Please check the examination details below before entering your candidate information

Candidate surname StemUp Model Solution | Other names

Centre Number | Candidate Number

Pearson Edexcel Level 3 GCE

Friday 16 May 2025

Afternoon

Paper reference **8FM0/24**

Further Mathematics

Advanced Subsidiary
Further Mathematics options
24: Further Statistics 2
(Part of option G only)

You must have:
Mathematical Formulae and Statistical Tables (Green), 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.
- Values from statistical tables should be quoted in full. If a calculator is used instead of tables the value should be given to an equivalent degree of accuracy.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- The total mark for this part of the examination is 40. There are 4 questions.
- 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 ▶

P76374A

©2025 Pearson Education Ltd.
Y:1/1/1/

P 7 6 3 7 4 A 0 1 1 6

Pearson

1. In a singing competition, two judges ranked the vocal **quality** of each of 8 singers.

The singers are labelled A to H and the table below shows the ranks given by each judge.

Rank	1	2	3	4	5	6	7	8
Judge 1	*C*	*B*	*A*	*G*	*E*	*F*	*H*	*D*
Judge 2	*B*	*A*	*C*	*G*	*D*	*E*	*F*	*H*

(a) Calculate the Spearman's rank correlation coefficient between the judges' ranks.

(4)

Each judge also gave a mark out of 20 for each singer's vocal **range**.

Singer	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*
Judge 1	18	13	16	12	11	7	13	6
Judge 2	15	17	14	14	9	8	12	8

(b) Without carrying out any further calculations, explain how the Spearman's rank correlation coefficient between the judges' marks for vocal **range** should be calculated.

(2)

(a) Ranks for each singer:

Singer	A	B	C	D	E	F	G	H
Judge 1	3	2	1	8	5	6	4	7
Judge 2	2	1	3	5	6	7	4	8
d	1	1	−2	3	−1	−1	0	−1
d^2	1	1	4	9	1	1	0	1

$\Sigma d^2 = 1 + 1 + 4 + 9 + 1 + 1 + 0 + 1 = 18$

$r_s = 1 - \frac{6\Sigma d^2}{n(n^2-1)} = 1 - \frac{6 \times 18}{8 \times 63} = \frac{11}{14} = 0.785714...$

$r_s = 0.786$ (3 s.f.)

(b) Rank each judge's marks for vocal range. Some marks are tied (e.g. Judge 1 gives B and G both 13; Judge 2 gives C and D both 14), so tied marks get the average of the ranks they occupy (e.g. ranks 3 and 4 shared, so 3.5 each). Then calculate the product moment correlation coefficient of these ranks, $r_s = S_{xy} / \sqrt{(S_{xx}S_{yy})}$, rather than using the Σd^2 formula.

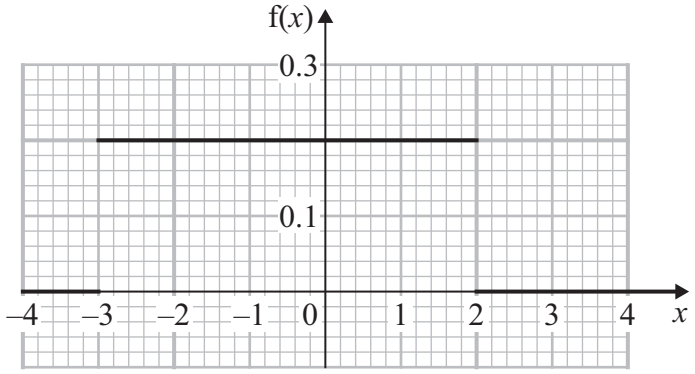
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Question 1 continued

(Total for Question 1 is 6 marks)

2. The graph of the probability density function f(x) of the continuous uniform random variable X is shown below.



(a) Write down the value of $P(X = 1)$

(1)

(b) Find $E(X)$

(1)

(c) Find $Var(X)$

(1)

(d) Sketch the cumulative distribution function of X for $-3 \leqslant x \leqslant 2$
You should label any points where the sketch touches or crosses the coordinate axes.

