OCR
Oxford Cambridge and RSA

# Friday 23 May 2025 – Afternoon

## AS Level Mathematics A

## H230/02 Pure Mathematics and Mechanics

**Time allowed: 1 hour 30 minutes**

*L18O5083L1*

**You must have:**
- the Printed Answer Booklet
- a scientific or graphical calculator

**QP**

**INSTRUCTIONS**
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided in the **Printed Answer Booklet**. If you need extra space use the lined page at the end of the Printed Answer Booklet. The question numbers must be clearly shown.
- Fill in the boxes on the front of the Printed Answer Booklet.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.
- Give non-exact numerical answers correct to **3** significant figures unless a different degree of accuracy is specified in the question.
- The acceleration due to gravity is denoted by $g\,\text{m}\,\text{s}^{-2}$. When a numerical value is needed use $g = 9.8$ unless a different value is specified in the question.
- Do **not** send this Question Paper for marking. Keep it in the centre or recycle it.

**INFORMATION**
- The total mark for this paper is **75**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **8** pages.

**ADVICE**
- Read each question carefully before you start your answer.

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# Formulae
# AS Level Mathematics A (H230)

## Binomial series

$$(a+b)^n = a^n + {}^n\mathrm{C}_1 a^{n-1}b + {}^n\mathrm{C}_2 a^{n-2}b^2 + \ldots + {}^n\mathrm{C}_r a^{n-r}b^r + \ldots + b^n \qquad (n \in \mathbb{N}),$$

where ${}^n\mathrm{C}_r = {}_n\mathrm{C}_r = \binom{n}{r} = \dfrac{n!}{r!(n-r)!}$

## Differentiation from first principles

$$\mathrm{f}'(x) = \lim_{h \to 0} \frac{\mathrm{f}(x+h) - \mathrm{f}(x)}{h}$$

## Standard deviation

$$\sqrt{\frac{\Sigma(x-\overline{x})^2}{n}} = \sqrt{\frac{\Sigma x^2}{n} - \overline{x}^2} \quad \text{or} \quad \sqrt{\frac{\Sigma f(x-\overline{x})^2}{\Sigma f}} = \sqrt{\frac{\Sigma f x^2}{\Sigma f} - \overline{x}^2}$$

## The binomial distribution

If $X \sim \mathrm{B}(n, p)$ then $\mathrm{P}(X = x) = \binom{n}{x} p^x (1-p)^{n-x}$, mean of $X$ is $np$, variance of $X$ is $np(1-p)$

## Kinematics

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$s = \frac{1}{2}(u+v)t$

$v^2 = u^2 + 2as$

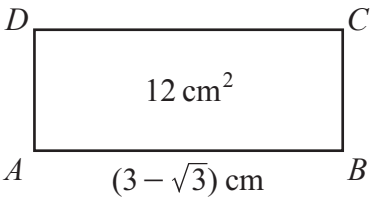
$s = vt - \frac{1}{2}at^2$

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## Section A
## Pure Mathematics

**1** Determine the equation of the line that passes through the point (1, 3) and is perpendicular to the line with equation $3x + 6y - 5 = 0$. Give your answer in the form $ax + by + c = 0$ where $a$, $b$ and $c$ are integers to be determined. **[3]**

**2** **In this question you must show detailed reasoning.**




The diagram shows the rectangle $ABCD$ where $AB = (3 - \sqrt{3})$ cm.

The area of $ABCD$ is 12 cm$^2$.

Find the perimeter of $ABCD$. Give your answer in the form $(a + b\sqrt{3})$ cm, where $a$ and $b$ are integers to be determined. **[4]**

**3** In a triangle $ABC$, $AB = 9$ cm, $BC = 7$ cm and $AC = 4$ cm.

**(a)** Show that $\cos CAB = \frac{2}{3}$. **[2]**

**(b)** Hence find the exact value of $\sin CAB$. **[2]**

**(c)** Find the exact area of triangle $ABC$. **[2]**

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**4** The cubic polynomial $2x^3 - kx^2 + 4x + k$, where $k$ is a constant, is denoted by $f(x)$.
It is given that $f'(2) = 16$.

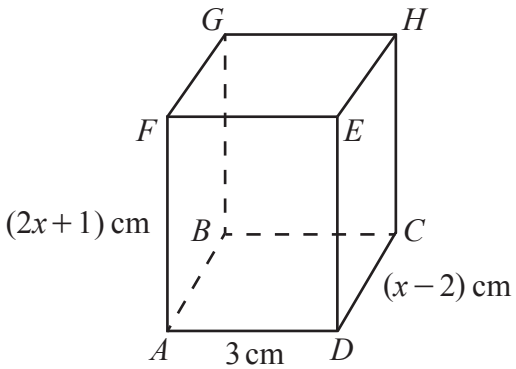
**(a)** Show that $k = 3$. **[4]**

For the remainder of the question, you should use this value of $k$.

**(b)** Use the factor theorem to show that $(2x + 1)$ is a factor of $f(x)$. **[2]**

**(c)** Hence show that the equation $f(x) = 0$ has only **one** real root. **[4]**

**5** **In this question you must show detailed reasoning.**




The diagram shows the cuboid $ABCDEFGH$ where $AD = 3$ cm, $AF = (2x + 1)$ cm and $DC = (x - 2)$ cm.

The volume of the cuboid is at most $9\,\text{cm}^3$.

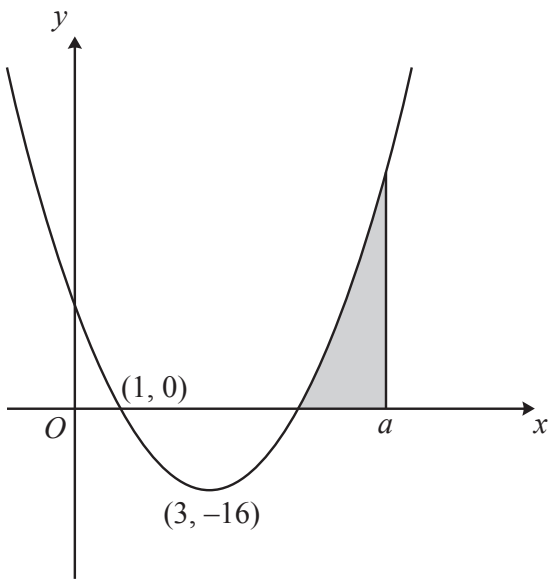
Find the range of possible values of $x$. Give your answer in interval notation. **[5]**

**6** **(a)** The curve $y = \ln x$ is stretched by a scale factor 3 in the $x$-direction.

State the equation of the curve after it has been stretched. **[2]**

**(b)** Describe fully the **single** transformation that transforms the curve $y = x^2 + 1$ to the curve $y = x^2 - 6x + 8$. **[4]**

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The diagram shows the curve with equation $y = \mathrm{f}(x)$ where $\mathrm{f}(x)$ is a quadratic function. The curve intersects the $x$-axis at the point $(1, 0)$ and has its minimum at the point $(3, -16)$.

**(a)** Show that $\mathrm{f}(x) = 4x^2 - 24x + 20$. **[3]**

The shaded region is enclosed by the curve, the $x$-axis, and the line $x = a$. The area of the shaded region is $\frac{100}{3}$ units$^2$.

**(b)** Determine the exact value of the constant $a$. **[6]**

**8** The curves $\mathrm{e}^x - 2\mathrm{e}^y = 1$ and $2\mathrm{e}^x + 3\mathrm{e}^{2y} = 41$ intersect at the point $P$.

**(a)** Show that the $y$-coordinate of $P$ satisfies the equation $3\mathrm{e}^{2y} + 4\mathrm{e}^y - 39 = 0$. **[1]**

**(b)** **In this question you must show detailed reasoning.**

Hence find the exact coordinates of $P$. **[5]**

## Section B
## Mechanics

**9** An athlete runs with velocity $v\,\text{m s}^{-1}$ along a horizontal straight running track $AB$. At time $t$ seconds after passing $A$, $v = 0.05t^2 - 0.4t + k$, where $k$ is a constant.

