the same height, [5]

(iii) the time for which P_1 is higher than P_2 and is moving upwards. [3]

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

MATHEMATICS **9709/04**

Paper 4 Mechanics 1 **(M1)**

May/June 2005

1 hour 15 minutes

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

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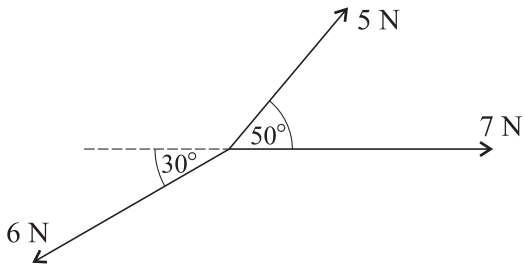
[Turn over

1 A small block is pulled along a rough horizontal floor at a constant speed of $1.5\,\mathrm{m\,s^{-1}}$ by a constant force of magnitude 30 N acting at an angle of $\theta°$ upwards from the horizontal. Given that the work done by the force in 20 s is 720 J, calculate the value of θ. [3]

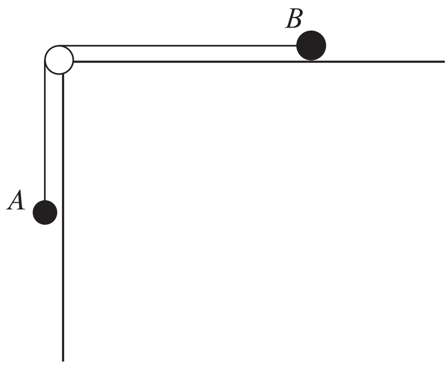
2



Three coplanar forces act at a point. The magnitudes of the forces are 5 N, 6 N and 7 N, and the directions in which the forces act are shown in the diagram. Find the magnitude and direction of the resultant of the three forces. [6]

3 A and B are points on the same line of greatest slope of a rough plane inclined at 30° to the horizontal. A is higher up the plane than B and the distance AB is 2.25 m. A particle P, of mass m kg, is released from rest at A and reaches B 1.5 s later. Find the coefficient of friction between P and the plane. [6]

4



Particles A and B, of masses 0.2 kg and 0.3 kg respectively, are connected by a light inextensible string. The string passes over a smooth pulley at the edge of a rough horizontal table. Particle A hangs freely and particle B is in contact with the table (see diagram).

(i) The system is in limiting equilibrium with the string taut and A about to move downwards. Find the coefficient of friction between B and the table. [4]

A force now acts on particle B. This force has a vertical component of 1.8 N upwards and a horizontal component of X N directed away from the pulley.

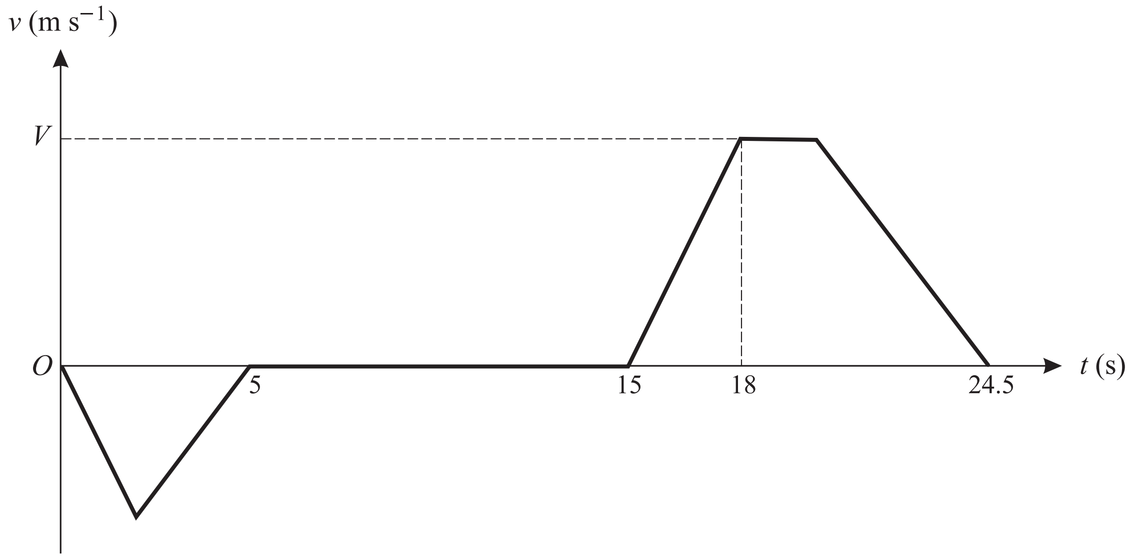
(ii) The system is now in limiting equilibrium with the string taut and A about to move **upwards**. Find X. [3]

5 A particle P moves along the x-axis in the positive direction. The velocity of P at time t s is $0.03t^2$ m s^{-1}. When $t = 5$ the displacement of P from the origin O is 2.5 m.

(i) Find an expression, in terms of t, for the displacement of P from O. [4]

(ii) Find the velocity of P when its displacement from O is 11.25 m. [3]

6



The diagram shows the velocity-time graph for a lift moving between floors in a building. The graph consists of straight line segments. In the first stage the lift travels downwards from the ground floor for 5 s, coming to rest at the basement after travelling 10 m.

(i) Find the greatest speed reached during this stage. [2]

The second stage consists of a 10 s wait at the basement. In the third stage, the lift travels upwards until it comes to rest at a floor 34.5 m above the basement, arriving 24.5 s after the start of the first stage. The lift accelerates at 2 m s^{-2} for the first 3 s of the third stage, reaching a speed of V m s^{-1}. Find

(ii) the value of V, [2]

(iii) the time during the third stage for which the lift is moving at constant speed, [3]

(iv) the deceleration of the lift in the final part of the third stage. [2]

7 A car of mass 1200 kg travels along a horizontal straight road. The power provided by the car's engine is constant and equal to 20 kW. The resistance to the car's motion is constant and equal to 500 N. The car passes through the points A and B with speeds 10 m s^{-1} and 25 m s^{-1} respectively. The car takes 30.5 s to travel from A to B.

(i) Find the acceleration of the car at A. [4]

(ii) By considering work and energy, find the distance AB. [8]

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General Certificate of Education
Advanced Subsidiary Level and Advanced Level

MATHEMATICS **9709/04**

Paper 4 Mechanics 1 **(M1)**

May/June 2006

1 hour 15 minutes

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

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UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

1 A car of mass 1200 kg travels on a horizontal straight road with constant acceleration a m s^{-2}.

(i) Given that the car's speed increases from 10 m s^{-1} to 25 m s^{-1} while travelling a distance of 525 m, find the value of a. [2]

The car's engine exerts a constant driving force of 900 N. The resistance to motion of the car is constant and equal to R N.

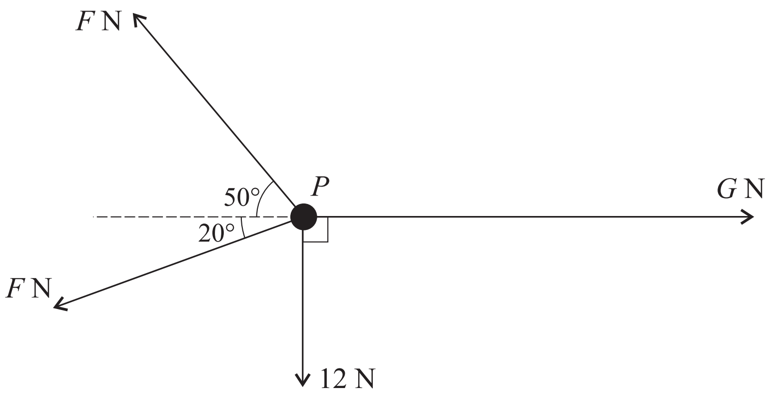
(ii) Find R. [2]

2 A motorcyclist starts from rest at A and travels in a straight line until he comes to rest again at B. The velocity of the motorcyclist t seconds after leaving A is v m s^{-1}, where $v = t - 0.01t^2$. Find

(i) the time taken for the motorcyclist to travel from A to B, [2]

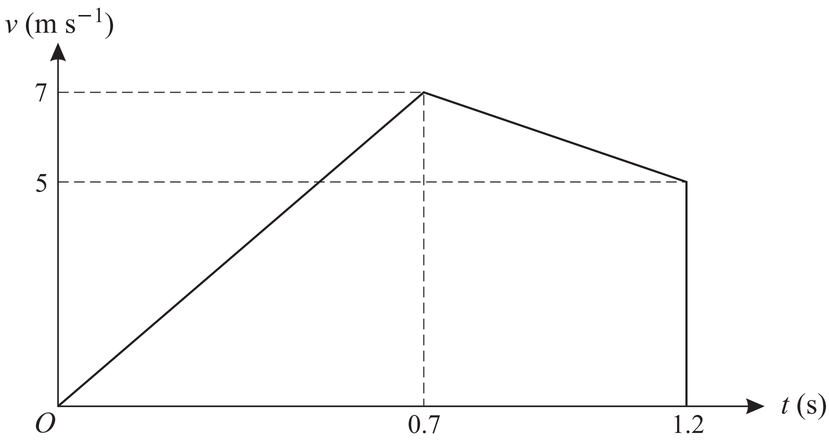
(ii) the distance AB. [3]

3



A particle P is in equilibrium on a smooth horizontal table under the action of horizontal forces of magnitudes F N, F N, G N and 12 N acting in the directions shown. Find the values of F and G. [6]

4



The diagram shows the velocity-time graph for the motion of a small stone which falls vertically from rest at a point A above the surface of liquid in a container. The downward velocity of the stone t s after leaving A is $v\,\mathrm{m\,s^{-1}}$. The stone hits the surface of the liquid with velocity $7\,\mathrm{m\,s^{-1}}$ when $t = 0.7$. It reaches the bottom of the container with velocity $5\,\mathrm{m\,s^{-1}}$ when $t = 1.2$.

(i) Find

(a) the height of A above the surface of the liquid,

(b) the depth of liquid in the container. [3]

(ii) Find the deceleration of the stone while it is moving in the liquid. [2]

(iii) Given that the resistance to motion of the stone while it is moving in the liquid has magnitude 0.7 N, find the mass of the stone. [3]

5

Particles P and Q are attached to opposite ends of a light inextensible string. P is at rest on a rough horizontal table. The string passes over a small smooth pulley which is fixed at the edge of the table. Q hangs vertically below the pulley (see diagram). The force exerted on the string by the pulley has magnitude $4\sqrt{2}$ N. The coefficient of friction between P and the table is 0.8.

(i) Show that the tension in the string is 4 N and state the mass of Q. [2]

(ii) Given that P is on the point of slipping, find its mass. [2]

A particle of mass 0.1 kg is now attached to Q and the system starts to move.

(iii) Find the tension in the string while the particles are in motion. [4]

6 A block of mass 50 kg is pulled up a straight hill and passes through points A and B with speeds $7\,\mathrm{m\,s^{-1}}$ and $3\,\mathrm{m\,s^{-1}}$ respectively. The distance AB is 200 m and B is 15 m higher than A. For the motion of the block from A to B, find

(i) the loss in kinetic energy of the block, [2]

(ii) the gain in potential energy of the block. [2]

The resistance to motion of the block has magnitude 7.5 N.

(iii) Find the work done by the pulling force acting on the block. [2]

The pulling force acting on the block has constant magnitude 45 N and acts at an angle $\alpha°$ upwards from the hill.

(iv) Find the value of α. [3]

7 Two particles P and Q move on a line of greatest slope of a smooth inclined plane. The particles start at the same instant and from the same point, each with speed $1.3\,\mathrm{m\,s^{-1}}$. Initially P moves down the plane and Q moves up the plane. The distance between the particles t seconds after they start to move is d m.

(i) Show that $d = 2.6t$. [4]

When $t = 2.5$ the difference in the vertical height of the particles is 1.6 m. Find

(ii) the acceleration of the particles down the plane, [3]

(iii) the distance travelled by P when Q is at its highest point. [3]

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

MATHEMATICS **9709/04**

Paper 4 Mechanics 1 **(M1)** **May/June 2007**

1 hour 15 minutes

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

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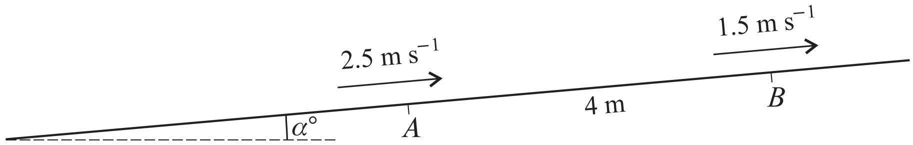
UNIVERSITY of CAMBRIDGE International Examinations

1

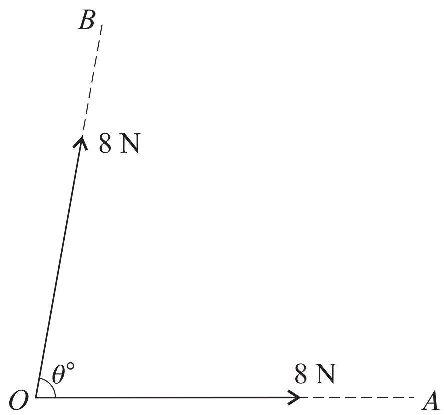


A particle slides up a line of greatest slope of a smooth plane inclined at an angle $\alpha°$ to the horizontal. The particle passes through the points A and B with speeds $2.5\,\text{m s}^{-1}$ and $1.5\,\text{m s}^{-1}$ respectively. The distance AB is 4 m (see diagram). Find

(i) the deceleration of the particle, [2]

(ii) the value of α. [2]

2



Two forces, each of magnitude 8 N, act at a point in the directions OA and OB. The angle between the forces is $\theta°$ (see diagram). The resultant of the two forces has component 9 N in the direction OA. Find

(i) the value of θ, [2]

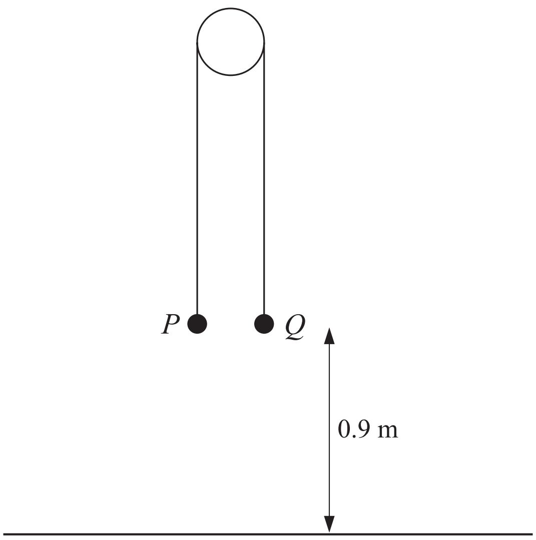
(ii) the magnitude of the resultant of the two forces. [3]

3 A car travels along a horizontal straight road with increasing speed until it reaches its maximum speed of $30\,\text{m s}^{-1}$. The resistance to motion is constant and equal to R N, and the power provided by the car's engine is 18 kW.

(i) Find the value of R. [3]

(ii) Given that the car has mass 1200 kg, find its acceleration at the instant when its speed is $20\,\text{m s}^{-1}$. [3]

4

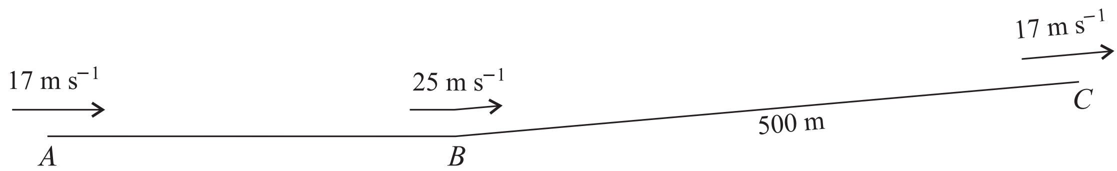


Particles P and Q, of masses 0.6 kg and 0.2 kg respectively, are attached to the ends of a light inextensible string which passes over a smooth fixed peg. The particles are held at rest with the string taut. Both particles are at a height of 0.9 m above the ground (see diagram). The system is released and each of the particles moves vertically. Find

(i) the acceleration of P and the tension in the string before P reaches the ground, [5]

(ii) the time taken for P to reach the ground. [2]

5

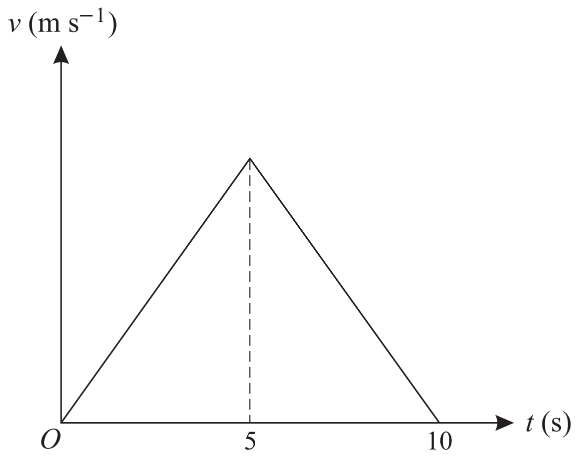


A lorry of mass 12 500 kg travels along a road that has a straight horizontal section AB and a straight inclined section BC. The length of BC is 500 m. The speeds of the lorry at A, B and C are 17 m s^{-1}, 25 m s^{-1} and 17 m s^{-1} respectively (see diagram).

(i) The work done against the resistance to motion of the lorry, as it travels from A to B, is 5000 kJ. Find the work done by the driving force as the lorry travels from A to B. [4]

(ii) As the lorry travels from B to C, the resistance to motion is 4800 N and the work done by the driving force is 3300 kJ. Find the height of C above the level of AB. [4]

6

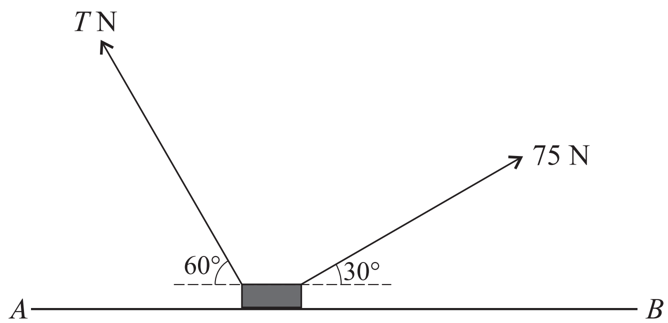


A particle P starts from rest at the point A and travels in a straight line, coming to rest again after 10 s. The velocity-time graph for P consists of two straight line segments (see diagram). A particle Q starts from rest at A at the same instant as P and travels along the same straight line as P. The velocity of Q is given by $v = 3t - 0.3t^2$ for $0 \leqslant t \leqslant 10$. The displacements from A of P and Q are the same when $t = 10$.

(i) Show that the greatest velocity of P during its motion is $10\,\mathrm{m\,s^{-1}}$. [6]

(ii) Find the value of t, in the interval $0 < t < 5$, for which the acceleration of Q is the same as the acceleration of P. [3]

7



Two light strings are attached to a block of mass 20 kg. The block is in equilibrium on a horizontal surface AB with the strings taut. The strings make angles of 60° and 30° with the horizontal, on either side of the block, and the tensions in the strings are T N and 75 N respectively (see diagram).

(i) Given that the surface is smooth, find the value of T and the magnitude of the contact force acting on the block. [5]

(ii) It is given instead that the surface is rough and that the block is on the point of slipping. The frictional force on the block has magnitude 25 N and acts towards A. Find the coefficient of friction between the block and the surface. [6]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
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MATHEMATICS **9709/04**

Paper 4 Mechanics 1 **(M1)** **May/June 2008**

1 hour 15 minutes

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

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[Turn over

1 A particle slides down a smooth plane inclined at an angle of $\alpha°$ to the horizontal. The particle passes through the point A with speed $1.5\,\mathrm{m\,s^{-1}}$, and 1.2 s later it passes through the point B with speed $4.5\,\mathrm{m\,s^{-1}}$. Find

(i) the acceleration of the particle, [2]

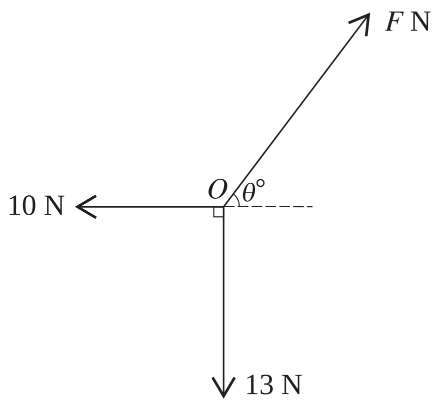
(ii) the value of α. [2]

2 A block is being pulled along a horizontal floor by a rope inclined at 20° to the horizontal. The tension in the rope is 851 N and the block moves at a constant speed of $2.5\,\mathrm{m\,s^{-1}}$.

(i) Show that the work done on the block in 12 s is approximately 24 kJ. [3]

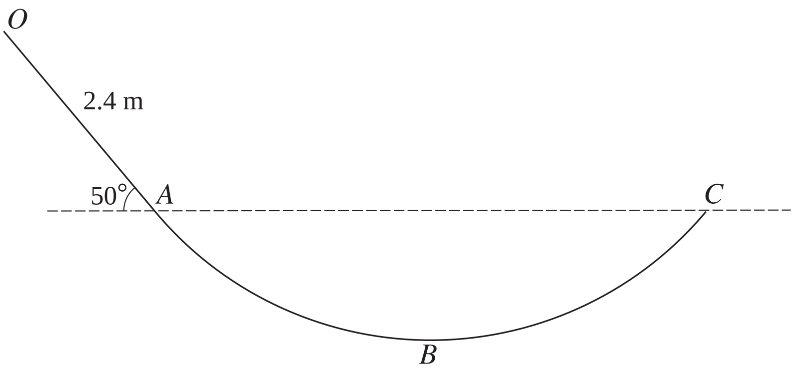
(ii) Hence find the power being applied to the block, giving your answer to the nearest kW. [1]

3



Three horizontal forces of magnitudes F N, 13 N and 10 N act at a fixed point O and are in equilibrium. The directions of the forces are as shown in the diagram. Find, in either order, the value of θ and the value of F. [5]

4



OABC is a vertical cross-section of a smooth surface. The straight part *OA* has length 2.4 m and makes an angle of 50° with the horizontal. *A* and *C* are at the same horizontal level and *B* is the lowest point of the cross-section (see diagram). A particle *P* of mass 0.8 kg is released from rest at *O* and moves on the surface. *P* remains in contact with the surface until it leaves the surface at *C*. Find

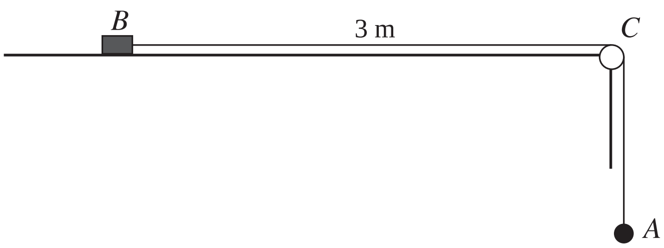
(i) the kinetic energy of *P* at *A*, [2]

(ii) the speed of *P* at *C*. [2]

The greatest speed of *P* is 8 m s^{-1}.

(iii) Find the depth of *B* below the horizontal through *A* and *C*. [3]

5



A block *B* of mass 0.6 kg and a particle *A* of mass 0.4 kg are attached to opposite ends of a light inextensible string. The block is held at rest on a rough horizontal table, and the coefficient of friction between the block and the table is 0.5. The string passes over a small smooth pulley *C* at the edge of the table and *A* hangs in equilibrium vertically below *C*. The part of the string between *B* and *C* is horizontal and the distance *BC* is 3 m (see diagram). *B* is released and the system starts to move.

(i) Find the acceleration of *B* and the tension in the string. [6]

(ii) Find the time taken for *B* to reach the pulley. [2]

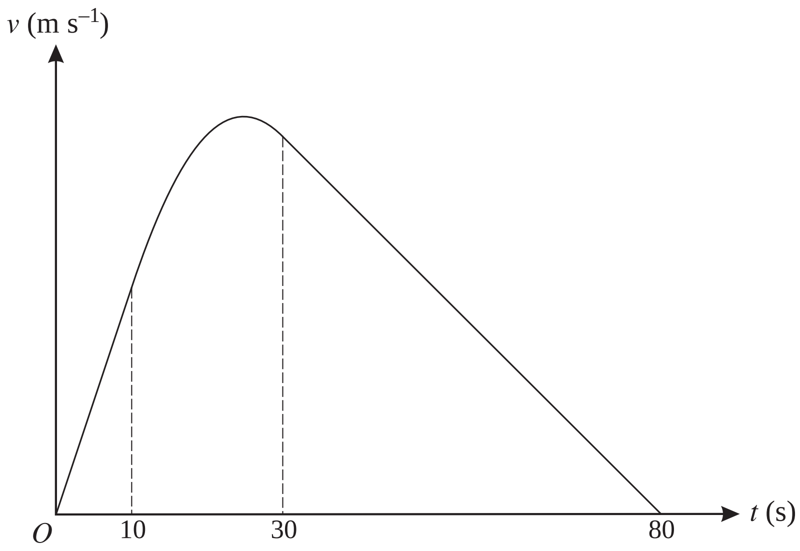
6 A particle *P* of mass 0.6 kg is projected vertically upwards with speed 5.2 m s^{-1} from a point *O* which is 6.2 m above the ground. Air resistance acts on *P* so that its deceleration is 10.4 m s^{-2} when *P* is moving upwards, and its acceleration is 9.6 m s^{-2} when *P* is moving downwards. Find

(i) the greatest height above the ground reached by *P*, [3]

(ii) the speed with which *P* reaches the ground, [2]

(iii) the total work done on *P* by the air resistance. [4]

7



An object P travels from A to B in a time of 80 s. The diagram shows the graph of v against t, where v m s^{-1} is the velocity of P at time t s after leaving A. The graph consists of straight line segments for the intervals $0 \leqslant t \leqslant 10$ and $30 \leqslant t \leqslant 80$, and a curved section whose equation is $v = -0.01t^2 + 0.5t - 1$ for $10 \leqslant t \leqslant 30$. Find

(i) the maximum velocity of P, [4]

(ii) the distance AB. [9]

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

MATHEMATICS **9709/04**

Paper 4 Mechanics 1 **(M1)** **May/June 2009**

1 hour 15 minutes

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

4159902989

READ THESE INSTRUCTIONS FIRST

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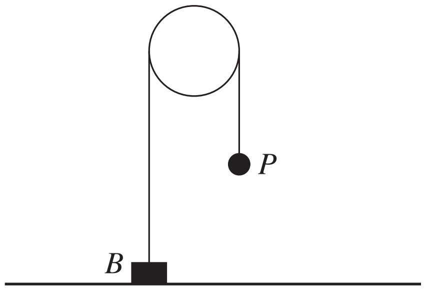
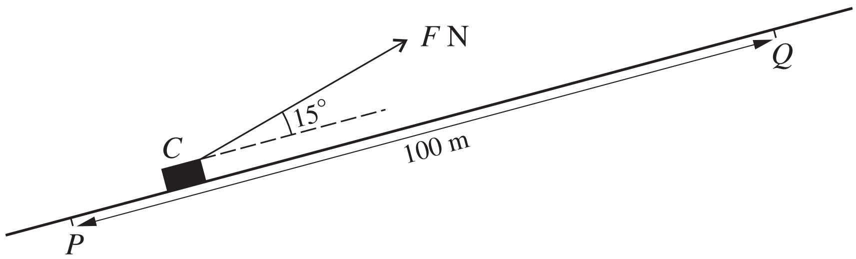
1



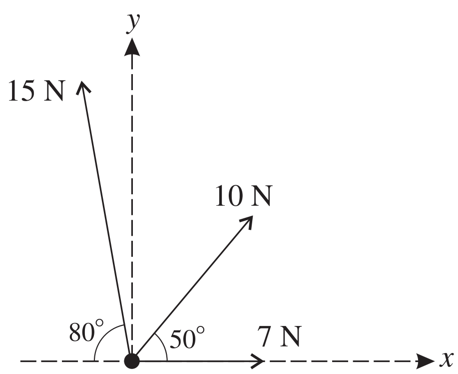
A block B of mass 5 kg is attached to one end of a light inextensible string. A particle P of mass 4 kg is attached to other end of the string. The string passes over a smooth pulley. The system is in equilibrium with the string taut and its straight parts vertical. B is at rest on the ground (see diagram). State the tension in the string and find the force exerted on B by the ground. [3]

2



A crate C is pulled at constant speed up a straight inclined path by a constant force of magnitude F N, acting upwards at an angle of 15° to the path. C passes through points P and Q which are 100 m apart (see diagram). As C travels from P to Q the work done against the resistance to C's motion is 900 J, and the gain in C's potential energy is 2100 J. Write down the work done by the pulling force as C travels from P to Q, and hence find the value of F. [3]

3



Forces of magnitudes 7 N, 10 N and 15 N act on a particle in the directions shown in the diagram.

(i) Find the component of the resultant of the three forces

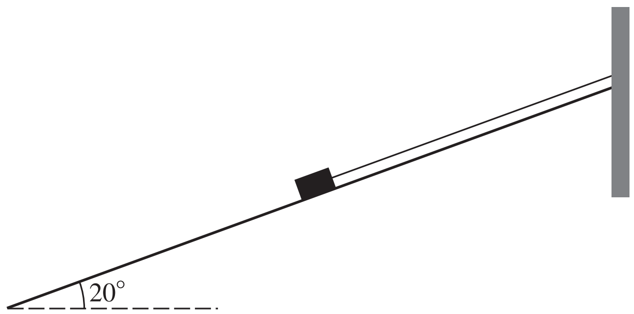
(a) in the x-direction,

(b) in the y-direction.

[3]

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

4



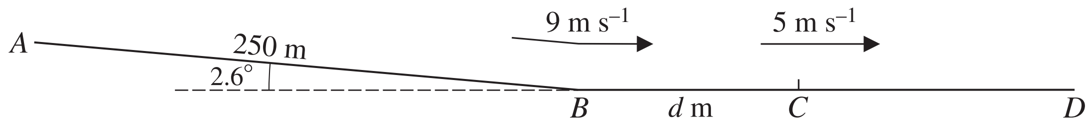
A block of mass 8 kg is at rest on a plane inclined at 20° to the horizontal. The block is connected to a vertical wall at the top of the plane by a string. The string is taut and parallel to a line of greatest slope of the plane (see diagram).

(i) Given that the tension in the string is 13 N, find the frictional and normal components of the force exerted on the block by the plane. [4]

The string is cut; the block remains at rest, but is on the point of slipping down the plane.

(ii) Find the coefficient of friction between the block and the plane. [2]

5



A cyclist and his machine have a total mass of 80 kg. The cyclist starts from rest at the top *A* of a straight path *AB*, and freewheels (moves without pedalling or braking) down the path to *B*. The path *AB* is inclined at 2.6° to the horizontal and is of length 250 m (see diagram).

(i) Given that the cyclist passes through *B* with speed $9\,\mathrm{m\,s^{-1}}$, find the gain in kinetic energy and the loss in potential energy of the cyclist and his machine. Hence find the work done against the resistance to motion of the cyclist and his machine. [3]

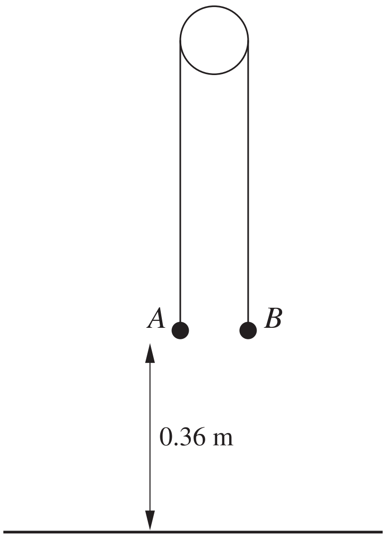
The cyclist continues to freewheel along a horizontal straight path *BD* until he reaches the point *C*, where the distance *BC* is *d* m. His speed at *C* is $5\,\mathrm{m\,s^{-1}}$. The resistance to motion is constant, and is the same on *BD* as on *AB*.

(ii) Find the value of *d*. [3]

The cyclist starts to pedal at *C*, generating 425 W of power.

(iii) Find the acceleration of the cyclist immediately after passing through *C*. [3]

6



Particles A and B are attached to the ends of a light inextensible string which passes over a smooth pulley. The system is held at rest with the string taut and its straight parts vertical. Both particles are at a height of 0.36 m above the floor (see diagram). The system is released and A begins to fall, reaching the floor after 0.6 s.

(i) Find the acceleration of A as it falls. [2]

The mass of A is 0.45 kg. Find

(ii) the tension in the string while A is falling, [2]

(iii) the mass of B, [3]

(iv) the maximum height above the floor reached by B. [3]

7 A particle P travels in a straight line from A to D, passing through the points B and C. For the section AB the velocity of the particle is $(0.5t - 0.01t^2)$ m s^{-1}, where t s is the time after leaving A.

(i) Given that the acceleration of P at B is 0.1 m s^{-2}, find the time taken for P to travel from A to B. [3]

The acceleration of P from B to C is constant and equal to 0.1 m s^{-2}.

(ii) Given that P reaches C with speed 14 m s^{-1}, find the time taken for P to travel from B to C. [3]

P travels with constant deceleration 0.3 m s^{-2} from C to D. Given that the distance CD is 300 m, find

(iii) the speed with which P reaches D, [2]

(iv) the distance AD. [6]

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General Certificate of Education
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MATHEMATICS **9709/41**

Paper 4 Mechanics 1 **(M1)** **May/June 2010**

1 hour 15 minutes

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

7490804446

READ THESE INSTRUCTIONS FIRST

If you have been given an Answer Booklet, follow the instructions on the front cover of the Booklet.
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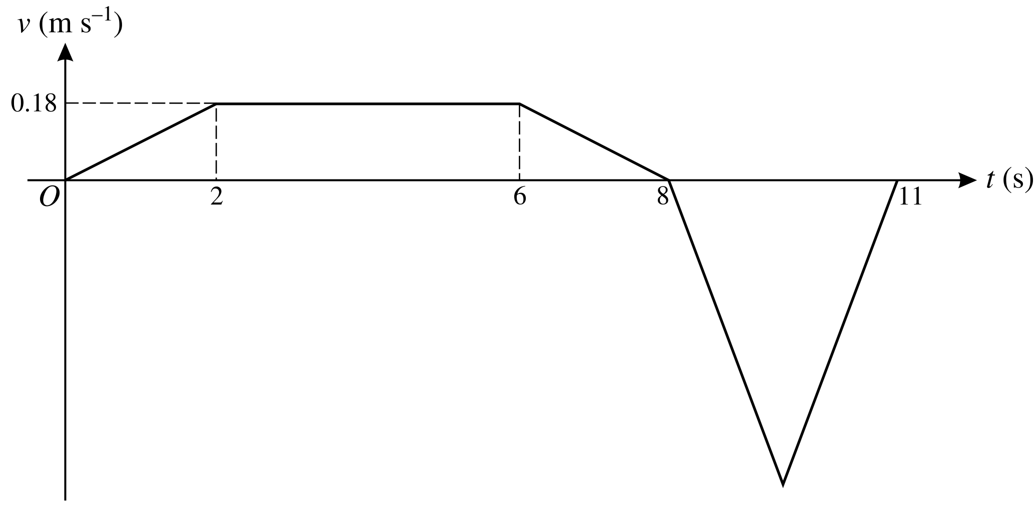
Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.

This document consists of **4** printed pages.

1 A car of mass 1150 kg travels up a straight hill inclined at 1.2° to the horizontal. The resistance to motion of the car is 975 N. Find the acceleration of the car at an instant when it is moving with speed $16\,\mathrm{m\,s^{-1}}$ and the engine is working at a power of 35 kW. [4]

2



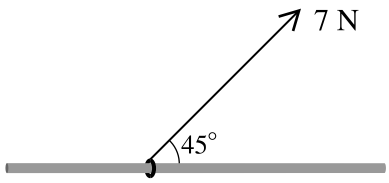
The diagram shows the velocity-time graph for the motion of a machine's cutting tool. The graph consists of five straight line segments. The tool moves forward for 8 s while cutting and then takes 3 s to return to its starting position. Find

(i) the acceleration of the tool during the first 2 s of the motion, [1]

(ii) the distance the tool moves forward while cutting, [2]

(iii) the greatest speed of the tool during the return to its starting position. [2]

3

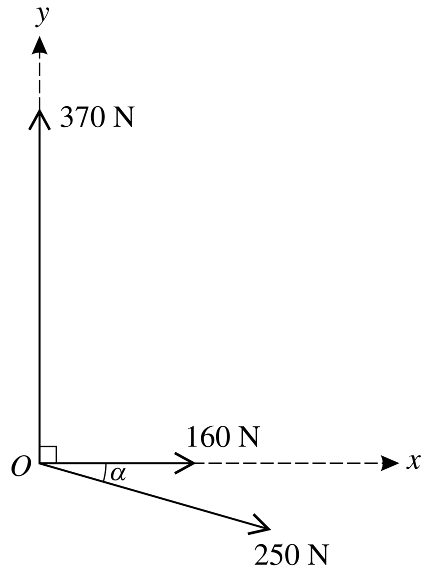


A small ring of mass 0.8 kg is threaded on a rough rod which is fixed horizontally. The ring is in equilibrium, acted on by a force of magnitude 7 N pulling upwards at 45° to the horizontal (see diagram).

(i) Show that the normal component of the contact force acting on the ring has magnitude 3.05 N, correct to 3 significant figures. [2]

(ii) The ring is in limiting equilibrium. Find the coefficient of friction between the ring and the rod. [3]

4



Coplanar forces of magnitudes 250 N, 160 N and 370 N act at a point O in the directions shown in the diagram, where the angle α is such that $\sin\alpha = 0.28$ and $\cos\alpha = 0.96$. Calculate the magnitude of the resultant of the three forces. Calculate also the angle that the resultant makes with the x-direction. [7]

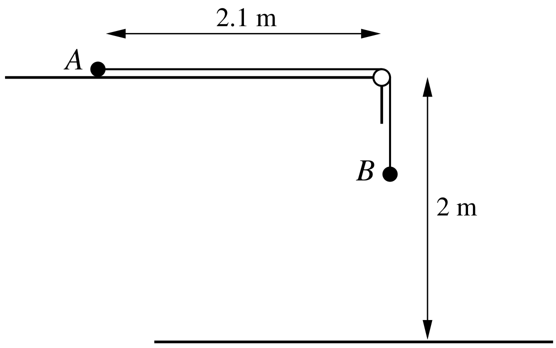
5 P and Q are fixed points on a line of greatest slope of an inclined plane. The point Q is at a height of 0.45 m above the level of P. A particle of mass 0.3 kg moves upwards along the line PQ.

