Pearson Edexcel

Mark Scheme (Results)

Summer 2025

Pearson Edexcel GCE

In A Level Further Mathematics (9FM0)

Paper 4B Further Statistics

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\sqrt{}$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- $*$ The answer is printed on the paper
- ⌐ The second mark is dependent on gaining the first mark

4. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

5. Where a candidate has made multiple responses <u>and indicates which response they wish to submit</u>, examiners should mark this response.
   If there are several attempts at a question <u>which have not been crossed out</u>, examiners should mark the final answer which is the answer that is the <u>most complete</u>.

6. Ignore wrong working or incorrect statements following a correct answer.

7. Mark schemes will firstly show the solution judged to be the most common response expected from candidates. Where appropriate, alternatives answers are provided in the notes. If examiners are not sure if an answer is acceptable, they will check the mark scheme to see if an alternative answer is given for the method used.

Qu	Scheme	Mark	AO
1(a)	$S_{xx} = 171.828 - \frac{50.46^2}{15}$ <u>or</u> $S_{yy} = 18\,004.47 - \frac{518.9^2}{15}$ $= 2.08056$ = **<u>2.081</u>** *(3dp) ; = 53.98933… = **<u>53.989*</u>** (3dp)	M1 A1*; A1*	1.1b 1.1b(x2)
		(3)	
(b)	$b = \left[\frac{S_{xy}}{S_{xx}} =\right] \frac{7.8284}{2.081} = (3.76...)$ $a = \frac{518.9}{15} - b\frac{50.46}{15} = 34.593... - "3.76..." \times 3.364\ (= 21.9...)$ Equation of line is: **<u>y = 21.9 + 3.76x</u>**	M1 M1 A1	1.1b 1.1b 1.1b
		(3)	
(c)	[RSS $= S_{yy} - \frac{(S_{xy}{}^2)}{S_{xx}}$ =] 24.5397… = awrt **<u>24.5</u>**	B1	1.1b
		(1)	
(d)	$\hat{y} = "21.9" + "3.76" \times 3.26$ (= 34.1576) [Residual = $y - \hat{y}$ = 36.8 – "34.15…" = 2.6424] = awrt **<u>2.6</u>**	M1 A1	3.4 1.1b
		(2)	
(e)	"2.64..."$^2 \approx 7$ which is a high proportion of RSS (so this value may be an outlier)	B1	2.4
		(1)	
			(10 marks)

Notes

(a)	M1 for either correct expression
*	1st A1 cso for 2.081 or better following a correct expression
*	2nd A1 cso for 53.989 or better following a correct expression
(b)	1st M1 for a correct numerical expression for gradient (or ft their $S_{xx} \neq 2.081$, $S_{xy} \neq 7.8284$) 2nd M1 for a correct expression for intercept (ft their b). May be implied by awrt 21.9 A1 for equation with a = awrt 21.9 and b = awrt 3.76 **Note** A correct equation scores M1M1A1
(c)	B1 for awrt 24.5
(d)	M1 for an expression for $\hat{y}$ or the residual (ft their regression line equation). Implied by awrt 2.6 A1 for awrt 2.6 (exact figures give 2.5979…)
(e)	B1 Dependent on $0.25 < \frac{"2.6"^2}{"24.5"} < 1$ for a suitable explanation based on their (d)^2 compared with their (c) or other suitable calculations which enable a comparison to be made. e.g. this residual is 27.5% of the total which is a large proportion". References to size e.g. "large" requires quoting the numerical value as well.

Qu	Scheme	Mark	AO
2(a)			

Student	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*
Rank 1	6	2	9	1	4	8	3	5	7
Rank 2	8	3	6	1	4	9	2	7	5

	M1	1.1b
$\sum d^2 = 4+1+9+0+0+1+1+4+4 \ (=24)$	dM1	1.1b
$r_s = 1 - \dfrac{6\times"24"}{9\times(9^2-1)}$	M1	1.1b
$= \dfrac{4}{5}$ or **<u>0.8</u>**	A1	1.1b
	(4)	
(b) $H_0 : \rho = 0 \quad H_1 : \rho > 0$	B1	2.5
cv one tail 5% = 0.6	M1	3.4
(Significant result so there is evidence that) the <u>lecturers agree</u> about the rank order of the essays.	A1	2.2b
	(3)	
		(7 marks)

Notes

(a)

1st M1 for an attempt to rank marks (at least 5 correct in one row) Allow reverse ranking. May be implied by 24

2nd dM1 **dep on 1st M1** for attempt at calculating d^2 (does not need to be summed). (Allow 1 error squaring their differences)
May be implied by 24

3rd M1 **indep of first two Ms** for using correct formula with their $12 < \sum d^2 < 240$
May be implied by 0.8 o.e.

A1 for 0.8 o.e.

(b)

B1 for both hypotheses correct in terms of ρ or ρ_s (condone if it appears as p). Do not allow hypotheses in words on their own.

M1 for selecting the correct critical value. Allow ±
If they scored B0 for 2-tail test allow 0.7

A1 **dep on** $0.7 < "0.8" < 1$ for a correct conclusion in context stating <u>agreement</u> (or <u>agree</u>) between <u>lecturers</u>. Do not allow correlation for agreement (not contextual)
Can award this mark independently of hypotheses.
Do NOT award this mark if contradictory statements are seen e.g. not significant so lecturers agree.
If a comparison is made then it must be correct.
Note that M0A1 is not possible

Qu	Scheme	Mark	AO
3(a)	$H_0 : \sigma_1^2 = \sigma_2^2 \quad H_1 : \sigma_1^2 \neq \sigma_2^2$	B1	2.5
	$F = \dfrac{143.8^2}{64.0^2} = (5.0484...)$	M1	3.4
	Critical value (5% one-tail) $F_{5,4} = 6.26$	B1	1.1b
	(Not significant) insufficient evidence of a difference in variances	A1	2.2b
		(4)	
(b)(i)	Need to assume variances are the same to carry out the test for means (the test showed that the variances could be assumed to be equal)	B1	2.4
(ii)	There is evidence it <u>increases mean yield</u> (but does not effect variance)	B1	2.2b
		(2)	
			(6 marks)

Notes

(a)

B1 for both hypotheses correct in terms of σ or σ^2
May use labelling of e.g. 1 and 2 or e.g. "with" and "without". Condone *x* and *y*.

M1 for a correct numerical expression for *F* (must have squares but does not need to be evaluated) May be implied by awrt 5.05
Could be reciprocal.

B1 for 6.26 (or better)
If reciprocal (0.198…) is used as test statistic then need $\dfrac{1}{5.19}$ or awrt 0.193

A1 dep on a critical value such that awrt $5.05 < \text{cv} < 7$ for a correct test statistic awrt 5.05, **and** correct conclusion. Condone e.g. variances are the same. Do not accept conclusions which do not refer to the variances. If an incorrect comparison or statement is made A0

(b)(i)

B1 for recognising that the test (for difference of means) requires the populations to have the same variance oe. **Must indicate that it is a requirement** (not just that you can assume the variances are equal). Must be in words.
Allow explanations suggesting that it enables a pooled estimate for σ^2 or a better estimate of σ^2 to be found (so that a *t*-test can be carried out on the difference between means of two independent distributions with unknown variances)
Do not allow references to the normal distribution being used.

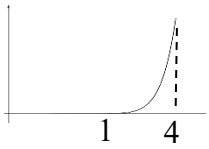
(ii)

B1 for a correct conclusion in context mentioning increase in **mean yield**.
Does not require the comment about variances.

Qu	Scheme	Mark	AO
4. (a)	(Prob =) 0.68268… = awrt **0.683** or awrt **68.3%** (o.e.)	B1	1.1b
		(1)	
(b)	$H_0 : \sigma^2 = 6^2 \quad H_1 : \sigma^2 < 6^2$	B1	2.5
	$s^2 = \dfrac{422\,862 - 25\times\left(\frac{3250}{25}\right)^2}{24} = (15.0833\ldots)$	M1	2.1
	Test statistic = $\dfrac{24\times\text{"15.0833..."}}{6^2}$ =, 10.0555… awrt **10.1**	M1,A1	1.1b,1.1b
	5% critical value (lower tail) $\chi_{24}^{\ 2}(5\%) = 13.848$	B1	3.4
	(Significant result so reject H_0) there is evidence that the treatment works oe **or** variance of weights is lower oe	A1	2.2b
		(6)	
(c)	$\bar{x} \pm t_{24}\dfrac{s}{\sqrt{25}}$ =, $130 \pm 2.064\times\dfrac{\text{"3.88..."}}{\sqrt{25}}$	M1A1ft	3.3, 3.4
	= (128.4…, 131.6…) = awrt **(128, 132)**	A1	1.1b
		(3)	
(d)(i)	Yes (or treatment worked) since 131 is in CI (and σ reduced)	B1	2.4
(ii)	Assume σ = "3.9" (or better) and suitable μ e.g. 131	M1	3.5a
	Proportion in range **(79% ~ 88%)**	A1	1.1b
		(3)	
			(13 marks)

Notes

(a)	B1 for awrt 0.683 or awrt 68.3% o.e. Do not accept a fraction
(b)	1st B1 for correct hypotheses in terms of σ or σ^2 Do not accept in words. 1st M1 for a correct expression for s or s^2 Implied by $\frac{181}{12}$ or 15.0833… 2nd M1 for a correct expression for ts (ft their 15.0833…) May be implied by awrt 10.1 1st A1 for awrt 10.1 or may see $\frac{181}{18}$ 2nd B1 for the correct cv of 13.848 (accept 13.8 or better or allow 13.85) 2nd A1 for a correct conclusion in context (independent of hypotheses but dep on M2 and their ts < cv where 12 < cv <15). Incorrect comparison or contradictory statement is A0
(c)	M1 for an attempt at a correct formula with 130 or their 3.88… **and** $\sqrt{25}$ **and** $t > 2$ 1st A1ft for a correct expression using t = 2.064 (or better) can ft their 3.88… = their s 2nd A1 for awrt (128, 132) **provided M1 clearly scored.**
(d)(i)	B1 dep on a CI in (c) which includes 131 and concluding variance lower in (b). For stating treatment was successful (o.e. condone e.g. yes) and mentioning 131 (or referred to as the mean) is inside CI. Do not allow reference to critical region for CI.
(ii)	M1 for evidence of a suitable σ used (ft their s) and a value of μ from their CI. Must see their values for μ and σ to score. A1 dep on σ = awrt 3.9 and $\mu = [\text{awrt}128, \text{awrt}132]$ for an answer in the range 0.79 to 0.88 inclusive (decimal or %)
NB	$\sigma = 3.9$, $\mu = 128.4$ gives 79.5%; $\sigma = 3.9$, $\mu = 131.6$ gives 87.2% $\sigma = 3.9$, $\mu = 131$ gives 87.6%

Qu	Scheme	Mark	AO
5 (a) (i)	$P(1.8 < X < 3.2) = \left[\dfrac{3.2-1.8}{4-1}\right] = \underline{\underline{\dfrac{7}{15}}}$ oe	B1	3.4
(ii)	$P(X > 3.2 \mid X > 1.8) = \dfrac{P(X>3.2)}{P(X>1.8)}$ or $\dfrac{\frac{4}{15}}{\frac{11}{15}}$ or $\dfrac{0.8}{2.2}$ oe	M1	2.1
	$= \underline{\underline{\dfrac{4}{11}}}$	A1	1.1b
		(3)	
(b)	$[1 - F(3.75)] = 1 - \left(\dfrac{3.75-1}{3}\right)^{10} = 0.581096$ awrt **<u>0.581</u>**	B1	3.4
		(1)	
(c)(i)	$f(y) = \dfrac{dF(y)}{dy} = \dfrac{10}{3} \times \left(\dfrac{y-1}{3}\right)^9$ or sketch of correct shape 	M1	1.1b
	Correct sketch showing $y = 1$ and 4 and $f(1) = 0$	A1	1.1b
(ii)	[From sketch mode of M is] **<u>4</u>**	B1	2.2a
		(3)	
(d)	$E(M) = k\int y \times 10(y-1)^9 \, dy = k\int y \, d(y-1)^{10}$ or $K\int (3u+1)u^9 \, du$	M1	2.1
	$= k\left[y(y-1)^{10}\right]_1^4 - k\int_1^4 (y-1)^{10} \, dy$ or $K\left\{\int_0^1 (3u^{10}+u^9) \, du = \left[\dfrac{3u^{11}}{11} + \ldots\right]\right\}$	M1	1.1b
	$= \left[y\left(\dfrac{y-1}{3}\right)^{10}\right]_1^4 - \dfrac{3}{11}\left[\left(\dfrac{y-1}{3}\right)^{11}\right]_1^4$ oe or $10\left[\dfrac{3u^{11}}{11} + \dfrac{u^{10}}{10}\right]_0^1$ oe	M1	1.1b
	$= \left[4 - \dfrac{3}{11}\right] = \underline{\underline{\dfrac{41}{11}}}$	A1	1.1b
		(4)	
		(11 marks)	

Notes

(a)(i)	B1 for $\frac{7}{15}$ or exact equivalent isw
(ii)	M1 for a correct ratio of prob expressions (must be $P(X > 3.2)$ on num) or values or awrt 0.364
	A1 for $\frac{4}{11}$ or exact equivalent isw
(b)	B1 for awrt 0.581
(c)(i)	M1 for correct expression <u>or</u> a sketch of correct shape with positive increasing gradient
	A1 for a fully correct sketch with 1 and 4 correctly indicated (dashed line not needed). Condone curves which appear almost linear provided this was not the intention. Ignore any labelling of the axes or values indicated on the vertical axis.
(ii)	B1 for 4
(d)	1st M1 for a correct expression for E(M) and an attempt to start to integrate. May be implied by further work. May use substitution e.g. $3u = y - 1$ so forms the integral expression in u. Allow any constant k (or K)
	2nd M1 for a correct first step of integration. Allow any k (or K) and still ignore limits.
	3rd M1 for a correctly integrated expression including limits (need not be substituted in)
	A1 dep on all previous method marks for $\frac{41}{11}$ or exact equivalent

Qu	Scheme	Mark	AO
6(a)	$\bar{x}_B = 2.8$ oe	B1	1.1b
	$s^2{}_B = \dfrac{461.34 - 51\times 2.8^2}{50}$; = **1.23** oe	M1;A1	1.1b;1.1b
		(3)	
(b)	Delivery rates must be normally distributed with equal variances	B1	2.4
		(1)	
(c)	$H_0 : \mu_A = \mu_B$ $H_1 : \mu_A \neq \mu_B$ oe	B1	2.5
	$s_p{}^2 = \dfrac{1.64\times 60 + "1.23"\times 50}{110}$; = 1.4536… **awrt 1.45**	M1;A1	1.1b;1.1b
	$t_{110} = \pm\dfrac{3.7 - "2.8"}{\sqrt{"1.45..."\left(\frac{1}{61}+\frac{1}{51}\right)}}$ = 3.93419… awrt **3.93 or 3.94**	M1;A1	3.4;1.1b
	5% 2-tail cv = ±1.982	B1	1.1b
	[significant result]there is evidence of a difference in mean delivery rates oe	A1	2.2b
		(7)	
(d)	[Let D = delivery A – delivery B] $H_0 : \mu_D = 0$ $H_1 : \mu_D \neq 0$	B1	2.5
	d = 0.5, – 0.3, 0.2, 0.2, – 0.3, 0.4, 0.3, 0.3, 0.7, 0.2 (may be opposite signs)	M1	2.1
	$\left[\bar{x}_D = 0.22 \quad s_D = 0.31552...\right]$ $t_{[9]} = \pm\dfrac{"0.22" - 0}{\frac{"0.31552..."}{\sqrt{10}}} = 2.2049...$; awrt **2.20**	M1;A1	3.4;1.1b
	Two-tail $t_9(5\%)$ cv = ±2.262	B1	1.1b
	[Not significant] insufficient evidence of a difference in delivery rates oe	A1	2.2b
		(6)	
			(17 marks)

	Notes
(a)	B1 for 2.8 (may be seen in a calculation but must be seen somewhere) oe M1 for a correct expression for s^2 Can ft their mean or implied by correct answer. A1 for 1.23 oe
(b)	B1 for mention of "normal" **and** "equal variance" (or standard deviation)
(c)	1st B1 for correct hypotheses, both in terms of μ. Can be μ_1 and μ_2 etc 1st M1 for correct attempt at $s_p{}^2$ ft their value for B ; 1st A1 for awrt 1.45 (implied by 2nd A1) ($\frac{1599}{1100}$) 2nd M1 for correct ft expression for test statistic using 3.7 allow (±) standardisation ; 2nd A1 for awrt (±) 3.93 or awrt (±) 3.94 2nd B1 for (±)1.982 (or better) 3rd A1 **dep on all previous Ms and** 1 < |cv| < "3.93" for correct conclusion mentioning "mean delivery rate" . Do not allow contradictory statements. Incorrect comparisons A0.
(d)	1st B1 for both hypotheses in terms of μ (or μ_d) but not μ_1 and μ_2 etc 1st M1 for attempting differences (at least 6 correct values) implied by mean or $s_D{}^2$ or s_D 2nd M for a correct express'n for t (ignore df) with their values for $\bar{x}_D$ and s_D **(correct method)** 1st A1 for awrt ±2.20 or ±2.205 (accept 2.2 if correct expression or $\bar{x}_D$ and s_D seen) 2nd B1 for correct cv i.e. ±2.262 or better 2nd A1 **dep on all previous Ms and** "2.20" < |cv| < 3 for correct conclusion in context. Do not allow contradictory statements. "mean delivery rate" or incorrect comparison is A0. **SC** **If they carry out a *t*-test for two independent samples** then allow **2nd M1** for standardising with diff of their means and pooled variance and **2nd B1** for cv of ±2.101

Qu	Scheme	Mark	AO
7 (a)	[Let $D = \bar{X} - Y$] E(D) = 0	B1	1.1b
	$(D=)\ \dfrac{X_1+X_2+X_3+X_4+X_5}{5} - \dfrac{X_1+X_5}{2}$ oe	M1	3.1a
	$= \dfrac{1}{10}\left[2\left(X_2+X_3+X_4\right)-3\left(X_1+X_5\right)\right]$ oe	M1 A1	2.1 1.1b
	Var(D) = $= \dfrac{1}{100}\left(4\times 3\sigma^2 + 9\times 2\sigma^2\right)$	dM1	1.1b
	$= \dfrac{3}{10}\sigma^2$	A1	1.1b
	So P($D > \sigma$) = $\mathrm{P}\left(Z > \dfrac{\sigma - 0}{\sigma\sqrt{\frac{3}{10}}}\right)$ = 0.03394… awrt **0.034**	A1	3.2a
		(7)	
(b)	(27.029, 37.371) since this is the narrower interval or her sample was greater oe	B1	2.2a
		(1)	
(c)	e.g. $37.371 - 27.029 = [2]\times\dfrac{\sigma}{\sqrt{"5"}}\times 1.96$ (or $38.177 - 21.823 = [2]\times\dfrac{\sigma}{\sqrt{"2"}}\times 1.96$)	M1	3.4
	$\sigma = \dfrac{10.342\times\sqrt{5}}{2\times 1.96}$ $\qquad$ $\sigma = \dfrac{16.354\times\sqrt{2}}{2\times 1.96}$	A1	1.1b
	= 5.8993… awrt **5.9** $\qquad$ = 5.900… awrt **5.9**	A1	1.1b
		(3)	
			(11 marks)

Notes

(a)

B1 for E(D) = 0 (May be implied by their other working). May use other letters.

1st M1 for an attempt at $\bar{X} - Y$ (any expression using X_1, X_2, X_3, X_4 and X_5). May be seen in attempt to find a probability or E(D)

2nd M1 for an attempt to eliminate the "repeats" – condone missing $\frac{1}{10}$ or errors in "2" and "3"

1st A1 for a correct expression for D with no "repeats"

3rd dM1 for a correct application of Var($aX - bY$) **dep on 2nd M1** but can ft their expression

2nd A1 for the correct variance (may be implied by a correct answer)

3rd A1 for awrt 0.034

(b)

B1 for choosing the correct interval **and** giving a suitable reason based on width or sample size. Contradictory or incorrect statements is B0. Do not accept just referring to the standard deviation being smaller without going onto explain the effect on the width of the interval

(c)

M1 for an attempt at a correct equation in σ. Condone wrong n and missing $\times 2$ must have 1.96.

Alternatively for an attempt to form two simultaneous equations in $\bar{x}$ and σ, condoning a wrong n. (Condone labelling $\bar{x}$ as μ) Must have 1.96

1st A1 for a correct expression for σ. May be implied by awrt 5.9

2nd A1 for awrt 5.9

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