Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

3333132430

MATHEMATICS **9709/41**

Paper 4 Mechanics **October/November 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.
- Write your answer to each question in the space provided.
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- You should use a calculator where appropriate.
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- 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 **12** pages.

1 A bus moves from rest with constant acceleration for 12 s. It then moves with constant speed for 30 s before decelerating uniformly to rest in a further 6 s. The total distance travelled is 585 m.

(a) Find the constant speed of the bus. [2]

(b) Find the magnitude of the deceleration. [1]

2 Two small smooth spheres A and B, of equal radii and of masses km kg and m kg respectively, where $k > 1$, are free to move on a smooth horizontal plane. A is moving towards B with speed $6\,\mathrm{m\,s^{-1}}$ and B is moving towards A with speed $2\,\mathrm{m\,s^{-1}}$. After the collision A and B coalesce and move with speed $4\,\mathrm{m\,s^{-1}}$.

(a) Find k. [3]

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(b) Find, in terms of m, the loss of kinetic energy due to the collision. [2]

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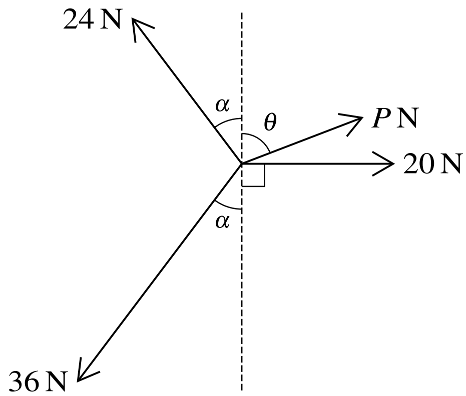

Coplanar forces of magnitudes 24 N, P N, 20 N and 36 N act at a point in the directions shown in the diagram. The system is in equilibrium.

Given that $\sin\alpha = \frac{3}{5}$, find the values of P and θ. [6]

4 A particle of mass 12 kg is stationary on a rough plane inclined at an angle of 25° to the horizontal. A force of magnitude P N acting parallel to a line of greatest slope of the plane is used to prevent the particle sliding down the plane. The coefficient of friction between the particle and the plane is 0.35.

(a) Draw a sketch showing the forces acting on the particle. [1]

(b) Find the least possible value of P. [5]

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5 A car of mass 1600 kg travels at constant speed $20\,\mathrm{m\,s^{-1}}$ up a straight road inclined at an angle of $\sin^{-1} 0.12$ to the horizontal.

(a) Find the change in potential energy of the car in 30 s. [3]

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(b) Given that the total work done by the engine of the car in this time is 1960 kJ, find the constant force resisting the motion. [3]

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

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(d) Given that this power is suddenly decreased by 15%, find the instantaneous deceleration of the car. [3]

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6 A particle P moves in a straight line starting from a point O and comes to rest 14 s later. At time t s after leaving O, the velocity $v\,\mathrm{m\,s^{-1}}$ of P is given by

$$v = pt^2 - qt \qquad 0 \leqslant t \leqslant 6,$$
$$v = 63 - 4.5t \qquad 6 \leqslant t \leqslant 14,$$

where p and q are positive constants.

The acceleration of P is zero when $t = 2$.

(a) Given that there are no instantaneous changes in velocity, find p and q. [3]

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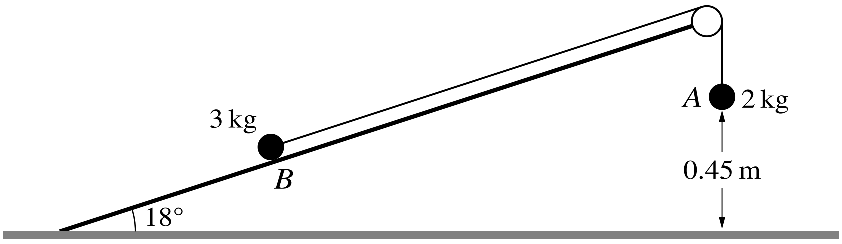
(b) Sketch the velocity-time graph. [3]

(c) Find the total distance travelled by P during the 14 s. [5]

7 

Two particles A and B of masses 2 kg and 3 kg respectively are connected by a light inextensible string. Particle B is on a smooth fixed plane which is at an angle of 18° to horizontal ground. The string passes over a fixed smooth pulley at the top of the plane. Particle A hangs vertically below the pulley and is 0.45 m above the ground (see diagram). The system is released from rest with the string taut. When A reaches the ground, the string breaks.

Find the total distance travelled by B before coming to instantaneous rest. You may assume that B does not reach the pulley. [8]

Additional Page

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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

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* 7 6 1 5 1 5 5 8 8 4 *

MATHEMATICS **9709/42**

Paper 4 Mechanics **October/November 2021**

1 hour 15 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS

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This document has **12** pages.

JC21 11_9709_42/2R

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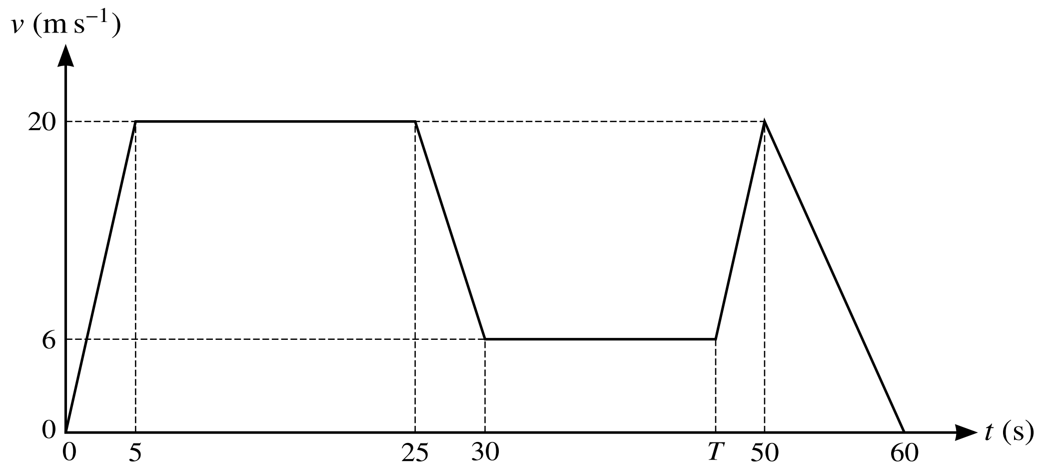

The diagram shows a velocity-time graph which models the motion of a car. The graph consists of six straight line segments. The car accelerates from rest to a speed of $20\,\text{m}\,\text{s}^{-1}$ over a period of 5 s, and then travels at this speed for a further 20 s. The car then decelerates to a speed of $6\,\text{m}\,\text{s}^{-1}$ over a period of 5 s. This speed is maintained for a further $(T - 30)$ s. The car then accelerates again to a speed of $20\,\text{m}\,\text{s}^{-1}$ over a period of $(50 - T)$ s, before decelerating to rest over a period of 10 s.

(a) Given that during the two stages of the motion when the car is accelerating, the accelerations are equal, find the value of T. [2]

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(b) Find the total distance travelled by the car during the motion. [2]

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2 A van of mass 3600 kg is towing a trailer of mass 1200 kg along a straight horizontal road using a light horizontal rope. There are resistance forces of 700 N on the van and 300 N on the trailer.

(a) The driving force exerted by the van is 2500 N.

Find the tension in the rope. [4]

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The driving force is now removed and the van driver applies a braking force which acts only on the van. The resistance forces remain unchanged.

(b) Find the least possible value of the braking force which will cause the rope to become slack. [2]

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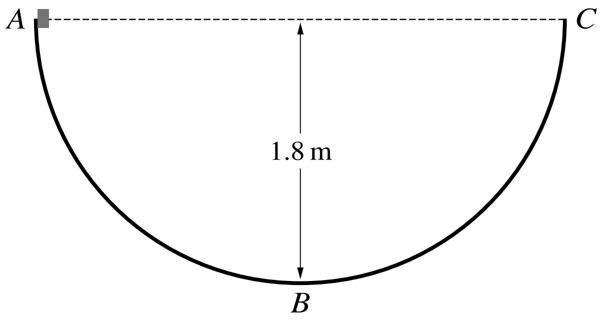

The diagram shows a semi-circular track ABC of radius 1.8 m which is fixed in a vertical plane. The points A and C are at the same horizontal level and the point B is at the bottom of the track. The section AB is smooth and the section BC is rough. A small block is released from rest at A.

(a) Show that the speed of the block at B is $6\,\text{m}\,\text{s}^{-1}$. [2]

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The block comes to instantaneous rest for the first time at a height of 1.2 m above the level of B. The work done against the resistance force during the motion of the block from B to this point is 4.5 J.

(b) Find the mass of the block. [3]

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4 A cyclist starts from rest at a point A and travels along a straight road AB, coming to rest at B. The displacement of the cyclist from A at time t s after the start is s m, where

$$s = 0.004(75t^2 - t^3).$$

(a) Show that the distance AB is 250 m. [4]

(b) Find the maximum velocity of the cyclist. [3]

5 A railway engine of mass 75 000 kg is moving up a straight hill inclined at an angle α to the horizontal, where $\sin\alpha = 0.01$. The engine is travelling at a constant speed of $30\,\mathrm{m\,s^{-1}}$. The engine is working at 960 kW. There is a constant force resisting the motion of the engine.

(a) Find the resistance force. [3]

The engine comes to a section of track which is horizontal. At the start of the section the engine is travelling at $30\,\mathrm{m\,s^{-1}}$ and the power of the engine is now reduced to 900 kW. The resistance to motion is no longer constant, but in the next 60 s the work done against the resistance force is 46 500 kJ.

(b) Find the speed of the engine at the end of the 60 s. [4]

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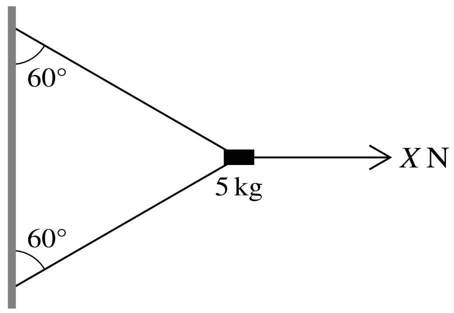

A block of mass 5 kg is held in equilibrium near a vertical wall by two light strings and a horizontal force of magnitude X N, as shown in the diagram. The two strings are both inclined at 60° to the vertical.

(a) Given that $X = 100$, find the tension in the lower string. [4]

(b) Find the least value of X for which the block remains in equilibrium in the position shown. [4]

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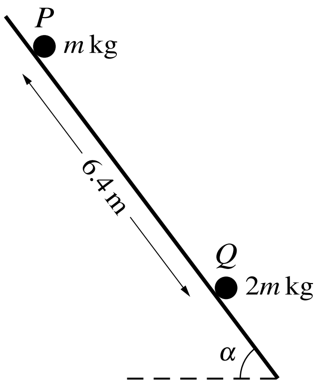

Particles P and Q have masses m kg and $2m$ kg respectively. The particles are initially held at rest 6.4 m apart on the same line of greatest slope of a rough plane inclined at an angle α to the horizontal, where $\sin\alpha = 0.8$ (see diagram). Particle P is released from rest and slides down the line of greatest slope. Simultaneously, particle Q is projected up the same line of greatest slope at a speed of $10\,\text{m s}^{-1}$. The coefficient of friction between each particle and the plane is 0.6.

(a) Show that the acceleration of Q up the plane is $-11.6\,\text{m s}^{-2}$. [4]

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(b) Find the time for which the particles are in motion before they collide. [5]

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(c) The particles coalesce on impact.

Find the speed of the combined particle immediately after the impact. [4]

Additional Page

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Cambridge Assessment International Education

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CANDIDATE NAME

CENTRE NUMBER

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2275268691

MATHEMATICS **9709/43**

Paper 4 Mechanics **October/November 2021**

1 hour 15 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS

- Answer **all** questions.
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INFORMATION

- The total mark for this paper is 50.
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This document has **12** pages. Any blank pages are indicated.

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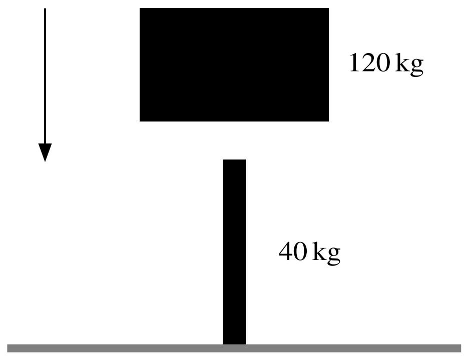
1



A metal post is driven vertically into the ground by dropping a heavy object onto it from above. The mass of the object is 120 kg and the mass of the post is 40 kg (see diagram). The object hits the post with speed $8\,\mathrm{m\,s^{-1}}$ and remains in contact with it after the impact.

(a) Calculate the speed with which the combined post and object moves immediately after the impact. [2]

(b) There is a constant force resisting the motion of magnitude 4800 N.

Calculate the distance the post is driven into the ground. [3]

2 A particle of mass 8 kg is suspended in equilibrium by two light inextensible strings which make angles of 60° and 45° above the horizontal.

(a) Draw a diagram showing the forces acting on the particle. [1]

(b) Find the tensions in the strings. [6]

3 A ball of mass 1.6 kg is released from rest at a point 5 m above horizontal ground. When the ball hits the ground it instantaneously loses 8 J of kinetic energy and starts to move upwards.

(a) Use an energy method to find the greatest height that the ball reaches after hitting the ground. [3]

(b) Find the total time taken, from the initial release of the ball until it reaches this greatest height. [3]

4 A car of mass 1400 kg is moving on a straight road against a constant force of 1250 N resisting the motion.

(a) The car moves along a horizontal section of the road at a constant speed of $36\,\mathrm{m\,s^{-1}}$.

(i) Calculate the work done against the resisting force during the first 8 seconds. [2]

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

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(iii) Given that this power is suddenly increased by 12 kW, find the instantaneous acceleration of the car. [3]

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(b) The car now travels at a constant speed of $32\,\mathrm{m\,s^{-1}}$ up a section of the road inclined at $\theta°$ to the horizontal, with the engine working at 64 kW.

Find the value of θ. [2]

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5 A particle P moves in a straight line, starting from rest at a point O on the line. At time t s after leaving O the acceleration of P is $k(16 - t^2)\ \mathrm{m\,s^{-2}}$, where k is a positive constant, and the displacement from O is s m. The velocity of P is $8\ \mathrm{m\,s^{-1}}$ when $t = 4$.

(a) Show that $s = \frac{1}{64}t^2(96 - t^2)$. [5]

(b) Find the speed of P at the instant that it returns to O. [3]

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(c) Find the maximum displacement of the particle from O. [3]

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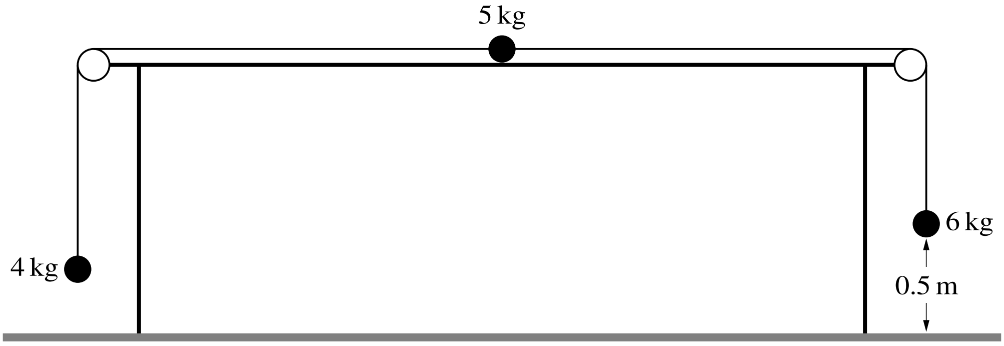

The diagram shows a particle of mass 5 kg on a rough horizontal table, and two light inextensible strings attached to it passing over smooth pulleys fixed at the edges of the table. Particles of masses 4 kg and 6 kg hang freely at the ends of the strings. The particle of mass 6 kg is 0.5 m above the ground. The system is in limiting equilibrium.

(a) Show that the coefficient of friction between the 5 kg particle and the table is 0.4. [2]

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The 6 kg particle is now replaced by a particle of mass 8 kg and the system is released from rest.

(b) Find the acceleration of the 4 kg particle and the tensions in the strings. [5]

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(c) In the subsequent motion the 8 kg particle hits the ground and does not rebound.

Find the time that elapses after the 8 kg particle hits the ground before the other two particles come to instantaneous rest. (You may assume this occurs before either particle reaches a pulley.) [5]

Additional Page

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Cambridge International AS & A Level

CANDIDATE NAME					
CENTRE NUMBER					
CANDIDATE NUMBER					

* 9 7 8 2 9 8 4 7 8 9 *

MATHEMATICS **9709/43**

Paper 4 Mechanics **May/June 2021**

1 hour 15 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS
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INFORMATION
- The total mark for this paper is 50.
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This document has **12** pages.

1 Particles P of mass 0.4 kg and Q of mass 0.5 kg are free to move on a smooth horizontal plane. P and Q are moving directly towards each other with speeds $2.5\,\mathrm{m\,s^{-1}}$ and $1.5\,\mathrm{m\,s^{-1}}$ respectively. After P and Q collide, the speed of Q is twice the speed of P.

Find the two possible values of the speed of P after the collision. [4]

2 A cyclist is travelling along a straight horizontal road. She is working at a constant rate of 150 W. At an instant when her speed is $4\,\mathrm{m\,s^{-1}}$, her acceleration is $0.25\,\mathrm{m\,s^{-2}}$. The resistance to motion is 20 N.

(a) Find the total mass of the cyclist and her bicycle. [3]

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The cyclist comes to a straight hill inclined at an angle θ above the horizontal. She ascends the hill at constant speed $3\,\mathrm{m\,s^{-1}}$. She continues to work at the same rate as before and the resistance force is unchanged.

(b) Find the value of θ. [2]

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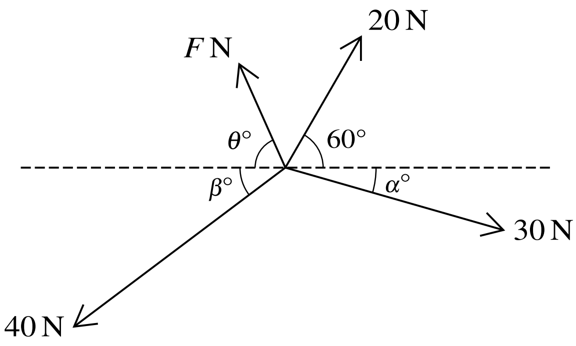

Four coplanar forces act at a point. The magnitudes of the forces are 20 N, 30 N, 40 N and F N. The directions of the forces are as shown in the diagram, where $\sin \alpha° = 0.28$ and $\sin \beta° = 0.6$.

Given that the forces are in equilibrium, find F and θ. [6]

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4 A particle is projected vertically upwards with speed $u\,\mathrm{m\,s^{-1}}$ from a point on horizontal ground. After 2 seconds, the height of the particle above the ground is 24 m.

(a) Show that $u = 22$. [2]

(b) The height of the particle above the ground is more than h m for a period of 3.6 s.

Find h. [4]

5 A car of mass 1400 kg is towing a trailer of mass 500 kg down a straight hill inclined at an angle of 5° to the horizontal. The car and trailer are connected by a light rigid tow-bar. At the top of the hill the speed of the car and trailer is $20\,\mathrm{m\,s^{-1}}$ and at the bottom of the hill their speed is $30\,\mathrm{m\,s^{-1}}$.

(a) It is given that as the car and trailer descend the hill, the engine of the car does 150 000 J of work, and there are no resistance forces.

Find the length of the hill. [5]

(b) It is given instead that there is a resistance force of 100 N on the trailer, the length of the hill is 200 m, and the acceleration of the car and trailer is constant.

Find the tension in the tow-bar between the car and trailer. [4]

6 A particle moves in a straight line and passes through the point A at time $t = 0$. The velocity of the particle at time t s after leaving A is $v \text{ m s}^{-1}$, where

$$v = 2t^2 - 5t + 3.$$

(a) Find the times at which the particle is instantaneously at rest. Hence or otherwise find the minimum velocity of the particle. [4]

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(b) Sketch the velocity-time graph for the first 3 seconds of motion. [3]

(c) Find the distance travelled between the two times when the particle is instantaneously at rest. [3]

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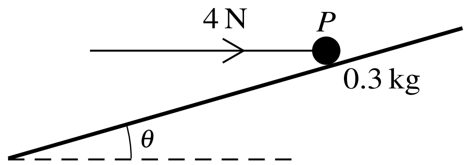

A particle P of mass 0.3 kg rests on a rough plane inclined at an angle θ to the horizontal, where $\sin\theta = \frac{7}{25}$. A horizontal force of magnitude 4 N, acting in the vertical plane containing a line of greatest slope of the plane, is applied to P (see diagram). The particle is on the point of sliding up the plane.

(a) Show that the coefficient of friction between the particle and the plane is $\frac{3}{4}$. [4]

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The force acting horizontally is replaced by a force of magnitude 4 N acting up the plane parallel to a line of greatest slope.

(b) Find the acceleration of P. [3]

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(c) Starting with P at rest, the force of 4 N parallel to the plane acts for 3 seconds and is then removed.

Find the total distance travelled until P comes to instantaneous rest. [3]

Additional Page

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CANDIDATE NAME

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4405618753

MATHEMATICS **9709/42**

Paper 4 Mechanics **May/June 2021**

1 hour 15 minutes

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1 A particle of mass 0.6 kg is projected with a speed of 4 m s^{-1} down a line of greatest slope of a smooth plane inclined at $10°$ to the horizontal.

Use an energy method to find the speed of the particle after it has moved 15 m down the plane. [3]

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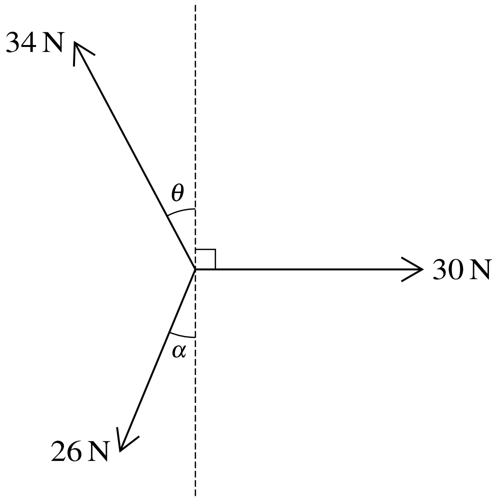

Coplanar forces of magnitudes 34 N, 30 N and 26 N act at a point in the directions shown in the diagram.

Given that $\sin\alpha = \frac{5}{13}$ and $\sin\theta = \frac{8}{17}$, find the magnitude and direction of the resultant of the three forces. [6]

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3 A ring of mass 0.3 kg is threaded on a horizontal rough rod. The coefficient of friction between the ring and the rod is 0.8. A force of magnitude 8 N acts on the ring. This force acts at an angle of 10° above the horizontal in the vertical plane containing the rod.

Find the time taken for the ring to move, from rest, 0.6 m along the rod. [6]

4 A particle of mass 12 kg is stationary on a rough plane inclined at an angle of 25° to the horizontal. A pulling force of magnitude P N acts at an angle of 8° above a line of greatest slope of the plane. This force is used to keep the particle in equilibrium. The coefficient of friction between the particle and the plane is 0.3.

Find the greatest possible value of P. [6]

5 A car of mass 1250 kg is pulling a caravan of mass 800 kg along a straight road. The resistances to the motion of the car and caravan are 440 N and 280 N respectively. The car and caravan are connected by a light rigid tow-bar.

(a) The car and caravan move along a horizontal part of the road at a constant speed of $30\,\mathrm{m\,s^{-1}}$.

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

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(ii) Given that this power is suddenly decreased by 8 kW, find the instantaneous deceleration of the car and caravan and the tension in the tow-bar. [4]

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(b) The car and caravan now travel along a part of the road inclined at $\sin^{-1} 0.06$ to the horizontal. The car and caravan travel up the incline at constant speed with the engine of the car working at 28 kW.

(i) Find this constant speed. [3]

(ii) Find the increase in the potential energy of the caravan in one minute. [2]

6 A particle A is projected vertically upwards from level ground with an initial speed of $30\,\mathrm{m\,s^{-1}}$. At the same instant a particle B is released from rest 15 m vertically above A. The mass of one of the particles is twice the mass of the other particle. During the subsequent motion A and B collide and coalesce to form particle C.

Find the difference between the two possible times at which C hits the ground. [8]

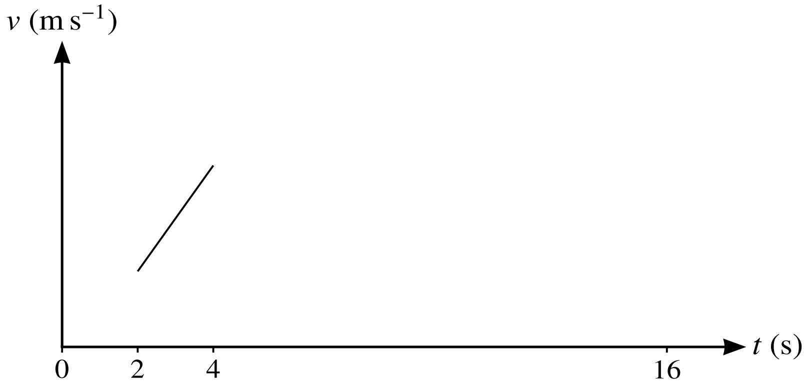
7 A particle P moving in a straight line starts from rest at a point O and comes to rest 16 s later. At time t s after leaving O, the acceleration $a\,\mathrm{m\,s^{-2}}$ of P is given by

$$\begin{array}{ll} a = 6 + 4t & 0 \leqslant t < 2, \\ a = 14 & 2 \leqslant t < 4, \\ a = 16 - 2t & 4 \leqslant t \leqslant 16. \end{array}$$

There is no sudden change in velocity at any instant.

(a) Find the values of t when the velocity of P is $55\,\mathrm{m\,s^{-1}}$. [5]

(b) Complete the sketch of the velocity-time diagram. [2]



(c) Find the distance travelled by P when it is decelerating. [3]

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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 Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

* 2 7 7 6 4 3 9 3 6 9 *

MATHEMATICS **9709/41**

Paper 4 Mechanics **May/June 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.
- Write your answer to each question in the space provided.
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- 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 $10\,\text{m}\,\text{s}^{-2}$.

INFORMATION

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

JC21 06_9709_41/RP

1 A winch operates by means of a force applied by a rope. The winch is used to pull a load of mass 50 kg up a line of greatest slope of a plane inclined at 60° to the horizontal. The winch pulls the load a distance of 5 m up the plane at constant speed. There is a constant resistance to motion of 100 N.

Find the work done by the winch. [3]

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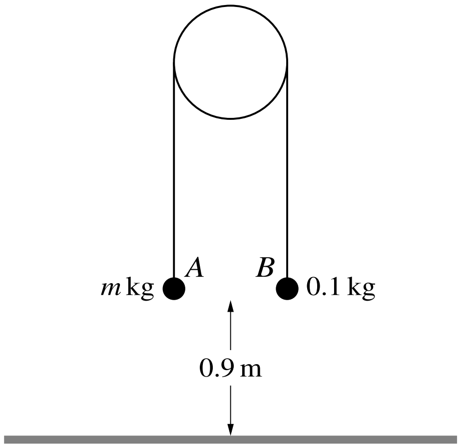

Two particles A and B have masses m kg and 0.1 kg respectively, where $m > 0.1$. The particles are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley and the particles hang vertically below it. Both particles are at a height of 0.9 m above horizontal ground (see diagram). The system is released from rest, and while both particles are in motion the tension in the string is 1.5 N. Particle B does not reach the pulley.

(a) Find m. [4]

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(b) Find the speed at which A reaches the ground. [2]

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3 Three particles P, Q and R, of masses 0.1 kg, 0.2 kg and 0.5 kg respectively, are at rest in a straight line on a smooth horizontal plane. Particle P is projected towards Q at a speed of $5\,\mathrm{m\,s^{-1}}$. After P and Q collide, P rebounds with speed $1\,\mathrm{m\,s^{-1}}$.

(a) Find the speed of Q immediately after the collision with P. [3]

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Q now collides with R. Immediately after the collision with Q, R begins to move with speed $V\,\mathrm{m\,s^{-1}}$.

(b) Given that there is no subsequent collision between P and Q, find the greatest possible value of V. [3]

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4 Two cyclists, Isabella and Maria, are having a race. They both travel along a straight road with constant acceleration, starting from rest at point A.

Isabella accelerates for 5 s at a constant rate $a\,\mathrm{m\,s^{-2}}$. She then travels at the constant speed she has reached for 10 s, before decelerating to rest at a constant rate over a period of 5 s.

Maria accelerates at a constant rate, reaching a speed of $5\,\mathrm{m\,s^{-1}}$ in a distance of 27.5 m. She then maintains this speed for a period of 10 s, before decelerating to rest at a constant rate over a period of 5 s.

(a) Given that $a = 1.1$, find which cyclist travels further. [5]

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(b) Find the value of a for which the two cyclists travel the same distance. [2]

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5 A particle moving in a straight line starts from rest at a point A and comes instantaneously to rest at a point B. The acceleration of the particle at time t s after leaving A is $a\,\mathrm{m\,s^{-2}}$, where

$$a = 6t^{\frac{1}{2}} - 2t.$$

(a) Find the value of t at point B. [3]

(b) Find the distance travelled from A to the point at which the acceleration of the particle is again zero. [5]

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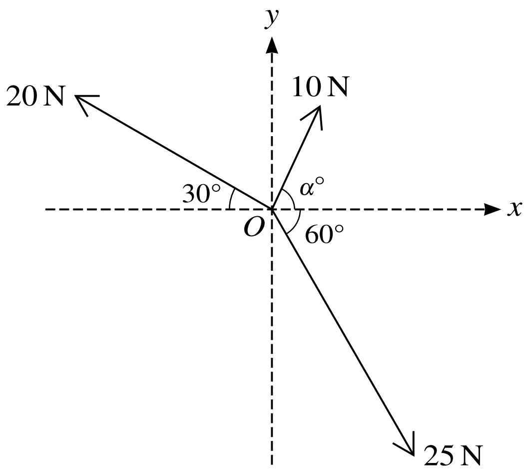

Three coplanar forces of magnitudes 10 N, 25 N and 20 N act at a point O in the directions shown in the diagram.

