RECOGNISING ACHIEVEMENT

GCE

Mathematics

Advanced GCE

Unit **4733:** Probability and Statistics 2

Mark Scheme for January 2013

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations and abbreviations

Annotation in scoris	Meaning
✓and ✖	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
Highlighting	

Other abbreviations in mark scheme	Meaning
E1	Mark for explaining
U1	Mark for correct units
G1	Mark for a correct feature on a graph
M1 dep*	Method mark dependent on a previous mark, indicated by *
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working
Ft or √	Follow through

Subject-specific Marking Instructions for GCE Mathematics (OCR) Statistics strand

a. Annotations should be used whenever appropriate during your marking.

The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

b. An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct *solutions* leading to correct answers are awarded full marks but work must not be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly.

Correct but unfamiliar or unexpected methods are often signalled by a correct result following an *apparently* incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) you should contact your Team Leader.

c. The following types of marks are available.

M
A suitable method has been selected and *applied* in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, eg by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B
Mark for a correct result or statement independent of Method marks.

E

A given result is to be established or a result has to be explained. This usually requires more working or explanation than the establishment of an unknown result.

Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d. When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation 'dep *' is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e. The abbreviation ft implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise A and B marks are given for correct work only — differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f. Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise.

Candidates are expected to give numerical answers to an appropriate degree of accuracy. 3 significant figures may often be the norm for this, but this always needs to be considered in the context of the problem in hand. For example, in quoting probabilities from Normal tables, we generally expect *some* evidence of interpolation and so quotation to 4 decimal places will often be appropriate. But even this does not always apply – quotations of the standard critical points for significance tests such as 1.96, 1.645, 2.576 (maybe even 2.58 – but not 2.57) will commonly suffice, especially if the calculated value of a test statistic is nowhere near any of these values. Sensible discretion *must* be exercised in such cases.

Discretion must also be exercised in the case of small variations in the degree of accuracy to which an answer is given. For example, if 3 significant figures are expected (either because of an explicit instruction or because the general context of a problem demands it) but only 2 are given, loss of an accuracy ("A") mark is likely to be appropriate; but if 4 significant figures are given, this should not normally be penalised. Likewise, answers which are slightly deviant from what is expected in a very minor manner (for example a Normal probability

given, after an attempt at interpolation, as 0.6418 whereas 0.6417 was expected) should not be penalised. However, answers which are *grossly* over- or under-specified should normally result in the loss of a mark. This includes cases such as, for example, insistence that the value of a test statistic is (say) 2.128888446667 merely because that is the value that happened to come off the candidate's calculator. Note that this applies to answers that are given as final stages of calculations; intermediate working should usually be carried out, and quoted, to a greater degree of accuracy to avoid the danger of premature approximation.

The situation regarding any particular cases where the accuracy of the answer may be a marking issue should be detailed in the mark scheme rationale. If in doubt, contact your Team Leader.

g. Rules for replaced work

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

NB Follow these maths-specific instructions rather than those in the assessor handbook.

h. Genuine misreading (of numbers or symbols, occasionally even of text) occurs. If this results in the object and/or difficulty of the question being considerably changed, it is likely that all the marks for that question, or section of the question, will be lost. However, misreads are often such that the object and/or difficulty remain substantially unaltered; these cases are considered below.

The simple rule is that *all* method ("M") marks [and of course all independent ("B") marks] remain accessible but at least some accuracy ("A") marks do not. It is difficult to legislate in an overall sense beyond this global statement because misreads, even when the object and/or difficulty remains unchanged, can vary greatly in their effects. For example, a misread of 1.02 as 10.2 (perhaps as a quoted value of a sample mean) may well be catastrophic; whereas a misread of 1.6748 as 1.6746 may have so slight an effect as to be almost unnoticeable in the candidate's work.

A misread should normally attract *some* penalty, though this would often be only 1 mark and should rarely if ever be more than 2. Commonly in sections of questions where there is a numerical answer either at the end of the section or to be obtained and commented on (eg the value of a test statistic), this answer will have an "A" mark that may actually be designated as "cao" [correct answer only]. This should be interpreted *strictly* – if the misread has led to failure to obtain this value, then this "A" mark must be withheld even if all method marks have been earned. It will also often be the case that such a mark is implicitly "cao" even if not explicitly designated as such.

On the other hand, we commonly allow "fresh starts" within a question or part of question. For example, a follow-through of the candidate's value of a test statistic is generally allowed (and often explicitly stated as such within the marking scheme), so that the candidate may exhibit knowledge of how to compare it with a critical value and draw conclusions. Such "fresh starts" are not affected by any earlier misreads.