(i) Given that the plane is smooth and that the particle just reaches Q, find the speed with which it passes through P. [3]

(ii) It is given instead that the plane is rough. The particle passes through P with the same speed as that found in part **(i)**, and just reaches a point R which is between P and Q. The work done against the frictional force in moving from P to R is 0.39 J. Find the potential energy gained by the particle in moving from P to R and hence find the height of R above the level of P. [4]

[Questions 6 and 7 are printed on the next page.]

6



Particles A and B, of masses 0.2 kg and 0.45 kg respectively, are connected by a light inextensible string of length 2.8 m. The string passes over a small smooth pulley at the edge of a rough horizontal surface, which is 2 m above the floor. Particle A is held in contact with the surface at a distance of 2.1 m from the pulley and particle B hangs freely (see diagram). The coefficient of friction between A and the surface is 0.3. Particle A is released and the system begins to move.

(i) Find the acceleration of the particles and show that the speed of B immediately before it hits the floor is $3.95\,\mathrm{m\,s^{-1}}$, correct to 3 significant figures. [7]

(ii) Given that B remains on the floor, find the speed with which A reaches the pulley. [4]

7 A vehicle is moving in a straight line. The velocity $v\,\mathrm{m\,s^{-1}}$ at time t s after the vehicle starts is given by

$$v = A(t - 0.05t^2) \quad \text{for } 0 \leqslant t \leqslant 15,$$

$$v = \frac{B}{t^2} \quad \text{for } t \geqslant 15,$$

where A and B are constants. The distance travelled by the vehicle between $t = 0$ and $t = 15$ is 225 m.

(i) Find the value of A and show that $B = 3375$. [5]

(ii) Find an expression in terms of t for the total distance travelled by the vehicle when $t \geqslant 15$. [3]

(iii) Find the speed of the vehicle when it has travelled a total distance of 315 m. [3]

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

MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **May/June 2010**

1 hour 15 minutes

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

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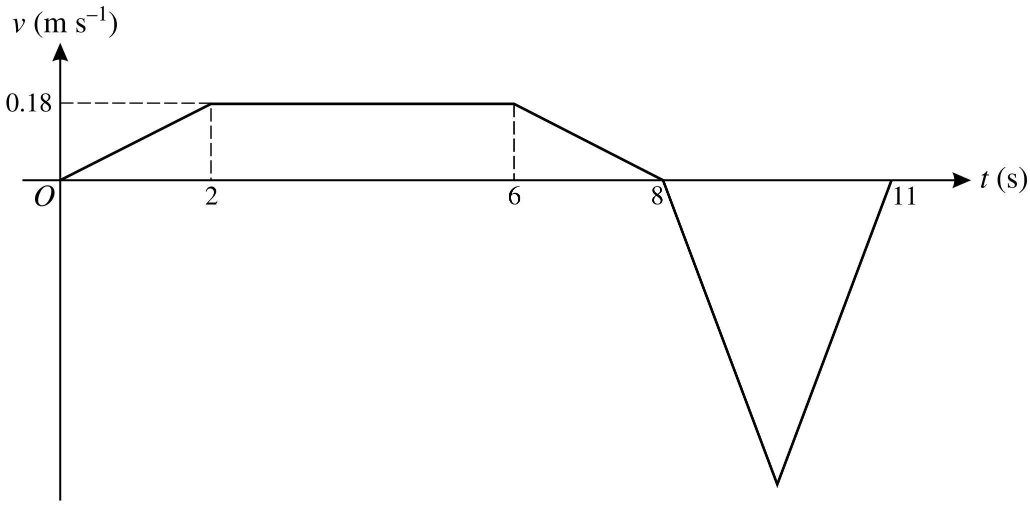

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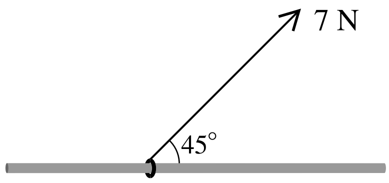
3

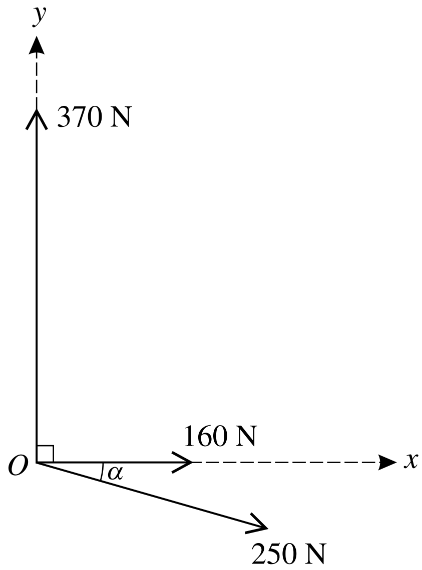


A small ring of mass 0.8 kg is threaded on a rough rod which is fixed horizontally. The ring is in equilibrium, acted on by a force of magnitude 7 N pulling upwards at 45° to the horizontal (see diagram).

(i) Show that the normal component of the contact force acting on the ring has magnitude 3.05 N, correct to 3 significant figures. [2]

(ii) The ring is in limiting equilibrium. Find the coefficient of friction between the ring and the rod. [3]

4



Coplanar forces of magnitudes 250 N, 160 N and 370 N act at a point O in the directions shown in the diagram, where the angle α is such that $\sin \alpha = 0.28$ and $\cos \alpha = 0.96$. Calculate the magnitude of the resultant of the three forces. Calculate also the angle that the resultant makes with the x-direction. [7]

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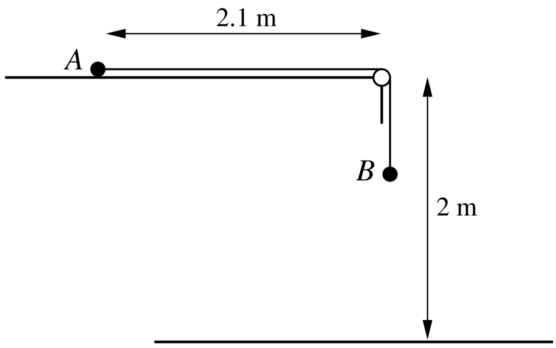
(i) Given that the plane is smooth and that the particle just reaches Q, find the speed with which it passes through P. [3]

(ii) It is given instead that the plane is rough. The particle passes through P with the same speed as that found in part **(i)**, and just reaches a point R which is between P and Q. The work done against the frictional force in moving from P to R is 0.39 J. Find the potential energy gained by the particle in moving from P to R and hence find the height of R above the level of P. [4]

[Questions 6 and 7 are printed on the next page.]

6



Particles A and B, of masses 0.2 kg and 0.45 kg respectively, are connected by a light inextensible string of length 2.8 m. The string passes over a small smooth pulley at the edge of a rough horizontal surface, which is 2 m above the floor. Particle A is held in contact with the surface at a distance of 2.1 m from the pulley and particle B hangs freely (see diagram). The coefficient of friction between A and the surface is 0.3. Particle A is released and the system begins to move.

(i) Find the acceleration of the particles and show that the speed of B immediately before it hits the floor is $3.95\,\text{m s}^{-1}$, correct to 3 significant figures. [7]

(ii) Given that B remains on the floor, find the speed with which A reaches the pulley. [4]

7 A vehicle is moving in a straight line. The velocity $v\,\text{m s}^{-1}$ at time t s after the vehicle starts is given by

$$v = A(t - 0.05t^2) \quad \text{for } 0 \leqslant t \leqslant 15,$$
$$v = \frac{B}{t^2} \quad \text{for } t \geqslant 15,$$

where A and B are constants. The distance travelled by the vehicle between $t = 0$ and $t = 15$ is 225 m.

(i) Find the value of A and show that $B = 3375$. [5]

(ii) Find an expression in terms of t for the total distance travelled by the vehicle when $t \geqslant 15$. [3]

(iii) Find the speed of the vehicle when it has travelled a total distance of 315 m. [3]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
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MATHEMATICS **9709/43**

Paper 4 Mechanics 1 **(M1)** **May/June 2010**

1 hour 15 minutes

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

6164918542

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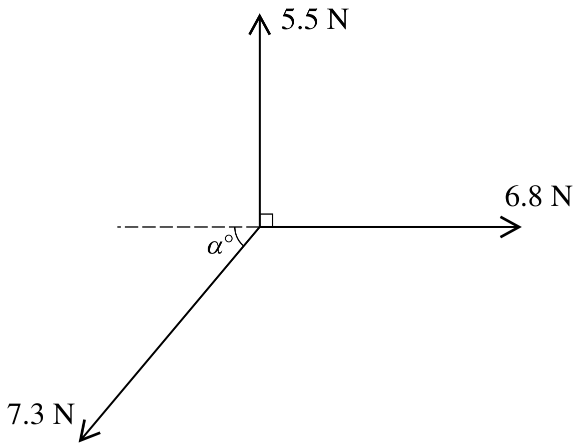
UNIVERSITY of CAMBRIDGE International Examinations

1



Three coplanar forces act at a point. The magnitudes of the forces are 5.5 N, 6.8 N and 7.3 N, and the directions in which the forces act are as shown in the diagram. Given that the resultant of the three forces is in the same direction as the force of magnitude 6.8 N, find the value of α and the magnitude of the resultant. [4]

2 A particle starts at a point O and moves along a straight line. Its velocity t s after leaving O is $(1.2t - 0.12t^2)$ m s^{-1}. Find the displacement of the particle from O when its acceleration is 0.6 m s^{-2}. [5]

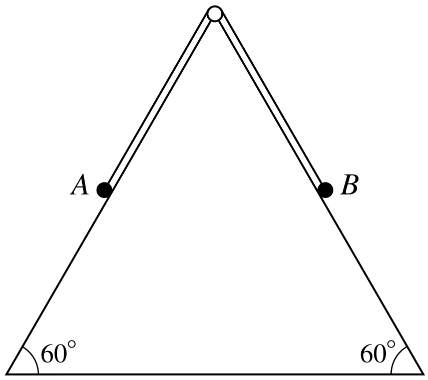
3 A load is pulled along a horizontal straight track, from A to B, by a force of magnitude P N which acts at an angle of 30° upwards from the horizontal. The distance AB is 80 m. The speed of the load is constant and equal to 1.2 m s^{-1} as it moves from A to the mid-point M of AB.

(i) For the motion from A to M the value of P is 25. Calculate the work done by the force as the load moves from A to M. [2]

The speed of the load increases from 1.2 m s^{-1} as it moves from M towards B. For the motion from M to B the value of P is 50 and the work done against resistance is the same as that for the motion from A to M. The mass of the load is 35 kg.

(ii) Find the gain in kinetic energy of the load as it moves from M to B and hence find the speed with which it reaches B. [5]

4



The diagram shows a vertical cross-section of a triangular prism which is fixed so that two of its faces are inclined at 60° to the horizontal. One of these faces is smooth and one is rough. Particles A and B, of masses 0.36 kg and 0.24 kg respectively, are attached to the ends of a light inextensible string which passes over a small smooth pulley fixed at the highest point of the cross-section. B is held at rest at a point of the cross-section on the rough face and A hangs freely in contact with the smooth face (see diagram). B is released and starts to move up the face with acceleration $0.25\,\mathrm{m\,s^{-2}}$.

(i) By considering the motion of A, show that the tension in the string is 3.03 N, correct to 3 significant figures. [2]

(ii) Find the coefficient of friction between B and the rough face, correct to 2 significant figures. [6]

5 A ball moves on the horizontal surface of a billiards table with deceleration of constant magnitude $d\,\mathrm{m\,s^{-2}}$. The ball starts at A with speed $1.4\,\mathrm{m\,s^{-1}}$ and reaches the edge of the table at B, 1.2 s later, with speed $1.1\,\mathrm{m\,s^{-1}}$.

(i) Find the distance AB and the value of d. [3]

AB is at right angles to the edge of the table containing B. The table has a low wall along each of its edges and the ball rebounds from the wall at B and moves directly towards A. The ball comes to rest at C where the distance BC is 2 m.

(ii) Find the speed with which the ball starts to move towards A and the time taken for the ball to travel from B to C. [3]

(iii) Sketch a velocity-time graph for the motion of the ball, from the time the ball leaves A until it comes to rest at C, showing on the axes the values of the velocity and the time when the ball is at A, at B and at C. [2]

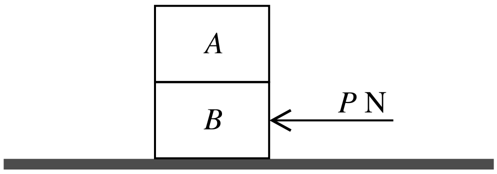
6 Particles P and Q move on a line of greatest slope of a smooth inclined plane. P is released from rest at a point O on the line and 2 s later passes through the point A with speed $3.5\,\mathrm{m\,s^{-1}}$.

(i) Find the acceleration of P and the angle of inclination of the plane. [4]

At the instant that P passes through A the particle Q is released from rest at O. At time t s after Q is released from O, the particles P and Q are 4.9 m apart.

(ii) Find the value of t. [5]

7



Two rectangular boxes A and B are of identical size. The boxes are at rest on a rough horizontal floor with A on top of B. Box A has mass 200 kg and box B has mass 250 kg. A horizontal force of magnitude P N is applied to B (see diagram). The boxes remain at rest if $P \leqslant 3150$ and start to move if $P > 3150$.

(i) Find the coefficient of friction between B and the floor. [3]

The coefficient of friction between the two boxes is 0.2. Given that $P > 3150$ and that no sliding takes place between the boxes,

(ii) show that the acceleration of the boxes is not greater than $2\,\mathrm{m\,s^{-2}}$, [3]

(iii) find the maximum possible value of P. [3]

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

MATHEMATICS **9709/41**

Paper 4 Mechanics 1 **(M1)** **May/June 2011**

1 hour 15 minutes

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

3847556196

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JC11 06_9709_41/3R

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[Turn over

1 A car of mass 700 kg is travelling along a straight horizontal road. The resistance to motion is constant and equal to 600 N.

(i) Find the driving force of the car's engine at an instant when the acceleration is $2\,\text{m}\,\text{s}^{-2}$. [2]

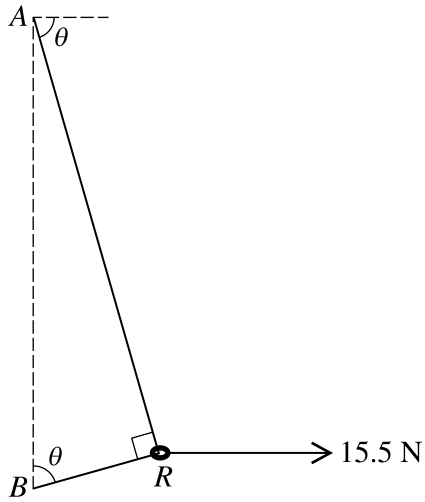
(ii) Given that the car's speed at this instant is $15\,\text{m}\,\text{s}^{-1}$, find the rate at which the car's engine is working. [2]

2 A load of mass 1250 kg is raised by a crane from rest on horizontal ground, to rest at a height of 1.54 m above the ground. The work done against the resistance to motion is 5750 J.

(i) Find the work done by the crane. [3]

(ii) Assuming the power output of the crane is constant and equal to 1.25 kW, find the time taken to raise the load. [2]

3



A small smooth ring R of weight 8.5 N is threaded on a light inextensible string. The ends of the string are attached to fixed points A and B, with A vertically above B. A horizontal force of magnitude 15.5 N acts on R so that the ring is in equilibrium with angle $ARB = 90°$. The part AR of the string makes an angle θ with the horizontal and the part BR makes an angle θ with the vertical (see diagram). The tension in the string is T N. Show that $T \sin \theta = 12$ and $T \cos \theta = 3.5$ and hence find θ. [6]

4 A block of mass 11 kg is at rest on a rough plane inclined at 30° to the horizontal. A force acts on the block in a direction up the plane parallel to a line of greatest slope. When the magnitude of the force is $2X$ N the block is on the point of sliding down the plane, and when the magnitude of the force is $9X$ N the block is on the point of sliding up the plane. Find

(i) the value of X, [3]

(ii) the coefficient of friction between the block and the plane. [4]

5 A train starts from rest at a station A and travels in a straight line to station B, where it comes to rest. The train moves with constant acceleration $0.025\,\text{m s}^{-2}$ for the first 600 s, with constant speed for the next 2600 s, and finally with constant deceleration $0.0375\,\text{m s}^{-2}$.

(i) Find the total time taken for the train to travel from A to B. [4]

(ii) Sketch the velocity-time graph for the journey and find the distance AB. [3]

(iii) The speed of the train t seconds after leaving A is $7.5\,\text{m s}^{-1}$. State the possible values of t. [1]

6 A particle travels in a straight line from a point P to a point Q. Its velocity t seconds after leaving P is $v\,\text{m s}^{-1}$, where $v = 4t - \frac{1}{16}t^3$. The distance PQ is 64 m.

(i) Find the time taken for the particle to travel from P to Q. [5]

(ii) Find the set of values of t for which the acceleration of the particle is positive. [4]

7 Loads A and B, of masses 1.2 kg and 2.0 kg respectively, 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. A is released and starts to move upwards. It does not reach the pulley in the subsequent motion.

(i) Find the acceleration of A and the tension in the string. [4]

(ii) Find, for the first 1.5 metres of A's motion,

(a) A's gain in potential energy,

(b) the work done on A by the tension in the string,

(c) A's gain in kinetic energy.

[3]

B hits the floor 1.6 seconds after A is released. B comes to rest without rebounding and the string becomes slack.

(iii) Find the time from the instant the string becomes slack until it becomes taut again. [4]

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MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **May/June 2011**

1 hour 15 minutes

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

2579131893

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JC11 06_9709_42/2R

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[Turn over

1 A load is pulled along horizontal ground for a distance of 76 m, using a rope. The rope is inclined at 5° above the horizontal and the tension in the rope is 65 N.

(i) Find the work done by the tension. [2]

At an instant during the motion the velocity of the load is $1.5\,\mathrm{m\,s^{-1}}$.

(ii) Find the rate of working of the tension at this instant. [2]

2 An object of mass 8 kg slides down a line of greatest slope of an inclined plane. Its initial speed at the top of the plane is $3\,\mathrm{m\,s^{-1}}$ and its speed at the bottom of the plane is $8\,\mathrm{m\,s^{-1}}$. The work done against the resistance to motion of the object is 120 J. Find the height of the top of the plane above the level of the bottom. [4]

3

The velocity-time graph shown models the motion of a parachutist falling vertically. There are four stages in the motion:

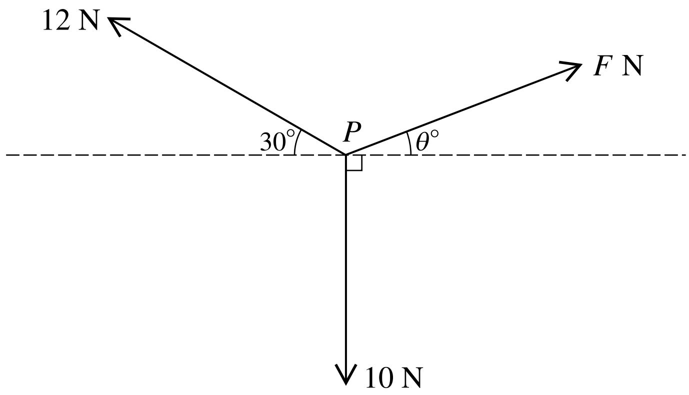
- falling freely with the parachute closed,
- decelerating at a constant rate with the parachute open,
- falling with constant speed with the parachute open,
- coming to rest instantaneously on hitting the ground.

(i) Show that the total distance fallen is 1048 m. [2]

The weight of the parachutist is 850 N.

(ii) Find the upward force on the parachutist due to the parachute, during the second stage. [5]

4



The three coplanar forces shown in the diagram act at a point P and are in equilibrium.

(i) Find the values of F and θ. [6]

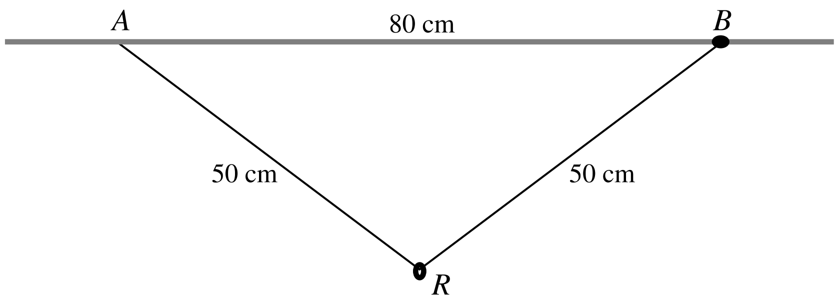
(ii) State the magnitude and direction of the resultant force at P when the force of magnitude 12 N is removed. [2]

5 Two particles P and Q are projected vertically upwards from horizontal ground at the same instant. The speeds of projection of P and Q are $12\,\text{m}\,\text{s}^{-1}$ and $7\,\text{m}\,\text{s}^{-1}$ respectively and the heights of P and Q above the ground, t seconds after projection, are h_P m and h_Q m respectively. Each particle comes to rest on returning to the ground.

(i) Find the set of values of t for which the particles are travelling in opposite directions. [3]

(ii) At a certain instant, P and Q are above the ground and $3h_P = 8h_Q$. Find the velocities of P and Q at this instant. [5]

6



A small smooth ring R, of mass 0.6 kg, is threaded on a light inextensible string of length 100 cm. One end of the string is attached to a fixed point A. A small bead B of mass 0.4 kg is attached to the other end of the string, and is threaded on a fixed rough horizontal rod which passes through A. The system is in equilibrium with B at a distance of 80 cm from A (see diagram).

(i) Find the tension in the string. [3]

(ii) Find the frictional and normal components of the contact force acting on B. [4]

(iii) Given that the equilibrium is limiting, find the coefficient of friction between the bead and the rod. [2]

7 A walker travels along a straight road passing through the points A and B on the road with speeds $0.9\,\mathrm{m\,s^{-1}}$ and $1.3\,\mathrm{m\,s^{-1}}$ respectively. The walker's acceleration between A and B is constant and equal to $0.004\,\mathrm{m\,s^{-2}}$.

(i) Find the time taken by the walker to travel from A to B, and find the distance AB. [3]

A cyclist leaves A at the same instant as the walker. She starts from rest and travels along the straight road, passing through B at the same instant as the walker. At time t s after leaving A the cyclist's speed is $kt^3\,\mathrm{m\,s^{-1}}$, where k is a constant.

(ii) Show that when $t = 64.05$ the speed of the walker and the speed of the cyclist are the same, correct to 3 significant figures. [5]

(ii) Find the cyclist's acceleration at the instant she passes through B. [2]

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MATHEMATICS **9709/43**

Paper 4 Mechanics 1 **(M1)** **May/June 2011**

1 hour 15 minutes

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

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JC11 06_9709_43/2R

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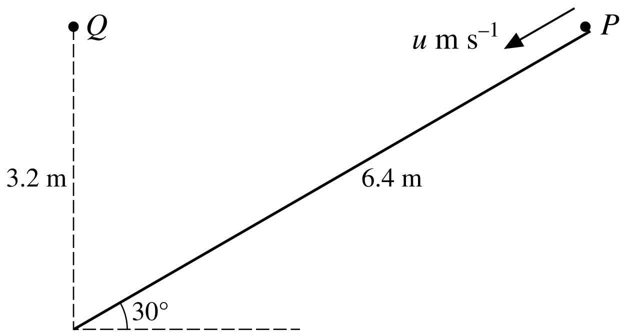
1 A block is pulled for a distance of 50 m along a horizontal floor, by a rope that is inclined at an angle of $\alpha°$ to the floor. The tension in the rope is 180 N and the work done by the tension is 8200 J. Find the value of α. [3]

2 A car of mass 1250 kg is travelling along a straight horizontal road with its engine working at a constant rate of P W. The resistance to the car's motion is constant and equal to R N. When the speed of the car is $19\,\text{m s}^{-1}$ its acceleration is $0.6\,\text{m s}^{-2}$, and when the speed of the car is $30\,\text{m s}^{-1}$ its acceleration is $0.16\,\text{m s}^{-2}$. Find the values of P and R. [6]

3

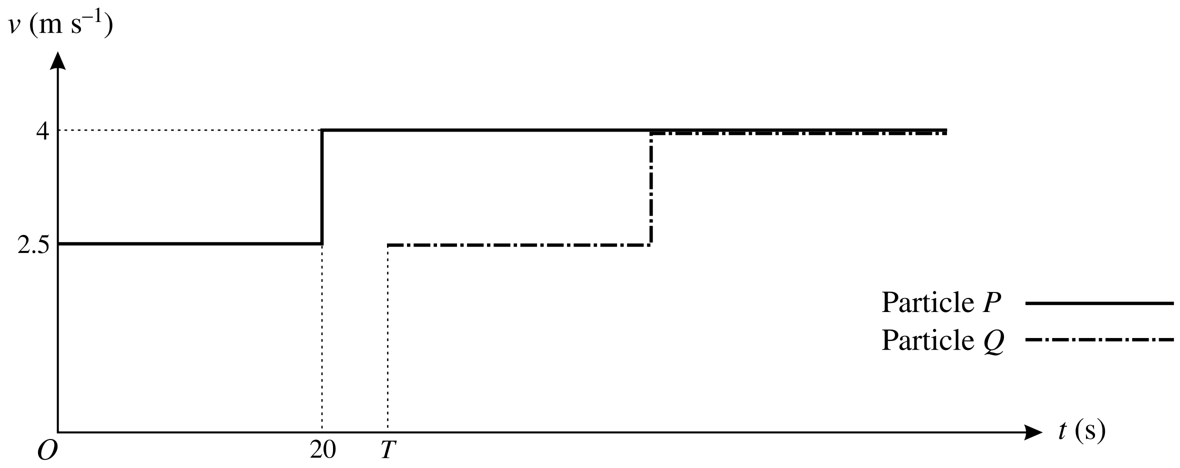


A particle P is projected from the top of a smooth ramp with speed $u\,\text{m s}^{-1}$, and travels down a line of greatest slope. The ramp has length 6.4 m and is inclined at 30° to the horizontal. Another particle Q is released from rest at a point 3.2 m vertically above the bottom of the ramp, at the same instant that P is projected (see diagram). Given that P and Q reach the bottom of the ramp simultaneously, find

(i) the value of u, [4]

(ii) the speed with which P reaches the bottom of the ramp. [2]

4



The diagram shows the velocity-time graphs for the motion of two particles P and Q, which travel in the same direction along a straight line. P and Q both start at the same point X on the line, but Q starts to move T s later than P. Each particle moves with speed $2.5\,\text{m}\,\text{s}^{-1}$ for the first 20 s of its motion. The speed of each particle changes instantaneously to $4\,\text{m}\,\text{s}^{-1}$ after it has been moving for 20 s and the particle continues at this speed.

(i) Make a rough copy of the diagram and shade the region whose area represents the displacement of P from X at the instant when Q starts. [1]

It is given that P has travelled 70 m at the instant when Q starts.

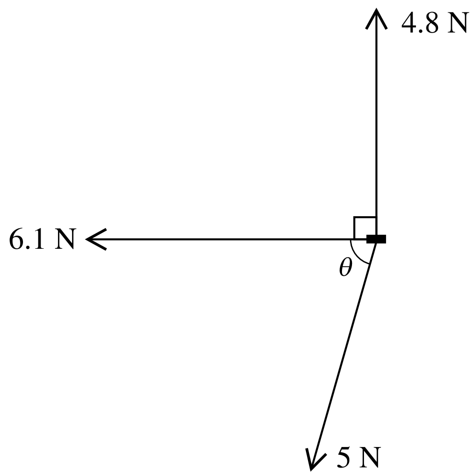
(ii) Find the value of T. [2]

(iii) Find the distance between P and Q when Q's speed reaches $4\,\text{m}\,\text{s}^{-1}$. [2]

(iv) Sketch a single diagram showing the displacement-time graphs for both P and Q, with values shown on the t-axis at which the speed of either particle changes. [2]

[Questions 5, 6 and 7 are printed on the next page.]

5



A small block of mass 1.25 kg is on a horizontal surface. Three horizontal forces, with magnitudes and directions as shown in the diagram, are applied to the block. The angle θ is such that $\cos\theta = 0.28$ and $\sin\theta = 0.96$. A horizontal frictional force also acts on the block, and the block is in equilibrium.

(i) Show that the magnitude of the frictional force is 7.5 N and state the direction of this force. [4]

(ii) Given that the block is in limiting equilibrium, find the coefficient of friction between the block and the surface. [2]

The force of magnitude 6.1 N is now replaced by a force of magnitude 8.6 N acting in the same direction, and the block begins to move.

(iii) Find the magnitude and direction of the acceleration of the block. [3]

6 A lorry of mass 15 000 kg climbs a hill of length 500 m at a constant speed. The hill is inclined at 2.5° to the horizontal. The resistance to the lorry's motion is constant and equal to 800 N.

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

On its return journey the lorry reaches the top of the hill with speed $20\,\mathrm{m\,s^{-1}}$ and continues down the hill with a constant driving force of 2000 N. The resistance to the lorry's motion is again constant and equal to 800 N.

(ii) Find the speed of the lorry when it reaches the bottom of the hill. [5]

7 A particle travels in a straight line from A to B in 20 s. Its acceleration t seconds after leaving A is $a\,\mathrm{m\,s^{-2}}$, where $a = \frac{3}{160}t^2 - \frac{1}{800}t^3$. It is given that the particle comes to rest at B.

(i) Show that the initial speed of the particle is zero. [4]

(ii) Find the maximum speed of the particle. [2]

(iii) Find the distance AB. [4]

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MATHEMATICS **9709/41**

Paper 4 Mechanics 1 **(M1)** **May/June 2012**

1 hour 15 minutes

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

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JC12 06_9709_41/FP

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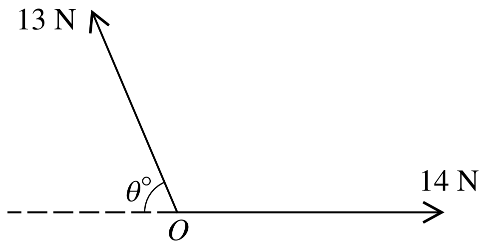
1 A car of mass 880 kg travels along a straight horizontal road with its engine working at a constant rate of P W. The resistance to motion is 700 N. At an instant when the car's speed is $16\,\mathrm{m\,s^{-1}}$ its acceleration is $0.625\,\mathrm{m\,s^{-2}}$. Find the value of P. [4]

2

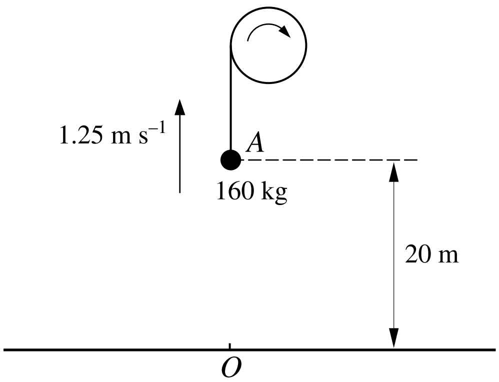


Forces of magnitudes 13 N and 14 N act at a point O in the directions shown in the diagram. The resultant of these forces has magnitude 15 N. Find

(i) the value of θ, [3]

(ii) the component of the resultant in the direction of the force of magnitude 14 N. [2]

3



A load of mass 160 kg is pulled vertically upwards, from rest at a fixed point O on the ground, using a winding drum. The load passes through a point A, 20 m above O, with a speed of $1.25\,\mathrm{m\,s^{-1}}$ (see diagram). Find, for the motion from O to A,

(i) the gain in the potential energy of the load, [1]

(ii) the gain in the kinetic energy of the load. [2]

The power output of the winding drum is constant while the load is in motion.

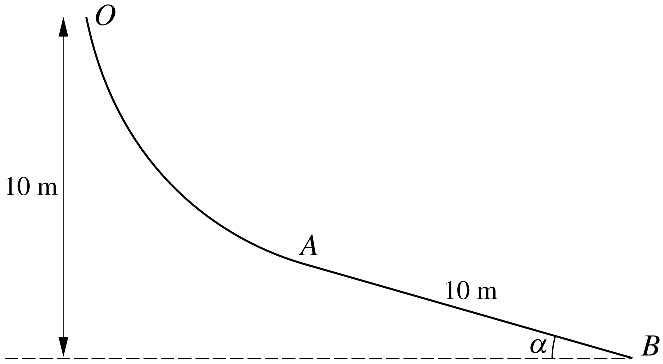
(iii) Given that the work done against the resistance to motion from O to A is 20 kJ and that the time taken for the load to travel from O to A is 41.7 s, find the power output of the winding drum. [3]

4 A particle P starts at the point O and travels in a straight line. At time t seconds after leaving O the velocity of P is $v\,\mathrm{m\,s^{-1}}$, where $v = 0.75t^2 - 0.0625t^3$. Find

(i) the positive value of t for which the acceleration is zero, [3]

(ii) the distance travelled by P before it changes its direction of motion. [5]

5



The diagram shows the vertical cross-section OAB of a slide. The straight line AB is tangential to the curve OA at A. The line AB is inclined at α to the horizontal, where $\sin\alpha = 0.28$. The point O is 10 m higher than B, and AB has length 10 m (see diagram). The part of the slide containing the curve OA is smooth and the part containing AB is rough. A particle P of mass 2 kg is released from rest at O and moves down the slide.

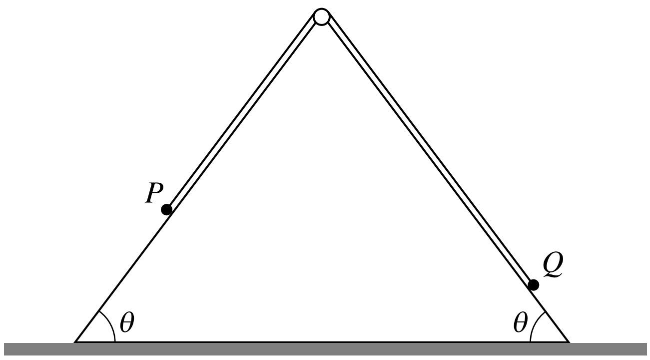
(i) Find the speed of P when it passes through A. [3]

The coefficient of friction between P and the part of the slide containing AB is $\frac{1}{12}$. Find

(ii) the acceleration of P when it is moving from A to B, [3]

(iii) the speed of P when it reaches B. [2]

6



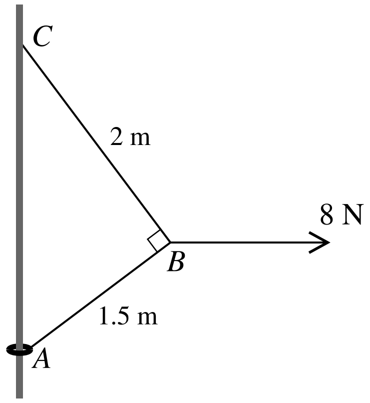
Particles P and Q, of masses 0.6 kg and 0.4 kg respectively, are attached to the ends of a light inextensible string. The string passes over a small smooth pulley which is fixed at the top of a vertical cross-section of a triangular prism. The base of the prism is fixed on horizontal ground and each of the sloping sides is smooth. Each sloping side makes an angle θ with the ground, where $\sin\theta = 0.8$. Initially the particles are held at rest on the sloping sides, with the string taut (see diagram). The particles are released and move along lines of greatest slope.

(i) Find the tension in the string and the acceleration of the particles while both are moving. [5]

The speed of P when it reaches the ground is $2\,\mathrm{m\,s^{-1}}$. On reaching the ground P comes to rest and remains at rest. Q continues to move up the slope but does not reach the pulley.

(ii) Find the time taken from the instant that the particles are released until Q reaches its greatest height above the ground. [4]

7



A small ring of mass 0.2 kg is threaded on a fixed vertical rod. The end A of a light inextensible string is attached to the ring. The other end C of the string is attached to a fixed point of the rod above A. A horizontal force of magnitude 8 N is applied to the point B of the string, where $AB = 1.5$ m and $BC = 2$ m. The system is in equilibrium with the string taut and AB at right angles to BC (see diagram).

(i) Find the tension in the part AB of the string and the tension in the part BC of the string. [5]

The equilibrium is limiting with the ring on the point of sliding up the rod.

(ii) Find the coefficient of friction between the ring and the rod. [5]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
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Advanced Subsidiary Level and Advanced Level

MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **May/June 2012**

1 hour 15 minutes

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

6418757803

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JC12 06_9709_42/FP

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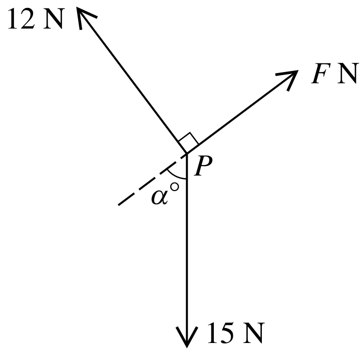
[Turn over

1 A block is pulled in a straight line along horizontal ground by a force of constant magnitude acting at an angle of $60°$ above the horizontal. The work done by the force in moving the block a distance of 5 m is 75 J. Find the magnitude of the force. [3]

2



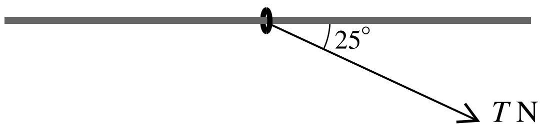
Three coplanar forces of magnitudes F N, 12 N and 15 N are in equilibrium acting at a point P in the directions shown in the diagram. Find α and F. [4]

3 A particle P moves in a straight line, starting from the point O with velocity $2\,\mathrm{m\,s^{-1}}$. The acceleration of P at time t s after leaving O is $2t^{\frac{2}{3}}\,\mathrm{m\,s^{-2}}$.

(i) Show that $t^{\frac{5}{3}} = \frac{5}{6}$ when the velocity of P is $3\,\mathrm{m\,s^{-1}}$. [4]

(ii) Find the distance of P from O when the velocity of P is $3\,\mathrm{m\,s^{-1}}$. [3]

4



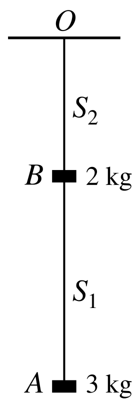
A ring of mass 4 kg is attached to one end of a light string. The ring is threaded on a fixed horizontal rod and the string is pulled at an angle of $25°$ below the horizontal (see diagram). With a tension in the string of T N the ring is in equilibrium.

(i) Find, in terms of T, the horizontal and vertical components of the force exerted on the ring by the rod. [4]

The coefficient of friction between the ring and the rod is 0.4.

