



Cambridge International AS & A Level

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MATHEMATICS**9709/41**

Paper 4 Mechanics

October/November 2025**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 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 car of mass 900 kg is moving along a straight horizontal road against a constant resistance to motion of 350 N . At an instant when the car is moving at 15 m s^{-1} its acceleration is 0.25 m s^{-2} .

(a) Find the driving force of the car's engine at this instant. [2]

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(b) Find the power of the car's engine at this instant. [2]

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- 2 Two particles, P and Q , of masses 3 kg and 5 kg respectively, are at rest on a smooth horizontal plane. P is projected at a speed of 4 m s^{-1} directly towards Q . After P and Q collide, P has speed 1 m s^{-1} .

(a) Find the two possible speeds of Q after the collision. [3]

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It is given that $\lambda \text{ J}$ of kinetic energy, where $\lambda > 0$, is lost during the collision.

(b) Find the value of λ . [2]

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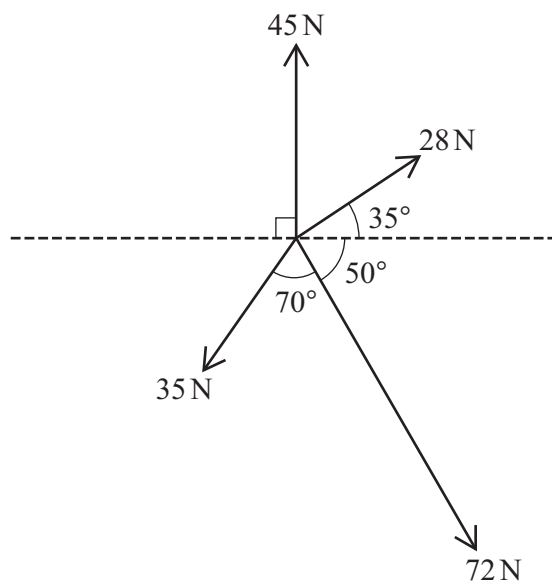
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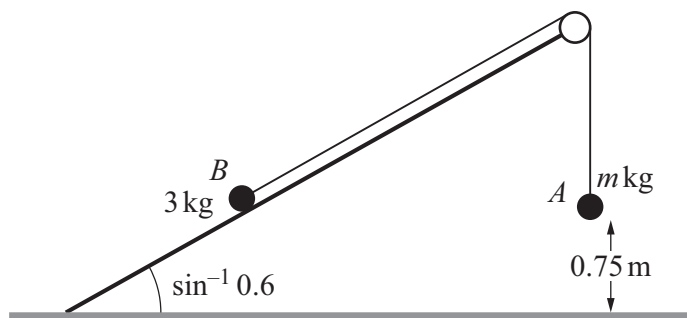


Coplanar forces of magnitudes 45 N, 28 N, 72 N and 35 N act at a point in the directions shown in the diagram.

Find, in either order, the magnitude and direction of the resultant force.

[6]

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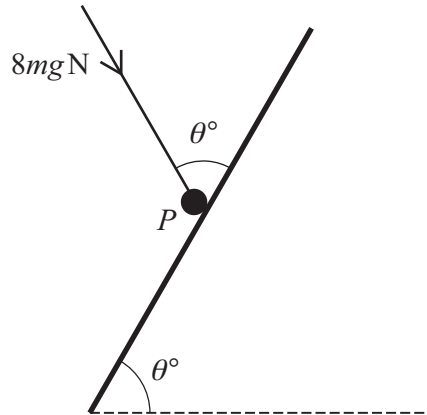
Two particles, A and B , of masses m kg and 3 kg respectively, are connected by a light inextensible string. Particle B is on a fixed plane which is at an angle of $\sin^{-1} 0.6$ to the horizontal ground. The string passes over a fixed smooth pulley at the top of the plane. Particle A hangs vertically below the pulley and is 0.75 m above the ground (see diagram).

The system is released from rest. In the subsequent motion B moves up a line of greatest slope of the plane and does not reach the pulley. As B moves up the plane there is a constant resistance to its motion of magnitude $\frac{10}{3}$ N. The speed of A immediately before it hits the ground is 2 m s^{-1} .

Use an energy method to find the value of m .