A misread may be of a symbol rather than a number – for example, an algebraic symbol in a mathematical expression. Such misreads are more likely to bring about a considerable change in the object and/or difficulty of the question; but, if they do not, they should be treated as far as possible in the same way as numerical misreads, *mutatis mutandis*. This also applied to misreads of text, which are fairly rare but can cause major problems in fair marking.

The situation regarding any particular cases that arise while you are marking for which you feel you need detailed guidance should be discussed with your Team Leader.

Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

Question			Answer	Marks	Guidance	
1			$n = 9$ CR is ≤ 2 **0.0083**	B1 M1A1 A1 **[4]**	Stated explicitly 2 seen but not ≤: M1A0. Allow "P(≤ 2)" Or more SF. "$n = 9$, CR ≥ 3", 0.0083 seen: B1M1A0A1	CR must be stated explicitly for A1 SR: ≤ 3 with 0.0424: (B1)M1A0 SR: If 0, give B1 for at least 3 of 0.0083, 0.0113, 0.0026, 0.0197, 0.0034 seen
2	(i)		$\hat{\mu} = \bar{x} = 38$ $\frac{\Sigma x^2}{10} - 38^2$ [= 16.2] ×10/9 to get **18**	B1 M1 M1 A1 **[4]**	38 stated separately Use of $\Sigma x^2/n - \bar{x}^2$ Multiply by 10/9 18 or a.r.t. 18.0 only	Correct single formula: M2 If single formula, divisor of 9 seen anywhere gets second M1
2	(ii)		$\Phi\left(\frac{40 - 38}{\sqrt{18}}\right) = \Phi(0.4714) =$ **0.3187**	M1 A1 **[2]**	Standardise with their μ and σ, allow cc, √ errors Answer, a.r.t. 0.319	√10 used: M0. Allow a.r.t. 0.311 [0.3106] from 16.2
3	(i)		Allocate 4-digit number to each DVD; Select using random numbers Ignore random numbers outside range	B1 B1 B1 **[3]**	"DVD" & "4 digits/1 to 9000/sequentially" etc must be mentioned *somewhere* Mention random numbers Unbiased method, mention of "outside range" or "repeats"	*Not* allocate "random" numbers, unless subsequently sorted If "pick random numbers in range 1 to 9000", must mention repeats
3	(ii)		B(100, 0.24) ≈ N(24, 18.24) $\Phi\left(\frac{19.5 - 24}{\sqrt{18.24}}\right) = \Phi(-1.0537)$ = **0.1461**	M1 A1 M1 A1 A1 **[5]**	N(attempt at *np*) Both parameters correct Standardise with their *np* and √*npq* or *npq* Both cc correct and √*npq* used Answer, a.r.t. 0.146	Allow 18.24/100 A1 but then M0A0 Allow cc/√ errors.

Question			Answer	Marks	Guidance	
4	**(i)**		Values taken by X	B1 **[1]**	This answer only	Not "values taken by f"
4	**(ii)**		$\int_0^a kx dx = 1 \Rightarrow k = \frac{2}{a^2}$	M1 A1 **[2]**	Use definite integral and equate to 1, Correctly obtain $2/a^2$	*Or* clear argument from triangle area
4	**(iii)**		$\int_0^a kx^2 dx = \left[k\frac{x^3}{3}\right]_0^a = \frac{2}{3}a$ $\int_0^a kx^3 dx = \left[k\frac{x^4}{4}\right]_0^a = \frac{a^2}{2}$ $\frac{a^2}{2} - \left(\frac{2}{3}a\right)^2 = \frac{1}{18}a^2$	M1 B1 A1√ M1* depM1 A1 **[6]**	Attempt to integrate $xf(x)$, limits 0 and a Correct indefinite integral seen Correct mean *or* correct $E(X^2)$ [$= a^2/2$], √ on k Attempt to integrate $x^2f(x)$, limits 0, a Subtract their μ^2 Correct final answer, ae exact f, no k now	either here or for $x^2f(x)$ Can be in terms of k Or decimal, $0.056a^2$ or better
5	**(i)**		Po(4200) ≈ N(4200, 4200) $1 - \Phi\left(\frac{4350.5 - 4200}{\sqrt{4200}}\right)$ = 1 – Φ(2.322) = **0.010**(1)	M1 M1 M1 A1 A1 **[5]**	Po(60λ) stated or implied N(60λ, 60λ) Standardise with their 60λ and $\sqrt{60\lambda}$ or 60λ 4350.5 explicitly seen and $\sqrt{60\lambda}$ not wrong Answer, allow a.r.t. 0.010	Allow wrong or no cc, or no √ $\sqrt{60\lambda}$ needn't be explicit Allow [0.0103,0.0106] from no CC, but *not* 0.0105 from wrong CC
5	**(ii)**		B(30, 0.010(1)) ≈ Po(0.30(3)) 1 – 0.9997 = **0.0003**	M1 A1 A1 **[3]**	B(30, their (i)) stated or implied Po(0.3) or 0.303 etc Final answer a.r.t. 0.0003	Exact binomial [0.00022]: M1A0A0 [0.30→0.000266. 0.303→0.000276. 0.309→0.000297]

