Mark Scheme (Results)

Summer 2014

Pearson Edexcel GCE in Statistics 2 (6684/01)

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Summer 2014
Publications Code UA040123

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.

PEARSON 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.

   - 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)
   - d… or dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - * The answer is printed on the paper or ag- answer given
   - $\sqsubset$ or d… 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	Marks
1.		
(a)	Po(9)	B1
(i)	$P(X \le 7) - P(X \le 6)$ = 0.3239 – 0.2068 $\quad \frac{e^{-9}9^7}{7!}$	M1
	= 0.1171	A1
(ii)	$P(X \ge 10) = 1 - P(X \le 9)$	M1
	= 1 – 0.5874	
	= 0.4126	A1
		(5)
(b)	Po(1.5)	B1
	P(next patient before 11:45) = 1- P(0)	M1
	= 1 - $e^{-1.5}$	
	= 0.7769	A1
		(3)
		[8]
	Notes	
(a) (i)	B1 Po(9) written or used in either (i) or (ii)	
	M1 writing $P(X \le 7) - P(X \le 6)$ or $\frac{e^{-\lambda}\lambda^7}{7!}$	
	This may be implied by 0.3239 – 0.2068	
	A1 awrt 0.117	
(ii)	M1 writing $1 - P(X \le 9)$	
	This may be implied by 1 – 0.5874.	
	A1 awrt 0.413	
(b)	B1 Po(1.5) written or used	
	M1 writing or using 1 – P(0) or 1 - $e^{-\lambda}$.	
	This may be implied by 1 – 0.2231	
	A1 awrt 0.777	

Question Number	Scheme	Marks
2. **(a)**	$\int_0^9 c\left(81-t^2\right)\mathrm{d}t = 1$ $c\left[81t-\frac{t^3}{3}\right]_0^9 = 1$ $c\left[81\times 9-\frac{9^3}{3}\right] = 1$ $486c = 1$ $c = \frac{1}{486}$	M1 A1 M1d A1cso (4)
(b)	$\mathrm{F}(t) = \frac{1}{486}\int_0^t 81-x^2\mathrm{d}x$ $= \frac{1}{486}\left[81t-\frac{x^3}{3}\right]_0^t$ $= \frac{t}{6}-\frac{t^3}{1458}$ $\mathrm{F}(t) = \begin{cases} 0 & t<0 \\ \frac{t}{6}-\frac{t^3}{1458} & 0\le t\le 9 \\ 1 & t>9 \end{cases}$	M1 A1cso (2)
(c)	$\mathrm{P}(T>3) = 1-\left(\frac{3}{6}-\frac{3^3}{1458}\right)$ $= \frac{14}{27}$ or awrt 0.519	M1 A1 (2)
(d)	$\mathrm{P}(T>7 \mid T>3) = \frac{0.068587}{0.5185}$ $= \frac{25}{189}$ or awrt 0.132	M1A1ft A1 (3)
(e)	${}^3C_2\left(0.5185\right)^2\left(1-0.5185\right) = \frac{2548}{6561}$ or awrt 0.388/ 0.387	M1A1ftA1 (3) [14]

	Notes	
(a)	1st M1 Attempting to integrate, For attempt $x^n \rightarrow x^{n+1}$ and c must remain as c or 1/486. Ignore limits 1st A1 Correct integration. Ignore limits. 2nd M1 dependent on previous M being awarded. Putting = 1 and substitution of 9 as a limit seen. Need at least one intermediate step before getting 486 or substitution of 1/486 and 9 seen and leading to an answer of 1 A1 $c = \frac{1}{486}$ cso or if verifying, the statement $c = \frac{1}{486}$	
(b)	M1 Attempting to integrate with correct limits **or** $\int f(t)dt$ + C and F(0) = 0 or F(9) = 1. Subst in c at some point A1 F(t) must be stated and cso. Condone use of < instead of ≤ etc.	
(c)	M1 using or writing 1 – F(3) or $\frac{1}{486}\int_3^9 81 - x^2 dx$ or 1 – P($X \leq 3$) A1 awrt 0.519	
(d)	M1 $\frac{a\ probability}{their\ (c)}$ where 0 < *a probability* < *their (c)* < 1. If *a probability* ≥ *their (c)*, give M0. A1ft $\frac{\frac{50}{729}}{their\ (c)}$ or $\frac{awrt 0.0686}{their\ (c)}$ A1 $\frac{25}{189}$ or awrt 0.132	
(e)	M1 Allow $(their\ '0.5185')^2(1 - their\ '0.5185')$ A1ft Allow ${}^3C_2$ (*their* '0.5185')^2(1 – *their* '0.5185') A1 awrt 0.388 or 0.387	