(ii) Given that the equilibrium is limiting, find the value of T. [3]

5



A block A of mass 3 kg is attached to one end of a light inextensible string S_1. Another block B of mass 2 kg is attached to the other end of S_1, and is also attached to one end of another light inextensible string S_2. The other end of S_2 is attached to a fixed point O and the blocks hang in equilibrium below O (see diagram).

(i) Find the tension in S_1 and the tension in S_2. [2]

The string S_2 breaks and the particles fall. The air resistance on A is 1.6 N and the air resistance on B is 4 N.

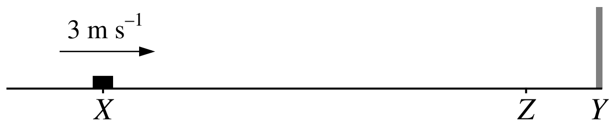
(ii) Find the acceleration of the particles and the tension in S_1. [5]

6 A car of mass 1250 kg travels from the bottom to the top of a straight hill which has length 400 m and is inclined to the horizontal at an angle of α, where $\sin\alpha = 0.125$. The resistance to the car's motion is 800 N. Find the work done by the car's engine in each of the following cases.

(i) The car's speed is constant. [4]

(ii) The car's initial speed is $6\,\mathrm{m\,s^{-1}}$, the car's driving force is 3 times greater at the top of the hill than it is at the bottom, and the car's power output is 5 times greater at the top of the hill than it is at the bottom. [5]

7



The frictional force acting on a small block of mass 0.15 kg, while it is moving on a horizontal surface, has magnitude 0.12 N. The block is set in motion from a point X on the surface, with speed $3\,\mathrm{m\,s^{-1}}$. It hits a vertical wall at a point Y on the surface 2 s later. The block rebounds from the wall and moves directly towards X before coming to rest at the point Z (see diagram). At the instant that the block hits the wall it loses 0.072 J of its kinetic energy. The velocity of the block, in the direction from X to Y, is $v\,\mathrm{m\,s^{-1}}$ at time t s after it leaves X.

(i) Find the values of v when the block arrives at Y and when it leaves Y, and find also the value of t when the block comes to rest at Z. Sketch the velocity-time graph. [9]

(ii) The displacement of the block from X, in the direction from X to Y, is s m at time t s. Sketch the displacement-time graph. Show on your graph the values of s and t when the block is at Y and when it comes to rest at Z. [4]

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

MATHEMATICS **9709/43**

Paper 4 Mechanics 1 **(M1)** **May/June 2012**

1 hour 15 minutes

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

6943954547

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JC12 06_9709_43/RP

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International Examinations

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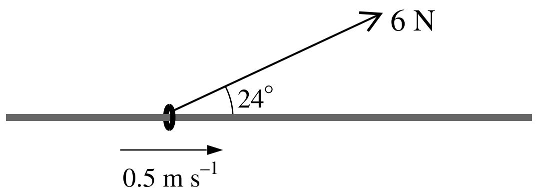
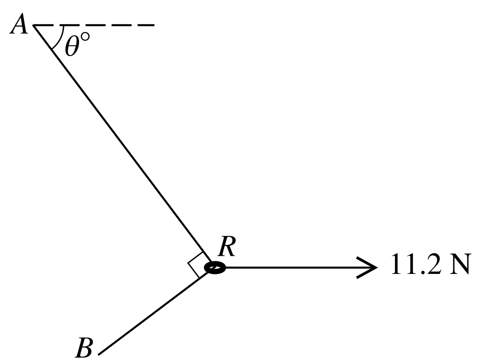
1



A ring is threaded on a fixed horizontal bar. The ring is attached to one end of a light inextensible string which is used to pull the ring along the bar at a constant speed of $0.5\,\mathrm{m\,s^{-1}}$. The string makes a constant angle of 24° with the bar and the tension in the string is 6 N (see diagram). Find the work done by the tension in a period of 8 s. [3]

2



A smooth ring R of mass 0.16 kg is threaded on a light inextensible string. The ends of the string are attached to fixed points A and B. A horizontal force of magnitude 11.2 N acts on R, in the same vertical plane as A and B. The ring is in equilibrium. The string is taut with angle $ARB = 90°$, and the part AR of the string makes an angle of $\theta°$ with the horizontal (see diagram). The tension in the string is T N.

(i) Find two simultaneous equations involving $T \sin\theta$ and $T \cos\theta$. [3]

(ii) Hence find T and θ. [3]

3 A particle P travels from a point O along a straight line and comes to instantaneous rest at a point A. The velocity of P at time t s after leaving O is $v\,\mathrm{m\,s^{-1}}$, where $v = 0.027(10t^2 - t^3)$. Find

(i) the distance OA, [4]

(ii) the maximum velocity of P while moving from O to A. [3]

4 A car of mass 1230 kg increases its speed from $4 \mathrm{~m~s^{-1}}$ to $21 \mathrm{~m~s^{-1}}$ in 24.5 s. The table below shows corresponding values of time t s and speed $v \mathrm{~m~s^{-1}}$.

t	0	0.5	16.3	24.5
v	4	6	19	21

(i) Using the values in the table, find the average acceleration of the car for $0 < t < 0.5$ and for $16.3 < t < 24.5$. [2]

While the car is increasing its speed the power output of its engine is constant and equal to P W, and the resistance to the car's motion is constant and equal to R N.

(ii) Assuming that the values obtained in part **(i)** are approximately equal to the accelerations at $v = 5$ and at $v = 20$, find approximations for P and R. [5]

5 A lorry of mass 16 000 kg moves on a straight hill inclined at angle $\alpha°$ to the horizontal. The length of the hill is 500 m.

(i) While the lorry moves from the bottom to the top of the hill at constant speed, the resisting force acting on the lorry is 800 N and the work done by the driving force is 2800 kJ. Find the value of α. [4]

(ii) On the return journey the speed of the lorry is $20 \mathrm{~m~s^{-1}}$ at the top of the hill. While the lorry travels down the hill, the work done by the driving force is 2400 kJ and the work done against the resistance to motion is 800 kJ. Find the speed of the lorry at the bottom of the hill. [4]

6

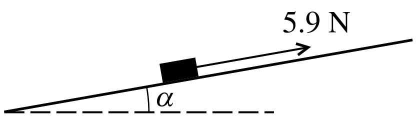


Fig. 1

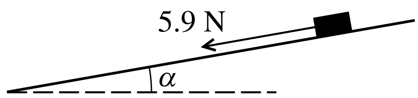


Fig. 2

A block of weight 6.1 N is at rest on a plane inclined at angle α to the horizontal, where $\tan \alpha = \frac{11}{60}$. The coefficient of friction between the block and the plane is μ. A force of magnitude 5.9 N acting parallel to a line of greatest slope is applied to the block.

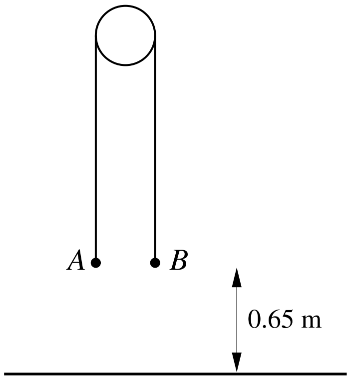
(i) When the force acts up the plane (see Fig. 1) the block remains at rest. Show that $\mu \geqslant \frac{4}{5}$. [5]

(ii) When the force acts down the plane (see Fig. 2) the block slides downwards. Show that $\mu < \frac{7}{6}$. [2]

(iii) Given that the acceleration of the block is $1.7 \mathrm{~m~s^{-2}}$ when the force acts down the plane, find the value of μ. [2]

[Question 7 is printed on the next page.]

7



Two particles A and B have masses 0.12 kg and 0.38 kg respectively. The particles are attached to the ends of a light inextensible string which passes over a fixed smooth pulley. A is held at rest with the string taut and both straight parts of the string vertical. A and B are each at a height of 0.65 m above horizontal ground (see diagram). A is released and B moves downwards. Find

(i) the acceleration of B while it is moving downwards, [2]

(ii) the speed with which B reaches the ground and the time taken for it to reach the ground. [3]

B remains on the ground while A continues to move with the string slack, without reaching the pulley. The string remains slack until A is at a height of 1.3 m above the ground for a second time. At this instant A has been in motion for a total time of T s.

(iii) Find the value of T and sketch the velocity-time graph for A for the first T s of its motion. [3]

(iv) Find the total distance travelled by A in the first T s of its motion. [2]

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

MATHEMATICS **9709/41**

Paper 4 Mechanics 1 **(M1)** **May/June 2013**

1 hour 15 minutes

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

1998330930

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JC13 06_9709_41/FP

UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

1 A block is at rest on a rough horizontal plane. The coefficient of friction between the block and the plane is 1.25.

(i) State, giving a reason for your answer, whether the minimum vertical force required to move the block is greater or less than the minimum horizontal force required to move the block. [2]

A horizontal force of continuously increasing magnitude P N and fixed direction is applied to the block.

(ii) Given that the weight of the block is 60 N, find the value of P when the acceleration of the block is $4\,\mathrm{m\,s^{-2}}$. [2]

2 A car of mass 1250 kg travels from the bottom to the top of a straight hill of length 600 m, which is inclined at an angle of 2.5° to the horizontal. The resistance to motion of the car is constant and equal to 400 N. The work done by the driving force is 450 kJ. The speed of the car at the bottom of the hill is $30\,\mathrm{m\,s^{-1}}$. Find the speed of the car at the top of the hill. [5]

3 The top of a cliff is 40 metres above the level of the sea. A man in a boat, close to the bottom of the cliff, is in difficulty and fires a distress signal vertically upwards from sea level. Find

(i) the speed of projection of the signal given that it reaches a height of 5 m above the top of the cliff, [2]

(ii) the length of time for which the signal is above the level of the top of the cliff. [2]

The man fires another distress signal vertically upwards from sea level. This signal is above the level of the top of the cliff for $\sqrt{(17)}$ s.

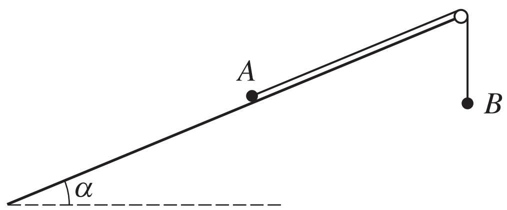
(iii) Find the speed of projection of the second signal. [3]

4 A train of mass 400 000 kg is moving on a straight horizontal track. The power of the engine is constant and equal to 1500 kW and the resistance to the train's motion is 30 000 N. Find

(i) the acceleration of the train when its speed is $37.5\,\mathrm{m\,s^{-1}}$, [4]

(ii) the steady speed at which the train can move. [2]

5



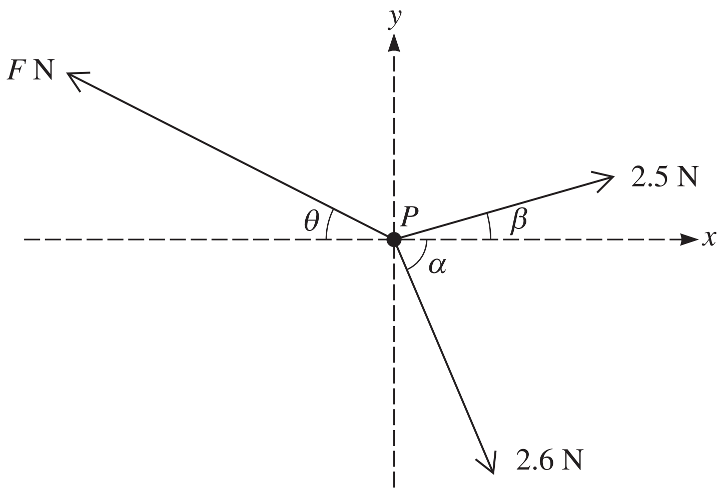
A light inextensible string has a particle A of mass 0.26 kg attached to one end and a particle B of mass 0.54 kg attached to the other end. The particle A is held at rest on a rough plane inclined at angle α to the horizontal, where $\sin\alpha = \frac{5}{13}$. The string is taut and parallel to a line of greatest slope of the plane. The string passes over a small smooth pulley at the top of the plane. Particle B hangs at rest vertically below the pulley (see diagram). The coefficient of friction between A and the plane is 0.2. Particle A is released and the particles start to move.

(i) Find the magnitude of the acceleration of the particles and the tension in the string. [6]

Particle A reaches the pulley 0.4 s after starting to move.

(ii) Find the distance moved by each of the particles. [2]

6



A particle P of mass 0.5 kg lies on a smooth horizontal plane. Horizontal forces of magnitudes F N, 2.5 N and 2.6 N act on P. The directions of the forces are as shown in the diagram, where $\tan\alpha = \frac{12}{5}$ and $\tan\beta = \frac{7}{24}$.

(i) Given that P is in equilibrium, find the values of F and $\tan\theta$. [6]

(ii) The force of magnitude F N is removed. Find the magnitude and direction of the acceleration with which P starts to move. [3]

[Question 7 is printed on the next page.]

7 A car driver makes a journey in a straight line from A to B, starting from rest. The speed of the car increases to a maximum, then decreases until the car is at rest at B. The distance travelled by the car t seconds after leaving A is $0.000\,011\,7(400t^3 - 3t^4)$ metres.

(i) Find the distance AB. [3]

(ii) Find the maximum speed of the car. [4]

(iii) Find the acceleration of the car

(a) as it starts from A,

(b) as it arrives at B.

[2]

(iv) Sketch the velocity-time graph for the journey. [2]

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

MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **May/June 2013**

1 hour 15 minutes

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

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JC13 06_9709_42/2R

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1

(i)

(ii)

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A B θ

A B A B θ θ

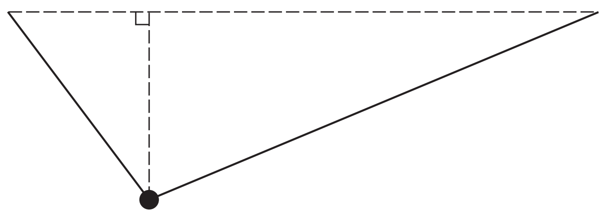
θ

(i)

B A

(ii) A B

3



P θ

A B P

A B PA PB

θ PA

PB

4 P

θ P

P θ

(i) P θ

P

(ii) P θ

5 θ

P

θ

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6 P A

P θ

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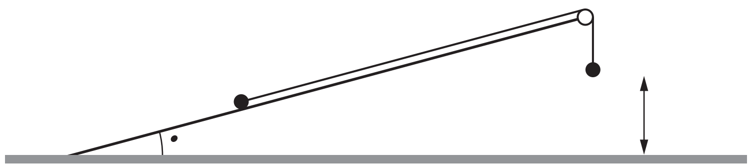
θ

(iii)

θ α

7



A B

P

$\frac{\theta}{}$ — A

P AP

B P A

(i)

(ii) B A P A

AN PA

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General Certificate of Education
Advanced Subsidiary Level and Advanced Level

MATHEMATICS **9709/43**

Paper 4 Mechanics 1 **(M1)** **May/June 2013**

1 hour 15 minutes

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JC13 06_9709_43/RP

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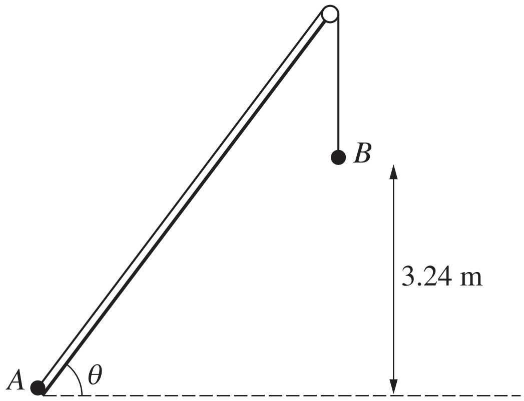
1 A straight ice track of length 50 m is inclined at 14° to the horizontal. A man starts at the top of the track, on a sledge, with speed 8 m s^{-1}. He travels on the sledge to the bottom of the track. The coefficient of friction between the sledge and the track is 0.02. Find the speed of the sledge and the man when they reach the bottom of the track. [4]

2



Particle A of mass 1.6 kg and particle B of mass 2 kg are attached to opposite ends of a light inextensible string. The string passes over a small smooth pulley fixed at the top of a smooth plane, which is inclined at angle θ, where $\sin\theta = 0.8$. Particle A is held at rest at the bottom of the plane and B hangs at a height of 3.24 m above the level of the bottom of the plane (see diagram). A is released from rest and the particles start to move.

(i) Show that the loss of potential energy of the system, when B reaches the level of the bottom of the plane, is 23.328 J. [3]

(ii) Hence find the speed of the particles when B reaches the level of the bottom of the plane. [2]

3 A car has mass 800 kg. The engine of the car generates constant power P kW as the car moves along a straight horizontal road. The resistance to motion is constant and equal to R N. When the car's speed is 14 m s^{-1} its acceleration is 1.4 m s^{-2}, and when the car's speed is 25 m s^{-1} its acceleration is 0.33 m s^{-2}. Find the values of P and R. [6]

4 An aeroplane moves along a straight horizontal runway before taking off. It starts from rest at O and has speed 90 m s^{-1} at the instant it takes off. While the aeroplane is on the runway at time t seconds after leaving O, its acceleration is $(1.5 + 0.012t)$ m s^{-2}. Find

(i) the value of t at the instant the aeroplane takes off, [4]

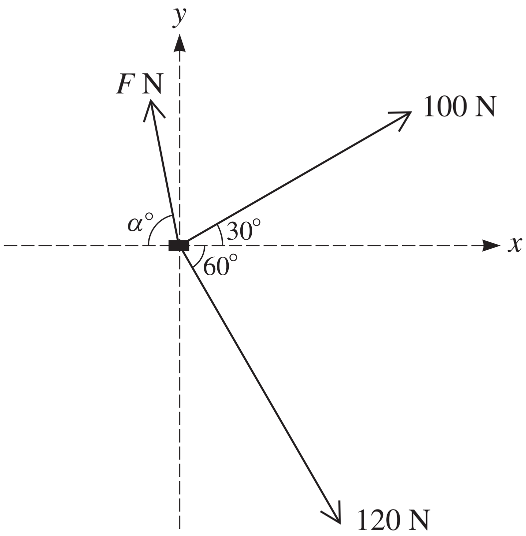
(ii) the distance travelled by the aeroplane on the runway. [3]

5 A particle P is projected vertically upwards from a point on the ground with speed 17 m s^{-1}. Another particle Q is projected vertically upwards from the same point with speed 7 m s^{-1}. Particle Q is projected T seconds later than particle P.

(i) Given that the particles reach the ground at the same instant, find the value of T. [2]

(ii) At a certain instant when both P and Q are in motion, P is 5 m higher than Q. Find the magnitude and direction of the velocity of each of the particles at this instant. [6]

6

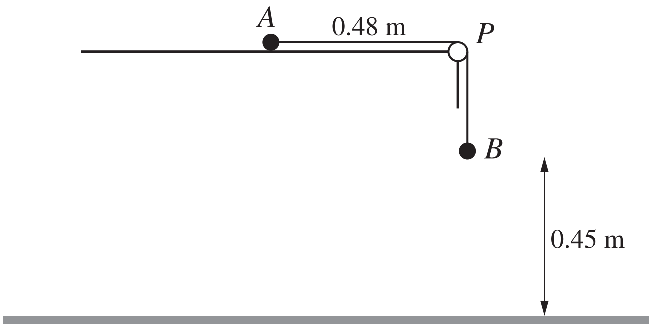


A small box of mass 40 kg is moved along a rough horizontal floor by three men. Two of the men apply horizontal forces of magnitudes 100 N and 120 N, making angles of 30° and 60° respectively with the positive x-direction. The third man applies a horizontal force of magnitude F N making an angle of $\alpha°$ with the negative x-direction (see diagram). The resultant of the three horizontal forces acting on the box is in the positive x-direction and has magnitude 136 N.

(i) Find the values of F and α. [6]

(ii) Given that the box is moving with constant speed, state the magnitude of the frictional force acting on the box and hence find the coefficient of friction between the box and the floor. [3]

7



Particle A of mass 1.26 kg and particle B of mass 0.9 kg are attached to the ends of a light inextensible string. The string passes over a small smooth pulley P which is fixed at the edge of a rough horizontal table. A is held at rest at a point 0.48 m from P, and B hangs vertically below P, at a height of 0.45 m above the floor (see diagram). The coefficient of friction between A and the table is $\frac{2}{7}$. A is released and the particles start to move.

(i) Show that the magnitude of the acceleration of the particles is $2.5\ \mathrm{m\,s^{-2}}$ and find the tension in the string. [5]

(ii) Find the speed with which B reaches the floor. [2]

(iii) Find the speed with which A reaches the pulley. [4]

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Cambridge International AS & A Level

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MATHEMATICS **9709/41**

Paper 4 Mechanics 1 **(M1)** **May/June 2014**

1 hour 15 minutes

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

* 2 5 0 6 4 9 7 6 3 3 *

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JC14 06_9709_41/RP

CAMBRIDGE International Examinations

[Turn over

1 *A ta v at tat* *a a hta taht tak v that th* *th ta k a th tta ta* *t th ta t k th va*

2 *A h a at a a* *t th hta A a* *t a k* *th a Th a* *at at th a* *t ha at*

(i) *th va*

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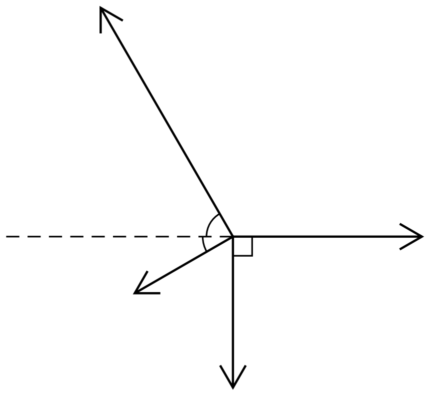

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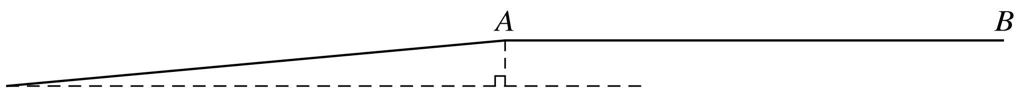

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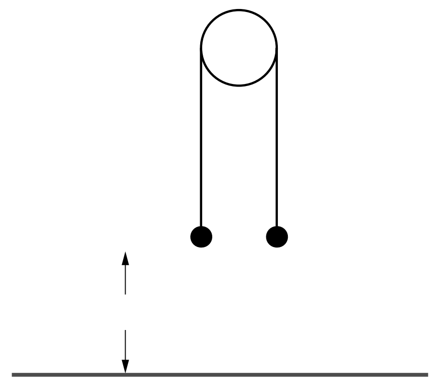

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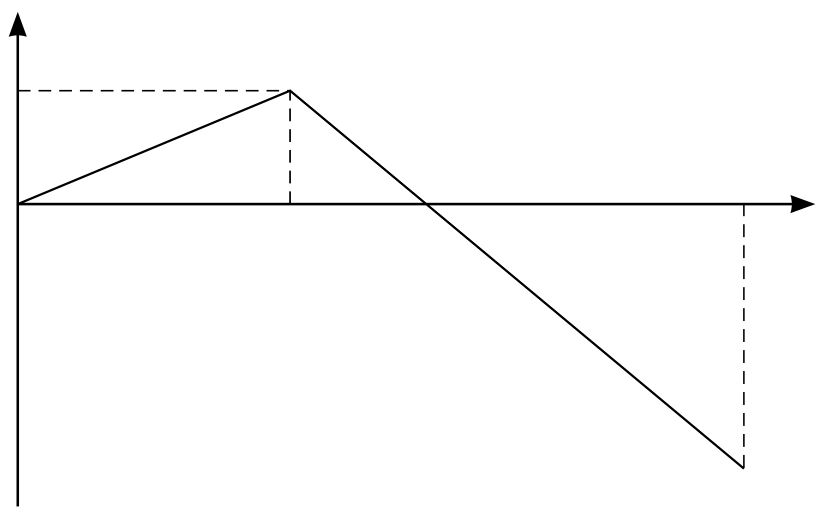

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[uestion 7 is printed on the next page.]

7 *T t a tav a a taht a tat ta at a av ta at Bth t a thh at av Ct tat th a a th th tat aat t h ah*

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MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **May/June 2014**

1 hour 15 minutes

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

0938503275

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This document consists of **4** printed pages.

JC14 06_9709_42/RP

1 *A a a tav a a tat t a a T ta t t a t tat a a t*

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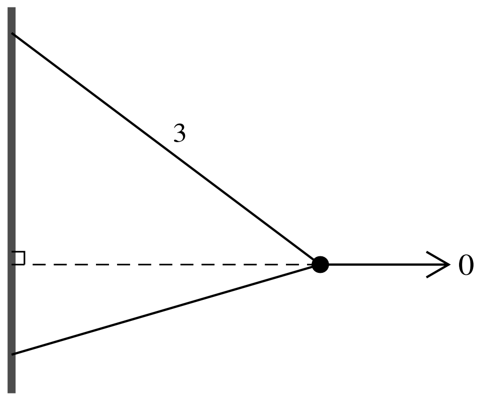

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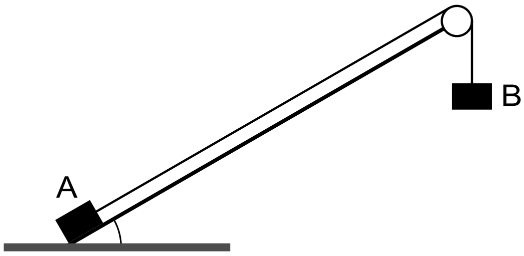

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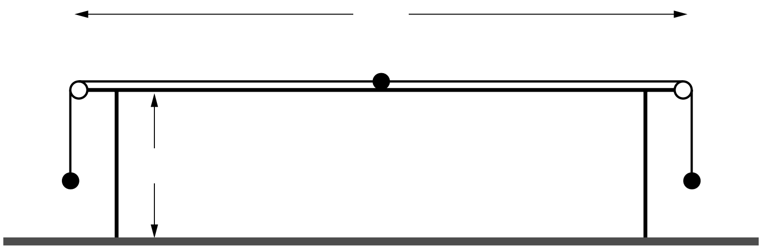
7



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MATHEMATICS **9709/43**

Paper 4 Mechanics 1 **(M1)** **May/June 2014**

1 hour 15 minutes

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

9189996608

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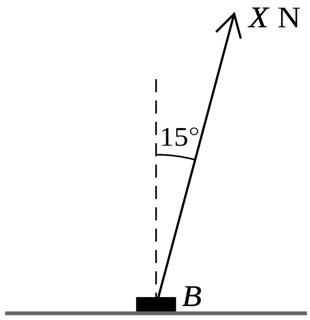
[Turn over

1



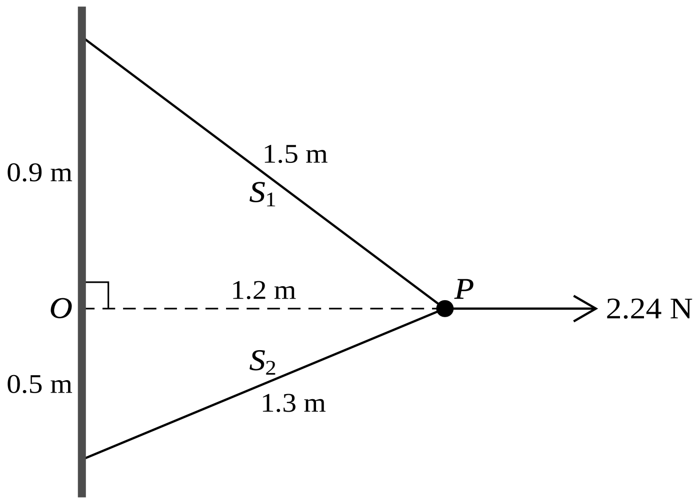
A block B of mass 7 kg is at rest on rough horizontal ground. A force of magnitude X N acts on B at an angle of 15° to the upward vertical (see diagram).

(i) Given that B is in equilibrium find, in terms of X, the normal component of the force exerted on B by the ground. [2]

(ii) The coefficient of friction between B and the ground is 0.4. Find the value of X for which B is in limiting equilibrium. [3]

2 A car of mass 1250 kg travels up a straight hill inclined at an angle α to the horizontal, where $\sin\alpha = 0.02$. The power provided by the car's engine is 23 kW. The resistance to motion is constant and equal to 600 N. Find the speed of the car at an instant when its acceleration is $0.5\ \text{m s}^{-2}$. [5]

3



A particle P of weight 1.4 N is attached to one end of a light inextensible string S_1 of length 1.5 m, and to one end of another light inextensible string S_2 of length 1.3 m. The other end of S_1 is attached to a wall at the point 0.9 m vertically above a point O of the wall. The other end of S_2 is attached to the wall at the point 0.5 m vertically below O. The particle is held in equilibrium, at the same horizontal level as O, by a horizontal force of magnitude 2.24 N acting away from the wall and perpendicular to it (see diagram). Find the tensions in the strings. [6]

4 A small ball of mass 0.4 kg is released from rest at a point 5 m above horizontal ground. At the instant the ball hits the ground it loses 12.8 J of kinetic energy and starts to move upwards.

(i) Show that the greatest height above the ground that the ball reaches after hitting the ground is 1.8 m. [4]

(ii) Find the time taken for the ball's motion from its release until reaching this greatest height. [3]

5 A lorry of mass 16 000 kg travels at constant speed from the bottom, O, to the top, A, of a straight hill. The distance OA is 1200 m and A is 18 m above the level of O. The driving force of the lorry is constant and equal to 4500 N.

(i) Find the work done against the resistance to the motion of the lorry. [3]

On reaching A the lorry continues along a straight horizontal road against a constant resistance of 2000 N. The driving force of the lorry is not now constant, and the speed of the lorry increases from 9 m s^{-1} at A to 21 m s^{-1} at the point B on the road. The distance AB is 2400 m.

(ii) Use an energy method to find F, where F N is the average value of the driving force of the lorry while moving from A to B. [3]

(iii) Given that the driving force at A is 1280 N greater than F N and that the driving force at B is 1280 N less than F N, show that the power developed by the lorry's engine is the same at B as it is at A. [2]

6 A particle starts from rest at a point O and moves in a horizontal straight line. The velocity of the particle is $v\text{ m s}^{-1}$ at time t s after leaving O. For $0 \leqslant t < 60$, the velocity is given by

$$v = 0.05t - 0.0005t^2.$$

The particle hits a wall at the instant when $t = 60$, and reverses the direction of its motion. The particle subsequently comes to rest at the point A when $t = 100$, and for $60 < t \leqslant 100$ the velocity is given by

$$v = 0.025t - 2.5.$$

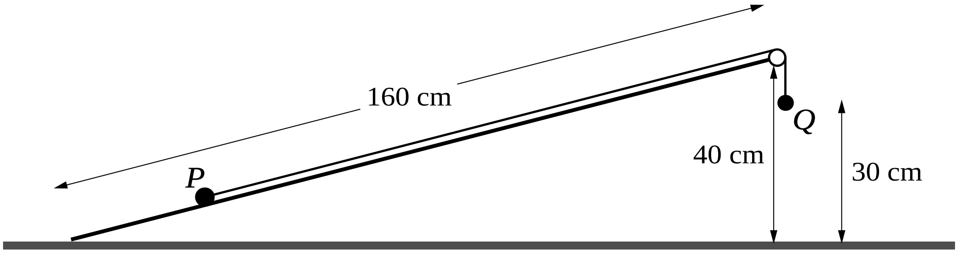
(i) Find the velocity of the particle immediately before it hits the wall, and its velocity immediately after its hits the wall. [2]

(ii) Find the total distance travelled by the particle. [4]

(iii) Find the maximum speed of the particle and sketch the particle's velocity-time graph for $0 \leqslant t \leqslant 100$, showing the value of t for which the speed is greatest. [4]

[Question 7 is printed on the next page.]

7



A smooth inclined plane of length 160 cm is fixed with one end at a height of 40 cm above the other end, which is on horizontal ground. Particles P and Q, of masses 0.76 kg and 0.49 kg respectively, are attached to the ends of a light inextensible string which passes over a small smooth pulley fixed at the top of the plane. Particle P is held at rest on the same line of greatest slope as the pulley and Q hangs vertically below the pulley at a height of 30 cm above the ground (see diagram). P is released from rest. It starts to move up the plane and does not reach the pulley. Find

(i) the acceleration of the particles and the tension in the string before Q reaches the ground, [4]

(ii) the speed with which Q reaches the ground, [2]

(iii) the total distance travelled by P before it comes to instantaneous rest. [3]

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MATHEMATICS **9709/41**

Paper 4 Mechanics 1 **(M1)** **May/June 2015**

1 hour 15 minutes

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

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JC15 06_9709_41/RP

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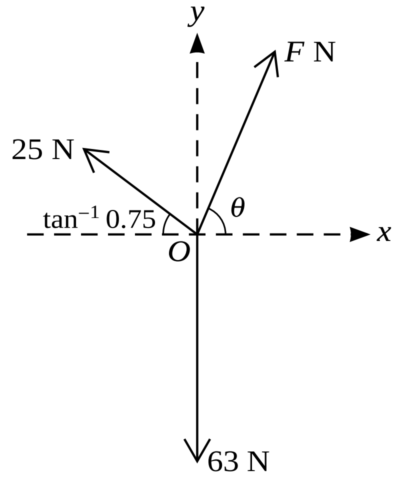
1 A block B of mass 2.7 kg is pulled at constant speed along a straight line on a rough horizontal floor. The pulling force has magnitude 25 N and acts at an angle of θ above the horizontal. The normal component of the contact force acting on B has magnitude 20 N.

(i) Show that $\sin\theta = 0.28$. [2]

(ii) Find the work done by the pulling force in moving the block a distance of 5 m. [2]

2



Three horizontal forces of magnitudes F N, 63 N and 25 N act at O, the origin of the x-axis and y-axis. The forces are in equilibrium. The force of magnitude F N makes an angle θ anticlockwise with the positive x-axis. The force of magnitude 63 N acts along the negative y-axis. The force of magnitude 25 N acts at $\tan^{-1} 0.75$ clockwise from the negative x-axis (see diagram). Find the value of F and the value of $\tan\theta$. [5]

3 A block of weight 6.1 N slides down a slope inclined at $\tan^{-1}\left(\frac{11}{60}\right)$ to the horizontal. The coefficient of friction between the block and the slope is $\frac{1}{4}$. The block passes through a point A with speed $2\,\text{m s}^{-1}$. Find how far the block moves from A before it comes to rest. [5]

4 A lorry of mass 14 000 kg moves along a road starting from rest at a point O. It reaches a point A, and then continues to a point B which it reaches with a speed of $24\,\text{m s}^{-1}$. The part OA of the road is straight and horizontal and has length 400 m. The part AB of the road is straight and is inclined downwards at an angle of $\theta°$ to the horizontal and has length 300 m.

(i) For the motion from O to B, find the gain in kinetic energy of the lorry and express its loss in potential energy in terms of θ. [3]

The resistance to the motion of the lorry is 4800 N and the work done by the driving force of the lorry from O to B is 5000 kJ.

(ii) Find the value of θ. [3]

5 A cyclist and her bicycle have a total mass of 84 kg. She works at a constant rate of P W while moving on a straight road which is inclined to the horizontal at an angle θ, where $\sin\theta = 0.1$. When moving uphill, the cyclist's acceleration is $1.25\,\text{m s}^{-2}$ at an instant when her speed is $3\,\text{m s}^{-1}$. When moving downhill, the cyclist's acceleration is $1.25\,\text{m s}^{-2}$ at an instant when her speed is $10\,\text{m s}^{-1}$. The resistance to the cyclist's motion, whether the cyclist is moving uphill or downhill, is R N. Find the values of P and R. [8]

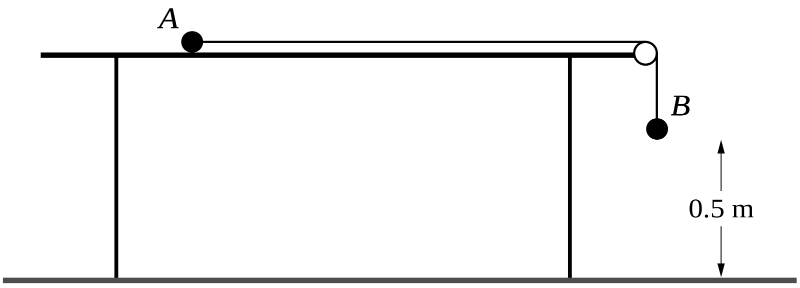
6 Two particles A and B start to move at the same instant from a point O. The particles move in the same direction along the same straight line. The acceleration of A at time t s after starting to move is $a\,\text{m s}^{-2}$, where $a = 0.05 - 0.0002t$.

(i) Find A's velocity when $t = 200$ and when $t = 500$. [4]

B moves with constant acceleration for the first 200 s and has the same velocity as A when $t = 200$. B moves with constant retardation from $t = 200$ to $t = 500$ and has the same velocity as A when $t = 500$.

(ii) Find the distance between A and B when $t = 500$. [6]

7



Particles A and B, of masses 0.3 kg and 0.7 kg respectively, are attached to the ends of a light inextensible string. Particle A is held at rest on a rough horizontal table with the string passing over a smooth pulley fixed at the edge of the table. The coefficient of friction between A and the table is 0.2. Particle B hangs vertically below the pulley at a height of 0.5 m above the floor (see diagram). The system is released from rest and 0.25 s later the string breaks. A does not reach the pulley in the subsequent motion. Find

(i) the speed of B immediately before it hits the floor, [9]

(ii) the total distance travelled by A. [3]

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MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **May/June 2015**

1 hour 15 minutes

* 1 3 4 1 3 5 8 9 4 2 *

Additional Materials: Answer Booklet/Paper
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[Turn over

1 One end of a light inextensible string is attached to a block. The string makes an angle of 60° above the horizontal and is used to pull the block in a straight line on a horizontal floor with acceleration $0.5\,\mathrm{m\,s^{-2}}$. The tension in the string is 8 N. The block starts to move with speed $0.3\,\mathrm{m\,s^{-1}}$. For the first 5 s of the block's motion, find

(i) the distance travelled, [2]

(ii) the work done by the tension in the string. [2]

2 The total mass of a cyclist and his cycle is 80 kg. The resistance to motion is zero.

(i) The cyclist moves along a horizontal straight road working at a constant rate of P W. Find the value of P given that the cyclist's speed is $5\,\mathrm{m\,s^{-1}}$ when his acceleration is $1.2\,\mathrm{m\,s^{-2}}$. [2]

(ii) The cyclist moves up a straight hill inclined at an angle α, where $\sin\alpha = 0.035$. Find the acceleration of the cyclist at an instant when he is working at a rate of 450 W and has speed $3.6\,\mathrm{m\,s^{-1}}$. [3]

3 A plane is inclined at an angle of $\sin^{-1}\left(\frac{1}{8}\right)$ to the horizontal. A and B are two points on the same line of greatest slope with A higher than B. The distance AB is 12 m. A small object P of mass 8 kg is released from rest at A and slides down the plane, passing through B with speed $4.5\,\mathrm{m\,s^{-1}}$. For the motion of P from A to B, find

(i) the increase in kinetic energy of P and the decrease in potential energy of P, [3]

(ii) the magnitude of the constant resisting force that opposes the motion of P. [2]

4 A particle P moves in a straight line. At time t seconds after starting from rest at the point O on the line, the acceleration of P is $a\,\mathrm{m\,s^{-2}}$, where $a = 0.075t^2 - 1.5t + 5$.

