Please check the examination details below before entering your candidate information

Candidate surname StemUp Model Solution | Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Thursday 5 June 2025

Afternoon (Time: 1 hour 30 minutes) | Paper reference WMA14/01

Mathematics

International Advanced Level
Pure Mathematics P4

You must have:
Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 10 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ▶

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1. **In this question you must show all stages of your working.**
Solutions relying on calculator technology are not acceptable.

The curve C has equation

$$2y^2 - 6xy = 7e^{2x-1} + 13$$

The point P with x coordinate $\frac{1}{2}$ lies on C.

(a) Find the two possible y coordinates of P.

(2)

Given that P lies above the x-axis,

(b) find an equation for the tangent to C at P, giving your answer in the form $ax + by + c = 0$ where a, b and c are integers.

(6)

(a) $x = \frac{1}{2}$: $2y^2 - 6\left(\frac{1}{2}\right)y = 7e^0 + 13$

$2y^2 - 3y - 20 = 0 \Rightarrow (2y + 5)(y - 4) = 0$

$y = 4$ or $y = -\frac{5}{2}$

(b) $4y\frac{dy}{dx} - 6x\frac{dy}{dx} - 6y = 14e^{2x-1}$

At $\left(\frac{1}{2}, 4\right)$: $16\frac{dy}{dx} - 3\frac{dy}{dx} - 24 = 14e^0$

$13\frac{dy}{dx} = 38 \Rightarrow \frac{dy}{dx} = \frac{38}{13}$

$y - 4 = \frac{38}{13}\left(x - \frac{1}{2}\right)$

$13y - 52 = 38x - 19$

$38x - 13y + 33 = 0$

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Question 1 continued

(Total for Question 1 is 8 marks)

2. A spherical ball of ice with radius r cm is melting.

The volume of the ball of ice, $V\,\text{cm}^3$, is decreasing at a constant rate, $k\,\text{cm}^3$ per second, where k is a constant.

Given that $V = \frac{4}{3}\pi r^3$, show that the rate of decrease of the radius of the ball of ice with respect to time is inversely proportional to the square of the radius.

(4)

$\frac{dV}{dt} = -k$ (volume decreasing at constant rate k)

$V = \frac{4}{3}\pi r^3 \Rightarrow \frac{dV}{dr} = 4\pi r^2$

$\frac{dV}{dt} = \frac{dV}{dr} \times \frac{dr}{dt} \Rightarrow -k = 4\pi r^2 \times \frac{dr}{dt}$

$\frac{dr}{dt} = -\frac{k}{4\pi r^2} = -\frac{k}{4\pi} \times \frac{1}{r^2}$

Rate of decrease of radius $= \frac{k}{4\pi} \times \frac{1}{r^2}$, where $\frac{k}{4\pi}$ is a constant

$\therefore$ rate of decrease of $r \propto \frac{1}{r^2}$, i.e. inversely proportional to r^2

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Question 2 continued

(Total for Question 2 is 4 marks)

3. Given that $y = 4$ at $x = \frac{\pi}{6}$, solve the differential equation

$$y\cos^2(2x)\frac{dy}{dx} = 3\sin(2x) \qquad y > 0 \qquad -\frac{\pi}{4} < x < \frac{\pi}{4}$$

giving your answer in the form $y^2 = g(x)$

(6)

$y\frac{dy}{dx} = \frac{3\sin 2x}{\cos^2 2x}$

$\int y\,dy = \int \frac{3\sin 2x}{\cos^2 2x}\,dx = \int 3\sec 2x \tan 2x\,dx$

$\frac{y^2}{2} = \frac{3}{2}\sec 2x + c$

$x = \frac{\pi}{6}$, $y = 4$: $\frac{16}{2} = \frac{3}{2}\sec\frac{\pi}{3} + c \Rightarrow 8 = \frac{3}{2} \times 2 + c \Rightarrow c = 5$

$\frac{y^2}{2} = \frac{3}{2}\sec 2x + 5$

$y^2 = 3\sec 2x + 10$

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Question 3 continued

(Total for Question 3 is 6 marks)

4. **In this question you must show all stages of your working.**
Solutions relying entirely on calculator technology are not acceptable.

$$f(x) = \frac{5 + 17x - 10x^2}{x(1 - x)(2x + 1)} \qquad x > 1$$

(a) Write $f(x)$ in the form

$$\frac{A}{x} + \frac{B}{1 - x} + \frac{C}{2x + 1}$$

where A, B and C are constants to be found.