(a) Given that the component of the resultant force in the x-direction is zero, find α, and hence find the magnitude of the resultant force. [4]

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(b) Given instead that $\alpha = 45$, find the magnitude and direction of the resultant of the three forces. [5]

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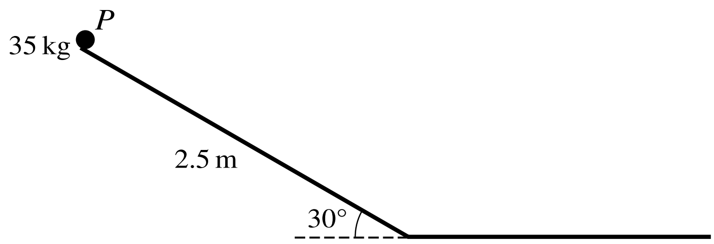

A slide in a playground descends at a constant angle of 30° for 2.5 m. It then has a horizontal section in the same vertical plane as the sloping section. A child of mass 35 kg, modelled as a particle P, starts from rest at the top of the slide and slides straight down the sloping section. She then continues along the horizontal section until she comes to rest (see diagram). There is no instantaneous change in speed when the child goes from the sloping section to the horizontal section.

The child experiences a resistance force on the horizontal section of the slide, and the work done against the resistance force on the horizontal section of the slide is 250 J per metre.

(a) It is given that the sloping section of the slide is smooth.

(i) Find the speed of the child when she reaches the bottom of the sloping section. [3]

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(ii) Find the distance that the child travels along the horizontal section of the slide before she comes to rest. [2]

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(b) It is given instead that the sloping section of the slide is rough and that the child comes to rest on the slide 1.05 m after she reaches the horizontal section.

Find the coefficient of friction between the child and the sloping section of the slide. [6]

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 Assessment International Education

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CANDIDATE NAME

CENTRE NUMBER

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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.
- Write your answer to each question in the space provided.
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- Do **not** write on any bar codes.
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- 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 $10\,\text{m}\,\text{s}^{-2}$.

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. 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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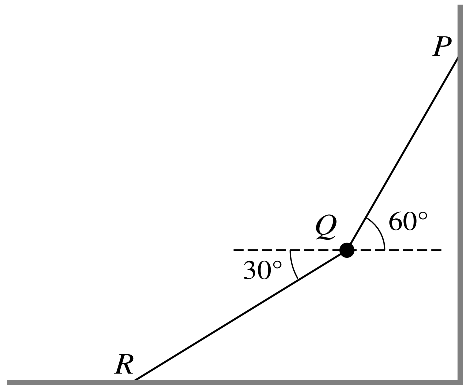

A particle Q of mass 0.2 kg is held in equilibrium by two light inextensible strings PQ and QR. P is a fixed point on a vertical wall and R is a fixed point on a horizontal floor. The angles which strings PQ and QR make with the horizontal are 60° and 30° respectively (see diagram).

Find the tensions in the two strings. [5]

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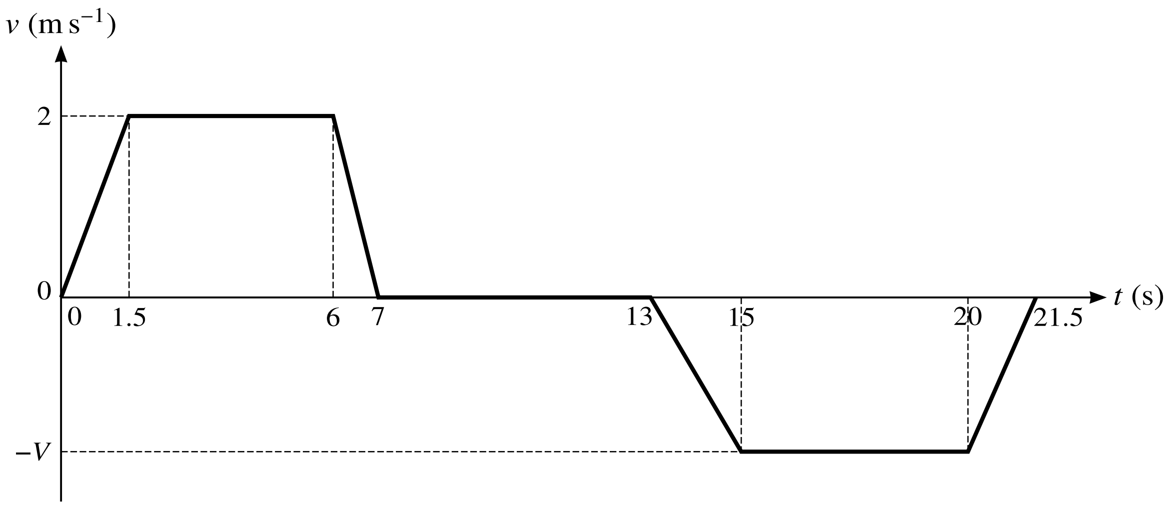

An elevator moves vertically, supported by a cable. The diagram shows a velocity-time graph which models the motion of the elevator. The graph consists of 7 straight line segments.

The elevator accelerates upwards from rest to a speed of $2\,\text{m s}^{-1}$ 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 $V\,\text{m s}^{-1}$ 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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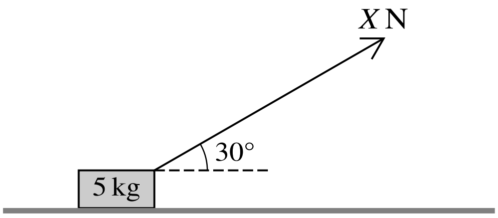

A block of mass 5 kg is being pulled along a rough horizontal floor by a force of magnitude X N acting at 30° above the horizontal (see diagram). The block starts from rest and travels 2 m in the first 5 s of its motion.

(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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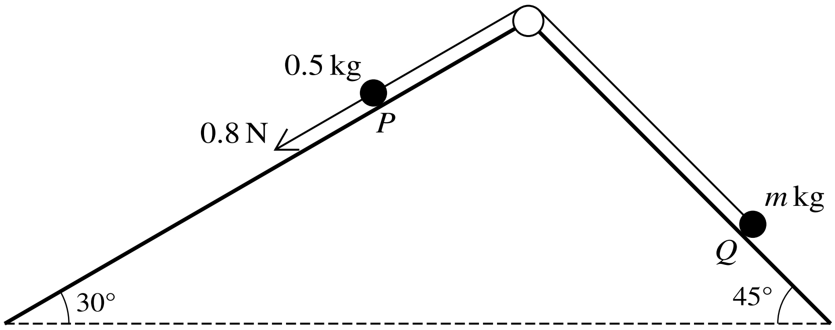

Two particles P and Q of masses 0.5 kg and m kg respectively are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the top of two inclined planes. The particles are initially at rest with P on a smooth plane inclined at 30° to the horizontal 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

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CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

* 7 9 5 8 3 5 5 3 2 8 *

MATHEMATICS **9709/41**

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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- 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 **12** pages. Blank pages are indicated.

JC20 11_9709_41/RP

1 A particle B of mass 5 kg is at rest on a smooth horizontal table. A particle A of mass 2.5 kg moves on the table with a speed of $6\,\mathrm{m\,s^{-1}}$ and collides directly with B. In the collision the two particles coalesce.

(a) Find the speed of the combined particle after the collision. [2]

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(b) Find the loss of kinetic energy of the system due to the collision. [3]

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2 A car of mass 1400 kg is moving along a straight horizontal road against a resistance of magnitude 350 N.

(a) Find, in kW, the rate at which the engine of the car is working when it is travelling at a constant speed of $20\,\mathrm{m\,s^{-1}}$. [2]

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(b) Find the acceleration of the car when its speed is $20\,\mathrm{m\,s^{-1}}$ and the engine is working at 15 kW. [3]

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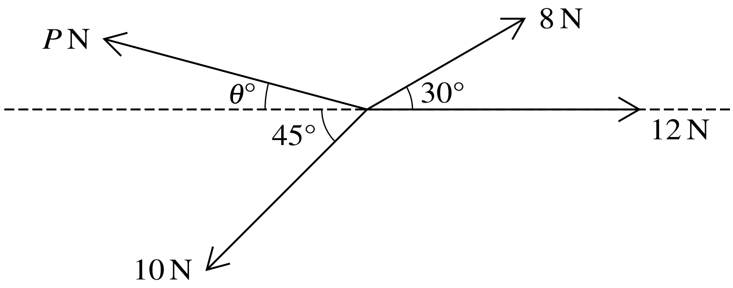

Coplanar forces of magnitudes 8 N, 12 N, 10 N and P N act at a point in the directions shown in the diagram. The system is in equilibrium.

Find P and θ. [6]

4 A particle P moves in a straight line. It starts from rest at a point O on the line and at time t s after leaving O it has acceleration $a\,\mathrm{m\,s^{-2}}$, where $a = 6t - 18$.

Find the distance P moves before it comes to instantaneous rest. [6]

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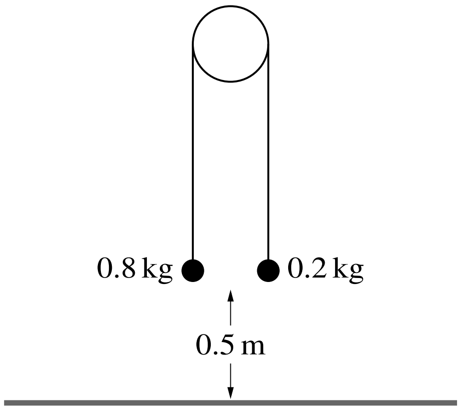

Two particles of masses 0.8 kg and 0.2 kg are connected by a light inextensible string that passes over a fixed smooth pulley. The system is released from rest with both particles 0.5 m above a horizontal floor (see diagram). In the subsequent motion the 0.2 kg particle does not reach the pulley.

(a) Show that the magnitude of the acceleration of the particles is 6 m s^{-2} and find the tension in the string. [4]

(b) When the 0.8 kg particle reaches the floor it comes to rest.

Find the greatest height of the 0.2 kg particle above the floor. [3]

6 A car of mass 1500 kg is pulling a trailer of mass 750 kg up a straight hill of length 800 m inclined at an angle of $\sin^{-1} 0.08$ to the horizontal. The resistances to the motion of the car and trailer are 400 N and 200 N respectively. The car and trailer are connected by a light rigid tow-bar. The car and trailer have speed $30\,\mathrm{m\,s^{-1}}$ at the bottom of the hill and $20\,\mathrm{m\,s^{-1}}$ at the top of the hill.

(a) Use an energy method to find the constant driving force as the car and trailer travel up the hill. [5]

After reaching the top of the hill the system consisting of the car and trailer travels along a straight level road. The driving force of the car's engine is 2400 N and the resistances to motion are unchanged.

(b) Find the acceleration of the system and the tension in the tow-bar. [4]

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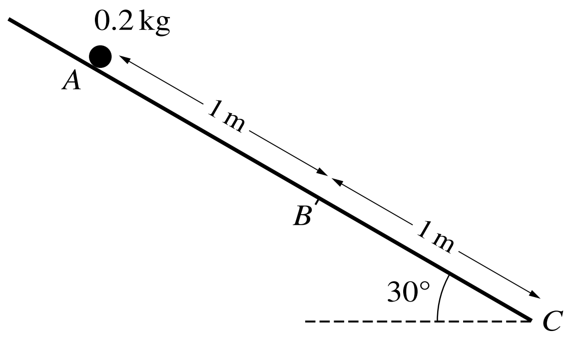

Three points A, B and C lie on a line of greatest slope of a plane inclined at an angle of 30° to the horizontal, with $AB = 1$ m and $BC = 1$ m, as shown in the diagram. A particle of mass 0.2 kg is released from rest at A and slides down the plane. The part of the plane from A to B is smooth. The part of the plane from B to C is rough, with coefficient of friction μ between the plane and the particle.

(a) Given that $\mu = \frac{1}{2}\sqrt{3}$, find the speed of the particle at C. [8]

(b) Given instead that the particle comes to rest at C, find the exact value of μ. [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 Assessment International Education

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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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- 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.

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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 $0.5\,\text{m}\,\text{s}^{-2}$ when its speed is $20\,\text{m}\,\text{s}^{-1}$. [3]

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

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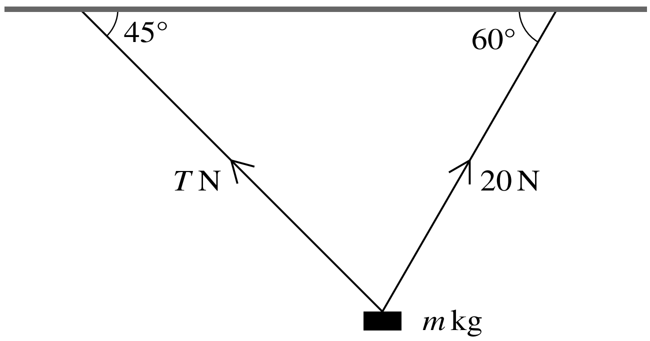

A block of mass m kg is held in equilibrium below a horizontal ceiling by two strings, as shown in the diagram. One of the strings is inclined at 45° to the horizontal and the tension in this string is T N. The other string is inclined at 60° to the horizontal and the tension in this string is 20 N.

Find T and m. [5]

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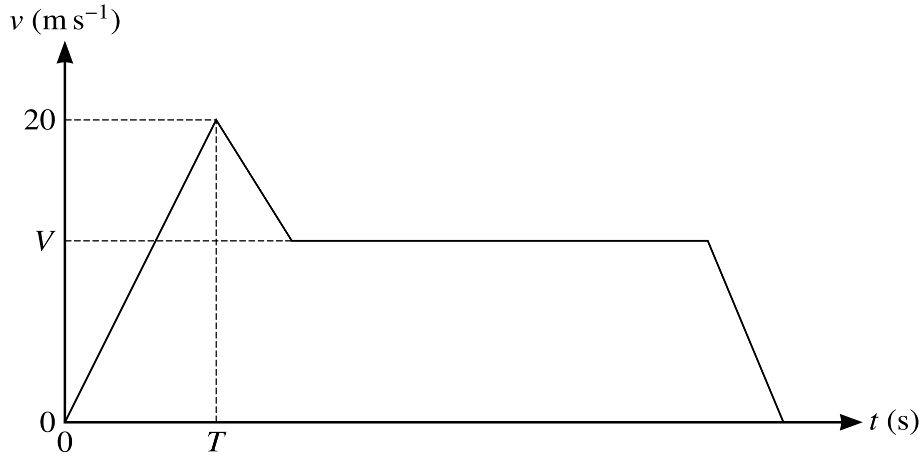

The diagram shows a velocity-time graph which models the motion of a car. The graph consists of four straight line segments. The car accelerates at a constant rate of $2\,\text{m s}^{-2}$ from rest to a speed of $20\,\text{m s}^{-1}$ over a period of T s. It then decelerates at a constant rate for 5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

(a) Find T. [1]

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(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 $40\,\text{m}\,\text{s}^{-1}$ 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]

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(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)

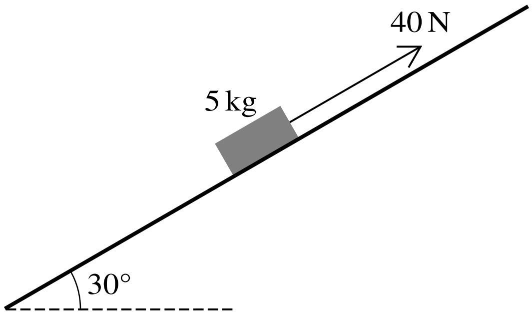

Fig. 6.1

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]

(b)

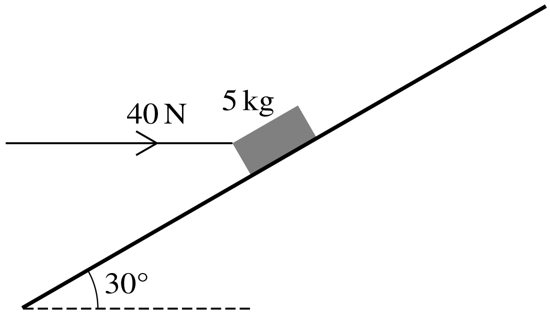

Fig. 6.2

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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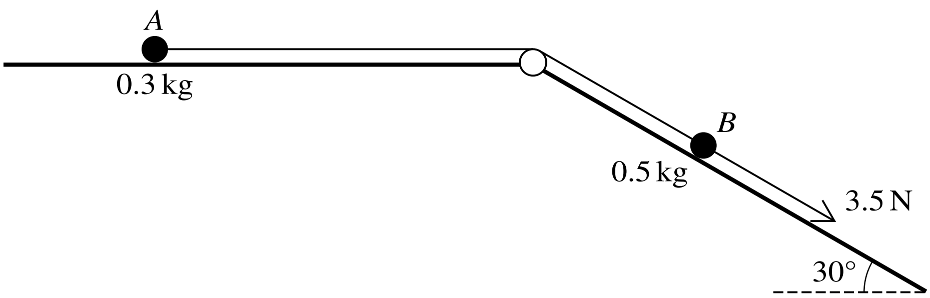

Two particles A and B, of masses 0.3 kg and 0.5 kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to a horizontal plane and to the top of an inclined plane. The particles are initially at rest with A on the horizontal 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]

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(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 Assessment International Education

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CANDIDATE NAME

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CANDIDATE NUMBER

0187019651

MATHEMATICS **9709/43**

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.
- 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 **12** pages. Blank pages are indicated.

1 A particle P is projected vertically upwards with speed $v \text{ m s}^{-1}$ from a point on the ground. P reaches its greatest height after 3 s.

(a) Find v. [1]

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(b) Find the greatest height of P above the ground. [2]

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2 A box of mass 5 kg is pulled at a constant speed a distance of 15 m up a rough plane inclined at an angle of 20° to the horizontal. The box moves along a line of greatest slope against a frictional force of 40 N. The force pulling the box is parallel to the line of greatest slope.

(a) Find the work done against friction. [1]

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(b) Find the change in gravitational potential energy of the box. [2]

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(c) Find the work done by the pulling force. [1]

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3 A string is attached to a block of mass 4 kg which rests in limiting equilibrium on a rough horizontal table. The string makes an angle of 24° above the horizontal and the tension in the string is 30 N.

(a) Draw a diagram showing all the forces acting on the block. [1]

(b) Find the coefficient of friction between the block and the table. [5]

4 Two small smooth spheres A and B, of equal radii and of masses 4 kg and m kg respectively, lie on a smooth horizontal plane. Initially, sphere B is at rest and A is moving towards B with speed $6\,\mathrm{m\,s^{-1}}$. After the collision A moves with speed $1.5\,\mathrm{m\,s^{-1}}$ and B moves with speed $3\,\mathrm{m\,s^{-1}}$.

Find the two possible values of the loss of kinetic energy due to the collision. [6]

5 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 velocity $v\,\mathrm{m\,s^{-1}}$, where $v = 4t^2 - 20t + 21$.

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

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(b) Find the initial acceleration of P. [2]

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(c) Find the minimum velocity of P. [2]

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(d) Find the distance travelled by P during the time when its velocity is negative. [4]

6 A car of mass 1600 kg is pulling a caravan of mass 800 kg. The car and the caravan are connected by a light rigid tow-bar. The resistances to the motion of the car and caravan are 400 N and 250 N respectively.

(a) The car and caravan are travelling along a straight horizontal road.

(i) Given that the car and caravan have a constant speed of $25 \mathrm{~m~s}^{-1}$, find the power of the car's engine. [2]

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(ii) The engine's power is now suddenly increased to 39 kW. Find the instantaneous acceleration of the car and caravan and find the tension in the tow-bar. [5]

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(b) The car and caravan now travel up a straight hill, inclined at an angle of $\sin^{-1} 0.05$ to the horizontal, at a constant speed of $v\,\mathrm{m\,s^{-1}}$. The car's engine is working at 32.5 kW.

Find v. [3]

[Turn over

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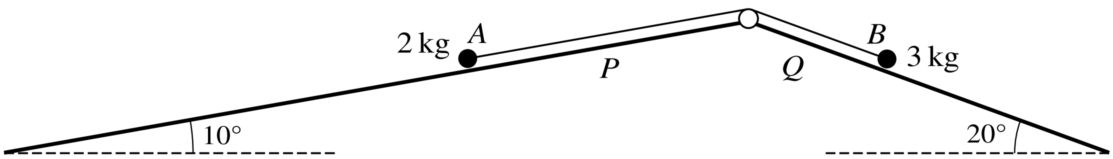

As shown in the diagram, particles A and B of masses 2 kg and 3 kg respectively are attached to the ends of a light inextensible string. The string passes over a small fixed smooth pulley which is attached to the top of two inclined planes. Particle A is on plane P, which is inclined at an angle of 10° to the horizontal. Particle B is on plane Q, which is inclined at an angle of 20° to the horizontal. The string is taut, and the two parts of the string are parallel to lines of greatest slope of their respective planes.

(a) It is given that plane P is smooth, plane Q is rough, and the particles are in limiting equilibrium.

Find the coefficient of friction between particle B and plane Q. [5]

(b) It is given instead that both planes are smooth and that the particles are released from rest at the same horizontal level.

Find the time taken until the difference in the vertical height of the particles is 1 m. [You should assume that this occurs before A reaches the pulley or B reaches the bottom of plane Q.] [6]

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 Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

* 8 7 3 3 4 4 9 6 1 6 *

MATHEMATICS **9709/41**

Paper 4 Mechanics **May/June 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 $10\,\text{m}\,\text{s}^{-2}$.

INFORMATION

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

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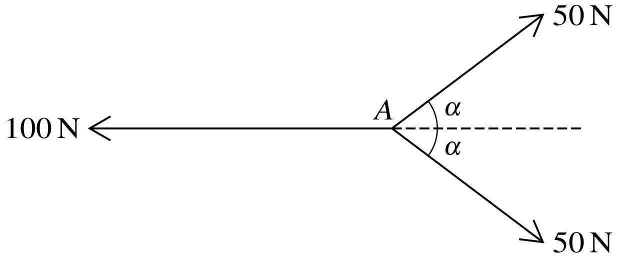

Three coplanar forces of magnitudes 100 N, 50 N and 50 N act at a point A, as shown in the diagram. The value of $\cos\alpha$ is $\frac{4}{5}$.

Find the magnitude of the resultant of the three forces and state its direction. [3]

2 A car of mass 1800 kg is towing a trailer of mass 400 kg along a straight horizontal road. The car and trailer are connected by a light rigid tow-bar. The car is accelerating at $1.5\,\mathrm{m\,s^{-2}}$. There are constant resistance forces of 250 N on the car and 100 N on the trailer.

(a) Find the tension in the tow-bar. [2]

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(b) Find the power of the engine of the car at the instant when the speed is $20\,\mathrm{m\,s^{-1}}$. [3]

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3 A particle P is projected vertically upwards with speed $5\,\mathrm{m\,s^{-1}}$ from a point A which is 2.8 m above horizontal ground.

(a) Find the greatest height above the ground reached by P. [3]

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(b) Find the length of time for which P is at a height of more than 3.6 m above the ground. [4]

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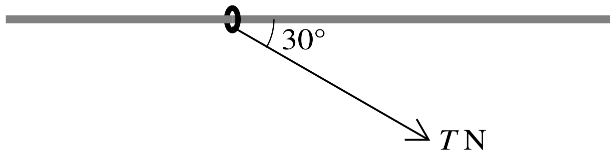

The diagram shows a ring of mass 0.1 kg threaded on a fixed horizontal rod. The rod is rough and the coefficient of friction between the ring and the rod is 0.8. A force of magnitude T N acts on the ring in a direction at 30° to the rod, downwards in the vertical plane containing the rod. Initially the ring is at rest.

(a) Find the greatest value of T for which the ring remains at rest. [4]

(b) Find the acceleration of the ring when $T = 3$. [3]

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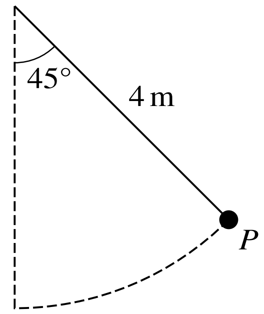

A child of mass 35 kg is swinging on a rope. The child is modelled as a particle P and the rope is modelled as a light inextensible string of length 4 m. Initially P is held at an angle of 45° to the vertical (see diagram).

(a) Given that there is no resistance force, find the speed of P when it has travelled half way along the circular arc from its initial position to its lowest point. [4]

(b) It is given instead that there is a resistance force. The work done against the resistance force as P travels from its initial position to its lowest point is X J. The speed of P at its lowest point is $4\,\mathrm{m\,s^{-1}}$.

Find X. [3]

6 A particle moves in a straight line AB. The velocity $v\,\mathrm{m\,s^{-1}}$ of the particle t s after leaving A is given by $v = k(t^2 - 10t + 21)$, where k is a constant. The displacement of the particle from A, in the direction towards B, is 2.85 m when $t = 3$ and is 2.4 m when $t = 6$.

(a) Find the value of k. Hence find an expression, in terms of t, for the displacement of the particle from A. [7]

(b) Find the displacement of the particle from A when its velocity is a minimum. [4]

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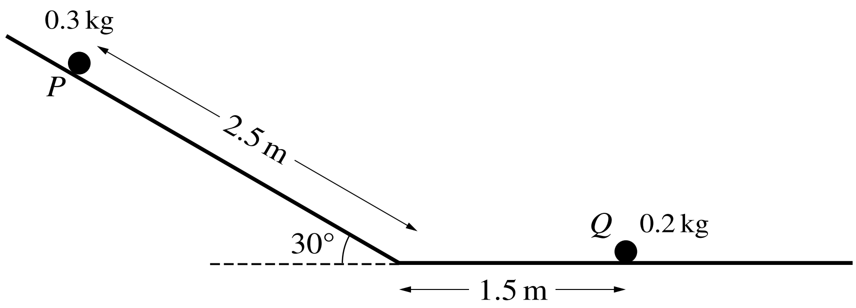

A particle P of mass 0.3 kg, lying on a smooth plane inclined at 30° to the horizontal, is released from rest. P slides down the plane for a distance of 2.5 m and then reaches a horizontal plane. There is no change in speed when P reaches the horizontal plane. A particle Q of mass 0.2 kg lies at rest on the horizontal plane 1.5 m from the end of the inclined plane (see diagram). P collides directly with Q.

(a) It is given that the horizontal plane is smooth and that, after the collision, P continues moving in the same direction, with speed $2\,\mathrm{m\,s^{-1}}$.

Find the speed of Q after the collision. [5]

(b) It is given instead that the horizontal plane is rough and that when P and Q collide, they coalesce and move with speed $1.2\,\text{m}\,\text{s}^{-1}$.

Find the coefficient of friction between P and the horizontal plane. [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

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CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

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MATHEMATICS **9709/42**

Paper 4 Mechanics **May/June 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.
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- 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 **12** pages. Blank pages are indicated.

1 A tram starts from rest and moves with uniform acceleration for 20 s. The tram then travels at a constant speed, $V\,\text{m}\,\text{s}^{-1}$, for 170 s before being brought to rest with a uniform deceleration of magnitude twice that of the acceleration. The total distance travelled by the tram is 2.775 km.

(a) Sketch a velocity-time graph for the motion, stating the total time for which the tram is moving. [2]

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(b) Find V. [2]

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(c) Find the magnitude of the acceleration. [2]

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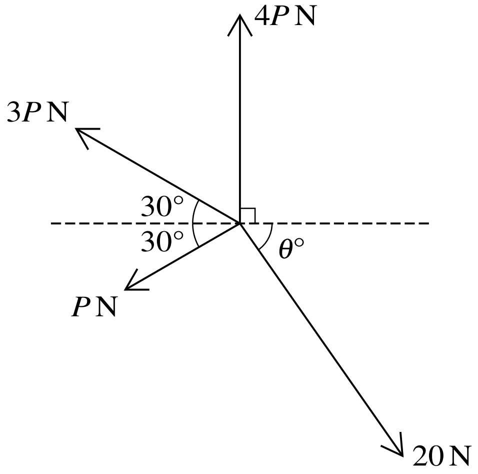

Coplanar forces of magnitudes 20 N, P N, $3P$ N and $4P$ N act at a point in the directions shown in the diagram. The system is in equilibrium.

Find P and θ. [6]

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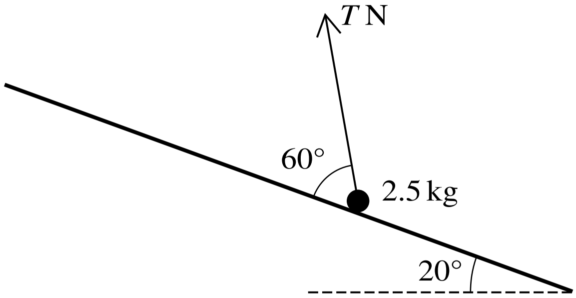

A particle of mass 2.5 kg is held in equilibrium on a rough plane inclined at 20° to the horizontal by a force of magnitude T N making an angle of 60° with a line of greatest slope of the plane (see diagram). The coefficient of friction between the particle and the plane is 0.3.

Find the greatest and least possible values of T. [8]

4 Small smooth spheres A and B, of equal radii and of masses 4 kg and 2 kg respectively, lie on a smooth horizontal plane. Initially B is at rest and A is moving towards B with speed $10\,\mathrm{m\,s^{-1}}$. After the spheres collide A continues to move in the same direction but with half the speed of B.

(a) Find the speed of B after the collision. [2]

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A third small smooth sphere C, of mass 1 kg and with the same radius as A and B, is at rest on the plane. B now collides directly with C. After this collision B continues to move in the same direction but with one third the speed of C.

(b) Show that there is another collision between A and B. [3]

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(c) A and B coalesce during this collision.

Find the total loss of kinetic energy in the system due to the three collisions. [5]

5 A car of mass 1250 kg is moving on a straight road.

(a) On a horizontal section of the road, the car has a constant speed of $32\,\mathrm{m\,s^{-1}}$ and there is a constant force of 750 N resisting the motion.

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

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(ii) Given that this power is suddenly decreased by 8 kW, find the instantaneous deceleration of the car. [3]

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(b) On a section of the road inclined at $\sin^{-1} 0.096$ to the horizontal, the resistance to the motion of the car is $(1000 + 8v)$ N when the speed of the car is $v \text{ m s}^{-1}$. The car travels up this section of the road at constant speed with the engine working at 60 kW.

Find this constant speed. [5]

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

$$v = 2t + 1 \qquad \text{for } 0 \leqslant t \leqslant 5,$$
$$v = 36 - t^2 \qquad \text{for } 5 \leqslant t \leqslant 7,$$
$$v = 2t - 27 \qquad \text{for } 7 \leqslant t \leqslant 13.5.$$

(a) Sketch the velocity-time graph for $0 \leqslant t \leqslant 13.5$. [3]

(b) Find the acceleration at the instant when $t = 6$. [2]

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(c) Find the total distance travelled by P in the interval $0 \leqslant t \leqslant 13.5$. [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.

Cambridge Assessment International Education

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CANDIDATE NAME

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CANDIDATE NUMBER

9540061596

MATHEMATICS **9709/43**

Paper 4 Mechanics **May/June 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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- 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 **12** pages. Blank pages are indicated.

