Oxford Cambridge and RSA

Thursday 15 May 2025 – Afternoon

AS Level Mathematics B (MEI)

H630/01 Pure Mathematics and Mechanics

Time allowed: 1 hour 30 minutes

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 your final answers to a degree of accuracy that is appropriate to the context.
- The acceleration due to gravity is denoted by $g\,\mathrm{m\,s^{-2}}$. 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 **70**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **8** pages.

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

Formulae AS Level Mathematics B (MEI) (H630)

Binomial series

$(a+b)^n = a^n + {}^nC_1 a^{n-1}b + {}^nC_2 a^{n-2}b^2 + \ldots + {}^nC_r a^{n-r}b^r + \ldots + b^n \qquad (n \in \mathbb{N}),$

where ${}^nC_r = {}_nC_r = \binom{n}{r} = \dfrac{n!}{r!(n-r)!}$

$(1+x)^n = 1 + nx + \dfrac{n(n-1)}{2!}x^2 + \ldots + \dfrac{n(n-1)\ldots(n-r+1)}{r!}x^r + \ldots \qquad (|x| < 1,\ n \in \mathbb{R})$

Differentiation from first principles

$\mathrm{f}'(x) = \lim\limits_{h \to 0} \dfrac{\mathrm{f}(x+h) - \mathrm{f}(x)}{h}$

Sample variance

$s^2 = \dfrac{1}{n-1}S_{xx}$ where $S_{xx} = \sum(x_i - \bar{x})^2 = \sum x_i^2 - \dfrac{(\sum x_i)^2}{n} = \sum x_i^2 - n\bar{x}^2$

Standard deviation, $s = \sqrt{\text{variance}}$

The binomial distribution

If $X \sim \mathrm{B}(n, p)$ then $\mathrm{P}(X = r) = {}^nC_r p^r q^{n-r}$ where $q = 1 - p$

Mean of X is np

Kinematics

Motion in a straight line

$v = u + at$

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

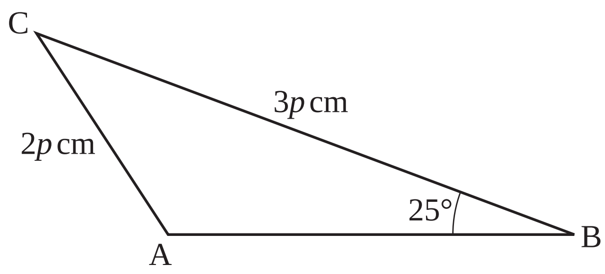
$s = \frac{1}{2}(u+v)t$

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

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

1 Expand $(2a-b)^4$. You must simplify your answer. **[3]**

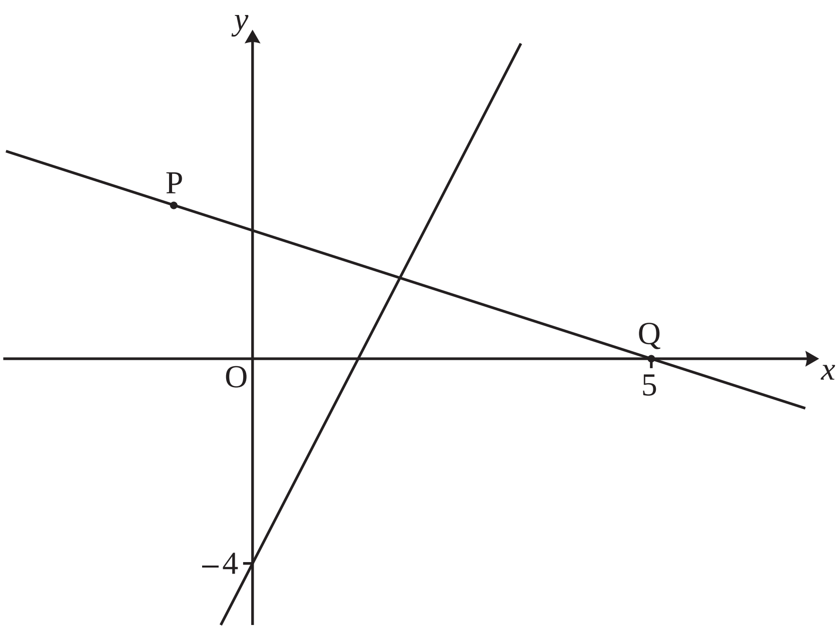
2 Triangle ABC is shown in the diagram. The length of AC is $2p$ cm and the length of BC is $3p$ cm, where p is a positive constant. The angle ABC is 25°.



