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Mark Scheme (Results)

Summer 2014

Pearson Edexcel International A Level in Statistics 3
(WST03/01)

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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.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL 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 $\surd$ 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. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme	Marks
1. (a)	165, 8	B1 **[1]**
(b)	Select <u>every 6th person</u> {having chosen the first person by} Selecting a random number between 1 and 6 **or** selecting a random number and then loop back to start when you reach the end.	B1 dB1
(b)(ii)	The <u>list</u> is alphabetical and <u>has not been **sorted** by gender</u>.	B1 **[3]**
(c)	Label male members 1- 180, female members 1 – 120 <u>Use random numbers</u> to select a ... Simple random sample of <u>30 male</u> members and <u>20 female</u> members	M1 M1 A1 **[3]**
(d)	**Any one of** • It (a stratified sample) is <u>not biased</u> as the members are chosen randomly. • You <u>can estimate</u> the <u>sampling errors</u> (for a stratified sample) • It (a stratrified sample) gives <u>more accurate estimates</u> as it is a random process. • A quota sample may <u>be biased</u> (whereas a stratrified sample is not). • It's <u>not possible</u> to <u>estimate/find</u> the <u>sampling errors</u> for a <u>quota sample</u> (whereas you can for a stratified sample)	B1 **[1]** **8**

	Notes	
(a)	**B1**	165 followed by 8 or 008.
(b)(i)	**1st B1**	For selecting every 6th (name on the list)
	2nd dB1	***is dependent on the first B1 mark being awarded.*** For idea of using random numbers to select first from 1 to 6 or 0 to 5 (o.e.) **or** selecting a random number between 1 and 300 and then looping back when the end of the list has been reached.
(b)(ii)	**B1**	A comment that implies <u>the list</u> (or sampling frame) has **not been sorted** by gender.
	Note	B0 for "the ordered list is not truly random"
	Note	B0 for "sample does not divide the members into gender."
(c)	**1st M1**	For suitable labelling of all 180 males <u>and</u> all 120 females. E.g. Allow labelling female members 181 – 300. Also allow labelling male members 0 – 179 and female members either 0 to 119 or 180 to 299.
	2nd M1	For use of random numbers to select males and females.
	A1	For 30 males <u>and</u> 20 females **(dependent on 2nd M1 only)**
	Note	A simple random sample of 30 males and 20 females scores 2nd M1 and A1.
(d)	**Note**	B0 for "a stratified sample can reflect the population structure." B0 for "estimates obtained from each of the strata."

Question Number	Scheme	Marks
2.	X follows a continuous unform distribution over $[\alpha - 3,\ 2\alpha + 3]$	
(a)	$\left\{\mathrm{E}(\bar{X}) = \mu =\right\}\ \dfrac{2\alpha + 3 + \alpha - 3}{2}$	M1
	$= \dfrac{3\alpha}{2}$. So $\bar{X}$ is a biased estimator.	A1
	bias $\left\{= \dfrac{3\alpha}{2} - \alpha\right\} = \pm\dfrac{\alpha}{2}$ bias $= \pm\dfrac{\alpha}{2}$	B1
		[3]
(b)	$k = \dfrac{2}{3}$ $\dfrac{2}{3}$	B1
		[1]
(c)	$\alpha = \dfrac{2}{3}\bar{X} = \dfrac{2}{3}(8)$ "their k" $\times 8$	M1
	Max value $= 2\left(\dfrac{16}{3}\right) + 3$ $2 \times$ "their α" $+ 3$ See notes	M1
	$= \dfrac{41}{3}$ $\dfrac{41}{3}$ or $13\dfrac{2}{3}$ or awrt 13.7	A1
		[3]
		7

	Notes	
(a)	**M1**	Using the formula $\left(\dfrac{a+b}{2}\right)$ or getting $\dfrac{3\alpha}{2}$
	A1	$\dfrac{3\alpha}{2}$ and concluding. Allow A1 for $\dfrac{3\alpha}{2} \neq \alpha$.
	Note	Also allow A1 for bias $= \pm\dfrac{\alpha}{2} \neq 0$
(c)	**1st M1**	An attempt to use the sample data given to find $\bar{x}$ and multiply by their k. Allow full expression for $\bar{x}$ or $\dfrac{\sum x}{n}$.
	Note	1st M1 can be implied by a correct recovery leading to $\alpha = \dfrac{16}{3}$
	2nd M1	$2 \times$ "their α" $+ 3$ where their α is a function of the sample mean - which found by applying $\dfrac{\sum x}{n}$ from the data values given in the question.
	Note	$2(13) + 3 = 39$ is M0M0A0