(3)

(b) Hence, use algebraic integration to find the exact value of

$$\int_2^4 f(x)\,dx$$

Write your answer in the form $p \ln 2 + q \ln\left(\frac{3}{5}\right)$, where p and q are integers to be found.

(5)

(a) $5 + 17x - 10x^2 \equiv A(1 - x)(2x + 1) + Bx(2x + 1) + Cx(1 - x)$

$x = 0$: $5 = A \Rightarrow A = 5$

$x = 1$: $5 + 17 - 10 = 12 = 3B \Rightarrow B = 4$

$x = -\frac{1}{2}$: $5 - \frac{17}{2} - \frac{10}{4} = -6 = C\left(-\frac{1}{2}\right)\left(\frac{3}{2}\right) = -\frac{3}{4}C \Rightarrow C = 8$

$f(x) = \frac{5}{x} + \frac{4}{1 - x} + \frac{8}{2x + 1}$

(b) $\int \left(\frac{5}{x} + \frac{4}{1 - x} + \frac{8}{2x + 1}\right) dx = 5 \ln|x| - 4 \ln|1 - x| + 4 \ln|2x + 1| + c$

$\int_2^4 f(x)\,dx = \left[5 \ln|x| - 4 \ln|1 - x| + 4 \ln|2x + 1|\right]_2^4$

$= (5 \ln 4 - 4 \ln 3 + 4 \ln 9) - (5 \ln 2 - 4 \ln 1 + 4 \ln 5)$

$= 10 \ln 2 - 4 \ln 3 + 8 \ln 3 - 5 \ln 2 - 4 \ln 5$

$= 5 \ln 2 + 4 \ln 3 - 4 \ln 5 = 5 \ln 2 + 4 \ln\left(\frac{3}{5}\right)$

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Question 4 continued

Question 4 continued

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Question 4 continued

(Total for Question 4 is 8 marks)

5. The curve C has parametric equations

$$x = \frac{3 + 2t}{1 - t} \qquad y = 1 - t^2 \qquad t \neq 1$$

The point P, where $t = 2$, lies on C.

(a) Use parametric differentiation to find the equation of the normal to C at P. Give your answer in the form $ax + by + c = 0$ where a, b and c are integers to be found.

(5)

(b) Show that a Cartesian equation for C can be expressed in the form

$$y = \frac{px + q}{(x + r)^2} \qquad x \neq k$$

where p, q, r and k are integers to be found.

(4)

(a) $\frac{dx}{dt} = \frac{2(1 - t) - (-1)(3 + 2t)}{(1 - t)^2} = \frac{5}{(1 - t)^2}$, $\frac{dy}{dt} = -2t$

$\frac{dy}{dx} = \frac{dy}{dt} \div \frac{dx}{dt} = -2t \times \frac{(1 - t)^2}{5}$

$t = 2$: $\frac{dy}{dx} = -4 \times \frac{(-1)^2}{5} = -\frac{4}{5}$

$t = 2$: $x = \frac{3 + 4}{1 - 2} = -7$, $y = 1 - 4 = -3$; $P(-7, -3)$

Gradient of normal $= \frac{5}{4}$

$y + 3 = \frac{5}{4}(x + 7) \Rightarrow 4y + 12 = 5x + 35$

$5x - 4y + 23 = 0$

(b) $x(1 - t) = 3 + 2t \Rightarrow x - 3 = t(x + 2) \Rightarrow t = \frac{x - 3}{x + 2}$

$y = 1 - \left(\frac{x - 3}{x + 2}\right)^2 = \frac{(x + 2)^2 - (x - 3)^2}{(x + 2)^2}$

$y = \frac{x^2 + 4x + 4 - x^2 + 6x - 9}{(x + 2)^2} = \frac{10x - 5}{(x + 2)^2}$, $x \neq -2$

$p = 10$, $q = -5$, $r = 2$, $k = -2$

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Question 5 continued

Question 5 continued

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Question 5 continued

(Total for Question 5 is 9 marks)

6. Relative to a fixed origin O,

- the point A has position vector $\mathbf{i} + 2\mathbf{j} - 3\mathbf{k}$
- the point B has position vector $5\mathbf{i} + 2\mathbf{j} + \mathbf{k}$

The line l passes through A and B.

