GradeMax



Mark Scheme (Results)

Summer 2025

Pearson Edexcel International Advanced Level In Statistics S3 (WST03) Paper 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.
- 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.

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
   - ⎾ 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

Special notes for marking Statistics exams (for AAs only)

- Any correct method should gain credit. If you cannot see how to apply the mark scheme but believe the method to be correct then please send to review.
- For method marks, we generally allow or condone a slip or transcription error if these are seen in an expression. We do not, however, condone or allow these errors in accuracy marks.

Question Number	Scheme	Marks
1 (a)	e.g. It reduces the potential of bias/favouritism in the selection of the players	B1
		(1)
(b)	[x =] 18	B1
		(1)
(c)	[Probability =] 0	B1
		(1)
	Notes	**Total 3**

(a)	**B1**	A correct reason referring to reducing bias or favouritism. May say e.g. “will not be selected based on ability” or “everyone has the same chance of being selected”. Condone e.g. “no bias” e.g. to make it fair Do not accept reasons relating to the benefits of taking a sample compared to a census e.g. “accurate”, “fast” but do not withhold the mark if there is a valid reason which is not contradicted by it
(b)	**B1**	Cao
(c)	**B1**	0 oe e.g. 0%

Question Number	Scheme	Marks
2 (a)	$\sum d^2 = 1+4+4+0+0+36+9+4+4+4 \left[= 66\right]$	M1
	$r_s = 1 - \dfrac{6\times '66'}{10\left(10^2-1\right)} = 0.6$	M1 A1
		(3)
(b)	$H_0 : \rho = 0 \qquad H_1 : \rho > 0$	B1
	Critical Value $r_s = 0.7455$ or CR: r_s …0.7455	B1
	e.g. Do not reject H_0 **or** e.g. not significant **or** e.g. does not lie in the critical region	M1
	e.g. there is insufficient evidence of a **positive correlation** between the **ranks** of **Judge 1** and **Judge 2**	A1ft
		(4)

	Notes		**Total 7**
(a)	**M1**	For finding the difference between ranks of judge 1 and judge 2 and evaluating $\sum d^2$. May be implied by 66. (Allow one error). May be implied by 0.6 or 0.4	
	M1	For using $1-\dfrac{6\sum d^2}{10(99)}$ with their $\sum d^2$ (this value cannot just be an attempt at adding the differences). May be implied by 0.6	
	A1	0.6 oe (a correct answer scores 3/3)	
(b)	**B1**	For both hypotheses correct. Must be in terms of ρ or ρ_s (condone if it appears as p) Must be attached to H_0 and H_1 (do not accept h for H) Do not allow hypotheses in words on their own.	
	B1	For CV of 0.7455 Allow $\pm$ and do not be concerned by use of a strict or inclusive inequality if a critical region is stated	
	M1	A correct statement independent of hypotheses ft part (a) $\left\|r_s\right\| < 1$ and their CV where $\left\|\text{CV}\right\| < 1$ with compatible signs. No context needed but do not allow contradicting non contextual statements. Condone e.g. "accept H_o", "reject H_1" lies in acceptance region. A correct contextual conclusion may imply this mark.	
	A1ft	Dependent on previous method mark and $\left\|r_s\right\| < \left\|\text{CV}\right\| < 1$. For a correct conclusion suggesting that there is insufficient evidence of a positive correlation between the ranks of the judges. Must mention <u>positive correlation</u> , <u>ranks</u> and the <u>judges</u> oe Condone e.g. "there isn't positive correlation between the ranks of the judges". Follow through their r_s with 0.7455 Note that M0A1ft is not possible. Note that a correct contextual conclusion on its own scores M1A1ft	
	Note	**Two-tailed test** Applying a two-tailed test scores a maximum of B0B0M1A0 allowing access to the M1 mark only	

Question Number	Scheme	Marks
3 (a)	$\frac{36\times 35}{250}$	M1
	5.04	A1
		(2)
(b)	H_0 : There is no association between when the car first experienced an engine problem and the type of engine H_1 : There is an association between when the car first experienced an engine problem and the type of engine	B1
	Observed | Expected | $\frac{(O-E)^2}{E}$ 10 | 5.04 | $\frac{(10-'5.04')^2}{'5.04'}(=4.881)$	M1
	$X^2 = 7.444 + '4.881'$	dM1
	$= 12.325$ awrt 12.3	A1
	$\nu = (3-1)(3-1) = 4$ $\quad \chi^2_4(0.05) = 9.488 \Rightarrow$ CR: X^2 …9.488	B1 B1ft
	[In the CR/Significant/Reject H_0] There is evidence of an association between when the car first experienced an engine problem and the type of engine	A1
		(7)