(i) Find an expression for the displacement of P from O in terms of t. [4]

(ii) Hence find the time taken for P to return to the point O. [3]

5 A particle P starts from rest at a point O on a horizontal straight line. P moves along the line with constant acceleration and reaches a point A on the line with a speed of $30\,\mathrm{m\,s^{-1}}$. At the instant that P leaves O, a particle Q is projected vertically upwards from the point A with a speed of $20\,\mathrm{m\,s^{-1}}$. Subsequently P and Q collide at A. Find

(i) the acceleration of P, [4]

(ii) the distance OA. [2]

6

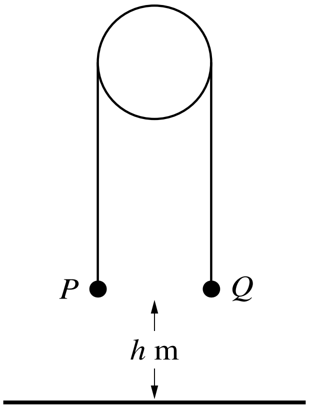


Fig. 1

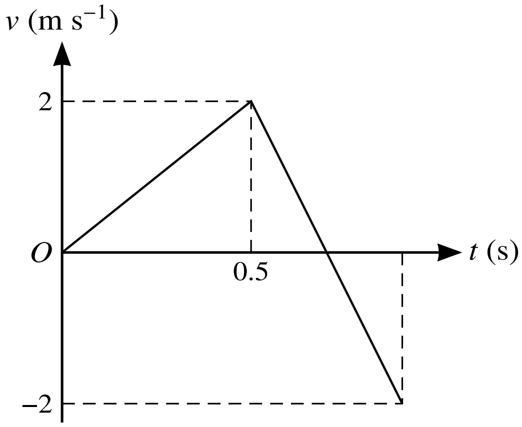


Fig. 2

Two particles P and Q have masses m kg and $(1 - m)$ kg respectively. The particles are attached to the ends of a light inextensible string which passes over a smooth fixed pulley. P is held at rest with the string taut and both straight parts of the string vertical. P and Q are each at a height of h m above horizontal ground (see Fig. 1). P is released and Q moves downwards. Subsequently Q hits the ground and comes to rest. Fig. 2 shows the velocity-time graph for P while Q is moving downwards or is at rest on the ground.

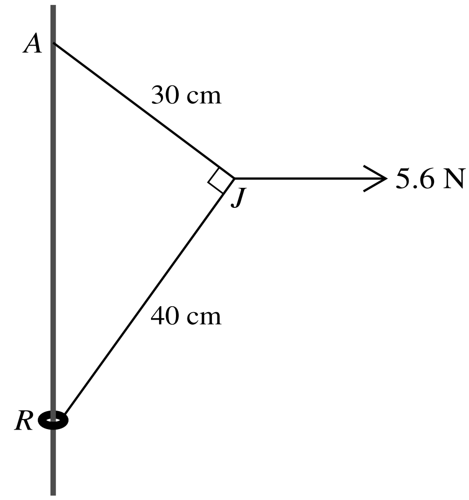
(i) Find the value of h. [2]

(ii) Find the value of m, and find also the tension in the string while Q is moving. [6]

(iii) The string is slack while Q is at rest on the ground. Find the total time from the instant that P is released until the string becomes taut again. [3]

[Question 7 is printed on the next page.]

7



A small ring R is attached to one end of a light inextensible string of length 70 cm. A fixed rough vertical wire passes through the ring. The other end of the string is attached to a point A on the wire, vertically above R. A horizontal force of magnitude 5.6 N is applied to the point J of the string 30 cm from A and 40 cm from R. The system is in equilibrium with each of the parts AJ and JR of the string taut and angle AJR equal to 90° (see diagram).

(i) Find the tension in the part AJ of the string, and find the tension in the part JR of the string. [5]

The ring R has mass 0.2 kg and is in limiting equilibrium, on the point of moving up the wire.

(ii) Show that the coefficient of friction between R and the wire is 0.341, correct to 3 significant figures. [4]

A particle of mass m kg is attached to R and R is now in limiting equilibrium, on the point of moving down the wire.

(iii) Given that the coefficient of friction is unchanged, find the value of m. [3]

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MATHEMATICS **9709/43**

Paper 4 Mechanics 1 **(M1)** **May/June 2015**

1 hour 15 minutes

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List of Formulae (MF9)

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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.

This document consists of **4** printed pages.

1 A block is pulled along a horizontal floor by a horizontal rope. The tension in the rope is 500 N and the block moves at a constant speed of $2.75\,\mathrm{m\,s^{-1}}$. Find the work done by the tension in 40 s and find the power applied by the tension. [4]

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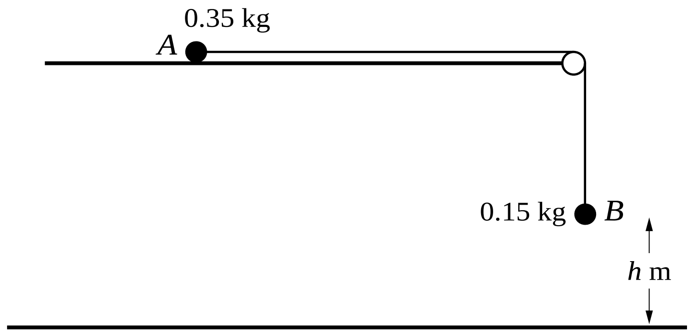

Particles A and B, of masses 0.35 kg and 0.15 kg respectively, are attached to the ends of a light inextensible string. A is held at rest on a smooth horizontal surface with the string passing over a small smooth pulley fixed at the edge of the surface. B hangs vertically below the pulley at a distance h m above the floor (see diagram). A is released and the particles move. B reaches the floor and A subsequently reaches the pulley with a speed of $3\,\mathrm{m\,s^{-1}}$.

(i) Explain briefly why the speed with which B reaches the floor is $3\,\mathrm{m\,s^{-1}}$. [1]

(ii) Find the value of h. [4]

3 A car of mass 860 kg travels along a straight horizontal road. The power provided by the car's engine is P W and the resistance to the car's motion is R N. The car passes through one point with speed $4.5\,\mathrm{m\,s^{-1}}$ and acceleration $4\,\mathrm{m\,s^{-2}}$. The car passes through another point with speed $22.5\,\mathrm{m\,s^{-1}}$ and acceleration $0.3\,\mathrm{m\,s^{-2}}$. Find the values of P and R. [6]

4 A lorry of mass 12 000 kg moves up a straight hill of length 500 m, starting at the bottom with a speed of $24\,\mathrm{m\,s^{-1}}$ and reaching the top with a speed of $16\,\mathrm{m\,s^{-1}}$. The top of the hill is 25 m above the level of the bottom of the hill. The resistance to motion of the lorry is 7500 N. Find the driving force of the lorry. [6]

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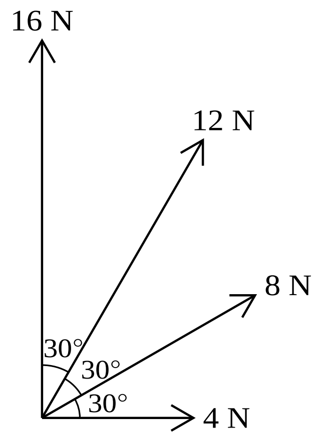

Fig. 1

Four coplanar forces of magnitudes 4 N, 8 N, 12 N and 16 N act at a point. The directions in which the forces act are shown in Fig. 1.

(i) Find the magnitude and direction of the resultant of the four forces. [5]

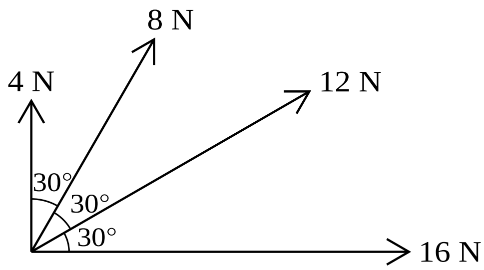

Fig. 2

The forces of magnitudes 4 N and 16 N exchange their directions and the forces of magnitudes 8 N and 12 N also exchange their directions (see Fig. 2).

(ii) State the magnitude and direction of the resultant of the four forces in Fig. 2. [2]

6 A small box of mass 5 kg is pulled at a constant speed of 2.5 m s^{-1} down a line of greatest slope of a rough plane inclined at 10° to the horizontal. The pulling force has magnitude 20 N and acts downwards parallel to a line of greatest slope of the plane.

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

The pulling force is removed while the box is moving at 2.5 m s^{-1}.

(ii) Find the distance moved by the box after the instant at which the pulling force is removed. [4]

[Question 7 is printed on the next page.]

7 A particle P moves on a straight line. It starts at a point O on the line and returns to O 100 s later. The velocity of P is $v\,\mathrm{m\,s^{-1}}$ at time t s after leaving O, where

$$v = 0.0001t^3 - 0.015t^2 + 0.5t.$$

(i) Show that P is instantaneously at rest when $t = 0$, $t = 50$ and $t = 100$. [2]

(ii) Find the values of v at the times for which the acceleration of P is zero, and sketch the velocity-time graph for P's motion for $0 \leqslant t \leqslant 100$. [7]

(iii) Find the greatest distance of P from O for $0 \leqslant t \leqslant 100$. [4]

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MATHEMATICS **9709/41**

Paper 4 Mechanics 1 **(M1)** **May/June 2016**

1 hour 15 minutes

Additional Materials: List of Formulae (MF9)

1753145841

READ THESE INSTRUCTIONS FIRST

An answer booklet is provided inside this question paper. You should follow the instructions on the front cover of the answer booklet. If you need additional answer paper ask the invigilator for a continuation booklet.

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[Turn over

1 A lift moves upwards from rest and accelerates at $0.9\,\mathrm{m\,s^{-2}}$ for 3 s. The lift then travels for 6 s at constant speed and finally slows down, with a constant deceleration, stopping in a further 4 s.

(i) Sketch a velocity-time graph for the motion. [3]

(ii) Find the total distance travelled by the lift. [2]

2 A box of mass 25 kg is pulled, at a constant speed, a distance of 36 m up a rough plane inclined at an angle of 20° to the horizontal. The box moves up a line of greatest slope against a constant frictional force of 40 N. The force pulling the box is parallel to the line of greatest slope. Find

(i) the work done against friction, [1]

(ii) the change in gravitational potential energy of the box, [2]

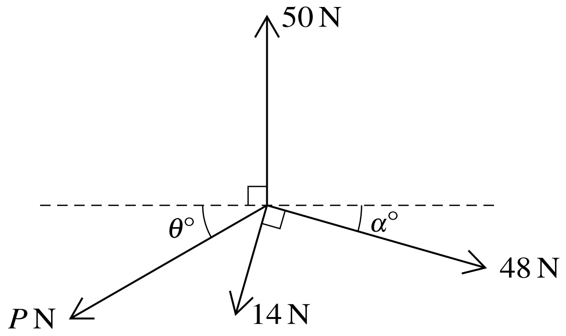
(iii) the work done by the pulling force. [2]

3 A car of mass 1000 kg is moving along a straight horizontal road against resistances of total magnitude 300 N.

(i) Find, in kW, the rate at which the engine of the car is working when the car has a constant speed of $40\,\mathrm{m\,s^{-1}}$. [3]

(ii) Find the acceleration of the car when its speed is $25\,\mathrm{m\,s^{-1}}$ and the engine is working at 90% of the power found in part **(i)**. [3]

4



Coplanar forces of magnitudes 50 N, 48 N, 14 N and P N act at a point in the directions shown in the diagram. The system is in equilibrium. Given that $\tan\alpha = \frac{7}{24}$, find the values of P and θ. [6]

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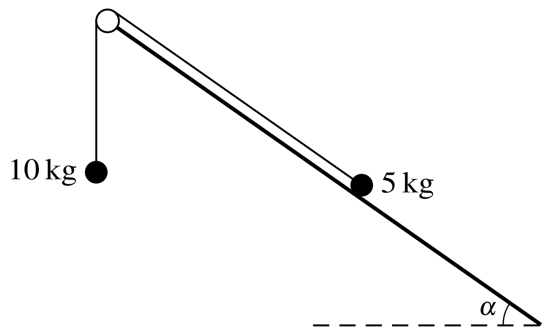

Two particles of masses 5 kg and 10 kg are connected by a light inextensible string that passes over a fixed smooth pulley. The 5 kg particle is on a rough fixed slope which is at an angle of α to the horizontal, where $\tan\alpha = \frac{3}{4}$. The 10 kg particle hangs below the pulley (see diagram). The coefficient of friction between the slope and the 5 kg particle is $\frac{1}{2}$. The particles are released from rest. Find the acceleration of the particles and the tension in the string. [7]

6 A particle P moves in a straight line. It starts at a point O on the line and at time t s after leaving O it has a velocity $v\,\mathrm{m\,s^{-1}}$, where $v = 6t^2 - 30t + 24$.

(i) Find the set of values of t for which the acceleration of the particle is negative. [2]

(ii) Find the distance between the two positions at which P is at instantaneous rest. [4]

(iii) Find the two positive values of t at which P passes through O. [3]

7 A particle of mass 30 kg is on a plane inclined at an angle of 20° to the horizontal. Starting from rest, the particle is pulled up the plane by a force of magnitude 200 N acting parallel to a line of greatest slope.

(i) Given that the plane is smooth, find

(a) the acceleration of the particle, [2]

(b) the change in kinetic energy after the particle has moved 12 m up the plane. [2]

(ii) It is given instead that the plane is rough and the coefficient of friction between the particle and the plane is 0.12.

(a) Find the acceleration of the particle. [4]

(b) The direction of the force of magnitude 200 N is changed, and the force now acts at an angle of 10° above the line of greatest slope. Find the acceleration of the particle. [4]

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MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **May/June 2016**

1 hour 15 minutes

Additional Materials: List of Formulae (MF9)

8269105851

READ THESE INSTRUCTIONS FIRST

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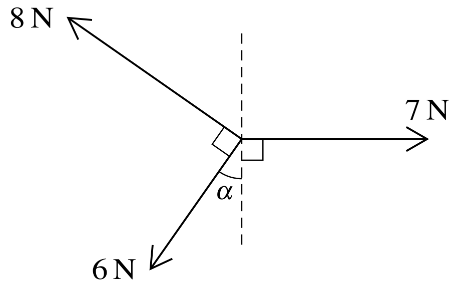

Coplanar forces of magnitudes 7 N, 6 N and 8 N act at a point in the directions shown in the diagram. Given that $\sin\alpha = \frac{3}{5}$, find the magnitude and direction of the resultant of the three forces. [5]

2 A particle P moves in a straight line, starting from a point O. At time t s after leaving O, the velocity of P, v m s^{-1}, is given by $v = 4t^2 - 8t + 3$.

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

(ii) Find the distance travelled by P between these two times. [3]

3 A particle of mass 8 kg is projected with a speed of 5 m s^{-1} up a line of greatest slope of a rough plane inclined at an angle α to the horizontal, where $\sin\alpha = \frac{5}{13}$. The motion of the particle is resisted by a constant frictional force of magnitude 15 N. The particle comes to instantaneous rest after travelling a distance x m up the plane.

(i) Express the change in gravitational potential energy of the particle in terms of x. [2]

(ii) Use an energy method to find x. [4]

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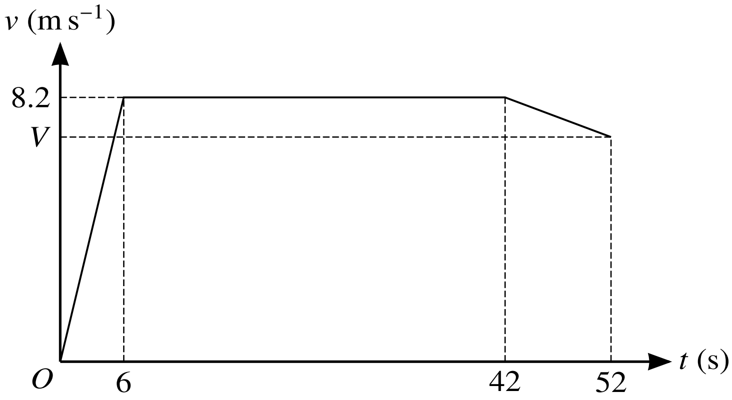

A sprinter runs a race of 400 m. His total time for running the race is 52 s. The diagram shows the velocity-time graph for the motion of the sprinter. He starts from rest and accelerates uniformly to a speed of 8.2 m s^{-1} in 6 s. The sprinter maintains a speed of 8.2 m s^{-1} for 36 s, and he then decelerates uniformly to a speed of V m s^{-1} at the end of the race.

(i) Calculate the distance covered by the sprinter in the first 42 s of the race. [2]

(ii) Show that $V = 7.84$. [3]

(iii) Calculate the deceleration of the sprinter in the last 10 s of the race. [2]

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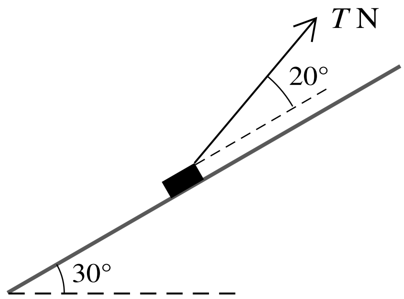

A block of mass 2.5 kg is placed on a plane which is inclined at an angle of 30° to the horizontal. The block is kept in equilibrium by a light string making an angle of 20° above a line of greatest slope. The tension in the string is T N, as shown in the diagram. The coefficient of friction between the block and plane is $\frac{1}{4}$. The block is in limiting equilibrium and is about to move up the plane. Find the value of T. [7]

6 A car of mass 1100 kg is moving on a road against a constant force of 1550 N resisting the motion.

(i) The car moves along a straight horizontal road at a constant speed of $40\,\mathrm{m\,s^{-1}}$.

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

(b) Given that this power is suddenly decreased by 22 kW, find the instantaneous deceleration of the car. [3]

(ii) The car now travels at constant speed up a straight road inclined at 8° to the horizontal, with the engine working at 80 kW. Assuming the resistance force remains the same, find this constant speed. [3]

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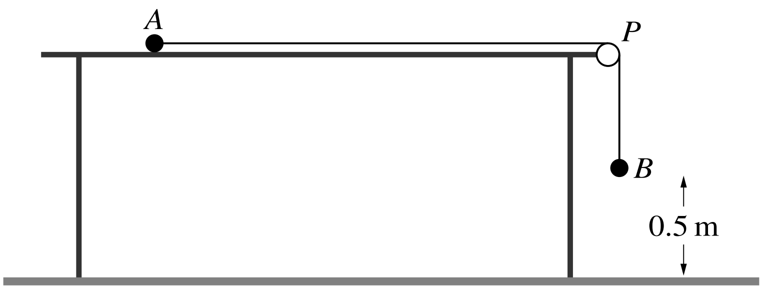

A particle A of mass 1.6 kg rests on a horizontal table and is attached to one end of a light inextensible string. The string passes over a small smooth pulley P fixed at the edge of the table. The other end of the string is attached to a particle B of mass 2.4 kg which hangs freely below the pulley. The system is released from rest with the string taut and with B at a height of 0.5 m above the ground, as shown in the diagram. In the subsequent motion A does not reach P before B reaches the ground.

(i) Given that the table is smooth, find the time taken by B to reach the ground. [5]

(ii) Given instead that the table is rough and that the coefficient of friction between A and the table is $\frac{3}{8}$, find the total distance travelled by A. You may assume that A does not reach the pulley. [7]

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MATHEMATICS **9709/43**

Paper 4 Mechanics 1 **(M1)** **May/June 2016**

1 hour 15 minutes

Additional Materials: List of Formulae (MF9)

2884178850

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This document consists of **3** printed pages, **1** blank page and **1** insert.

JC16 06_9709_43/2R

1 A particle of mass 8 kg is pulled at a constant speed a distance of 20 m up a rough plane inclined at an angle of 30° to the horizontal by a force acting along a line of greatest slope.

(i) Find the change in gravitational potential energy of the particle. [2]

(ii) The total work done against gravity and friction is 1146 J. Find the frictional force acting on the particle. [2]

2 Alan starts walking from a point O, at a constant speed of $4\,\mathrm{m\,s^{-1}}$, along a horizontal path. Ben walks along the same path, also starting from O. Ben starts from rest 5 s after Alan and accelerates at $1.2\,\mathrm{m\,s^{-2}}$ for 5 s. Ben then continues to walk at a constant speed until he is at the same point, P, as Alan.

(i) Find how far Ben has travelled when he has been walking for 5 s and find his speed at this instant. [2]

(ii) Find the distance OP. [3]

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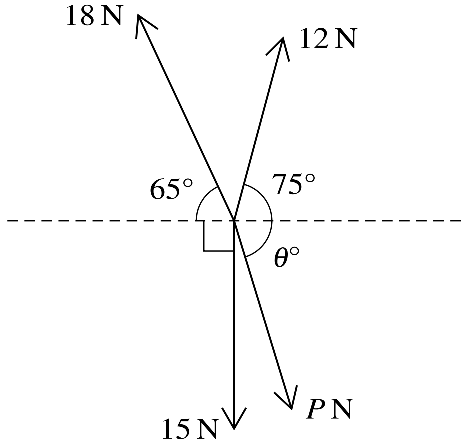

The coplanar forces shown in the diagram are in equilibrium. Find the values of P and θ. [6]

4 A particle of mass 15 kg is stationary on a rough plane inclined at an angle of 20° to the horizontal. The coefficient of friction between the particle and the plane is 0.2. A force of magnitude X N acting parallel to a line of greatest slope of the plane is used to keep the particle in equilibrium. Show that the least possible value of X is 23.1, correct to 3 significant figures, and find the greatest possible value of X. [7]

5 The motion of a car of mass 1400 kg is resisted by a constant force of magnitude 650 N.

(i) Find the constant speed of the car on a horizontal road, assuming that the engine works at a rate of 20 kW. [2]

(ii) The car is travelling at a constant speed of $10\,\mathrm{m\,s^{-1}}$ up a hill inclined at an angle of θ to the horizontal, where $\sin\theta = \frac{1}{7}$. Find the power of the car's engine. [3]

(iii) The car descends the same hill with the engine working at 80% of the power found in part **(ii)**. Find the acceleration of the car at an instant when the speed is $20\,\mathrm{m\,s^{-1}}$. [3]

6 Two particles of masses 1.3 kg and 0.7 kg are connected by a light inextensible string that passes over a fixed smooth pulley. The particles are held at the same vertical height with the string taut. The distance of each particle above a horizontal plane is 2 m, and the distance of each particle below the pulley is 4 m. The particles are released from rest.

(i) Find

(a) the tension in the string before the particle of mass 1.3 kg reaches the plane,

(b) the time taken for the particle of mass 1.3 kg to reach the plane.

[6]

(ii) Find the greatest height of the particle of mass 0.7 kg above the plane. [4]

7 A particle P moves in a straight line. At time t s, the displacement of P from O is s m and the acceleration of P is $a\,\mathrm{m\,s^{-2}}$, where $a = 6t - 2$. When $t = 1$, $s = 7$ and when $t = 3$, $s = 29$.

(i) Find the set of values of t for which the particle is decelerating. [2]

(ii) Find s in terms of t. [5]

(iii) Find the time when the velocity of the particle is $10\,\mathrm{m\,s^{-1}}$. [3]

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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

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

2 A particle of mass 0.8 kg is projected with a speed of $12\,\mathrm{m\,s^{-1}}$ up a line of greatest slope of a rough plane inclined at an angle of $10°$ 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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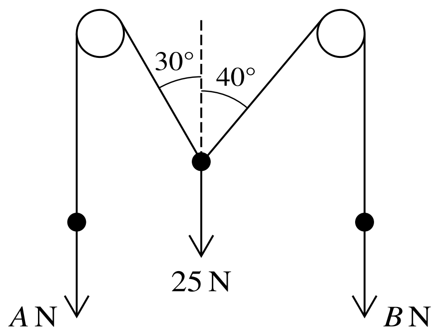

Two light inextensible strings are attached to a particle of weight 25 N. The strings pass over two smooth fixed pulleys and have particles of weights A N and B N hanging vertically at their ends. The sloping parts of the strings make angles of 30° and 40° respectively with the vertical (see diagram). The system is in equilibrium. Find the values of A and B. [6]

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

(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 $20\,\mathrm{m\,s^{-1}}$, $12\,\mathrm{m\,s^{-1}}$ and $6\,\mathrm{m\,s^{-1}}$ respectively.

(i) Find the ratio of distances $AB : BC$. [4]

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

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

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

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

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(iii) The particle is at O when $t = 3$. Find the distance of P from O when $t = 0$. [4]

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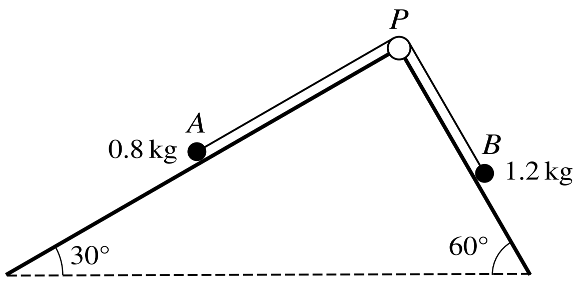

As shown in the diagram, a particle A of mass 0.8 kg lies on a plane inclined at an angle of 30° to the horizontal and a particle B of mass 1.2 kg lies on a plane inclined at an angle of 60° to the horizontal. The particles are connected by a light inextensible string which passes over a small smooth pulley P fixed at the top of the planes. The parts AP and BP of the string are parallel to lines of greatest slope of the respective planes. The particles are released from rest with both parts of the string taut.

(i) Given that both planes are smooth, find the acceleration of A and the tension in the string. [6]

(ii) It is given instead that both planes are rough, with the same coefficient of friction, μ, for both particles. Find the value of μ for which the system is in limiting equilibrium. [6]

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CANDIDATE NAME

CENTRE NUMBER

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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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JC17 06_9709_42/4R

1 One end of a light inextensible string is attached to a block. The string makes an angle of $\theta°$ 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 $1.5\,\mathrm{m\,s^{-1}}$ for 12 s. The work done by the tension in the string is 50 J. Find θ. [3]

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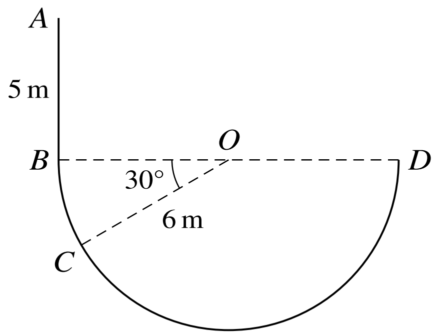

The diagram shows a wire $ABCD$ consisting of a straight part AB of length 5 m and a part BCD in the shape of a semicircle of radius 6 m and centre O. The diameter BD of the semicircle is horizontal and AB is vertical. A small ring is threaded onto the wire and slides along the wire. The ring starts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

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

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The part BCD of the wire is smooth. The mass of the ring is 0.2 kg.

(ii) (a) Find the speed of the ring at C, where angle $BOC = 30°$. [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 $10\,\mathrm{m\,s^{-1}}$. 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 $16\,\mathrm{m\,s^{-1}}$ at O and has a constant deceleration of $2\,\mathrm{m\,s^{-2}}$.

(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]

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 $42\,\mathrm{m\,s^{-1}}$.

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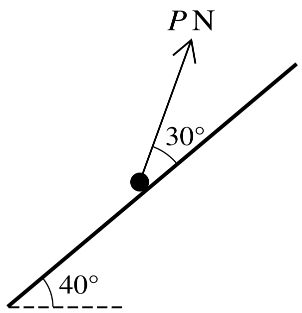
(ii) On a part of the road that is inclined at $\theta°$ to the horizontal, the car moves up the hill at a constant speed of $24\,\mathrm{m\,s^{-1}}$, with the engine working at $80\,\mathrm{kW}$. Find θ. [4]

5



A particle of mass 0.12 kg is placed on a plane which is inclined at an angle of 40° to the horizontal. The particle is kept in equilibrium by a force of magnitude P N acting up the plane at an angle of 30° above a line of greatest slope, as shown in the diagram. The coefficient of friction between the particle and the plane is 0.32. Find the set of possible values of P. [8]

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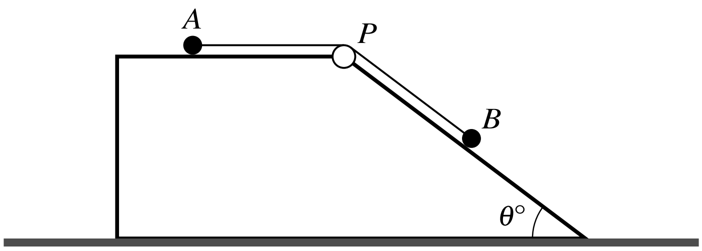

The diagram shows a fixed block with a horizontal top surface and a surface which is inclined at an angle of $\theta°$ to the horizontal, where $\sin\theta = \frac{3}{5}$. A particle A of mass 0.3 kg rests on the horizontal surface and is attached to one end of a light inextensible string. The string passes over a small smooth pulley P fixed at the edge of the block. The other end of the string is attached to a particle B of mass 1.5 kg which rests on the sloping surface of the block. The system is released from rest with the string taut.

(i) Given that the block is smooth, find the acceleration of particle A and the tension in the string. [5]

(ii) It is given instead that the block is rough. The coefficient of friction between A and the block is μ and the coefficient of friction between B and the block is also μ. 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 $5\,\mathrm{m\,s^{-1}}$. Find the acceleration of particle A and the value of μ. [9]

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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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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.

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 **12** printed pages.

JC17 06_9709_43/2R

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[Turn over

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° 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]

(ii) Find the speed attained by the wheelbarrow after 12 m. [3]

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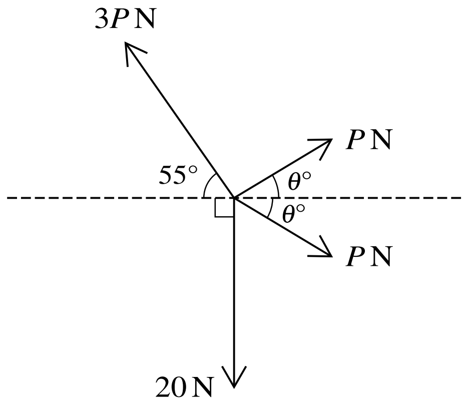

The four coplanar forces shown in the diagram are in equilibrium. Find the values of P and θ. [5]

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 $25\,\mathrm{m\,s^{-1}}$. 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]

(iii) The distance from A to B is 3300 m. Find how far the train travels while it is decelerating. [3]

4 A particle P moves in a straight line starting from a point O. At time t s after leaving O, the velocity, $v\,\mathrm{m\,s^{-1}}$, of P is given by $v = (2t - 5)^3$.

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

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

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

(i) Find t. [5]

(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 $40\,\mathrm{m\,s^{-1}}$. Find the resistance to motion. [2]

(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 $45\,\mathrm{m\,s^{-1}}$. [3]

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

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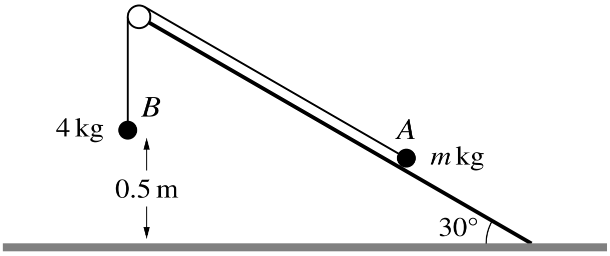

Two particles A and B of masses m kg and 4 kg respectively are connected by a light inextensible string that passes over a fixed smooth pulley. Particle A is on a rough fixed slope which is at an angle of 30° to the horizontal ground. Particle B hangs vertically below the pulley and is 0.5 m above the ground (see diagram). The coefficient of friction between the slope and particle A is 0.2.

(i) In the case where the system is in equilibrium with particle A on the point of moving directly up the slope, show that $m = 5.94$, correct to 3 significant figures. [6]

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(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]

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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)

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

JC18 06_9709_41/3R

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

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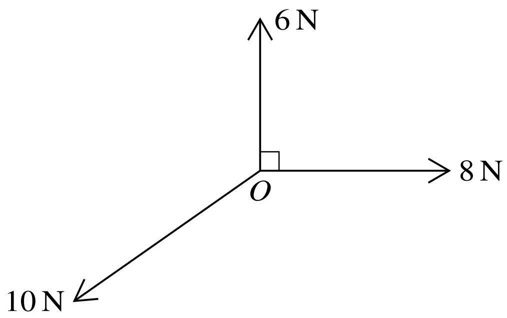
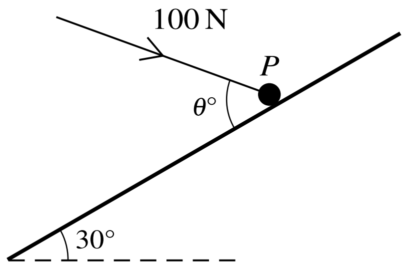


The diagram shows three coplanar forces acting at the point O. The magnitudes of the forces are 6 N, 8 N and 10 N. The angle between the 6 N force and the 8 N force is 90°. The forces are in equilibrium. Find the other angles between the forces. [4]

3



A particle P of mass 8 kg is on a smooth plane inclined at an angle of 30° to the horizontal. A force of magnitude 100 N, making an angle of $\theta°$ with a line of greatest slope and lying in the vertical plane containing the line of greatest slope, acts on P (see diagram).

(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]

(ii) Given instead that $\theta = 30$, find the acceleration of P. [2]

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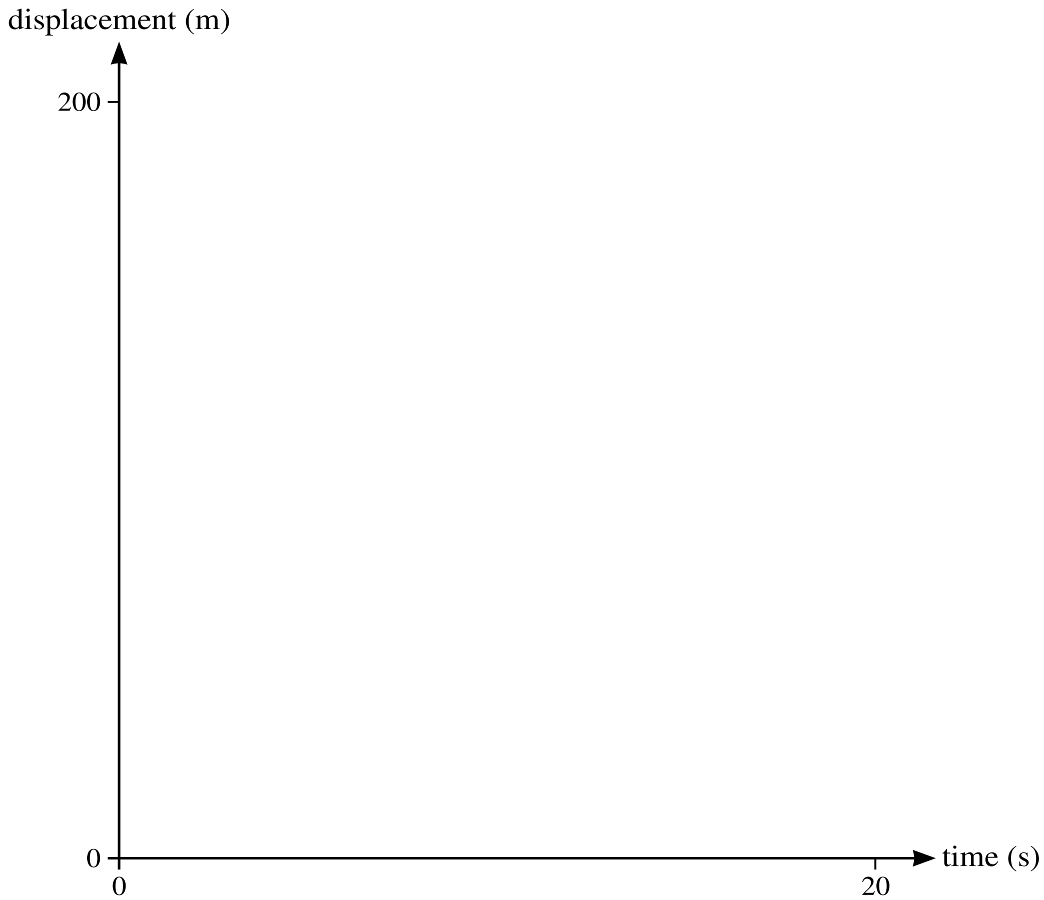
(iii) Find the minimum velocity of P. [3]

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 $12\,\mathrm{m\,s^{-1}}$. He maintains this speed for the next 10 s, before decelerating uniformly to cross the finishing line with speed $V\,\mathrm{m\,s^{-1}}$.

(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]



(ii) Find the value of V. [2]

6 A car has mass 1250 kg.

(i) The car is moving along a straight level road at a constant speed of $36\,\mathrm{m\,s^{-1}}$ 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]

(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 $\theta°$ to the horizontal, where $\sin\theta° = 0.1$, and the engine is working at 63 kW. Find the speed of the car. [3]

(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 $20\,\mathrm{m\,s^{-1}}$. Eight seconds later the car has speed $24\,\mathrm{m\,s^{-1}}$ 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]

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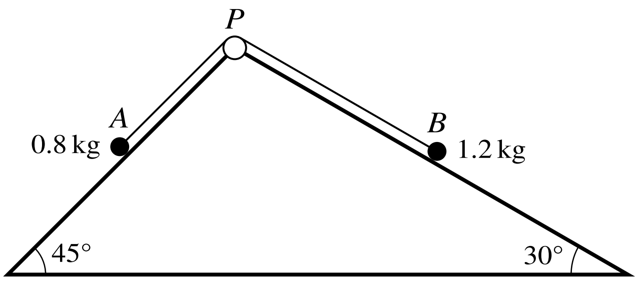

The diagram shows a triangular block with sloping faces inclined to the horizontal at 45° and 30°. Particle A of mass 0.8 kg lies on the face inclined at 45° and particle B of mass 1.2 kg lies on the face inclined at 30°. The particles are connected by a light inextensible string which passes over a 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]

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(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]

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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.