(a) Write down a vector equation for l

(2)

Given also that

- the point C has position vector $3\mathbf{i} + \alpha\mathbf{j} + 5\mathbf{k}$ where α is a constant
- the points A, B and C form the triangle ABC
- angle BAC is 45°

(b) find the exact possible values of α

(6)

(a) $\overrightarrow{AB} = (5\mathbf{i} + 2\mathbf{j} + \mathbf{k}) - (\mathbf{i} + 2\mathbf{j} - 3\mathbf{k}) = 4\mathbf{i} + 4\mathbf{k}$

$\mathbf{r} = \mathbf{i} + 2\mathbf{j} - 3\mathbf{k} + \lambda(4\mathbf{i} + 4\mathbf{k})$

(b) $\overrightarrow{AC} = (3\mathbf{i} + \alpha\mathbf{j} + 5\mathbf{k}) - (\mathbf{i} + 2\mathbf{j} - 3\mathbf{k}) = 2\mathbf{i} + (\alpha - 2)\mathbf{j} + 8\mathbf{k}$

$|\overrightarrow{AB}| = \sqrt{(4^2 + 4^2)} = \sqrt{32}$

$|\overrightarrow{AC}| = \sqrt{(2^2 + (\alpha - 2)^2 + 8^2)} = \sqrt{(68 + (\alpha - 2)^2)}$

$\overrightarrow{AB} \cdot \overrightarrow{AC} = 4 \times 2 + 0 \times (\alpha - 2) + 4 \times 8 = 8 + 32 = 40$

$\cos 45° = \dfrac{\overrightarrow{AB} \cdot \overrightarrow{AC}}{|\overrightarrow{AB}|\,|\overrightarrow{AC}|} \Rightarrow \dfrac{1}{\sqrt{2}} = \dfrac{40}{\sqrt{32} \times \sqrt{(68 + (\alpha - 2)^2)}}$

$\sqrt{32} \times \sqrt{(68 + (\alpha - 2)^2)} = 40\sqrt{2} \Rightarrow 4\sqrt{2}\sqrt{(68 + (\alpha - 2)^2)} = 40\sqrt{2}$

$\sqrt{(68 + (\alpha - 2)^2)} = 10 \Rightarrow 68 + (\alpha - 2)^2 = 100$

$(\alpha - 2)^2 = 32 \quad (\alpha^2 - 4\alpha - 28 = 0)$

$\alpha - 2 = \pm\sqrt{32} = \pm 4\sqrt{2}$

$\alpha = 2 + 4\sqrt{2}$ or $\alpha = 2 - 4\sqrt{2}$

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Question 6 continued

Question 6 continued

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Question 6 continued

(Total for Question 6 is 8 marks)

7. (a) Show that the substitution $u = \tan x$ transforms

$$\int \frac{\tan x + \tan^3 x}{(4 + \sec^2 x)^3}\, \mathrm{d}x$$

to

$$\int \frac{u}{(k+u^2)^n}\, \mathrm{d}u$$

where k and n are integers to be found.

(4)

(b) Hence find

$$\int \frac{\tan x + \tan^3 x}{(4+\sec^2 x)^3}\, \mathrm{d}x$$

(2)

(a) $u = \tan x \Rightarrow \frac{du}{dx} = \sec^2 x \Rightarrow dx = \frac{du}{\sec^2 x} = \frac{du}{1+u^2}$

$\sec^2 x = 1 + \tan^2 x = 1 + u^2$, so $4 + \sec^2 x = 5 + u^2$

$\tan x + \tan^3 x = u + u^3 = u(1 + u^2)$

$$\int \frac{\tan x + \tan^3 x}{(4+\sec^2 x)^3}\, dx = \int \frac{u + u^3}{(5+u^2)^3} \times \frac{1}{1+u^2}\, du$$

$$= \int \frac{u(1+u^2)}{(5+u^2)^3(1+u^2)}\, du = \int \frac{u}{(5+u^2)^3}\, du$$

$k = 5$, $n = 3$

(b) $\int \frac{u}{(5+u^2)^3}\, du = -\frac{1}{4}(5+u^2)^{-2} + c$

$$= -\frac{1}{4(5+\tan^2 x)^2} + c$$

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Question 7 continued

(Total for Question 7 is 6 marks)

8. (a) Find, in ascending powers of x, the first three non-zero terms of the binomial series expansion of

$$\frac{1}{\sqrt{4+x}}$$

giving each coefficient as a simplified fraction.

(4)

Using the expansion from part (a),

(b) state the first three non-zero terms of the binomial series expansion of $\frac{1}{\sqrt{4-x}}$

(1)

(c) Hence, or otherwise, show that

$$\frac{1}{\sqrt{4+x}} \times \frac{1}{\sqrt{4-x}} \approx a + bx^2$$

where a and b are fully simplified fractions to be found.

(2)

(d) Use

$$\frac{1}{\sqrt{4+x}} \times \frac{1}{\sqrt{4-x}} = a + bx^2$$

with $x = 1$ and the values of a and b to find a fully simplified rational approximation for $\sqrt{135}$

Show your working and make your method clear.

(3)

(a) $\frac{1}{\sqrt{(4+x)}} = (4+x)^{-\frac{1}{2}} = 4^{-\frac{1}{2}}\left(1+\frac{x}{4}\right)^{-\frac{1}{2}} = \frac{1}{2}\left(1+\frac{x}{4}\right)^{-\frac{1}{2}}$

$\left(1+\frac{x}{4}\right)^{-\frac{1}{2}} = 1 + (-\frac{1}{2})\left(\frac{x}{4}\right) + \frac{(-\frac{1}{2})(-3/2)}{2!}\left(\frac{x}{4}\right)^2 + \ldots$

$= 1 - \frac{x}{8} + \frac{3}{128}x^2 + \ldots$

$\frac{1}{\sqrt{(4+x)}} = \frac{1}{2} - \frac{1}{16}x + \frac{3}{256}x^2 + \ldots$

(b) $\frac{1}{\sqrt{(4-x)}} = \frac{1}{2} + \frac{1}{16}x + \frac{3}{256}x^2 + \ldots$

(c) $\left(\frac{1}{2} - \frac{x}{16} + \frac{3x^2}{256}\right)\left(\frac{1}{2} + \frac{x}{16} + \frac{3x^2}{256}\right)$

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Question 8 continued

$= \frac{1}{4} + \frac{x}{32} - \frac{x}{32} + \frac{3}{512}x^2 - \frac{1}{256}x^2 + \frac{3}{512}x^2 + \ldots$

$\approx \frac{1}{4} + \frac{1}{128}x^2 \quad ; \quad a = \frac{1}{4}, \; b = \frac{1}{128}$

(d) $x = 1$: $\frac{1}{\sqrt{5}} \times \frac{1}{\sqrt{3}} = \frac{1}{\sqrt{15}} \approx \frac{1}{4} + \frac{1}{128} = \frac{33}{128}$

$\sqrt{15} \approx \frac{128}{33}$

$\sqrt{135} = \sqrt{(9 \times 15)} = 3\sqrt{15} \approx 3 \times \frac{128}{33} = \frac{128}{11}$

Question 8 continued

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Question 8 continued

(Total for Question 8 is 10 marks)

9. **In this question you must show all stages of your working.**
Solutions relying entirely on calculator technology are not acceptable.

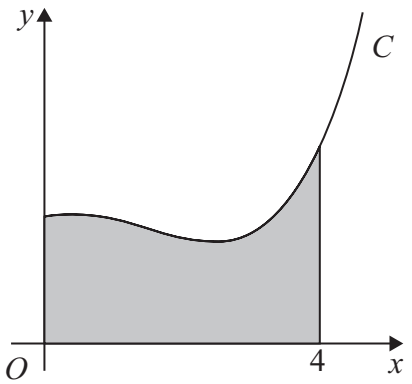


Figure 1

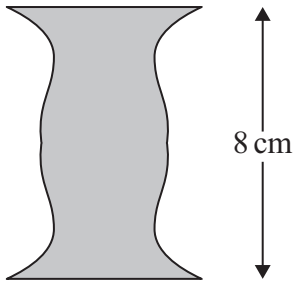


Figure 2

Figure 1 shows a sketch of part of the curve C with equation

$$y = \cos x + \frac{1}{5}e^x$$

The finite region, shown shaded in Figure 1, is bounded by C, the y-axis, the x-axis and the line with equation $x = 4$

The region is rotated through 2π radians about the x-axis to form a solid S.

(a) Show that the exact volume of S is given by

$$\pi \int_0^4 \left(A + B\cos 2x + Ce^x \cos x + De^{2x} \right) dx$$

where A, B, C and D are constants to be found.

(4)

(b) Find $\int e^x \cos x \, dx$

(4)

Figure 2 represents a paperweight formed by joining two of these solids together.
The paperweight is 8 cm high.

(c) Using the answers to parts (a) and (b), find, by algebraic integration, the volume of the paperweight, giving your answer to 2 significant figures.

(4)

(a) $V = \pi \int_0^4 \left(\cos x + \frac{1}{5} e^x \right)^2 dx$

$\left(\cos x + \frac{1}{5} e^x \right)^2 = \cos^2 x + \frac{2}{5} e^x \cos x + \frac{1}{25} e^{2x}$

$\cos^2 x = \frac{1 + \cos 2x}{2}$

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Question 9 continued

$$V = \pi \int_0^4 \left(\frac{1}{2} + \frac{1}{2}\cos 2x + \frac{2}{5} e^x \cos x + \frac{1}{25} e^{2x} \right) dx$$

$$A = \frac{1}{2}, \quad B = \frac{1}{2}, \quad C = \frac{2}{5}, \quad D = \frac{1}{25}$$

(b) $\int e^x \cos x \, dx = e^x \sin x - \int e^x \sin x \, dx$

$= e^x \sin x - \left(-e^x \cos x + \int e^x \cos x \, dx \right)$

$\int e^x \cos x \, dx = e^x \sin x + e^x \cos x - \int e^x \cos x \, dx$

$2 \int e^x \cos x \, dx = e^x \sin x + e^x \cos x$

$\int e^x \cos x \, dx = \frac{1}{2} e^x (\sin x + \cos x) + c$

(c) $V = \pi \left[\frac{1}{2} x + \frac{\sin 2x}{4} + \frac{2}{5} \times \frac{1}{2} e^x (\sin x + \cos x) + \frac{1}{50} e^{2x} \right]_0^4$

$= \pi \left[\left(2 + \frac{\sin 8}{4} + \frac{1}{5} e^4 (\sin 4 + \cos 4) + \frac{1}{50} e^8 \right) - \left(\frac{1}{5} + \frac{1}{50} \right) \right]$

$= \pi(46.4649... - 0.22) = \pi \times 46.2449... = 145.282...$

Paperweight $= 2 \times 145.282... = 290.565...$

Volume $\approx 290 \text{ cm}^3$

Question 9 continued

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Question 9 continued

(Total for Question 9 is 12 marks)

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10. **In this question you must show all stages of your working.**
Solutions relying on calculator technology are not acceptable.

Use proof by contradiction to show that for all angles x, where $90° < x < 180°$

$$\left| \frac{\cos 2x}{\cos x - \sin x} \right| < 1$$

(4)

Assume there is an angle x, $90° < x < 180°$, such that $\left| \frac{\cos 2x}{\cos x - \sin x} \right| \geq 1$

$\frac{\cos 2x}{\cos x - \sin x} = \frac{(\cos x - \sin x)(\cos x + \sin x)}{\cos x - \sin x} = \cos x + \sin x$

($\cos x - \sin x \neq 0$ since $\cos x < 0$ and $\sin x > 0$ for $90° < x < 180°$)

So $|\cos x + \sin x| \geq 1 \Rightarrow (\cos x + \sin x)^2 \geq 1$

$\cos^2 x + 2 \sin x \cos x + \sin^2 x \geq 1 \Rightarrow 1 + 2 \sin x \cos x \geq 1$

$\Rightarrow \sin 2x \geq 0$

But $90° < x < 180° \Rightarrow 180° < 2x < 360°$, so $\sin 2x < 0$

This is a contradiction, so the assumption is false.

Hence for all angles x, where $90° < x < 180°$, $\left| \frac{\cos 2x}{\cos x - \sin x} \right| < 1$

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Question 10 continued

Question 10 continued

(Total for Question 10 is 4 marks)

TOTAL FOR PAPER IS 75 MARKS

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