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Cambridge Assessment International Education

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CANDIDATE NAME

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9705999848

MATHEMATICS **9709/42**

Paper 4 Mechanics **February/March 2024**

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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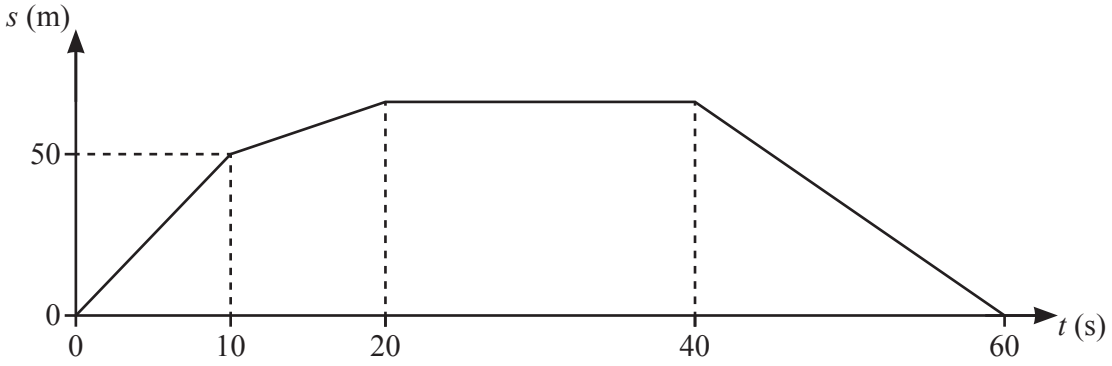
1



The displacement of a particle at time t s after leaving a fixed point O is s m. The diagram shows a displacement-time graph which models the motion of the particle. The graph consists of 4 straight line segments. The particle travels 50 m in the first 10 s, then travels at $2\,\text{m}\,\text{s}^{-1}$ for a period of 10 s. The particle then comes to rest for a period of 20 s, before returning to its starting point when $t = 60$.

(a) Find the velocity of the particle during the last 20 s of its motion. [2]

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(b) Sketch a velocity-time graph for the motion of the particle from $t = 0$ to $t = 60$. [3]

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2 A particle is projected vertically upwards from horizontal ground. The speed of the particle 2 seconds after it is projected is $5\,\text{m}\,\text{s}^{-1}$ and it is travelling **downwards**.

(a) Find the speed of projection of the particle. [2]

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(b) Find the distance travelled by the particle between the two times at which its speed is $10\,\text{m}\,\text{s}^{-1}$. [2]

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3 A crate of mass 600 kg is being pulled up a line of greatest slope of a rough plane at a constant speed of $2\,\text{m}\,\text{s}^{-1}$ by a rope attached to a winch. The plane is inclined at an angle of 30° to the horizontal and the rope is parallel to the plane. The winch is working at a constant rate of 8 kW.

Find the coefficient of friction between the crate and the plane. [5]

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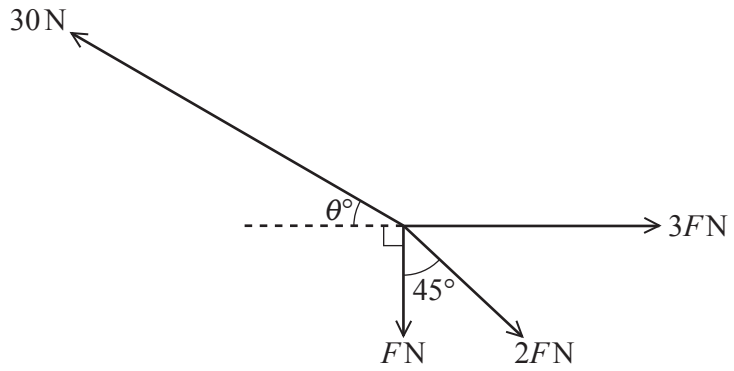

Four coplanar forces act at a point. The magnitudes of the forces are FN, $2F$N, $3F$N and 30 N. The directions of the forces are as shown in the diagram.

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

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

$$v = t^3 - \tfrac{9}{2}t^2 + 1 \text{ for } 0 \leqslant t \leqslant 4.$$

You may assume that the velocity of the particle is positive for $t < \frac{1}{2}$, is zero at $t = \frac{1}{2}$ and is negative for $t > \frac{1}{2}$.

(a) Find the distance travelled between $t = 0$ and $t = \frac{1}{2}$. [4]

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(b) Find the positive value of t at which the acceleration is zero. Hence find the total distance travelled between $t = 0$ and this instant. [4]

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6 A car of mass 1800 kg is towing a trailer of mass 300 kg up a straight road inclined at an angle α to the horizontal, where $\sin\alpha = 0.05$. The car and trailer are connected by a tow-bar which is light and rigid and is parallel to the road. There is a resistance force of 800 N acting on the car and a resistance force of F N acting on the trailer. The driving force of the car's engine is 3000 N.

(a) It is given that $F = 100$.

Find the acceleration of the car and the tension in the tow-bar. [5]

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(b) It is given instead that the total work done against F in moving a distance of 50 m up the road is 6000 J. The speed of the car at the start of the 50 m is $20\,\text{m}\,\text{s}^{-1}$.

Use an energy method to find the speed of the car at the end of the 50 m. [5]

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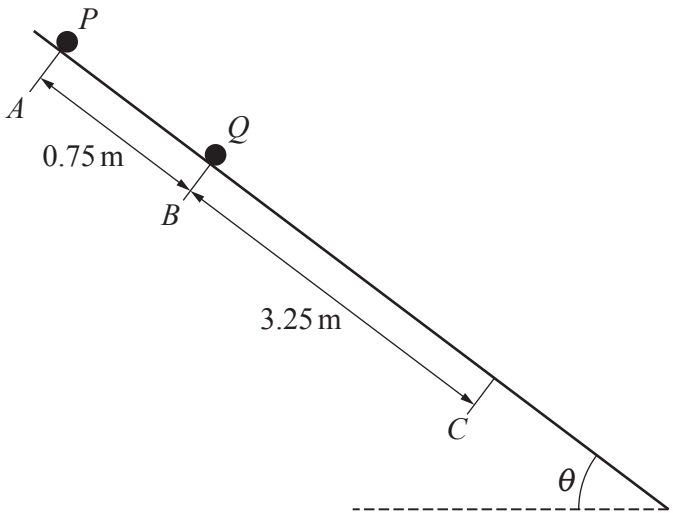

The diagram shows two particles P and Q which lie on a line of greatest slope of a plane ABC. Particles P and Q are each of mass m kg. The plane is inclined at an angle θ to the horizontal, where $\sin\theta = 0.6$. The length of AB is 0.75 m and the length of BC is 3.25 m. The section AB of the plane is smooth and the section BC is rough. The coefficient of friction between each particle and the section BC is 0.25. Particle P is released from rest at A. At the same instant, particle Q is released from rest at B.

(a) Verify that particle P reaches B 0.5 s after it is released, with speed 3 m s^{-1}. [3]

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(b) Find the time that it takes from the instant the two particles are released until they collide. [4]

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The two particles coalesce when they collide. The coefficient of friction between the combined particle and the plane is still 0.25 .

(c) Find the time that it takes from the instant the particles collide until the combined particle reaches *C*. [5]

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