Additional Materials: List of Formulae (MF9)

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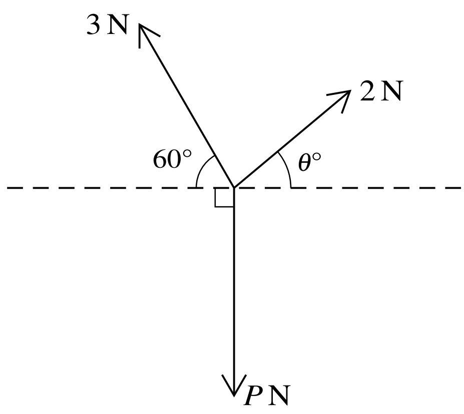
1 A man has mass 80 kg. He runs along a horizontal road against a constant resistance force of magnitude P N. The total work done by the man in increasing his speed from $4\,\mathrm{m\,s^{-1}}$ to $5.5\,\mathrm{m\,s^{-1}}$ while running a distance of 60 metres is 1200 J. Find the value of P. [4]

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 $15\,\mathrm{m\,s^{-1}}$ its deceleration is $0.2\,\mathrm{m\,s^{-2}}$. Find the power of the engine of the train. [4]

3



The three coplanar forces shown in the diagram have magnitudes 3 N, 2 N and P N. Given that the three forces are in equilibrium, find the values of θ and P. [4]

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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 $3\,\mathrm{m\,s^{-2}}$ and find the speed of P at A. [6]

(ii) P reaches D with a speed of $61\,\mathrm{m\,s^{-1}}$. 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]

6 A particle P moves in a straight line passing through a point O. At time t s, the acceleration, $a \text{ m s}^{-2}$, 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]

(ii) Find the distance the particle travels between the times of instantaneous rest. [3]

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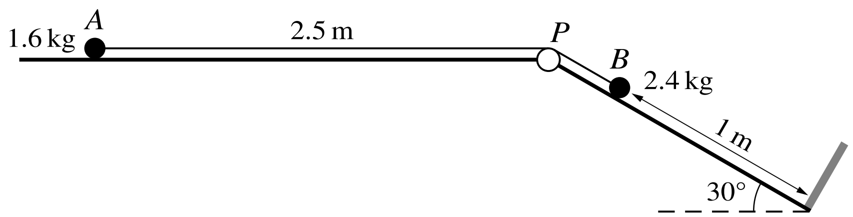

As shown in the diagram, a particle A of mass 1.6 kg lies on a horizontal plane and a particle B of mass 2.4 kg lies on a plane inclined at an angle of 30° to the horizontal. The particles are connected by a light inextensible string which passes over a small smooth pulley P fixed at the top of the inclined plane. The distance AP is 2.5 m and the distance of B from the bottom of the inclined plane is 1 m. There is a barrier at the bottom of the inclined plane preventing any further motion of B. The part BP of the string is parallel to a line of greatest slope of the inclined plane. The particles are released from rest with both parts of the string taut.

(i) Given that both planes are smooth, find the acceleration of A and the tension in the string. [5]

(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]

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MATHEMATICS **9709/43**

Paper 4 Mechanics 1 **(M1)** **May/June 2018**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

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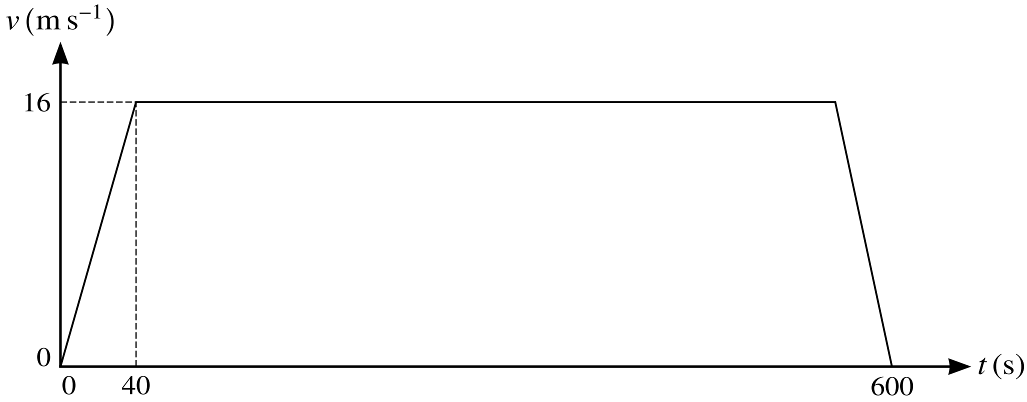

The diagram shows the velocity-time graph for a train which travels from rest at one station to rest at the next station. The graph consists of three straight line segments. The distance between the two stations is 9040 m.

(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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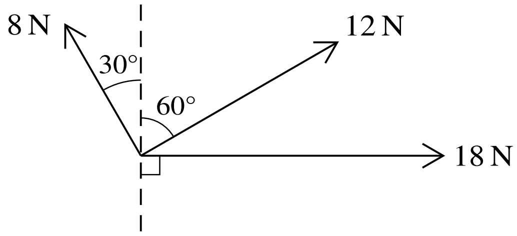
2 A small ball is projected vertically downwards with speed $5\,\mathrm{m\,s^{-1}}$ from a point A at a height of $7.2\,\mathrm{m}$ above horizontal ground. The ball hits the ground with speed $V\,\mathrm{m\,s^{-1}}$ and rebounds vertically upwards with speed $\frac{1}{2}V\,\mathrm{m\,s^{-1}}$. The highest 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]

3



Coplanar forces of magnitudes 8 N, 12 N and 18 N act at a point in the directions shown in the diagram. Find the magnitude and direction of the single additional force acting at the same point which will produce equilibrium. [6]

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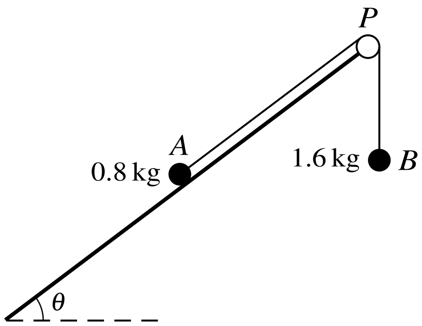

Two particles A and B, of masses 0.8 kg and 1.6 kg respectively, are connected by a light inextensible string. Particle A is placed on a smooth plane inclined at an angle θ to the horizontal, where $\sin\theta = \frac{3}{5}$. The string passes over a small smooth pulley P fixed at the top of the plane, and B hangs freely (see diagram). The section AP of the string is parallel to a line of greatest slope of the plane. The particles are released from rest with both sections of the string taut. Use an energy method to find the speed of the particles after each particle has moved a distance of 0.5 m, assuming that A has not yet reached the pulley. [6]

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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]

6 A car of mass 1400 kg travelling at a speed of $v \text{ m s}^{-1}$ experiences a resistive force of magnitude $40v$ 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]

(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]

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

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

$$v = 12t - 4t^2 \quad \text{for } 0 \leqslant t \leqslant 2,$$
$$v = 16 - 4t \quad \text{for } 2 \leqslant t \leqslant 4.$$

(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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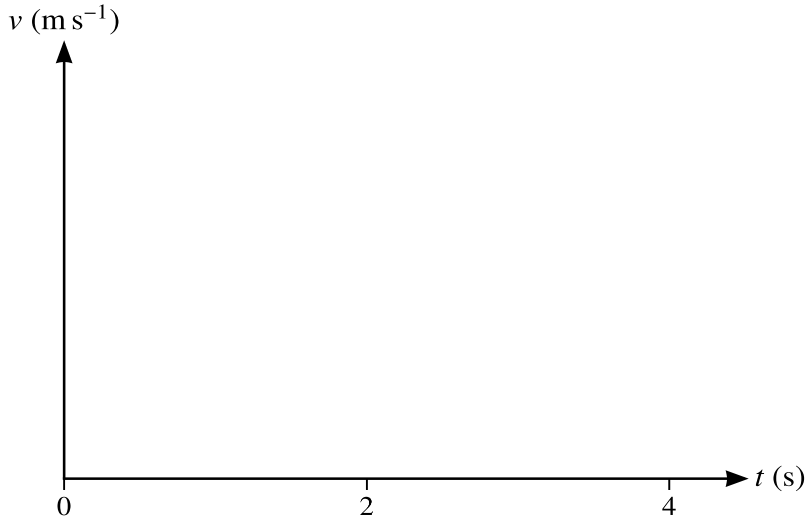
(iii) Sketch the velocity-time graph for $0 \leqslant t \leqslant 4$. [3]



(iv) Find the distance travelled by P in the interval $0 \leqslant t \leqslant 4$. [5]

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Additional Page

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Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME							
CENTRE NUMBER						CANDIDATE NUMBER	

3115764768

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)

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.
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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.
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.

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Cambridge Assessment International Education

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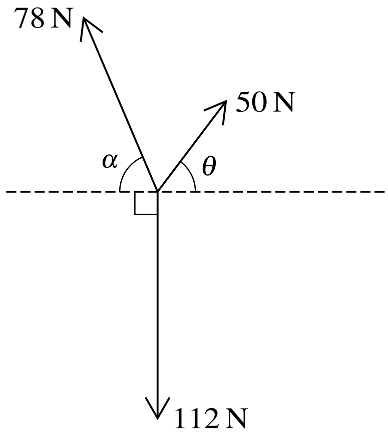

Given that $\tan\alpha = \frac{12}{5}$ and $\tan\theta = \frac{4}{3}$, show that the coplanar forces shown in the diagram are in equilibrium. [3]

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

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

(ii) Find the length of time for which P is higher than $23\,\mathrm{m}$ above the ground. [3]

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

3 A lorry has mass 12 000 kg.

(i) The lorry moves at a constant speed of $5\,\mathrm{m\,s^{-1}}$ 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]

When the speed of the lorry is $v \text{ m s}^{-1}$ the magnitude of the resistance to motion is kv^2 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]

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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]

The force of magnitude 20 N is now removed.

(ii) Find the acceleration of the particle. [2]

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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 $v\,\mathrm{m\,s^{-1}}$ of P at time t s is given by

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

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

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

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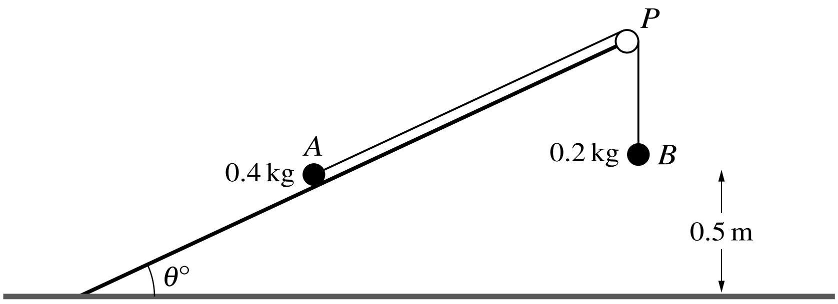

Two particles A and B, of masses 0.4 kg and 0.2 kg respectively, are connected by a light inextensible string. Particle A is held on a smooth plane inclined at an angle of $\theta°$ to the horizontal. The string passes over a small smooth pulley P fixed at the top of the plane, and B hangs freely 0.5 m above horizontal ground (see diagram). The particles are released from rest with both sections of the string taut.

(i) Given that the system is in equilibrium, find θ. [3]

(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]

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

[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]

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CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

1330165820

MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **May/June 2019**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

READ THESE INSTRUCTIONS FIRST

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Where a numerical value for the acceleration due to gravity is needed, use $10\,\mathrm{m\,s^{-2}}$.
The use of an electronic calculator is expected, where appropriate.
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The total number of marks for this paper is 50.

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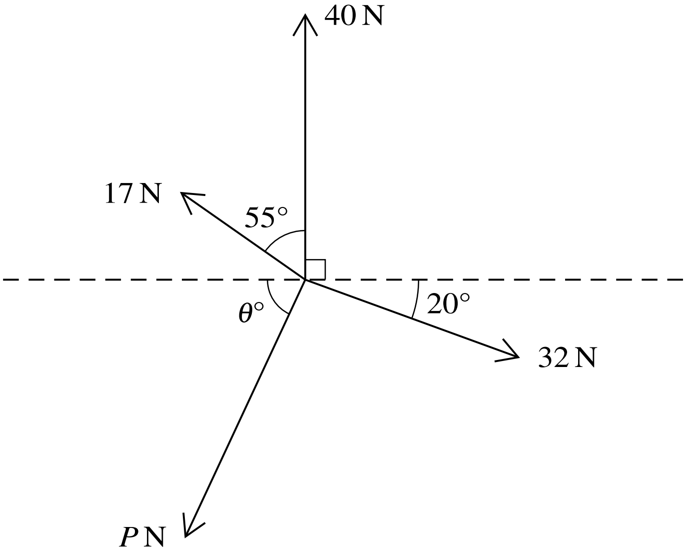

Coplanar forces of magnitudes 40 N, 32 N, P N and 17 N act at a point in the directions shown in the diagram. The system is in equilibrium. Find the values of P and θ. [6]

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]

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]

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]

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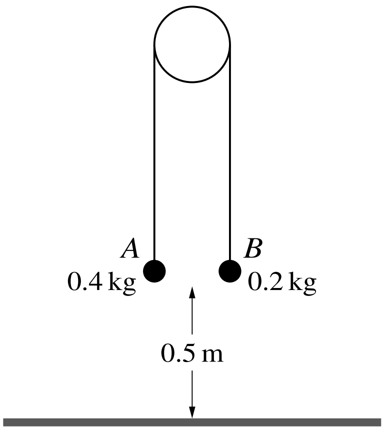

Two particles A and B, of masses 0.4 kg and 0.2 kg respectively, are connected by a light inextensible string which passes over a fixed smooth pulley. Both A and B are 0.5 m above the ground. The particles hang vertically (see diagram). The particles are released from rest. In the subsequent motion B 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 $\frac{10}{3}$ m s^{-2} and find the tension in the string. [4]

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(ii) Find the maximum height of B above the ground. [4]

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 $(Av + B)$ 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]

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 $6t(t-3)\,\mathrm{m\,s^{-1}}$ and the velocity of Q after t seconds is $(10-2t)\,\mathrm{m\,s^{-1}}$.

(i) Sketch, on the same axes, velocity-time graphs for P and Q for $0 \leqslant t \leqslant 5$. [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 $0 \leqslant t \leqslant 5$. [4]

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CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

8409955746

MATHEMATICS **9709/43**

Paper 4 Mechanics 1 **(M1)** **May/June 2019**

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.
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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.

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

Cambridge Assessment International Education

[Turn over

1 A bus moves in a straight line between two bus stops. The bus starts from rest and accelerates at $2.1\,\text{m}\,\text{s}^{-2}$ 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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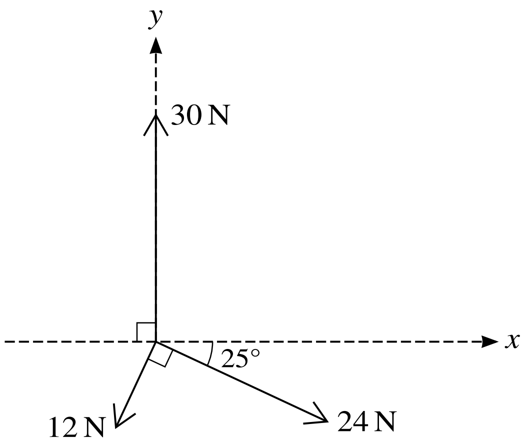

Coplanar forces of magnitudes 12 N, 24 N and 30 N act at a point in the directions shown in the diagram.

(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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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 $0.4\,\mathrm{m\,s^{-2}}$. [4]

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

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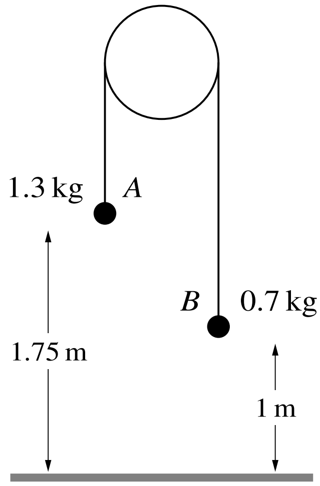

Two particles A and B, of masses 1.3 kg and 0.7 kg respectively, are connected by a light inextensible string which passes over a smooth fixed pulley. Particle A is 1.75 m above the floor and particle B is 1 m above the floor (see diagram). The system is released from rest with the string taut, and the 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 $3\,\mathrm{m\,s^{-2}}$ and find the tension in the string. [4]

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(ii) Find the difference in the times that it takes the particles to hit the ground. [6]

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 $a\,\mathrm{m\,s^{-2}}$ of P at time t s is given by $a = 6t - 12$. The displacement of P from a fixed point O on the line is s 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]

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

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

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MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **February/March 2016**

1 hour 15 minutes

* 2 4 1 7 4 1 4 7 2 7 *

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

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.
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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.

This document consists of **3** printed pages and **1** blank page.

1 A cyclist has mass 85 kg and rides a bicycle of mass 20 kg. The cyclist rides along a horizontal road against a total resistance force of 40 N. Find the total work done by the cyclist in increasing his speed from $5\,\mathrm{m\,s^{-1}}$ to $10\,\mathrm{m\,s^{-1}}$ while travelling a distance of 50 m. [3]

2 A constant resistance of magnitude 1350 N acts on a car of mass 1200 kg.

(i) The car is moving along a straight level road at a constant speed of $32\,\mathrm{m\,s^{-1}}$. Find, in kW, the rate at which the engine of the car is working. [2]

(ii) The car travels at a constant speed up a hill inclined at an angle of θ to the horizontal, where $\sin\theta = 0.1$, with the engine working at 76.5 kW. Find this speed. [3]

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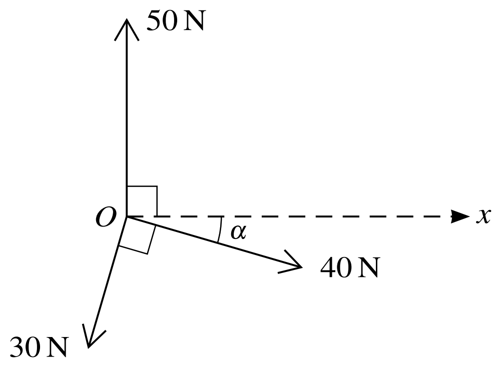

Coplanar forces of magnitudes 50 N, 40 N and 30 N act at a point O in the directions shown in the diagram, where $\tan\alpha = \frac{7}{24}$.

(i) Find the magnitude and direction of the resultant of the three forces. [6]

(ii) The force of magnitude 50 N is replaced by a force of magnitude P N acting in the same direction. The resultant of the three forces now acts in the positive x-direction. Find the value of P. [1]

4 A particle P of mass 0.8 kg is placed on a rough horizontal table. The coefficient of friction between P and the table is μ. A force of magnitude 5 N, acting upwards at an angle α above the horizontal, where $\tan\alpha = \frac{3}{4}$, is applied to P. The particle is on the point of sliding on the table.

(i) Find the value of μ. [4]

(ii) The magnitude of the force acting on P is increased to 10 N, with the direction of the force remaining the same. Find the acceleration of P. [3]

5 A car of mass 1200 kg is pulling a trailer of mass 800 kg up a hill inclined at an angle α to the horizontal, where $\sin\alpha = 0.1$. The system of the car and the trailer is modelled as two particles connected by a light inextensible cable. The driving force of the car's engine is 2500 N and the resistances to the car and trailer are 100 N and 150 N respectively.

(i) Find the acceleration of the system and the tension in the cable. [4]

(ii) When the car and trailer are travelling at a speed of $30\,\mathrm{m\,s^{-1}}$, the driving force becomes zero. The cable remains taut. Find the time, in seconds, before the system comes to rest. [3]

6 Two particles A and B, of masses 0.8 kg and 0.2 kg respectively, are connected by a light inextensible string. Particle A is placed on a horizontal surface. The string passes over a small smooth pulley P fixed at the edge of the surface, and B hangs freely. The horizontal section of the string, AP, is of length 2.5 m. The particles are released from rest with both sections of the string taut.

(i) Given that the surface is smooth, find the time taken for A to reach the pulley. [5]

(ii) Given instead that the surface is rough and the coefficient of friction between A and the surface is 0.1, find the speed of A immediately before it reaches the pulley. [5]

7 A particle P moves in a straight line. The velocity $v\,\mathrm{m\,s^{-1}}$ at time t s is given by

$$\begin{aligned} v &= 5t(t-2) && \text{for } 0 \leqslant t \leqslant 4, \\ v &= k && \text{for } 4 \leqslant t \leqslant 14, \\ v &= 68 - 2t && \text{for } 14 \leqslant t \leqslant 20, \end{aligned}$$

where k is a constant.

(i) Find k. [1]

(ii) Sketch the velocity-time graph for $0 \leqslant t \leqslant 20$. [3]

(iii) Find the set of values of t for which the acceleration of P is positive. [2]

(iv) Find the total distance travelled by P in the interval $0 \leqslant t \leqslant 20$. [5]

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4508415906

MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **February/March 2017**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

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CAMBRIDGE International Examinations

[Turn over

1 A particle of mass 0.4 kg is projected with a speed of $12\,\mathrm{m\,s^{-1}}$ up a line of greatest slope of a smooth plane inclined at 30° to the horizontal.

(i) Find the initial kinetic energy of the particle. [1]

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(ii) Use an energy method to find the distance the particle moves up the plane before coming to instantaneous rest. [3]

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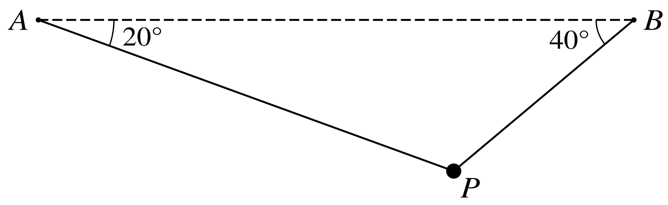

A particle P of mass 1.6 kg is suspended in equilibrium by two light inextensible strings attached to points A and B. The strings make angles of 20° and 40° respectively with the horizontal (see diagram). Find the tensions in the two strings. [6]

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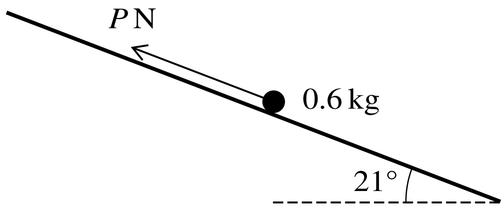

A particle of mass 0.6 kg is placed on a rough plane which is inclined at an angle of 21° to the horizontal. The particle is kept in equilibrium by a force of magnitude P N acting parallel to a line of greatest slope of the plane, as shown in the diagram. The coefficient of friction between the particle and the plane is 0.3. Show that the least possible value of P is 0.470, correct to 3 significant figures, and find the greatest possible value of P. [6]

4 A car of mass 900 kg is moving on a straight horizontal road $ABCD$. There is a constant resistance of magnitude 800 N in the sections AB and BC, and a constant resistance of magnitude R N in the section CD. The power of the car's engine is a constant 36 kW.

(i) The car moves from A to B at a constant speed in 120 s. Find the speed of the car and the distance AB. [3]

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The car's engine is switched off at B.

(ii) The distance BC is 450 m. Find the speed of the car at C. [3]

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(iii) The car comes to rest at D. The distance AD is 6637.5 m. Find the deceleration of the car and the value of R. [4]

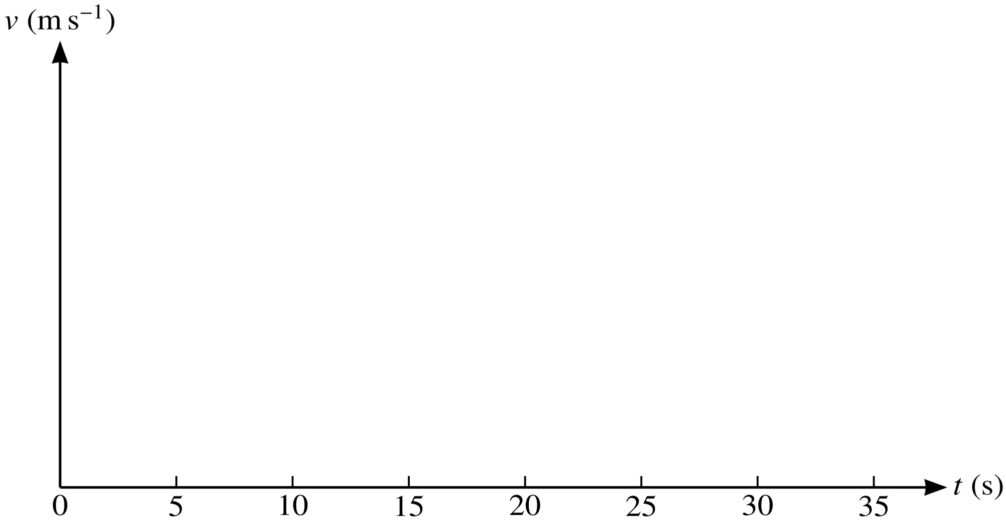
5 A particle P moves in a straight line starting from a point O and comes to rest 35 s later. At time t s after leaving O, the velocity $v\,\mathrm{m\,s^{-1}}$ of P is given by

$$\begin{aligned} v &= \tfrac{4}{5}t^2 && 0 \leqslant t \leqslant 5,\\ v &= 2t + 10 && 5 \leqslant t \leqslant 15,\\ v &= a + bt^2 && 15 \leqslant t \leqslant 35, \end{aligned}$$

where a and b are constants such that $a > 0$ and $b < 0$.

(i) Show that the values of a and b are 49 and -0.04 respectively. [3]

(ii) Sketch the velocity-time graph. [4]



(iii) Find the total distance travelled by P during the 35 s. [5]

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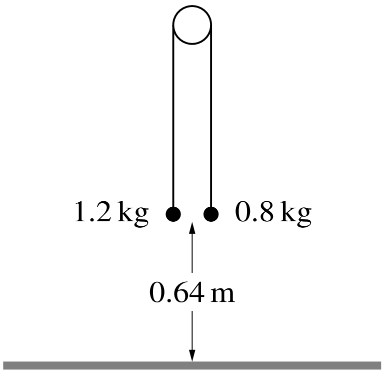

Two particles of masses 1.2 kg and 0.8 kg are connected by a light inextensible string that passes over a fixed smooth pulley. The particles hang vertically. The system is released from rest with both particles 0.64 m above the floor (see diagram). In the subsequent motion the 0.8 kg particle does not reach the pulley.

(i) Show that the acceleration of the particles is $2\,\mathrm{m\,s^{-2}}$ and find the tension in the string. [4]

(ii) Find the total distance travelled by the 0.8 kg particle during the first second after the particles are released. [8]

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Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

* 3 7 7 1 0 3 5 4 1 8 *

MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **February/March 2019**

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 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.

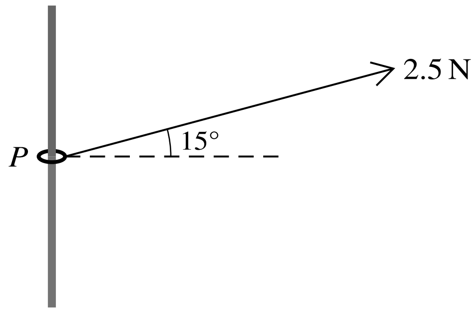
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper is 50.

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

JC19 03_9709_42/2R

Cambridge Assessment International Education

1



A small ring P of mass 0.03 kg is threaded on a rough vertical rod. A light inextensible string is attached to the ring and is pulled upwards at an angle of 15° to the horizontal. The tension in the string is 2.5 N (see diagram). The ring is in limiting equilibrium and on the point of sliding up the rod. Find the coefficient of friction between the ring and the rod. [4]

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2 A particle is projected vertically upwards with speed $30\,\mathrm{m\,s^{-1}}$ from a point on horizontal ground.

(i) Show that the maximum height above the ground reached by the particle is 45 m. [2]

(ii) Find the time that it takes for the particle to reach a height of 33.75 m above the ground for the first time. Find also the speed of the particle at this time. [4]

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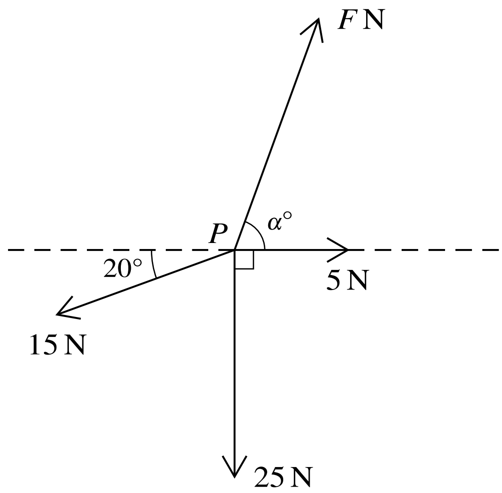

Four coplanar forces of magnitudes F N, 5 N, 25 N and 15 N are acting at a point P in the directions shown in the diagram. Given that the forces are in equilibrium, find the values of F and α. [6]

  [Turn over

4 A car of mass 1500 kg is pulling a trailer of mass 300 kg along a straight horizontal road at a constant speed of $20\,\mathrm{m\,s^{-1}}$. The system of the car and trailer is modelled as two particles, connected by a light rigid horizontal rod. The power of the car's engine is 6000 W. There are constant resistances to motion of R N on the car and 80 N on the trailer.

(i) Find the value of R. [2]

The power of the car's engine is increased to 12 500 W. The resistance forces do not change.

(ii) Find the acceleration of the car and trailer and the tension in the rod at an instant when the speed of the car is $25\,\mathrm{m\,s^{-1}}$. [5]

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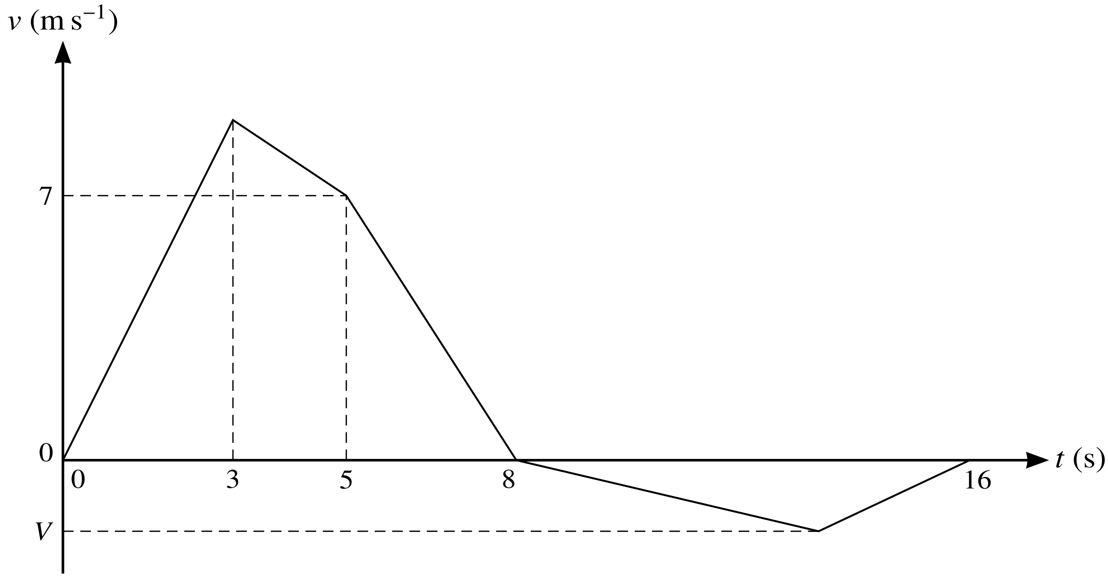

The velocity of a particle moving in a straight line is $v\,\mathrm{m\,s^{-1}}$ at time t seconds after leaving a fixed point O. The diagram shows a velocity-time graph which models the motion of the particle from $t = 0$ to $t = 16$. The graph consists of five straight line segments. The acceleration of the particle from $t = 0$ to $t = 3$ is $3\,\mathrm{m\,s^{-2}}$. The velocity of the particle at $t = 5$ is $7\,\mathrm{m\,s^{-1}}$ and it comes to instantaneous rest at $t = 8$. The particle then comes to rest again at $t = 16$. The minimum velocity of the particle is $V\,\mathrm{m\,s^{-1}}$.

(i) Find the distance travelled by the particle in the first 8 s of its motion. [3]

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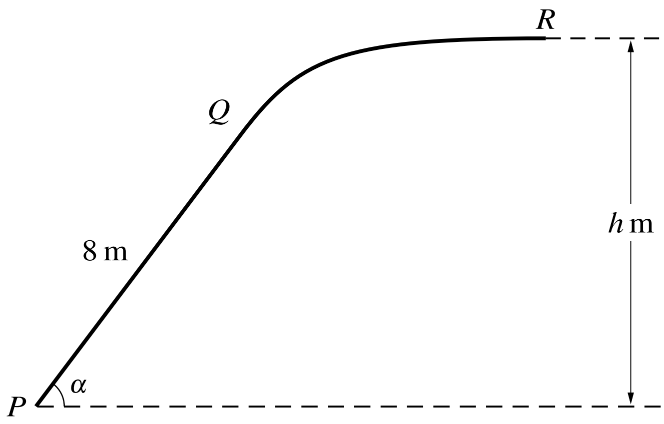
(ii) Given that when the particle comes to rest at $t = 16$ its displacement from O is $32\,\mathrm{m}$, find the value of V. [4]

6 A particle moves in a straight line. It starts from rest at a fixed point O on the line. Its acceleration at time t s after leaving O is $a\,\mathrm{m\,s^{-2}}$, where $a = 0.4t^3 - 4.8t^{\frac{1}{2}}$.

(i) Show that, in the subsequent motion, the acceleration of the particle when it comes to instantaneous rest is $16\,\mathrm{m\,s^{-2}}$. [6]

(ii) Find the displacement of the particle from O at $t = 5$. [3]

7



The diagram shows the vertical cross-section PQR of a slide. The part PQ is a straight line of length 8 m inclined at angle α to the horizontal, where $\sin\alpha = 0.8$. The straight part PQ is tangential to the curved part QR, and R is h m above the level of P. The straight part PQ of the slide is rough and the curved part QR is smooth. A particle of mass 0.25 kg is projected with speed $15\,\text{m s}^{-1}$ from P towards Q and comes to rest at R. The coefficient of friction between the particle and PQ is 0.5.

(i) Find the work done by the friction force during the motion of the particle from P to Q. [4]

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(ii) Hence find the speed of the particle at Q. [4]

(iii) Find the value of h. [3]

Additional Page

If you use the following lined page to complete the answer(s) to any question(s), the question number(s) must be clearly shown.

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CAMBRIDGE INTERNATIONAL EXAMINATIONS

General Certificate of Education Advanced Subsidiary Level
General Certificate of Education Advanced Level

MATHEMATICS 9709/4

PAPER 4 Mechanics 1 **(M1)**

OCTOBER/NOVEMBER SESSION 2002

1 hour 15 minutes

Additional materials:
- Answer paper
- Graph paper
- List of Formulae (MF9)

TIME 1 hour 15 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided on the answer paper/answer booklet.

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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INFORMATION FOR CANDIDATES

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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.

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

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

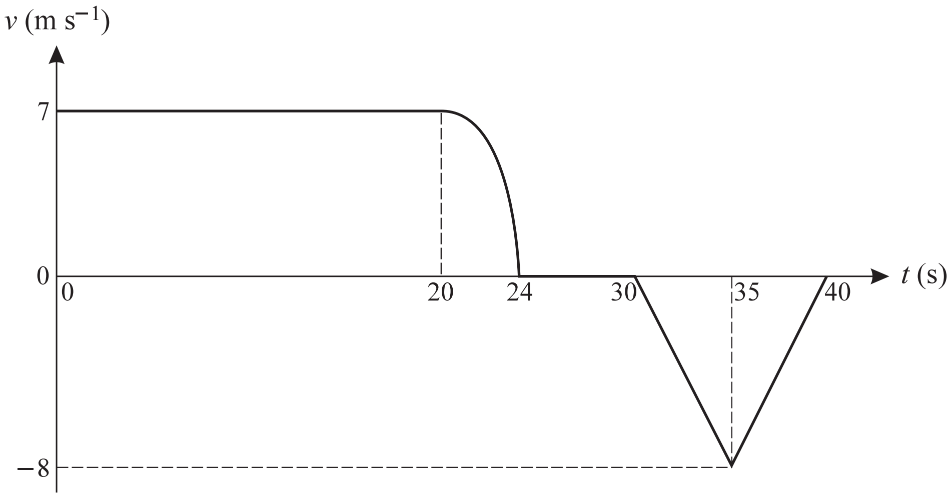
This question paper consists of 4 printed pages.

UNIVERSITY of CAMBRIDGE
Local Examinations Syndicate

[Turn over

1 A car of mass 1000 kg travels along a horizontal straight road with its engine working at a constant rate of 20 kW. The resistance to motion of the car is 600 N. Find the acceleration of the car at an instant when its speed is 25 m s^{-1}. [3]

2

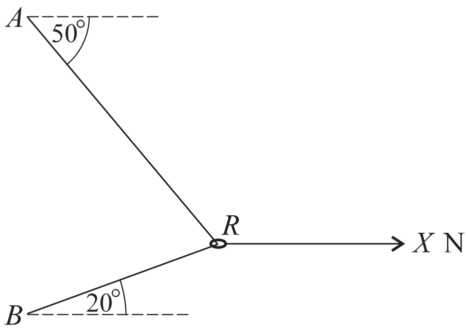


A man runs in a straight line. He passes through a fixed point A with constant velocity 7 m s^{-1} at time $t = 0$. At time t s his velocity is v m s^{-1}. The diagram shows the graph of v against t for the period $0 \leqslant t \leqslant 40$.

(i) Show that the man runs more than 154 m in the first 24 s. [2]

(ii) Given that the man runs 20 m in the interval $20 \leqslant t \leqslant 24$, find how far he is from A when $t = 40$. [2]

3



A light inextensible string has its ends attached to two fixed points A and B, with A vertically above B. A smooth ring R, of mass 0.8 kg, is threaded on the string and is pulled by a horizontal force of magnitude X newtons. The sections AR and BR of the string make angles of 50° and 20° respectively with the horizontal, as shown in the diagram. The ring rests in equilibrium with the string taut. Find

(i) the tension in the string, [3]

(ii) the value of X. [3]

4 Two particles A and B are projected vertically upwards from horizontal ground at the same instant. The speeds of projection of A and B are 5 m s^{-1} and 8 m s^{-1} respectively. Find

(i) the difference in the heights of A and B when A is at its maximum height, [4]

(ii) the height of A above the ground when B is 0.9 m above A. [4]

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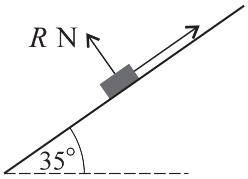

Fig. 1

A force, whose direction is upwards parallel to a line of greatest slope of a plane inclined at 35° to the horizontal, acts on a box of mass 15 kg which is at rest on the plane. The normal component of the contact force on the box has magnitude R newtons (see Fig. 1).

