

Mark Scheme (Results)

Summer 2017

Pearson Edexcel GCE Further Mathematics

Statistics S3 (6691)

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Summer 2017
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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 and can be used if you are using the annotation facility on ePEN.

- bod – benefit of doubt
- ft – follow through
- the symbol $\surd$ 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
- $\lfloor$ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. 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.

6. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
    - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

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

Question Number	Scheme	Notes	Marks
1(a)	-(accurate) estimates for each strata / job **-more** representative of the population -reflects population structure	Any 1 oe	B1
			(1)
(b)	Total staff=720	May be implied by calculations	B1
	$\text{Managers} = \frac{72}{720} \times 40 = 4$	For one correct calculation, follow through their 720.	M1
	$\text{Drivers} = \frac{108}{720} \times 40 = 6$		
	$\text{Administrators} = \frac{180}{720} \times 40 = 10$		
	$\text{Warehouse} = \frac{360}{720} \times 40 = 20$	4, 6, 10, 20 only. Must identify which job the values relate to.	A1
			(3)
(c)	Label all managers 1 – 72 o.e.	Idea of **sampling frame** or **list** of **managers**. Need not give the specific term.	B1
	Using random numbers in range 1-72 or 0-71 select 4 (managers).	Use of **random numbers** to select required number of managers. Must mention use of random numbers or some **random** selection process. If they are describing systematic sampling score B0.	B1
			(2)
			Total 6

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Notes</th><th>Marks</th></tr>
<tr><td>2.(a)</td><td>$a=\frac{45}{360}\times100=12.5$</td><td>For one correct calculation</td><td>M1</td></tr>
<tr><td></td><td>$b=\frac{90}{360}\times100=25$</td><td></td><td></td></tr>
<tr><td></td><td>$c=\frac{135}{360}\times100=37.5$</td><td>12.5, 25, 37.5 only</td><td>A1</td></tr>
<tr><td></td><td></td><td></td><td>(2)</td></tr>
<tr><td>(b)</td><td>H_0 : Continuous uniform distribution is a suitable model
H_1 : Continuous uniform distribution is not a suitable model</td><td>Both
Accept in terms of Linda's claim.
Accept U[0,360).</td><td>B1</td></tr>
<tr><td></td><td>
<table>
<tr><th>O</th><th>E</th><th>$\frac{(O-E)^2}{E}$</th><th>$\frac{O^2}{E}$</th></tr>
<tr><td>18</td><td>12.5</td><td>2.42</td><td>25.92</td></tr>
<tr><td>16</td><td>12.5</td><td>0.98</td><td>20.48</td></tr>
<tr><td>18</td><td>25</td><td>1.96</td><td>12.96</td></tr>
<tr><td>29</td><td>37.5</td><td>1.927</td><td>22.43</td></tr>
<tr><td>19</td><td>12.5</td><td>3.38</td><td>28.88</td></tr>
<tr><td>100</td><td>100</td><td>10.67</td><td>110.67</td></tr>
</table>
</td><td>M1 for attempting $\frac{(O-E)^2}{E}$ or $\frac{O^2}{E}$ with at least 3 correct expressions or values.

A1 for all values correct to 2dp or as fractions. Can be implied by correct answer if all not listed.</td><td>M1A1</td></tr>
<tr><td></td><td>$\sum\frac{(O-E)^2}{E}=10.67$ or
$\sum\frac{O^2}{E}-100=10.67$</td><td>awrt 10.7</td><td>A1</td></tr>
<tr><td></td><td>$\nu=5-1=4, \chi^2_4(5\%)=9.488$</td><td>4 can be implied by awrt 9.488 seen or $p=$awrt 0.03</td><td>B1,B1ft</td></tr>
<tr><td></td><td>(10.7>9.488) Reject H_0</td><td>Correct for their test stat and cv or thier p to 5% . Can be implied by correct conclusion from their test stat and cv.</td><td>M1</td></tr>
<tr><td></td><td>Linda's claim is not supported.</td><td>A correct comment suggesting that continuous uniform model is not suitable or Linda's claim is not correct. Linda's claim must be described in full if Linda is not mentioned.
Follow through from their test stat and cv, but hypotheses must be correct.</td><td>A1ft</td></tr>
<tr><td></td><td></td><td></td><td>(8)</td></tr>
<tr><td></td><td></td><td></td><td>Total 10</td></tr>
</table>