	Notes	**Total 9**
(a)	**M1**	For a correct method for finding the expected value (ignore other values if found)
	A1	5.04 oe isw e.g. if they attempt to find other expected frequencies as well. 5.04 with no incorrect working seen is 2/2
(b)	**B1**	Both hypotheses correct. Engine problems and type of engine mentioned at least once. (may be written in terms of independence (or association) e.g. H_0 : When the car first experienced an engine problem and the type of engine are independent H_1 : When the car first experienced an engine problem and the type of engine are not independent
	M1	For a correct method for finding the contribution to the X^2 value (seen or implied). May be seen in (a) or by the table
	dM1	Dependent on the previous method mark. For finding the test statistic X^2. Usually by adding their value to 7.444 (seen or implied). If they attempt to find the individual values using the table then the method must be correct.
	A1	awrt 12.3 (sight of awrt scores M1dM1A1)
	B1	$\nu = 4$ If not seen then may be implied by 9.488 or 11.143
	B1ft	9.488 or better or ft their DoF (e.g. $\nu = 2$, 5.991 or better or $\nu = 8$, 15.507 or $\nu = 9$, 16.919 or better)
	A1	Dependent on all previous method marks and their X^2 must lie in the critical region i.e. $X^2 >$"9.488" (where $X^2 > 7.444$) A correct contextualised conclusion which is rejecting H_0 Must mention **engine problem** and **type of engine** oe **If hypotheses are the wrong way round, then A0 here**. Do not withhold this mark if their hypotheses are in terms of ρ. Contradictory statements score A0. Condone "relationship" or "connection" here but **not** "correlation".

Question Number	Scheme	Marks
4 (a)	$\left[\bar{y}=\frac{23200}{80}\Rightarrow\right]\ \bar{y}=290$	B1
	$\left[s_y^{\,2}=\right]\frac{6741351-80(290)^2}{80-1}$ or $\left[s_y^{\,2}=\right]\frac{80}{79}\left(\frac{6741351}{80}-\left(\frac{23200}{80}\right)^2\right)$	M1
	$=169$	A1
		(3)
(b)	$H_0:\mu_x-\mu_y=200$ $\quad H_1:\mu_x-\mu_y>200$ oe	B1
	$z=\pm\frac{500-'290'-200}{\sqrt{\frac{'169'}{80}+\frac{1156}{80}}}$	M1 A1ft
	$=2.45718...$ awrt 2.46	A1
	One tailed c.v. Z = 1.6449 **or** CR: Z …1.6449	B1
	e.g. In CR/Significant/Reject H_0	M1
	Sufficient evidence to support the research **student's belief**	A1
		(7)
(c)	Assume that $s^2=\sigma^2$	B1
		(1)
	Notes	**Total 11**

(a)	**B1**	For $\bar{y}=290$
	M1	A correct method for $s_y^{\,2}$. May be implied by 169 on its own (not within a calculation)
	A1	169 do not isw
(b)	**B1**	Both hypotheses correct. Allow equivalent hypotheses. Must be in terms of μ . Use of $\bar{X}-\bar{Y}$ is B0. Allow *g* for *x* and *r* for *y* but use of any other letters must be defined.
	M1	An attempt at $\pm\frac{500-a-200}{\sqrt{\frac{b}{80}+\frac{1156}{80}}}$ oe with at least 1 of *a* or *b* correct using their 290 or their 169 May be implied by awrt ±2.46 or may state e.g. $N\left(\pm200,\frac{'169'}{80}+\frac{1156}{80}\right)$ (μ may be 0)
	A1ft	A correct expression [se $\sqrt{\frac{265}{16}}=4.0697...$] or imp by awrt ±2.46 or *p*-value of awrt 0.0072
	A1	awrt $z=$ 2.46 (possibly $\pm$) or $P(\bar{X}-\bar{Y}>210)=$ awrt 0.00716 Correct answer scores M1A1ftA1 but $200-(500-290)\rightarrow-10$ loses this 2nd A mark
	B1	awrt $\pm$ 1.6449 or better seen or a comparison of *p*-value awrt 0.007 < 0.05 oe
	M1	Dep. on $1<\lvert z\rvert<3$ or $0<P(\bar{X}-\bar{Y}>'210')<0.5$ A correct statement ft on their *z* value and CV, with compatible signs, or prob. Context not needed but do not accept contradicting non contextual comments
	A1	Dep on all **previous M and A marks** but independent of hypotheses. A correct contextual statement e.g. the **mean weight** of **grey squirrels** is **more than 200g greater** than (the mean weight) of **red squirrels** o.e. Must mention **mean weight** at least once if they mention weight or weights. Condone the **difference** (in **mean weights**) is **greater than 200g**
(c)	**B1**	Assume that sample variance = population variance oe (but not e.g. $s_x=s_y$).