(i) Show that $R = 123$, correct to 3 significant figures. [1]

Fig. 2

When the force parallel to the plane acting on the box has magnitude X newtons the box is about to move *down* the plane, and when this force has magnitude $5X$ newtons the box is about to move *up* the plane (see Fig. 2).

(ii) Find the value of X and the coefficient of friction between the box and the plane. [7]

[Questions 6 and 7 are printed overleaf.]

6 **(i)** A particle P of mass 1.2 kg is released from rest at the top of a slope and starts to move. The slope has length 4 m and is inclined at $25°$ to the horizontal. The coefficient of friction between P and the slope is $\frac{1}{4}$. Find

(a) the frictional component of the contact force on P, [2]

(b) the acceleration of P, [2]

(c) the speed with which P reaches the bottom of the slope. [2]

(ii) After reaching the bottom of the slope, P moves freely under gravity and subsequently hits a horizontal floor which is 3 m below the bottom of the slope.

(a) Find the loss in gravitational potential energy of P during its motion from the bottom of the slope until it hits the floor. [1]

(b) Find the speed with which P hits the floor. [3]

7 A particle P starts to move from a point O and travels in a straight line. At time t s after P starts to move its velocity is $v\,\mathrm{m\,s^{-1}}$, where $v = 0.12t - 0.0006t^2$.

(i) Verify that P comes to instantaneous rest when $t = 200$, and find the acceleration with which it starts to return towards O. [3]

(ii) Find the maximum speed of P for $0 \leqslant t \leqslant 200$. [3]

(iii) Find the displacement of P from O when $t = 200$. [3]

(iv) Find the value of t when P reaches O again. [2]

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

MATHEMATICS **9709/04**

Paper 4 Mechanics 1 **(M1)**

October/November 2003

1 hour 15 minutes

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

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 on both sides of the paper.
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You are reminded of the need for clear presentation in your answers.

This document consists of **4** printed pages.

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Local Examinations Syndicate

1 A motorcycle of mass 100 kg is travelling on a horizontal straight road. Its engine is working at a rate of 8 kW. At an instant when the speed of the motorcycle is 25 m s^{-1} its acceleration is 0.5 m s^{-2}. Find, at this instant,

(i) the force produced by the engine, [1]

(ii) the resistance to motion of the motorcycle. [3]

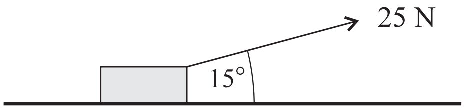
2 A stone is released from rest and falls freely under gravity. Find

(i) the speed of the stone after 2 s, [1]

(ii) the time taken for the stone to fall a distance of 45 m from its initial position, [2]

(iii) the distance fallen by the stone from the instant when its speed is 30 m s^{-1} to the instant when its speed is 40 m s^{-1}. [2]

3

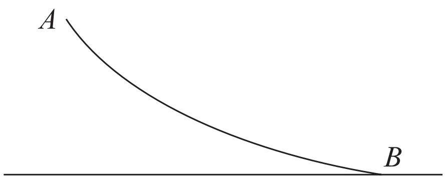


A crate of mass 3 kg is pulled at constant speed along a horizontal floor. The pulling force has magnitude 25 N and acts at an angle of 15° to the horizontal, as shown in the diagram. Find

(i) the work done by the pulling force in moving the crate a distance of 2 m, [2]

(ii) the normal component of the contact force on the crate. [3]

4



The diagram shows a vertical cross-section of a surface. A and B are two points on the cross-section. A particle of mass 0.15 kg is released from rest at A.

(i) Assuming that the particle reaches B with a speed of 8 m s^{-1} and that there are no resistances to motion, find the height of A above B. [3]

(ii) Assuming instead that the particle reaches B with a speed of 6 m s^{-1} and that the height of A above B is 4 m, find the work done against the resistances to motion. [3]

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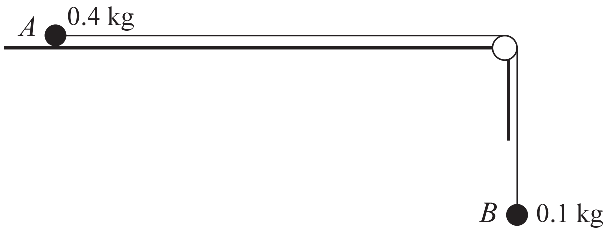
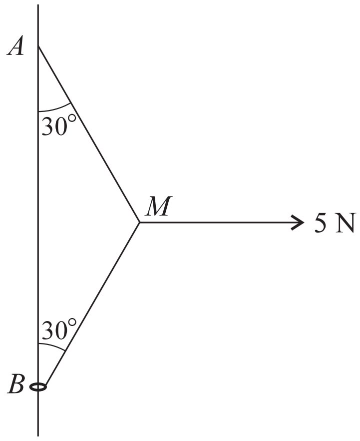


Particles A and B, of masses 0.4 kg and 0.1 kg respectively, are attached to the ends of a light inextensible string. Particle A is held at rest on a horizontal table with the string passing over a smooth pulley at the edge of the table. Particle B hangs vertically below the pulley (see diagram). The system is released from rest. In the subsequent motion a constant frictional force of magnitude 0.6 N acts on A. Find

(i) the tension in the string, [4]

(ii) the speed of B 1.5 s after it starts to move. [3]

6



One end of a light inextensible string is attached to a fixed point A of a fixed vertical wire. The other end of the string is attached to a small ring B, of mass 0.2 kg, through which the wire passes. A horizontal force of magnitude 5 N is applied to the mid-point M of the string. The system is in equilibrium with the string taut, with B below A, and with angles ABM and BAM equal to 30° (see diagram).

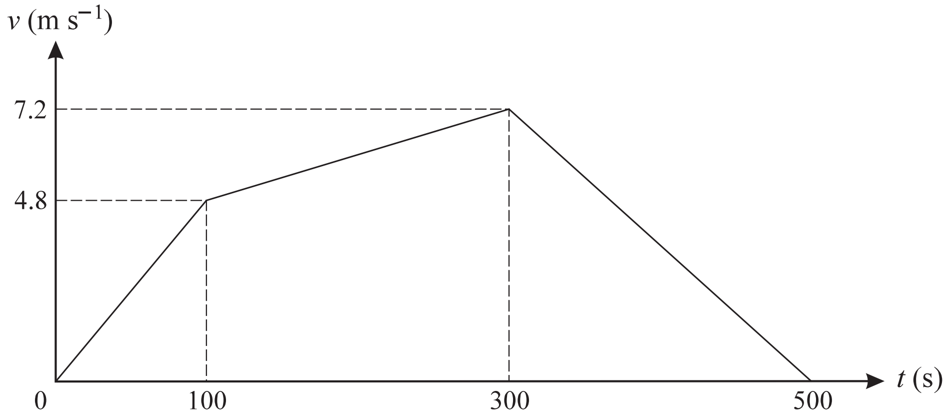
(i) Show that the tension in BM is 5 N. [3]

(ii) The ring is on the point of sliding up the wire. Find the coefficient of friction between the ring and the wire. [5]

(iii) A particle of mass m kg is attached to the ring. The ring is now on the point of sliding down the wire. Given that the coefficient of friction between the ring and the wire is unchanged, find the value of m. [2]

[Turn over

7



A tractor A starts from rest and travels along a straight road for 500 seconds. The velocity-time graph for the journey is shown above. This graph consists of three straight line segments. Find

(i) the distance travelled by A, [3]

(ii) the initial acceleration of A. [2]

Another tractor B starts from rest at the same instant as A, and travels along the same road for 500 seconds. Its velocity t seconds after starting is $(0.06t - 0.00012t^2)\ \mathrm{m\,s^{-1}}$. Find

(iii) how much greater B's initial acceleration is than A's, [2]

(iv) how much further B has travelled than A, at the instant when B's velocity reaches its maximum. [6]

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

MATHEMATICS **9709/04**

Paper 4 Mechanics 1 **(M1)**

October/November 2004

1 hour 15 minutes

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

READ THESE INSTRUCTIONS FIRST

If you have been given an Answer Booklet, follow the instructions on the front cover of the Booklet.
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This document consists of **3** printed pages and **1** blank page.

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International Examinations

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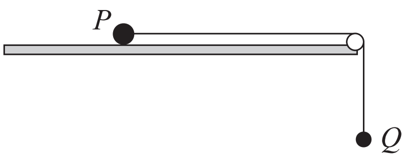


Two particles P and Q, of masses 1.7 kg and 0.3 kg respectively, are connected by a light inextensible string. P is held on a smooth horizontal table with the string taut and passing over a small smooth pulley fixed at the edge of the table. Q is at rest vertically below the pulley. P is released. Find the acceleration of the particles and the tension in the string. [5]

2

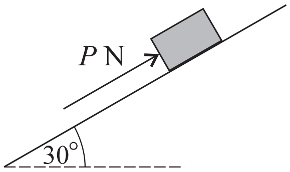


Fig. 1

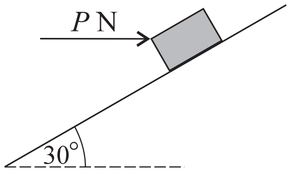


Fig. 2

A small block of weight 18 N is held at rest on a smooth plane inclined at 30° to the horizontal, by a force of magnitude P N. Find

(i) the value of P when the force is parallel to the plane, as in Fig. 1, [2]

(ii) the value of P when the force is horizontal, as in Fig. 2. [3]

3 A car of mass 1250 kg travels down a straight hill with the engine working at a power of 22 kW. The hill is inclined at 3° to the horizontal and the resistance to motion of the car is 1130 N. Find the speed of the car at an instant when its acceleration is 0.2 m s^{-2}. [5]

4 A lorry of mass 16 000 kg climbs from the bottom to the top of a straight hill of length 1000 m at a constant speed of 10 m s^{-1}. The top of the hill is 20 m above the level of the bottom of the hill. The driving force of the lorry is constant and equal to 5000 N. Find

(i) the gain in gravitational potential energy of the lorry, [1]

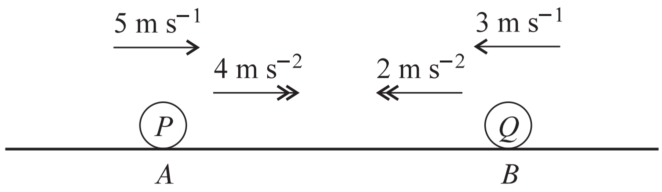
(ii) the work done by the driving force, [1]

(iii) the work done against the force resisting the motion of the lorry. [1]

On reaching the top of the hill the lorry continues along a straight horizontal road against a constant resistance of 1500 N. The driving force of the lorry is not now constant, and the speed of the lorry increases from 10 m s^{-1} at the top of the hill to 25 m s^{-1} at the point P. The distance of P from the top of the hill is 2000 m.

(iv) Find the work done by the driving force of the lorry while the lorry travels from the top of the hill to P. [5]

5

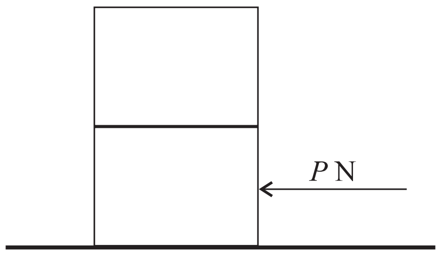


Particles P and Q start from points A and B respectively, at the same instant, and move towards each other in a horizontal straight line. The initial speeds of P and Q are $5\,\mathrm{m\,s^{-1}}$ and $3\,\mathrm{m\,s^{-1}}$ respectively. The accelerations of P and Q are constant and equal to $4\,\mathrm{m\,s^{-2}}$ and $2\,\mathrm{m\,s^{-2}}$ respectively (see diagram).

(i) Find the speed of P at the instant when the speed of P is 1.8 times the speed of Q. [4]

(ii) Given that $AB = 51$ m, find the time taken from the start until P and Q meet. [4]

6



Two identical boxes, each of mass 400 kg, are at rest, with one on top of the other, on horizontal ground. A horizontal force of magnitude P newtons is applied to the lower box (see diagram). The coefficient of friction between the lower box and the ground is 0.75 and the coefficient of friction between the two boxes is 0.4.

(i) Show that the boxes will remain at rest if $P \leqslant 6000$. [2]

The boxes start to move with acceleration $a\,\mathrm{m\,s^{-2}}$.

(ii) Given that no sliding takes place between the boxes, show that $a \leqslant 4$ and deduce the maximum possible value of P. [7]

7 A particle starts from rest at the point A and travels in a straight line until it reaches the point B. The velocity of the particle t seconds after leaving A is $v\,\mathrm{m\,s^{-1}}$, where $v = 0.009t^2 - 0.0001t^3$. Given that the velocity of the particle when it reaches B is zero, find

(i) the time taken for the particle to travel from A to B, [2]

(ii) the distance AB, [4]

(iii) the maximum velocity of the particle. [4]

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

MATHEMATICS **9709/04**

Paper 4 Mechanics 1 **(M1)**

October/November 2005

1 hour 15 minutes

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

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UNIVERSITY *of* CAMBRIDGE
International Examinations

1 A car travels in a straight line with constant acceleration $a\,\text{m}\,\text{s}^{-2}$. It passes the points A, B and C, in this order, with speeds $5\,\text{m}\,\text{s}^{-1}$, $7\,\text{m}\,\text{s}^{-1}$ and $8\,\text{m}\,\text{s}^{-1}$ respectively. The distances AB and BC are d_1 m and d_2 m respectively.

(i) Write down an equation connecting

(a) d_1 and a,

(b) d_2 and a.

[2]

(ii) Hence find d_1 in terms of d_2. [2]

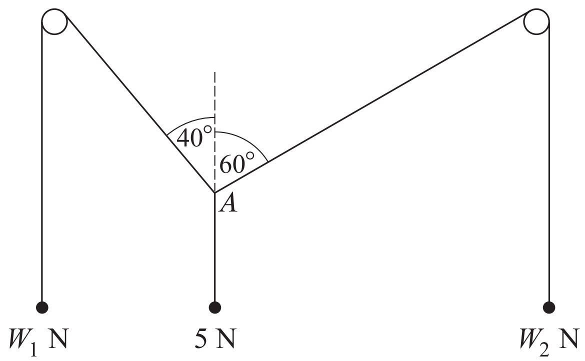
2 A crate of mass 50 kg is dragged along a horizontal floor by a constant force of magnitude 400 N acting at an angle α° upwards from the horizontal. The total resistance to motion of the crate has constant magnitude 250 N. The crate starts from rest at the point O and passes the point P with a speed of $2\,\text{m}\,\text{s}^{-1}$. The distance OP is 20 m. For the crate's motion from O to P, find

(i) the increase in kinetic energy of the crate, [1]

(ii) the work done against the resistance to the motion of the crate, [1]

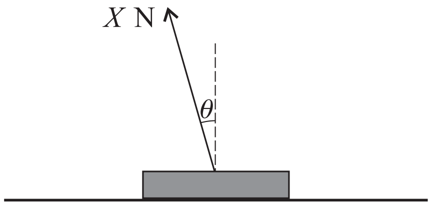
(iii) the value of α. [3]

3



Each of three light strings has a particle attached to one of its ends. The other ends of the strings are tied together at a point A. The strings are in equilibrium with two of them passing over fixed smooth horizontal pegs, and with the particles hanging freely. The weights of the particles, and the angles between the sloping parts of the strings and the vertical, are as shown in the diagram. Find the values of W_1 and W_2. [6]

4

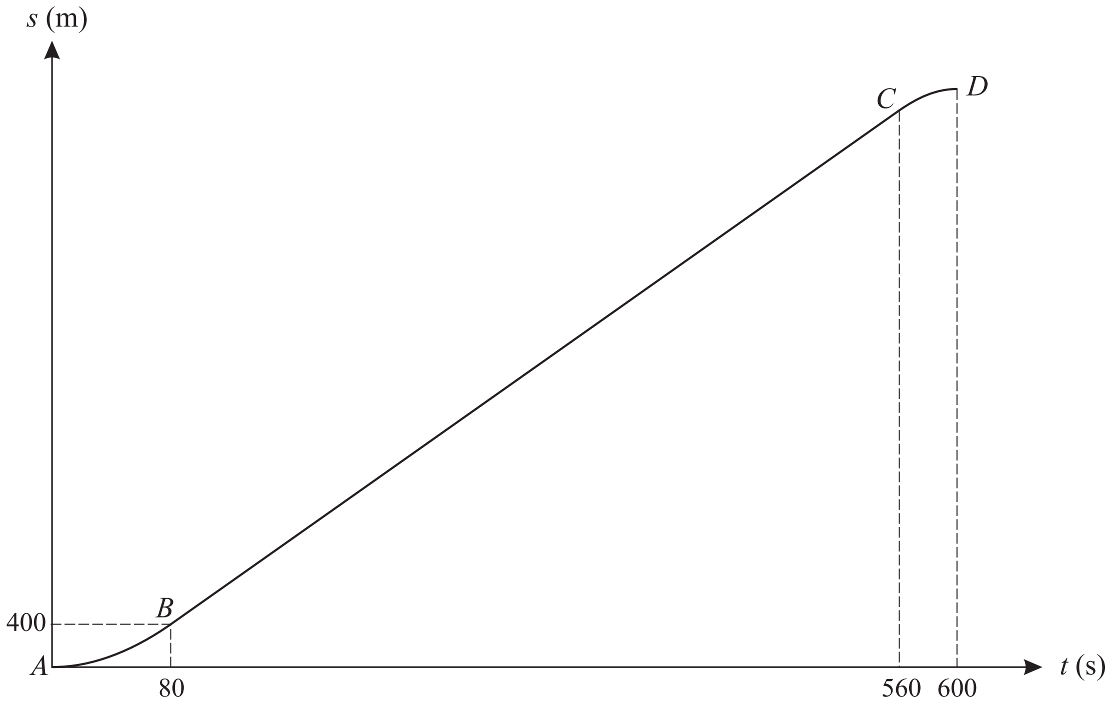


A stone slab of mass 320 kg rests in equilibrium on rough horizontal ground. A force of magnitude X N acts upwards on the slab at an angle of θ to the vertical, where $\tan\theta = \frac{7}{24}$ (see diagram).

(i) Find, in terms of X, the normal component of the force exerted on the slab by the ground. [3]

(ii) Given that the coefficient of friction between the slab and the ground is $\frac{3}{8}$, find the value of X for which the slab is about to slip. [3]

5



The diagram shows the displacement-time graph for a car's journey. The graph consists of two curved parts AB and CD, and a straight line BC. The line BC is a tangent to the curve AB at B and a tangent to the curve CD at C. The gradient of the curves at $t = 0$ and $t = 600$ is zero, and the acceleration of the car is constant for $0 < t < 80$ and for $560 < t < 600$. The displacement of the car is 400 m when $t = 80$.

(i) Sketch the velocity-time graph for the journey. [3]

(ii) Find the velocity at $t = 80$. [2]

(iii) Find the total distance for the journey. [2]

(iv) Find the acceleration of the car for $0 < t < 80$. [2]

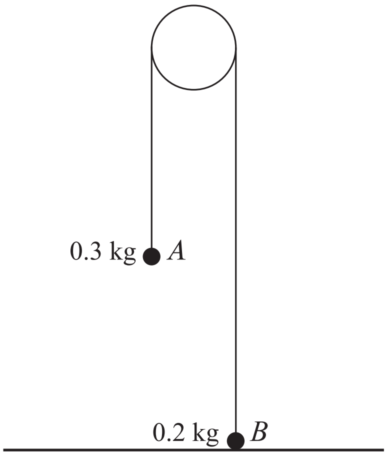
6 A particle P starts from rest at O and travels in a straight line. Its velocity $v\,\mathrm{m\,s^{-1}}$ at time t s is given by $v = 8t - 2t^2$ for $0 \leqslant t \leqslant 3$, and $v = \dfrac{54}{t^2}$ for $t > 3$. Find

(i) the distance travelled by P in the first 3 seconds, [4]

(ii) an expression in terms of t for the displacement of P from O, valid for $t > 3$, [3]

(iii) the value of v when the displacement of P from O is 27 m. [3]

7



Two particles A and B, of masses 0.3 kg and 0.2 kg respectively, are attached to the ends of a light inextensible string which passes over a smooth fixed pulley. Particle B is held on the horizontal floor and particle A hangs in equilibrium. Particle B is released and each particle starts to move vertically with constant acceleration of magnitude $a\,\mathrm{m\,s^{-2}}$.

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

Particle A hits the floor 1.2 s after it starts to move, and does not rebound upwards.

(ii) Show that A hits the floor with a speed of $2.4\,\mathrm{m\,s^{-1}}$. [1]

(iii) Find the gain in gravitational potential energy by B, from leaving the floor until reaching its greatest height. [5]

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

MATHEMATICS **9709/04**

Paper 4 Mechanics 1 **(M1)**

October/November 2006

1 hour 15 minutes

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

READ THESE INSTRUCTIONS FIRST

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UNIVERSITY of CAMBRIDGE International Examinations

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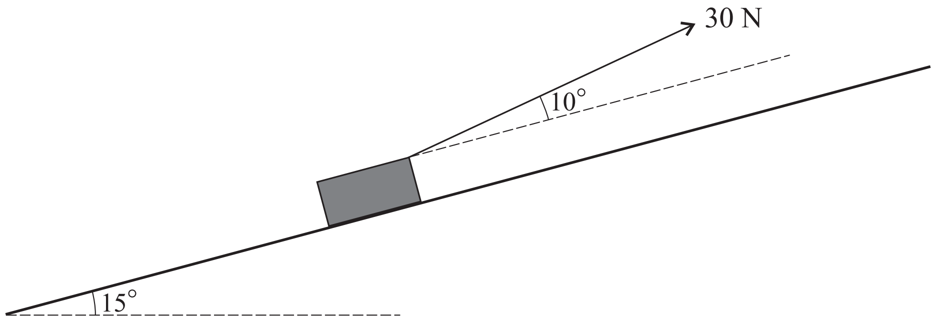
1



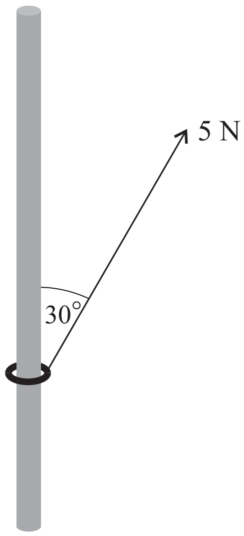
A box of mass 8 kg is pulled, at constant speed, up a straight path which is inclined at an angle of 15° to the horizontal. The pulling force is constant, of magnitude 30 N, and acts upwards at an angle of 10° from the path (see diagram). The box passes through the points A and B, where $AB = 20$ m and B is above the level of A. For the motion from A to B, find

(i) the work done by the pulling force, [2]

(ii) the gain in potential energy of the box, [2]

(iii) the work done against the resistance to motion of the box. [1]

2



A small ring of mass 0.6 kg is threaded on a rough rod which is fixed vertically. The ring is in equilibrium, acted on by a force of magnitude 5 N pulling upwards at 30° to the vertical (see diagram).

(i) Show that the frictional force acting on the ring has magnitude 1.67 N, correct to 3 significant figures. [2]

(ii) The ring is on the point of sliding down the rod. Find the coefficient of friction between the ring and the rod. [3]

3 A cyclist travels along a straight road working at a constant rate of 420 W. The total mass of the cyclist and her cycle is 75 kg. Ignoring any resistance to motion, find the acceleration of the cyclist at an instant when she is travelling at $5\,\text{m}\,\text{s}^{-1}$,

(i) given that the road is horizontal,

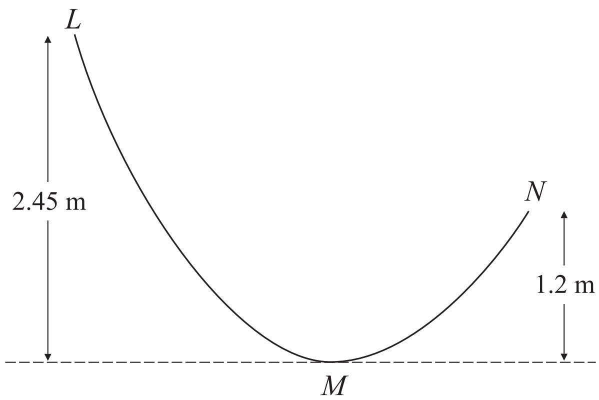
(ii) given instead that the road is inclined at 1.5° to the horizontal and the cyclist is travelling up the slope. [5]

4 The velocity of a particle t s after it starts from rest is $v\,\text{m}\,\text{s}^{-1}$, where $v = 1.25t - 0.05t^2$. Find

(i) the initial acceleration of the particle, [2]

(ii) the displacement of the particle from its starting point at the instant when its acceleration is $0.05\,\text{m}\,\text{s}^{-2}$. [5]

5



The diagram shows the vertical cross-section LMN of a fixed smooth surface. M is the lowest point of the cross-section. L is 2.45 m above the level of M, and N is 1.2 m above the level of M. A particle of mass 0.5 kg is released from rest at L and moves on the surface until it leaves it at N. Find

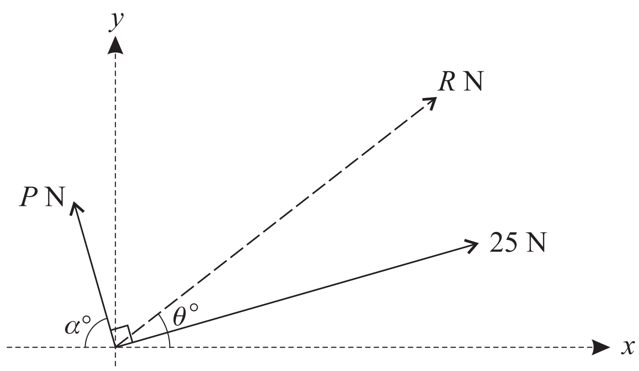
(i) the greatest speed of the particle, [3]

(ii) the kinetic energy of the particle at N. [2]

The particle is now projected from N, with speed $v\,\text{m}\,\text{s}^{-1}$, along the surface towards M.

(iii) Find the least value of v for which the particle will reach L. [2]

6



Forces of magnitudes P N and 25 N act at right angles to each other. The resultant of the two forces has magnitude R N and makes an angle of $\theta°$ with the x-axis (see diagram). The force of magnitude P N has components -2.8 N and 9.6 N in the x-direction and the y-direction respectively, and makes an angle of $\alpha°$ with the negative x-axis.

(i) Find the values of P and R. [3]

(ii) Find the value of α, and hence find the components of the force of magnitude 25 N in

(a) the x-direction,

(b) the y-direction.

[4]

(iii) Find the value of θ. [3]

7 A particle of mass m kg moves up a line of greatest slope of a rough plane inclined at 21° to the horizontal. The frictional and normal components of the contact force on the particle have magnitudes F N and R N respectively. The particle passes through the point P with speed $10\,\text{m s}^{-1}$, and 2 s later it reaches its highest point on the plane.

(i) Show that $R = 9.336m$ and $F = 1.416m$, each correct to 4 significant figures. [5]

(ii) Find the coefficient of friction between the particle and the plane. [1]

After the particle reaches its highest point it starts to move down the plane.

(iii) Find the speed with which the particle returns to P. [5]

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

MATHEMATICS **9709/04**

Paper 4 Mechanics 1 **(M1)** **October/November 2007**

1 hour 15 minutes

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

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READ THESE INSTRUCTIONS FIRST

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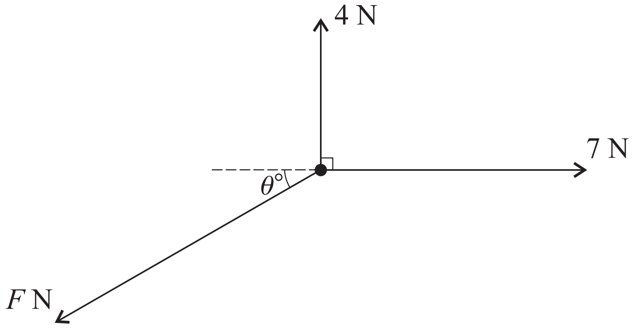
1 A car of mass 900 kg travels along a horizontal straight road with its engine working at a constant rate of P kW. The resistance to motion of the car is 550 N. Given that the acceleration of the car is 0.2 m s^{-2} at an instant when its speed is 30 m s^{-1}, find the value of P. [4]

2 A particle is projected vertically upwards from a point O with initial speed 12.5 m s^{-1}. At the same instant another particle is released from rest at a point 10 m vertically above O. Find the height above O at which the particles meet. [5]

3

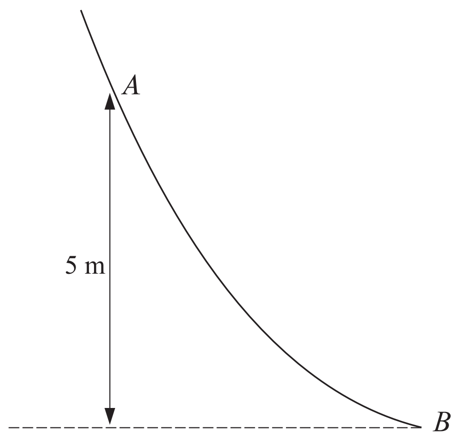


A particle is in equilibrium on a smooth horizontal table when acted on by the three horizontal forces shown in the diagram.

(i) Find the values of F and θ. [4]

(ii) The force of magnitude 7 N is now removed. State the magnitude and direction of the resultant of the remaining two forces. [2]

4

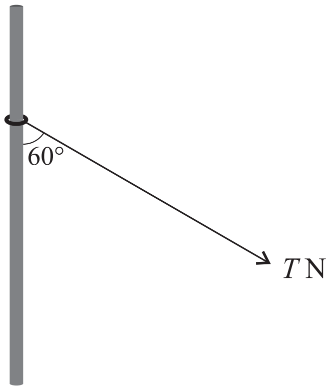


The diagram shows the vertical cross-section of a surface. A and B are two points on the cross-section, and A is 5 m higher than B. A particle of mass 0.35 kg passes through A with speed 7 m s^{-1}, moving on the surface towards B.

(i) Assuming that there is no resistance to motion, find the speed with which the particle reaches B. [3]

(ii) Assuming instead that there is a resistance to motion, and that the particle reaches B with speed 11 m s^{-1}, find the work done against this resistance as the particle moves from A to B. [3]

5



A ring of mass 4 kg is threaded on a fixed rough vertical rod. A light string is attached to the ring, and is pulled with a force of magnitude T N acting at an angle of 60° to the downward vertical (see diagram). The ring is in equilibrium.

(i) The normal and frictional components of the contact force exerted on the ring by the rod are R N and F N respectively. Find R and F in terms of T. [4]

(ii) The coefficient of friction between the rod and the ring is 0.7. Find the value of T for which the ring is about to slip. [3]

6 **(i)** A man walks in a straight line from A to B with constant acceleration $0.004\,\mathrm{m\,s^{-2}}$. His speed at A is $1.8\,\mathrm{m\,s^{-1}}$ and his speed at B is $2.2\,\mathrm{m\,s^{-1}}$. Find the time taken for the man to walk from A to B, and find the distance AB. [3]

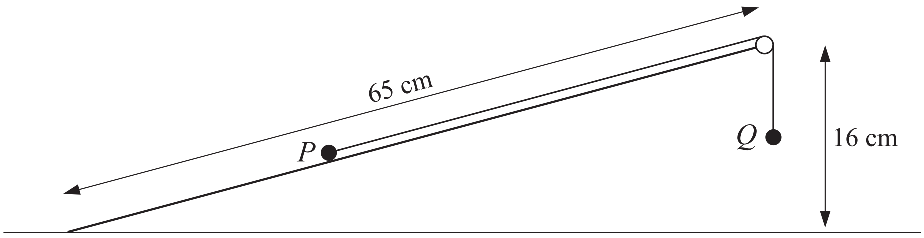
(ii) A woman cyclist leaves A at the same instant as the man. She starts from rest and travels in a straight line to B, reaching B at the same instant as the man. At time t s after leaving A the cyclist's speed is $k(200t - t^2)\,\mathrm{m\,s^{-1}}$, where k is a constant. Find

(a) the value of k, [4]

(b) the cyclist's speed at B. [1]

(iii) Sketch, using the same axes, the velocity-time graphs for the man's motion and the woman's motion from A to B. [3]

7



A rough inclined plane of length 65 cm is fixed with one end at a height of 16 cm above the other end. Particles P and Q, of masses 0.13 kg and 0.11 kg respectively, are attached to the ends of a light inextensible string which passes over a small smooth pulley at the top of the plane. Particle P is held at rest on the plane and particle Q hangs vertically below the pulley (see diagram). The system is released from rest and P starts to move up the plane.

(i) Draw a diagram showing the forces acting on P during its motion up the plane. [1]

(ii) Show that $T - F > 0.32$, where T N is the tension in the string and F N is the magnitude of the frictional force on P. [4]

The coefficient of friction between P and the plane is 0.6.

(iii) Find the acceleration of P. [6]

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

MATHEMATICS **9709/04**

Paper 4 Mechanics 1 **(M1)** **October/November 2008**

1 hour 15 minutes

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

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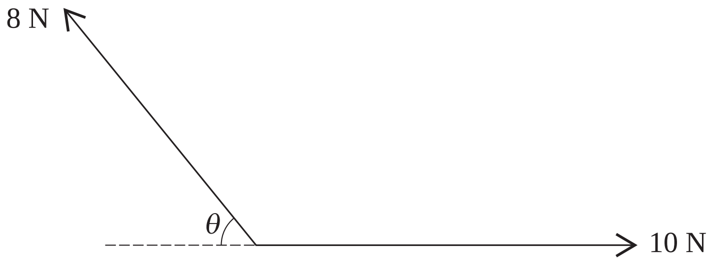
1



Forces of magnitudes 10 N and 8 N act in directions as shown in the diagram.

(i) Write down in terms of θ the component of the resultant of the two forces

(a) parallel to the force of magnitude 10 N, [1]

(b) perpendicular to the force of magnitude 10 N. [1]

(ii) The resultant of the two forces has magnitude 8 N. Show that $\cos\theta = \frac{5}{8}$. [3]

2 A block of mass 20 kg is at rest on a plane inclined at 10° to the horizontal. A force acts on the block parallel to a line of greatest slope of the plane. The coefficient of friction between the block and the plane is 0.32. Find the least magnitude of the force necessary to move the block,

(i) given that the force acts up the plane,

(ii) given instead that the force acts down the plane.

[6]

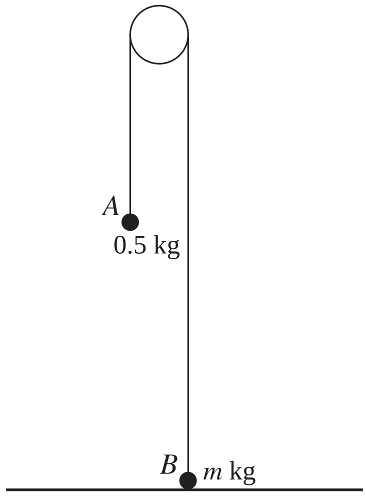
3 A car of mass 1200 kg is travelling on a horizontal straight road and passes through a point A with speed $25\,\mathrm{m\,s^{-1}}$. The power of the car's engine is 18 kW and the resistance to the car's motion is 900 N.

(i) Find the deceleration of the car at A. [4]

(ii) Show that the speed of the car does not fall below $20\,\mathrm{m\,s^{-1}}$ while the car continues to move with the engine exerting a constant power of 18 kW. [2]

4 A load of mass 160 kg is lifted vertically by a crane, with constant acceleration. The load starts from rest at the point O. After 7 s, it passes through the point A with speed $0.5\,\mathrm{m\,s^{-1}}$. By considering energy, find the work done by the crane in moving the load from O to A. [6]

5



Particles A and B, of masses 0.5 kg and m kg respectively, are attached to the ends of a light inextensible string which passes over a smooth fixed pulley. Particle B is held at rest on the horizontal floor and particle A hangs in equilibrium (see diagram). B is released and each particle starts to move vertically. A hits the floor 2 s after B is released. The speed of each particle when A hits the floor is $5\,\mathrm{m\,s^{-1}}$.

(i) For the motion while A is moving downwards, find

(a) the acceleration of A, [2]

(b) the tension in the string. [3]

(ii) Find the value of m. [3]

6 A train travels from A to B, a distance of 20 000 m, taking 1000 s. The journey has three stages. In the first stage the train starts from rest at A and accelerates uniformly until its speed is $V\,\mathrm{m\,s^{-1}}$. In the second stage the train travels at constant speed $V\,\mathrm{m\,s^{-1}}$ for 600 s. During the third stage of the journey the train decelerates uniformly, coming to rest at B.

(i) Sketch the velocity-time graph for the train's journey. [2]

(ii) Find the value of V. [3]

(iii) Given that the acceleration of the train during the first stage of the journey is $0.15\,\mathrm{m\,s^{-2}}$, find the distance travelled by the train during the third stage of the journey. [4]

7 A particle P is held at rest at a fixed point O and then released. P falls freely under gravity until it reaches the point A which is 1.25 m below O.

(i) Find the speed of P at A and the time taken for P to reach A. [3]

The particle continues to fall, but now its downward acceleration t seconds after passing through A is $(10 - 0.3t)\,\mathrm{m\,s^{-2}}$.

