Cambridge Assessment International Education

# Cambridge International AS & A Level

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**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 [ ].

This document has **12** pages.

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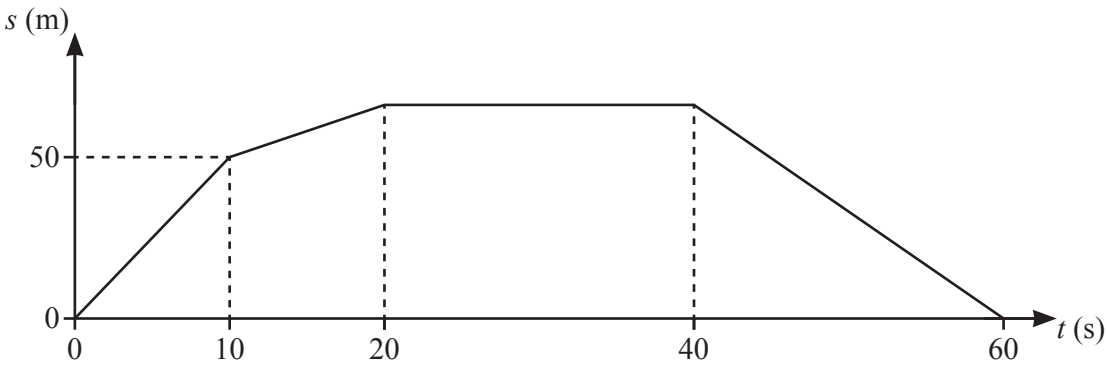
**1**




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 $2\,\mathrm{m\,s^{-1}}$ 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]

**2** A particle is projected vertically upwards from horizontal ground. The speed of the particle 2 seconds after it is projected is $5\,\mathrm{m\,s^{-1}}$ 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 $10\,\mathrm{m\,s^{-1}}$. [2]

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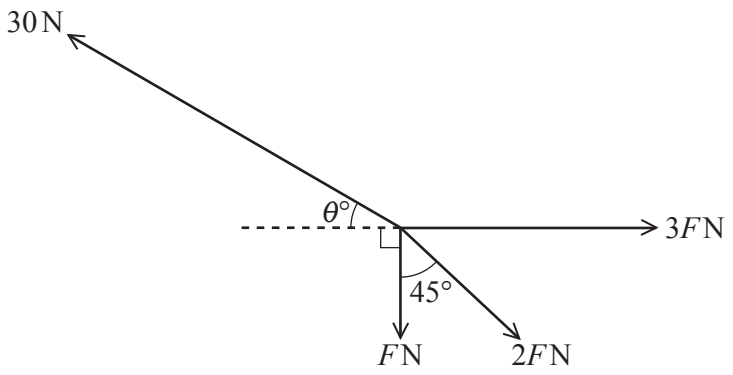
**3** A crate of mass 600 kg is being pulled up a line of greatest slope of a rough plane at a constant speed of $2\,\mathrm{m\,s^{-1}}$ by a rope attached to a winch. The plane is inclined at an angle of 30° to the horizontal and the rope is parallel to the plane. The winch is working at a constant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

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

**4**




Four coplanar forces act at a point. The magnitudes of the forces are $F$ N, $2F$ 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 $\theta$. [6]

**5** A particle moves in a straight line starting from a point $O$. The velocity $v\,\mathrm{m\,s^{-1}}$ 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]

**(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]

**6** A car of mass 1800 kg is towing a trailer of mass 300 kg up a straight road inclined at an angle $\alpha$ 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 $20\,\mathrm{m\,s^{-1}}$.

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

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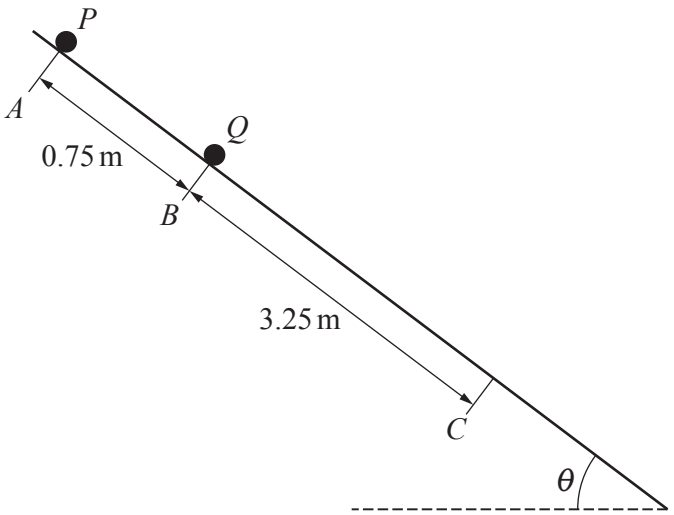


The diagram shows two particles $P$ and $Q$ which lie on a line of greatest slope of a plane $ABC$. Particles $P$ and $Q$ are each of mass $m$ kg. The plane is inclined at an angle $\theta$ to the horizontal, where $\sin\theta = 0.6$ . The length of $AB$ is 0.75 m and the length of $BC$ is 3.25 m. The 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 $3\,\mathrm{m\,s^{-1}}$. [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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## Additional page

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