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Candidate surname

Other names

**Pearson Edexcel  
Level 3 GCE**

Centre Number

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Candidate Number

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**Friday 22 May 2020**

Afternoon (Time: 1 hour 30 minutes)

Paper Reference **9FM0/3A**

**Further Mathematics**

**Advanced**

**Paper 3A: Further Pure Mathematics 1**

**You must have:**

Mathematical Formulae and Statistical Tables (Green), 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 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.

Turn over ►

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1. Use l'Hospital's Rule to show that

$$\lim_{x \rightarrow \frac{\pi}{2}} \frac{(e^{\sin x} - \cos(3x) - e)}{\tan(2x)} = -\frac{3}{2}$$

(5)

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2.

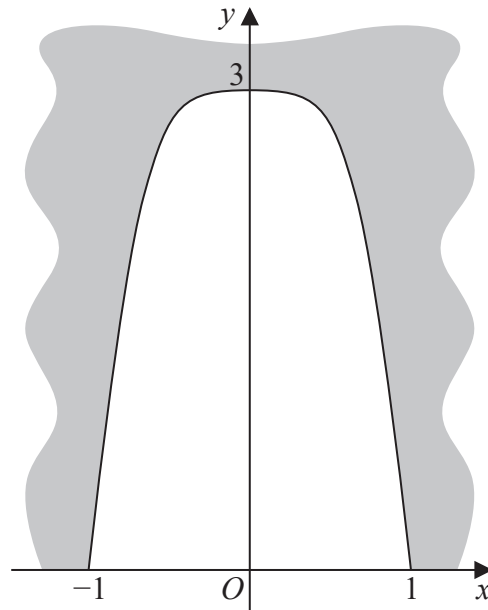


Figure 1

Figure 1 shows a sketch of the vertical cross-section of the entrance to a tunnel. The width at the base of the tunnel entrance is 2 metres and its maximum height is 3 metres.

The shape of the cross-section can be modelled by the curve with equation  $y = f(x)$  where

$$f(x) = 3 \cos\left(\frac{\pi}{2}x^2\right) \quad x \in [-1, 1]$$

A wooden door of uniform thickness 85 mm is to be made to seal the tunnel entrance.

Use Simpson's rule with 6 intervals to estimate the volume of wood required for this door, giving your answer in  $\text{m}^3$  to 4 significant figures.

(6)





3. The points  $A$ ,  $B$  and  $C$ , with position vectors  $\mathbf{a} = 3\mathbf{i} - 2\mathbf{j} + \mathbf{k}$ ,  $\mathbf{b} = \mathbf{i} + 4\mathbf{j} + 5\mathbf{k}$  and  $\mathbf{c} = -2\mathbf{i} + 3\mathbf{j} + 3\mathbf{k}$  respectively, lie on the plane  $\Pi$

(a) Find  $\vec{AB} \times \vec{AC}$  (3)

(b) Find an equation for  $\Pi$  in the form  $\mathbf{r} \cdot \mathbf{n} = p$  (2)

The point  $D$  has position vector  $8\mathbf{i} + 7\mathbf{j} + 5\mathbf{k}$

(c) Determine the volume of the tetrahedron  $ABCD$  (4)



**Question 3 continued**

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4.

$$f(x) = x^4 \sin(2x)$$

Use Leibnitz's theorem to show that the coefficient of  $(x - \pi)^8$  in the Taylor series expansion of  $f(x)$  about  $\pi$  is

$$\frac{a\pi + b\pi^3}{315}$$

where  $a$  and  $b$  are integers to be determined.

(8)

$$\left[ \begin{array}{l} \text{The Taylor series expansion of } f(x) \text{ about } x = k \text{ is given by} \\ f(x) = f(k) + (x - k)f'(k) + \frac{(x - k)^2}{2!}f''(k) + \dots + \frac{(x - k)^r}{r!}f^{(r)}(k) + \dots \end{array} \right]$$

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5. The ellipse  $E$  has equation

$$\frac{x^2}{36} + \frac{y^2}{16} = 1$$

The points  $S$  and  $S'$  are the foci of  $E$ .

(a) Find the coordinates of  $S$  and  $S'$  (3)

(b) Show that for any point  $P$  on  $E$ , the triangle  $PSS'$  has constant perimeter and determine its value. (4)



**Question 5 continued**

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Lined writing area for the answer to Question 5.

**(Total for Question 5 is 7 marks)**



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6. A physics student is studying the movement of particles in an electric field. In one experiment, the distances in micrometres of two moving particles,  $A$  and  $B$ , from a fixed point  $O$  are modelled by

$$d_A = |5t - 31|$$

$$d_B = |3t^2 - 25t + 8|$$

respectively, where  $t$  is the time in seconds after motion begins.

- (a) Use algebra to find the range of time for which particle  $A$  is further away from  $O$  than particle  $B$  is from  $O$ .

(8)

It was recorded that the distance of particle  $B$  from  $O$  was less than the distance of particle  $A$  from  $O$  for approximately 4 seconds.

- (b) Use this information to assess the validity of the model.

(2)





Question 6 continued

Lined writing area for the answer to Question 6.

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Question 6 continued

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**Question 6 continued**

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**(Total for Question 6 is 10 marks)**



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7. The points  $P(9p^2, 18p)$  and  $Q(9q^2, 18q)$ ,  $p \neq q$ , lie on the parabola  $C$  with equation

$$y^2 = 36x$$

The line  $l$  passes through the points  $P$  and  $Q$

- (a) Show that an equation for the line  $l$  is

$$(p + q)y = 2(x + 9pq) \quad (3)$$

The normal to  $C$  at  $P$  and the normal to  $C$  at  $Q$  meet at the point  $A$ .

- (b) Show that the coordinates of  $A$  are

$$(9(p^2 + q^2 + pq + 2), -9pq(p + q)) \quad (7)$$

Given that the points  $P$  and  $Q$  vary such that  $l$  always passes through the point  $(12, 0)$

- (c) find, in the form  $y^2 = f(x)$ , an equation for the locus of  $A$ , giving  $f(x)$  in simplest form.

(4)









8. 
$$f(x) = \frac{3}{13 + 6\sin x - 5\cos x}$$

Using the substitution  $t = \tan\left(\frac{x}{2}\right)$

(a) show that  $f(x)$  can be written in the form

$$\frac{3(1+t^2)}{2(3t+1)^2+6} \quad (3)$$

(b) Hence solve, for  $0 < x < 2\pi$ , the equation

$$f(x) = \frac{3}{7}$$

giving your answers to 2 decimal places where appropriate.

(5)

(c) Use the result of part (a) to show that

$$\int_{\frac{\pi}{3}}^{\frac{4\pi}{3}} f(x) dx = K \left( \arctan\left(\frac{\sqrt{3}-9}{3}\right) - \arctan\left(\frac{\sqrt{3}+3}{3}\right) + \pi \right)$$

where  $K$  is a constant to be determined.

(8)





**Question 8 continued**

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