(ii) Find the total distance P has fallen, 3 s after being released from O. [7]

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General Certificate of Education
Advanced Subsidiary Level and Advanced Level

MATHEMATICS **9709/41**

Paper 4 Mechanics 1 **(M1)** **October/November 2009**

1 hour 15 minutes

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

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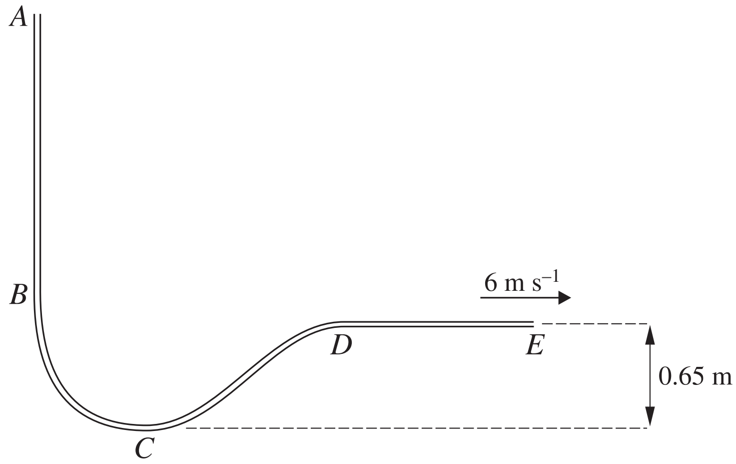
1 A car of mass 1000 kg moves along a horizontal straight road, passing through points A and B. The power of its engine is constant and equal to 15 000 W. The driving force exerted by the engine is 750 N at A and 500 N at B. Find the speed of the car at A and at B, and hence find the increase in the car's kinetic energy as it moves from A to B. [4]

2

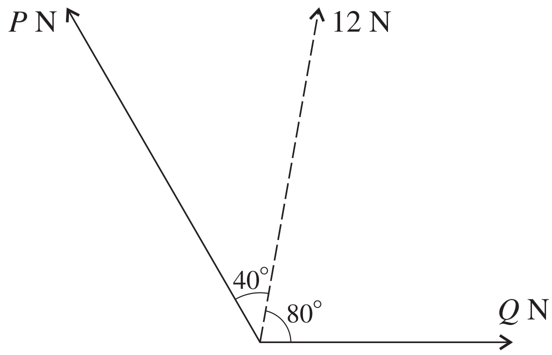


A smooth narrow tube AE has two straight parts, AB and DE, and a curved part BCD. The part AB is vertical with A above B, and DE is horizontal. C is the lowest point of the tube and is 0.65 m below the level of DE. A particle is released from rest at A and travels through the tube, leaving it at E with speed 6 m s^{-1} (see diagram). Find

(i) the height of A above the level of DE, [2]

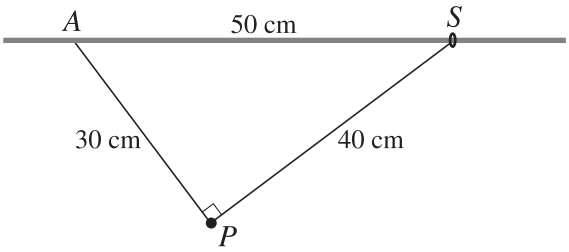
(ii) the maximum speed of the particle. [2]

3



Two forces have magnitudes P N and Q N. The resultant of the two forces has magnitude 12 N and acts in a direction 40° clockwise from the force of magnitude P N and 80° anticlockwise from the force of magnitude Q N (see diagram). Find the value of Q. [4]

4



A particle P of weight 5 N is attached to one end of each of two light inextensible strings of lengths 30 cm and 40 cm. The other end of the shorter string is attached to a fixed point A of a rough rod which is fixed horizontally. A small ring S of weight W N is attached to the other end of the longer string and is threaded on to the rod. The system is in equilibrium with the strings taut and $AS = 50$ cm (see diagram).

(i) By resolving the forces acting on P in the direction of PS, or otherwise, find the tension in the longer string. [3]

(ii) Find the magnitude of the frictional force acting on S. [2]

(iii) Given that the coefficient of friction between S and the rod is 0.75, and that S is in limiting equilibrium, find the value of W. [3]

5 A particle P of mass 0.6 kg moves upwards along a line of greatest slope of a plane inclined at 18° to the horizontal. The deceleration of P is $4\,\text{m}\,\text{s}^{-2}$.

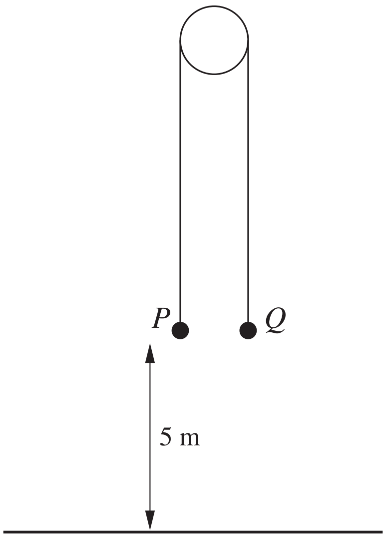
(i) Find the frictional and normal components of the force exerted on P by the plane. Hence find the coefficient of friction between P and the plane, correct to 2 significant figures. [6]

After P comes to instantaneous rest it starts to move down the plane with acceleration $a\,\text{m}\,\text{s}^{-2}$.

(ii) Find the value of a. [2]

[Questions 6 and 7 are printed on the next page.]

6



Particles P and Q, of masses 0.55 kg and 0.45 kg respectively, are attached to the ends of a light inextensible string which passes over a smooth fixed pulley. The particles are held at rest with the string taut and its straight parts vertical. Both particles are at a height of 5 m above the ground (see diagram). The system is released.

(i) Find the acceleration with which P starts to move. [3]

The string breaks after 2 s and in the subsequent motion P and Q move vertically under gravity.

(ii) At the instant that the string breaks, find

(a) the height above the ground of P and of Q, [2]

(b) the speed of the particles. [1]

(iii) Show that Q reaches the ground 0.8 s later than P. [4]

7 A particle P starts from rest at the point A at time $t = 0$, where t is in seconds, and moves in a straight line with constant acceleration $a\,\mathrm{m\,s^{-2}}$ for 10 s. For $10 \leqslant t \leqslant 20$, P continues to move along the line with velocity $v\,\mathrm{m\,s^{-1}}$, where $v = \dfrac{800}{t^2} - 2$. Find

(i) the speed of P when $t = 10$, and the value of a, [2]

(ii) the value of t for which the acceleration of P is $-a\,\mathrm{m\,s^{-2}}$, [4]

(iii) the displacement of P from A when $t = 20$. [6]

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

MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **October/November 2009**

1 hour 15 minutes

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

9129891802

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1

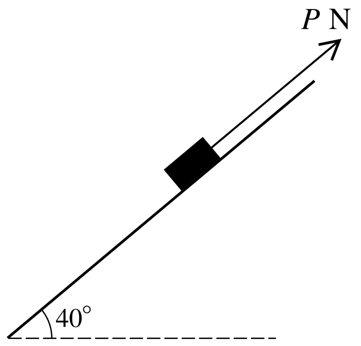


Fig. 1

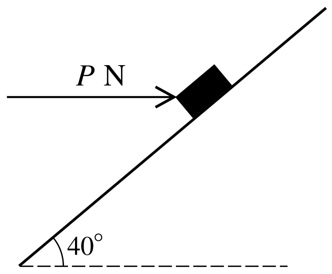


Fig. 2

A small block of weight 12 N is at rest on a smooth plane inclined at 40° to the horizontal. The block is held in equilibrium by a force of magnitude P N. Find the value of P when

(i) the force is parallel to the plane as in Fig. 1, [2]

(ii) the force is horizontal as in Fig. 2. [2]

2 A lorry of mass 15 000 kg moves with constant speed 14 m s^{-1} from the top to the bottom of a straight hill of length 900 m. The top of the hill is 18 m above the level of the bottom of the hill. The total work done by the resistive forces acting on the lorry, including the braking force, is 4.8×10^6 J. Find

(i) the loss in gravitational potential energy of the lorry, [1]

(ii) the work done by the driving force. [1]

On reaching the bottom of the hill the lorry continues along a straight horizontal road against a constant resistance of 1600 N. There is no braking force acting. The speed of the lorry increases from 14 m s^{-1} at the bottom of the hill to 16 m s^{-1} at the point X, where X is 2500 m from the bottom of the hill.

(iii) By considering energy, find the work done by the driving force of the lorry while it travels from the bottom of the hill to X. [3]

3 A car of mass 1250 kg travels along a horizontal straight road with increasing speed. The power provided by the car's engine is constant and equal to 24 kW. The resistance to the car's motion is constant and equal to 600 N.

(i) Show that the speed of the car cannot exceed 40 m s^{-1}. [3]

(ii) Find the acceleration of the car at an instant when its speed is 15 m s^{-1}. [3]

4 A particle moves up a line of greatest slope of a rough plane inclined at an angle α to the horizontal, where $\cos\alpha = 0.96$ and $\sin\alpha = 0.28$.

(i) Given that the normal component of the contact force acting on the particle has magnitude 1.2 N, find the mass of the particle. [2]

(ii) Given also that the frictional component of the contact force acting on the particle has magnitude 0.4 N, find the deceleration of the particle. [3]

The particle comes to rest on reaching the point X.

(iii) Determine whether the particle remains at X or whether it starts to move down the plane. [2]

5

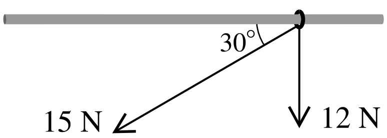


Fig. 1

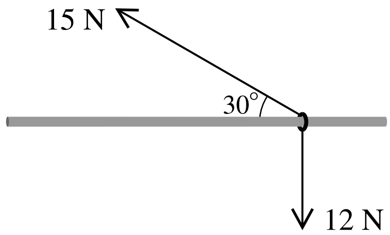


Fig. 2

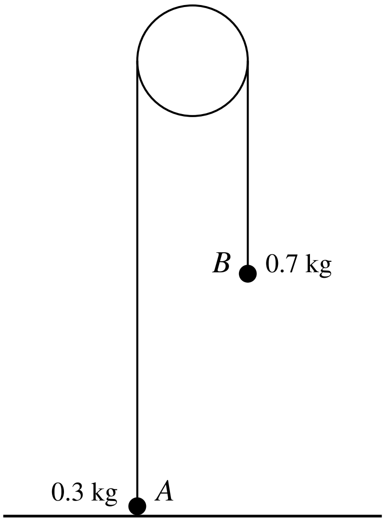
A small ring of weight 12 N is threaded on a fixed rough horizontal rod. A light string is attached to the ring and the string is pulled with a force of 15 N at an angle of 30° to the horizontal.

(i) When the angle of 30° is **below** the horizontal (see Fig. 1), the ring is in limiting equilibrium. Show that the coefficient of friction between the ring and the rod is 0.666, correct to 3 significant figures. [5]

(ii) When the angle of 30° is **above** the horizontal (see Fig. 2), the ring is moving with acceleration $a\,\text{m}\,\text{s}^{-2}$. Find the value of a. [4]

[Questions 6 and 7 are printed on the next page.]

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 which passes over a smooth fixed pulley. Particle A is held on the horizontal floor and particle B hangs in equilibrium. Particle A is released and both particles start to move vertically.

(i) Find the acceleration of the particles. [3]

The speed of the particles immediately before B hits the floor is $1.6\,\mathrm{m\,s^{-1}}$. Given that B does not rebound upwards, find

(ii) the maximum height above the floor reached by A, [3]

(iii) the time taken by A, from leaving the floor, to reach this maximum height. [3]

7 A motorcyclist starts from rest at A and travels in a straight line. For the first part of the motion, the motorcyclist's displacement x metres from A after t seconds is given by $x = 0.6t^2 - 0.004t^3$.

(i) Show that the motorcyclist's acceleration is zero when $t = 50$ and find the speed $V\,\mathrm{m\,s^{-1}}$ at this time. [5]

For $t \geqslant 50$, the motorcyclist travels at constant speed $V\,\mathrm{m\,s^{-1}}$.

(ii) Find the value of t for which the motorcyclist's average speed is $27.5\,\mathrm{m\,s^{-1}}$. [5]

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 2010**

1 hour 15 minutes

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

7969954022

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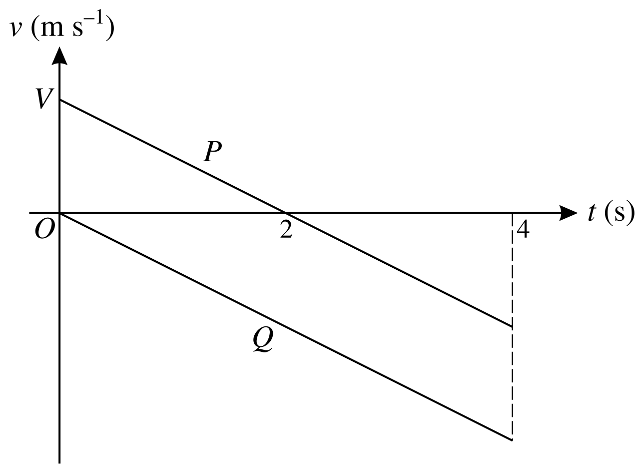
1



Two particles P and Q move vertically under gravity. The graphs show the upward velocity v m s^{-1} of the particles at time t s, for $0 \leqslant t \leqslant 4$. P starts with velocity V m s^{-1} and Q starts from rest.

(i) Find the value of V. [2]

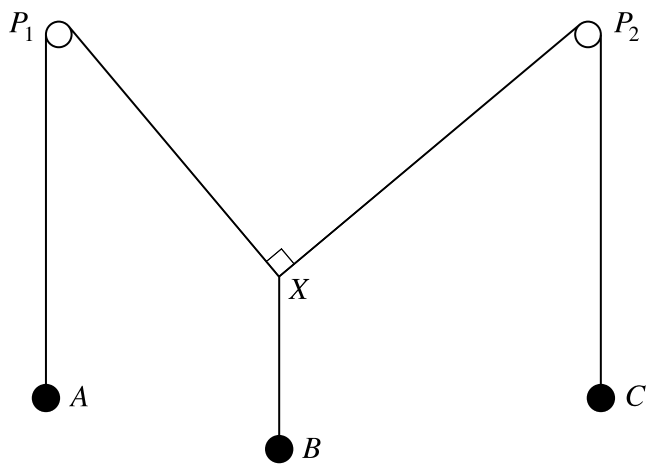
Given that Q reaches the horizontal ground when $t = 4$, find

(ii) the speed with which Q reaches the ground, [1]

(iii) the height of Q above the ground when $t = 0$. [2]

2 A car of mass 600 kg travels along a horizontal straight road, with its engine working at a rate of 40 kW. The resistance to motion of the car is constant and equal to 800 N. The car passes through the point A on the road with speed 25 m s^{-1}. The car's acceleration at the point B on the road is half its acceleration at A. Find the speed of the car at B. [5]

3



The diagram shows three particles A, B and C hanging freely in equilibrium, each being attached to the end of a string. The other ends of the three strings are tied together and are at the point X. The strings carrying A and C pass over smooth fixed horizontal pegs P_1 and P_2 respectively. The weights of A, B and C are 5.5 N, 7.3 N and W N respectively, and the angle P_1XP_2 is a right angle. Find the angle AP_1X and the value of W. [5]

4 A particle P starts from a fixed point O at time $t = 0$, where t is in seconds, and moves with constant acceleration in a straight line. The initial velocity of P is $1.5\,\text{m}\,\text{s}^{-1}$ and its velocity when $t = 10$ is $3.5\,\text{m}\,\text{s}^{-1}$.

(i) Find the displacement of P from O when $t = 10$. [2]

Another particle Q also starts from O when $t = 0$ and moves along the same straight line as P. The acceleration of Q at time t is $0.03t\,\text{m}\,\text{s}^{-2}$.

(ii) Given that Q has the same velocity as P when $t = 10$, show that it also has the same displacement from O as P when $t = 10$. [5]

5 A particle of mass 0.8 kg slides down a rough inclined plane along a line of greatest slope AB. The distance AB is 8 m. The particle starts at A with speed $3\,\text{m}\,\text{s}^{-1}$ and moves with constant acceleration $2.5\,\text{m}\,\text{s}^{-2}$.

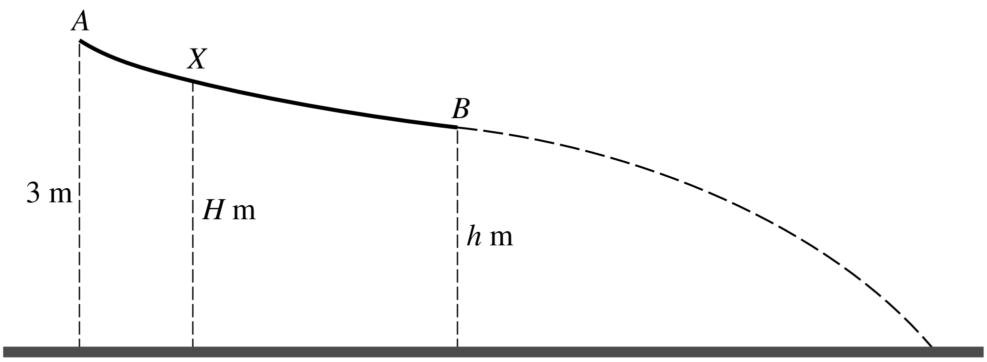
(i) Find the speed of the particle at the instant it reaches B. [2]

(ii) Given that the work done against the frictional force as the particle moves from A to B is 7 J, find the angle of inclination of the plane. [4]

When the particle is at the point X its speed is the same as the average speed for the motion from A to B.

(iii) Find the work done by the frictional force for the particle's motion from A to X. [3]

6



A smooth slide AB is fixed so that its highest point A is 3 m above horizontal ground. B is h m above the ground. A particle P of mass 0.2 kg is released from rest at a point on the slide. The particle moves down the slide and, after passing B, continues moving until it hits the ground (see diagram). The speed of P at B is v_B and the speed at which P hits the ground is v_G.

(i) In the case that P is released at A, it is given that the kinetic energy of P at B is 1.6 J. Find

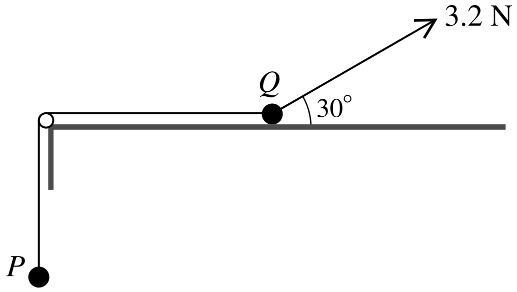
(a) the value of h, [3]

(b) the kinetic energy of the particle immediately before it reaches the ground, [1]

(c) the ratio $v_G : v_B$. [2]

(ii) In the case that P is released at the point X of the slide, which is H m above the ground (see diagram), it is given that $v_G : v_B = 2.55$. Find the value of H correct to 2 significant figures. [3]

7



Particles P and Q, of masses 0.2 kg and 0.5 kg respectively, are connected by a light inextensible string. The string passes over a smooth pulley at the edge of a rough horizontal table. P hangs freely and Q is in contact with the table. A force of magnitude 3.2 N acts on Q, upwards and away from the pulley, at an angle of 30° to the horizontal (see diagram).

(i) The system is in limiting equilibrium with P about to move upwards. Find the coefficient of friction between Q and the table. [6]

The force of magnitude 3.2 N is now removed and P starts to move downwards.

(ii) Find the acceleration of the particles and the tension in the string. [4]

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

MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **October/November 2010**

1 hour 15 minutes

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

3189572710

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This document consists of **3** printed pages and **1** blank page.

1 A block of mass 400 kg rests in limiting equilibrium on horizontal ground. A force of magnitude 2000 N acts on the block at an angle of 15° to the upwards vertical. Find the coefficient of friction between the block and the ground, correct to 2 significant figures. [5]

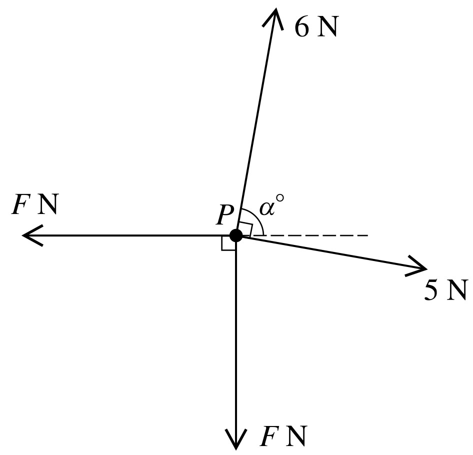
2 A cyclist, working at a constant rate of 400 W, travels along a straight road which is inclined at 2° to the horizontal. The total mass of the cyclist and his cycle is 80 kg. Ignoring any resistance to motion, find, correct to 1 decimal place, the acceleration of the cyclist when he is travelling

(i) uphill at $4\,\mathrm{m\,s^{-1}}$,

(ii) downhill at $4\,\mathrm{m\,s^{-1}}$.

[5]

3



A particle P is in equilibrium on a smooth horizontal table under the action of four horizontal forces of magnitudes 6 N, 5 N, F N and F N acting in the directions shown. Find the values of α and F. [6]

4 A block of mass 20 kg is pulled from the bottom to the top of a slope. The slope has length 10 m and is inclined at 4.5° to the horizontal. The speed of the block is $2.5\,\mathrm{m\,s^{-1}}$ at the bottom of the slope and $1.5\,\mathrm{m\,s^{-1}}$ at the top of the slope.

(i) Find the loss of kinetic energy and the gain in potential energy of the block. [3]

(ii) Given that the work done against the resistance to motion is 50 J, find the work done by the pulling force acting on the block. [2]

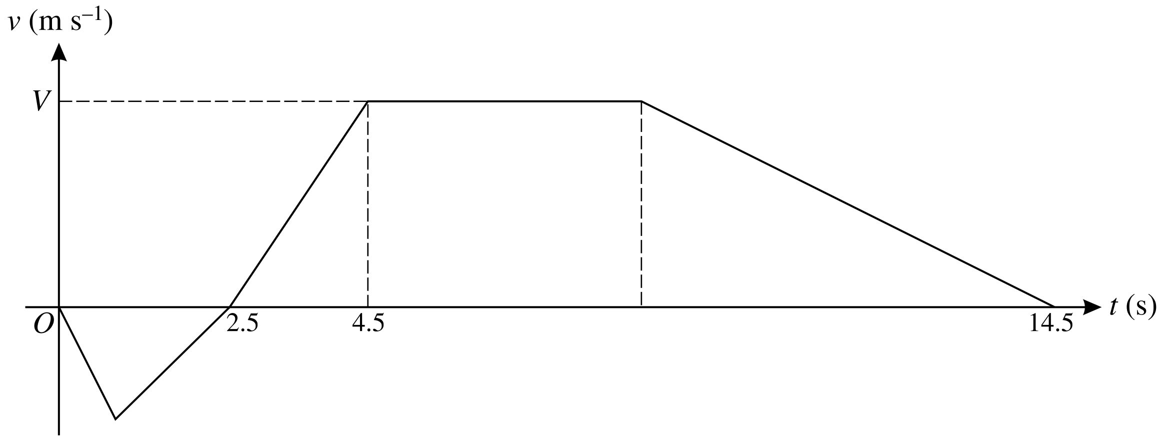
(iii) Given also that the pulling force is constant and acts at an angle of 15° upwards from the slope, find its magnitude. [2]

5 Particles P and Q are projected vertically upwards, from different points on horizontal ground, with velocities of $20\,\mathrm{m\,s^{-1}}$ and $25\,\mathrm{m\,s^{-1}}$ respectively. Q is projected 0.4 s later than P. Find

(i) the time for which P's height above the ground is greater than 15 m, [3]

(ii) the velocities of P and Q at the instant when the particles are at the same height. [5]

6



The diagram shows the velocity-time graph for a particle P which travels on a straight line AB, where $v\,\mathrm{m\,s^{-1}}$ is the velocity of P at time t s. The graph consists of five straight line segments. The particle starts from rest when $t = 0$ at a point X on the line between A and B and moves towards A. The particle comes to rest at A when $t = 2.5$.

(i) Given that the distance XA is 4 m, find the greatest speed reached by P during this stage of the motion. [2]

In the second stage, P starts from rest at A when $t = 2.5$ and moves towards B. The distance AB is 48 m. The particle takes 12 s to travel from A to B and comes to rest at B. For the first 2 s of this stage P accelerates at $3\,\mathrm{m\,s^{-2}}$, reaching a velocity of $V\,\mathrm{m\,s^{-1}}$. Find

(ii) the value of V, [2]

(iii) the value of t at which P starts to decelerate during this stage, [3]

(iv) the deceleration of P immediately before it reaches B. [2]

7 A particle P travels in a straight line. It passes through the point O of the line with velocity $5\,\mathrm{m\,s^{-1}}$ at time $t = 0$, where t is in seconds. P's velocity after leaving O is given by

$$(0.002t^3 - 0.12t^2 + 1.8t + 5)\,\mathrm{m\,s^{-1}}.$$

The velocity of P is increasing when $0 < t < T_1$ and when $t > T_2$, and the velocity of P is decreasing when $T_1 < t < T_2$.

(i) Find the values of T_1 and T_2 and the distance OP when $t = T_2$. [7]

(ii) Find the velocity of P when $t = T_2$ and sketch the velocity-time graph for the motion of P. [3]

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MATHEMATICS **9709/43**

Paper 4 Mechanics 1 **(M1)** **October/November 2010**

1 hour 15 minutes

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

6604966683

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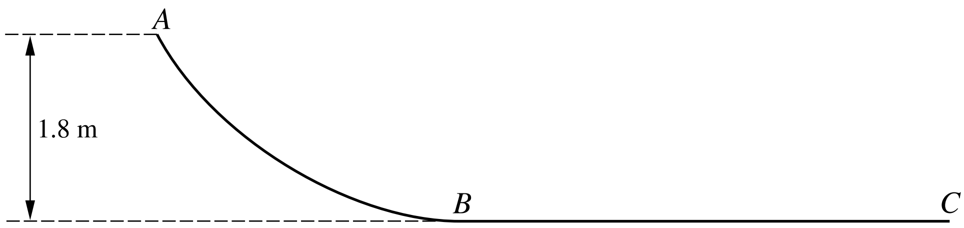
1 A particle P is released from rest at a point on a smooth plane inclined at 30° to the horizontal. Find the speed of P

(i) when it has travelled 0.9 m,

(ii) 0.8 s after it is released.

[4]

2

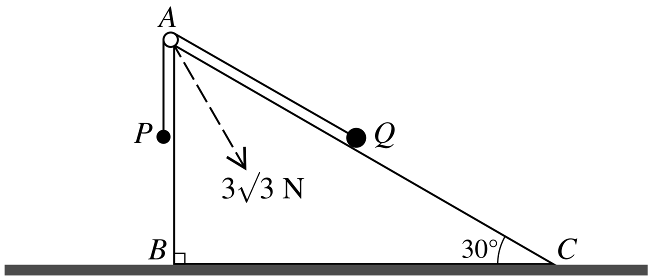


The diagram shows the vertical cross-section ABC of a fixed surface. AB is a curve and BC is a horizontal straight line. The part of the surface containing AB is smooth and the part containing BC is rough. A is at a height of 1.8 m above BC. A particle of mass 0.5 kg is released from rest at A and travels along the surface to C.

(i) Find the speed of the particle at B. [2]

(ii) Given that the particle reaches C with a speed of $5\ \mathrm{m\,s^{-1}}$, find the work done against the resistance to motion as the particle moves from B to C. [2]

3



A small smooth pulley is fixed at the highest point A of a cross-section ABC of a triangular prism. Angle $ABC = 90^\circ$ and angle $BCA = 30^\circ$. The prism is fixed with the face containing BC in contact with a horizontal surface. Particles P and Q are attached to opposite ends of a light inextensible string, which passes over the pulley. The particles are in equilibrium with P hanging vertically below the pulley and Q in contact with AC. The resultant force exerted on the pulley by the string is $3\sqrt{3}$ N (see diagram).

(i) Show that the tension in the string is 3 N. [2]

The coefficient of friction between Q and the prism is 0.75.

(ii) Given that Q is in limiting equilibrium and on the point of moving upwards, find its mass. [5]

4 A particle starts from rest at a point X and moves in a straight line until, 60 seconds later, it reaches a point Y. At time t s after leaving X, the acceleration of the particle is

$$\begin{array}{rll} 0.75\,\mathrm{m\,s^{-2}} & \text{for} & 0 < t < 4, \\ 0\,\mathrm{m\,s^{-2}} & \text{for} & 4 < t < 54, \\ -0.5\,\mathrm{m\,s^{-2}} & \text{for} & 54 < t < 60. \end{array}$$

(i) Find the velocity of the particle when $t = 4$ and when $t = 60$, and sketch the velocity-time graph. [5]

(ii) Find the distance XY. [2]

5 A force of magnitude F N acts in a horizontal plane and has components 27.5 N and −24 N in the x-direction and the y-direction respectively. The force acts at an angle of $\alpha°$ below the x-axis.

(i) Find the values of F and α. [4]

A second force, of magnitude 87.6 N, acts in the same plane at 90° anticlockwise from the force of magnitude F N. The resultant of the two forces has magnitude R N and makes an angle of $\theta°$ with the positive x-axis.

(ii) Find the values of R and θ. [3]

6 A particle travels along a straight line. It starts from rest at a point A on the line and comes to rest again, 10 seconds later, at another point B on the line. The velocity t seconds after leaving A is

$$\begin{array}{rll} 0.72t^2 - 0.096t^3 & \text{for} & 0 \leqslant t \leqslant 5, \\ 2.4t - 0.24t^2 & \text{for} & 5 \leqslant t \leqslant 10. \end{array}$$

(i) Show that there is no instantaneous change in the acceleration of the particle when $t = 5$. [4]

(ii) Find the distance AB. [4]

[Question 7 is printed on the next page.]

7 A car of mass 1250 kg travels along a horizontal straight road. The power of the car's engine is constant and equal to 24 kW and the resistance to the car's motion is constant and equal to R N. The car passes through the point A on the road with speed 20 m s^{-1} and acceleration 0.32 m s^{-2}.

(i) Find the value of R. [3]

The car continues with increasing speed, passing through the point B on the road with speed 29.9 m s^{-1}. The car subsequently passes through the point C.

(ii) Find the acceleration of the car at B, giving the answer in m s^{-2} correct to 3 decimal places. [2]

(iii) Show that, while the car's speed is increasing, it cannot reach 30 m s^{-1}. [2]

(iv) Explain why the speed of the car is approximately constant between B and C. [1]

(v) State a value of the approximately constant speed, and the maximum possible error in this value at any point between B and C. [1]

The work done by the car's engine during the motion from B to C is 1200 kJ.

(vi) By assuming the speed of the car is constant from B to C, find, in either order,

(a) the approximate time taken for the car to travel from B to C,

(b) an approximation for the distance BC.

[4]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
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Advanced Subsidiary Level and Advanced Level

MATHEMATICS **9709/41**

Paper 4 Mechanics 1 **(M1)** **October/November 2011**

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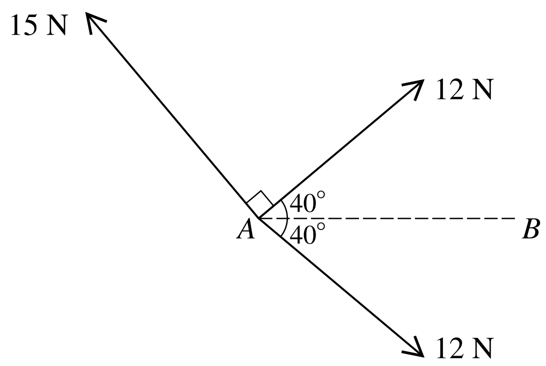
International Examinations

1 One end of a light inextensible string is attached to a block. The string is used to pull the block along a horizontal surface with a speed of $2\,\mathrm{m\,s^{-1}}$. The string makes an angle of 20° with the horizontal and the tension in the string is 25 N. Find the work done by the tension in a period of 8 seconds. [3]

2 Particles A of mass 0.65 kg and B of mass 0.35 kg are attached to the ends of a light inextensible string which passes over a fixed smooth pulley. B is held at rest with the string taut and both of its straight parts vertical. The system is released from rest and the particles move vertically. Find the tension in the string and the magnitude of the resultant force exerted on the pulley by the string. [5]

3



Three coplanar forces of magnitudes 15 N, 12 N and 12 N act at a point A in directions as shown in the diagram.

(i) Find the component of the resultant of the three forces

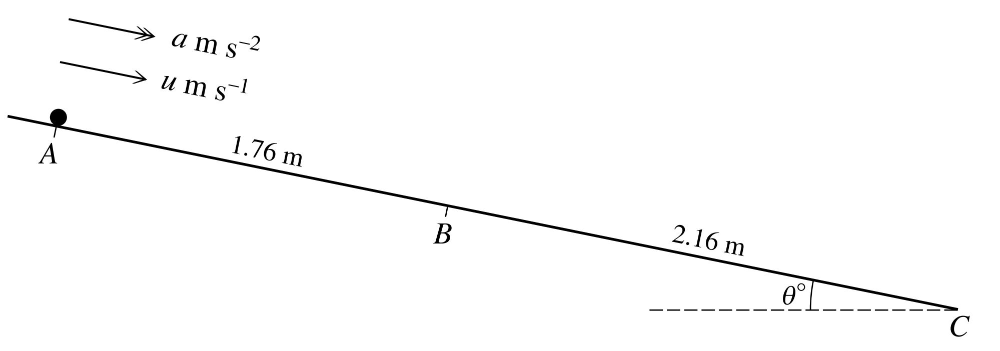
(a) in the direction of AB,

(b) perpendicular to AB.

[3]

(ii) Hence find the magnitude and direction of the resultant of the three forces. [3]

4



A, B and C are three points on a line of greatest slope of a smooth plane inclined at an angle of θ° to the horizontal. A is higher than B and B is higher than C, and the distances AB and BC are 1.76 m and 2.16 m respectively. A particle slides down the plane with constant acceleration $a\,\mathrm{m\,s^{-2}}$. The speed of the particle at A is $u\,\mathrm{m\,s^{-1}}$ (see diagram). The particle takes 0.8 s to travel from A to B and takes 1.4 s to travel from A to C. Find

(i) the values of u and a, [6]

(ii) the value of θ. [2]

5

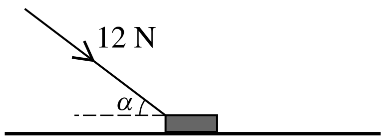


Fig. 1

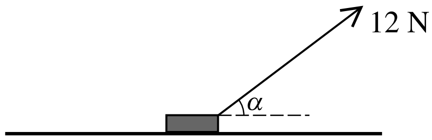


Fig. 2

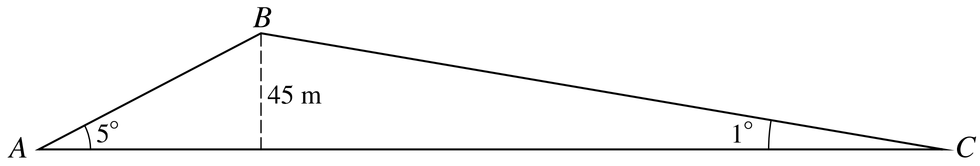
A block of mass 2 kg is at rest on a horizontal floor. The coefficient of friction between the block and the floor is μ. A force of magnitude 12 N acts on the block at an angle α to the horizontal, where $\tan\alpha = \frac{3}{4}$. When the applied force acts downwards as in Fig. 1 the block remains at rest.

(i) Show that $\mu \geqslant \frac{6}{17}$. [5]

When the applied force acts upwards as in Fig. 2 the block slides along the floor.

(ii) Find another inequality for μ. [3]

6



AB and *BC* are straight roads inclined at 5° to the horizontal and 1° to the horizontal respectively. *A* and *C* are at the same horizontal level and *B* is 45 m above the level of *A* and *C* (see diagram, which is not to scale). A car of mass 1200 kg travels from *A* to *C* passing through *B*.

(i) For the motion from *A* to *B*, the speed of the car is constant and the work done against the resistance to motion is 360 kJ. Find the work done by the car's engine from *A* to *B*. [3]

The resistance to motion is constant throughout the whole journey.

(ii) For the motion from *B* to *C* the work done by the driving force is 1660 kJ. Given that the speed of the car at *B* is 15 m s^{-1}, show that its speed at *C* is 29.9 m s^{-1}, correct to 3 significant figures. [4]

(iii) The car's driving force immediately after leaving *B* is 1.5 times the driving force immediately before reaching *C*. Find, correct to 2 significant figures, the ratio of the power developed by the car's engine immediately after leaving *B* to the power developed immediately before reaching *C*. [3]

[Question 7 is printed on the next page.]

7 A particle P starts from a point O and moves along a straight line. P's velocity t s after leaving O is $v\,\mathrm{m\,s^{-1}}$, where

$$v = 0.16t^{\frac{3}{2}} - 0.016t^2.$$

P comes to rest instantaneously at the point A.

(i) Verify that the value of t when P is at A is 100. [1]

(ii) Find the maximum speed of P in the interval $0 < t < 100$. [4]

(iii) Find the distance OA. [3]

(iv) Find the value of t when P passes through O on returning from A. [2]

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

MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **October/November 2011**

1 hour 15 minutes

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

4519530340

READ THESE INSTRUCTIONS FIRST

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This document consists of **4** printed pages.

JC11 11_9709_42/2R

UNIVERSITY of CAMBRIDGE International Examinations

1 A racing cyclist, whose mass with his cycle is 75 kg, works at a rate of 720 W while moving on a straight horizontal road. The resistance to the cyclist's motion is constant and equal to R N.

(i) Given that the cyclist is accelerating at $0.16\,\mathrm{m\,s^{-2}}$ at an instant when his speed is $12\,\mathrm{m\,s^{-1}}$, find the value of R. [3]

(ii) Given that the cyclist's acceleration is positive, show that his speed is less than $15\,\mathrm{m\,s^{-1}}$. [2]

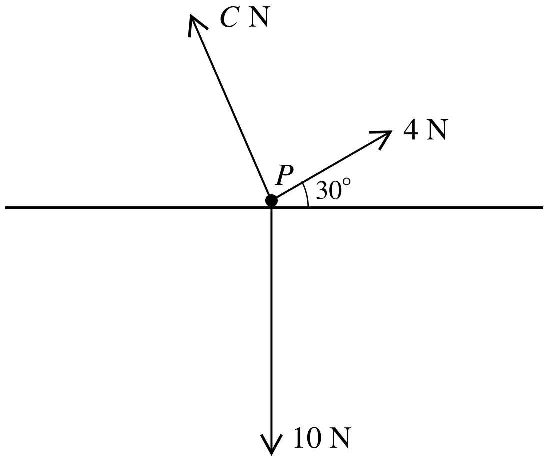
2 A block of mass 6 kg is sliding down a line of greatest slope of a plane inclined at 8° to the horizontal. The coefficient of friction between the block and the plane is 0.2.

(i) Find the deceleration of the block. [3]

(ii) Given that the initial speed of the block is $3\,\mathrm{m\,s^{-1}}$, find how far the block travels. [2]

3 A particle P moves in a straight line. It starts from a point O on the line with velocity $1.8\,\mathrm{m\,s^{-1}}$. The acceleration of P at time t s after leaving O is $0.8t^{-0.75}\,\mathrm{m\,s^{-2}}$. Find the displacement of P from O when $t = 16$. [6]

4



A particle P has weight 10 N and is in limiting equilibrium on a rough horizontal table. The forces shown in the diagram represent the weight of P, an applied force of magnitude 4 N acting on P in a direction at 30° above the horizontal, and the contact force exerted on P by the table (the resultant of the frictional and normal components) of magnitude C N.