[6]

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A particle P of mass m kg is in equilibrium on a rough plane inclined at an angle θ° to the horizontal. The equilibrium of P is maintained by a force of magnitude $8mg$ N making an angle θ° with a line of greatest slope (see diagram). The coefficient of friction between P and the plane is 0.5 and P is on the point of slipping down the plane.

Find the value of θ .

[6]

[illegible]



- 6** A particle A of mass 2.5 kg is released from rest from the top of a smooth plane, which makes an angle of $\sin^{-1} 0.2$ with the horizontal. The particle A collides 2 seconds later with a particle B , of mass 3 kg , which is moving up a line of greatest slope of the plane. The speed of B immediately before the collision is 3.5 m s^{-1} . Immediately after the collision, B has a velocity of 0.5 m s^{-1} down the plane.

Find the distance A moves up the plane after the collision.

[6]

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- 7 A particle P starts from a point O and moves in a straight line. The velocity $v \text{ m s}^{-1}$ of P , at time $t \text{ s}$ after leaving O , is given by $v = \frac{1}{3}(2t-3)(t-4)$.

(a) Find the acceleration of P when $t = 2$.

[2]

[illegible]

(b) Find the total distance travelled by P in the first 3 seconds of its motion.

[5]

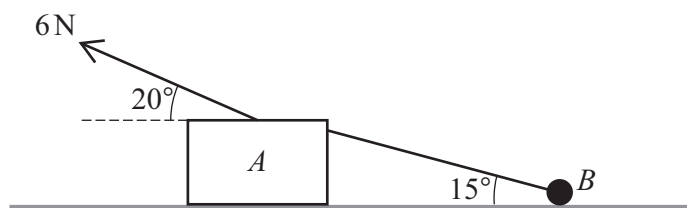
[illegible]



(c) Determine whether P returns to O .

[2]





A block A of mass 2 kg and a particle B of mass 0.5 kg are connected by a light inextensible string inclined at 15° to the horizontal. They are pulled across a horizontal surface with acceleration 1.2 m s^{-2} by a force of magnitude 6 N , applied to A , acting at 20° above the horizontal as shown in the diagram. The string and the force applied to A are in the same vertical plane.

The contact between B and the surface is smooth and the contact between A and the surface is rough.

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

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(b) Find the coefficient of friction between A and the surface.

[6]

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MATHEMATICS**9709/42**

Paper 4 Mechanics

October/November 2025**1 hour 15 minutes**

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS

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INFORMATION

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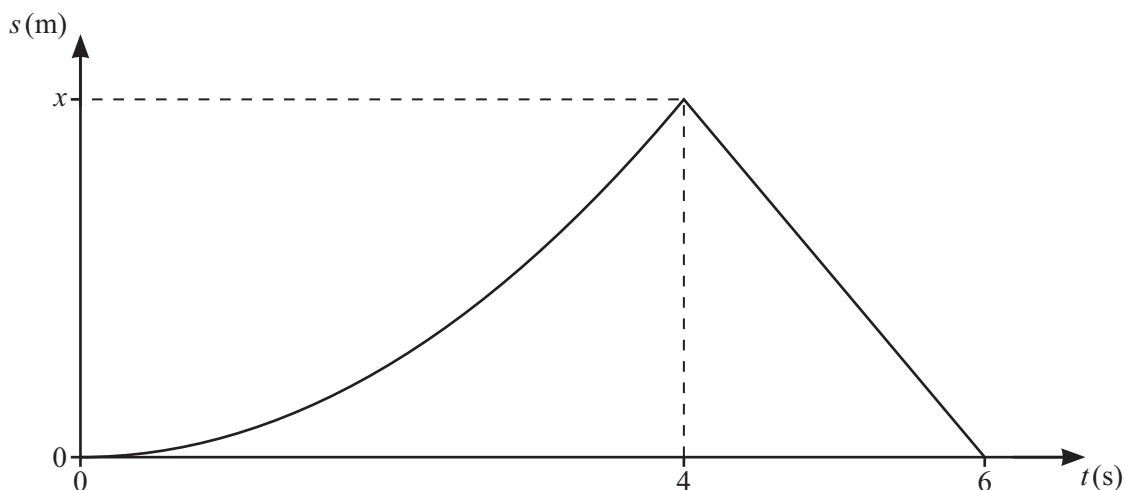
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1



The diagram shows the displacement-time graph for the motion of a particle. The particle starts from rest at a point O and travels with constant acceleration $a \text{ m s}^{-2}$, taking 4 s to move a distance of $x \text{ m}$. The particle then returns to O with constant speed of 40 m s^{-1} , over a period of 2 s.