Question			Answer	Marks	Guidance	
6	(i)		H_0: $\mu = 28.0$ H_1: $\mu > 28.0$	B2	One error, e.g. p, or μ_0, μ_1, or 2-tail: B1.	But $\bar{x}$ etc: B0
			α: $\frac{28.98 - 28}{12/\sqrt{30}} = 0.4473$ [$p = 0.3274$]	M1	Standardise with √30, allow √ errors, cc	CC is CORRECT here
				A1	Correct value of z or p: z = art 0.447 or p in range [0.327, 0.328]	*Not* –0.447 but can be recovered if 0.327 used. Not 0.455/0.3246
			$z < 1.645$, or $p > 0.05$ OR: CC: $28.98 - \frac{1}{60} \rightarrow 0.4397$, $p = 0.33$	A1	Compare z (incl 30) with 1.645, or p with 0.05, or with 0.95 if correct tail	Needs μ and $\bar{x}$ right way round
			β: $28 + 1.645 \times 12/\sqrt{30}$ $= 31.6$ $28.98 < 31.6$	M1 A1√ A1	$28 + z \times 12/\sqrt{30}$, allow √ errors, cc Correct CV, √ on z (only) Explicitly compare 28.98	Ignore 28 – …, do not allow 28.98 – ...
			γ: Totals used: $\frac{869.4 - 840}{12\sqrt{30}} = 0.4473$		Same scheme	NB: If totals used, allow ANY plausible CC or none
			Do not reject H_0. Insufficient evidence of an increase in mean score	M1 A1	Consistent first conclusion Contextualised, "evidence" or exact equivalent somewhere	Needs correct method & comparison, 30 used, μ and $\bar{x}$ right way round "Evidence" in either part of conclusion
			SD unchanged, *or* random sample/indept	B1 **[8]**	One of these seen, nothing irrelevant	
6	(ii)		Yes because population not stated to be normal	B2 **[2]**	Partial answer: B1 "Yes as parent distribution not normal" (i.e., "stated to be" omitted): B2 SR: "No as assumed normal" if in (i): B1	"Yes, because n large": B1 "Yes, as not normal and n large": B1 "Yes as not normal, but can be used as n large": B2
7	(i)		$\frac{\mu - 20}{\sigma/\sqrt{n}} = 1.0$; $\frac{35 - \mu}{\sigma/\sqrt{n}} = 2.0$	M1 A1	Standardise either 20 or 35, equate to Φ^{-1} Both equations completely correct	With $\sqrt{n}$ or n and z, allow "1 –", cc Including signs, but can have wrong z
			Solve to get $\sigma = 5\sqrt{n}$	B1 M1 A1 **[5]**	Both correct z-values seen (to 3 SF at least) Correctly obtain $\sigma = k\sqrt{n}$ or $\sigma^2 = kn$ $\sigma = 5\sqrt{n}$ or $\sqrt{25n}$ only.	Independent of previous marks Allow √ errors, ALLOW from not Φ^{-1} [only mark from 0.7998 & 0.8358]
7	(ii)		Binya is right	B1	Binya stated	"Aidan" used: max B0B1M0
			$\mu = 25$	B1	$\mu = 25$ following no wrong working	But allow if $\sqrt{n}$ omitted or wrong
			$1 - \Phi\left(\frac{32 - \mu}{5}\right) = 1 - \Phi(1.4)$	M1	Standardise with their $\sigma/\sqrt{n}$ and their numerical μ	NB: use of 1.282 probably implies "Aidan"
			$= 1 - 0.9192$ = **0.0808**	A1 **[4]**	Answer, a.r.t. 0.081, CWO.	