(i) Find the value of C. [3]

(ii) Find the coefficient of friction between P and the table. [2]

5 Particles A and B, of masses 0.9 kg and 0.6 kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley. The system is released from rest with the string taut, with its straight parts vertical and with the particles at the same height above the horizontal floor. In the subsequent motion, B does not reach the pulley.

(i) Find the acceleration of A and the tension in the string during the motion before A hits the floor. [4]

After A hits the floor, B continues to move vertically upwards for a further 0.3 s.

(ii) Find the height of the particles above the floor at the instant that they started to move. [4]

6 A lorry of mass 16 000 kg climbs a straight hill $ABCD$ which makes an angle θ with the horizontal, where $\sin\theta = \frac{1}{20}$. For the motion from A to B, the work done by the driving force of the lorry is 1200 kJ and the resistance to motion is constant and equal to 1240 N. The speed of the lorry is $15\,\text{m s}^{-1}$ at A and $12\,\text{m s}^{-1}$ at B.

(i) Find the distance AB. [5]

For the motion from B to D the gain in potential energy of the lorry is 2400 kJ.

(ii) Find the distance BD. [1]

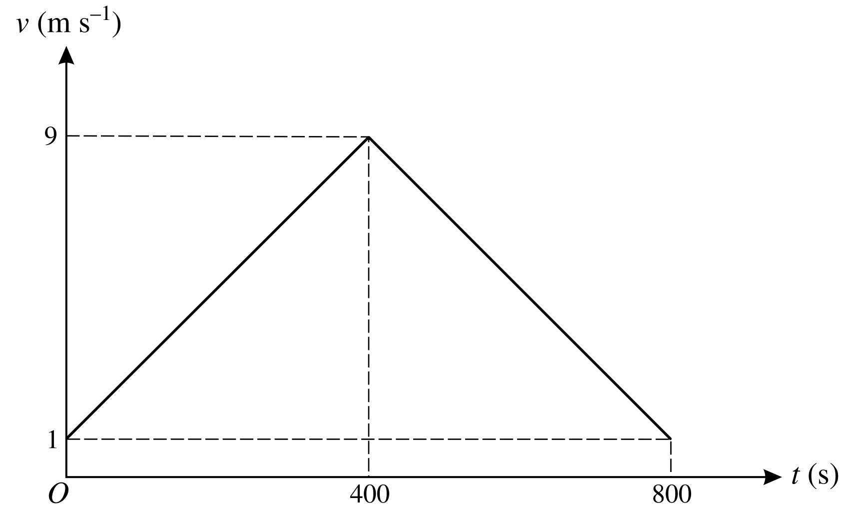
For the motion from B to D the driving force of the lorry is constant and equal to 7200 N. From B to C the resistance to motion is constant and equal to 1240 N and from C to D the resistance to motion is constant and equal to 1860 N.

(iii) Given that the speed of the lorry at D is $7\,\text{m s}^{-1}$, find the distance BC. [4]

[Question 7 is printed on the next page.]

7 A tractor travels in a straight line from a point A to a point B. The velocity of the tractor is $v\,\mathrm{m\,s^{-1}}$ at time t s after leaving A.

(i)



The diagram shows an approximate velocity-time graph for the motion of the tractor. The graph consists of two straight line segments. Use the graph to find an approximation for

(a) the distance AB, [2]

(b) the acceleration of the tractor for $0 < t < 400$ and for $400 < t < 800$. [2]

(ii) The actual velocity of the tractor is given by $v = 0.04t - 0.000\,05t^2$ for $0 \leqslant t \leqslant 800$.

(a) Find the values of t for which the actual acceleration of the tractor is given correctly by the approximate velocity-time graph in part **(i)**. [3]

For the interval $0 \leqslant t \leqslant 400$, the approximate velocity of the tractor in part **(i)** is denoted by $v_1\,\mathrm{m\,s^{-1}}$.

(b) Express v_1 in terms of t and hence show that $v_1 - v = 0.000\,05(t - 200)^2 - 1$. [2]

(c) Deduce that $-1 \leqslant v_1 - v \leqslant 1$. [2]

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

MATHEMATICS **9709/43**

Paper 4 Mechanics 1 **(M1)** **October/November 2011**

1 hour 15 minutes

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

7905752214

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UNIVERSITY of CAMBRIDGE International Examinations

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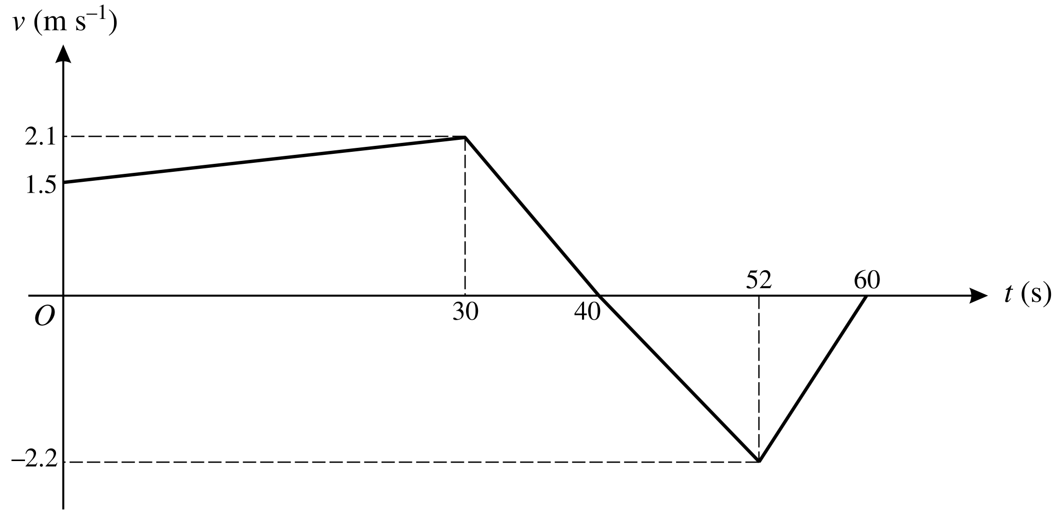


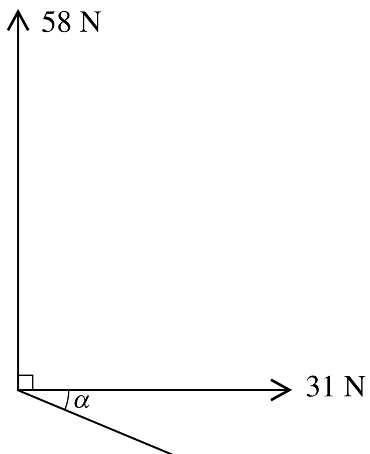
A woman walks in a straight line. The woman's velocity t seconds after passing through a fixed point A on the line is $v\,\mathrm{m\,s^{-1}}$. The graph of v against t consists of 4 straight line segments (see diagram). The woman is at the point B when $t = 60$. Find

(i) the woman's acceleration for $0 < t < 30$ and for $30 < t < 40$, [3]

(ii) the distance AB, [2]

(iii) the total distance walked by the woman. [1]

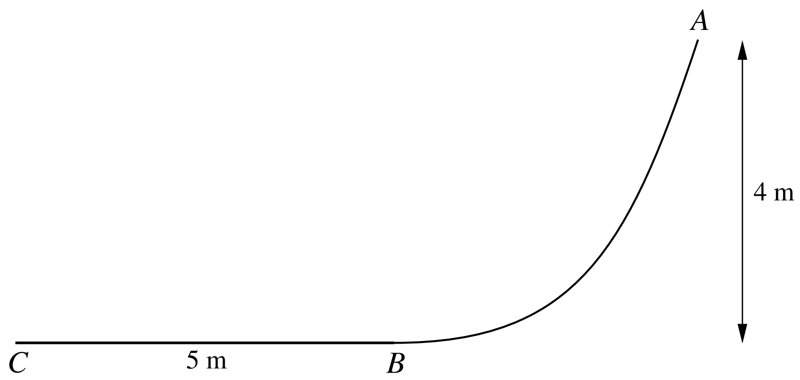
2



Coplanar forces of magnitudes 58 N, 31 N and 26 N act at a point in the directions shown in the diagram. Given that $\tan\alpha = \frac{5}{12}$, find the magnitude and direction of the resultant of the three forces. [6]

3 Particles P and Q are attached to opposite ends of a light inextensible string which passes over a fixed smooth pulley. The system is released from rest with the string taut, with its straight parts vertical, and with both particles at a height of 2 m above horizontal ground. P moves vertically downwards and does not rebound when it hits the ground. At the instant that P hits the ground, Q is at the point X, from where it continues to move vertically upwards without reaching the pulley. Given that P has mass 0.9 kg and that the tension in the string is 7.2 N while P is moving, find the total distance travelled by Q from the instant it first reaches X until it returns to X. [6]

4



ABC is a vertical cross-section of a surface. The part of the surface containing AB is smooth and A is 4 m higher than B. The part of the surface containing BC is horizontal and the distance BC is 5 m (see diagram). A particle of mass 0.8 kg is released from rest at A and slides along ABC. Find the speed of the particle at C in each of the following cases.

(i) The horizontal part of the surface is smooth. [3]

(ii) The coefficient of friction between the particle and the horizontal part of the surface is 0.3. [3]

5 A particle P moves in a straight line. It starts from rest at A and comes to rest instantaneously at B. The velocity of P at time t seconds after leaving A is $v\,\mathrm{m\,s^{-1}}$, where $v = 6t^2 - kt^3$ and k is a constant.

(i) Find an expression for the displacement of P from A in terms of t and k. [2]

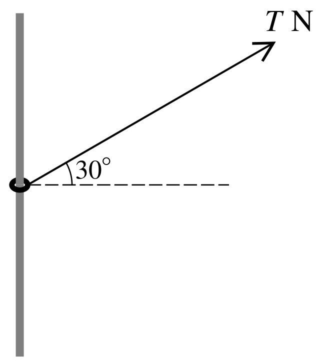
(ii) Find an expression for t in terms of k when P is at B. [1]

Given that the distance AB is 108 m, find

(iii) the value of k, [2]

(iv) the maximum value of v when the particle is moving from A towards B. [3]

6



The diagram shows a ring of mass 2 kg threaded on a fixed rough vertical rod. A light string is attached to the ring and is pulled upwards at an angle of 30° to the horizontal. The tension in the string is T N. The coefficient of friction between the ring and the rod is 0.24. Find the two values of T for which the ring is in limiting equilibrium. [8]

7 A car of mass 600 kg travels along a straight horizontal road starting from a point A. The resistance to motion of the car is 750 N.

(i) The car travels from A to B at constant speed in 100 s. The power supplied by the car's engine is constant and equal to 30 kW. Find the distance AB. [3]

(ii) The car's engine is switched off at B and the car's speed decreases until the car reaches C with a speed of $20\,\mathrm{m\,s^{-1}}$. Find the distance BC. [3]

(iii) The car's engine is switched on at C and the power it supplies is constant and equal to 30 kW. The car takes 14 s to travel from C to D and reaches D with a speed of $30\,\mathrm{m\,s^{-1}}$. Find the distance CD. [4]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
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Advanced Subsidiary Level and Advanced Level

MATHEMATICS **9709/41**

Paper 4 Mechanics 1 **(M1)** **October/November 2012**

1 hour 15 minutes

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

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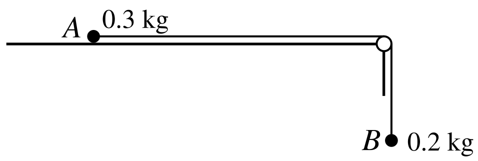
International Examinations

[Turn over

1 An object is released from rest at a height of 125 m above horizontal ground and falls freely under gravity, hitting a moving target P. The target P is moving on the ground in a straight line, with constant acceleration $0.8\,\mathrm{m\,s^{-2}}$. At the instant the object is released P passes through a point O with speed $5\,\mathrm{m\,s^{-1}}$. Find the distance from O to the point where P is hit by the object. [4]

2

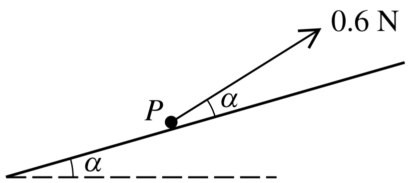


Particles A and B, of masses 0.3 kg and 0.2 kg respectively, are attached to the ends of a light inextensible string. A is held at rest on a rough horizontal table with the string passing over a small smooth pulley at the edge of the table. B hangs vertically below the pulley (see diagram). The system is released and B starts to move downwards with acceleration $1.6\,\mathrm{m\,s^{-2}}$. Find

(i) the tension in the string after the system is released, [2]

(ii) the frictional force acting on A. [3]

3



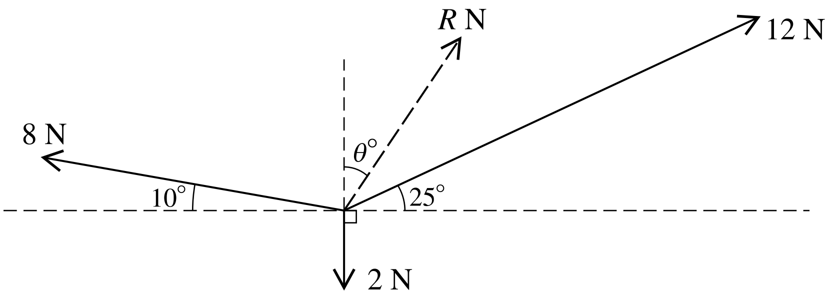
A particle P of mass 0.5 kg rests on a rough plane inclined at angle α to the horizontal, where $\sin\alpha = 0.28$. A force of magnitude 0.6 N, acting upwards on P at angle α from a line of greatest slope of the plane, is just sufficient to prevent P sliding down the plane (see diagram). Find

(i) the normal component of the contact force on P, [2]

(ii) the frictional component of the contact force on P, [3]

(iii) the coefficient of friction between P and the plane. [2]

4



Three coplanar forces of magnitudes 8 N, 12 N and 2 N act at a point. The resultant of the forces has magnitude R N. The directions of the three forces and the resultant are shown in the diagram. Find R and θ. [7]

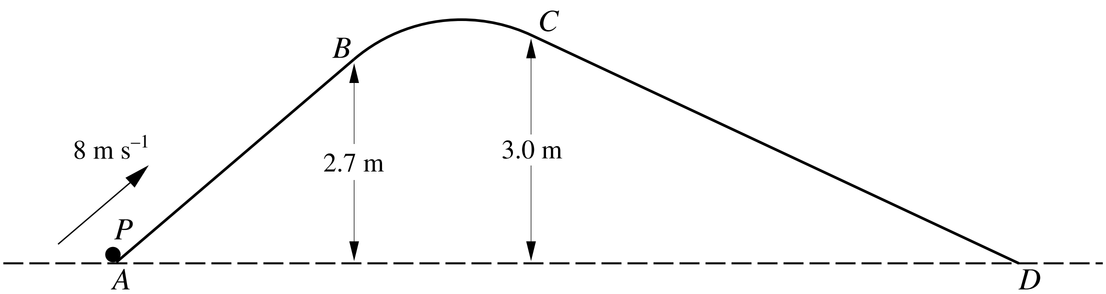
5 Particle P travels along a straight line from A to B with constant acceleration $0.05\,\mathrm{m\,s^{-2}}$. Its speed at A is $2\,\mathrm{m\,s^{-1}}$ and its speed at B is $5\,\mathrm{m\,s^{-1}}$.

(i) Find the time taken for P to travel from A to B, and find also the distance AB. [3]

Particle Q also travels along the same straight line from A to B, starting from rest at A. At time t s after leaving A, the speed of Q is $kt^3\,\mathrm{m\,s^{-1}}$, where k is a constant. Q takes the same time to travel from A to B as P does.

(ii) Find the value of k and find Q's speed at B. [5]

6



The diagram shows the vertical cross-section $ABCD$ of a surface. BC is a circular arc, and AB and CD are tangents to BC at B and C respectively. A and D are at the same horizontal level, and B and C are at heights 2.7 m and 3.0 m respectively above the level of A and D. A particle P of mass 0.2 kg is given a velocity of $8\,\mathrm{m\,s^{-1}}$ at A, in the direction of AB (see diagram). The parts of the surface containing AB and BC are smooth.

(i) Find the decrease in the speed of P as P moves along the surface from B to C. [4]

The part of the surface containing CD exerts a constant frictional force on P, as it moves from C to D, and P comes to rest as it reaches D.

(ii) Find the speed of P when it is at the mid-point of CD. [5]

7 A car of mass 1200 kg moves in a straight line along horizontal ground. The resistance to motion of the car is constant and has magnitude 960 N. The car's engine works at a rate of 17 280 W.

(i) Calculate the acceleration of the car at an instant when its speed is $12\,\mathrm{m\,s^{-1}}$. [3]

The car passes through the points A and B. While the car is moving between A and B it has constant speed $V\,\mathrm{m\,s^{-1}}$.

(ii) Show that $V = 18$. [2]

At the instant that the car reaches B the engine is switched off and subsequently provides no energy. The car continues along the straight line until it comes to rest at the point C. The time taken for the car to travel from A to C is 52.5 s.

(iii) Find the distance AC. [5]

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General Certificate of Education
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MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **October/November 2012**

1 hour 15 minutes

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

1855091403

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JC12 11_9709_42/FP

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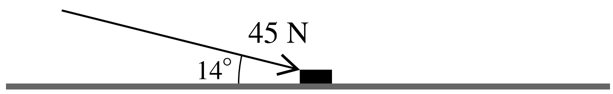
International Examinations

1



A block is pushed along a horizontal floor by a force of magnitude 45 N acting at an angle of 14° to the horizontal (see diagram). Find the work done by the force in moving the block a distance of 25 m. [3]

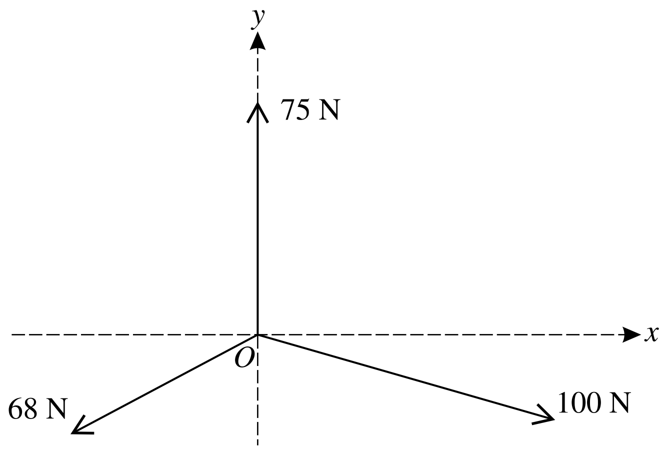
2 Particles A and B of masses m kg and $(1 - m)$ kg respectively are attached to the ends of a light inextensible string which passes over a fixed smooth pulley. The system is released from rest with the straight parts of the string vertical. A moves vertically downwards and 0.3 seconds later it has speed $0.6\,\mathrm{m\,s^{-1}}$. Find

(i) the acceleration of A, [2]

(ii) the value of m and the tension in the string. [4]

3 A car travels along a straight road with constant acceleration $a\,\mathrm{m\,s^{-2}}$. It passes through points A, B and C; the time taken from A to B and from B to C is 5 s in each case. The speed of the car at A is $u\,\mathrm{m\,s^{-1}}$ and the distances AB and BC are 55 m and 65 m respectively. Find the values of a and u. [6]

4



Three coplanar forces of magnitudes 68 N, 75 N and 100 N act at an origin O, as shown in the diagram. The components of the three forces in the positive x-direction are −60 N, 0 N and 96 N, respectively. Find

(i) the components of the three forces in the positive y-direction, [3]

(ii) the magnitude and direction of the resultant of the three forces. [4]

5 A, B and C are three points on a line of greatest slope of a plane which is inclined at $\theta°$ to the horizontal, with A higher than B and B higher than C. Between A and B the plane is smooth, and between B and C the plane is rough. A particle P is released from rest on the plane at A and slides down the line ABC. At time 0.8 s after leaving A, the particle passes through B with speed $4\,\mathrm{m\,s^{-1}}$.

(i) Find the value of θ. [3]

At time 4.8 s after leaving A, the particle comes to rest at C.

(ii) Find the coefficient of friction between P and the rough part of the plane. [5]

6 A car of mass 1250 kg moves from the bottom to the top of a straight hill of length 500 m. The top of the hill is 30 m above the level of the bottom. The power of the car's engine is constant and equal to 30 000 W. The car's acceleration is $4\,\mathrm{m\,s^{-2}}$ at the bottom of the hill and is $0.2\,\mathrm{m\,s^{-2}}$ at the top. The resistance to the car's motion is 1000 N. Find

(i) the car's gain in kinetic energy, [5]

(ii) the work done by the car's engine. [3]

7 A particle P starts to move from a point O and travels in a straight line. The velocity of P is $k(60t^2 - t^3)\,\mathrm{m\,s^{-1}}$ at time t s after leaving O, where k is a constant. The maximum velocity of P is $6.4\,\mathrm{m\,s^{-1}}$.

(i) Show that $k = 0.0002$. [3]

P comes to instantaneous rest at a point A on the line. Find

(ii) the distance OA, [5]

(iii) the magnitude of the acceleration of P at A, [2]

(iv) the speed of P when it subsequently passes through O. [2]

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

MATHEMATICS **9709/43**

Paper 4 Mechanics 1 **(M1)** **October/November 2012**

1 hour 15 minutes

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

2406834266

READ THESE INSTRUCTIONS FIRST

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The total number of marks for this paper is 50.
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JC12 11_9709_43/FP

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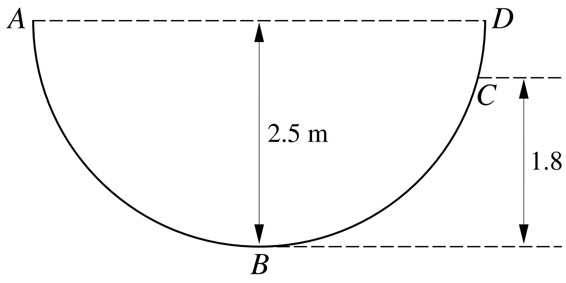
1



$ABCD$ is a semi-circular cross-section, in a vertical plane, of the inner surface of half a hollow cylinder of radius 2.5 m which is fixed with its axis horizontal. AD is horizontal, B is the lowest point of the cross-section and C is at a height of 1.8 m above the level of B (see diagram). A particle P of mass 0.8 kg is released from rest at A and comes to instantaneous rest at C.

(i) Find the work done on P by the resistance to motion while P travels from A to C. [2]

The work done on P by the resistance to motion while P travels from A to B is 0.6 times the work done while P travels from A to C.

(ii) Find the speed of P when it passes through B. [3]

2 A particle moves in a straight line. Its velocity t seconds after leaving a fixed point O on the line is $v\,\mathrm{m\,s^{-1}}$, where $v = 0.2t + 0.006t^2$. For the instant when the acceleration of the particle is 2.5 times its initial acceleration,

(i) show that $t = 25$, [3]

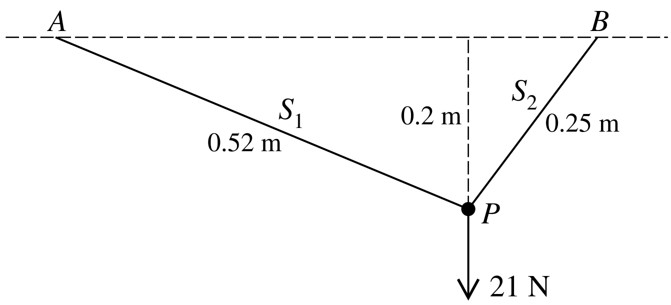
(ii) find the displacement of the particle from O. [3]

3 A particle P is projected vertically upwards, from a point O, with a velocity of $8\,\mathrm{m\,s^{-1}}$. The point A is the highest point reached by P. Find

(i) the speed of P when it is at the mid-point of OA, [4]

(ii) the time taken for P to reach the mid-point of OA while moving upwards. [2]

4



A particle P of weight 21 N is attached to one end of each of two light inextensible strings, S_1 and S_2, of lengths 0.52 m and 0.25 m respectively. The other end of S_1 is attached to a fixed point A, and the other end of S_2 is attached to a fixed point B at the same horizontal level as A. The particle P hangs in equilibrium at a point 0.2 m below the level of AB with both strings taut (see diagram). Find the tension in S_1 and the tension in S_2. [6]

5 An object of mass 12 kg slides down a line of greatest slope of a smooth plane inclined at $10°$ to the horizontal. The object passes through points A and B with speeds $3\,\mathrm{m\,s^{-1}}$ and $7\,\mathrm{m\,s^{-1}}$ respectively.

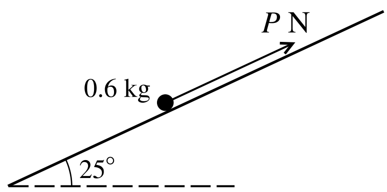
(i) Find the increase in kinetic energy of the object as it moves from A to B. [2]

(ii) Hence find the distance AB, assuming there is no resisting force acting on the object. [3]

The object is now pushed up the plane from B to A, with constant speed, by a horizontal force.

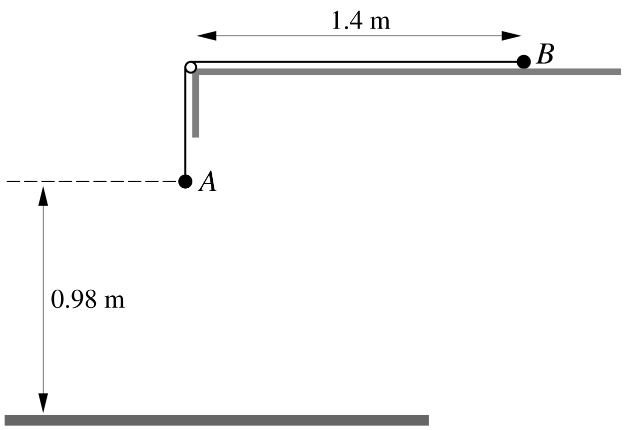
(iii) Find the magnitude of this force. [3]

6



The diagram shows a particle of mass 0.6 kg on a plane inclined at $25°$ to the horizontal. The particle is acted on by a force of magnitude P N directed up the plane parallel to a line of greatest slope. The coefficient of friction between the particle and the plane is 0.36. Given that the particle is in equilibrium, find the set of possible values of P. [9]

7



Particles A and B have masses 0.32 kg and 0.48 kg respectively. The particles are attached to the ends of a light inextensible string which passes over a small smooth pulley fixed at the edge of a smooth horizontal table. Particle B is held at rest on the table at a distance of 1.4 m from the pulley. A hangs vertically below the pulley at a height of 0.98 m above the floor (see diagram). A, B, the string and the pulley are all in the same vertical plane. B is released and A moves downwards.

(i) Find the acceleration of A and the tension in the string. [5]

A hits the floor and B continues to move towards the pulley. Find the time taken, from the instant that B is released, for

(ii) A to reach the floor, [2]

(iii) B to reach the pulley. [3]

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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

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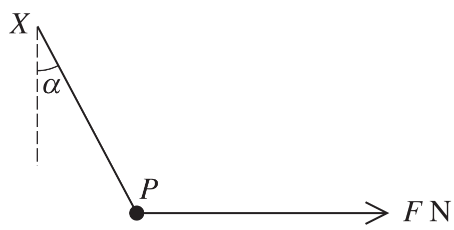
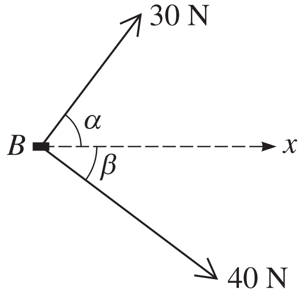


A particle P of mass 0.3 kg is attached to one end of a light inextensible string. The other end of the string is attached to a fixed point X. A horizontal force of magnitude F N is applied to the particle, which is in equilibrium when the string is at an angle α to the vertical, where $\tan\alpha = \frac{8}{15}$ (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 $-0.2\ \text{m s}^{-2}$.

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

The cyclist's speed is $7\ \text{m s}^{-1}$ 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]

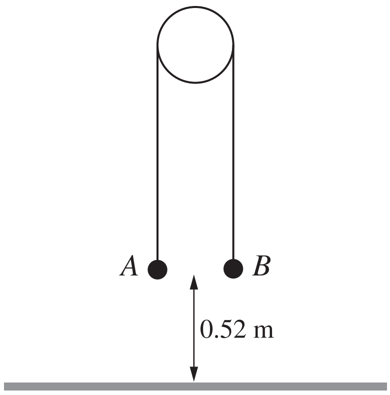
5 A lorry of mass 15 000 kg climbs from the bottom to the top of a straight hill, of length 1440 m, at a constant speed of $15\,\mathrm{m\,s^{-1}}$. The top of the hill is 16 m above the level of the bottom of the hill. The resistance to motion is constant and equal to 1800 N.

(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]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
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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)

2432296032

READ THESE INSTRUCTIONS FIRST

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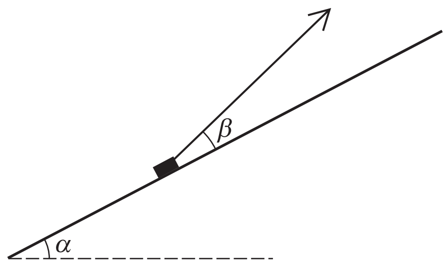
1



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]

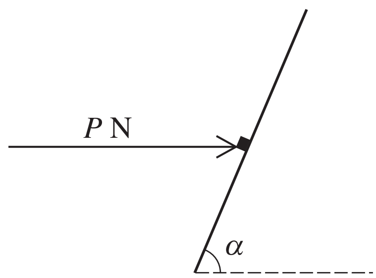
2 A box of mass 25 kg is pulled in a straight line along a horizontal floor. The box starts from rest at a point A and has a speed of $3\,\mathrm{m\,s^{-1}}$ when it reaches a point B. The distance AB is 15 m. The pulling force has magnitude 220 N and acts at an angle of $\alpha°$ above the horizontal. 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]

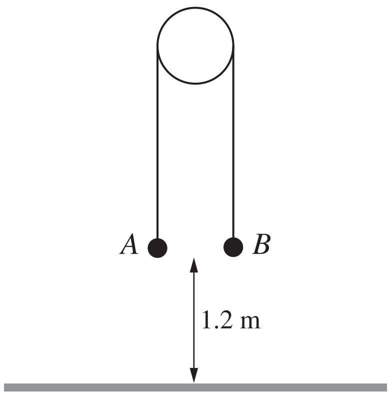
5 A particle P moves in a straight line. P starts from rest at O and travels to A where it comes to rest, taking 50 seconds. The speed of P at time t seconds after leaving O is $v\,\mathrm{m\,s^{-1}}$, where v is defined as follows.

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

(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.

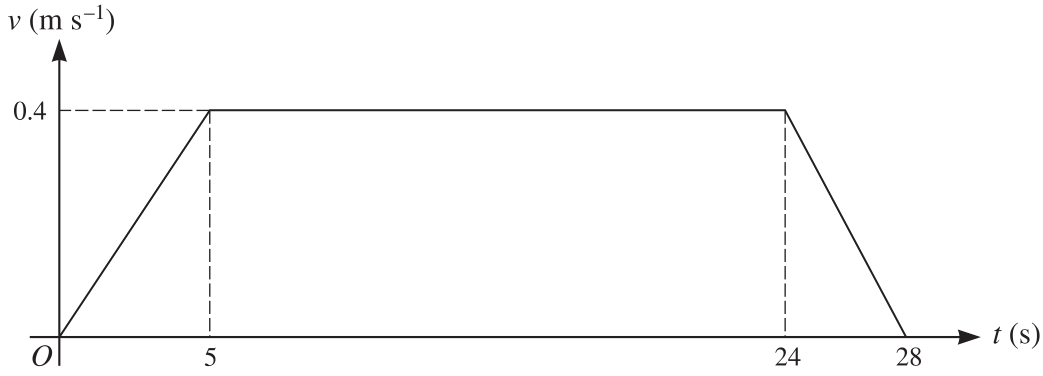
(i) Find the work done on B by the tension in the string, as B moves to the floor. [5]

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]

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

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)

7205360621

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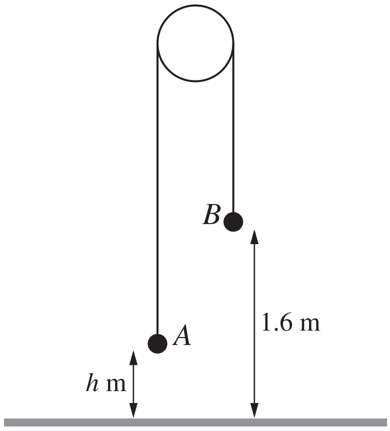
1 A particle moves up a line of greatest slope of a rough plane inclined at an angle α to the horizontal, where $\sin\alpha = 0.28$. The coefficient of friction between the particle and the plane is $\frac{1}{3}$.

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

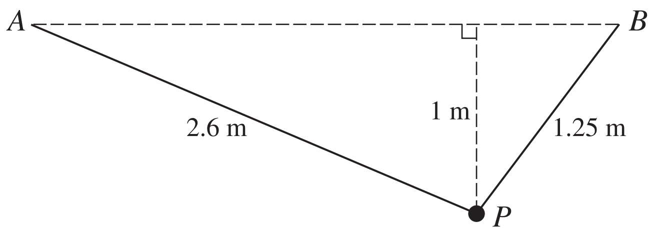
(ii) Given that the particle's initial speed is $5.4\,\mathrm{m\,s^{-1}}$, find the distance that the particle travels up the plane. [2]

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 m s^{-2}, reaching a speed of V m s^{-1}. The car then continues to move at V m s^{-1} for T_2 s. It then decelerates for T_3 s at 1 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 m s^{-1} and its acceleration at B is 0.096 m s^{-2}. Find the acceleration of the lorry at A and show that its speed at B is 24 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 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 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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MATHEMATICS **9709/04**

Paper 4 Mechanics 1 **(M1)** **For Examination from 2017**

SPECIMEN PAPER **1 hour 15 minutes**

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

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CAMBRIDGE International Examinations

1 A weightlifter performs an exercise in which he raises a mass of 200 kg from rest vertically through a distance of 0.7 m and holds it at that height.

(i) Find the work done by the weightlifter. [2]

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(ii) Given that the time taken to raise the mass is 1.2 s, find the average power developed by the weightlifter. [2]

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2 A particle of mass 0.5 kg starts from rest and slides down a line of greatest slope of a smooth plane. The plane is inclined at an angle of 30° to the horizontal.

(i) Find the time taken for the particle to reach a speed of $2.5 \mathrm{~m~s^{-1}}$. [3]

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When the particle has travelled 3 m down the slope from its starting point, it reaches rough horizontal ground at the bottom of the slope. The frictional force acting on the particle is 1 N.

(ii) Find the distance that the particle travels along the ground before it comes to rest. [3]

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3 A lorry of mass 24 000 kg is travelling up a hill which is inclined at 3° to the horizontal. The power developed by the lorry's engine is constant, and there is a constant resistance to motion of 3200 N.

(i) When the speed of the lorry is $25\,\mathrm{m\,s^{-1}}$, its acceleration is $0.2\,\mathrm{m\,s^{-2}}$. Find the power developed by the lorry's engine. [4]

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(ii) Find the steady speed at which the lorry moves up the hill if the power is 500 kW and the resistance remains 3200 N. [2]

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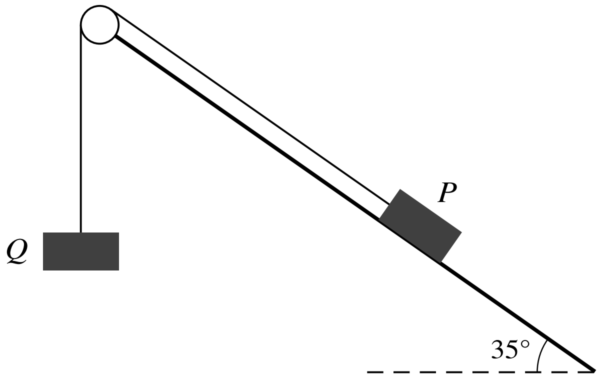

Blocks P and Q, of mass m kg and 5 kg respectively, are attached to the ends of a light inextensible string. The string passes over a small smooth pulley which is fixed at the top of a rough plane inclined at 35° to the horizontal. Block P is at rest on the plane and block Q hangs vertically below the pulley (see diagram). The coefficient of friction between block P and the plane is 0.2. Find the set of values of m for which the two blocks remain at rest. [6]

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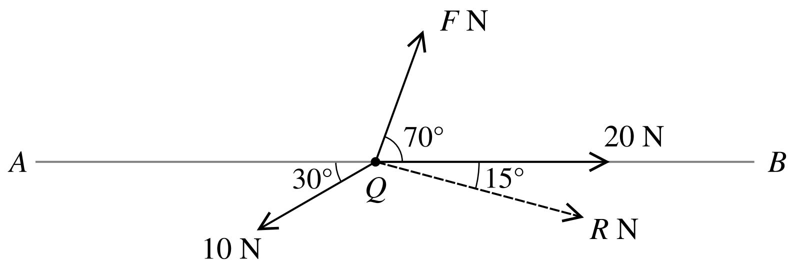

A small bead Q can move freely along a smooth horizontal straight wire AB of length 3 m. Three horizontal forces of magnitudes F N, 10 N and 20 N act on the bead in the directions shown in the diagram. The magnitude of the resultant of the three forces is R N in the direction shown in the diagram.

(i) Find the values of F and R. [5]

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(ii) Initially the bead is at rest at A. It reaches B with a speed of $11.7\,\mathrm{m\,s^{-1}}$. Find the mass of the bead. [3]

6 A particle P moves in a straight line, starting from a point O. The velocity of P, measured in m s^{-1}, at time t s after leaving O is given by

$$v = 0.6t - 0.03t^2.$$

(i) Verify that, when $t = 5$, the particle is 6.25 m from O. Find the acceleration of the particle at this time. [4]

(ii) Find the values of t at which the particle is travelling at half of its maximum velocity. [6]

7 A cyclist starts from rest at point A and moves in a straight line with acceleration $0.5\,\mathrm{m\,s^{-2}}$ for a distance of 36 m. The cyclist then travels at constant speed for 25 s before slowing down, with constant deceleration, to come to rest at point B. The distance AB is 210 m.

(i) Find the total time that the cyclist takes to travel from A to B. [5]

24 s after the cyclist leaves point A, a car starts from rest from point A, with constant acceleration $4\,\mathrm{m\,s^{-2}}$, towards B. It is given that the car overtakes the cyclist while the cyclist is moving with constant speed.

(ii) Find the time that it takes from when the cyclist starts until the car overtakes her. [5]

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