Find the value of x and the value of a .

[3]

[illegible]



- 2 A railway locomotive of mass 240 000 kg is towing a coach of mass 36 000 kg down a hill inclined at an angle of $\sin^{-1} 0.04$ to the horizontal. The driving force produced by the locomotive is 450 000 N and there are resistances to motion of 120 000 N on the locomotive and 15 000 N on the coach. The coupling between the locomotive and the coach is light, rigid and parallel to the hill.

Find the acceleration of the locomotive and the tension in the coupling. [5]

[illegible]

- 3 A car of mass 1400 kg travelling on a straight horizontal road accelerates uniformly from a speed of 15 m s^{-1} to 20 m s^{-1} over a distance of 175 m.

(a) Find the time taken to travel the 175 m. [2]

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There is a constant resistance force of 800 N to the motion of the car.

(b) (i) Use an energy method throughout to find the average power of the car's engine as the speed increases from 15 m s^{-1} to 20 m s^{-1} . [4]

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(ii) Find the steady speed that the car could maintain on the horizontal road if the engine is working at the power found in (b)(i). [2]

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- 4 A particle P of mass 0.1 kg is projected vertically upwards with speed 30 m s^{-1} from horizontal ground. At the same instant a particle Q of mass 0.4 kg is projected vertically upwards with speed 10 m s^{-1} from a height of 15 m above the ground. P and Q move in the same vertical line.

(a) Find the height above the ground at which P and Q collide.

[4]

[illegible]



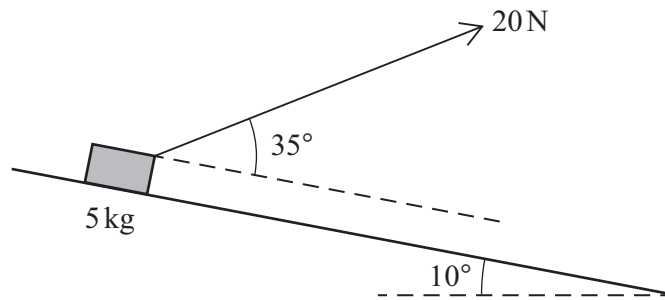
When P and Q collide, they coalesce.

- (b)** Find the speed of the combined particle at the instant that it reaches the ground. [5]

[illegible]



5



A block of mass 5 kg is being pulled straight down a line of greatest slope of a rough plane by a force of magnitude 20 N. The plane is inclined at an angle of 10° to the horizontal and the 20 N force acts at an angle of 35° above the line of greatest slope of the plane (see diagram). The coefficient of friction between the block and the plane is 0.4. The speed of the block when it passes a point O is 2 ms^{-1} .

Find the speed of the block when it has moved 3 m down the plane from O .

[6]

[illegible]



- 6 A particle starts from rest at a point O . The acceleration of the particle at time t s after leaving O is $a \text{ ms}^{-2}$, where

$$a = 2(t+1)^{-\frac{1}{2}} - 1 \text{ for } t \geq 0.$$

Find the distance that the particle travels from O until the time at which its acceleration is zero. [8]



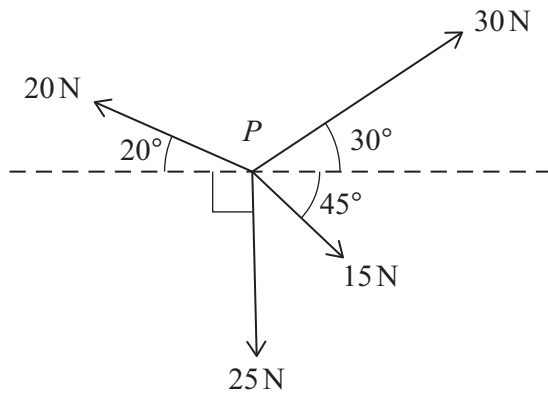


Fig. 7.1

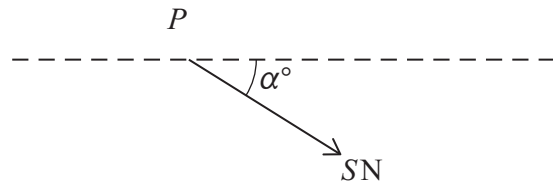


Fig. 7.2

Four coplanar forces of magnitudes 20 N, 30 N, 15 N and 25 N act at a point P in the directions shown in Fig. 7.1. The forces act in a vertical plane. The resultant of these forces has magnitude S N and acts at an angle α° below the horizontal as shown in Fig. 7.2.