Question Number	Scheme	Marks
3. **(a)**	Any two of • Emails are independent/occur at random • Emails occur singly • Emails occur at a constant rate	B1B1d (2)
(b)	$X \sim$ Po(4) $P(X = 0) = 0.0183$ $P(X \geq 9) = 0.0214$ CR $X = 0$; $X \geq 9$	B1B1 (2)
(c)	0.0183 + 0.0214 = 0.0397 or 3.97%	M1A1 (2)
(d)	8 is not in the critical region **or** $P(X \geq 8) = 0.0511$ therefore there is evidence that the company's **<u>claim</u>** is true	M1 A1ft (2)
(e)	$H_0 : \lambda = 6$ (or $\lambda = 2$) $H_1 : \lambda < 6$ (or $\lambda = 2$) allow λ or μ Po(6) $P(X \leq 2) = 0.0620$ CR $X \leq 2$ 0.0620 < 0.10 Reject H_0 or Significant. There is evidence at the 10% level of significance that the mean **<u>rate/number/amount</u>** of **<u>emails</u>** received **<u>is lower/ has decreased/is less</u>**. Or **<u>fewer emails</u>** are received	B1 M1 A1 M1 dep. A1 cso (5) [13]
	Notes	
(a)	B1 any correct statement with context of emails in B1d Dependent on previous B1. Any correct statement, need not have context **SC** for 2 correct statements without context B1 B0	
(b)	B1 $X = 0$ or $X \leq 0$ Allow any letter. B1 $X \geq 9$ or $X > 8$ Allow any letter. **SC** if write correct CR's as probability statements award B1 B0 For these 2 marks ignore any union sign ($\cup$) or intersection sign ($\cap$)	
(c)	M1 adding their probabilities of 'their' critical regions if sum gives a probability less than 1 or award if a correct answer given A1 awrt 0.0397	
(d)	M1 correct reason ft their CR. Do not allow non-contextual contradictions. A1 correct conclusion for their CR. Allow conclusion in context of **<u>emails</u>** are **<u>received</u>** at a rate of 2 every 5 mins	
(e)	B1 both hypotheses correct, must have λ or μ and either 2 or 6. M1 using Po(6) may be implied by correct answer. A1 0.062 or $X \leq 2$ M1 dependent on previous method being awarded. Do not allow conflicting non-contextual statements. Follow through their hypotheses.	