(3)

(e) Find $P(X^2 > 1.96)$

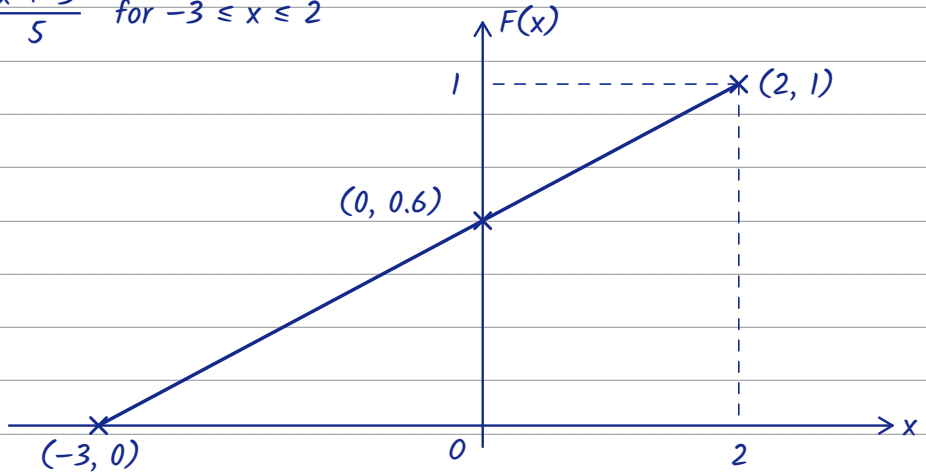
(3)

(a) $P(X = 1) = 0$ (X is continuous)

(b) $X \sim U[-3, 2]$: $E(X) = \frac{-3 + 2}{2} = -\frac{1}{2}$

(c) $Var(X) = \frac{(2 - (-3))^2}{12} = \frac{25}{12}$ $(= 2.083...)$

(d) $F(x) = \frac{x + 3}{5}$ for $-3 \leqslant x \leqslant 2$



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Question 2 continued

(e) $X^2 > 1.96 \Rightarrow X > 1.4$ or $X < -1.4$

$P(X^2 > 1.96) = P(X > 1.4) + P(X < -1.4)$

$= \frac{2 - 1.4}{2 - (-3)} + \frac{-1.4 - (-3)}{2 - (-3)} = \frac{0.6}{5} + \frac{1.6}{5}$

$= \frac{11}{25} \quad (= 0.44)$

Question 2 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Question 2 continued

(Total for Question 2 is 9 marks)

3. Dina is investigating the relationship between a marathon runner's body mass index (BMI), $x\,\text{kg m}^{-2}$, and the runner's average speed when running a marathon, $v\,\text{m s}^{-1}$

She collects data from 20 marathon runners.

Some summary statistics are given below.

$$\bar{x} = 19.8 \quad \bar{v} = 5.2 \quad \sum xv = 2056.63 \quad S_{xx} = 15.78 \quad S_{vv} = 0.94$$

(a) Show that $S_{xv} = -2.57$

(1)

(b) Find the value of the product moment correlation coefficient between v and x

(2)

(c) Use a suitable test, with a 5% level of significance, to assess whether or not there is evidence of a negative correlation between BMI and average speed.
State the hypotheses and the critical value used.

(3)

(d) Find the equation of the regression line of v on x in the form $v = a + bx$ giving the values of a and b to 2 decimal places.

(3)

(e) Calculate the residual sum of squares (RSS).

(2)

Information about 2 of the 20 marathon runners is listed in the table below.

Runner	BMI	Residual
A	20.9	0.18
B	19.7	–0.22

(f) Determine which of these runners took the shorter amount of time to run the marathon.
You must show your working.

(3)

(a) $S_{xv} = \Sigma xv - \frac{\Sigma x \Sigma v}{n} = 2056.63 - \frac{(19.8 \times 20)(5.2 \times 20)}{20} = 2056.63 - \frac{396 \times 104}{20}$

$= 2056.63 - 2059.2 = -2.57$ as required

(b) $r = \frac{S_{xv}}{\sqrt{(S_{xx}S_{vv})}} = \frac{-2.57}{\sqrt{(15.78 \times 0.94)}} = -0.667291...$

$r = -0.667$ (3 s.f.)

(c) H_0: $\rho = 0$ H_1: $\rho < 0$

$n = 20$, 5% one-tailed critical value: $r = -0.3783$

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Question 3 continued

$-0.667 < -0.3783$, so the result is significant: reject H_0

There is evidence of a negative correlation between BMI and average speed.

