

Please write clearly in block capitals.

Centre number

Candidate number

Surname \_\_\_\_\_

Forename(s) \_\_\_\_\_

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I declare this is my own work.

## INTERNATIONAL AS FURTHER MATHEMATICS

(9665/FM02) Unit FPSM1 Pure Mathematics, Statistics and Mechanics

Thursday 15 January 2026

07:00 UK Time

Time allowed: 1 hour 30 minutes

### Materials

- For this paper you must have the OxfordAQA Booklet of Formulae and Statistical Tables (enclosed).
- You may use a graphical calculator.

### Instructions

- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.

### Information

- The marks for questions are shown in brackets.
- There are three sections to this paper.
- The maximum mark for this paper is 80. There are 40 marks for **Section A**, 20 marks for **Section B** and 20 marks for **Section C**.

### Advice

- Unless stated otherwise, you may quote formulae, without proof, from the booklet.
- Show all necessary working; otherwise marks may be lost.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
<b>TOTAL</b>	



**Section A****Pure Mathematics**

Answer **all** questions in the spaces provided.

1 The matrix **A** is defined by  $\mathbf{A} = \begin{bmatrix} 3 & q \\ 4-q & 2 \end{bmatrix}$  where  $q$  is a positive constant.

1 (a) The matrix **B** represents a reflection in the line  $x + y = 0$

1 (a) (i) Write down the matrix **B**

**[1 mark]**

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Answer \_\_\_\_\_

1 (a) (ii) The matrix **C** represents the following sequence of transformations:

- the transformation represented by **A**

followed by

- the transformation represented by **B**

Find the matrix **C** in terms of  $q$

**[3 marks]**

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Answer \_\_\_\_\_



1 (b) The triangle  $T$  has area 3 square units.

The image of  $T$  under the transformation represented by  $\mathbf{A}$  has area 21 square units.

Find the exact value of  $q$

[4 marks]

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$q =$  \_\_\_\_\_

8

Turn over for the next question

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- 3 The variables  $p$  and  $q$  are related by the equation

$$q = \frac{A}{(p+B)^2}$$

where  $A$  and  $B$  are constants.

It is given that  $Y = \frac{1}{\sqrt{q}}$

- 3 (a) Show that there is a linear relationship between  $p$  and  $Y$

[2 marks]

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- 3 (b) Some values of  $p$  and  $q$  are obtained in an experiment.

The values are shown in the table below.

$p$	-0.7	0.2	0.8	1.5	2.0
$q$	0.91	0.26	0.15	0.11	0.087

- 3 (b) (i) Complete the table below.

Give your values of  $Y$  to two decimal places.

[2 marks]

$p$	-0.7	0.2	0.8	1.5	2.0
$Y$	1.05			3.02	

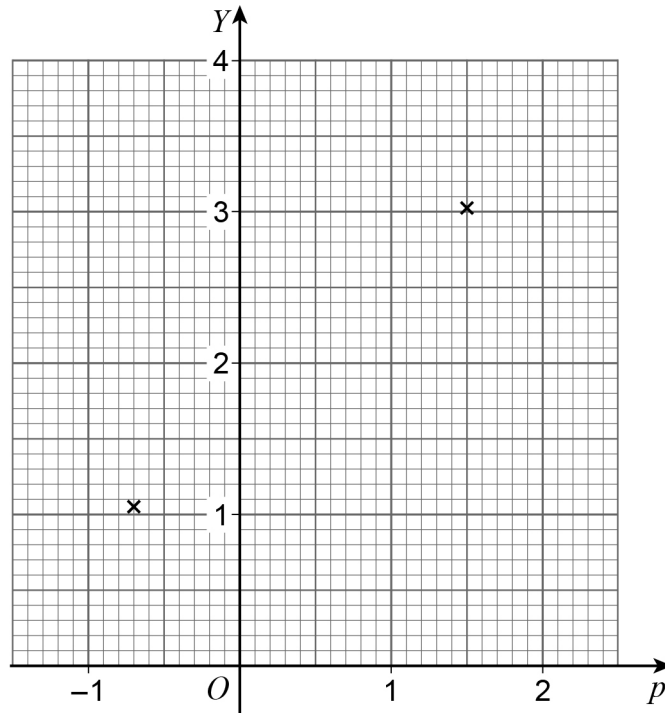


3 (b) (ii) Plot the remaining values of  $p$  and  $Y$  on **Figure 1**

Draw a line of best fit.