[Turn over

1 Particles P of mass m kg and Q of mass 0.2 kg are free to move on a smooth horizontal plane. P is projected at a speed of $2\,\mathrm{m\,s^{-1}}$ towards Q which is stationary. After the collision P and Q move in opposite directions with speeds of $0.5\,\mathrm{m\,s^{-1}}$ and $1\,\mathrm{m\,s^{-1}}$ respectively.

Find m. [3]

2 A minibus of mass 4000 kg is travelling along a straight horizontal road. The resistance to motion is 900 N.

(a) Find the driving force when the acceleration of the minibus is $0.5\,\mathrm{m\,s^{-2}}$. [2]

(b) Find the power required for the minibus to maintain a constant speed of $25\,\mathrm{m\,s^{-1}}$. [2]

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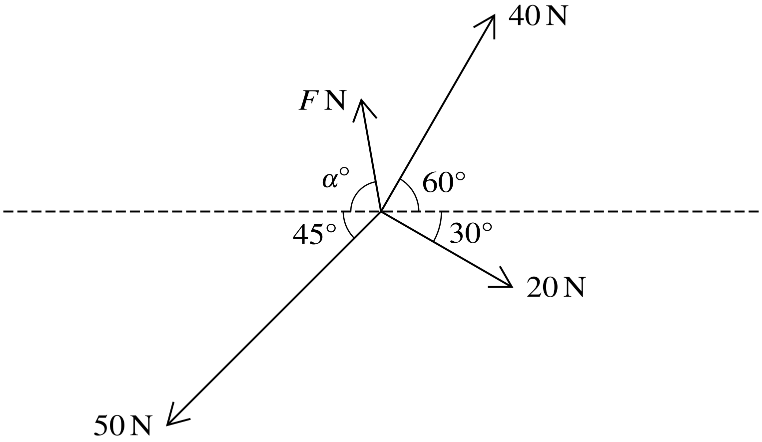
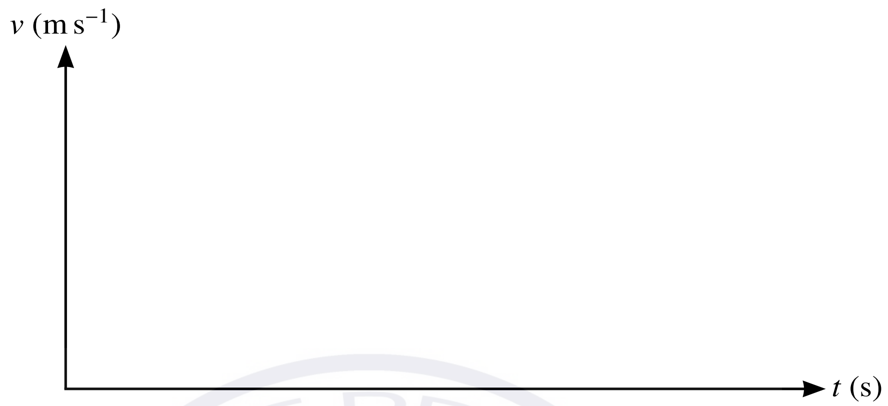


Four coplanar forces of magnitudes 40 N, 20 N, 50 N and F N act at a point in the directions shown in the diagram. The four forces are in equilibrium.

Find F and α. [6]

4 A car starts from rest and moves in a straight line with constant acceleration $a\,\mathrm{m\,s^{-2}}$ for a distance of 50 m. The car then travels with constant velocity for 500 m for a period of 25 s, before decelerating to rest. The magnitude of this deceleration is $2a\,\mathrm{m\,s^{-2}}$.

(a) Sketch the velocity-time graph for the motion of the car. [1]



(b) Find the value of a. [3]

(c) Find the total time for which the car is in motion. [3]

5 A block B of mass 4 kg is pushed up a line of greatest slope of a smooth plane inclined at 30° to the horizontal by a force applied to B, acting in the direction of motion of B. The block passes through points P and Q with speeds $12\,\mathrm{m\,s^{-1}}$ and $8\,\mathrm{m\,s^{-1}}$ respectively. P and Q are 10 m apart with P below the level of Q.

(a) Find the decrease in kinetic energy of the block as it moves from P to Q. [2]

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(b) Hence find the work done by the force pushing the block up the slope as the block moves from P to Q. [3]

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(c) At the instant the block reaches Q, the force pushing the block up the slope is removed.

Find the time taken, after this instant, for the block to return to P. [4]

6 A particle travels in a straight line PQ. The velocity of the particle t s after leaving P is $v \text{ m s}^{-1}$, where

$$v = 4.5 + 4t - 0.5t^2.$$

(a) Find the velocity of the particle at the instant when its acceleration is zero. [3]

The particle comes to instantaneous rest at Q.

(b) Find the distance PQ. [6]

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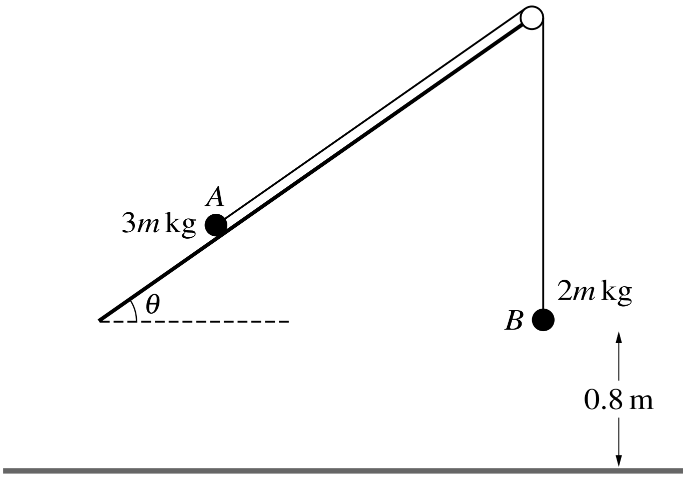

Two particles A and B, of masses $3m$ kg and $2m$ kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the edge of a plane. The plane is inclined at an angle θ to the horizontal. A lies on the plane and B hangs vertically, 0.8 m above the floor, which is horizontal. The string between A and the pulley is parallel to a line of greatest slope of the plane (see diagram). Initially A and B are at rest.

(a) Given that the plane is smooth, find the value of θ for which A remains at rest. [3]

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It is given instead that the plane is rough, $\theta = 30°$ and the acceleration of A up the plane is $0.1\ \mathrm{m\,s^{-2}}$.

(b) Show that the coefficient of friction between A and the plane is $\frac{1}{10}\sqrt{3}$. [5]

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(c) When B reaches the floor it comes to rest.

Find the length of time after B reaches the floor for which A is moving up the plane. [You may assume that A does not reach the pulley.] [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.

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Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

8787335916

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

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.

JC20 03_9709_42/RP

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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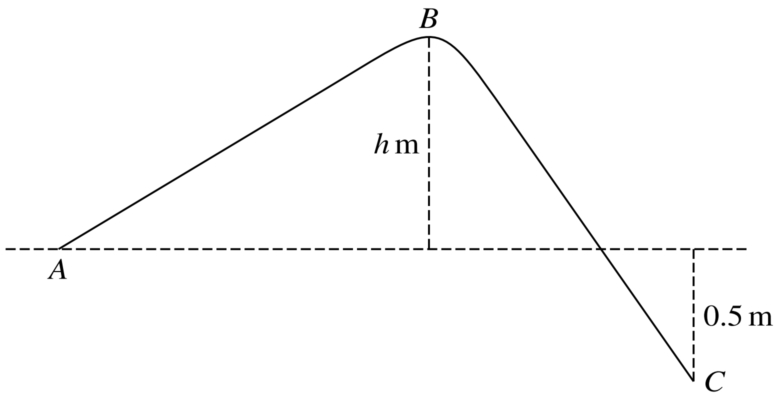

The diagram shows the vertical cross-section of a surface. A, B and C are three points on the cross-section. The level of B is h m above the level of A. The level of C is 0.5 m below the level of A. A particle of mass 0.2 kg is projected up the slope from A with initial speed $5\,\text{m}\,\text{s}^{-1}$.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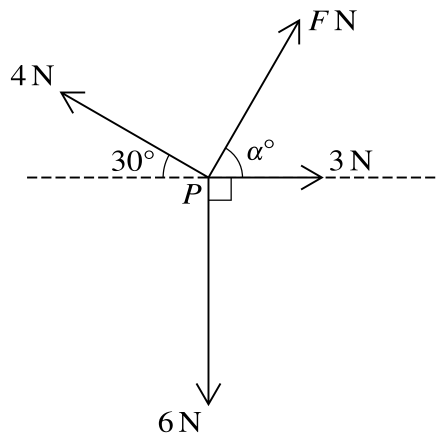

Coplanar forces, of magnitudes F N, 3 N, 6 N and 4 N, act at a point P, as shown in the diagram.

(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 $12\,\mathrm{m\,s^{-2}}$. 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 $22\,\mathrm{m\,s^{-1}}$. 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 $8\,\mathrm{m\,s^{-1}}$. [2]

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

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]

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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	

8827910224

MATHEMATICS **9709/41**

Paper 4 Mechanics 1 **(M1)** **October/November 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 $10\,\mathrm{m\,s^{-2}}$.
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.

1 A crane is lifting a load of 1250 kg vertically at a constant speed $V\,\mathrm{m\,s^{-1}}$. Given that the power of the crane is a constant 20 kW, find the value of V. [2]

2 The total mass of a cyclist and her bicycle is 75 kg. The cyclist ascends a straight hill of length 0.7 km inclined at 1.5° to the horizontal. Her speed at the bottom of the hill is $10\,\text{m}\,\text{s}^{-1}$ and at the top it is $5\,\text{m}\,\text{s}^{-1}$. There is a resistance to motion, and the work done against this resistance as the cyclist ascends the hill is 2000 J. The cyclist exerts a constant force of magnitude F N in the direction of motion. Find F. [5]

3 A block of mass 3 kg is at rest on a rough plane inclined at 60° to the horizontal. A force of magnitude 15 N acting up a line of greatest slope of the plane is just sufficient to prevent the block from sliding down the plane.

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

The force of magnitude 15 N is now replaced by a force of magnitude X N acting up the line of greatest slope.

(ii) Find the greatest value of X for which the block does not move. [2]

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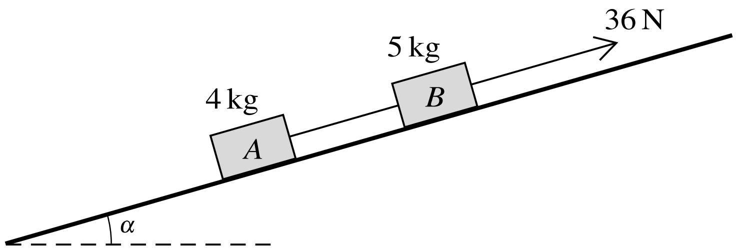

Two blocks A and B of masses 4 kg and 5 kg respectively are joined by a light inextensible string. The blocks rest on a smooth plane inclined at an angle α to the horizontal, where $\tan\alpha = \frac{7}{24}$. The string is parallel to a line of greatest slope of the plane with B above A. A force of magnitude 36 N acts on B, parallel to a line of greatest slope of the plane (see diagram).

(i) Find the acceleration of the blocks and the tension in the string. [5]

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(ii) At a particular instant, the speed of the blocks is 1 m s^{-1}. Find the time, after this instant, that it takes for the blocks to travel 0.65 m. [2]

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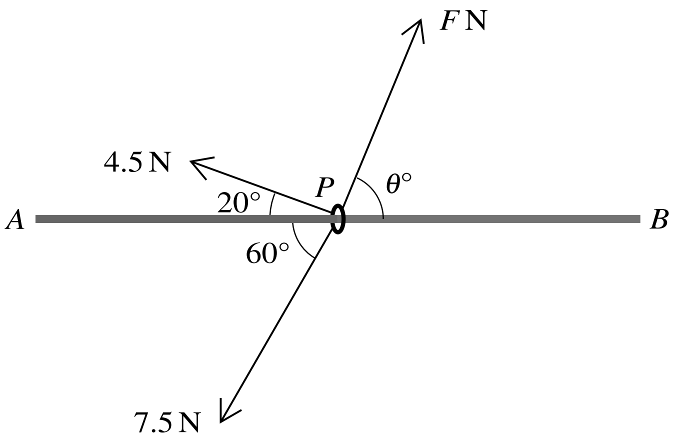

A small ring P is threaded on a fixed smooth horizontal rod AB. Three horizontal forces of magnitudes 4.5 N, 7.5 N and F N act on P (see diagram).

(i) Given that these three forces are in equilibrium, find the values of F and θ. [6]

(ii) It is given instead that the values of F and θ are 9.5 and 30 respectively, and the acceleration of the ring is $1.5\,\mathrm{m\,s^{-2}}$. Find the mass of the ring. [2]

6 A particle of mass 0.4 kg is released from rest at a height of 1.8 m above the surface of the water in a tank. There is no instantaneous change of speed when the particle enters the water. The water exerts an upward force of 5.6 N on the particle when it is in the water.

(i) Find the velocity of the particle at the instant when it reaches the surface of the water. [2]

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(ii) Find the time that it takes from the instant when the particle enters the water until it comes to instantaneous rest in the water. You may assume that the tank is deep enough so that the particle does not reach the bottom of the tank. [4]

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(iii) Sketch a velocity-time graph for the motion of the particle from the instant at which it is released until it comes to instantaneous rest in the water. [3]

7 A particle moves in a straight line, starting from rest at a point O, and comes to instantaneous rest at a point P. The velocity of the particle at time t s after leaving O is $v\,\mathrm{m\,s^{-1}}$, where

$$v = 0.6t^2 - 0.12t^3.$$

(i) Show that the distance OP is 6.25 m. [5]

On another occasion, the particle also moves in the same straight line. On this occasion, the displacement of the particle at time t s after leaving O is s m, where

$$s = kt^3 + ct^5.$$

It is given that the particle passes point P with velocity $1.25\,\mathrm{m\,s^{-1}}$ at time $t = 5$.

(ii) Find the values of the constants k and c. [5]

(iii) Find the acceleration of the particle at time $t = 5$. [2]

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CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

5762236653

MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **October/November 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 $10\,\mathrm{m\,s^{-2}}$.
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 **13** printed pages and **3** blank pages.

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[Turn over

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1 A particle moves in a straight line. The displacement of the particle at time t s is s m, where

$$s = t^3 - 6t^2 + 4t.$$

Find the velocity of the particle at the instant when its acceleration is zero. [4]

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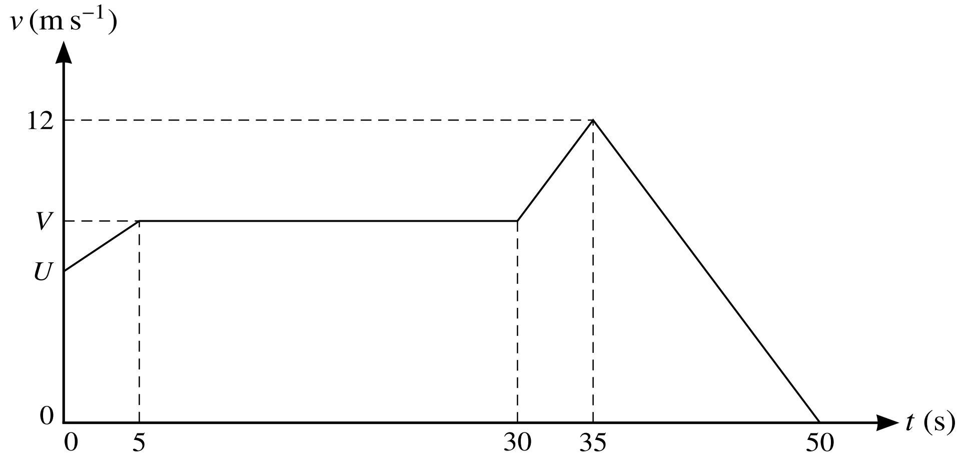

The diagram shows a velocity-time graph which models the motion of a tractor. The graph consists of four straight line segments. The tractor passes a point O at time $t = 0$ with speed U m s^{-1}. The tractor accelerates to a speed of V m s^{-1} over a period of 5 s, and then travels at this speed for a further 25 s. The tractor then accelerates to a speed of 12 m s^{-1} over a period of 5 s. The tractor then decelerates to rest over a period of 15 s.

(i) Given that the acceleration of the tractor between $t = 30$ and $t = 35$ is 0.8 m s^{-2}, find the value of V. [2]

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(ii) Given also that the total distance covered by the tractor in the 50 seconds of motion is 375 m, find the value of U. [3]

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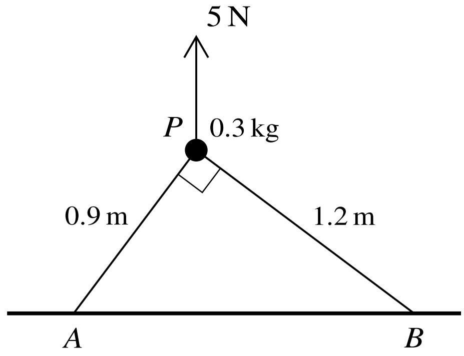

A particle P of mass 0.3 kg is held in equilibrium above a horizontal plane by a force of magnitude 5 N, acting vertically upwards. The particle is attached to two strings PA and PB of lengths 0.9 m and 1.2 m respectively. The points A and B lie on the plane and angle $APB = 90°$ (see diagram). Find the tension in each of the strings. [5]

4 A lorry of mass 25 000 kg travels along a straight horizontal road. There is a constant force of 3000 N resisting the motion.

(i) Find the power required to maintain a constant speed of $30\,\mathrm{m\,s^{-1}}$. [2]

The lorry comes to a straight hill inclined at $2°$ to the horizontal. The driver switches off the engine of the lorry at the point A which is at the foot of the hill. Point B is further up the hill. The speeds of the lorry at A and B are $30\,\mathrm{m\,s^{-1}}$ and $25\,\mathrm{m\,s^{-1}}$ respectively. The resistance force is still 3000 N.

(ii) Use an energy method to find the height of B above the level of A. [5]

5 Two particles A and B move in the same vertical line. Particle A is projected vertically upwards from the ground with speed $20\,\mathrm{m\,s^{-1}}$. One second later particle B is dropped from rest from a height of 40 m.

(i) Find the height above the ground at which the two particles collide. [4]

(ii) Find the difference in the speeds of the two particles at the instant when the collision occurs. [3]

6 A block of mass 3 kg is initially at rest on a rough horizontal plane. A force of magnitude 6 N is applied to the block at an angle of θ above the horizontal, where $\cos\theta = \frac{24}{25}$. The force is applied for a period of 5 s, during which time the block moves a distance of 4.5 m.

(i) Find the magnitude of the frictional force on the block. [4]

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(ii) Show that the coefficient of friction between the block and the plane is 0.165, correct to 3 significant figures. [3]

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(iii) When the block has moved a distance of 4.5 m, the force of magnitude 6 N is removed and the block then decelerates to rest. Find the total time for which the block is in motion. [4]

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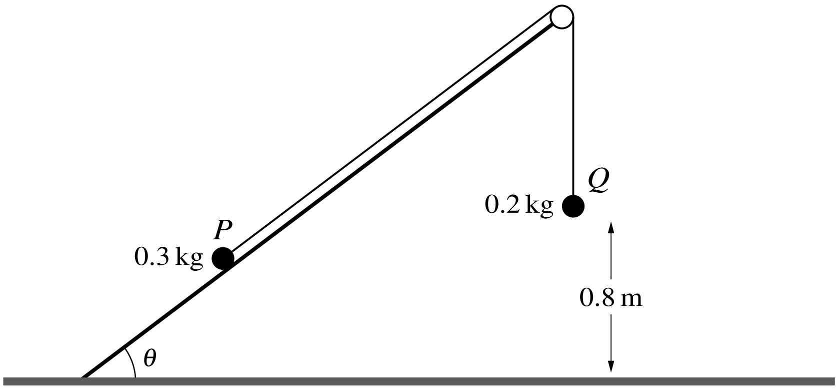

Two particles P and Q, of masses 0.3 kg and 0.2 kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the edge of a smooth plane. The plane is inclined at an angle θ to the horizontal, where $\sin\theta = \frac{3}{5}$. P lies on the plane and Q hangs vertically below the pulley at a height of 0.8 m above the floor (see diagram). The string between P and the pulley is parallel to a line of greatest slope of the plane. P is released from rest and Q moves vertically downwards.

(i) Find the tension in the string and the magnitude of the acceleration of the particles. [5]

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Q hits the floor and does not bounce. It is given that P does not reach the pulley in the subsequent motion.

(ii) Find the time, from the instant at which P is released, for Q to reach the floor. [2]

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(iii) When Q hits the floor the string becomes slack. Find the time, from the instant at which P is released, for the string to become taut again. [4]

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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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CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

* 3 7 3 3 6 8 1 5 7 4 *

MATHEMATICS **9709/43**

Paper 4 Mechanics 1 **(M1)** **October/November 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 $10\,\mathrm{m\,s^{-2}}$.
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 **13** printed pages and **3** blank pages.

JC19 11_9709_43/2R

Cambridge Assessment International Education

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1 A crate of mass 500 kg is being pulled along rough horizontal ground by a horizontal rope attached to a winch. The winch produces a constant pulling force of 2500 N and the crate is moving at constant speed. Find the coefficient of friction between the crate and the ground. [3]

2 A train of mass 150 000 kg ascends a straight slope inclined at $\alpha°$ to the horizontal with a constant driving force of 16 000 N. At a point A on the slope the speed of the train is $45\,\mathrm{m\,s^{-1}}$. Point B on the slope is 500 m beyond A. At B the speed of the train is $42\,\mathrm{m\,s^{-1}}$. There is a resistance force acting on the train and the train does 4×10^6 J of work against this resistance force between A and B. Find the value of α. [5]

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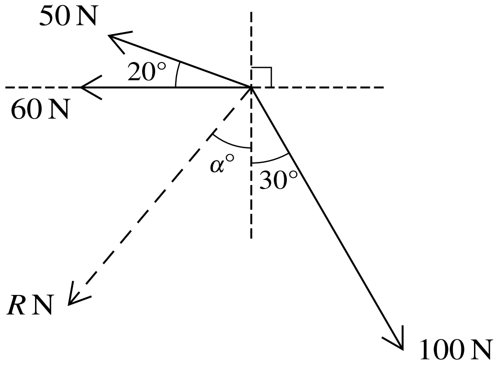

Three coplanar forces of magnitudes 50 N, 60 N and 100 N act at a point. The resultant of the forces has magnitude R N. The directions of these forces are shown in the diagram. Find the values of R and α. [6]

4 A car travels along a straight road with constant acceleration. It passes through points P, Q, R and S. The times taken for the car to travel from P to Q, Q to R and R to S are each equal to 10 s. The distance QR is 1.5 times the distance PQ. At point Q the speed of the car is $20\,\mathrm{m\,s^{-1}}$.

(i) Show that the acceleration of the car is $0.8\,\mathrm{m\,s^{-2}}$. [3]

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(ii) Find the distance QS and hence find the average speed of the car between Q and S. [3]

5 A cyclist is travelling along a straight horizontal road. The total mass of the cyclist and his bicycle is 80 kg. His power output is a constant 240 W. His acceleration when he is travelling at $6\,\mathrm{m\,s^{-1}}$ is $0.3\,\mathrm{m\,s^{-2}}$.

(i) Show that the resistance to the cyclist's motion is 16 N. [3]

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(ii) Find the steady speed that the cyclist can maintain if his power output and the resistance force are both unchanged. [2]

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(iii) The cyclist later ascends a straight hill inclined at 3° to the horizontal. His power output and the resistance force are still both unchanged. Find his acceleration when he is travelling at $4\,\mathrm{m\,s^{-1}}$. [3]

6 Particle P travels in a straight line from A to B. The velocity of P at time t s after leaving A is denoted by $v\,\mathrm{m\,s^{-1}}$, where

$$v = 0.04t^3 + ct^2 + kt.$$

P takes 5 s to travel from A to B and it reaches B with speed $10\,\mathrm{m\,s^{-1}}$. The distance AB is 25 m.

(i) Find the values of the constants c and k. [6]

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(ii) Show that the acceleration of P is a minimum when $t = 2.5$. [3]

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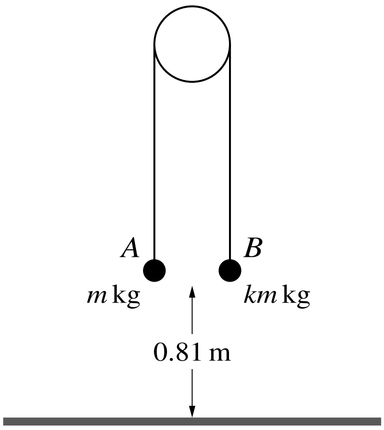

Two particles A and B have masses m kg and km kg respectively, where $k > 1$. The particles are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley and the particles hang vertically below it. Both particles are at a height of 0.81 m above horizontal ground (see diagram). The system is released from rest and particle B reaches the ground 0.9 s later. The particle A does not reach the pulley in its subsequent motion.

(i) Find the value of k and show that the tension in the string before B reaches the ground is equal to $12m$ N. [7]

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At the instant when B reaches the ground, the string breaks.

(ii) Show that the speed of A when it reaches the ground is $5.97\ \text{m s}^{-1}$, correct to 3 significant figures, and find the time taken, after the string breaks, for A to reach the ground. [4]

(iii) Sketch a velocity-time graph for the motion of particle A from the instant when the system is released until A reaches the ground. [2]

Additional Page

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CANDIDATE NAME

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MATHEMATICS **9709/41**

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

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

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.
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.

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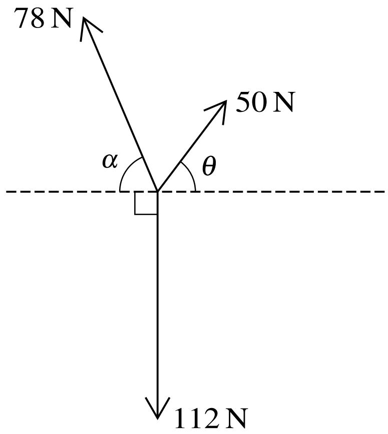
1



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

(iii) Find the work done against friction during the first 2 s of motion. [3]

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]

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

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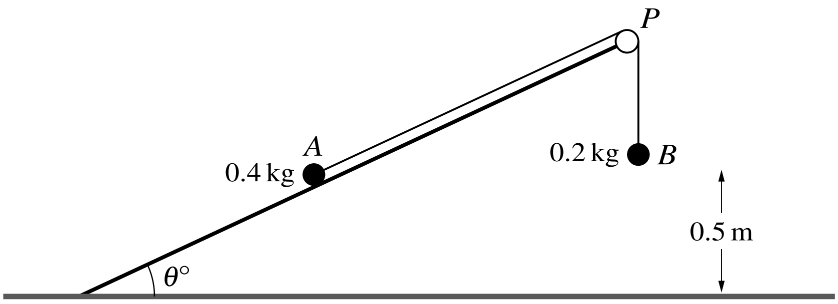

Two particles A and B, of masses 0.4 kg and 0.2 kg respectively, are connected by a light inextensible string. Particle A is held on a smooth plane inclined at an angle of $\theta°$ to the horizontal. The string passes over a small smooth pulley P fixed at the top of the plane, and B hangs freely 0.5 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]

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(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]

Additional Page

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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)

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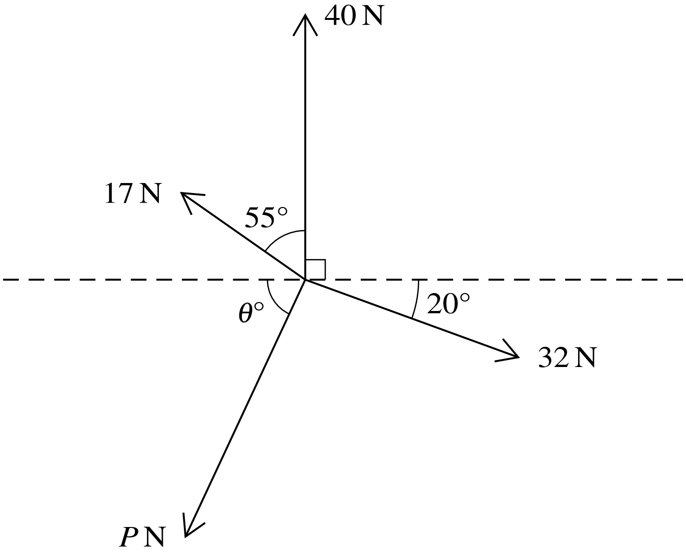

Coplanar forces of magnitudes 40 N, 32 N, P N and 17 N act at a point in the directions shown in the diagram. The system is in equilibrium. Find the values of P and θ. [6]

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2 A car moves in a straight line with initial speed $u\,\mathrm{m\,s^{-1}}$ and constant acceleration $a\,\mathrm{m\,s^{-2}}$. 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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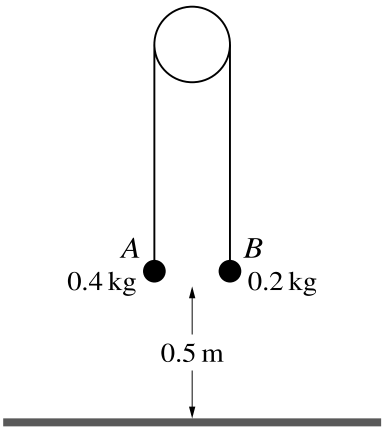

Two particles A and B, of masses 0.4 kg and 0.2 kg respectively, are connected by a light inextensible string which passes over a fixed smooth pulley. Both A and B are 0.5 m above the ground. The particles hang vertically (see diagram). The particles are released from rest. In the subsequent motion B 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 $\frac{10}{3}\,\mathrm{m\,s^{-2}}$ 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 $v\,\mathrm{m\,s^{-1}}$, 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 $18\,\mathrm{m\,s^{-1}}$ 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 $12\,\mathrm{m\,s^{-1}}$ 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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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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CANDIDATE NAME

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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

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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.

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

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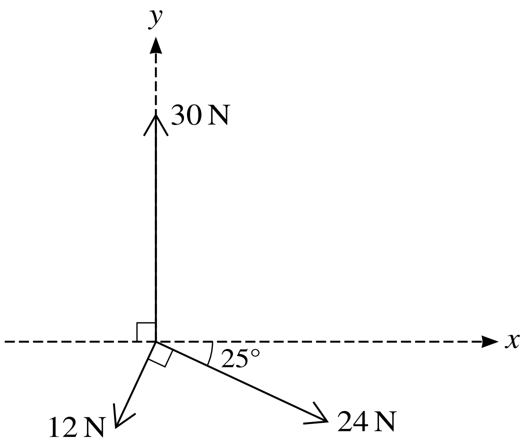

Coplanar forces of magnitudes 12 N, 24 N and 30 N act at a point in the directions shown in the diagram.