Question Number	Scheme	Marks
3. (a)	$H_0 : \mu_A = \mu_B \quad H_1 : \mu_A > \mu_B$	B1
	s.e. $= \sqrt{\frac{35^2}{80} + \frac{28^2}{100}}$ $\{= 4.81170448...\}$	M1 A1
	$z = \frac{532 - 520}{"4.8117..."}$; $= 2.4939...$ $\frac{\pm(532-520)}{"4.8117..."}$	dM1;
	awrt 2.49	A1
	One tailed c.v. $Z = 2.3263$ or CR: $Z \geqslant 2.3263$ or p-value = awrt $0.006 < 0.01$ or $"0.994" > 0.99$ Critical value of 2.3263 Or a correct probability comparison.	B1
	[in the CR/significant/Reject H_0 / $"0.006" < 0.01$ / $"0.994" > 0.99$] Conclude either • that the <u>mean weight</u> of <u>grapefruit</u> from <u>farm *A*</u> is <u>greater</u> than that of <u>farm *B*</u>. • that the <u>average weight</u> of <u>grapefruit</u> from <u>farm *A*</u> is <u>greater</u> than that of <u>farm *B*</u>. • that the <u>grocer</u>'s belief is <u>correct</u>. A correct conclusion in context which is based on ***their*** *z*-value and ***their*** critical value, where $\lvert c.v. \rvert > 1$.	A1
		[7] **7**

Notes

B1 If μ_1, μ_2 used then it must be clear which refers to farm *A* and to farm *B*.

1st M1 Condone minor slips e.g. $\sqrt{\frac{35^2}{100} + \frac{28^2}{80}}$ or $\sqrt{\frac{35}{80} + \frac{28^2}{100}}$ etc.
i.e. swapped *n* or one s.d. and one variance.

1st A1 s.e. $= \sqrt{\frac{35^2}{80} + \frac{28^2}{100}}$. Or can be implied by s.e. = awrt 4.81

2nd dM1 ***is dependent upon the 1st M1.***
You can follow through their s.e. if 1st M1 mark has been awarded.

Note M1A1dM1 is scored for writing $z = \pm \frac{(532 - 520)}{\sqrt{\frac{35^2}{80} + \frac{28^2}{100}}}$

Special Case **SC: M1A0M0A0 for** s.e. $= \sqrt{\frac{35}{80} + \frac{28}{100}}$ $\{= 0.847...\}$

Final A1 Dependent on the first two method marks being scored.
For a contextualised comment which is rejecting H_0.
Contradictory statements score final A0. E.g. "significant, do not reject H_0".

<u>Alternative method for 2nd "M1A1B1" marks:</u> Let $D = \bar{x}_A - \bar{x}_B$

$2.3263 = \frac{D - 0}{4.8117...}$	dM1: dependent upon the 1st M1 for $\frac{D}{\text{their } "4.8117..."} = 2.3263 / 2.32 / 2.33$
	A1: D = awrt 11.2
So, $D = 11.193$	B1: 2.3263