- (a)** Find the value of S and the value of α .

[6]

[illegible]



A small ring of mass 0.6 kg is threaded on a rough straight horizontal wire. The four forces shown in Fig. 7.1 act on the ring and are in the same vertical plane as the wire. The ring starts from rest and takes 3 s to travel a distance of 2 m along the wire.

- (b) Find the coefficient of friction between the ring and the wire. [5]

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MATHEMATICS**9709/43**

Paper 4 Mechanics

October/November 2025**1 hour 15 minutes**

You must answer on the question paper.

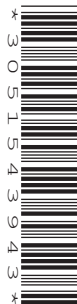
You will need: List of formulae (MF19)

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INFORMATION

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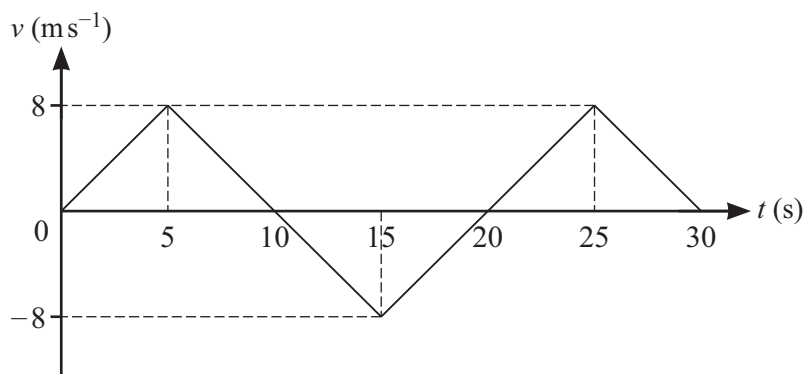
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1



The diagram shows the velocity-time graph for the motion of an athlete. The athlete runs in a straight line from point A to point B , runs back to point A and finishes at point B . The graph consists of four straight line segments.

- (a) Find the deceleration of the athlete 7 seconds after leaving A . [1]

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- (b)** Find the total distance travelled by the athlete. [2]

[illegible]

- 2 The engine of a motorcycle can generate a maximum power of 105 kW. The mass of the motorcycle and its rider is 400 kg. The total resistance to the motion of the motorcycle and its rider is cv N, where $v \text{ m s}^{-1}$ is the motorcyclist's speed and c is a constant.

The motorcyclist travels along a straight horizontal road under maximum engine power. When the motorcyclist's speed is 35 m s^{-1} , his acceleration is 0.5 m s^{-2} .

- (a) Show that $c = 80$. [3]

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The motorcyclist now travels up a straight hill under maximum engine power. The hill makes an angle of $\sin^{-1}\left(\frac{3}{20}\right)$ with the horizontal.

- (b) Find the steady speed at which the motorcyclist travels up the hill. [3]

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- 3 A block of mass 4 kg is pulled along a rough horizontal road by a constant force of magnitude 25 N acting at an angle of 36° above the horizontal. The block moves in a straight line passing through two points A and B on the road, where $AB = 120$ m. The coefficient of friction between the block and the road is 0.4.

- (a) Find the work done against friction in moving the block from A to B . [3]

[illegible]

The speed of the block at A is 7 m s^{-1} .

- (b) Use an energy method to find the speed of the block at B . [4]

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



- 4 A particle P moves in a straight line. At time t s after passing through a point O on the line, the displacement of P from O is s m, where $s = 0.01t^3 - 0.3t^2 - 2.07t$.

- (a)** Find the value of s when P has its minimum velocity, and find also the speed of P at this instant.