Question Number	Scheme	Marks
5 (a)	$\hat{p} = \dfrac{0\times2+1\times40+2\times90+3\times85+4\times30+5\times3}{250\times5}$ or $\hat{p} = \dfrac{40+180+255+120+15}{250\times5}\left(=\dfrac{610}{1250}=\dfrac{122}{250}\right)$	M1
	$=0.488$	A1
		(2)
(b)	$250 - (41.92 + \ldots + 6.92)$	M1
	$= 8.79$	A1
		(2)
(c)	H_0 : Binomial distribution is suitable/sensible (model) H_1 : Binomial distribution is not suitable/sensible (model)	B1
	$\dfrac{(2-'8.8')^2}{'8.8'}\left[=5.25...\right]$	M1
	$\left[\sum\dfrac{(O-E)^2}{E}=\right]5.70+'5.25'=10.95$	dM1 A1
	$\nu = 6-1-1=4$	B1
	$\chi^2_4(0.05)=9.488 \Rightarrow$ CR..9.488	B1ft
	[In CR/Significant/Reject H_0] Significant evidence to suggest that a binomial distribution is not a suitable model	A1
		(7)

	Notes	**Total 11**
(a)	**M1**	For a correct method to find $\hat{p}$ May be implied by 0.488. Allow one error or omission for one of their products.
	A1	0.488 oe e.g. $\dfrac{61}{125}$
(b)	**M1**	For a correct method to find r (Allow $0.512^5\times250$) May be implied by 8.79 or 8.8(0)
	A1	Allow 8.8(0)
(c)	**B1**	Both Hypotheses correct. Must be attached to H_0 and H_1 Do not allow B(5, 0.488) is a suitable model
	M1	For use of $\dfrac{(O-E)^2}{E}$ ft their part (b). If no value is found in (b) or they use 5.7 then M0. May be implied by awrt 5.25 or awrt 10.95 or 10.9 or 11.0
	dM1	Dependent on the first method mark. For 5.70 + '5.25' ft their 5.25 May correctly attempt $\sum\dfrac{(O-E)^2}{E}$ or $\sum\left(\dfrac{O^2}{E}\right)-250$. May be implied by awrt 10.95 or allow 10.9 or 11.0
	A1	awrt 10.95 (allow 10.9 or 11.0)
	B1	4 [degrees of freedom] If not seen then may be implied by 9.488 or 11.143 (or better)
	B1ft	9.488 or better or ft on their dof e.g. 2: 5.991, 3: 7.815, 5: 11.07(0), 6: 12.592
	A1	Dependent on all previous method marks and a critical value > 5 where X^2>CV Requires a correct conclusion rejecting the null hypothesis. Must mention the (binomial) distribution/model

Question Number	Scheme	Marks
6 (a)	e.g. based solely on **known observations** or e.g. contains **no unknown** (population) **parameters**	B1
		(1)
(b)	$\left[\mathrm{E}(R)=\frac{1}{2}\mathrm{E}(X_1)+\frac{3}{4}\mathrm{E}(X_{20})\right]=\frac{1}{2}\mu+\frac{3}{4}\mu$	M1
	$\mathrm{E}(R)=\frac{1}{2}\mu+\frac{3}{4}\mu=\frac{5}{4}\mu\neq\mu$ e.g. So R is a biased estimator for μ	A1
		(2)
(c)	$'\frac{5}{4}\mu'-\mu=\frac{1}{4}\mu$	B1ft
		(1)
(d)	**One of** $a-b=2$ oe **or** $14a+6b=20$ oe **or** $\frac{a-b}{2}=\frac{14a+6b}{20}$ $\left[-4b=a\right]$ oe	B1
	Two of $a-b=2$ oe **,** $14a+6b=20$ oe , $\frac{a-b}{2}=\frac{14a+6b}{20}$ oe	B1
	Solves simultaneously e.g. $14a+6(a-2)=20\Rightarrow a=...,\ b=...$	M1
	a =1.6 oe, b = −0.4 oe	A1
		(4)