Question Number	Scheme	Marks
4. (a)		
	Man | ***A*** | ***B*** | ***C*** | ***D*** | ***E*** | ***F*** | ***G*** | ***H*** | ***I*** | ***J*** Rank x | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 Rank w | 2 | 7 | 4 | 3 | 1 | 9 | 6 | 5 | 8 | 10	
	Attempt to rank both for x and for w. (at least four correct).	M1
	or	
	Man | ***A*** | ***B*** | ***C*** | ***D*** | ***E*** | ***F*** | ***G*** | ***H*** | ***I*** | ***J*** Rank x | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 Rank w | 9 | 4 | 7 | 8 | 10 | 2 | 5 | 6 | 3 | 1	
	For finding the difference between each of the ranks and evaluating $\sum d^2$.	M1
	$\sum d^2 = 1 + 25 + 1 + 1 + 16 + 9 + 1 + 9 + 1 + 0; = 64$	
	$\sum d^2 = 64$	A1
	Using $1 - \frac{6\sum d^2}{10(99)}$ with their $\sum d^2$	dM1;
	$r_s = 1 - \frac{6(64)}{10(99)}; = 0.6121212...$	
	$\frac{101}{165}$ or awrt 0.612	A1
		[5]
(b)	$H_0 : \rho = 0$, $H_1 : \rho > 0$ — Both hypotheses stated correctly	B1
	Critical Value $r_s = 0.5636$ or CR: $r_s \geqslant 0.5636$ — Critical value of 0.5636	B1
	Either • Since $r_s = 0.6121...$ lies <u>in</u> the <u>CR</u> • Result is <u>significant</u> • Reject H_0 (condone H_1) — see notes	M1
	conclude that there is a <u>positive correlation</u> between systolic <u>blood pressure</u> and <u>weight</u>. — Conclusion in context	A1
		[4]
(c)	**Both** either • Critical Value $r = 0.5494$ • CR: $r \geqslant 0.5494$ **and** either • Since $r = 0.5114$ <u>does not lie in the CR</u> • Result is <u>not significant</u> • Do not reject H_0 (or accept H_0)	M1
	Conclude that there is <u>no positive correlation</u> — Context not required here.	A1
		[2]
(d)	Either • A comment that conveys both the ideas "as x increases, w increases" **and** "the relationship is non-linear" • "There is a positive correlation" **and** "the relationship is non-linear" • Data is not (bi-variate) normal — Any one of these or equivalent.	B1
		[1]
		12

	Notes	
4. (a)		
	3rd dM1	***is dependent on 1st M1*** for use of $1-\frac{6\sum d^2}{10(99)}$ with their $\sum d^2$
	Note	If a candidate finds $\sum d^2 = 266$, leading to r_s = awrt -0.612 then award M1M1A1M1A1.
(b)	**1st B1**	Both hypotheses stated in terms of ρ.
	M1	For a correct statement relating their r_s $\left(\lvert r_s\rvert < 1\right)$ with their c.v. where $\lvert$their c.v.$\rvert < 1$
	A1	For a contextualised comment which is rejecting H_0, which must mention "positive correlation", "blood pressure" and "weight". (Use of "association" is A0.) Follow through their r_s with their c.v. (provided $\lvert$their c.v.$\rvert < 1$)
	Two-tailed test	Applying a two-tailed test scores a maximum of B0B1M1A0 **So Award SC B0B1** for $H_0: \rho = 0$, $H_1: \rho \neq 0$ followed by critical value $r_s = (\pm)\, 0.6485$ and allow access to the M1 mark only.

Question Number	Scheme	Marks
5. (a)	H_0 : There is no association between type of drink and gender (independent) H_1 : There is an association between type of drink and gender (dependent) Correct hypotheses	B1
	<table><tr><th>Expected</th><th>Tea</th><th>Coffee</th><th>Hot Chocolate</th><th>Total</th></tr><tr><td>Male</td><td>46.53</td><td>34.31</td><td>13.16</td><td>94</td></tr><tr><td>Female</td><td>52.47</td><td>38.69</td><td>14.84</td><td>106</td></tr><tr><td>Total</td><td>99</td><td>73</td><td>28</td><td>200</td></tr></table> Some attempt at $\frac{(\text{Row Total})(\text{Column Total})}{(\text{Grand Total})}$ Can be implied by at least one correct E_i to 1d.p.	M1
	All expected frequencies are correct. Condone exact fractions.	A1
	<table><tr><th>Observed</th><th>Expected</th><th>$\frac{(O-E)^2}{E}$</th><th>$\frac{O^2}{E}$</th></tr><tr><td>57</td><td>46.53</td><td>2.3559...</td><td>69.8259...</td></tr><tr><td>26</td><td>34.31</td><td>2.0127...</td><td>19.7027...</td></tr><tr><td>11</td><td>13.16</td><td>0.3545...</td><td>9.1945...</td></tr><tr><td>42</td><td>52.47</td><td>2.0892...</td><td>33.6192...</td></tr><tr><td>47</td><td>38.69</td><td>1.7849...</td><td>57.0949...</td></tr><tr><td>17</td><td>14.84</td><td>0.3144...</td><td>19.4744...</td></tr><tr><td colspan="2">Totals</td><td>8.9116...</td><td>208.9116...</td></tr></table> At least 2 correct terms for $\frac{(O-E)^2}{E}$ or $\frac{O^2}{E}$ or correct expressions with their E_i. Accept 2 sf accuracy for the dM1 mark.	dM1
	At least 5 correct $\frac{(O-E)^2}{E}$ or $\frac{O^2}{E}$ terms to either 2 dp or better. Allow truncation.	A1
	$X^2 = \sum \frac{(O-E)^2}{E}$ or $\sum \frac{O^2}{E} - 200$;= 8.9116... For applying either $\sum \frac{(O-E)^2}{E}$ or $\sum \frac{O^2}{E} - 200$	dM1
	8.9 or awrt (8.88 – 8.91)	A1
	$\nu = (2-1)(3-1) = 2$ $\nu = 2$	B1
	$\chi^2_2(0.05) = 5.991 \Rightarrow$ CR: $X^2 \geqslant 5.991$ 5.991 or ft $\chi^2_{\text{their } \nu}(0.05)$	B1ft
	[in the CR/significant/Reject H_0]	
	conclude that there is an association between type of <u>drink</u> preferred and <u>gender</u>. (or they are not independent.) A correct conclusion in context which is based on ***their*** X^2-value and ***their*** χ^2-critical value.	A1
		[10]
(b)	$\chi^2_2(0.005) = 10.597 \Rightarrow$ CR: $X^2 \geqslant 10.597$ Critical value of 10.597	B1
	[not in the CR/not significant/do not reject H_0]	
	Either • Conclude there is no association between type of drink preferred and gender (or they are independent). • The conclusion would change (if a correct H_0 has been rejected in part (a)). Any one of these.	B1
		[2] **12**

	Notes	
5. (a)	**1st B1**	For both hypotheses. Must mention "drink" and "gender" or "sex" at least once. Use of "relationship" or "correlation" or "connection" is B0.
	2nd dM1	Dependent on the first method mark. At least 2 correct terms (as in 3rd or 4th column) or ***correct expressions*** with their E_i
	2nd A1	All correct terms to either 2 d.p. or better. Allow truncated answers.
	3rd dM1	***Dependent on the second method mark.*** For applying either $\sum \frac{(O-E)^2}{E}$ or $\sum \frac{O^2}{E} - 200$
	3rd A1	8.9 or awrt (8.88 – 8.91)
	2nd B1	$\nu = 2$ This mark can be implied by a correct critical value of 5.991
	Note	If 8.9 or awrt (8.88 – 8.91) is seen (from a calculator) **without** the expected frequencies stated then award **special case** M0A0M1A1M1A1.
	Final A1	***Dependent on the third method mark.*** A correct contextualised conclusion which is rejecting H_0. Must mention "drink" and "gender" or "sex". No follow through. If e.g. hypotheses are the wrong way round A0 here.
	Note	Contradictory statements score A0. E.g. "significant, do not reject H_0".
	Note	Condone "relationship" or "connection" here but **not** "correlation". e.g. "There is evidence of a relationship between grades and gender"
	Note	**Full accuracy gives** $X^2 = 8.911619...$ and p-value 0.0116 to 0.0117