[6]

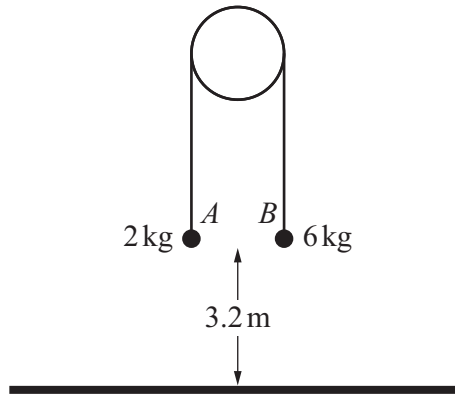
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(b) Find the acceleration of P at the instant when the direction of motion of P changes.

[4]

[illegible]



Particles A and B , of masses 2 kg and 6 kg respectively, are attached to the ends of a light inextensible string. The string passes over a smooth fixed pulley and the particles hang vertically below the pulley. Both particles are initially held at rest at a height of 3.2 m above horizontal ground (see diagram). Particle A is projected vertically **downwards** with a speed of 1.2 m s^{-1} .

- (a) Find the tension in the string and the magnitude of the acceleration of the particles. [4]

[illegible]



In the subsequent motion, A does **not** hit the ground and neither particle reaches the pulley. When B hits the ground, it does **not** rebound.

- (b) Find the time that B is in motion. [2]

[illegible]

- (c) Find the distance between the lowest and highest points that A reaches. [4]

[illegible]



- 6** Particle P of mass m kg and particle Q of mass 2 kg are free to move on a smooth horizontal plane. P and Q are moving directly towards each other with speeds u m s⁻¹ and $3u$ m s⁻¹ respectively. P and Q collide and the direction of motion of each particle is reversed by the collision. Immediately after the collision the speed of P is $\frac{u}{3}$ m s⁻¹.
- (a)** Find, in terms of m and u , an expression for the velocity of Q after the collision and hence show that $m > 4.5$. [3]

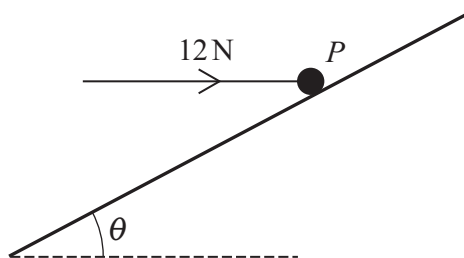
[illegible]



Q subsequently hits a vertical wall which is perpendicular to the direction of motion of Q . The speed of Q after the impact with the wall is a quarter of its speed before the impact with the wall. There are no further collisions between P and Q .

- (b) Given that m is an integer, determine the largest possible value of m . [4]

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A particle P of mass 6 kg lies on a rough plane inclined at an acute angle θ to the horizontal. A horizontal force of magnitude 12 N acts on P as shown in the diagram. The line of action of this horizontal force lies in a vertical plane which contains the line of greatest slope of the plane that passes through P . The coefficient of friction between P and the plane is μ .

P is in equilibrium and on the point of sliding down the plane.

- (a) Show that $\mu = \frac{5 \tan \theta - 1}{5 + \tan \theta}$. [5]

[illegible]

- (b) Hence find the set of possible values of θ . [2]

[illegible]



Additional page

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MATHEMATICS**9709/45**

Paper 4 Mechanics

October/November 2025**1 hour 15 minutes**

You must answer on the question paper.

You will need: List of formulae (MF19)

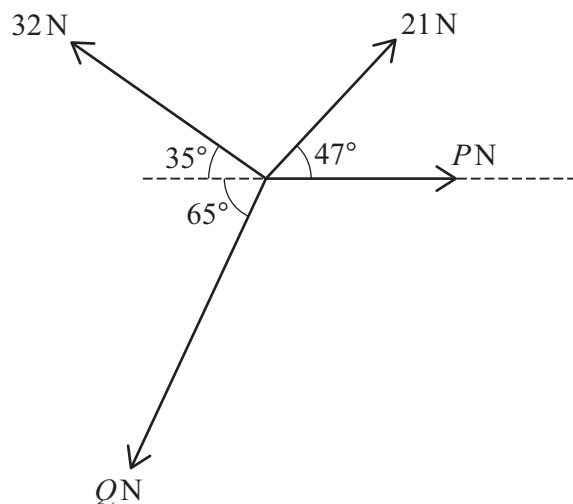
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Coplanar forces of magnitudes P N, Q N, 32 N and 21 N act at a point in the directions shown in the diagram. The forces are in equilibrium.