(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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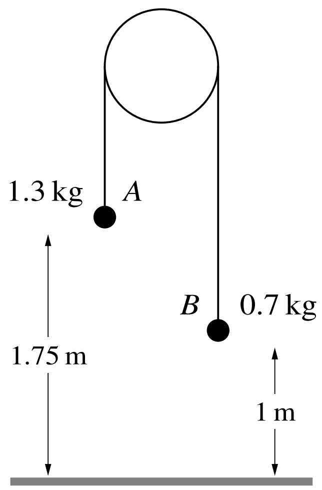
3 A car of mass 1400 kg is travelling up a hill inclined at an angle of 4° to the horizontal. There is a constant resistance to motion of magnitude 1550 N acting on the car.

(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 $40\,\text{m}\,\text{s}^{-1}$. Find the maximum possible power of the engine. [3]

4



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]

(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 $20\,\mathrm{m\,s^{-1}}$.

(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]

(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]

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]

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

Additional Page

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3771035418

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)

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JC19 03_9709_42/2R

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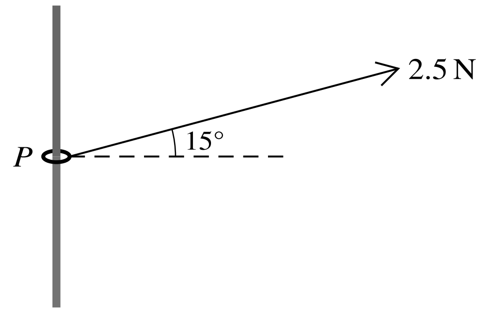
1



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]

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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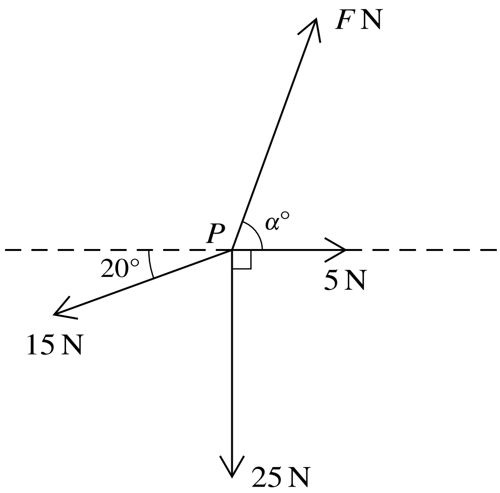

Four coplanar forces of magnitudes F N, 5 N, 25 N and 15 N are acting at a point P in the directions shown in the diagram. Given that the forces are in equilibrium, find the values of F and α. [6]

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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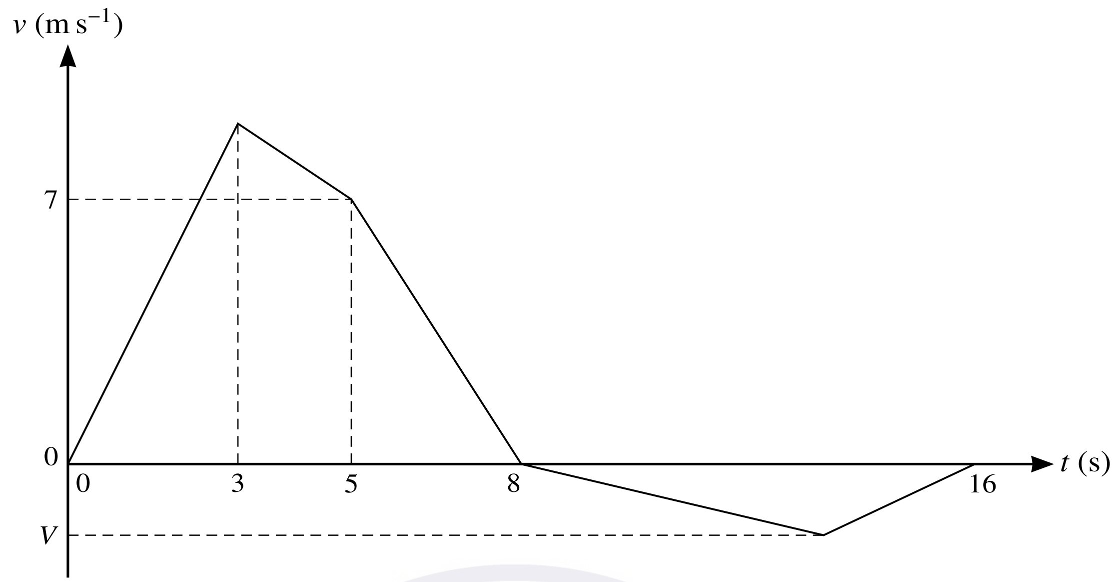

The velocity of a particle moving in a straight line is $v \text{ m s}^{-1}$ at time t seconds after leaving a fixed point O. The diagram shows a velocity-time graph which models the motion of the particle from $t = 0$ to $t = 16$. The graph consists of five straight line segments. The acceleration of the particle from $t = 0$ to $t = 3$ is 3 m s^{-2}. The velocity of the particle at $t = 5$ is 7 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 $V \text{ m s}^{-1}$.

(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 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]

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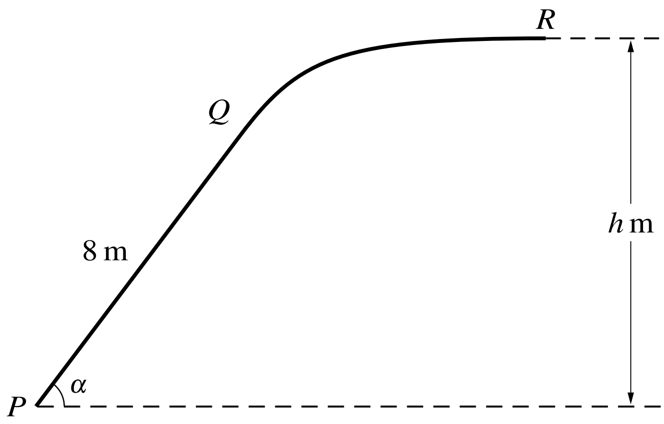

The diagram shows the vertical cross-section PQR of a slide. The part PQ is a straight line of length 8 m inclined at angle α to the horizontal, where $\sin\alpha = 0.8$. The straight part PQ is tangential to the curved part QR, and R is h m above the level of P. The straight part PQ of the slide is rough and the curved part QR is smooth. A particle of mass 0.25 kg is projected with speed $15\,\mathrm{m\,s^{-1}}$ 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]

(ii) Hence find the speed of the particle at Q. [4]

(iii) Find the value of h. [3]

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2515174191

MATHEMATICS **9709/41**

Paper 4 Mechanics 1 **(M1)** **October/November 2018**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

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JC18 11_9709_41/3R

CAMBRIDGE International Examinations

1 A particle of mass 0.2 kg moving in a straight line experiences a constant resistance force of 1.5 N. When the particle is moving at speed $2.5\,\mathrm{m\,s^{-1}}$, a constant force of magnitude F N is applied to it in the direction in which it is moving. Given that the speed of the particle 5 seconds later is $4.5\,\mathrm{m\,s^{-1}}$, find the value of F. [4]

2 A high-speed train of mass 490 000 kg is moving along a straight horizontal track at a constant speed of $85\,\text{m}\,\text{s}^{-1}$. The engines are supplying 4080 kW of power.

(i) Show that the resistance force is 48 000 N. [1]

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(ii) The train comes to a hill inclined at an angle $\theta°$ above the horizontal, where $\sin\theta° = \frac{1}{200}$. Given that the resistance force is unchanged, find the power required for the train to keep moving at the same constant speed of $85\,\text{m}\,\text{s}^{-1}$. [3]

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3 A van of mass 2500 kg descends a hill of length 0.4 km inclined at 4° to the horizontal. There is a constant resistance to motion of 600 N and the speed of the van increases from $20\,\mathrm{m\,s^{-1}}$ to $30\,\mathrm{m\,s^{-1}}$ as it descends the hill. Find the work done by the van's engine as it descends the hill. [5]

4 Two particles A and B, of masses m kg and 0.3 kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley and the particles hang freely below it. The system is released from rest, with both particles 0.8 m above horizontal ground. Particle A reaches the ground with a speed of $0.6\,\mathrm{m\,s^{-1}}$.

(i) Find the tension in the string during the motion before A reaches the ground. [4]

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

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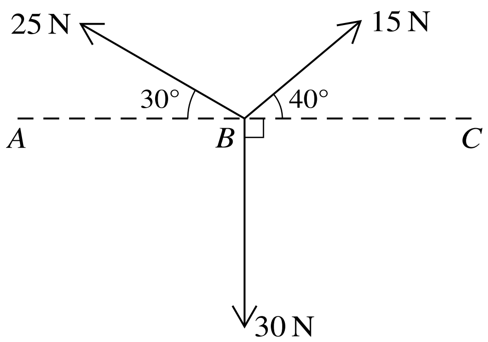

Coplanar forces, of magnitudes 15 N, 25 N and 30 N, act at a point B on the line ABC in the directions shown in the diagram.

(i) Find the magnitude and direction of the resultant force. [6]

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(ii) The force of magnitude 15 N is now replaced by a force of magnitude F N acting in the same direction. The new resultant force has zero component in the direction BC. Find the value of F, and find also the magnitude and direction of the new resultant force. [3]

6 A particle is projected from a point P with initial speed $u\,\mathrm{m\,s^{-1}}$ up a line of greatest slope PQR of a rough inclined plane. The distances PQ and QR are both equal to 0.8 m. The particle takes 0.6 s to travel from P to Q and 1 s to travel from Q to R.

(i) Show that the deceleration of the particle is $\frac{2}{3}\,\mathrm{m\,s^{-2}}$ and hence find u, giving your answer as an exact fraction. [6]

(ii) Given that the plane is inclined at 3° to the horizontal, find the value of the coefficient of friction between the particle and the plane. [4]

7 A particle moves in a straight line starting from rest from a point O. The acceleration of the particle at time t s after leaving O is $a\,\mathrm{m\,s^{-2}}$, where

$$a = 5.4 - 1.62t.$$

(i) Find the positive value of t at which the velocity of the particle is zero, giving your answer as an exact fraction. [4]

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(ii) Find the velocity of the particle at $t = 10$ and sketch the velocity-time graph for the first ten seconds of the motion. [3]

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(iii) Find the total distance travelled during the first ten seconds of the motion. [5]

Additional Page

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Cambridge International AS & A Level

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Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER | CANDIDATE NUMBER

3141176339

MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **October/November 2018**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

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

At the end of the examination, fasten all your work securely together.
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JC18 11_9709_42/2R

CAMBRIDGE International Examinations

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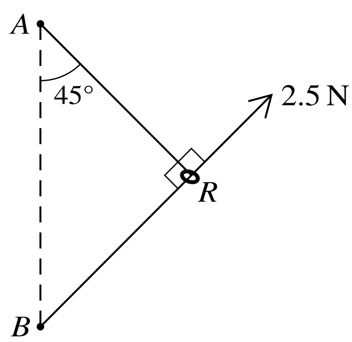
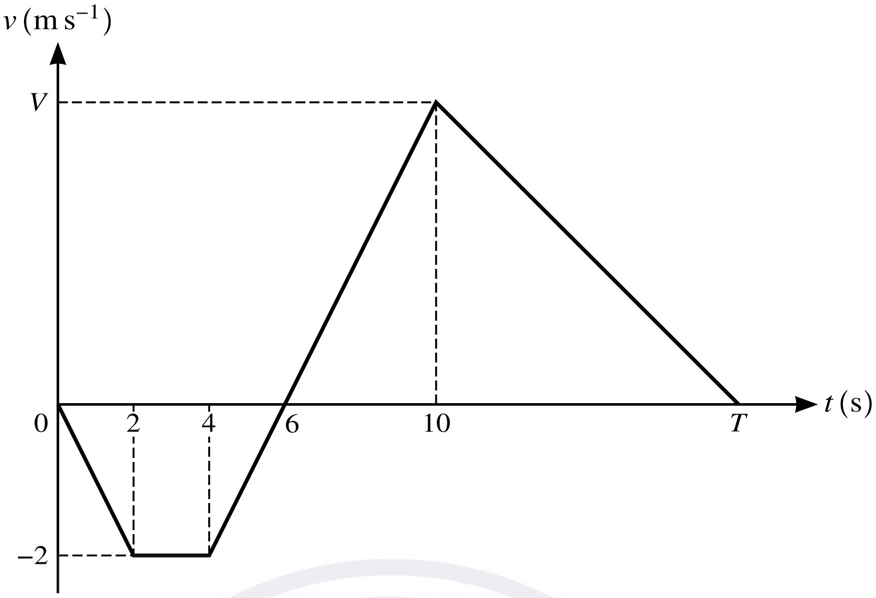


A smooth ring R of mass m kg is threaded on a light inextensible string ARB. The ends of the string are attached to fixed points A and B with A vertically above B. The string is taut and angle $ARB = 90°$. The angle between the part AR of the string and the vertical is 45°. The ring is held in equilibrium in this position by a force of magnitude 2.5 N, acting on the ring in the direction BR (see diagram). Calculate the tension in the string and the mass of the ring. [4]

2 A block of mass 5 kg is being pulled by a rope up a rough plane inclined at 6° to the horizontal. The rope is parallel to a line of greatest slope of the plane and the block is moving at constant speed. The coefficient of friction between the block and the plane is 0.3. Find the tension in the rope. [4]

3



The velocity of a particle moving in a straight line is v m s^{-1} at time t seconds. The diagram shows a velocity-time graph which models the motion of the particle from $t = 0$ to $t = T$. The graph consists of four straight line segments. The particle reaches its maximum velocity V m s^{-1} at $t = 10$.

(i) Find the acceleration of the particle during the first 2 seconds. [1]

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

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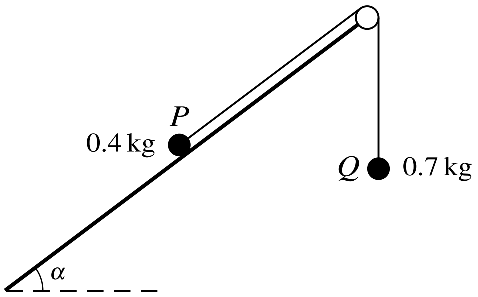
At $t = 6$, the particle is instantaneously at rest at the point A. At $t = T$, the particle comes to rest at the point B. At $t = 0$ the particle starts from rest at a point one third of the way from A to B.

(iii) Find the distance AB and hence find the value of T. [4]

4



Two particles P and Q, of masses 0.4 kg and 0.7 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 edge of a rough plane. The coefficient of friction between P and the plane is 0.5. The plane is inclined at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$. Particle P lies on the plane and particle Q hangs vertically. The string between P and the pulley is parallel to a line of greatest slope of the plane (see diagram). A force of magnitude X N, acting directly down the plane, is applied to P.

(i) Show that the greatest value of X for which P remains stationary is 6.2. [4]

(ii) Given instead that $X = 0.8$, find the acceleration of P. [4]

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

$$a = 1.2t^{\frac{1}{2}} - 0.6t.$$

(i) At time T s after leaving O the particle reaches its maximum velocity. Find the value of T. [2]

(ii) Find the velocity of the particle when its acceleration is maximum (you do not need to verify that the acceleration is a maximum rather than a minimum). [6]

6 A car of mass 1200 kg is driving along a straight horizontal road at a constant speed of 15 m s^{-1}. There is a constant resistance to motion of 350 N.

(i) Find the power of the car's engine. [1]

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The car comes to a hill inclined at $1°$ to the horizontal, still travelling at 15 m s^{-1}.

(ii) The car starts to descend the hill with reduced power and with an acceleration of 0.12 m s^{-2}. Given that there is no change in the resistance force, find the new power of the car's engine at the instant when it starts to descend the hill. [3]

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(iii) When the car is travelling at $20\,\mathrm{m\,s^{-1}}$ down the hill, the power is cut off and the car gradually slows down. Assuming that the resistance force remains 350 N, find the distance travelled from the moment when the power is cut off until the speed of the car is reduced to $18\,\mathrm{m\,s^{-1}}$. [4]

7 A particle of mass 0.3 kg is released from rest above a tank containing water. The particle falls vertically, taking 0.8 s to reach the water surface. There is no instantaneous change of speed when the particle enters the water. The depth of water in the tank is 1.25 m. The water exerts a force on the particle resisting its motion. The work done against this resistance force from the instant that the particle enters the water until it reaches the bottom of the tank is 1.2 J.

(i) Use an energy method to find the speed of the particle when it reaches the bottom of the tank. [4]

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When the particle reaches the bottom of the tank, it bounces back vertically upwards with initial speed $7\,\mathrm{m\,s^{-1}}$. As the particle rises through the water, it experiences a constant resistance force of 1.8 N. The particle comes to instantaneous rest t seconds after it bounces on the bottom of the tank.

(ii) Find the value of t. [7]

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CANDIDATE NAME

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4362225277

MATHEMATICS **9709/43**

Paper 4 Mechanics 1 **(M1)** **October/November 2018**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

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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.

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JC18 11_9709_43/RP

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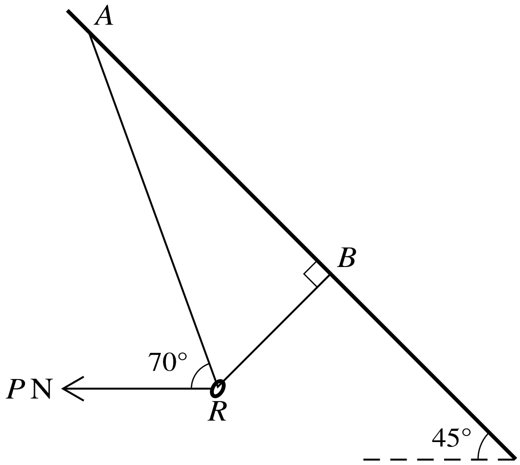

A small smooth ring R of mass 0.2 kg is threaded onto a light inextensible string ARB. The two ends of the string are attached to points A and B on a sloping roof inclined at 45° to the horizontal. A horizontal force of magnitude P N, acting in the plane ARB, is applied to the ring. The section BR of the string is perpendicular to the roof and the section AR of the string is inclined at 70° to the horizontal (see diagram). The system is in equilibrium. Find the tension in the string and the value of P. [4]

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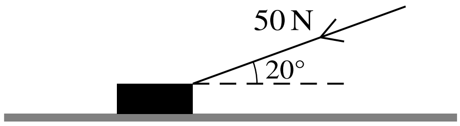

A block is pushed along a horizontal floor by a force of magnitude 50 N which acts at an angle of 20° to the horizontal (see diagram). The coefficient of friction between the block and the floor is 0.3. Given that the speed of the block is constant, find the mass of the block. [5]

3 A particle of mass 1.2 kg moves in a straight line AB. It is projected with speed $7.5\,\mathrm{m\,s^{-1}}$ from A towards B and experiences a resistance force. The work done against this resistance force in moving from A to B is 25 J.

(i) Given that AB is horizontal, find the speed of the particle at B. [2]

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(ii) It is given instead that AB is inclined at $30°$ below the horizontal and that the speed of the particle at B is $9\,\mathrm{m\,s^{-1}}$. The work done against the resistance force remains the same. Find the distance AB. [3]

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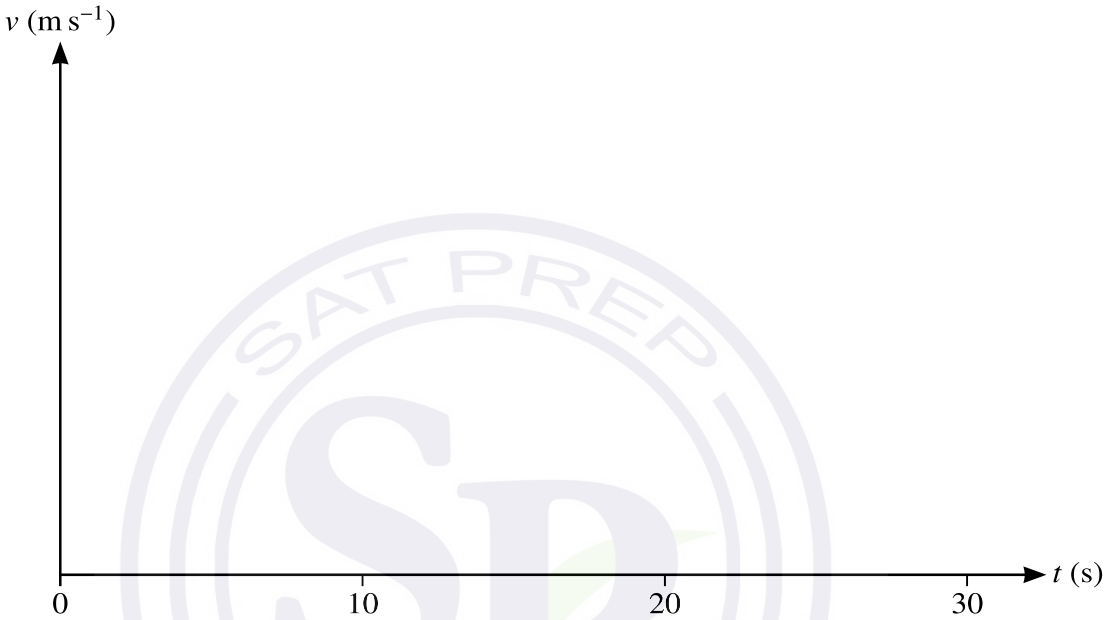
4 A runner sets off from a point P at time $t = 0$, where t is in seconds. The runner starts from rest and accelerates at $1.2\,\mathrm{m\,s^{-2}}$ for 5 s. For the next 12 s the runner moves at constant speed before decelerating uniformly over a period of 3 s, coming to rest at Q. A cyclist sets off from P at time $t = 10$ and accelerates uniformly for 10 s, before immediately decelerating uniformly to rest at Q at time $t = 30$.

(i) Sketch the velocity-time graph for the runner and show that the distance PQ is 96 m. [4]



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(ii) Find the magnitude of the acceleration of the cyclist. [3]

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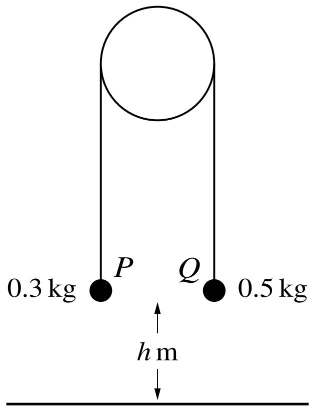

Two particles P and Q, of masses 0.3 kg and 0.5 kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley with the particles hanging freely below it. Q is held at rest with the string taut at a height of h m above a horizontal floor (see diagram). Q is now released and both particles start to move. The pulley is sufficiently high so that P does not reach it at any stage. The time taken for Q to reach the floor is 0.6 s.

(i) Find the acceleration of Q before it reaches the floor and hence find the value of h. [6]

Q remains at rest when it reaches the floor, and P continues to move upwards.

(ii) Find the velocity of P at the instant when Q reaches the floor and the total time taken from the instant at which Q is released until the string becomes taut again. [3]

6 A van of mass 3200 kg travels along a horizontal road. The power of the van's engine is constant and equal to 36 kW, and there is a constant resistance to motion acting on the van.

(i) When the speed of the van is $20\,\mathrm{m\,s^{-1}}$, its acceleration is $0.2\,\mathrm{m\,s^{-2}}$. Find the resistance force. [3]

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When the van is travelling at $30\,\mathrm{m\,s^{-1}}$, it begins to ascend a hill inclined at $1.5°$ to the horizontal. The power is increased and the resistance force is still equal to the value found in part **(i)**.

(ii) Find the power required to maintain this speed of $30\,\mathrm{m\,s^{-1}}$. [3]

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(iii) The engine is now stopped, with the van still travelling at $30\,\mathrm{m\,s^{-1}}$, and the van decelerates to rest. Find the distance the van moves up the hill from the point at which the engine is stopped until it comes to rest. [4]

7 A particle moves in a straight line. The particle is initially at rest at a point O on the line. At time t s after leaving O, the acceleration $a\,\mathrm{m\,s^{-2}}$ of the particle is given by $a = 25 - t^2$ for $0 \leqslant t \leqslant 9$.

(i) Find the maximum velocity of the particle in this time period. [4]

(ii) Find the total distance travelled until the maximum velocity is reached. [2]

The acceleration of the particle for $t > 9$ is given by $a = -3t^{-\frac{1}{2}}$.

(iii) Find the velocity of the particle when $t = 25$. [4]

Additional Page

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CANDIDATE NAME

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8411468102 3

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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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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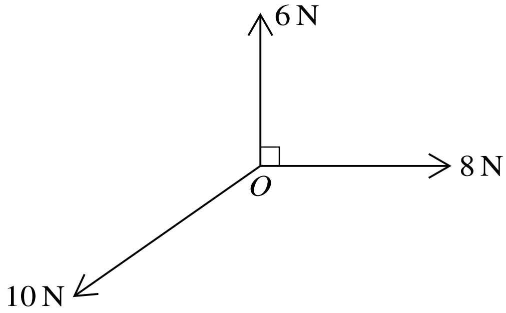
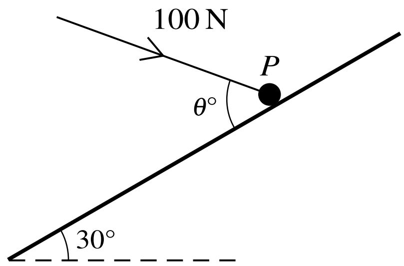


The diagram shows three coplanar forces acting at the point O. The magnitudes of the forces are 6 N, 8 N and 10 N. The angle between the 6 N force and the 8 N force is 90°. The forces are in equilibrium. Find the other angles between the forces. [4]

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 $v \text{ m s}^{-1}$.

(i) Find an expression for v in terms of t. [2]

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

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

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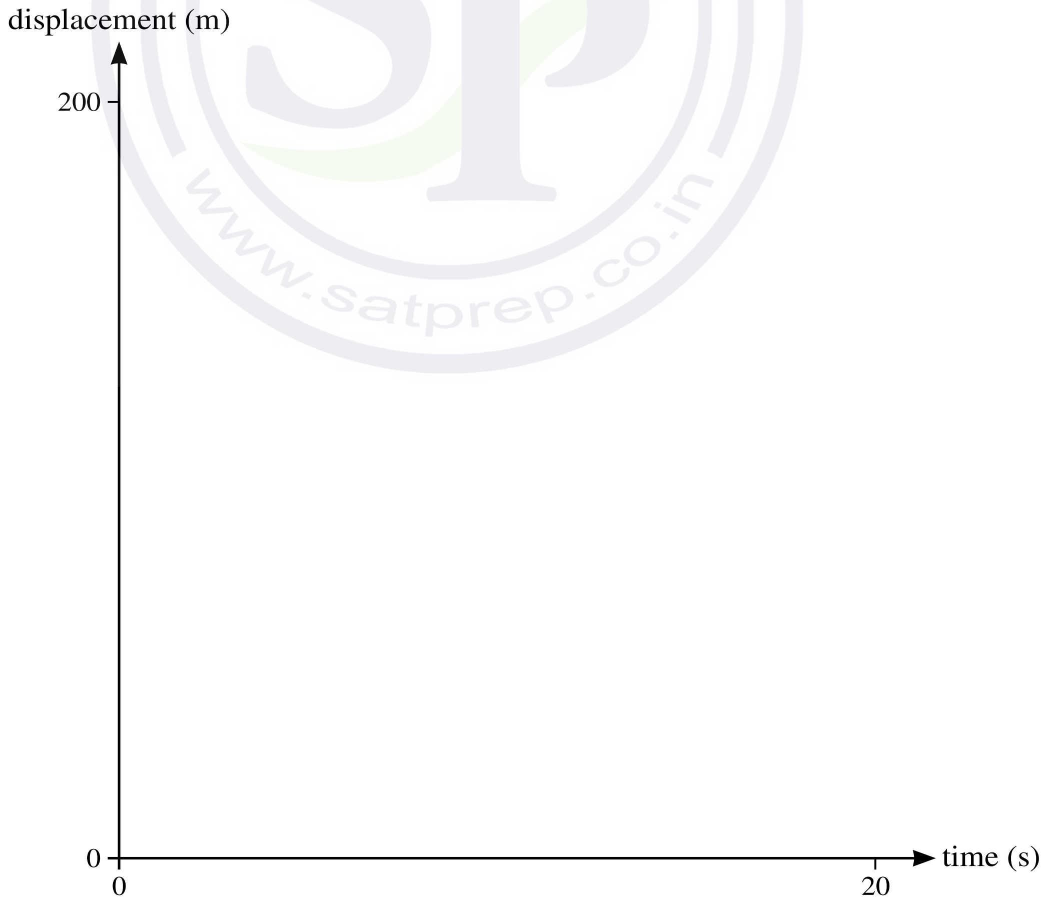


(ii) Find the value of V. [2]

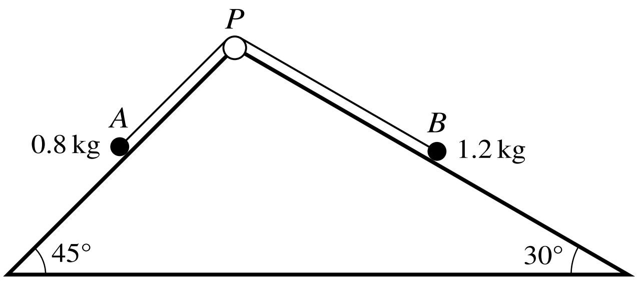
6 A car has mass 1250 kg.