Calculate the size of the **obtuse** angle CAB. **[2]**

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

The graph below shows the line $y = 3x - 4$ and the line through P and Q where P is (–1, 3) and Q is (5, 0).



Use an **algebraic** method to find the coordinates of the point of intersection of the two lines. **[4]**

4 **(a)** Show that the equation $x^2 + kx - k^2 = 0$ has real roots for all real values of k. **[2]**

(b) Show that the roots of the equation $x^2 + kx - k^2 = 0$ are $\left(\frac{-1 \pm \sqrt{5}}{2}\right)k$. **[2]**

5 Two blocks A and B have masses 5 kg and 2 kg respectively. The blocks are joined together by a light rigid horizontal bar and slide across a horizontal surface. The resistances on the blocks A and B are modelled as 7 N and 1.75 N respectively. There are no other external horizontal forces.

(a) Calculate the acceleration of the system, according to the model. **[3]**

(b) In reality, the acceleration of the system is **not** constant. State an improvement that could be made to the model so that it will produce results which are closer to the real situation. **[1]**

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

Solve the equation $6\cos^2 x = 5 - \sin x$ giving all the roots in the interval $0° < x < 360°$. **[4]**

7 The point A has position vector $\begin{pmatrix} -2 \\ 1 \end{pmatrix}$. The vector $\overrightarrow{AB}$ is $\begin{pmatrix} 8 \\ 6 \end{pmatrix}$.

(a) On the axes in your Printed Answer Book, draw the position of the points A and B. **[2]**

(b) Calculate the distance AB. **[1]**

(c) Show that the midpoint of AB lies on the line $y = 2x$. **[2]**

8 On the planet Mars, acceleration due to gravity is $3.71\,\mathrm{m\,s^{-2}}$.

(a) Calculate the time it would take an object to fall to the planet's surface from rest from a point 2 m above the surface. There are no resistances to the motion of the object. **[2]**

(b) The mass of the object is 2.5 kg.

Calculate the magnitude of the normal contact force when the object is at rest on the planet's surface. **[1]**

9 **(a)** Write the expression $\frac{1}{x^2}\left(3+x^{\frac{5}{2}}\right)$ in the form $3x^p + x^q$. **[1]**

(b) A curve has gradient function $\frac{dy}{dx} = \frac{1}{x^2}\left(3+x^{\frac{5}{2}}\right)$. The curve passes through the point (1, –2).

Determine the equation of the curve. **[4]**

10 In this question, the **i** direction is horizontal and the **j** direction is vertically upwards.

A particle of mass 3 kg is in equilibrium.

(a) Explain what is meant by a particle. **[1]**

The following forces are acting on the particle:

- the weight of the particle
- a horizontal force of $h\mathbf{i}$ N
- the force $\mathbf{F} = k\mathbf{i} + (k-5)\mathbf{j}$ N.

(b) Calculate the value of h. **[3]**

(c) The force **F** is removed.

State the vector equation of motion of the particle. **[1]**

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

You are given that $f(x) = (x+2)(x^2 - 7x + 6)$.

(a) Solve the equation $f(x) = 0$. **[3]**

(b) Show that there is a minimum point on the curve $y = f(x)$ when $x = 4$. **[4]**

(c) Find the exact coordinates of the other stationary point on the curve $y = f(x)$. **[2]**

12 A student dissolves 0.5 kg of salt in a bucket of water. Water leaks out of a hole in the bucket so the student lets fresh water flow in so that the bucket stays full.