Find the value of P and the value of Q .

[5]

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- 2** An athlete runs along a straight horizontal road. The athlete starts from rest and accelerates at 0.5 m s^{-2} reaching a speed of $V \text{ m s}^{-1}$. The athlete maintains this speed of $V \text{ m s}^{-1}$ for T s before decelerating at 0.2 m s^{-2} back to rest. The athlete covers a total distance of 1350 m in 246 seconds.

(a) Sketch the velocity-time graph for the motion of the athlete.

[1]



- (b)** Find T in terms of V , and hence show that $7V^2 - 492V + 2700 = 0$.

[4]

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- (c) Find the value of V , giving a justification for your answer.

[2]

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3 A car of mass 800 kg is moving on a straight road.

When the car is moving at a constant speed of 20 ms^{-1} on a horizontal section of the road, the engine of the car is working at PW .

When the car is moving at a constant speed of 12 ms^{-1} up a section of the road inclined at $\sin^{-1} 0.15$ to the horizontal, the engine of the car is also working at PW .

On both sections of the road there is a constant force of magnitude R N resisting the motion of the car.

(a) Find the value of R and the value of P .

[5]

[illegible]



- (b)** Find the acceleration of the car when it is moving at 10 ms^{-1} up the inclined section of the road with the engine working at 32 kW . [3]

[illegible]



- 4 A particle P moves in a straight line. At time t s after leaving a point O on the line, the acceleration $a \text{ ms}^{-2}$ of P is given by $a = kt - 3$, where k is a positive constant. At time $t = 0$, the velocity of P is 1 ms^{-1} .

(a) Given that P is never at instantaneous rest, show that $k > 4.5$.

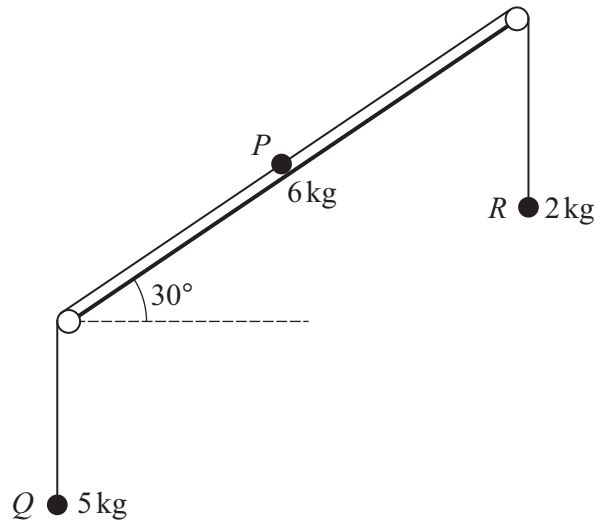
[4]

[illegible]



(b) Given instead that $k = 2.5$, find the total distance travelled by P in the interval $1 \leq t \leq 3$. [6]

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The diagram shows a particle P of mass 6 kg on a rough plane inclined at an angle of 30° to the horizontal. Two light inextensible strings are attached to P . The strings pass over small smooth pulleys, which are fixed at the ends of the plane. The non-vertical parts of the string are parallel to a line of greatest slope of the plane. Particles Q and R , of masses 5 kg and 2 kg respectively, hang vertically at the ends of the strings.

Both strings are taut, and the system is released from rest.

It is given that the tension in the string attached to Q is twice the tension in the string attached to R .

- (a) Find, in terms of g , the tension in each of the strings and the magnitude of the acceleration of the particles. [5]

[illegible]



(b) Find the coefficient of friction between P and the plane.

[5]

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(c) It is given that when the system is released from rest, P is at the midpoint of the plane. In the subsequent motion, R does not reach the pulley at the top of the plane, and P takes 1.5 s to reach the pulley at the bottom of the plane.

Find the total length of the plane.

[2]

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- 6** Two particles A and B of masses km and m respectively, where k and m are constants, are free to move in a straight line on a smooth horizontal plane. Particle A is projected towards B with speed $2u$ and at the same instant B is projected towards A with speed u .

The particles collide. After the collision the speed of A is u and both particles move in the same direction as A 's original motion.

It is given that 35% of the total kinetic energy is lost in the collision. Find, in terms of u , the speed of B after the collision. [8]

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Additional page

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

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