(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]

7



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]

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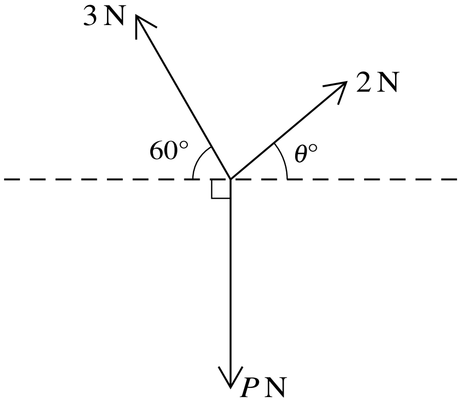
1 A man has mass 80 kg. He runs along a horizontal road against a constant resistance force of magnitude P N. The total work done by the man in increasing his speed from $4\,\mathrm{m\,s^{-1}}$ to $5.5\,\mathrm{m\,s^{-1}}$ while running a distance of 60 metres is 1200 J. Find the value of P. [4]

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]

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]

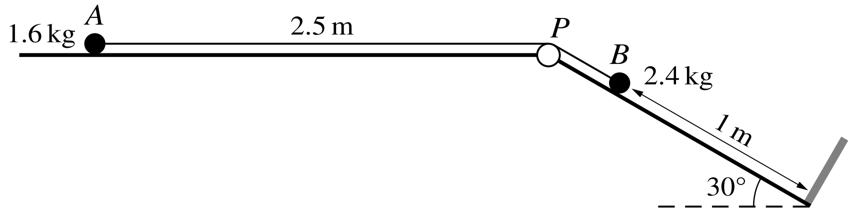
5 A particle of mass 20 kg is on a rough plane inclined at an angle of 60° to the horizontal. Equilibrium is maintained by a force of magnitude P N acting on the particle, in a direction parallel to a line of greatest slope of the plane. The greatest possible value of P is twice the least possible value 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, $a\,\mathrm{m\,s^{-2}}$, 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]

7



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 number of marks is given in brackets [ ] at the end of each question or part question.
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JC18 06_9709_43/2R

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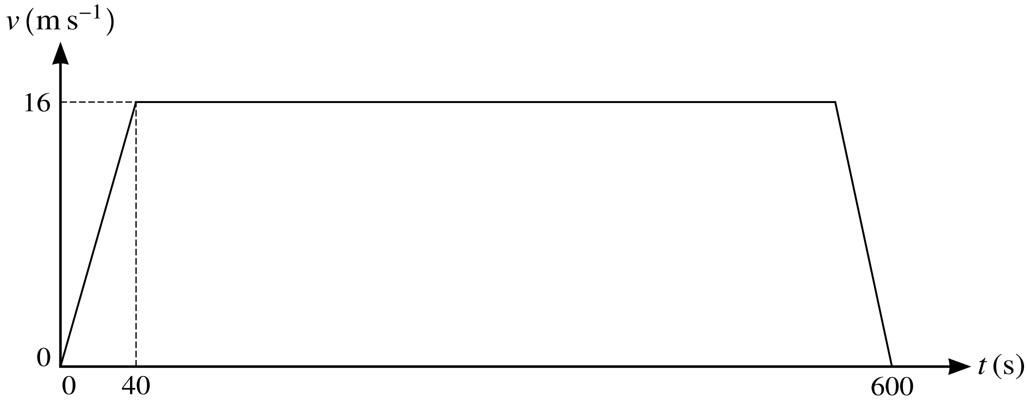
1



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 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]

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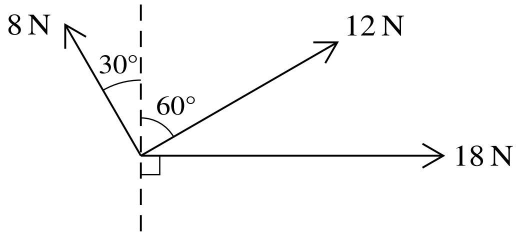

Coplanar forces of magnitudes 8 N, 12 N and 18 N act at a point in the directions shown in the diagram. Find the magnitude and direction of the single additional force acting at the same point which will produce equilibrium. [6]

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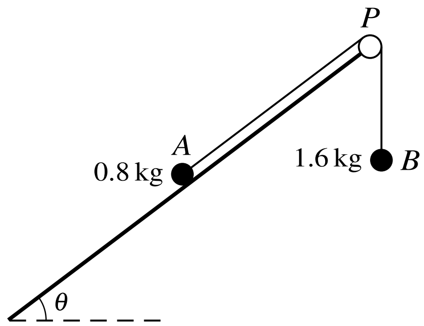

Two particles A and B, of masses 0.8 kg and 1.6 kg respectively, are connected by a light inextensible string. Particle A is placed on a smooth plane inclined at an angle θ to the horizontal, where $\sin\theta = \frac{3}{5}$. The string passes over a small smooth pulley P fixed at the top of the plane, 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]

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]

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(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]

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(iii) The car travels down a hill inclined at an angle of $\theta°$ to the horizontal at a constant speed of $50\,\text{m}\,\text{s}^{-1}$. The power of the car's engine is $60\,\text{kW}$. 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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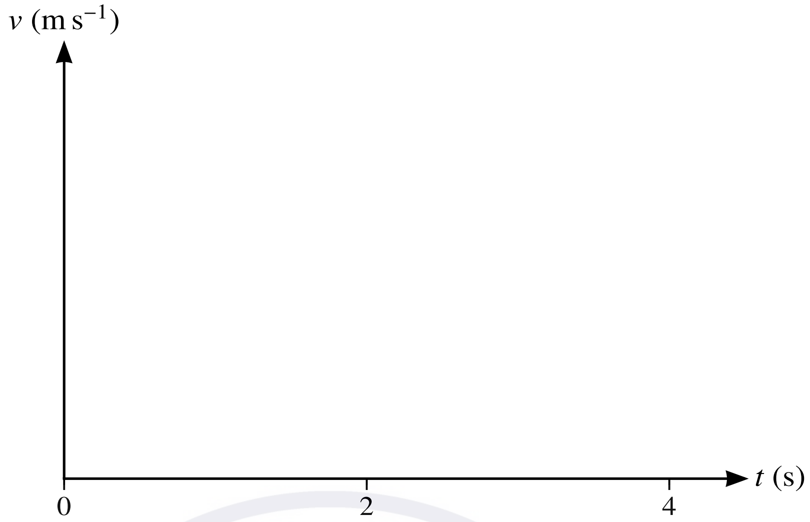
(iii) Sketch the velocity-time graph for $0 \leqslant t \leqslant 4$. [3]



(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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CENTRE NUMBER		CANDIDATE NUMBER	

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MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **February/March 2018**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

READ THESE INSTRUCTIONS FIRST

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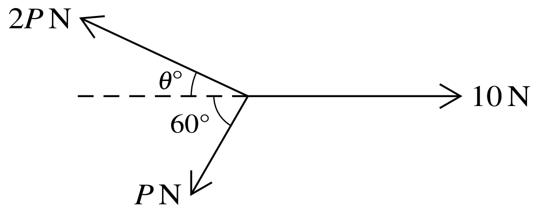
The total number of marks for this paper is 50.

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

1 Two particles A and B, of masses 0.8 kg and 0.2 kg respectively, are connected by a light inextensible string that passes over a fixed smooth pulley. The particles hang vertically. The system is released from rest. Show that the acceleration of A has magnitude $6\,\mathrm{m\,s^{-2}}$ and find the tension in the string. [4]

2



The three coplanar forces shown in the diagram are in equilibrium. Find the values of θ and P. [4]

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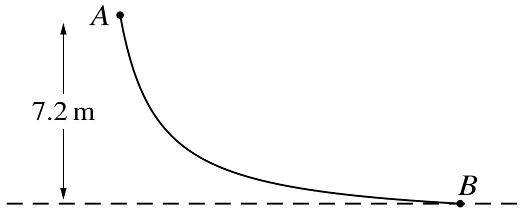

A girl, of mass 40 kg, slides down a slide in a water park. The girl starts at the point A and slides to the point B which is 7.2 metres vertically below the level of A, as shown in the diagram.

(i) Given that the slide is smooth and that the girl starts from rest at A, find the speed of the girl at B. [2]

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(ii) It is given instead that the slide is rough. On one occasion the girl starts from rest at A and reaches B with a speed of $10\,\mathrm{m\,s^{-1}}$. On another occasion the girl is pushed from A with an initial speed $V\,\mathrm{m\,s^{-1}}$ and reaches B with speed $11\,\mathrm{m\,s^{-1}}$. Given that the work done against friction is the same on both occasions, find V. [3]

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4 A particle of mass 12 kg is on a rough plane inclined at an angle of 25° to the horizontal. A force of magnitude P N acts on the particle. This force is horizontal and the particle is on the point of moving up a line of greatest slope of the plane. The coefficient of friction between the particle and the plane is 0.8. Find the value of P. [6]

5 A small rocket is fired vertically upwards, starting from rest at ground level, and moves with constant acceleration. The rocket reaches a height of 200 m after 10 s.

(i) Show that the speed of the rocket after 10 s is $40\,\mathrm{m\,s^{-1}}$ and find the acceleration of the rocket during the first 10 s. [4]

(ii) After 10 s, the rocket's fuel stops burning and there is no upward force acting on the rocket. Find the maximum height above ground level reached by the rocket. [2]

(iii) Find the total time from the instant the rocket is fired until it returns to the ground. [4]

6 A car of mass 1200 kg has a greatest possible constant speed of $60\,\text{m}\,\text{s}^{-1}$ along a straight level road. When the car is travelling at a speed of $v\,\text{m}\,\text{s}^{-1}$ there is a resistive force of magnitude $35v$ N.

(i) Find the greatest possible power of the car. [2]

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(ii) The car travels along a straight level road. Show that, at an instant when its speed is $30\,\text{m}\,\text{s}^{-1}$, the greatest possible acceleration of the car is $2.625\,\text{m}\,\text{s}^{-2}$. [3]

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(iii) The car travels at a constant speed up a hill inclined at an angle of $\sin^{-1}\left(\frac{7}{48}\right)$ to the horizontal. Find the greatest possible speed of the car. [5]

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

$$v = 4 + 0.2t \qquad \text{for } 0 \leqslant t \leqslant 10,$$

$$v = -2 + \frac{800}{t^2} \qquad \text{for } 10 \leqslant t \leqslant 20.$$

(i) Find the acceleration of P during the first 10 s. [1]

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(ii) Find the acceleration of P when $t = 20$. [2]

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(iii) Sketch the velocity-time graph for $0 \leqslant t \leqslant 20$. [3]

(iv) Find the total distance travelled by P in the interval $0 \leqslant t \leqslant 20$. [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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CANDIDATE NUMBER

* 5 6 1 6 2 1 9 7 2 2 *

MATHEMATICS **9709/43**

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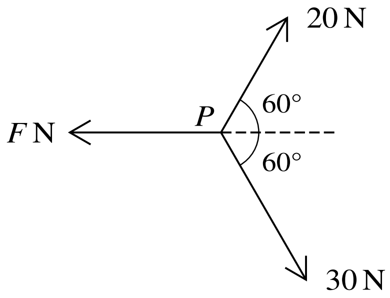
1



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

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

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

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

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3 A particle is released from rest and slides down a line of greatest slope of a rough plane which is inclined at 25° to the horizontal. The coefficient of friction between the particle and the plane is 0.4.

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

(ii) Find the distance travelled by the particle in the first 3 s after it is released. [2]

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

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

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

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

(i) Show that the value of k is 0.1. [5]

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

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

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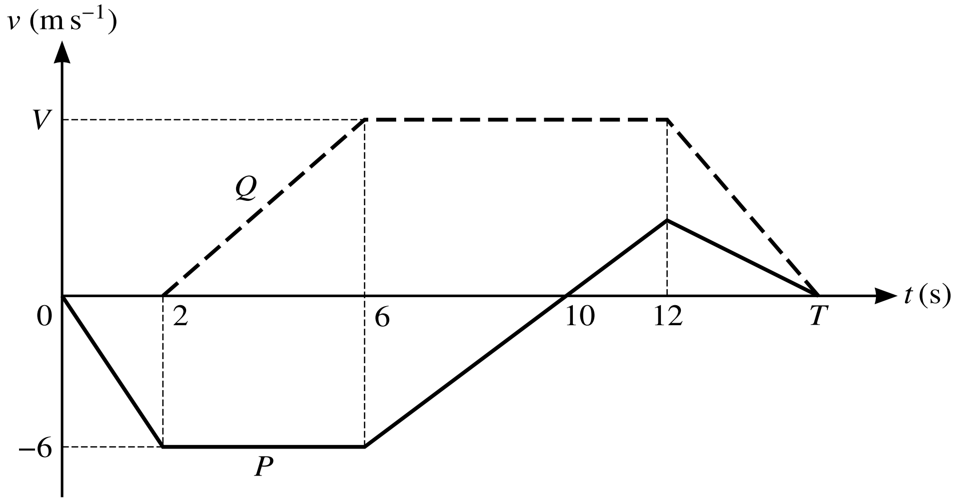

The diagram shows the velocity-time graphs for two particles, P and Q, which are moving in the same straight line. The graph for P consists of four straight line segments. The graph for Q consists of three straight line segments. Both particles start from the same initial position O on the line. Q starts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

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

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

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

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

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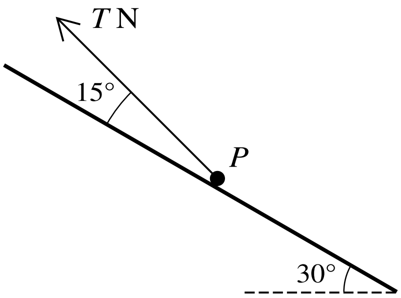

A particle P of mass 0.2 kg rests on a rough plane inclined at 30° to the horizontal. The coefficient of friction between the particle and the plane is 0.3. A force of magnitude T N acts upwards on P at 15° above a line of greatest slope of the plane (see diagram).

(i) Find the least value of T for which the particle remains at rest. [6]

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

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

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MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **October/November 2017**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

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JC17 11_9709_42/RP

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1 A particle of mass 0.2 kg is resting in equilibrium on a rough plane inclined at 20° to the horizontal.

(i) Show that the friction force acting on the particle is 0.684 N, correct to 3 significant figures. [1]

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

(ii) Find this acceleration. [4]

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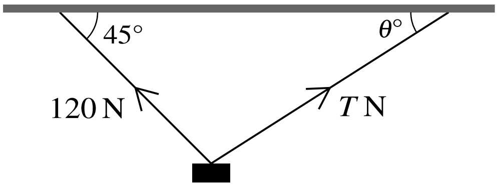

A block of mass 15 kg hangs in equilibrium below a horizontal ceiling attached to two strings as shown in the diagram. One of the strings is inclined at 45° to the horizontal and the tension in this string is 120 N. The other string is inclined at $\theta°$ to the horizontal and the tension in this string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

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

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

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

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

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

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

(ii) Find the set of values of t for which the two particles are moving in the same direction. [4]

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[Turn over

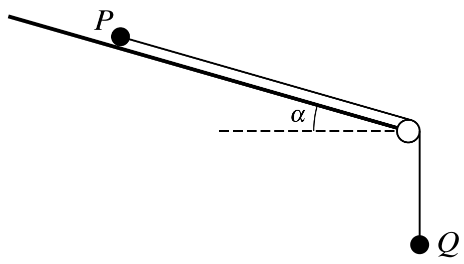
5 A cyclist is riding up a straight hill inclined at an angle α to the horizontal, where $\sin\alpha = 0.04$. The total mass of the bicycle and rider is 80 kg. The cyclist is riding at a constant speed of $4\,\mathrm{m\,s^{-1}}$. There is a force resisting the motion. The work done by the cyclist against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

(i) Find the power output of the cyclist. [4]

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

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

6



Two particles P and Q, each of mass m kg, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the edge of a rough plane. The plane is inclined at an angle α to the horizontal, where $\tan\alpha = \frac{7}{24}$. Particle P rests on the plane and particle Q hangs vertically, as shown in the diagram. The string between P and the pulley is parallel to a line of greatest slope of the plane. The system is in limiting equilibrium.

(i) Show that the coefficient of friction between P and the plane is $\frac{4}{3}$. [5]

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

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

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

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

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

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

(iii) Find the distance travelled by the particle while its velocity is positive. [4]

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MATHEMATICS **9709/41**

Paper 4 Mechanics 1 **(M1)** **October/November 2017**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

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JC17 11_9709_41/RP

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[Turn over

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

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

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

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

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

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

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

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

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

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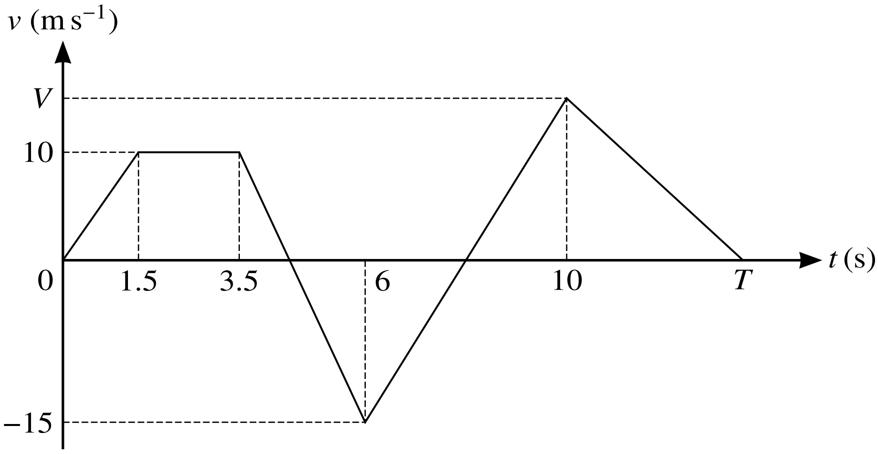

The diagram shows the velocity-time graph of a particle which moves in a straight line. The graph consists of 5 straight line segments. The particle starts from rest at a point A at time $t = 0$, and initially travels towards point B on the line.

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

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

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

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

$$v = 1.5 + 0.4t \qquad \text{for } 0 \leqslant t \leqslant 5,$$
$$v = \frac{100}{t^2} - 0.1t \qquad \text{for } t \geqslant 5.$$

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

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

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

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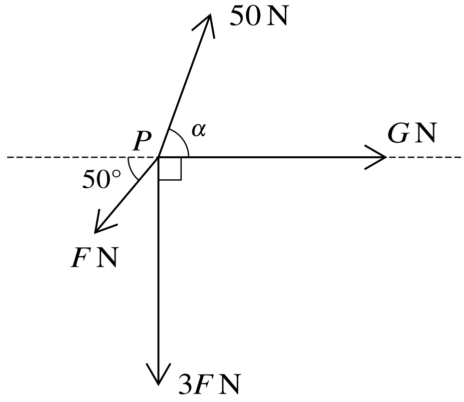

Coplanar forces, of magnitudes F N, $3F$ N, G N and 50 N, act at a point P, as shown in the diagram.

(i) Given that $F = 0$, $G = 75$ and $\alpha = 60°$, find the magnitude and direction of the resultant force. [4]

(ii) Given instead that $G = 0$ and the forces are in equilibrium, find the values of F and α. [5]

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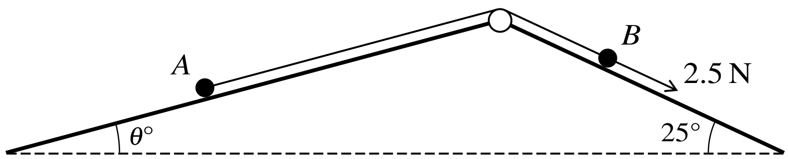

Two particles A and B of masses 0.9 kg and 0.4 kg respectively are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the top of two inclined planes. The particles are initially at rest with A on a smooth plane inclined at angle $\theta°$ to the horizontal and B on a plane inclined at angle 25° 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 2.5 N is applied to B acting down the plane (see diagram).

(i) For the case where $\theta = 15$ and the plane on which B rests is smooth, find the acceleration of B. [5]

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(ii) For a different value of θ, the plane on which B rests is rough with coefficient of friction between the plane and B of 0.8. The system is in limiting equilibrium with B on the point of moving in the direction of the 2.5 N force. Find the value of θ. [5]

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Cambridge International AS & A Level

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Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

2044311977

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)

READ THESE INSTRUCTIONS FIRST

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Write in dark blue or black pen.
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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 $10\,\mathrm{m\,s^{-2}}$.
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

CAMBRIDGE International Examinations

[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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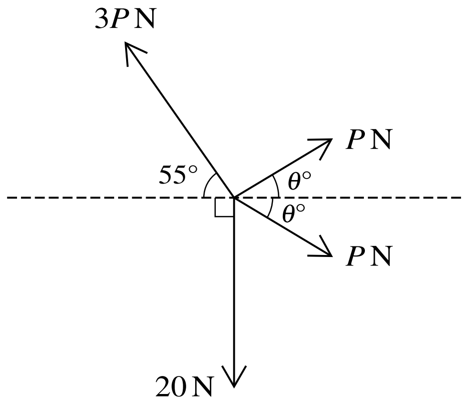
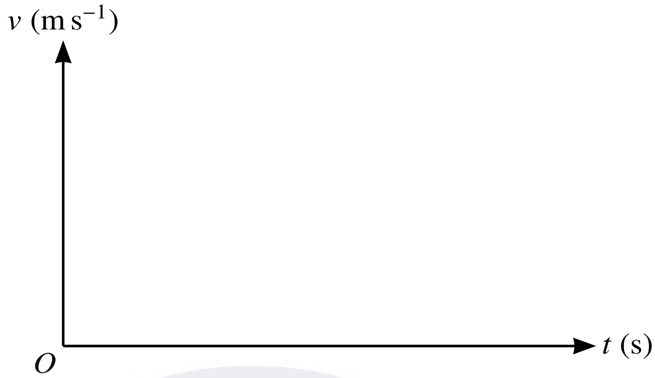


The four coplanar forces shown in the diagram are in equilibrium. Find the values of P and θ. [5]

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]

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

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5 A particle is projected vertically upwards from a point O with a speed of $12\,\mathrm{m\,s^{-1}}$. 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]

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

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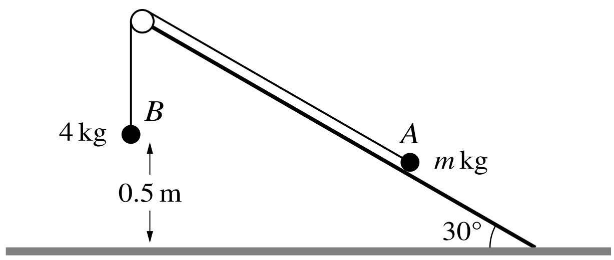
(ii) It is given instead that the resistance to motion of the car is $(590 + 2v)$ N when the speed of the car is $v\,\mathrm{m\,s^{-1}}$. The car travels at a constant speed with the engine working at 16 kW. Find this speed. [3]

7



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]

(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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CANDIDATE NAME

CENTRE NUMBER | CANDIDATE NUMBER

* 4 8 0 9 9 4 5 2 7 5 *

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

JC17 06_9709_41/RP

CAMBRIDGE International Examinations

[Turn over

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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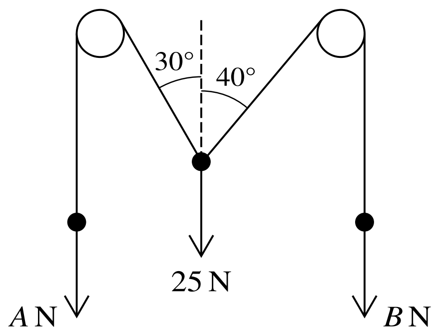

Two light inextensible strings are attached to a particle of weight 25 N. The strings pass over two smooth fixed pulleys and have particles of weights A N and B N hanging vertically at their ends. The sloping parts of the strings make angles of 30° and 40° respectively with the vertical (see diagram).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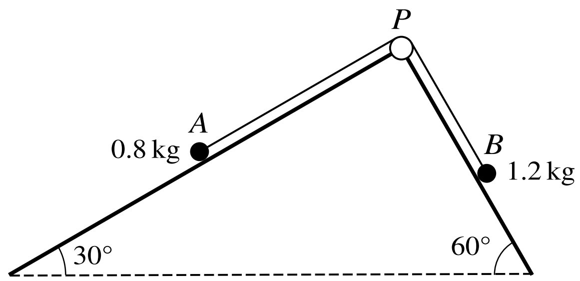

As shown in the diagram, a particle A of mass 0.8 kg lies on a plane inclined at an angle of 30° to the horizontal and a particle B of mass 1.2 kg lies on a plane inclined at an angle of 60° to the horizontal. The particles are connected by a light inextensible string which passes over a small smooth 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

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9849593396

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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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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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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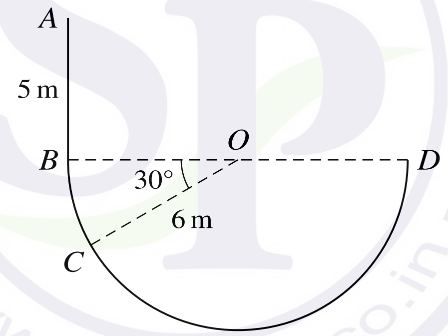

The diagram shows a wire $ABCD$ consisting of a straight part AB of length 5 m and a part BCD in the shape of a semicircle of radius 6 m and centre O. The diameter BD of the semicircle is horizontal and AB is vertical. A small ring is threaded onto the wire and slides along the wire. The ring starts 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]

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

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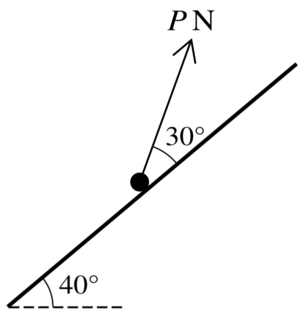
(ii) On a part of the road that is inclined at $\theta°$ to the horizontal, the car moves up the hill at a constant speed of $24\,\mathrm{m\,s^{-1}}$, with the engine working at 80 kW. Find θ. [4]

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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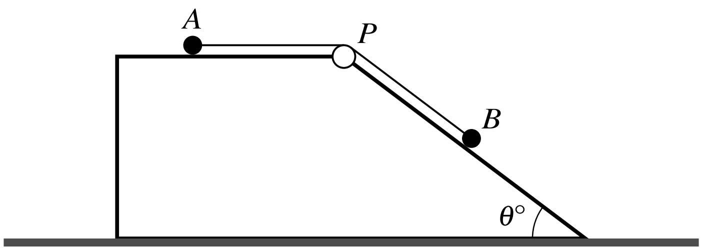

The diagram shows a fixed block with a horizontal top surface and a surface which is inclined at an angle of $\theta°$ to the horizontal, where $\sin\theta = \frac{3}{5}$. A particle A of mass 0.3 kg rests on the horizontal surface and is attached to one end of a light inextensible string. The string 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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CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

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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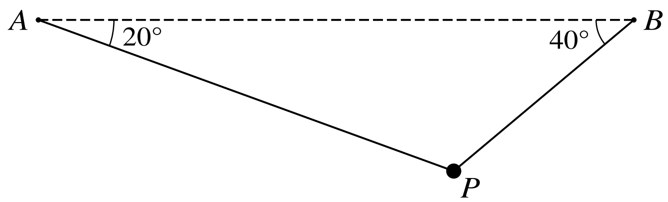
[Turn over

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]

(ii) Use an energy method to find the distance the particle moves up the plane before coming to instantaneous rest. [3]

2



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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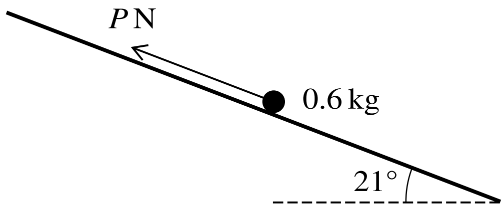

A particle of mass 0.6 kg is placed on a rough plane which is inclined at an angle of 21° to the horizontal. The particle is kept in equilibrium by a force of magnitude P N acting parallel to a line of greatest slope of the plane, as shown in the diagram. The coefficient of friction between the particle 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]

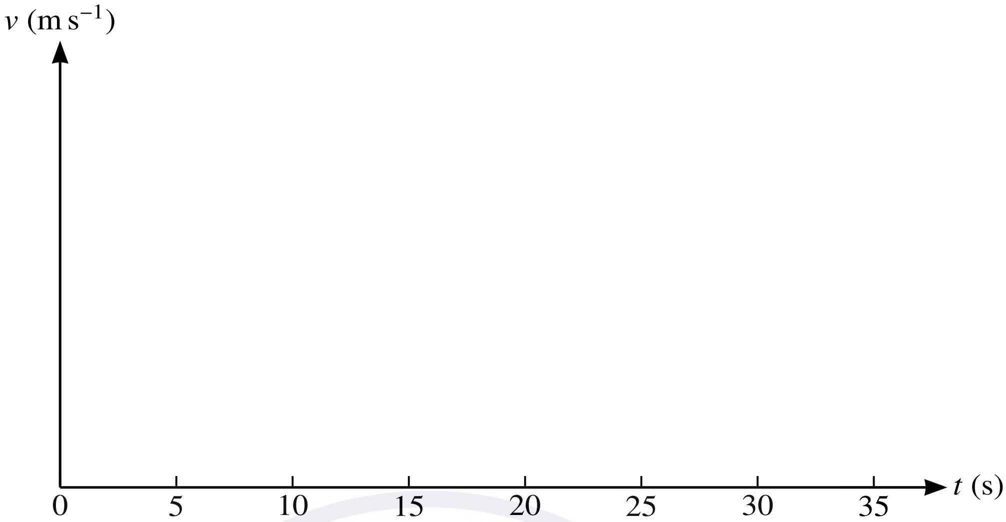
5 A particle P moves in a straight line starting from a point O and comes to rest 35 s later. At time t s after leaving O, the velocity $v\,\mathrm{m\,s^{-1}}$ of P is given by

$$\begin{aligned} v &= \tfrac{4}{5}t^2 && 0 \leqslant t \leqslant 5, \\ v &= 2t + 10 && 5 \leqslant t \leqslant 15, \\ v &= a + bt^2 && 15 \leqslant t \leqslant 35, \end{aligned}$$

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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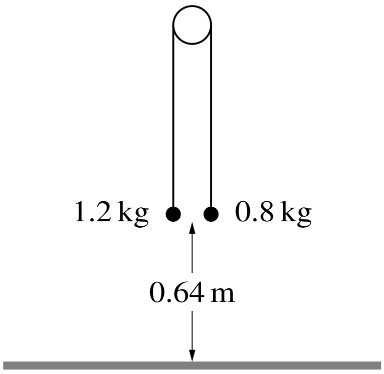

Two particles of masses 1.2 kg and 0.8 kg are connected by a light inextensible string that passes over a fixed smooth pulley. The particles hang vertically. The system is released from rest with both particles 0.64 m above the floor (see diagram). In the subsequent motion the 0.8 kg particle does not 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]

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(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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MATHEMATICS **9709/43**

Paper 4 Mechanics 1 **(M1)** **October/November 2016**

1 hour 15 minutes

9056656137

Additional Materials: List of Formulae (MF9)

READ THESE INSTRUCTIONS FIRST

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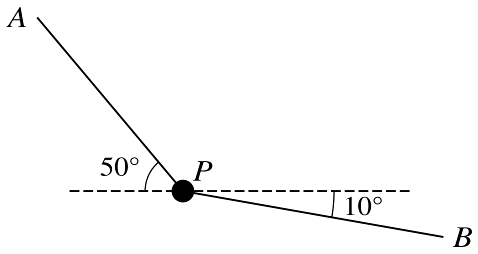
1 A crane is used to raise a block of mass 50 kg vertically upwards at constant speed through a height of 3.5 m. There is a constant resistance to motion of 25 N.

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

(ii) Given that the time taken to raise the block is 2 s, find the power of the crane. [2]

2



The diagram shows a small object P of mass 20 kg held in equilibrium by light ropes attached to fixed points A and B. The rope PA is inclined at an angle of 50° above the horizontal, the rope PB is inclined at an angle of 10° below the horizontal, and both ropes are in the same vertical plane. Find the tension in the rope PA and the tension in the rope PB. [5]

3

Particles P and Q, of masses 7 kg and 3 kg respectively, are attached to the two ends of a light inextensible string. The string passes over two small smooth pulleys attached to the two ends of a horizontal table. The two particles hang vertically below the two pulleys. The two particles are both initially at rest, 0.5 m below the level of the table, and 0.4 m above the horizontal floor (see diagram).