[2 marks]

**Figure 1**



3 (b) (iii) Use your line of best fit to estimate the value of  $A$  and the value of  $B$

[3 marks]

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$A =$  \_\_\_\_\_  $B =$  \_\_\_\_\_

Turn over ►



4 A function  $f$  is defined by  $f(x) = 2x^{\frac{3}{2}} - 5x + 2$

4 (a) Show that the equation  $f(x) = 0$  has a root  $\alpha$  in the interval  $0 < x < 1$

[2 marks]

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4 (b) The equation  $f(x) = 0$  also has a root  $\beta$  in the interval  $5 < x < 6$

Use the Newton-Raphson method **once** with an initial value of  $x_1 = 5.5$  to find an improved estimate,  $x_2$ , to  $\beta$

Give your answer to three decimal places.

[4 marks]

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Answer \_\_\_\_\_

6



5 The matrix  $\mathbf{M}$  is defined by  $\mathbf{M} = \frac{1}{5} \begin{bmatrix} 1-4k & 2+2k \\ 2+2k & 4-k \end{bmatrix}$  where  $k$  is a constant.

5 (a) In the case when  $\mathbf{M}$  is singular find the value of  $k$

[2 marks]

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$k =$  \_\_\_\_\_

5 (b) In the case when  $\mathbf{M}^2 = \mathbf{I}$  where  $\mathbf{I}$  is the  $2 \times 2$  identity matrix find the possible values of  $k$

[3 marks]

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Answer \_\_\_\_\_

Question 5 continues on the next page

Turn over ►





5 (c) (ii) The matrix  $\mathbf{M}$  satisfies the equation  $\mathbf{M} = \mathbf{R}^{-1}\mathbf{S}\mathbf{R}$  where

- the matrix  $\mathbf{R}$  represents a rotation about  $(0,0)$
- the matrix  $\mathbf{S}$  represents a stretch parallel to the  $y$ -axis.

Find the scale factor of the stretch represented by  $\mathbf{S}$

[2 marks]

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Answer \_\_\_\_\_

13

Turn over for the next section

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**Section B****Statistics**

Answer **all** questions in the spaces provided.

**6** A game is played.

The random variable  $X$  represents the score achieved in the game.

The probability distribution of  $X$  is given in the table.

$x$	0	4	8
$P(X = x)$	0.5	0.3	0.2

**6 (a)** Find  $G_X(t)$ , the probability generating function of  $X$

**[1 mark]**

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Answer \_\_\_\_\_

**6 (b)** A different second game is played.

The random variable  $Y$  represents the score achieved in the second game.

The random variables  $X$  and  $Y$  are independent.

The probability generating function of  $Y$  is given by

$$G_Y(t) = 1 - k + kt$$

where  $k$  is a constant.

The total score from the two games is  $X + Y$

Show that the probability generating function for the total score is given by

$$G_{X+Y}(t) = 0.5(1-k) + 0.5kt + 0.3(1-k)t^4 + 0.3kt^5 + 0.2(1-k)t^8 + 0.2kt^9$$

**[2 marks]**

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7 The random variable  $S$  has a geometric distribution with parameter  $p$

7 (a) State the variance of  $S$  in terms of  $p$

[1 mark]

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Answer \_\_\_\_\_

7 (b) The random variable  $T$  has the same distribution as  $S$

The population product moment correlation coefficient between  $S$  and  $T$  is  $\frac{3}{4}$

The variance of  $S - T$  is 2

Find the value of  $p$

Give your answer to four significant figures.

[3 marks]

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$p =$  \_\_\_\_\_



7 (c) Find  $E(S+T)$

Give your answer to three significant figures.

[2 marks]

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Answer \_\_\_\_\_

6

**Turn over for the next question**

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- 8** Bag  $A$  contains  $n$  balls which are uniquely numbered  $1, 2, 3, \dots, n$  where  $n > 10$   
A ball is randomly selected from bag  $A$   
The random variable  $X$  represents the number on the ball selected from bag  $A$

- 8 (a)** State the standard deviation of  $X$   
Give your answer in terms of  $n$

[1 mark]

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Answer \_\_\_\_\_

- 8 (b)** Bag  $B$  contains  $n + 2$  balls which are uniquely numbered  $1, 2, 3, \dots, n + 2$   
A ball is randomly selected from one of bag  $A$  or bag  $B$   
The probability that the ball is selected from bag  $A$  is  $0.6$

Show that the probability that the ball is selected from bag  $A$  given that the ball selected is numbered 1 is

$$\frac{0.6n+1.2}{n+1.2}$$

[3 marks]

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- 8 (c)** The probability that the ball is selected from bag  $A$  given that the ball selected is numbered 1 is  $\frac{13}{21}$

Determine the distribution of the random variable  $X$

**[3 marks]**

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Answer \_\_\_\_\_

      
7

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**Section C****Mechanics**

Answer **all** questions in the spaces provided.

- 9** A coin of mass  $m$  kg is placed so that it lies flat on a rotating horizontal disc. The coin follows a circular path of radius  $r$  metres at a speed of  $v$  m s<sup>-1</sup>

A student models the magnitude of the resultant force  $F$  newtons which acts on the coin by

$$F = m^\alpha r^\beta v^\gamma$$

where  $\alpha$ ,  $\beta$  and  $\gamma$  are constants.

Use dimensional analysis to find the value of  $\alpha$ , the value of  $\beta$  and the value of  $\gamma$

**[3 marks]**

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$\alpha =$  \_\_\_\_\_  $\beta =$  \_\_\_\_\_  $\gamma =$  \_\_\_\_\_

3

**Turn over for the next question**

**Turn over ►**



**10** A ball of mass 0.3 kg falls vertically and then collides with a horizontal surface.

The magnitude of the force  $F$  newtons exerted by the surface on the ball at time  $t$  seconds after the ball makes contact with the surface is modelled by

$$F = 270t(1 - 5t)$$

**10 (a)** The ball is in contact with the surface for 0.2 seconds.

Find the magnitude of the impulse exerted by the surface on the ball while they are in contact.

**[2 marks]**

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Answer \_\_\_\_\_

**10 (b)** The speed of the ball is  $4 \text{ m s}^{-1}$  when it collides with the surface.

Find the speed of the ball when it first loses contact with the surface.

**[3 marks]**

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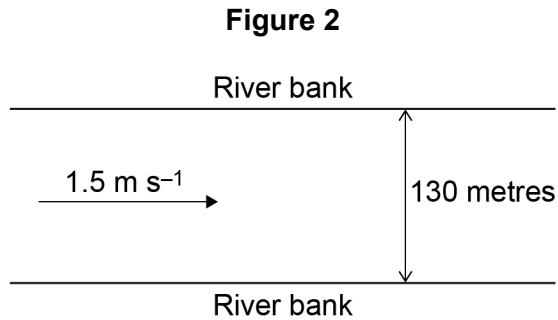
Answer \_\_\_\_\_

5



- 11** The water in a river flows at a constant speed of  $1.5 \text{ m s}^{-1}$   
The banks of the river are parallel.  
The width of the river is 130 metres.

**Figure 2** shows the river and the water flow.



- A boat crosses the river and travels the shortest possible distance.  
The boat moves with a speed of  $2.5 \text{ m s}^{-1}$  relative to the water.  
Find the time that it takes for the boat to cross the river.

**[3 marks]**

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Answer \_\_\_\_\_

3

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**12 (b)** It is given that sphere  $A$  changes direction as a result of the collision.

**12 (b) (i)** Show that  $m < \frac{4}{3}$

**[2 marks]**

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**12 (b) (ii)** It is given that  $m = \frac{1}{2}$

Find the range of possible values of  $e$

**[3 marks]**

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Answer \_\_\_\_\_

9

**END OF QUESTIONS**



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