Question Number	Scheme	Notes	Marks
3.			
(a)	<table><tr><th></th><th>Senior Judge</th><th>Junior Judge</th><th>d</th><th>d^2</th></tr><tr><td>A</td><td>1</td><td>3</td><td>-2</td><td>4</td></tr><tr><td>B</td><td>2</td><td>1</td><td>1</td><td>1</td></tr><tr><td>C</td><td>4</td><td>5</td><td>-1</td><td>1</td></tr><tr><td>D</td><td>3</td><td>2</td><td>1</td><td>1</td></tr><tr><td>E</td><td>6</td><td>6</td><td>0</td><td>0</td></tr><tr><td>F</td><td>5</td><td>4</td><td>1</td><td>1</td></tr><tr><td></td><td></td><td></td><td></td><td>8</td></tr></table>	M1 for an attempt to rank judges lists (at least 4 correct for each judge) A1 for correct rankings for both (may be reversed). Can be implied by correct d^2 or r_s N.B. Table could be ordered in terms of Senior Judge.	M1A1
	$\sum d^2 = 8$ or 62	8 or 62 or correct d^2 row	A1
	$r_s = 1 - \frac{6\times 8}{6\times 35} = \frac{27}{35} = 0.771$	M1 for use of the correct formula, follow through their $\sum d^2$ (Dependent on 1st M1) If answer is not correct, a correct expression is required. A1 exact fraction or awrt $(\pm)0.771$	dM1A1
			(5)
(b)	$H_0 : \rho = 0$ $H_1 : \rho > 0$	Both hypotheses in terms of ρ or ρ_s . Hypotheses just in words e.g. "no correlation" score B0	B1
	Critical value ± 0.8286	Accept ± 0.8857 if 2-tailed H_1.	B1
	(0.771<0.8286) so insufficient evidence to reject H_0	Follow through their r_s and their c.v. if |cv| <1 and $\lvert r_s \rvert < 1$	M1
	There is insufficient evidence to suggest a **positive** correlation between the judges.	A correct contextualised comment that includes "judges".	A1 ft
			(4)
(c)	(For positive correlation c.v.is 0.8286>0.771)		
	Training of junior judge was ineffective.	o.e. Follow through from their cv and r_s	B1 ft
			(1)
			Total 10

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Notes</th><th>Marks</th></tr>
<tr><td>4(a)</td><td>$\frac{72\times50}{150}=24,\ \frac{78\times50}{150}=26$</td><td>For one correct $\frac{\text{Row Total}\times\text{Column Total}}{\text{Grand Total}}$; can be implied by correct answers.</td><td>M1</td></tr>
<tr><td></td><td>$\frac{72\times64}{150}=30.72,\ \frac{78\times64}{150}=33.28$</td><td>24, 26, 30.72, 33.28 only.</td><td>A1</td></tr>
<tr><td></td><td></td><td></td><td>(2)</td></tr>
<tr><td>(b)</td><td>H_0 : Perceived (body) weight is independent of gender (no association)
H_1 : Perceived (body) weight is not independent of gender (association)</td><td>Both hypotheses required. Must mention “Perceived”, “weight” and “gender” at least once.
Use of “relationship” or “correlation” or “connection” or “link” award B0.</td><td>B1</td></tr>
<tr><td></td><td><table><tr><th>O</th><th>E</th><th>$\frac{(O-E)^2}{E}$</th><th>$\frac{O^2}{E}$</th></tr><tr><td>20</td><td>17.28</td><td>0.428148</td><td>23.14815</td></tr><tr><td>22</td><td>24</td><td>0.166667</td><td>20.16667</td></tr><tr><td>30</td><td>30.72</td><td>0.016875</td><td>29.29688</td></tr><tr><td>16</td><td>18.72</td><td>0.395214</td><td>13.67521</td></tr><tr><td>28</td><td>26</td><td>0.153846</td><td>30.15385</td></tr><tr><td>34</td><td>33.28</td><td>0.015577</td><td>34.73558</td></tr><tr><td>150</td><td>150</td><td>1.176327</td><td>151.1763</td></tr></table></td><td>M1 for at least 2 correct terms (as in 3rd or 4th column) or correct expressions.
A1 for all correct. Accept 2sf accuracy.
Allow truncation e.g. 1.17…</td><td>M1A1</td></tr>
<tr><td></td><td>$\sum\frac{(O-E)^2}{E}$ or $\sum\frac{O^2}{E}-150=1.18$</td><td>Awrt 1.18-1.19</td><td>A1</td></tr>
<tr><td></td><td>$\nu=(3-1)(2-1)=2,\chi^2_2(10\%)=4.605$</td><td>2 can be implied by 4.605 seen</td><td>B1B1ft</td></tr>
<tr><td></td><td>(Accept H_0) Perceived (body) weight is independent of gender (no association)</td><td>A correct comment in context - must mention “weight” and “gender”.
Condone “relationship” or “connection” here but not “correlation”.
Follow through from their test stat and cv, but hypotheses must be correct.</td><td>A1ft</td></tr>
<tr><td></td><td></td><td></td><td>(7)</td></tr>
<tr><td>(c)</td><td><table><tr><th>O</th><th>E</th><th>$\frac{(O-E)^2}{E}$</th><th>$\frac{O^2}{E}$</th></tr><tr><td>36</td><td>50</td><td>3.92</td><td>25.92</td></tr><tr><td>50</td><td>50</td><td>0</td><td>50</td></tr><tr><td>64</td><td>50</td><td>3.92</td><td>81.92</td></tr><tr><td>150</td><td>150</td><td>7.84</td><td>157.84</td></tr></table></td><td>B1 for $E_i=50$, could be implied.
M1 for combining values and for attempting $\frac{(O-E)^2}{E}$ or $\frac{O^2}{E}$ with at least 2 correct expressions or values.
A1 for all correct, can be implied by correct answer below.</td><td>B1
M1A1</td></tr>
<tr><td></td><td>$\sum\frac{(O-E)^2}{E}$ or $\sum\frac{O^2}{E}-150=7.84$</td><td>Awrt 7.84</td><td>A1</td></tr>
<tr><td></td><td>$\nu=2,\chi^2_2(2.5\%)=7.378$</td><td>0.025 or 2.5%</td><td>A1</td></tr>
<tr><td></td><td></td><td></td><td>(5)</td></tr>
<tr><td></td><td></td><td></td><td>Total 14</td></tr>
</table>

Question Number	Scheme	Notes	Marks
5.			
(a)	$\bar{x} = \frac{60}{15} = 4$	4 cao	B1
	$s^2 = \frac{1}{14}\left(1946 - 15\times 4^2\right) = 121.857...$	M1 Use of complete, correct formula and attempt to substitute. A1 awrt 122 or $\frac{853}{7}$	M1,A1
			(3)
(b)(i)	$\bar{x} \pm 1.96 \times \frac{10}{\sqrt{15}} = 4 \pm 5.06$	Accept use of $\bar{x} \pm z \times \frac{10 \text{ or "their } s\text{"}}{\sqrt{15}}$, A1 all correct. Accept $\bar{x} = 0835$.	M1,A1
	$(-1.06, 9.06)$	Can be implied from correct interval below.	A1
	$(08\,29\,56, 08\,40\,04)$	Accept $(08\,29.94, 0840.06)$ or expressed using words or as an inequality. Accept answers to the nearest minute ie (0830,0840).	A1
(ii)	Paul samples times of **buses randomly** or **independently** of each other	Context required.	B1
			(5)
(c)	0 / 0831 / 8.31(am) is 'contained in' the confidence interval	Award if comment about their interval is correct. Only accept 'above the lower limit of' etc if the statement taken as a whole clearly means 'contained in'.	M1
	Paul's belief is not supported / 0831 arrival time is reasonable	Must contain some context	A1cao
			(2)
			Total 10

Question Number	Scheme	Notes	Marks
6.			
(a)	$H_0 : \mu_{new} - \mu_{old} = 8$	Accept equivalent rearranged equation. Definitions of parameters must be clear e.g. use of 1 and 2 without definitions scores B0. Accept '*x*' for 'new' and '*y*' for 'old' as defined in the question.	B1
	$H_1 : \mu_{new} - \mu_{old} > 8$	Accept equivalent rearranged strict inequality. Definitions of parameters must be clear e.g. use of 1 and 2 without definitions scores B0. Accept '*x*' for 'new' and '*y*' for 'old' as defined in the question.	B1
	$z = \dfrac{\pm(83-74-8)}{\sqrt{\dfrac{7}{50}+\dfrac{6}{40}}}$	M1 for attempting standard error. Condone swapping 7 and 6. Accept 6.86 and 5.85 for 7 and 6.	M1
	$z = \dfrac{\pm 1}{0.5385...} = 1.86$	dM1 for 1/ "their standard error" A1 for awrt 1.86 NB -1.86 is A0. If 8 missing from H_1 then accept $z = \dfrac{9}{0.5385...} = \text{awrt}\,16.7$ and must be consistent with their H_1.	dM1A1
	cv $z = 1.6449$	Accept $\pm$ or probability of 0.9686	B1
	(1.86>1.6449) so reject H_0	(Or 0.95<0.9686)	
	Evidence to support engineer's claim (that the new battery will last more than 8 hours longer than the old battery).	Correct comment in context. Must mention "engineers claim" or "battery", "old", "new" and "8".	A1cso
			(7)
(b)	Sample sizes are large		B1
	CLT guarantees sample means ($\bar{X}$ and $\bar{Y}$) are approximately normally distributed.	Must mention **means** and **normal.** No assumptions are being made so B0 if key to answer.	B1
			(2)
			Total 9