(i) Find the acceleration of the particles and the speed of P immediately before it reaches the floor. [4]

(ii) Determine whether Q comes to instantaneous rest before it reaches the pulley directly above it. [2]

4 A ball A is released from rest at the top of a tall tower. One second later, another ball B is projected vertically upwards from ground level near the bottom of the tower with a speed of $20\,\mathrm{m\,s^{-1}}$. The two balls are at the same height 1.5 s after ball B is projected.

(i) Show that the height of the tower is 50 m. [3]

(ii) Find the length of time for which ball B has been in motion when ball A reaches the ground. Hence find the total distance travelled by ball B up to the instant when ball A reaches the ground. [5]

5 A particle P starts from a fixed point O and moves in a straight line. At time t s after leaving O, the velocity $v\,\mathrm{m\,s^{-1}}$ of P is given by $v = 6t - 0.3t^2$. The particle comes to instantaneous rest at point X.

(i) Find the distance OX. [4]

A second particle Q starts from rest from O, at the same instant as P, and also travels in a straight line. The acceleration $a\,\mathrm{m\,s^{-2}}$ of Q is given by $a = k - 12t$, where k is a constant. The displacement of Q from O is 400 m when $t = 10$.

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

6 A cyclist is cycling with constant power of 160 W along a horizontal straight road. There is a constant resistance to motion of 20 N. At an instant when the cyclist's speed is $5\,\mathrm{m\,s^{-1}}$, his acceleration is $0.15\,\mathrm{m\,s^{-2}}$.

(i) Show that the total mass of the cyclist and bicycle is 80 kg. [3]

The cyclist comes to a hill inclined at 2° to the horizontal. When the cyclist starts climbing the hill, he increases his power to a constant 300 W. The resistance to motion remains 20 N.

(ii) Show that the steady speed up the hill which the cyclist can maintain when working at this power is $6.26\,\mathrm{m\,s^{-1}}$, correct to 3 significant figures. [2]

(iii) Find the acceleration at an instant when the cyclist is travelling at 90% of the speed in part **(ii)**. [4]

7 A box of mass 50 kg is at rest on a plane inclined at 10° to the horizontal.

(i) Find an inequality for the coefficient of friction between the box and the plane. [2]

In fact the coefficient of friction between the box and the plane is 0.19.

(ii) A girl pushes the box with a force of 50 N, acting down a line of greatest slope of the plane, for a distance of 5 m. She then stops pushing. Use an energy method to find the speed of the box when it has travelled a further 5 m. [5]

The box then comes to a plane inclined at 20° below the horizontal. The box moves down a line of greatest slope of this plane. The coefficient of friction is still 0.19 and the girl is not pushing the box.

(iii) Find the acceleration of the box. [2]

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MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **October/November 2016**

1 hour 15 minutes

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[Turn over

1 A particle of mass 2 kg is initially at rest on a rough horizontal plane. A force of magnitude 10 N is applied to the particle at 15° above the horizontal. It is given that 10 s after the force is applied, the particle has a speed of $3.5\ \mathrm{m\,s^{-1}}$.

(i) Show that the magnitude of the frictional force is 8.96 N, correct to 3 significant figures. [3]

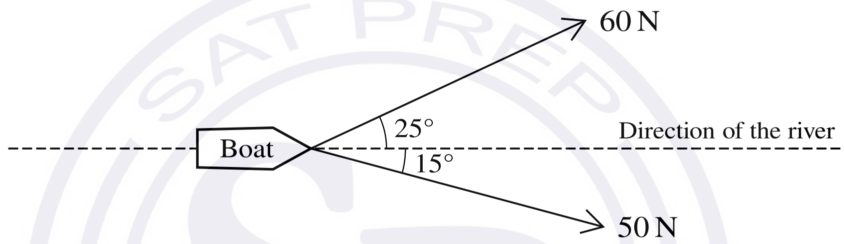
(ii) Find the coefficient of friction between the particle and the plane. [3]

2 A particle moves in a straight line. Its displacement t s after leaving a fixed point O on the line is s m, where $s = 2t^2 - \frac{80}{3}t^{\frac{3}{2}}$.

(i) Find the time at which the acceleration of the particle is zero. [4]

(ii) Find the displacement and velocity of the particle at this instant. [2]

3



A boat is being pulled along a river by two people. One of the people walks along a path on one side of the river and the other person walks along a path on the opposite side of the river. The first person exerts a horizontal force of 60 N at an angle of 25° to the direction of the river. The second person exerts a horizontal force of 50 N at an angle of 15° to the direction of the river (see diagram).

(i) Find the total force exerted by the two people in the direction of the river. [2]

(ii) Find the magnitude and direction of the resultant force exerted by the two people. [4]

4 A girl on a sledge starts, with a speed of $5\ \mathrm{m\,s^{-1}}$, at the top of a slope of length 100 m which is at an angle of 20° to the horizontal. The sledge slides directly down the slope.

(i) Given that there is no resistance to the sledge's motion, find the speed of the sledge at the bottom of the slope. [3]

(ii) It is given instead that the sledge experiences a resistance to motion such that the total work done against the resistance is 8500 J, and the speed of the sledge at the bottom of the slope is $21\ \mathrm{m\,s^{-1}}$. Find the total mass of the girl and the sledge. [3]

5 A particle of mass m kg is resting on a rough plane inclined at 30° to the horizontal. A force of magnitude 10 N applied to the particle up a line of greatest slope of the plane is just sufficient to stop the particle sliding down the plane. When a force of 75 N is applied to the particle up a line of greatest slope of the plane, the particle is on the point of sliding up the plane. Find m and the coefficient of friction between the particle and the plane. [6]

6 A van of mass 3000 kg is pulling a trailer of mass 500 kg along a straight horizontal road at a constant speed of $25\,\mathrm{m\,s^{-1}}$. The system of the van and the trailer is modelled as two particles connected by a light inextensible cable. There is a constant resistance to motion of 300 N on the van and 100 N on the trailer.

(i) Find the power of the van's engine. [2]

(ii) Write down the tension in the cable. [1]

The van reaches the bottom of a hill inclined at 4° to the horizontal with speed $25\,\mathrm{m\,s^{-1}}$. The power of the van's engine is increased to 25 000 W.

(iii) Assuming that the resistance forces remain the same, find the new tension in the cable at the instant when the speed of the van up the hill is $20\,\mathrm{m\,s^{-1}}$. [5]

7 A car starts from rest and moves in a straight line from point A with constant acceleration $3\,\mathrm{m\,s^{-2}}$ for 10 s. The car then travels at constant speed for 30 s before decelerating uniformly, coming to rest at point B. The distance AB is 1.5 km.

(i) Find the total distance travelled in the first 40 s of motion. [3]

When the car has been moving for 20 s, a motorcycle starts from rest and accelerates uniformly in a straight line from point A to a speed $V\,\mathrm{m\,s^{-1}}$. It then maintains this speed for 30 s before decelerating uniformly to rest at point B. The motorcycle comes to rest at the same time as the car.

(ii) Given that the magnitude of the acceleration $a\,\mathrm{m\,s^{-2}}$ of the motorcycle is three times the magnitude of its deceleration, find the value of a. [6]

(iii) Sketch the displacement-time graph for the motion of the car. [3]

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MATHEMATICS **9709/41**

Paper 4 Mechanics 1 **(M1)** **October/November 2016**

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1

Two particles P and Q, of masses 0.6 kg and 0.4 kg respectively, are connected by a light inextensible string. The string passes over a small smooth light pulley fixed at the edge of a smooth horizontal table. Initially P is held at rest on the table and Q hangs vertically (see diagram). P is then released. Find the tension in the string and the acceleration of Q. [4]

2 A particle of mass 0.1 kg is released from rest on a rough plane inclined at 20° to the horizontal. It is given that, 5 seconds after release, the particle has a speed of $2\,\mathrm{m\,s^{-1}}$.

(i) Find the acceleration of the particle and hence show that the magnitude of the frictional force acting on the particle is 0.302 N, correct to 3 significant figures. [3]

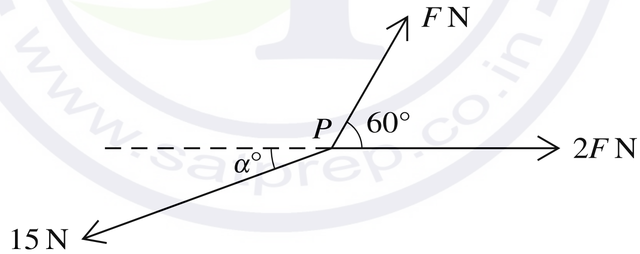
(ii) Find the coefficient of friction between the particle and the plane. [2]

3 A particle P is projected vertically upwards from a point O. When the particle is at a height of 0.5 m, its speed is $6\,\mathrm{m\,s^{-1}}$. Find

(i) the greatest height reached by the particle above O, [3]

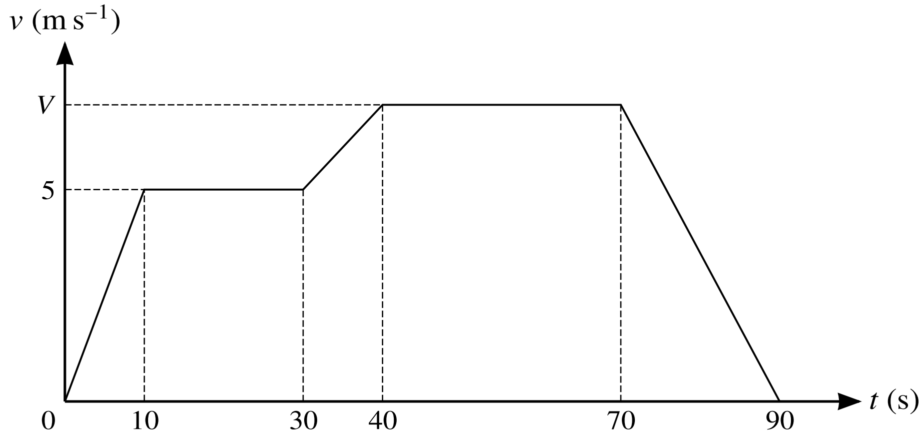
(ii) the time after projection at which the particle returns to O. [3]

4



Three coplanar forces of magnitudes F N, $2F$ N and 15 N act at a point P, as shown in the diagram. Given that the forces are in equilibrium, find the values of F and α. [6]

5



The diagram shows a velocity-time graph which models the motion of a cyclist. The graph consists of five straight line segments. The cyclist accelerates from rest to a speed of $5\,\mathrm{m\,s^{-1}}$ over a period of 10 s, and then travels at this speed for a further 20 s. The cyclist then descends a hill, accelerating to speed $V\,\mathrm{m\,s^{-1}}$ over a period of 10 s. This speed is maintained for a further 30 s. The cyclist then decelerates to rest over a period of 20 s.

(i) Find the acceleration of the cyclist during the first 10 seconds. [1]

(ii) Show that the total distance travelled by the cyclist in the 90 seconds of motion may be expressed as $(45V + 150)$ m. Hence find V, given that the total distance travelled by the cyclist is 465 m. [3]

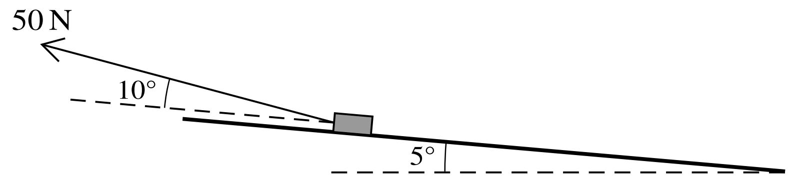
(iii) The combined mass of the cyclist and the bicycle is 80 kg. The cyclist experiences a constant resistance to motion of 20 N. Use an energy method to find the vertical distance which the cyclist descends during the downhill section from $t = 30$ to $t = 40$, assuming that the cyclist does no work during this time. [4]

6 A block of mass 25 kg is pulled along horizontal ground by a force of magnitude 50 N inclined at 10° above the horizontal. The block starts from rest and travels a distance of 20 m. There is a constant resistance force of magnitude 30 N opposing motion.

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

(ii) Use an energy method to find the speed of the block when it has moved a distance of 20 m. [2]

(iii) Find the greatest power exerted by the 50 N force. [2]



After the block has travelled the 20 m, it comes to a plane inclined at 5° to the horizontal. The force of 50 N is now inclined at an angle of 10° to the plane and pulls the block directly up the plane (see diagram). The resistance force remains 30 N.

(iv) Find the time it takes for the block to come to rest from the instant when it reaches the foot of the inclined plane. [4]

7 A racing car is moving in a straight line. The acceleration $a\,\mathrm{m\,s^{-2}}$ at time t s after the car starts from rest is given by

$$a = 15t - 3t^2 \qquad \text{for } 0 \leqslant t \leqslant 5,$$
$$a = -\frac{625}{t^2} \qquad \text{for } 5 < t \leqslant k,$$

where k is a constant.

(i) Find the maximum acceleration of the car in the first five seconds of its motion. [3]

(ii) Find the distance of the car from its starting point when $t = 5$. [3]

(iii) The car comes to rest when $t = k$. Find the value of k. [5]

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MATHEMATICS **9709/43**

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

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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]

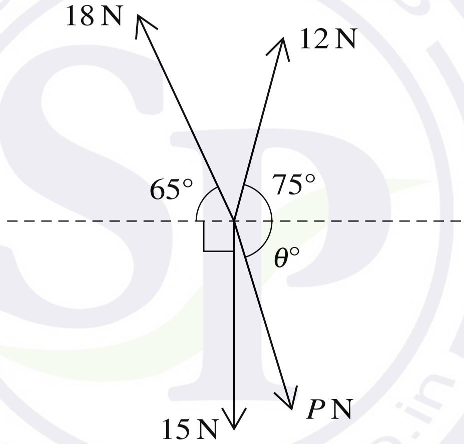
(ii) The total work done against gravity and friction is 1146 J. Find the frictional force acting on the particle. [2]

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]

3



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 **9709/42**

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

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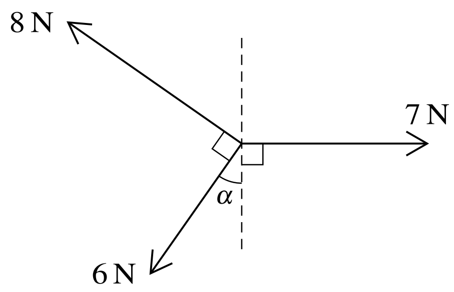


Coplanar forces of magnitudes 7 N, 6 N and 8 N act at a point in the directions shown in the diagram. Given that $\sin\alpha = \frac{3}{5}$, find the magnitude and direction of the resultant of the three forces. [5]

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, $v\ \mathrm{m\,s^{-1}}$, is given by $v = 4t^2 - 8t + 3$.

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

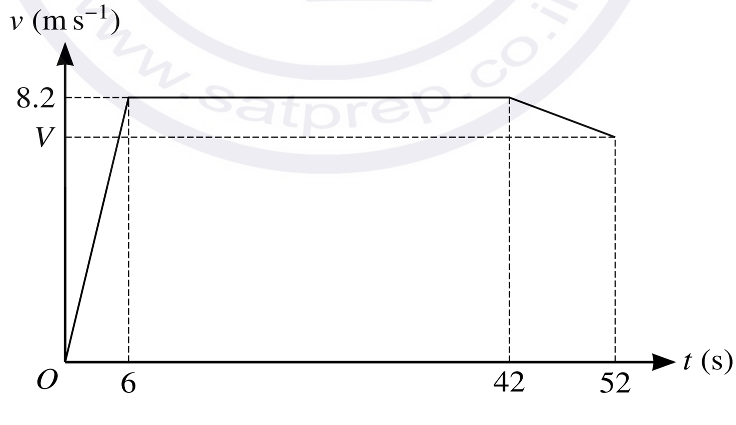
(ii) Find the distance travelled by P between these two times. [3]

3 A particle of mass 8 kg is projected with a speed of $5\ \mathrm{m\,s^{-1}}$ 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]

4



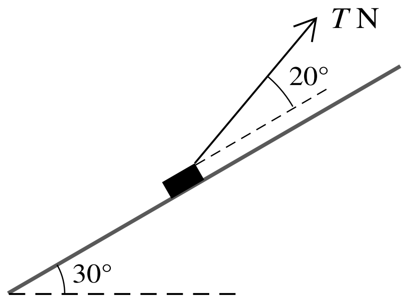
A sprinter runs a race of 400 m. His total time for running the race is 52 s. The diagram shows the velocity-time graph for the motion of the sprinter. He starts from rest and accelerates uniformly to a speed of $8.2\ \mathrm{m\,s^{-1}}$ in 6 s. The sprinter maintains a speed of $8.2\ \mathrm{m\,s^{-1}}$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

5



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]

7

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 **9709/41**

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

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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]

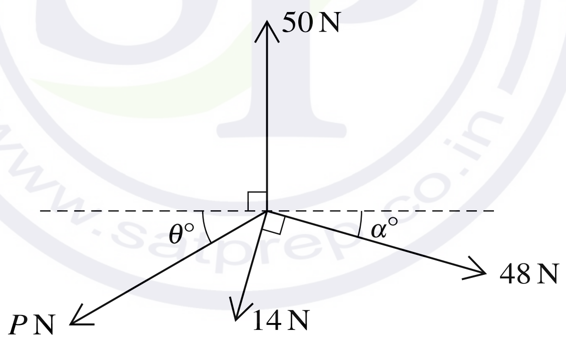
(iii) the work done by the pulling force. [2]

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]

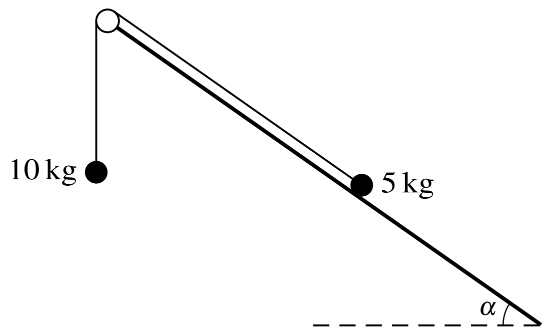
(ii) Find the acceleration of the car when its speed is $25\,\mathrm{m\,s^{-1}}$ and the engine is working at 90% of the power found in part **(i)**. [3]

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]

5



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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Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **February/March 2016**

1 hour 15 minutes

* 2 4 1 7 7 4 1 4 7 2 7 *

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

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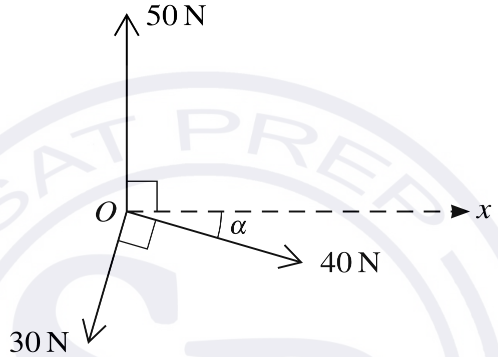
1 A cyclist has mass 85 kg and rides a bicycle of mass 20 kg. The cyclist rides along a horizontal road against a total resistance force of 40 N. Find the total work done by the cyclist in increasing his speed from $5\,\mathrm{m\,s^{-1}}$ to $10\,\mathrm{m\,s^{-1}}$ while travelling a distance of 50 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]

3



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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Cambridge International Examinations
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MATHEMATICS **9709/43**

Paper 4 Mechanics 1 **(M1)** **October/November 2015**

1 hour 15 minutes

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

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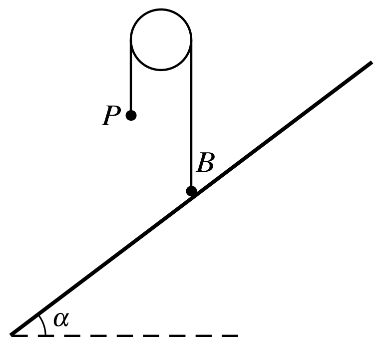
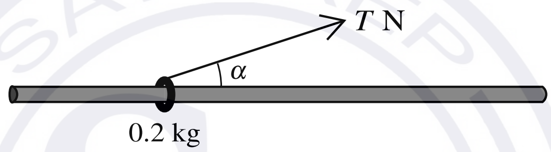
JC15 11_9709_43/2R

1



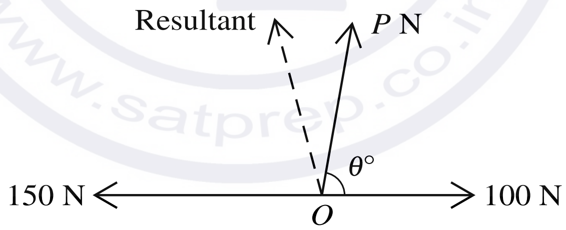
A small ball B of mass 4 kg is attached to one end of a light inextensible string. A particle P of mass 3 kg is attached to the other end of the string. The string passes over a fixed smooth pulley. The system is in equilibrium with the string taut and its straight parts vertical. B is at rest on a rough plane inclined to the horizontal at an angle of α, where $\cos\alpha = 0.8$ (see diagram). State the tension in the string and find the normal component of the contact force exerted on B by the plane. [3]

2



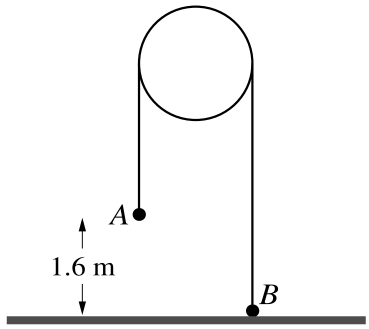
A ring of mass 0.2 kg is threaded on a fixed rough horizontal rod and a light inextensible string is attached to the ring at an angle α above the horizontal, where $\cos\alpha = 0.96$. The ring is in limiting equilibrium with the tension in the string T N (see diagram). Given that the coefficient of friction between the ring and the rod is 0.25, find the value of T. [5]

3



Three horizontal forces of magnitudes 150 N, 100 N and P N have directions as shown in the diagram. The resultant of the three forces is shown by the broken line in the diagram. This resultant has magnitude 120 N and makes an angle 75° with the 150 N force. Find the values of P and θ. [7]

4



Particles A and B, of masses 0.35 kg and 0.15 kg respectively, are attached to the ends of a light inextensible string which passes over a fixed smooth pulley. The system is at rest with B held on the horizontal floor, the string taut and its straight parts vertical. A is at a height of 1.6 m above the floor (see diagram). B is released and the system begins to move; B does not reach the pulley. Find

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

(ii) the greatest height above the floor reached by B. [3]

5 A cyclist and his bicycle have a total mass of 90 kg. The cyclist starts to move with speed $3\,\mathrm{m\,s^{-1}}$ from the top of a straight hill, of length 500 m, which is inclined at an angle of $\sin^{-1} 0.05$ to the horizontal. The cyclist moves with constant acceleration until he reaches the bottom of the hill with speed $5\,\mathrm{m\,s^{-1}}$. The cyclist generates 420 W of power while moving down the hill. The resistance to the motion of the cyclist and his bicycle, R N, and the cyclist's speed, $v\,\mathrm{m\,s^{-1}}$, both vary.

(i) Show that $R = \dfrac{420}{v} + 43.56$. [5]

(ii) Find the cyclist's speed at the mid-point of the hill. Hence find the decrease in the value of R when the cyclist moves from the top of the hill to the mid-point of the hill, and when the cyclist moves from the mid-point of the hill to the bottom of the hill. [3]

6 A particle P starts from rest at a point O of a straight line and moves along the line. The displacement of the particle at time t s after leaving O is x m, where

$$x = 0.08t^2 - 0.0002t^3.$$

(i) Find the value of t when P returns to O and find the speed of P as it passes through O on its return. [4]

(ii) For the motion of P until the instant it returns to O, find

(a) the total distance travelled, [3]

(b) the average speed. [2]

[Question 7 is printed on the next page.]

7 A straight hill AB has length 400 m with A at the top and B at the bottom and is inclined at an angle of $4°$ to the horizontal. A straight horizontal road BC has length 750 m. A car of mass 1250 kg has a speed of $5\,\mathrm{m\,s^{-1}}$ at A when starting to move down the hill. While moving down the hill the resistance to the motion of the car is 2000 N and the driving force is constant. The speed of the car on reaching B is $8\,\mathrm{m\,s^{-1}}$.

(i) By using work and energy, find the driving force of the car. [5]

On reaching B the car moves along the road BC. The driving force is constant and twice that when the car was on the hill. The resistance to the motion of the car continues to be 2000 N. Find

(ii) the acceleration of the car while moving from B to C, [3]

(iii) the power of the car's engine as the car reaches C. [3]

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **October/November 2015**

1 hour 15 minutes

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

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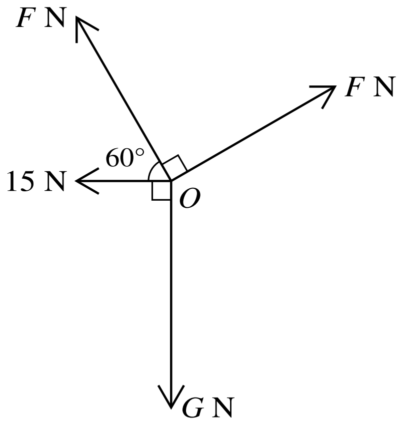
JC15 11_9709_42/RP

1



Four horizontal forces act at a point O and are in equilibrium. The magnitudes of the forces are F N, G N, 15 N and F N, and the forces act in directions as shown in the diagram.

(i) Show that $F = 41.0$, correct to 3 significant figures. [3]

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

2 A particle is released from rest at a point H m above horizontal ground and falls vertically. The particle passes through a point 35 m above the ground with a speed of $(V - 10)\ \mathrm{m\,s^{-1}}$ and reaches the ground with a speed of $V\ \mathrm{m\,s^{-1}}$. Find

(i) the value of V, [3]

(ii) the value of H. [2]

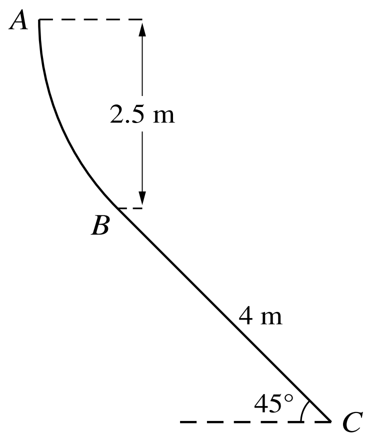
3 A particle P moves along a straight line for 100 s. It starts at a point O and at time t seconds after leaving O the velocity of P is $v\ \mathrm{m\,s^{-1}}$, where

$$v = 0.000\,04t^3 - 0.006t^2 + 0.288t.$$

(i) Find the values of t at which the acceleration of P is zero. [3]

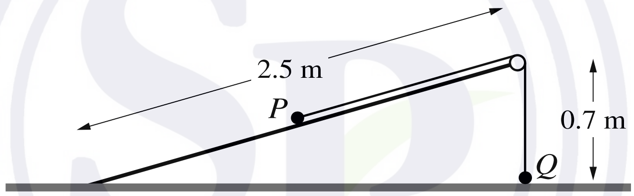
(ii) Find the displacement of P from O when $t = 100$. [3]

4



The diagram shows a vertical cross-section ABC of a surface. The part of the surface containing AB is smooth and A is 2.5 m above the level of B. The part of the surface containing BC is rough and is at 45° to the horizontal. The distance BC is 4 m (see diagram). A particle P of mass 0.2 kg is released from rest at A and moves in contact with the curve AB and then with the straight line BC. The coefficient of friction between P and the part of the surface containing BC is 0.4. Find the speed with which P reaches C. [6]

5



A smooth inclined plane of length 2.5 m is fixed with one end on the horizontal floor and the other end at a height of 0.7 m above the floor. Particles P and Q, of masses 0.5 kg and 0.1 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 Q is held at rest on the floor vertically below the pulley. The string is taut and P is at rest on the plane (see diagram). Q is released and starts to move vertically upwards towards the pulley and P moves down the plane.

(i) Find the tension in the string and the magnitude of the acceleration of the particles before Q reaches the pulley. [5]

At the instant just before Q reaches the pulley the string breaks; P continues to move down the plane and reaches the floor with a speed of $2\,\mathrm{m\,s^{-1}}$.

(ii) Find the length of the string. [3]

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

6

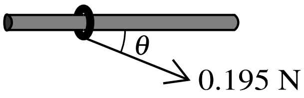


Fig. 1

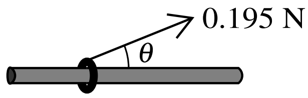


Fig. 2

A small ring of mass 0.024 kg is threaded on a fixed rough horizontal rod. A light inextensible string is attached to the ring and the string is pulled with a force of magnitude 0.195 N at an angle of θ with the horizontal, where $\sin\theta = \frac{5}{13}$. When the angle θ is below the horizontal (see Fig. 1) the ring is in limiting equilibrium.

(i) Find the coefficient of friction between the ring and the rod. [6]

When the angle θ is above the horizontal (see Fig. 2) the ring moves.

(ii) Find the acceleration of the ring. [4]

7 A car of mass 1600 kg moves with constant power 14 kW as it travels along a straight horizontal road. The car takes 25 s to travel between two points A and B on the road.

(i) Find the work done by the car's engine while the car travels from A to B. [2]

The resistance to the car's motion is constant and equal to 235 N. The car has accelerations at A and B of $0.5\,\mathrm{m\,s^{-2}}$ and $0.25\,\mathrm{m\,s^{-2}}$ respectively. Find

(ii) the gain in kinetic energy by the car in moving from A to B, [5]

(iii) the distance AB. [3]

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

* 2 8 4 8 3 9 6 7 3 5 *

MATHEMATICS **9709/41**

Paper 4 Mechanics 1 **(M1)** **October/November 2015**

1 hour 15 minutes

Additional Materials: Answer Booklet/Paper
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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]

(ii) Given that the time taken to raise the mass is 1.2 s, find the average power developed by the weightlifter. [2]

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]

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.

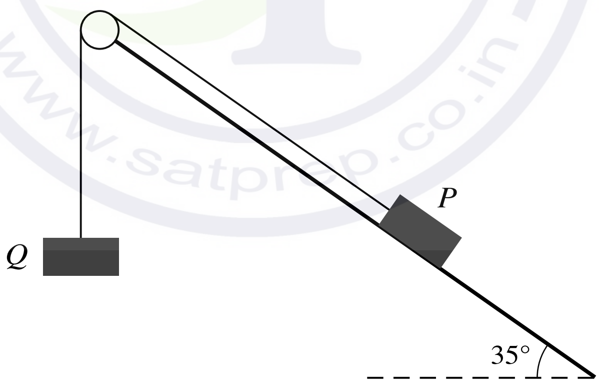
(ii) Find the distance that the particle travels along the ground before it comes to rest. [3]

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]

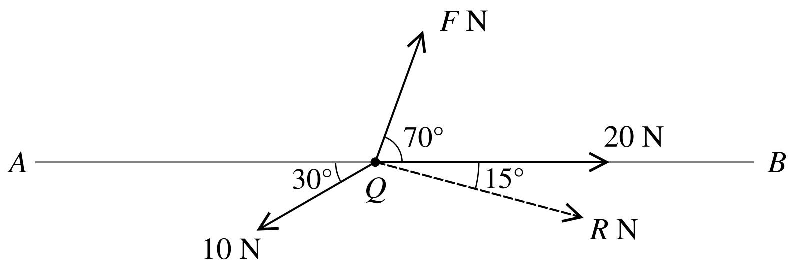
(ii) Find the steady speed at which the lorry moves up the hill if the power is 500 kW and the resistance remains 3200 N. [2]

4



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]

5



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]

(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 $\mathrm{m\,s^{-1}}$, 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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MATHEMATICS **9709/43**

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

1 hour 15 minutes

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Additional Materials: Answer Booklet/Paper
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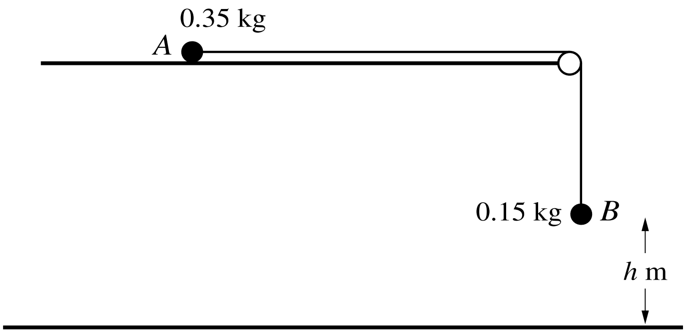
JC15 06_9709_43/RP

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]

2



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]

5

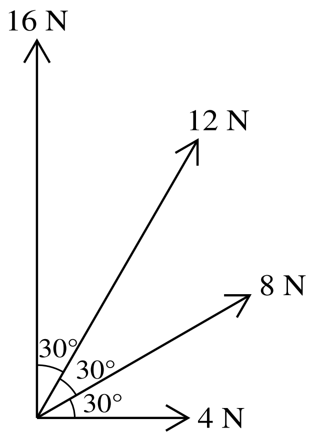


Fig. 1

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]

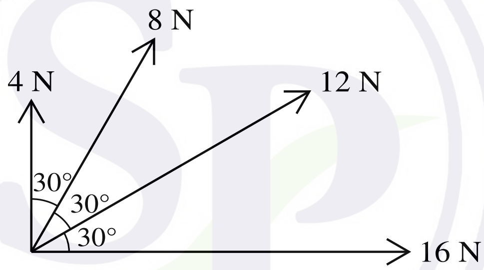


Fig. 2

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 $2.5\,\mathrm{m\,s^{-1}}$ 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 $2.5\,\mathrm{m\,s^{-1}}$.

(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 **9709/42**

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
Graph Paper
List of Formulae (MF9)

READ THESE INSTRUCTIONS FIRST

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Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

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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 $10\,\mathrm{m\,s^{-2}}$.
The use of an electronic calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper is 50.
Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.

JC15 06_9709_42/RP

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

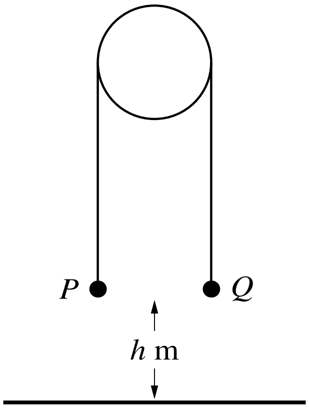


Fig. 1

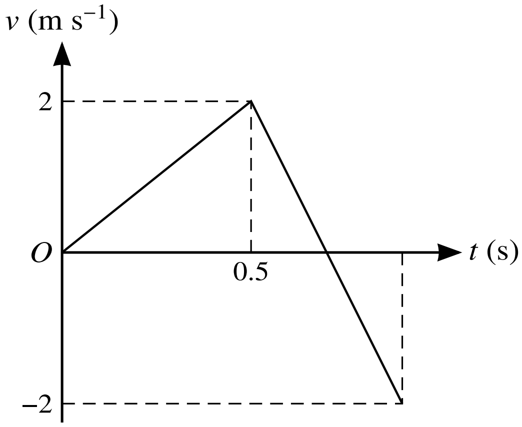


Fig. 2

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.

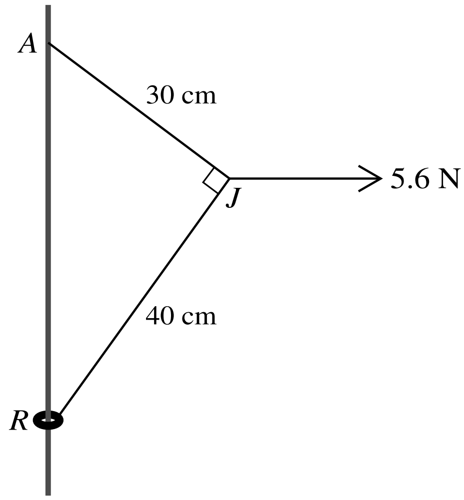
(i) Find the value of h. [2]

(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 **9709/41**

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

1 hour 15 minutes

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

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

READ THESE INSTRUCTIONS FIRST

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The total number of marks for this paper is 50.
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This document consists of **3** printed pages and **1** blank page.

JC15 06_9709_41/RP

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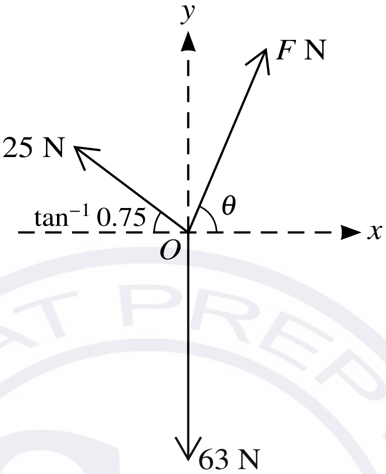
[Turn over

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 $2\,\mathrm{m\,s^{-1}}$. 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 $24\,\mathrm{m\,s^{-1}}$. 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 $1.25\,\mathrm{m\,s^{-2}}$ at an instant when her speed is $3\,\mathrm{m\,s^{-1}}$. When moving downhill, the cyclist's acceleration is $1.25\,\mathrm{m\,s^{-2}}$ at an instant when her speed is $10\,\mathrm{m\,s^{-1}}$. 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 $a\,\mathrm{m\,s^{-2}}$, 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 **9709/43**

Paper 4 Mechanics 1 **(M1)** **October/November 2014**

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

JC14 11_9709_43/RP

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[Turn over

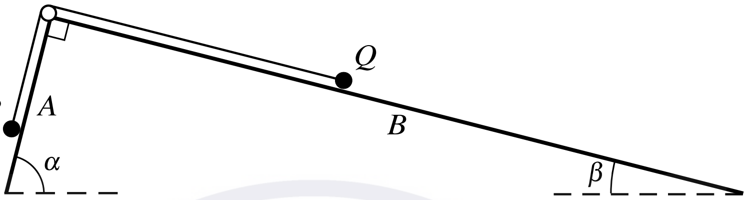
1 A car of mass 1400 kg moves on a horizontal straight road. The resistance to the car's motion is constant and equal to 800 N and the power of the car's engine is constant and equal to P W. At an instant when the car's speed is $18\,\mathrm{m\,s^{-1}}$ its acceleration is $0.5\,\mathrm{m\,s^{-2}}$.

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

The car continues and passes through another point with speed $25\,\mathrm{m\,s^{-1}}$.

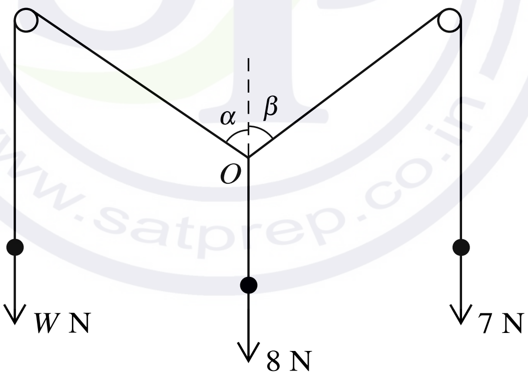
(ii) Find the car's acceleration at this point. [2]

2



The tops of each of two smooth inclined planes A and B meet at a right angle. Plane A is inclined at angle α to the horizontal and plane B is inclined at angle β to the horizontal, where $\sin\alpha = \frac{63}{65}$ and $\sin\beta = \frac{16}{65}$. A small smooth pulley is fixed at the top of the planes and a light inextensible string passes over the pulley. Two particles P and Q, each of mass 0.65 kg, are attached to the string, one at each end. Particle Q is held at rest at a point of the same line of greatest slope of the plane B as the pulley. Particle P rests freely below the pulley in contact with plane A (see diagram). Particle Q is released and the particles start to move with the string taut. Find the tension in the string. [5]

3



Each of three light inextensible strings has a particle attached to one of its ends. The other ends of the strings are tied together at a point O. Two of the strings pass over fixed smooth pegs and the particles hang freely in equilibrium. The weights of the particles and the angles between the sloping parts of the strings and the vertical are as shown in the diagram. It is given that $\sin\beta = 0.8$ and $\cos\beta = 0.6$.

(i) Show that $W\cos\alpha = 3.8$ and find the value of $W\sin\alpha$. [3]

(ii) Hence find the values of W and α. [3]

4 A particle P starts from rest and moves in a straight line for 18 seconds. For the first 8 seconds of the motion P has constant acceleration $0.25\,\mathrm{m\,s^{-2}}$. Subsequently P's velocity, $v\,\mathrm{m\,s^{-1}}$ at time t seconds after the motion started, is given by

$$v = -0.1t^2 + 2.4t - k,$$

where $8 \leqslant t \leqslant 18$ and k is a constant.

(i) Find the value of v when $t = 8$ and hence find the value of k. [2]

(ii) Find the maximum velocity of P. [2]

(iii) Find the displacement of P from its initial position when $t = 18$. [3]

5 A box of mass 8 kg is on a rough plane inclined at 5° to the horizontal. A force of magnitude P N acts on the box in a direction upwards and parallel to a line of greatest slope of the plane. When $P = 7X$ the box moves up the line of greatest slope with acceleration $0.15\,\mathrm{m\,s^{-2}}$ and when $P = 8X$ the box moves up the line of greatest slope with acceleration $1.15\,\mathrm{m\,s^{-2}}$. Find the value of X and the coefficient of friction between the box and the plane. [8]

6

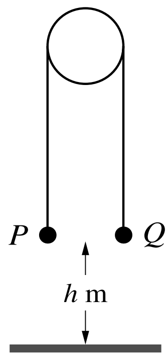


Fig. 1

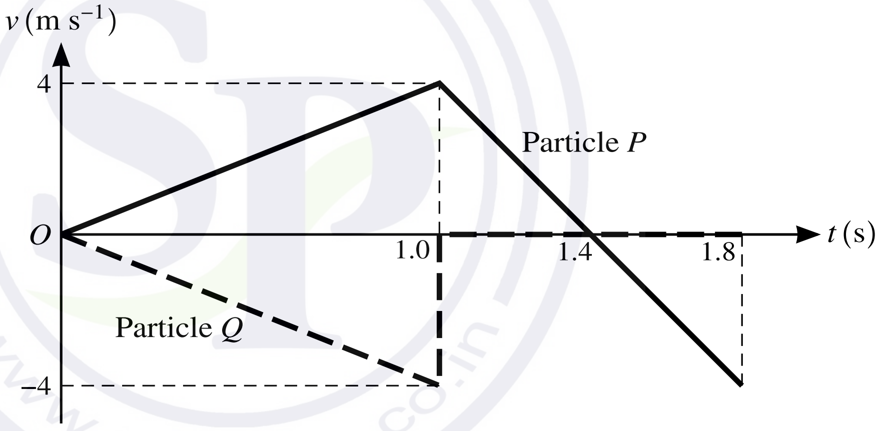


Fig. 2

Particles P and Q have a total mass of 1 kg. The particles are attached to opposite ends of a light inextensible string which passes over a smooth fixed pulley. P is held at rest and Q hangs freely, with both straight parts of the string vertical. Both particles are at a height of h m above the floor (see Fig. 1). P is released from rest and the particles start to move with the string taut. Fig. 2 shows the velocity-time graphs for P's motion and for Q's motion, where the positive direction for velocity is vertically upwards. Find

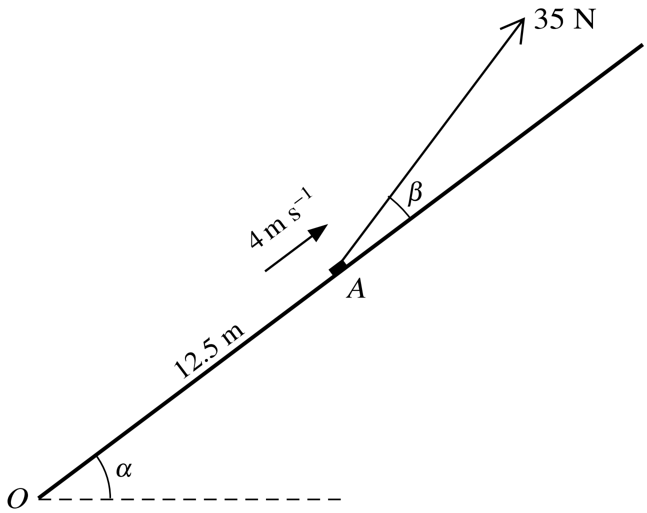
(i) the magnitude of the acceleration with which the particles start to move and the mass of each of the particles, [5]

(ii) the value of h, [1]

(iii) the greatest height above the floor reached by particle P. [2]

[Question 7 is printed on the next page.]

7



A small block of mass 3 kg is initially at rest at the bottom O of a rough plane inclined at an angle α to the horizontal, where $\sin\alpha = 0.6$ and $\cos\alpha = 0.8$. A force of magnitude 35 N acts on the block at an angle β above the plane, where $\sin\beta = 0.28$ and $\cos\beta = 0.96$. The block starts to move up a line of greatest slope of the plane and passes through a point A with speed $4\,\mathrm{m\,s^{-1}}$. The distance OA is 12.5 m (see diagram).

(i) For the motion of the block from O to A, find the work done against the frictional force acting on the block. [4]

(ii) Find the coefficient of friction between the block and the plane. [3]

At the instant that the block passes through A the force of magnitude 35 N ceases to act.

(iii) Find the distance the block travels up the plane after passing through A. [4]

Cambridge International AS & A Level

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MATHEMATICS **9709/42**

Paper 4 Mechanics 1 **(M1)** **October/November 2014**

1 hour 15 minutes

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

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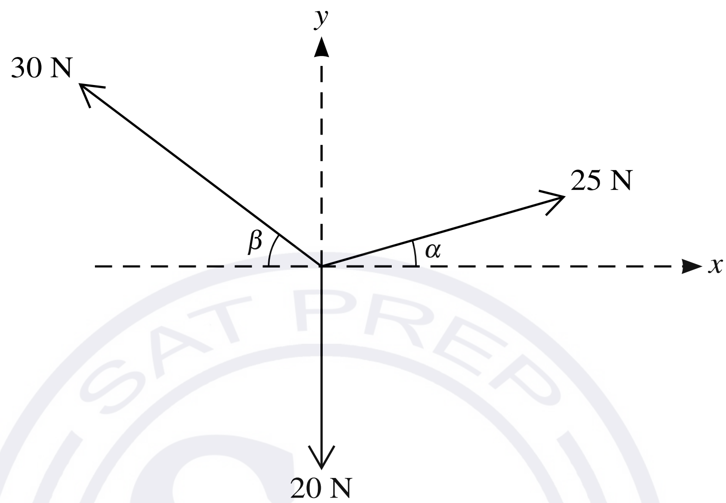
1 A particle P is projected vertically upwards with speed $11\,\mathrm{m\,s^{-1}}$ from a point on horizontal ground. At the same instant a particle Q is released from rest at a point h m above the ground. P and Q hit the ground at the same instant, when Q has speed $V\,\mathrm{m\,s^{-1}}$.

(i) Find the time after projection at which P hits the ground. [2]

(ii) Hence find the values of h and V. [2]

2



Three coplanar forces act at a point. The magnitudes of the forces are 20 N, 25 N and 30 N, and the directions in which the forces act are as shown in the diagram, where $\sin\alpha = 0.28$ and $\cos\alpha = 0.96$, and $\sin\beta = 0.6$ and $\cos\beta = 0.8$.

(i) Show that the resultant of the three forces has a zero component in the x-direction. [2]

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

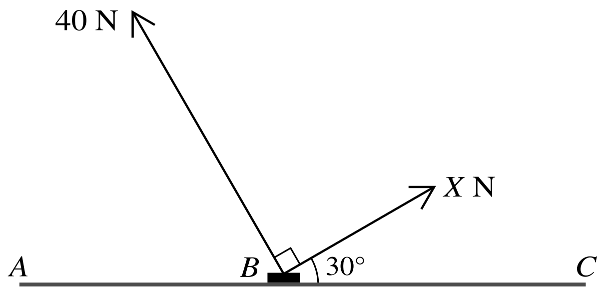
(iii) The force of magnitude 20 N is replaced by another force. The effect is that the resultant force is unchanged in magnitude but reversed in direction. State the magnitude and direction of the replacement force. [1]

3 A train of mass 200 000 kg moves on a horizontal straight track. It passes through a point A with speed $28\,\mathrm{m\,s^{-1}}$ and later it passes through a point B. The power of the train's engine at B is 1.2 times the power of the train's engine at A. The driving force of the train's engine at B is 0.96 times the driving force of the train's engine at A.

(i) Show that the speed of the train at B is $35\,\mathrm{m\,s^{-1}}$. [2]

(ii) For the motion from A to B, find the work done by the train's engine given that the work done against the resistance to the train's motion is 2.3×10^6 J. [3]

4

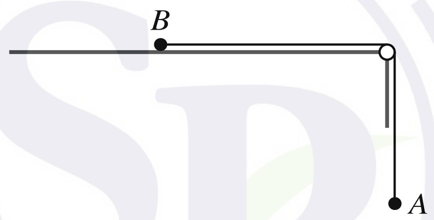


Forces of magnitude X N and 40 N act on a block B of mass 15 kg, which is in equilibrium in contact with a horizontal surface between points A and C on the surface. The forces act in the same vertical plane and in the directions shown in the diagram.

(i) Given that the surface is smooth, find the value of X. [2]

(ii) It is given instead that the surface is rough and that the block is in limiting equilibrium. The frictional force acting on the block has magnitude 10 N in the direction towards A. Find the coefficient of friction between the block and the surface. [5]

5



Particles A and B, each of mass 0.3 kg, are connected by a light inextensible string. The string passes over a small smooth pulley fixed at the edge of a rough horizontal surface. Particle A hangs freely and particle B is held at rest in contact with the surface (see diagram). The coefficient of friction between B and the surface is 0.7. Particle B is released and moves on the surface without reaching the pulley.

(i) Find, for the first 0.9 m of B's motion,

(a) the work done against the frictional force acting on B, [2]

(b) the loss of potential energy of the system, [1]

(c) the gain in kinetic energy of the system. [2]

At the instant when B has moved 0.9 m the string breaks. A is at a height of 0.54 m above a horizontal floor at this instant.

(ii) Find the speed with which A reaches the floor. [3]

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

6 ABC is a line of greatest slope of a plane inclined at angle α to the horizontal, where $\sin\alpha = 0.28$ and $\cos\alpha = 0.96$. The point A is at the top of the plane, the point C is at the bottom of the plane and the length of AC is 5 m. The part of the plane above the level of B is smooth and the part below the level of B is rough. A particle P is released from rest at A and reaches C with a speed of $2\,\text{m}\,\text{s}^{-1}$. The coefficient of friction between P and the part of the plane below B is 0.5. Find

(i) the acceleration of P while moving

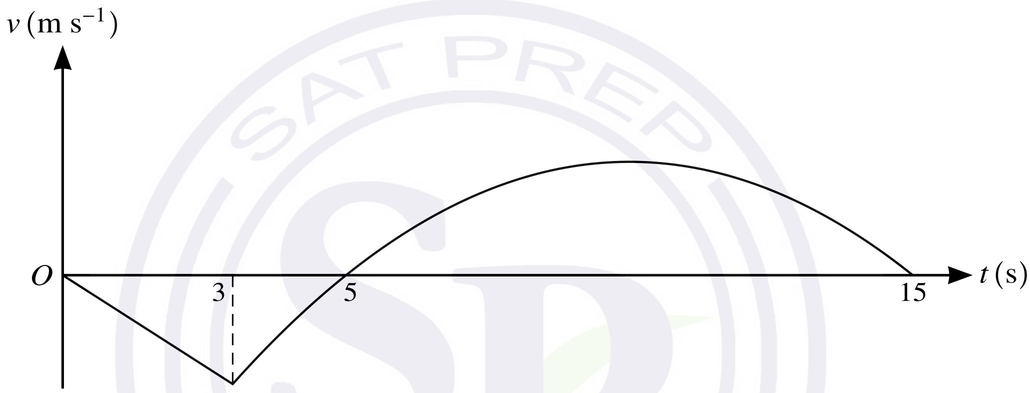
(a) from A to B,

(b) from B to C, [3]

(ii) the distance AB, [3]

(iii) the time taken for P to move from A to C. [3]

7



The diagram shows the velocity-time graph for the motion of a particle P which moves on a straight line BAC. It starts at A and travels to B taking 5 s. It then reverses direction and travels from B to C taking 10 s. For the first 3 s of P's motion its acceleration is constant. For the remaining 12 s the velocity of P is $v\,\text{m}\,\text{s}^{-1}$ at time t s after leaving A, where

$$v = -0.2t^2 + 4t - 15 \quad \text{for } 3 \leqslant t \leqslant 15.$$

(i) Find the value of v when $t = 3$ and the magnitude of the acceleration of P for the first 3 s of its motion. [3]

(ii) Find the maximum velocity of P while it is moving from B to C. [3]

(iii) Find the average speed of P,

(a) while moving from A to B,

(b) for the whole journey. [6]

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MATHEMATICS **9709/41**

Paper 4 Mechanics 1 **(M1)** **October/November 2014**

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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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.

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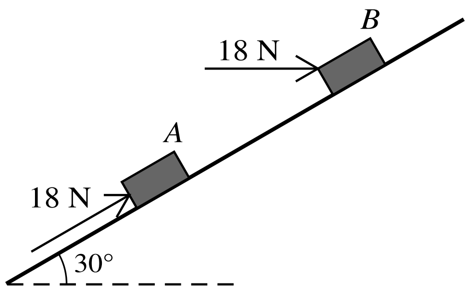
The use of an electronic calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper is 50.
Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.

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

1 A car of mass 800 kg is moving on a straight horizontal road with its engine working at a rate of 22.5 kW. Find the resistance to the car's motion at an instant when the car's speed is $18\,\mathrm{m\,s^{-1}}$ and its acceleration is $1.2\,\mathrm{m\,s^{-2}}$. [4]

2



Small blocks A and B are held at rest on a smooth plane inclined at 30° to the horizontal. Each is held in equilibrium by a force of magnitude 18 N. The force on A acts upwards parallel to a line of greatest slope of the plane, and the force on B acts horizontally in the vertical plane containing a line of greatest slope (see diagram). Find the weight of A and the weight of B. [4]

3

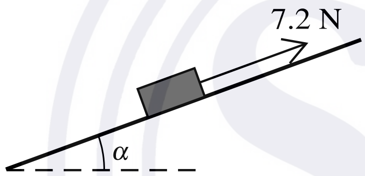


Fig. 1

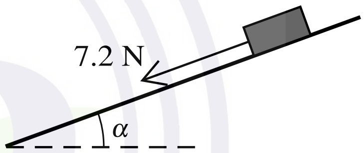


Fig. 2

A block of weight 7.5 N is at rest on a plane which is inclined to the horizontal at angle α, where $\tan\alpha = \frac{7}{24}$. The coefficient of friction between the block and the plane is μ. A force of magnitude 7.2 N acting parallel to a line of greatest slope is applied to the block. When the force acts up the plane (see Fig. 1) the block remains at rest.

(i) Show that $\mu \geqslant \frac{17}{24}$. [4]

When the force acts down the plane (see Fig. 2) the block slides downwards.

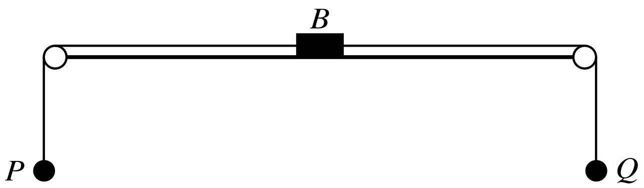
(ii) Show that $\mu < \frac{31}{24}$. [2]

4 Particles P and Q move on a straight line AOB. The particles leave O simultaneously, with P moving towards A and with Q moving towards B. The initial speed of P is $1.3\,\mathrm{m\,s^{-1}}$ and its acceleration in the direction OA is $0.1\,\mathrm{m\,s^{-2}}$. Q moves with acceleration in the direction OB of $0.016t\,\mathrm{m\,s^{-2}}$, where t seconds is the time elapsed since the instant that P and Q started to move from O. When $t = 20$, particle P passes through A and particle Q passes through B.

(i) Given that the speed of Q at B is the same as the speed of P at A, find the speed of Q at time $t = 0$. [4]

(ii) Find the distance AB. [3]

5



A small block B of mass 0.25 kg is attached to the mid-point of a light inextensible string. Particles P and Q, of masses 0.2 kg and 0.3 kg respectively, are attached to the ends of the string. The string passes over two smooth pulleys fixed at opposite sides of a rough table, with B resting in limiting equilibrium on the table between the pulleys and particles P and Q and block B are in the same vertical plane (see diagram).

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

Q is now removed so that P and B begin to move.

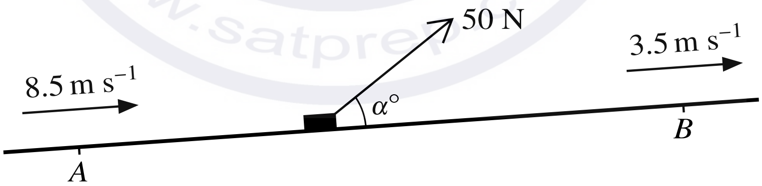
(ii) Find the acceleration of P and the tension in the part PB of the string. [6]

6 A particle of mass 3 kg falls from rest at a point 5 m above the surface of a liquid which is in a container. There is no instantaneous change in speed of the particle as it enters the liquid. The depth of the liquid in the container is 4 m. The downward acceleration of the particle while it is moving in the liquid is $5.5\,\mathrm{m\,s^{-2}}$.

(i) Find the resistance to motion of the particle while it is moving in the liquid. [2]

(ii) Sketch the velocity-time graph for the motion of the particle, from the time it starts to move until the time it reaches the bottom of the container. Show on your sketch the velocity and the time when the particle enters the liquid, and when the particle reaches the bottom of the container. [7]

7



A block of mass 60 kg is pulled up a hill in the line of greatest slope by a force of magnitude 50 N acting at an angle $\alpha°$ above the hill. The block passes through points A and B with speeds $8.5\,\mathrm{m\,s^{-1}}$ and $3.5\,\mathrm{m\,s^{-1}}$ respectively (see diagram). The distance AB is 250 m and B is 17.5 m above the level of A. The resistance to motion of the block is 6 N. Find the value of α. [11]

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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)

READ THESE INSTRUCTIONS FIRST

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The total number of marks for this paper is 50.
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JC14 06_9709_43/FP

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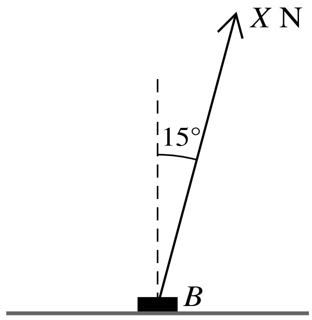
1



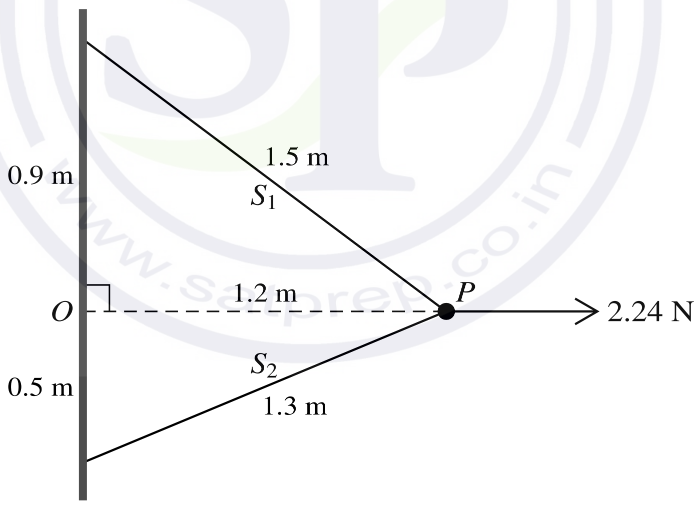
A block B of mass 7 kg is at rest on rough horizontal ground. A force of magnitude X N acts on B at an angle of 15° to the upward vertical (see diagram).

(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 $0.5\,\mathrm{m\,s^{-2}}$. [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 $9\,\mathrm{m\,s^{-1}}$ at A to $21\,\mathrm{m\,s^{-1}}$ 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 $v\,\mathrm{m\,s^{-1}}$ 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

$$v = 0.025t - 2.5.$$

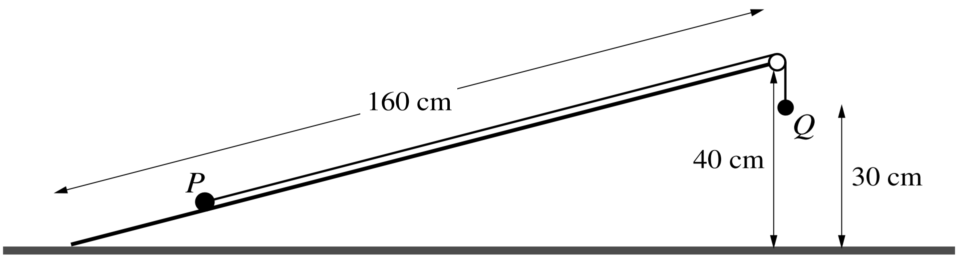
(i) Find the velocity of the particle immediately before it hits the wall, and its velocity immediately after its hits the wall. [2]

(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 **9709/42**

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

1 hour 15 minutes

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

* 0 9 3 8 5 0 3 2 7 5 *

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JC14 06_9709_42/RP

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[Turn over

1 A car of mass 600 kg travels along a straight horizontal road. The resistance to the car's motion is constant and equal to R N.