Question			Answer	Marks	Guidance	
8	(i)		Failures do not occur at regular or predictable intervals	B1 **[1]**	*Not* equivalent of "independent". *Not* "equally likely at any moment"	Both right and wrong: B0
8	(ii)		Failures occur independently; Might not happen if a power cut … and at constant average rate; Might not happen if manipulated to change more rapidly at peak times	B1 B1 B1 B1 **[4]**	"Failures" needed in one reason, else B0(B3) Plausible reason Exact equivalents only Must be during one day and not week/year Allow any answers that show correct statistical understanding, however implausible	*Not* "randomly", allow "singly" only if also "independent" in this part Not "equal probability", *not* "constant rate", but allow second mark if OK. Extra wrong reason loses explanation mark
8	(iii)		$e^{-\lambda}\frac{\lambda^7}{7!} = e^{-\lambda}\frac{\lambda^8}{8!} \Rightarrow \lambda = 8$ **0.1396**	M1 A1 M1 A1 B1√ **[5]**	At least one correct formula Both sides correct Cancel exp and some λ Obtain $\lambda = 8$ only, CWO Answer in range [0.139, 0.14], √ on their λ	 [before rounding]
9	(i)		4.81% or 0.0481	B1 **[1]**	One of these only, or more SF	N(18, 7.2) → 0.0468: B1
9	(ii)		P(≥ 14) = 0.7077	M1 A1 **[2]**	Allow M1 for answer 0.5722 or 0.8192 0.708 or 0.7077 or more SF	0.2923: 0 N(15, 7.5) → 0.78: M1A1; 0.8194 or 0.7674: M1A0
9	(iii)		Only way that $p = 0.5$ for second test is if Type II error on first, where 0.2 × 0.7077 = 0.14154. Therefore 0.14154 × 0.2923 + 0.85846 × 0.0481 = **0.0827**	M1 M1 M2 A1 **[5]**	0.2 × 0.7077 × 0.2923 [= 0.04137] Consider 1 – 0.14154 0.2 × (ii) × (1 – (ii)) + (1 – [0.2 × (ii)]) × (i) [= 0.04137 + 0.04127] Answer, a.r.t. 0.083 OR: 0.8 × 0.0481 × 0.0481 [0.00185] + 0.8 × 0.9519 × 0.0481 [0.03663] M1 + 0.2 × 0.2923 × 0.0481 [0.00281] M1 + 0.2 × 0.7077 × 0.2923 [0.04137] M1 Add up 4 terms of 3 multiplications M1 Answer 0.0827 A1	Normal: 0.1416×0.292 + 0.8584×0.0468 or 0.00175+0.03569+0.00273+0.04135 = 0.0815: full marks Any two of these three M1 Third of these three M1 This one M1 SR: No 0.8 or 0.2 but 2 products: M1 4 products: M2

APPENDIX 1

Generic mark scheme issues for S2:

1 Standardisation using the normal distribution.

(a) When *stating* parameters of normal distributions, don't worry about the difference between σ and σ^2, so allow N(9, 16) or N(9, 4^2) or N(9, 4). When *calculating* $\frac{\bar{x}-\mu}{\sigma/\sqrt{n}}$, the following mistakes are accuracy mistakes and not method mistakes so can generally score M1A0:

- confusion of σ with σ^2 or $\sqrt{\sigma}$
- n versus $\sqrt{n}$
- wrong or no continuity corrections.

(b) Some candidates are taught to calculate, for example, P(X > 5) from N(9, 16) by calculating instead P(X < 13). This is a correct method, though it looks very strange the first time you see it.

(c) In hypothesis tests, use of $\frac{\mu-\bar{x}}{\sigma}$ instead of $\frac{\bar{x}-\mu}{\sigma}$ is not penalised if it leads to a correct probability, but if the candidate is using a z-value in a hypothesis test, an answer of z = –2.15 when it ought to be 2.15 is an accuracy error and loses the relevant A1. When finding μ or σ from probabilities, some candidates are taught to use $\frac{\mu-\bar{x}}{\sigma}$ whenever $\mu > \bar{x}$; provided the signs are consistent this gains full marks.

(d) When calculating normal approximations to binomial or Poisson distributions, use of the wrong, or no, continuity correction generally loses the last two marks: A0 A0.

2 **Conclusions to hypothesis tests.** There are generally 2 marks for these.

(a) In order to gain M1, candidates must not only say the correct "Reject/do not reject H_0" but have done the whole test in essence correctly apart from numerical errors. In other words:

- they must have compared their *p* value with a critical *p* value or other "like-with-like" (e.g. *not* say 0.0234 with 1.96)
- using the correct tail (e.g. *not* –2.61 with +2.576), and
- the working should in general have accuracy errors only.

Thus miscalculation of *z*, comparison with 1.645 instead of 1.96, or using *n* instead of $\sqrt{n}$, or omission of a continuity correction when it is necessary, are all accuracy errors and the candidate can still gain the last M1 A1. Omission of $\sqrt{n}$ where it is necessary is a method mistake and so gets M0. In hypothesis tests using discrete distributions, use of P(≤ 12) or P(> 12) or P(= 12) when it should be P(≥ 12) is a method mistake and usually loses all the final marks in a question.

(b) The A1 mark is for interpreting the answer *in the context of the question*, and *without over-assertiveness*. Thus "The mean number of applicants has increased" is over-assertive and gets A0 (although we allow "There is sufficient evidence to reject H_0. The mean number of applicants has increased", A1), and "There is sufficient evidence that the mean has increased" is not contextualised, so that too is A0.

(c) A wrong statement such as –2.61 > –2.576 generally gets B0 for comparison but can get the subsequent M1A1. Otherwise:

(d) If there is a self-contradiction, award M1 only if "Reject/Accept H_0" is consistent with their comparison. Thus if, say, we had $z = 2.61 > z_{crit} = 2.576$:
"Reject H_0, there is insufficient evidence that the mean number of … has changed" is M1A0.
but "Do not reject H_0, there is evidence that the mean number of … has changed" is M0A0.
If they omit any mention of H_0/H_1 and just say "there is evidence that the mean number of …" etc, that's A2 or A0.

(e) We don't usually worry about differences between "Reject H_0" and "Accept H_1" etc.

APPENDIX 2

Question 6(i) specific examples – marks out of 7 (rather than 8: condition not included)

α	H_0: $\bar{x} = 28.0$; H_1: $\bar{x} > 28.0$ *[wrong symbol]* $z = \frac{28.98 - 28.0}{\sqrt{12/30}} = 1.550$ *[wrong √]* < 1.645 Accept H_0, no increase in average score *[over-assertive, otherwise A1]*	B0B0 M1 A0 A1 M1A0 **3**	δ	$H_0 = 28.0$; $H_1 > 28.0$ *[missing symbol]* $z = \frac{28.0 - 28.98}{12/\sqrt{30}} = -0.447$ *[loses 1]* > -1.645 Insufficient evidence to reject H_0. No change in average score. *[OK]*	B1 only M1 A0 A1 M1 A1 **5**
β	H_0: $\mu = 28.98$; H_1: $\mu < 28.98$ *[WRONG]* $z = \frac{28.98 - 28.0}{12/\sqrt{30}} = 0.447$ *[allow this – BOD]* < 1.645 Accept H_0. Insufficient evidence of a change in maximum daily temperature.	B0B0 M1 A1 A1 M1 A1 **5**	ε	H_0: $\mu = 28.0$; H_1: $\mu \neq 28.0$ *[two-tail]* $z = \frac{28.98 - 28.0}{12/\sqrt{30}} = 0.447$ < 1.96 [also if < 1.645] Accept H_0. Insufficient evidence of a change in average score.	B1B0 M1 A1 A0 M1 A1 **5**
γ	*CONTRAST:* H_0: $\mu = 28.98$; H_1: $\mu < 28.98$ *[WRONG]* $z = \frac{28.0 - 28.98}{12/\sqrt{30}} = -0.447$ *[DON'T allow this]* > -1.645 Accept H_0. Insufficient evidence of a change in average score.	B0B0 M1 A0 A1 M0 A0 **2**	ζ	H_0: $\mu = 28.0$; H_1: $\mu > 28.0$ $z = \frac{28.0 - 28.98}{12/\sqrt{30}} = -0.447$ *but then…* So $p = 0.327 > 0.05$ *[OK here]* Accept H_0. Insufficient evidence of a change in average score.	B2 M1 A1 A1 M1 A1 **7**
			η	H_0: $\mu = 28.0$; H_1: $\mu > 28.0$ $z = \frac{28.98 - 28.0}{12} = 0.0817$ *[no √30]* < 1.645 Accept H_0. Insufficient evidence of a change in average score.	B2 M0 A0 A0 M0 A0 **2**

Question 8, specimen answers:

(i) There is no pattern to the failures and they occur independently of one another B0
Equally likely to occur at any moment in time B0
Impossible to predict B1

(ii) Failures occur singly, unlikely as there could be a power failure that affects all lights in an area: B0B1
Failures occur independently of each other: (B1)
Likely because one failure does not cause another B1

Mean number of traffic light failures is constant each day B0 (OK if each hour etc)
Failures occur at constant average rate: (B1)
Unlikely as could change with season B0
Likely as each set has same probability of failing B0
Likely as they run in the same mode all day B1

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