Question Number	Scheme	Notes	Marks
7(a)	$L \sim \mathrm{N}(1510, 20^2)$ and $M \sim \mathrm{N}(520, 10^2)$		
	$W = L - (M_1 + M_2 + M_3)$	Allow $L-(M+M+M)$ but **not** $L-3M$ Can be implied by correct $\mathrm{Var}(W)$. May use $W = L - (M_1 + M_2 + M_3) - 15$ for B1.	B1
	$\mathrm{E}(W) = 1510 - 3\times 520 = -50$	Accept 50 if definition reversed. Accept $\mathrm{E}(W) = 1510 - 3\times 520 - 15 = -65$	B1
	$\mathrm{Var}(W) = 20^2 + 10^2 + 10^2 + 10^2 = 700$	Attempt $\mathrm{Var}(W) = \mathrm{Var}(L) + 3\mathrm{Var}(M)$. Do not condone missing squares, cao.	M1,A1
	$\mathrm{P}(W > 15) \quad = \mathrm{P}\left(Z > \dfrac{15 - -50}{\sqrt{700}}\right)$	Attempting the correct probability and standardising with their mean and sd dependent on 1st M1. If values for W is not being used or not their variance score M0. Must use 15. Accept $\mathrm{P}(W > 0) \quad = \mathrm{P}\left(Z > \dfrac{0 - -65}{\sqrt{700}}\right)$	dM1
	$= \mathrm{P}(Z > 2.456769...)$		
	$= 0.0069$	0.0071 by calc. awrt 0.007	A1
			(6)
(b)	$X = 3M - L$	Can be implied by correct variance.	
	$\mathrm{E}(X) = 3\times 520 - 1510 = 50$	Accept -50 if reversed.	B1
	$\mathrm{Var}(X) = 3^2 \times 10^2 + 20^2 = 1300$	Attempt $\mathrm{Var}(W) = 3^2\mathrm{Var}(M) + \mathrm{Var}(S)$. Do not condone missing squares, cao. Condone $10^2 + 3^2 \times 20^2$ for M1A0.	M1,A1
	$\mathrm{P}(X > 0) = \mathrm{P}\left(Z > \dfrac{-50}{\sqrt{1300}}\right)$	Attempting the correct probability and standardising with their mean and sd.	dM1
	$= \mathrm{P}(Z > -1.38675...) = 0.9177$	0.9172 by calc. awrt 0.917-0.918	A1
			(5)
(c)	P(all 5 bags weigh more than 520 grams) = $= \left(\dfrac{1}{2}\right)^5 = \dfrac{1}{32} = 0.03125$	0.03125	B1

	$\bar{M} \sim \mathrm{N}(520, \frac{10^2}{5})$ or $\sum_{i=1}^{5} M_i \sim \mathrm{N}(2600, 500)$	Both mean and variance required in either case. Can be implied below.	B1
	$\mathrm{P}(\bar{M} > d) = \mathrm{P}\left(Z > \frac{d-520}{\frac{10}{\sqrt{5}}} \right) = 0.03125$ or $\mathrm{P}(T > 5d) = \mathrm{P}\left(Z > \frac{5d-2600}{\sqrt{500}} \right) = 0.03125$	Standardise using d, 520 and 10 or 5d, 2600 and $\sqrt{500}$.	M1
	$\Rightarrow \frac{d-520}{\frac{10}{\sqrt{5}}} = 1.86(27...)$ or $\frac{5d-2600}{\sqrt{500}} = 1.86(27...)$	Equate to z value	M1
	$d = 528.3$	awrt 528.3	A1
			(5)
ALT (c)	Accept use d as difference to 520 provided 520 added to final answer:		
	P(all 5 bags weigh more than 520 grams) = $= \left(\frac{1}{2}\right)^5 = \frac{1}{32} = 0.03125$	0.03125	B1
	$\bar{M} \sim \mathrm{N}(0, \frac{10^2}{5})$ or $\sum_{i=1}^{5} M_i \sim \mathrm{N}(0, 500)$	Both mean and variance required in either case. Can be implied below.	B1
	$\mathrm{P}(\bar{M} > d) = \mathrm{P}\left(Z > \frac{d}{\frac{10}{\sqrt{5}}} \right) = 0.03125$ or $\mathrm{P}(T > 5d) = \mathrm{P}\left(Z > \frac{5d}{\sqrt{500}} \right) = 0.03125$	Standardise using d and 10 or $5d$ and $\sqrt{500}$.	M1
	$\Rightarrow \frac{d}{\frac{10}{\sqrt{5}}} = 1.86(27...)$ or $\frac{5d}{\sqrt{500}} = 1.86(27...)$	Equate to z value	M1
	$d = 520 + 8.3 = 528.3$	awrt 528.3	A1
			(5)
			Total 16

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