Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Wednesday 10 June 2026

Afternoon (Time: 1 hour 30 minutes)

Paper reference **WFM03/01**

Mathematics

International Advanced Subsidiary/Advanced Level
Further Pure Mathematics F3

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

Total Marks

Candidates may use any calculator allowed 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 8 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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Pearson

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

$$\mathbf{M} = \begin{pmatrix} -5 & 3 \\ 3 & 3 \end{pmatrix}$$

(a) Determine the eigenvalues of matrix **M**

(3)

(b) Determine a normalised eigenvector for each eigenvalue of **M**

(3)

(c) Hence write down a diagonal matrix **D** and an orthogonal matrix **P** such that

$$\mathbf{D} = \mathbf{P}^{\mathrm{T}}\mathbf{M}\mathbf{P}$$

(2)

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Question 1 continued

Question 1 continued

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Question 1 continued

(Total for Question 1 is 8 marks)

2. The ellipse E has equation $\frac{x^2}{64} + \frac{y^2}{16} = 1$ and eccentricity e

(a) Determine the exact value of e

(2)

(b) Hence determine the shortest distance between a focus of E and its corresponding directrix, giving your answer as a simplified surd.

(2)

Given that

- the point P lies on E
- the line through P parallel to the x-axis meets the line with equation $x = 14$ at the point X
- the midpoint of PX is M

(c) show that, as P varies, the locus of M is a circle, giving a Cartesian equation for this circle.

(4)

(d) Hence write down the radius of the circle and the coordinates of its centre.

(2)

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Question 2 continued

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Question 2 continued

(Total for Question 2 is 10 marks)

3. (a) Starting with the definition of $\operatorname{sech} x$ in terms of exponentials, show that

$$\frac{\mathrm{d}}{\mathrm{d}x}(\operatorname{sech} x) = -\operatorname{sech} x \tanh x$$

(3)

The curve with equation

$$y = k \arctan(\mathrm{e}^x) + \operatorname{sech} 2x$$

where k is a constant, has a turning point when $x = \ln 3$

(b) Determine, in simplest form, the exact value of k

(*Solutions relying entirely on calculator technology are not acceptable.*)

(4)

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Question 3 continued

(Total for Question 3 is 7 marks)

4.

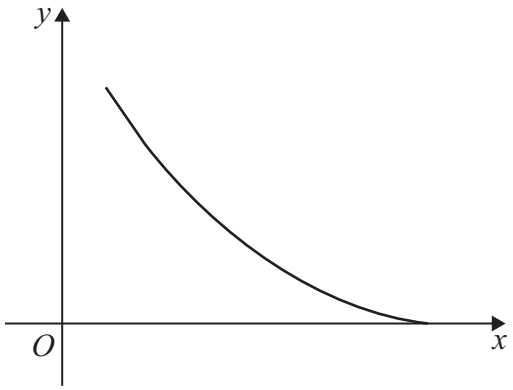


Figure 1

Figure 1 shows the curve with parametric equations

$$x = 4\cos^3\theta \qquad y = 4\sin^3\theta \qquad 0 \leqslant \theta \leqslant k$$

where k is a positive constant and $k < \frac{\pi}{2}$

The curve is rotated through 2π radians about the x-axis.

The area of the curved surface generated is given by S.

(a) Show that

$$S = 96\pi \int_0^k \sin^4\theta \cos\theta \, \mathrm{d}\theta$$

(5)

Given that $S = \frac{27\sqrt{3}}{5}\pi$

(b) use algebraic integration to determine the value of k.

(3)

(c) Hence use algebraic integration to determine the length of the curve.

(3)

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Question 4 continued

Question 4 continued

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Question 4 continued

(Total for Question 4 is 11 marks)

5.

$$\mathbf{S} = \begin{pmatrix} 1 & 0 & p \\ -1 & 2 & 3 \\ 2 & -2 & 0 \end{pmatrix} \qquad \mathbf{T} = \begin{pmatrix} 2 & 1 & -3 \\ 0 & -3 & -1 \\ q & 0 & 1 \end{pmatrix}$$

where p and q are constants.

Given that $\det \mathbf{S} = \det \mathbf{T}$

(a) show that $p = 5q + 6$

(3)

The transformations S and T are represented by **S** and **T** respectively.

The transformation U, represented by the matrix **U**, is the transformation S followed by the transformation T.

(b) Determine **U**, giving your answer in terms of q.

(3)

The point $(2, -3, 1)$ is transformed by U to the point $(r, 5, 14)$ where r is a constant.

(c) Determine the possible values of q.

(3)

Given that $q > 0$

(d) determine the value of r.

(2)

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Question 5 continued

Question 5 continued

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Question 5 continued

(Total for Question 5 is 11 marks)

6. (a) Express $16x^2 - 48x + 40$ in the form $a(x + b)^2 + c$, where a, b and c are constants to be determined.

(2)

(b) Hence use a hyperbolic substitution to determine

$$\int \frac{1}{\sqrt{16x^2 - 48x + 40}} \, dx$$

(4)

The region R is bounded by the curve with equation $y = \dfrac{1}{\sqrt{16x^2 - 48x + 40}}$,

the x-axis, the line with equation $x = \dfrac{41}{24}$ and the line with equation $x = \dfrac{15}{8}$

(c) Using the answer to part (b) and showing all your working, determine the area of R, giving your answer in the form $p \ln q$ where p and q are rational numbers.

(3)

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Question 6 continued

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Question 6 continued

(Total for Question 6 is 9 marks)

7. The point P has coordinates (6, 1, –2)

The plane Π has vector equation

$$\mathbf{r} = \begin{pmatrix} 6 \\ 1 \\ -2 \end{pmatrix} + s \begin{pmatrix} 2 \\ 3 \\ -1 \end{pmatrix} + t \begin{pmatrix} 4 \\ -1 \\ 2 \end{pmatrix}$$

where s and t are scalar parameters.

(a) Determine a Cartesian equation for Π

(3)

The point Q has coordinates (0, 9, 32)

The point R is the reflection of Q in Π

(b) Determine the coordinates of R

(4)

(c) Show that the exact area of the triangle PQR is $4\sqrt{k}$ where k is an integer to be determined.

(3)

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Question 7 continued

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Question 7 continued

(Total for Question 7 is 10 marks)

8. $$I_n = \int_0^{\frac{1}{2}} x^n \mathrm{e}^{-2x} \mathrm{d}x \qquad n \geqslant 0$$

(a) Show that, for $n > 0$

$$I_n = \frac{n}{2} I_{n-1} - \frac{1}{2^{n+1}\mathrm{e}}$$

(3)

$$J_n = \int_0^{\frac{1}{2}} x^n \mathrm{e}^{2x} \mathrm{d}x \qquad n \geqslant 0$$

(b) Show that, for $n \geqslant 0$

$$\int_0^{\frac{1}{2}} x^n \sinh 2x \, \mathrm{d}x = \frac{J_n - I_n}{2}$$

(1)

Hence given that, for $n > 0$

$$J_n = \frac{\mathrm{e}}{2^{n+1}} - \frac{n}{2} J_{n-1}$$

(c) show that

$$\int_0^{\frac{1}{2}} x^3 \sinh 2x \, \mathrm{d}x = \frac{1}{16}\left(\frac{k}{\mathrm{e}} - \mathrm{e}\right)$$

where k is an integer to be determined.

(5)

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Question 8 continued

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Question 8 continued

Question 8 continued

(Total for Question 8 is 9 marks)

TOTAL FOR PAPER IS 75 MARKS

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