(d) $b = \frac{S_{xv}}{S_{xx}} = \frac{-2.57}{15.78} = -0.162864...$

$a = \bar{v} - b\bar{x} = 5.2 - (-0.162864...)(19.8) = 8.424714...$

$v = 8.42 - 0.16x$

(e) $RSS = S_{vv} - \frac{(S_{xv})^2}{S_{xx}} = 0.94 - \frac{(-2.57)^2}{15.78} = 0.521438...$

$RSS = 0.521$ (3 s.f.)

(f) Actual speed = predicted speed + residual

$v_A = 8.42 - 0.16(20.9) + 0.18 = 5.076 + 0.18 = 5.256 \text{ m s}^{-1}$

$v_B = 8.42 - 0.16(19.7) - 0.22 = 5.268 - 0.22 = 5.048 \text{ m s}^{-1}$

$v_A > v_B$: A ran the same marathon distance at a higher average speed, so runner A took the shorter amount of time.

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Question 3 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Question 3 continued

(Total for Question 3 is 14 marks)

4. Subrat is modelling the time, t seconds, it takes for a computer to carry out a particular process.
He models the time using the continuous random variable T with cumulative distribution function

$$F(t) = \begin{cases} 0 & t < 0 \\ at^4 - \frac{1}{8}t^3 + bt^2 & 0 \leqslant t \leqslant 4 \\ 1 & t > 4 \end{cases}$$

where a and b are constants.

(a) Find, in terms of a and b, the probability that the computer takes less than 2 seconds to carry out the process.

(2)

(b) Find, in terms of a and b, the probability density function of T for all values of t

(2)

The probability that the computer takes less than 2 seconds to carry out the process is $\frac{11}{16}$

(c) Find the exact value of the mode of T
You must show all stages of your working.

(7)

(a) $P(T < 2) = F(2) = a(2^4) - (1/8)(2^3) + b(2^2)$

$P(T < 2) = 16a + 4b - 1$

(b) $f(t) = \frac{d}{dt}\left(at^4 - \frac{1}{8}t^3 + bt^2\right) = 4at^3 - \frac{3}{8}t^2 + 2bt$

$f(t) = 4at^3 - \frac{3}{8}t^2 + 2bt, \quad 0 \leq t \leq 4$

$f(t) = 0, \quad$ otherwise

(c) $F(4) = 1$: $256a - 8 + 16b = 1 \Rightarrow 256a + 16b = 9$ (1)

$F(2) = \frac{11}{16}$: $16a + 4b - 1 = \frac{11}{16} \Rightarrow 16a + 4b = \frac{27}{16}$ (2)

(2) × 4: $64a + 16b = \frac{27}{4}$ (3)

(1) − (3): $192a = 9 - \frac{27}{4} = \frac{9}{4} \Rightarrow a = \frac{3}{256}$

$4b = \frac{27}{16} - 16 \times \frac{3}{256} = \frac{27}{16} - \frac{3}{16} = \frac{3}{2} \Rightarrow b = \frac{3}{8}$

$f(t) = \frac{3}{64}t^3 - \frac{3}{8}t^2 + \frac{3}{4}t, \quad 0 \leq t \leq 4$

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Question 4 continued

$f'(t) = 12at^2 - \frac{3}{4}t + 2b = \frac{9}{64}t^2 - \frac{3}{4}t + \frac{3}{4}$

At the mode $f'(t) = 0$: $\frac{9}{64}t^2 - \frac{3}{4}t + \frac{3}{4} = 0$

$\times 64/3$: $3t^2 - 16t + 16 = 0$

$(3t - 4)(t - 4) = 0$

$t = \frac{4}{3}$ or $t = 4$

$f''(t) = \frac{9}{32}t - \frac{3}{4}$: $f''\left(\frac{4}{3}\right) = -\frac{3}{8} < 0$ (maximum), $f''(4) = \frac{3}{8} > 0$ (minimum)

Also $f\left(\frac{4}{3}\right) = \frac{4}{9}$, $f(0) = 0$ and $f(4) = 0$, so the maximum is at $t = \frac{4}{3}$

$\therefore$ the mode of T is $\frac{4}{3}$

Question 4 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Question 4 continued

Question 4 continued

(Total for Question 4 is 11 marks)

TOTAL FOR FURTHER STATISTICS 2 IS 40 MARKS

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA