OCR
Oxford Cambridge and RSA

GCE

Mathematics

Unit **4733**: Probability and Statistics 2

Advanced GCE

Mark Scheme for June 2014

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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.

1. **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

2. 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/Indicative content	Marks	Guidance
1		N(35, 10.5)	M1	Normal, mean 35
			A1	Both parameters correct, allow $\sqrt{10.5}$ or 10.5^2
		$1-\Phi\left(\frac{40.5-35}{\sqrt{10.5}}\right) = 1-\Phi(1.697)$	M1	Standardise, their *np*, *npq*, allow no $\sqrt{}$ or 10.5^2, allow wrong or no cc
			A1	Both 40.5 and $\sqrt{npq}$ [Ans 0.0448 or 0.9552 can imply first 4 marks]
		= 1 – 0.9552 = **0.0448**	A1	Answer, a.r.t. 0.045. [Exact binomial (0.040232): 0/5]
			[5]	
2	(i)		M1	Consider any two conditions, out of *np*, *nq* (allow *npq*), size of *n*, size of *p*
		np = 147 > 5 so not Poisson	A1	147 stated, or "*p* not small", no wrong conditions for Poisson seen
		nq = 3 < 5 so not normal	A1	3 [not *just* 2.94] stated, or "*p* not close to ½", no wrong conditions for normal seen (apart from *npq*)
				If spurious extra reasons seen ("not independent" etc), max 2/3
			[3]	
2	(ii)	*A* ~ B(150, 0.98) so 150 – *A* ~ B(150, 0.02)	M1	Clearly consider complement, with *p* = 0.02
		≈ Po(3)	A1	Po(3) stated or implied
		P(A < 146) = P(150 – *A* > 4) = 1 – 0.8153	M1	1 – Po(3) probability, e.g. 0.3528 or 0.0839
		= **0.1847**	A1	0.185 or better [Exact binomial (0.1830): 0/4. N(3, 2.94): M1A0M0A0]
			[4]	
3	(i)	$\frac{\mu-40}{\sigma} = 0.9544$	M1	Standardise with μ and σ and equate to Φ^{-1}, allow σ^2 but not $\sqrt{n}$, allow 1–, cc, wrong signs. P(…): M0 here. But can recover both marks from part (ii).
			B1	[0.954, 0.955] seen
			[2]	
3	(ii)	$\frac{60-\mu}{\sigma} = 0.674(5)$	M1	Standardise as in (i) but do not give if "1 –" or wrong signs in *either* equation
			B1	[0.674, 0.675] seen. (Other errors lead to loss of A marks.)
		Solve to get $\sigma = 12.3$ [12.278]	A1	σ, a.r.t. 12.3, cwo
		$\mu = 51.7(18)$	A1	μ, a.r.t. 51.7, cwo [NB: ***CARE!*** either or both can be obtained from wrong equns.]
			[4]	{note for scoris zoning – (i) to be visible in marking (ii)}
3	(iii)	Based on a sample/small sample, etc	B1	Any similar comment, e.g. "frequencies not probabilities" (but not *just* "*n* is small") *and* no wrong comments. Not "because data is grouped". No scattergun.
			[1]	

4	(i)	Snakes must occur independently of one another	B1 **[1]**	Contextualised ("snakes" must be mentioned); not *just* "singly" but allow both independent and singly. Allow explanation, e.g. "Occurrence of one snake doesn't affect occurrences of others". Allow "snakes must occur randomly". Otherwise, more than one condition, "e.g. "randomly, independently, singly and at constant rate": 0.
4	(ii)	$1 - P(\leq 5)$ $= 1 - 0.7851$ $= \mathbf{0.2149}$	M1 A1 **[2]**	Give M1 for 0.3712, 0.1107 or 0.2307. Answer 0.7851 is M0. Answer, a.r.t. 0.215
4	(iii)	Po(3.08) $e^{-3.08}\left(\frac{3.08^2}{2!}+\frac{3.08^3}{3!}\right)$ [= 0.2180 + 0.2238] $= \mathbf{0.4418}$	M1 M1 A1ft A1 **[4]**	Po(3.08) stated or implied. [Just $\lambda = 3.08$ is M0 unless Poisson later.] Correct formula for Po ($r > 0$) used at least once, can be implied Completely correct formula for their λ (not 4), can be implied Final answer, a.r.t. 0.442 No working: last 3 marks either 0 or 3, no "nearly right".
5	(i)	$\int_0^1 \frac{\pi}{2}\sin(\pi x)\,dx = \left[-\frac{1}{2}\cos(\pi x)\right]_0^1 = \frac{1}{2}-\left(-\frac{1}{2}\right)=1$ and function non-negative for all x in range	M1 B1 A1 B1 **[4]**	Attempt to integrate f(x), limits (0, 1) somewhere, evidence e.g. "from calculator" Correctly integrate $\sin(\pi x)$ to $-\frac{1}{2}\cos(\pi x)$ Fully correct, need to see $-\frac{1}{2}\cos(\pi x)$ and final 1, no wrong working seen Non-negative asserted explicitly, allow positive or equivalent. Not just graph drawn. *(Most will not get this mark!)*
5	(ii)	 $E(X) = ½$	M1 A1 B1 **[3]**	Correct shape, through 0, allow below axis outside range. Allow partial curve if clearly part of sine curve. Fully correct including no extension beyond [0, 1]. Don't worry about grads at ends. Ignore labelling of axes ½ or 0.5, needs to be simplified, no working needed, *no* ft
5	(iii)	$\int_q^1 \frac{1}{2}\pi\sin(\pi x)dx = 0.75;\ \{\left[-\frac{1}{2}\cos(\pi x)\right]_q^1 = 0.75\}$ $\cos(\pi q) = 0.5$ Solve to get $q = ⅓$	M1 A1 A1 **[3]**	Equate integral to correct probability, correct limits *somewhere* allow complementary probability (= 0.25) only if limits (0, q) $\cos(\pi q) = 0.5$ or exact equivalent $q = ⅓$ or a.r.t. 0.333. SR: Numerical (no working needed): 0.333 B3, 0.33 B2
5	(iv)	$\int_0^1 \frac{\pi}{2}x^2\sin(\pi x)\,dx - \left(\frac{1}{2}\right)^2$	M1 A1ft **[2]**	Integral part correct, allow limits omitted, ignore dx Subtract their $[E(X)]^2$, allow μ in form of integral, correct limits needed, not just "μ^2" {note for scoris zoning – (ii) needs to be visible here}
5	(v)	Values of x in range close to E(X) are more likely than those further away	B1 **[1]**	Need to see "values of x" or equivalent, and probably not "occur" *Not* "the probability of x is greater when x is close to E(X)" etc. *Not* "PDF greater …"

6	(i)	Sample is random	B1 **[1]**	Indicate random sample. Allow "unbiased sample" or "randomly selected" or "all equally likely". Allow "representative" provided it's clearly "of company" (not city) Not just "independent". Withhold if extra wrong bits.
6	(ii)	List population, number sequentially Select using random numbers	B1 B1 **[2]**	List can be implied; must imply employees or people. "Sequential" can be assumed. Not "select numbers randomly", Don't need "ignore outside range" etc. Number randomly *and* select randomly, B1, but "assign random nos & arrange", B2 SC: Put names into hat/lottery machine and take them out: B2 SC: Systematic: B1 for list, can get second B1 if starting-point random
6	(iii)	H_0: $p = 0.4$; H_1: $p < 0.4$ B(12, 0.4) α: P(≤ 2) = **0.0834** > 0.05	B2 M1 A1 A1	Both correct, B2. Allow π. One error, e.g, μ or no symbol, B1, but $\bar{x}$, z etc: B0. B(12, 0.4) stated or implied. Can be implied by N(4.8, 2.88) but no further marks. 0.1673, 0.0398, 0.1513, 0.0421: M1A0(A1M1A1) P(≤ 2) = 0.0834, or P(> 2) = 0.9166. Compare numerical P(≤ 2) with 0.05, or P(> 2) with 0.95
		β: CR is ≤ 1 0.0196 seen and compare 2 with ≤ 1	A1 A1	CR is ≤ 1 stated. Explicitly compare 2 with CR, probability 0.0196 must be seen
		Do not reject H_0. Insufficient evidence that proportion of employees from group *Z* is less.	M1 A1ft **[7]**	Correct first conclusion, needs P(≤ 2 | $p = 0.4$) or fully consistent equivalent In context (mention "employees", "city" etc), acknowledge uncertainty ("evidence") *Not* "there is evidence that the proportion of employees is 0.4" FT on wrong *p*-value or wrong critical value if previous mark gained SC: Normal: B2 M1 max SC: P(= 2) or P(≥ 2) or P(< 2): B2 M1 max SC: two-tailed: can get B1B0 M1A1A0 M1A1 (don't give second A1 for 0.05)
6	(iv)	Yes as H_0 is rejected	M1 A1 **[2]**	Realise this changes conclusion (FT!), or "more likely to reject H_0", "larger CR" More supportive [just "more supportive" without evidence is M0A0]
7	(i)	$\hat{\mu} = \bar{x} = 81$ $\frac{329800}{50} - 81^2$ [= 35] $\times \frac{50}{49}$; = 35.71 $1 - \Phi\left(\frac{90-81}{\sqrt{35.71}}\right) = 1 - \Phi(1.506) = 1 - 0.9339$ **= 6.61%** or **0.0661**	B1 M1 M1 A1 M1 A1 **[6]**	81 only, can be implied Correct formula for biased estimate, their "81", can be implied Multiply by 50/49. SC: single formula: M2, or M1 if wrong but divisor 49 anywhere [can be recovered if correctly done in part (ii)] A.r.t. 35.7 – can't be recovered from part (ii). Can be implied Standardise with their μ and σ, allow σ^2, cc but not $\sqrt{50}$ Answer, a.r.t. 6.6% or 0.066

7	(ii)	H_0: $\mu = 80$ H_1: $\mu \neq 80$	B2	Correct, B2. One error, e.g. wrong or no symbol, >, B1, but x or $\bar{x}$ or t etc, or 81, B0. NB: If both hypotheses involve 81, *can't* get final M1
		α: $z = \dfrac{81-80}{\sqrt{35.71/50}} = 1.183$ [*or* $p = 0.1183$]	M1 A1	Standardise, with √50, allow √, sign or cc errors, allow from biased variance z, a.r.t. 1.18, or p, a.r.t. 0.118. Allow –1.18.
		< 1.645	B1	Their $z < 1.645$ or $p > 0.05$, *not* if one-tail. Allow –1.18 > –1.645. *Not* just 1.645 seen.
		β: CV $80 + 1.645\sqrt{\dfrac{35.71}{50}} = 81.39$	M1 B1	$80 + zs/\sqrt{50}$, allow √ or cc errors, ignore – (no marks for – alone); $z = 1.645$ used in this expression (not just seen), *not* from one-tail
		$81 < 81.39$	A1	Compare CV with 81, allow 81.08 from one-tailed ($z = 1.282$) (but not on their σ) SC: $81 - 1.645\sqrt{\dfrac{35.71}{50}}$: If H_0: $\mu = 80$: (B2) M1B1A0M0A0. If H_0: $\mu = 81$: (B0) M1B1A1 (79.61) M0A0
		Do not reject H_0.	M1	Correct first conclusion, needs √50, correct comparison type, μ and $\bar{x}$ not consistently wrong way round (thus H_0: $\mu = 81$ can get B0 M1A1A1 M0A0, max 3/7) In method *β*, it needs to be clear that comparison involves $\bar{x}$.
		Insufficient evidence that the mean time is not 80 minutes.	A1ft **[7]**	Contextualised (mention "time"), acknowledge uncertainty ("evidence that…") *Not* "significant evidence that mean time is 80" FT on wrong z-value or wrong critical value if previous mark gained SC: One-tailed: can get B1B0 M1A1B0 M1A1, max 5/7 No √50: can get B2 M0 B1 M0, max 3/7
7	(iii)	(a) Yes (single observation only) (b) No, CLT applies to large sample	B1 B1 **[2]**	No reason needed, but withhold if wrong reason seen. Allow "yes, no dist^n given" "No" *and* refer to central limit theorem or "large sample" {note for scoris zoning – (a) and (b) to be in single zone}
8	(i)	$P(W = 0 \mid \lambda = 3.6)$ = **0.0273** or 2.73%	M1 A1 **[2]**	Use this conditional probability. *Not* 0.9727, not *just* 2.5% etc Answer a.r.t. 0.0273 or 2.73%. ISW if appropriate (e.g. "0.0273, ∴2.5%")
8	(ii)	$1 - e^{-\lambda_0} = 0.8$ $e^{-\lambda_0} = 0.2$ $\lambda_0 = -\ln(0.2)$ = **1.609**	M1 A1 M1 A1 **[4]**	Use $P(W > 0 \mid \lambda = \lambda_0)$, formula needed but allow if wrong This exact equation, or $e^{\lambda_0} = 5$, or exact equivalent RHS Solve using ln or otherwise [independent of first M1, e.g. –ln(0.8) = 0.223 is M1 here] Final answer, exact or a.r.t. 1.61, cwo SC: No working: 1.60 (tables etc): B0. 1.61 (T&I): SC B4.

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