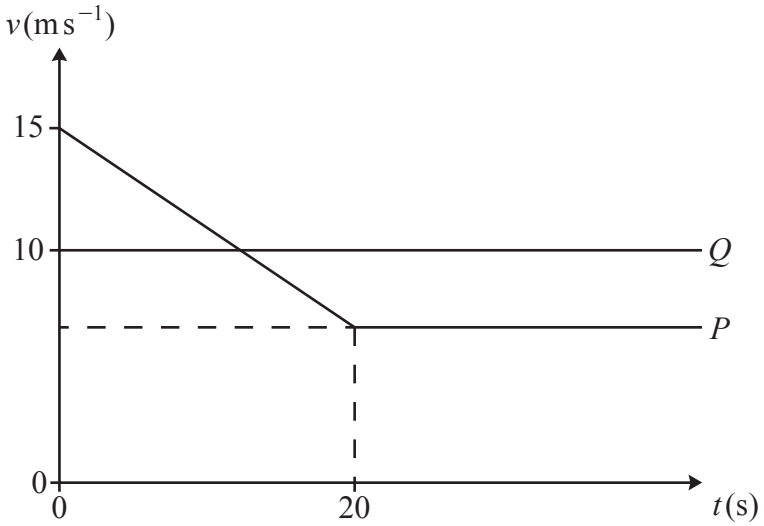
**(a)** Find the acceleration of the athlete when $t = 6$. **[2]**

**(b)** Given that the minimum velocity of the athlete is $6.6\,\text{m s}^{-1}$, show that $k = 7.4$. **[3]**

The athlete runs in a straight line from $A$ to $B$ in 13.1 seconds.

**(c)** Calculate the distance $AB$. **[2]**

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The velocity-time graph represents the motion of two cyclists $P$ and $Q$ who are travelling along a straight, horizontal road. At time $t = 0$, the cyclists pass the same point on the road with $P$ cycling at $15\,\text{m s}^{-1}$ and $Q$ cycling at $10\,\text{m s}^{-1}$.

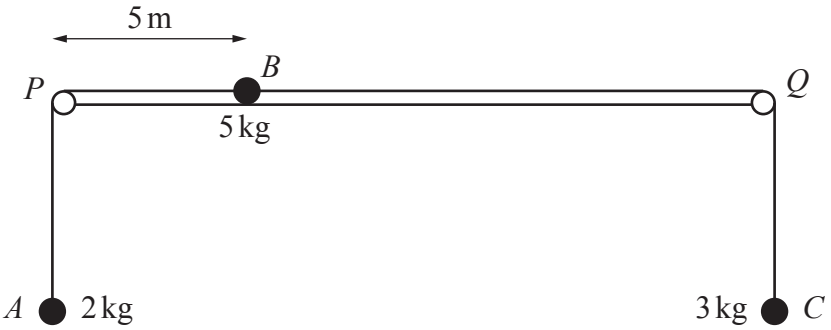
From time $t = 0$, $P$ cycles with constant deceleration $0.4\,\text{m s}^{-2}$ for 20 seconds and $Q$ cycles at a constant velocity of $10\,\text{m s}^{-1}$. From $t = 20$ onwards, $P$'s velocity remains constant.

**(a)** Find the value of $t$ when $P$ and $Q$ have the same velocity. **[2]**

**(b)** Determine the value of $t$ when $Q$ overtakes $P$. **[4]**

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**11**




One end of a light inextensible string is attached to a particle $A$ of mass 2 kg. The other end of the string is attached to a second particle $B$ of mass 5 kg. Particle $B$ is in contact with a smooth horizontal surface. The string passes over a small smooth pulley $P$ which is fixed at one edge of the surface. Particle $A$ hangs vertically below $P$.

A second light inextensible string is attached to $B$. The other end of this second string is attached to a third particle $C$ of mass 3 kg. This string passes over a small smooth pulley $Q$ which is fixed at the other edge of the surface. Particle $C$ hangs vertically below $Q$ (see diagram).

The system is released from rest with the strings taut and $B$ a distance 5 m from $P$. In the subsequent motion $A$ does not reach $P$.

**(a)** Determine, in terms of $g$, the tension in the string connecting $B$ and $C$. **[4]**

When the particles have been in motion for 3 seconds the string connecting $A$ and $B$ breaks. Particle $B$ reaches $Q$ after a further 2 seconds.

**(b)** Determine the distance $PQ$. **[6]**

**(c)** State what it would mean about the tension in the string connecting $B$ and $C$ if pulley $Q$ could **not** be assumed to be smooth. **[1]**

It is given that in fact the horizontal surface is **not** smooth. When the system, as shown in the diagram, is released, it remains at rest. (You may assume that pulley $Q$ **is** smooth.)

**(d)** Complete the diagram in the Printed Answer Booklet showing all the forces acting on $B$. **[1]**

**(e)** State the magnitude of the frictional force acting on $B$. Give a brief justification for your answer. **[1]**

**END OF QUESTION PAPER**

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