They assume that the salty water remaining in the bucket mixes with the fresh water that flows in, so the concentration of salt is uniform throughout the bucket.

They model the mass M kg of salt remaining after t minutes by $M = ak^t$ where a and k are constants.

(a) Show that the model for M can be rewritten in the form $\log_{10}M = t\log_{10}k + \log_{10}a$. **[1]**

The student measures the concentration of salt in the bucket at certain times to estimate the mass of the salt remaining. The results are shown in the table below.

t minutes	8	13	21	35	50
M kg	0.4	0.3	0.2	0.1	0.05

The student uses this data and plots $y = \log_{10}M$ against $x = t$ using graph drawing software. The software gives $y = -0.0214x - 0.2403$ for the equation of the line of best fit.

(b) **(i)** Find the values of a and k that follow from the equation of the line. **[3]**

(ii) Interpret the value of k in context. **[1]**

(c) It is known that when $t = 0$ the mass of salt in the bucket is 0.5 kg.

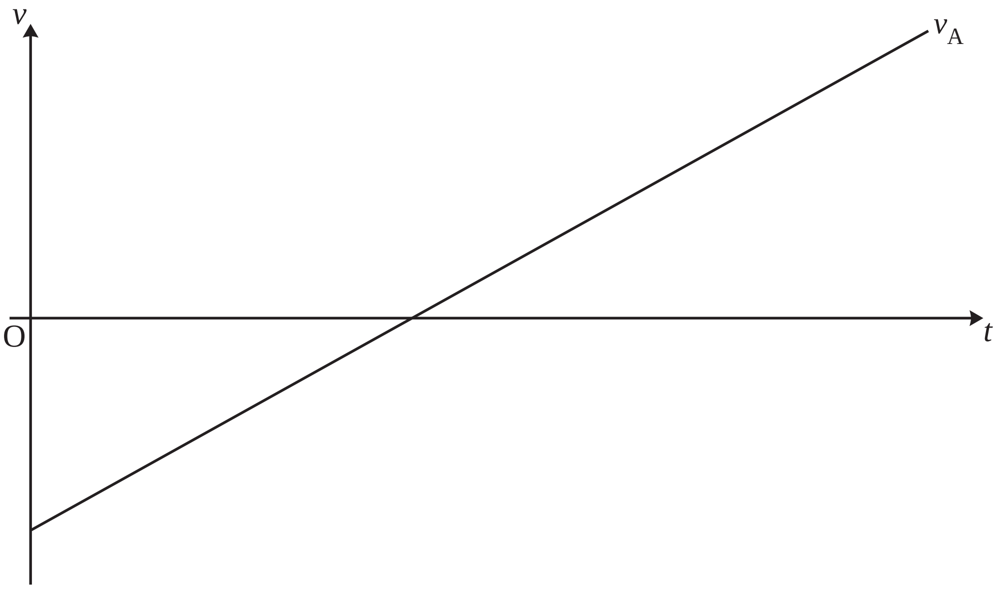
Comment on the accuracy when the model is used to estimate the initial mass of the salt. **[2]**

(d) Use the model to predict the value of t at which $M = 0.01$kg. **[2]**

(e) Rewrite the model for M in the form $M = ae^{-ht}$ where h is a constant to be determined. **[2]**

(f) Find the rate at which the mass of salt is decreasing when $t = 10$. **[2]**

13 Particles A and B are moving along the same straight line. The graph below is the velocity–time graph for particle A with velocity $v_A\,\text{m s}^{-1}$ at time t s. Particle A travels with constant acceleration. It has an initial velocity of $-3\,\text{m s}^{-1}$ and is instantaneously at rest when $t = 4$.



The velocity for particle B at time t s is given by $v_B = 1.5 + 0.03t^2\,\text{m s}^{-1}$. The particles are **first** travelling at the same velocity at time $t = T$ s. You are given that A and B do not collide.

(a) Show that $T = 10$. **[3]**

(b) Hence, or otherwise, determine which particle has travelled the greater **distance** by time T s and by how much. **[6]**

END OF QUESTION PAPER