(i) Find the value of R, given that the car's acceleration is $1.4\,\mathrm{m\,s^{-2}}$ at an instant when the car's speed is $18\,\mathrm{m\,s^{-1}}$ and its engine is working at a rate of 22.5 kW. [4]

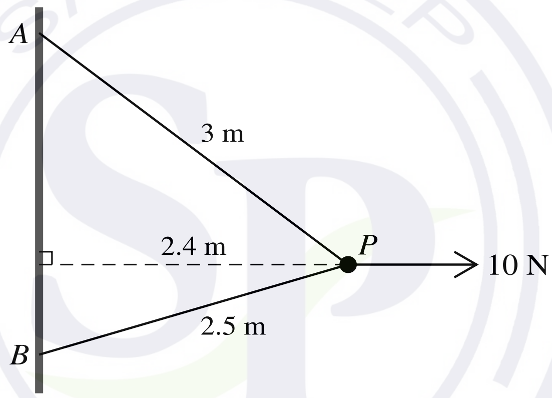
(ii) Find the rate of working of the car's engine when the car is moving with a constant speed of $15\,\mathrm{m\,s^{-1}}$. [1]

2 A and B are two points which are 10 m apart on the same horizontal plane. A particle P starts to move from rest at A, directly towards B, with constant acceleration $0.5\,\mathrm{m\,s^{-2}}$. Another particle Q is moving directly towards A with constant speed $0.75\,\mathrm{m\,s^{-1}}$, and passes through B at the instant that P starts to move. At time T s after this instant, particles P and Q collide. Find

(i) the value of T, [4]

(ii) the speed of P immediately before the collision. [1]

3



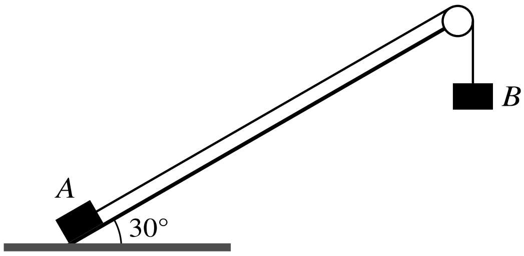
A and B are fixed points of a vertical wall with A vertically above B. A particle P of mass 0.7 kg is attached to A by a light inextensible string of length 3 m. P is also attached to B by a light inextensible string of length 2.5 m. P is maintained in equilibrium at a distance of 2.4 m from the wall by a horizontal force of magnitude 10 N acting on P (see diagram). Both strings are taut, and the 10 N force acts in the plane APB which is perpendicular to the wall. Find the tensions in the strings. [6]

4 A particle P moves on a straight line, starting from rest at a point O of the line. The time after P starts to move is t s, and the particle moves along the line with constant acceleration $\frac{1}{4}\,\mathrm{m\,s^{-2}}$ until it passes through a point A at time $t = 8$. After passing through A the velocity of P is $\frac{1}{2}t^{\frac{2}{3}}\,\mathrm{m\,s^{-1}}$.

(i) Find the acceleration of P immediately after it passes through A. Hence show that the acceleration of P decreases by $\frac{1}{12}\,\mathrm{m\,s^{-2}}$ as it passes through A. [4]

(ii) Find the distance moved by P from $t = 0$ to $t = 27$. [3]

5



A light inextensible rope has a block A of mass 5 kg attached at one end, and a block B of mass 16 kg attached at the other end. The rope passes over a smooth pulley which is fixed at the top of a rough plane inclined at an angle of 30° to the horizontal. Block A is held at rest at the bottom of the plane and block B hangs below the pulley (see diagram). The coefficient of friction between A and the plane is $\frac{1}{\sqrt{3}}$. Block A is released from rest and the system starts to move. When each of the blocks has moved a distance of x m each has speed $v\,\mathrm{m\,s^{-1}}$.

(i) Write down the gain in kinetic energy of the system in terms of v. [1]

(ii) Find, in terms of x,

(a) the loss of gravitational potential energy of the system, [2]

(b) the work done against the frictional force. [3]

(iii) Show that $21v^2 = 220x$. [2]

6 A particle P of mass 0.2 kg is released from rest at a point 7.2 m above the surface of the liquid in a container. P falls through the air and into the liquid. There is no air resistance and there is no instantaneous change of speed as P enters the liquid. When P is at a distance of 0.8 m below the surface of the liquid, P's speed is $6\,\mathrm{m\,s^{-1}}$. The only force on P due to the liquid is a constant resistance to motion of magnitude R N.

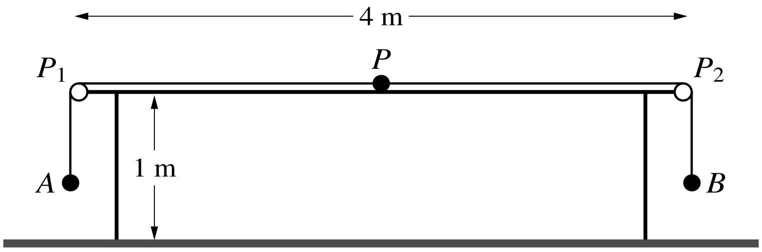
(i) Find the deceleration of P while it is falling through the liquid, and hence find the value of R. [5]

The depth of the liquid in the container is 3.6 m. P is taken from the container and attached to one end of a light inextensible string. P is placed at the bottom of the container and then pulled vertically upwards with constant acceleration. The resistance to motion of R N continues to act. The particle reaches the surface 4 s after leaving the bottom of the container.

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

[Question 7 is printed on the next page.]

7



A light inextensible string of length 5.28 m has particles A and B, of masses 0.25 kg and 0.75 kg respectively, attached to its ends. Another particle P, of mass 0.5 kg, is attached to the mid-point of the string. Two small smooth pulleys P_1 and P_2 are fixed at opposite ends of a rough horizontal table of length 4 m and height 1 m. The string passes over P_1 and P_2 with particle A held at rest vertically below P_1, the string taut and B hanging freely below P_2. Particle P is in contact with the table halfway between P_1 and P_2 (see diagram). The coefficient of friction between P and the table is 0.4. Particle A is released and the system starts to move with constant acceleration of magnitude $a\,\mathrm{m\,s^{-2}}$. The tension in the part AP of the string is T_A N and the tension in the part PB of the string is T_B N.

(i) Find T_A and T_B in terms of a. [3]

(ii) Show by considering the motion of P that $a = 2$. [3]

(iii) Find the speed of the particles immediately before B reaches the floor. [2]

(iv) Find the deceleration of P immediately after B reaches the floor. [2]

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)

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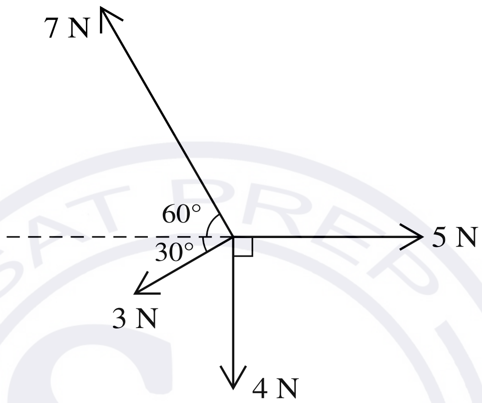
1 A train is moving at constant speed $V \mathrm{~m~s^{-1}}$ along a horizontal straight track. Given that the power of the train's engine is 1330 kW and the total resistance to the train's motion is 28 kN, find the value of V. [3]

2 A rough plane is inclined at an angle of $\alpha°$ to the horizontal. A particle of mass 0.25 kg is in equilibrium on the plane. The normal reaction force acting on the particle has magnitude 2.4 N. Find

(i) the value of α, [2]

(ii) the least possible value of the coefficient of friction. [2]

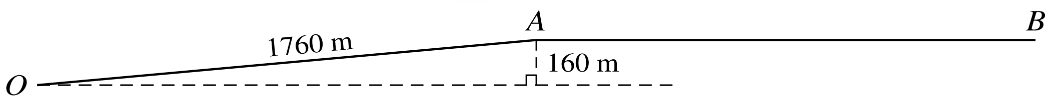
3



Four coplanar forces act at a point. The magnitudes of the forces are 5 N, 4 N, 3 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 four forces. [6]

4 A particle is projected vertically upwards with speed $9 \mathrm{~m~s^{-1}}$ from a point 3.15 m above horizontal ground. The particle moves freely under gravity until it hits the ground. For the particle's motion from the instant of projection until the particle hits the ground, find the total distance travelled and the total time taken. [6]

5



A car of mass 1100 kg starts from rest at O and travels along a road OAB. The section OA is straight, of length 1760 m, and inclined to the horizontal with A at a height of 160 m above the level of O. The section AB is straight and horizontal (see diagram). While the car is moving the driving force of the car is 1800 N and the resistance to the car's motion is 700 N. The speed of the car is $v \mathrm{~m~s^{-1}}$ when the car has travelled a distance of x m from O.

(i) For the car's motion from O to A, write down its increase in kinetic energy in terms of v and its increase in potential energy in terms of x. Hence find the value of k for which $kv^2 = x$ for $0 \leqslant x \leqslant 1760$. [4]

(ii) Show that $v^2 = 2x - 3200$ for $x \geqslant 1760$. [4]

6

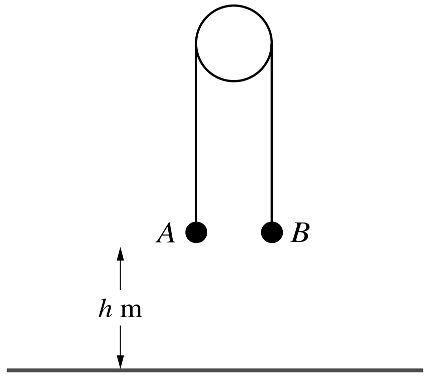


Fig. 1

Particles A of mass 0.25 kg and B of mass 0.75 kg are attached to opposite ends of a light inextensible string which passes over a fixed smooth pulley. The system is held at rest with the string taut and its straight parts vertical. Both particles are at a height of h m above the floor (see Fig. 1). The system is released from rest, and 0.6 s later, when both particles are in motion, the string breaks. The particle A does not reach the pulley in the subsequent motion.

(i) Find the acceleration of A and the distance travelled by A before the string breaks. [4]

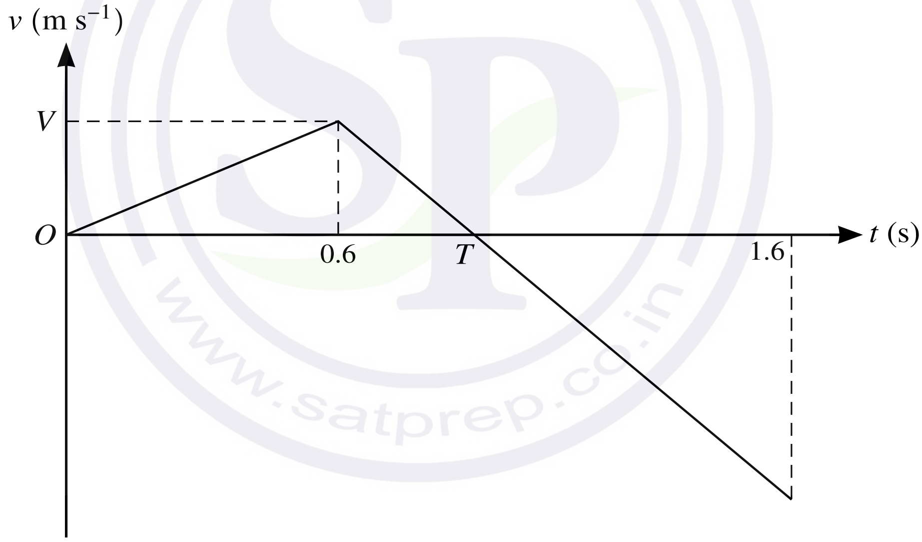


Fig. 2

The velocity-time graph shown in Fig. 2 is for the motion of particle A until it hits the floor. The velocity of A when the string breaks is $V\,\mathrm{m\,s^{-1}}$ and T s is the time taken for A to reach its greatest height.

(ii) Find the value of V and the value of T. [3]

(iii) Find the distance travelled by A upwards and the distance travelled by A downwards and hence find h. [3]

[Question 7 is printed on the next page.]

7 Two cyclists P and Q travel along a straight road ABC, starting simultaneously at A and arriving simultaneously at C. Both cyclists pass through B 400 s after leaving A. Cyclist P starts with speed $3\,\mathrm{m\,s^{-1}}$ and increases this speed with constant acceleration $0.005\,\mathrm{m\,s^{-2}}$ until he reaches B.

(i) Show that the distance AB is 1600 m and find P's speed at B. [3]

Cyclist Q travels from A to B with speed $v\,\mathrm{m\,s^{-1}}$ at time t seconds after leaving A, where

$$v = 0.04t - 0.0001t^2 + k,$$

and k is a constant.

(ii) Find the value of k and the maximum speed of Q before he has reached B. [6]

Cyclist P travels from B to C, a distance of 1400 m, at the speed he had reached at B. Cyclist Q travels from B to C with constant acceleration $a\,\mathrm{m\,s^{-2}}$.

(iii) Find the time taken for the cyclists to travel from B to C and find the value of a. [4]

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

7205360621

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

READ THESE INSTRUCTIONS FIRST

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UNIVERSITY of CAMBRIDGE International Examinations

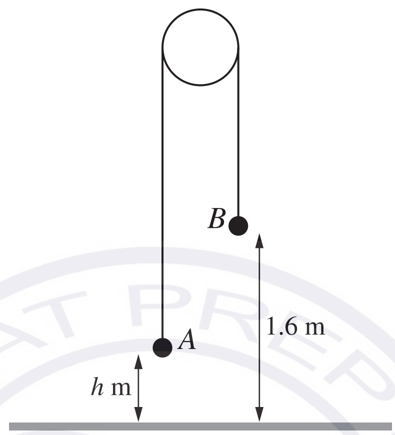
[Turn over

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]

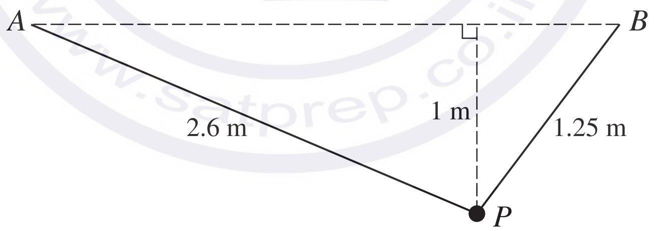
(ii) Given that the particle's initial speed is $5.4\,\mathrm{m\,s^{-1}}$, find the distance that the particle travels up the plane. [2]

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 $0.3\ \mathrm{m\,s^{-2}}$, reaching a speed of $V\ \mathrm{m\,s^{-1}}$. The car then continues to move at $V\ \mathrm{m\,s^{-1}}$ for T_2 s. It then decelerates for T_3 s at $1\ \mathrm{m\,s^{-2}}$, 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 $16\ \mathrm{m\,s^{-1}}$ and its acceleration at B is $0.096\ \mathrm{m\,s^{-2}}$. Find the acceleration of the lorry at A and show that its speed at B is $24\ \mathrm{m\,s^{-1}}$. [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 $16\ \mathrm{m\,s^{-1}}$. 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 $v\ \mathrm{m\,s^{-1}}$ 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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General Certificate of Education
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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

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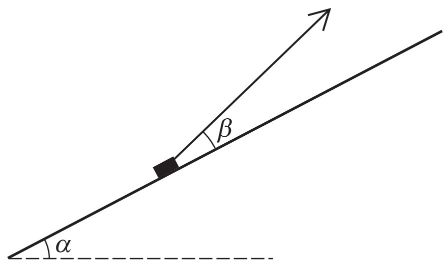
1



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]

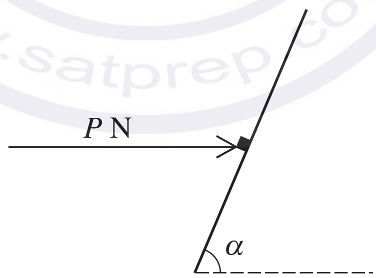
2 A box of mass 25 kg is pulled in a straight line along a horizontal floor. The box starts from rest at a point A and has a speed of $3\,\text{m s}^{-1}$ when it reaches a point B. The distance AB is 15 m. The pulling force has magnitude 220 N and acts at an angle of $\alpha°$ above the horizontal. 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 $v\,\text{m s}^{-1}$ 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 $4\,\text{m s}^{-1}$.

(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]

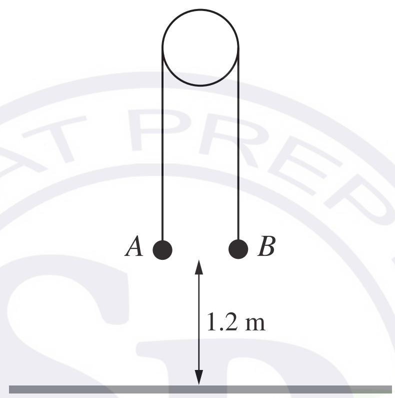
5 A particle P moves in a straight line. P starts from rest at O and travels to A where it comes to rest, taking 50 seconds. The speed of P at time t seconds after leaving O is $v\,\mathrm{m\,s^{-1}}$, where v is defined as follows.

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

(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.

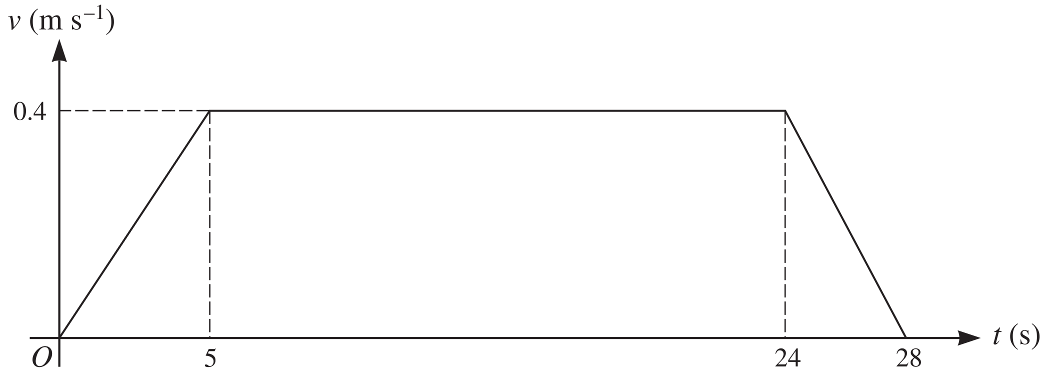
(i) Find the work done on B by the tension in the string, as B moves to the floor. [5]

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
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Advanced Subsidiary Level and Advanced Level

MATHEMATICS **9709/41**

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

1 hour 15 minutes

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

8725173182

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JC13 11_9709_41/RP

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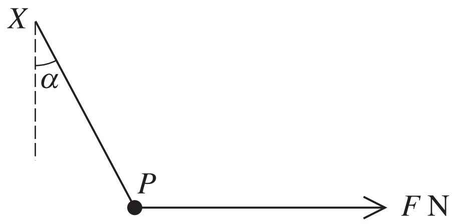
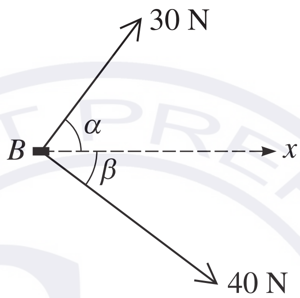
1



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

2



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

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

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

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

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

The cyclist's speed is 7 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 $8\,\text{m}\,\text{s}^{-1}$ and $3\,\text{m}\,\text{s}^{-1}$, respectively, both in the direction AB.

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

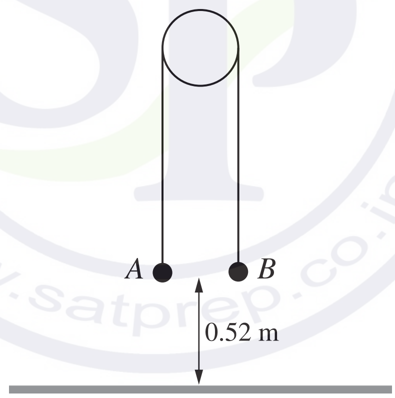
5 A lorry of mass 15 000 kg climbs from the bottom to the top of a straight hill, of length 1440 m, at a constant speed of $15\,\text{m}\,\text{s}^{-1}$. The top of the hill is 16 m above the level of the bottom of the hill. The resistance to motion is constant and equal to 1800 N.

(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 $24\,\text{m}\,\text{s}^{-1}$. 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 $1.6\,\text{m}\,\text{s}^{-1}$ 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
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

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

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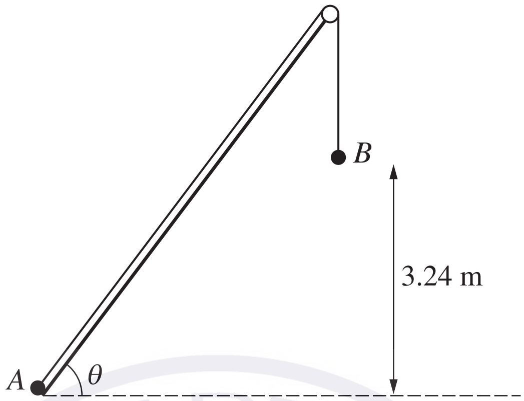
UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

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 $8\,\text{m}\,\text{s}^{-1}$. 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 $14\,\text{m}\,\text{s}^{-1}$ its acceleration is $1.4\,\text{m}\,\text{s}^{-2}$, and when the car's speed is $25\,\text{m}\,\text{s}^{-1}$ its acceleration is $0.33\,\text{m}\,\text{s}^{-2}$. 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 $90\,\text{m}\,\text{s}^{-1}$ at the instant it takes off. While the aeroplane is on the runway at time t seconds after leaving O, its acceleration is $(1.5 + 0.012t)\,\text{m}\,\text{s}^{-2}$. Find

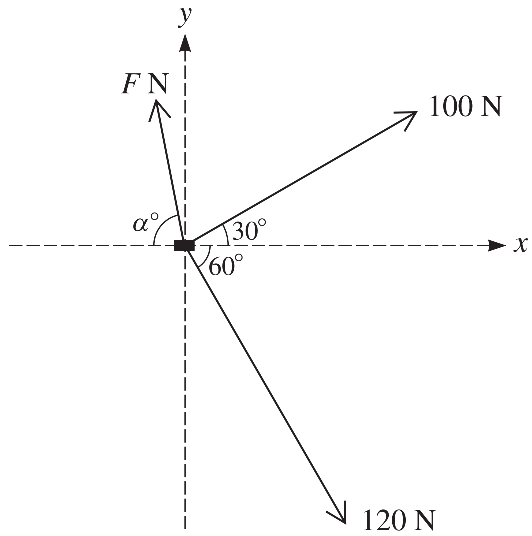
(i) the value of t at the instant the aeroplane takes off, [4]

(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 $17\,\text{m}\,\text{s}^{-1}$. Another particle Q is projected vertically upwards from the same point with speed $7\,\text{m}\,\text{s}^{-1}$. 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]

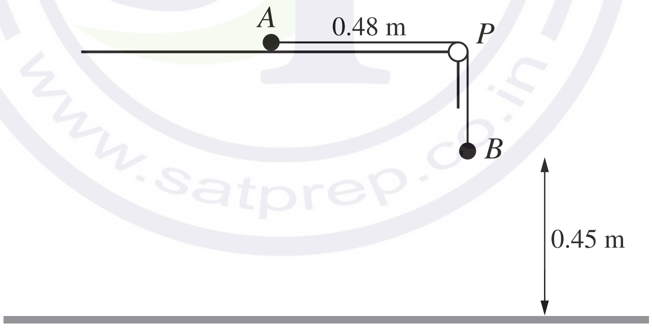
(ii) At a certain instant when both P and Q are in motion, P is 5 m higher than Q. Find the magnitude and direction of the velocity of each of the particles at this instant. [6]

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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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
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List of Formulae (MF9)

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1 A string is attached to a block of weight 30 N, which is in contact with a rough horizontal plane. When the string is horizontal and the tension in it is 24 N, the block is in limiting equilibrium.

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

The block is now in motion and the string is at an angle of 30° upwards from the plane. The tension in the string is 25 N.

(ii) Find the acceleration of the block. [4]

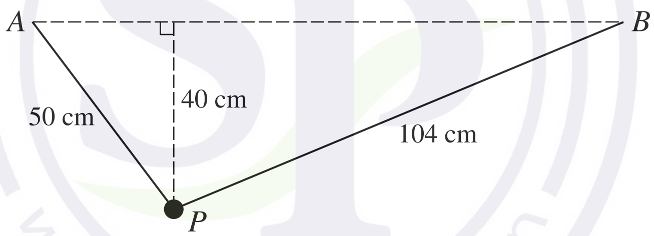
2 A and B are two points 50 metres apart on a straight path inclined at an angle θ to the horizontal, where $\sin\theta = 0.05$, with A above the level of B. A block of mass 16 kg is pulled down the path from A to B. The block starts from rest at A and reaches B with a speed of $10\,\mathrm{m\,s^{-1}}$. The work done by the pulling force acting on the block is 1150 J.

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

The block is now pulled up the path from B to A. The work done by the pulling force and the work done against the resistance to motion are the same as in the case of the downward motion.

(ii) Show that the speed of the block when it reaches A is the same as its speed when it started at B. [2]

3



A particle P of mass 2.1 kg is attached to one end of each of two light inextensible strings. The other ends of the strings are attached to points A and B which are at the same horizontal level. P hangs in equilibrium at a point 40 cm below the level of A and B, and the strings PA and PB have lengths 50 cm and 104 cm respectively (see diagram). Show that the tension in the string PA is 20 N, and find the tension in the string PB. [5]

4 A particle P is released from rest at the top of a smooth plane which is inclined at an angle α to the horizontal, where $\sin\alpha = \frac{16}{65}$. The distance travelled by P from the top to the bottom is S metres, and the speed of P at the bottom is $8\,\mathrm{m\,s^{-1}}$.

(i) Find the value of S and hence find the speed of P when it has travelled $\frac{1}{2}S$ metres. [5]

The time taken by P to travel from the top to the bottom of the plane is T seconds.

(ii) Find the distance travelled by P at the instant when it has been moving for $\frac{1}{2}T$ seconds. [2]

5 A car of mass 1000 kg is travelling on a straight horizontal road. The power of its engine is constant and equal to P kW. The resistance to motion of the car is 600 N. At an instant when the car's speed is $25\,\text{m}\,\text{s}^{-1}$, its acceleration is $0.2\,\text{m}\,\text{s}^{-2}$. Find

(i) the value of P, [4]

(ii) the steady speed at which the car can travel. [3]

6 A particle P moves in a straight line. It starts from rest at a point O and moves towards a point A on the line. During the first 8 seconds P's speed increases to $8\,\text{m}\,\text{s}^{-1}$ with constant acceleration. During the next 12 seconds P's speed decreases to $2\,\text{m}\,\text{s}^{-1}$ with constant deceleration. P then moves with constant acceleration for 6 seconds, reaching A with speed $6.5\,\text{m}\,\text{s}^{-1}$.

(i) Sketch the velocity-time graph for P's motion. [2]

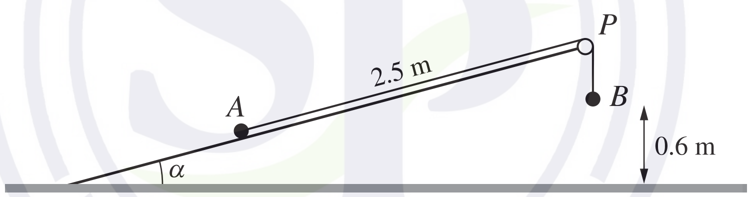
The displacement of P from O, at time t seconds after P leaves O, is s metres.

(ii) Shade the region of the velocity-time graph representing s for a value of t where $20 \leqslant t \leqslant 26$. [1]

(iii) Show that, for $20 \leqslant t \leqslant 26$,

$$s = 0.375t^2 - 13t + 202.$$ [6]

7



Particles A of mass 0.26 kg and B of mass 0.52 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 top of a smooth plane. The plane is inclined at an angle α to the horizontal, where $\sin\alpha = \frac{16}{65}$ and $\cos\alpha = \frac{63}{65}$. A is held at rest at a point 2.5 metres from P, with the part AP of the string parallel to a line of greatest slope of the plane. B hangs freely below P at a point 0.6 m above the floor (see diagram). A is released and the particles start to move. Find

(i) the magnitude of the acceleration of the particles and the tension in the string, [5]

(ii) the speed with which B reaches the floor and the distance of A from P when A comes to instantaneous rest. [6]

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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)

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READ THESE INSTRUCTIONS FIRST

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

Answer **all** the questions.
Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.
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.
You are reminded of the need for clear presentation in your answers.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper is 50.
Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.

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

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 $4\,\text{m s}^{-2}$. [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 $30\,\text{m s}^{-1}$. 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.

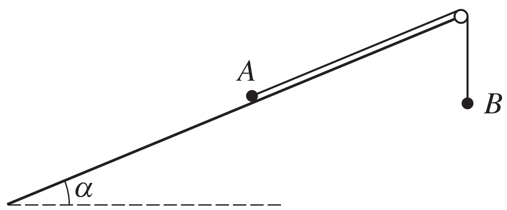
(iii) Find the speed of projection of the second signal. [3]

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 $37.5\,\text{m s}^{-1}$, [4]

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

5



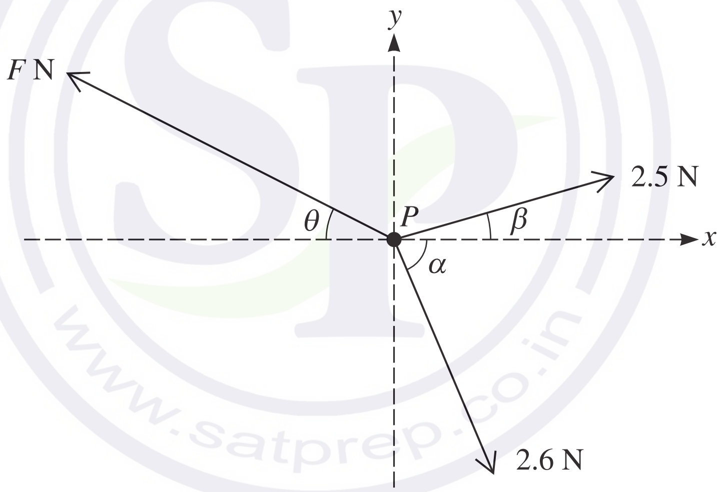
A light inextensible string has a particle A of mass 0.26 kg attached to one end and a particle B of mass 0.54 kg attached to the other end. The particle A is held at rest on a rough plane inclined at angle α to the horizontal, where $\sin\alpha = \frac{5}{13}$. The string is taut and parallel to a line 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]