Question Number	Scheme	Marks
6. (a)	$\hat{p} = \dfrac{0(2)+1(21)+2(45)+3(42)+4(12)+5(3)}{8(2+21+45+42+12+3) \text{ or } 8(125)} \left\{= \dfrac{300}{1000}\right\} = 0.3$ (*) Answer is given. See notes.	M1 A1cso **[2]**
(b)	$r = 125 \times {}^{8}C_{3}(0.3)^{3}(0.7)^{5}$ $\{= 31.76523...\}$ (formula) or $r = 125 \times (0.8059 - 0.5518)$ $\{= 31.7625\}$ (tables) $s = 125 - (7.21 + 24.71 + 37.06 + \text{their } r + 17.02 + 5.83)$ $\{= 1.40477... \text{ or } 1.4075\}$ or $s = 125 \times (1 - 0.9887)$ $\{= 1.4125\}$	M1
	$r = 31.76523$ or 31.7625 or 31.7575 r = awrt 31.77 or r = awrt 31.76	A1
	$s = 1.40477$ or 1.4075 or 1.4125 $s = 1.4$ or awrt1.40 or s = awrt1.41	A1 **[3]**
(c)	See table below	
	For applying either $\mathrm{X}^2 = \sum \dfrac{(O-E)^2}{E}$ or $\sum \dfrac{O^2}{E} - 125$;= awrt 13.3 $\sum \dfrac{(O-E)^2}{E}$ or $\sum \dfrac{O^2}{E} - 125$ awrt 13.3	dM1 A1
	$v = 6 - 1 - 1 = 4$ see notes	B1 ft
	$\chi^2_4(0.05) = 9.488 \Rightarrow$ CR: $\mathrm{X}^2 \geqslant 9.488$ a correct ft for their $\chi^2_k(0.05)$, where $k = n - 1 - 1$ from their n.	B1
	H_0 : Binomial distribution is a good(or suitable) model (or fit). H_1 : Binomial distribution is not a suitable model. [in the CR/significant/Reject H_0] Correct hypotheses	B1
	Binomial distribution is not a suitable model. A correct conclusion (context not required here) which is based on ***their*** X^2-value and ***their*** χ^2-critical value.	A1 **[8]**
(d)	Following from a correct conclusion in part (c), a comment conveying **either** • p is not constant • employer's belief is not justified.	B1 **[1]** **14**

# failed tasks	O_i	E_i	Comb O_i	Comb E_i	$\dfrac{(O-E)^2}{E}$	$\dfrac{O^2}{E}$
0	2	7.21	2	7.21	3.7648...	0.5548...
1	21	24.71	21	24.71	0.5570...	17.8470...
2	45	37.06	45	37.06	1.7011...	54.6411...
3	42	31.77 (31.76)	42	31.77 (31.76)	3.2941... (3.3016...)	55.5241... (55.5416...)
4	12	17.02	12	17.02	1.4806...	8.4606...
5	3	5.83	3	7.23 (7.24) {7.25}	2.4748… (2.4831…)	1.2448… (1.2431…)
$\geqslant 6$	0	1.40 (1.41)				
				Totals	13.2724... (13.2882...)	138.2724... (138.2882...)

M1 M1

	Notes	
6. (a)	**M1**	Must show clearly how to get either 300 or 1000.
	A1 cso	Showing how to get <u>both</u> 300 and 1000 and reaching $p = 0.3$
(b)	**M1**	For any correct method (or a correct expression) for finding either r or s.
	A1	r = awrt 31.77 or r = awrt 31.76
	A1	$s = 1.4$ or awrt1.40 or s = awrt1.41
(c)	**1st M1**	For an attempt to pool 5 failed tasks and $\geqslant 6$ failed tasks ONLY.
	Note	Give 1st M0 for pooling 0 failed tasks and 1 failed task.
	2nd M1	For an attempt at the test statistic, at least 2 correct expressions/values (to awrt 2 d.p. or truncated 2 d.p.)
	3rd dM1	***Dependent on the second method mark.*** For applying either $\sum \frac{(O-E)^2}{E}$ or $\sum \frac{O^2}{E} - 125$
	1st A1	awrt 13.3
	1st B1ft	For their evaluated $n-1-1$. i.e. realising that they must subtract 2 from their n.
	2nd B1	For a correct ft for their $\chi^2_k(0.05)$, where $k = n-1-1$ from their n.
	3rd B1	Must have both hypotheses and mention Binomial at least once. Inclusion of 0.3 for p in hypotheses is B0 but condone in conclusion.
	Final A1	***Dependent on the 2nd and 3rd Method marks only.*** A correct conclusion (context not required) which is rejecting H_0.
	Note	No follow through on their hypotheses if they are stated the wrong way round.
	Note	Contradictory statements score A0. E.g. "significant, do not reject H_0".
	Note	Condone mentioning of Bin(8, 0.3) in conclusion
	Note	Full accuracy gives a combined expected frequency of 7.245956..., $\frac{(O-E)^2}{E} = 2.4880$, $\frac{O^2}{E} = 1.2421$, $X^2 = 13.28333...$
	Note	p-value for the test is 0.0099 to 0.0100
	Note	No combining gives $X^2 = 13.58...$
	Note	Combining 0/1 and 4/5/$\geqslant$6 gives $X^2 = 11.02$