	Notes	Total 8
(a)	**B1**	For a correct explanation. Allow a valid explanation which suggests one of the following that it is • based (solely) on observations/calculations/values/information/data oe • contains no unknown (population) parameters • calculated/measured • numerical property of a sample/derived from a sample Do not allow "because it is known" (too vague) but condone "because X_1 and X_{20} are known"
(b)	**M1**	For use of $\mathrm{E}(R)=a\mathrm{E}(X_1)+b\mathrm{E}(X_{20})$. May be implied by a correct expression or $\frac{5}{4}\mu$
	A1	Requires an expression in terms of μ before proceeding to a correct simplified value of $\frac{5}{4}\mu$, a reason (e.g. $\neq\mu$) **and** a conclusion (e.g. biased estimator). Must see use of expectation notation e.g. $\mathrm{E}(R)$ or $\frac{1}{2}\mathrm{E}(X_1)+\frac{3}{4}\mathrm{E}(X_{20})$
(c)	**B1ft**	Follow through their part (b) $-\mu$ Their part (b) must be in terms of μ. May be seen in (b)
(d)	**B1**	For a correct equation in a and b only. μ must not be present
	dB1	Dep on 1st B1. For a second different correct equation in a and b only. μ must not be present
	M1	Dependent on at least one correct equation. For solving simultaneously and proceeding to values for a and b. You do not need to be concerned with the mechanics of the rearrangement as long as values for a and b are achieved. May be implied by a correct value for a or a correct value for b.
	A1	For correct values of a and b

Question Number	Scheme	Marks
7 (a)	$\left[\mathrm{P}\left(\bar{X}_n < 45.2\right) = 0.3446\right] \Rightarrow \dfrac{45.2-\mu}{\frac{\sigma}{\sqrt{n}}} = -0.4$ oe	M1
	$45.2 + \dfrac{0.4\sigma}{\sqrt{n}} = \mu$ oe	A1
	$\left[\mathrm{P}\left(\bar{X}_n > 75.2\right) = 0.0179\right] \Rightarrow \dfrac{75.2-\mu}{\frac{\sigma}{\sqrt{n}}} = 2.1$ oe	M1
	$75.2 - \dfrac{2.1\sigma}{\sqrt{n}} = \mu$ oe	A1
	e.g. $45.2 + \dfrac{0.4\sigma}{\sqrt{n}} = 75.2 - \dfrac{2.1\sigma}{\sqrt{n}}$ or e.g. $\dfrac{30}{\frac{\sigma}{\sqrt{n}}} = 2.5$ oe	M1
	$\dfrac{2.5\sigma}{\sqrt{n}} = 30 \Rightarrow \left[\sigma = 12\sqrt{n}\right]$*	A1*
		(6)
(b)	$\mu = 45.2 + \dfrac{0.4\times 12\sqrt{n}}{\sqrt{n}}$ or $\mu = 75.2 - \dfrac{2.1\times 12\sqrt{n}}{\sqrt{n}}$	M1
	$\mu = 50$	A1
		(2)
(c)	$\dfrac{\sigma}{\sqrt{n}} = \left[\dfrac{12\sqrt{n}}{\sqrt{n}}\right] = 12$	B1
	$\mathrm{P}\left(\bar{X}_n > 59\right) = \mathrm{P}\left(Z > \dfrac{59-'50'}{12}\right)$	M1
	$= 0.2266$ awrt 0.227	A1
		(3)
	Notes	**Total 11**

(a)	**Note**	**If they have not used the tables then maximum score M1A1M1A1M1A0* (5/6)**
	M1	For standardising with μ and $\dfrac{\sigma}{\sqrt{n}}$ and setting = $\pm$awrt 0.4
	A1	For a correct equation with compatible signs. Condone use of e.g. awrt 0.4
	M1	For standardising with μ and $\dfrac{\sigma}{\sqrt{n}}$ and setting = $\pm$awrt 2.1
	A1	For a correct equation with compatible signs. Condone use of e.g. awrt 2.1
	M1	Dependent on at least one correct equation. For solving their 2 equations simultaneously to eliminate μ. Note they may eliminate $\dfrac{\sigma}{\sqrt{n}}$ first to find μ (= 50) and then substitute this back into one of their simultaneous equations which can score this mark.
	A1*	Answer is given so no incorrect working must be seen. They must have an intermediate stage where the equation without μ has the constant terms collected and does not have any fractions within fractions before proceeding to the given answer.

		e.g. $\frac{30}{\frac{\sigma}{\sqrt{n}}} = 2.5 \Rightarrow \frac{25\sigma}{\sqrt{n}} = 300 \Rightarrow \sigma = 12\sqrt{n}$
(b)	**Note**	**If they do not have an equation in (a) involving the standard error $\frac{\sigma}{\sqrt{n}}$ then M0A0**
	M1	For substitution of $\sigma = 12\sqrt{n}$ into an equation for μ. May be implied by 50
	A1	50
(c)	**B1**	Correct SE seen or may be implied e.g. N(...,144) or awrt 0.227
	M1	For standardising using their μ and standard error = 12. Can be implied by awrt 0.227
	A1	awrt 0.227 (correct answer provided no incorrect working seen in (c) scores 3/3)

Question Number	Scheme	Marks
8(a)	$X = S_1 + S_2 + S_3$	
	$[X \sim]\text{N}(54, 0.0027)$ or e.g. $[\text{E}(X) =]54$, $[\text{Var}(X) =]0.0027$	M1 A1
	$\left[\text{P}(X > 54.1) =\right]\text{P}\left(Z > \pm\dfrac{54.1-'54'}{\sqrt{'0.0027'}}\right)\left[= \text{P}(Z > 1.924...)\right]$	M1
	$[=1-0.9726] = 0.0274$ (Calc 0.02714…) awrt 0.027	A1
		(4)
(b)	$Y = C_1 - C_2$	
	$[Y \sim]\text{N}(0, 0.0018)$ or e.g. $[\text{E}(Y) =]0$, $[\text{Var}(X) =]0.0018$	M1
	$\left[\text{P}(Y > 0.02) =\right]\text{P}\left(Z > \pm\dfrac{0.02-'0'}{\sqrt{'0.0018'}}\right)\left[= \text{P}(Z > 0.4714...)\right]$	M1
	$[=1-0.6808] = 0.3192$ (Calc 0.31867…) awrt 0.319	A1
	$2\times\text{P}(Y > 0.02) = 2\times'0.3192' = 0.6384$ (Calc 0.63735…) awrt 0.637 - awrt 0.638	M1 A1
		(5)
(c)	$T = P_1 + C_1 + ... + C_5 + S_1 + ... + S_{28}$	
	Let $R = T - 30P_1 = C_1 + ... + C_5 + S_1 + ... + S_{28} - 29P_1$ (or e.g. $Q = T - 30P_1 - 190$)	M1 A1
	$[R \sim]\text{N}(194, 33.6697)$ or e.g. $[\text{E}(R) =]194$, $[\text{Var}(R) =]33.6697$ (or $\text{N}(4, 33.6697)$)	M1 A1
	$\left[\text{P}(R < 190) =\right]\text{P}\left(Z < \pm\dfrac{190-'194'}{\sqrt{'33.6697'}}\right)\left[= \text{P}(Z < -0.68935...)\right]$ (or e.g. $\text{P}(Q < 0)$)	M1
	$[=1-0.7549] = 0.2451$ (Calc 0.2453…) awrt 0.245	A1
		(6)

	Notes		Total 15
(a)	**M1**	For N(54, …) oe seen or used. May see e.g. $[\text{E}(X) =]\ 3\times18$. Implied by awrt 0.027	
	A1	For N(54, 0.0027) oe seen or used (Standard deviation (0.05196…) May be seen in their standardisation. The unevaluated expressions for μ and σ^2 can score	
	M1	For standardising with 54.1, their mean $\neq 18$ or 6 and their standard deviation $\neq 0.03$ or 0.0027 (if their mean/or their sd/var are incorrect then working must be shown. Allow $\pm$ stand	
	A1	awrt 0.027 **provided standardisation seen**	
(b)	**M1**	For N(0, 0.0018) oe seen or used e.g. seen in their standardisation. The unevaluated expressions for μ and σ^2 can score. Implied by awrt 0.319 or awrt 0.637– awrt 0.638	
	M1	For standardising with 0.02, their mean and their standard deviation $\neq 0.0018$. Allow $\pm$ stand	
	A1	awrt 0.319 **provided standardisation seen.** May be implied by their final answer	
	M1	For 2 × their 0.319 provided their probability of "0.319" is < 0.5 Imp by correct prob statement	
	A1	**Dep on all previous method marks scored and standardisation seen** awrt 0.637– awrt 0.638	
(c)	**M1**	For sight or use of $T - 30P_1$ may be implied by sight of 194 oe or awrt 33.7 oe. May attempt $T - 30P_1 - 190$ May be implied by sight of 4.	
	A1	for $C_1 + ... + C_5 + S_1 + ... + S_{28} - 29P_1$ oe May be implied by sight of awrt 33.7.	
	M1	For N(194, …) oe seen or used. May be unsimplified. (or N(4, …))	
	A1	For N(194, 33.6697) oe seen or used. The expressions for μ and σ^2 can score. (or N(4,33.6697))	
	M1	For standardising with 190, their mean and their standard deviation $\neq 33.6697$. Allow $\pm$ stand	
	A1	**Dependent on all previous marks scored** for awrt 0.245 **provided standardisation seen**	

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