Question Number	Scheme	Marks
7. (a)	$X = 4Y - 3W$, $Y \sim N(40, 3^2)$, $W \sim N(50, 2^2)$; Y, W are independent.	
	$\{E(X) = 4E(Y) - 3E(W) = 4(40) - 3(50)\} \Rightarrow E(X) = 10$ $\quad E(X) = 10$ (seen or implied)	B1
	$\text{Var}(X) = 16\,\text{Var}(Y) + 9\,\text{Var}(W)$ $\quad$ Either $(4^2)\text{Var}(Y)$ or $+(3^2)\text{Var}(W)$	M1
	For adding the variances	M1
	$\{\text{Var}(X) = 16(9) + 9(4)\} \Rightarrow \text{Var}(X) = 180$ $\quad \text{Var}(X) = 180$	A1
	{So $X \sim N(10, 180)$}	
	$\{P(X > 25) =\}\ P\left(Z > \frac{25 - 10}{\sqrt{180}}\right)$ $\quad$ Standardising $(\pm)$ with their mean and their standard deviation	M1
	$= P(Z > 1.11803...)$ $\quad$ awrt ± 1.12	A1
	$= 1 - 0.8686$	
	$= 0.1314$ (or 0.131777...) $\quad$ awrt 0.131 or awrt 0.132	A1
		[7]
(b)	$A = \sum_{i=1}^{3} Y_i$, $C \sim N(115, \sigma^2)$; $P(A - C < 0) = 0.2$; A, C are independent.	
	$\{E(A - C) = 3E(Y) - E(C) = 3(40) - (115)\} \Rightarrow E(A - C) = 5$ $\quad E(A - C) = 5$	B1
	$\text{Var}(A - C) = 3\text{Var}(Y) + \text{Var}(C)$ $\quad 3\text{Var}(Y)$ and a + ...	M1
	$\{\text{Var}(A - C) = 3(9) + \sigma^2\} \Rightarrow \text{Var}(A - C) = 27 + \sigma^2$ $\quad \text{Var}(A - C) = 27 + \sigma^2$	A1
	{So $A - C \sim N(5, 27 + \sigma^2)$}	
	$\{P(A - C < 0) = 0.2\} \Rightarrow P\left(Z < \frac{-5}{\sqrt{27 + \sigma^2}}\right) = 0.2$	
	$\frac{-5}{\sqrt{27 + \sigma^2}} = k\ (= -0.8416)$ $\quad$ Standardising $(\pm)$ with their mean and their standard deviation which is in terms of σ^2 and setting the result equal to k, where $\lvert k \rvert$ is in the interval [0.84, 0.85].	M1
	± 0.8416 or awrt ± 0.8416	B1
	Correct equation. See notes	A1
	$\sigma^2 = \left(\frac{-5}{-0.8416}\right)^2 - 27 \Rightarrow \sigma^2 = ...$ $\quad$ Squaring and rearranging leading to a positive value for σ^2.	dM1
	$\sigma^2 = 8.2962...$ (= 8.4308... from using -0.84) $\quad$ awrt 8.3 or awrt 8.4	A1 **cso**
	(= 8.2945... from calculator, so need awrt 8.29 for full marks if no prior working is shown.)	**[8]**
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(a)	**Note**	Condone applying reversed variances, e.g. $16(4) + 9(9)$ for the first 2 method marks.
	Note	$\text{Var}(X) = 180$ with no working gets M1M1A1
	Note	$\text{Var}(X) = 48$ with no working gets M0M1A0
	Note	$\text{Var}(X) = 108$ with no working gets M1M0A0
	Note	$\text{Var}(X) = 24$ with no working gets M0M0A0
(b)	**2nd M1**	Allow $\frac{\pm \text{ their } E(A - C)}{\sqrt{\text{their Var}(A - C)}} = k$, where $\lvert k \rvert$ is in the interval $(0.84, 0.85)$.
	2nd B1	For either -0.8416 or 0.8416
	2nd A1	E.g. Allow $\frac{-5}{\sqrt{27 + \sigma^2}} = [-0.85, -0.84]$ or $\frac{5}{\sqrt{27 + \sigma^2}} = [0.84, 0.85]$
	3rd M1	***Dependent on the 2nd M1 mark being awarded.***

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