Question Number	Scheme	Marks
4. (a)	X is the random variable the Number of successes, $X \sim B(10, 0.75)$	B1
(i)	P (X = 6) = $(0.75)^6 (0.25)^4 \, {}^{10}C_6$ or $P(X \le 6) - P(X \le 5)$	M1
	= 0.145998 awrt 0.146	A1
(ii)	Using $X \sim B(10, 0.75)$	
	$P(X \ge 8) = P(X = 8) + P(X = 9) + P(X = 10)$	M1
	$= (0.75)^8 (0.25)^2 \, {}^{10}C_8 + (0.75)^9 (0.25)^1 \, {}^{10}C_9 + (0.75)^{10}$	
	= 0.52559 awrt 0.526	A1
	Or	
	Using $Y \sim B(10, 0.25)$ and $P(Y \le 2) = 0.5256$	(5)
(b)	$1 - P(0) = 0.8$ or $P(0) = 0.2$	M1
	$(1-p)^{20} = 0.2$	
	$1 - p = 0.9227$	
	$p = 0.0773$	A1
	$\frac{3}{200}(90 - x) = 0.0773$	M1
	$x = 84.84$	
	$x = 85$	A1cao (4)
(c)	X – successes ~B(100, 0.975)	B1
	Y – not successes ~B(100, 0.025)	
	Y~Po(2.5)	M1A1
	$P(Y \le 5) = 0.958$	M1A1 (5)
	Notes	[14]
(a)	B1 writing or using p = 0.75 or p = 0.25 anywhere in (a)(i) or (a)(ii)	
(i)	M1 writing or using $(p)^6 (1-p)^4 \, {}^{10}C_6$ **or** writing for p =0.75, $P(X \le 6) - (X \le 5)$ **or** for p = 0.25, P($X \le 4$) – P($X \le 3$) **or** correct answer.	
(ii)	M1 writing B(10, 0.75) and writing or using $P(X = 8) + P(X = 9) + P(X = 10)$ oe **or** writing B(10, 0.25) and writing or using $P(Y \le 2)$.	
	Using correct Binomial must be shown by $(0.75)^n (0.25)^{10-n}$ or a correct answer.	
(b)	M1 for writing or using 1 – P(0) = 0.8 or P(0) = 0.2 or $(1-p)^{20} = 0.2$. Allow any inequality sign.	
	A1 awrt 0.0773 or awrt 0.923.	
	M1 subst in $\frac{3}{200}(90 - x)$ for p **NB** this may be substituted in earlier for p.	
	Allow for $\frac{3}{200}(90 - x) = k$ where $0 < k < 1$ $k \neq 0.8$ or 0.2 Allow any inequality sign	
	A1 condone $x \ge 85$. Do not allow $x \le 85$.	
(c)	B1 writing or using 0.975 or 0.025, may be implied by Po(2.5)	
	M1 using Po approximation	
	A1 Po(2.5)	
	M1 writing or using $P(Y \le 5)$	
	A1 awrt 0.958	
	SC use of normal approximation can get B1 M0A0M1A0	
	B1 writing or using 0.975 or 0.025 implied by normal with mean 97.5 or answer of 0.973	
	M1 for awrt 0.973	

Question Number	Scheme	Marks
5.(a)	n is large and p close to 0.5	B1B1 (2)
(b)	There would be no pea seeds left	B1 (1)
(c)	H_0: $p = 0.55$ H_1 : $p \neq 0.55$	B1 (1)
(d)	X~N(121, 54.45)	B1
	P($X \geq 134.5$) = $P\left(Z \geq \frac{134.5-121}{\sqrt{54.45}}\right)$ or $\pm\frac{x-0.5-121}{\sqrt{54.45}} = 1.96$	M1M1A1
	= P($Z \geq 1.8295..$)	
	= 1 – 0.9664	
	= 0.0336/0.0337 $x = 135.96$	A1
	Accept H_0 not in CR, not significant	M1
	The **company's claim** is justified **or** **55**% of its pea **seeds germinate**	A1cso (7)
	Alternative	
	X~N(99, 54.45)	B1
	P($X \leq 85$) = $P\left(Z \leq \frac{85.5-99}{\sqrt{54.45}}\right)$ or $\pm\frac{x+0.5-99}{\sqrt{54.45}} = 1.96$	M1 M1 A1
	= P($Z \geq 1.8295..$)	
	= 1 – 0.9664	
	= 0.0336/0.0337 $x = 107.5$	
	Accept H_0 not in CR, not significant	M1
	The **company's claim** is justified **or** **55**% of its pea **seeds germinate**	A1cso [11]
	Notes	
(a)	B1 accept $n > 50$ (or any number bigger than 50)	
	B1 p close to 0.5	
	NB Do not accept $np > 5$, $nq > 5$.	
(b)	Must have the idea of no peas left. They must mention either **pea** or **seeds**.	
(c)	B1 both hypotheses correct. Must use p or π and 0.55 oe. Accept the hypotheses in part (d).	
(d)	B1 correct mean and Var, may be seen in the standardiation formula as 121 and $\sqrt{54.45}$ or 7.38 to 2dp or implied by a correct answer	
	M1 for attempting a continuity correction (Method 1:135/85 $\pm$ 0.5 / Method 2:$x \pm 0.5$)	
	M1 for standardising using their mean and their standard deviation and using either Method 1 [134.5, 135, 135.5, 85, 85.5 or 84.5 accept $\pm z$.] Method 2 [($x \pm 0.5$) and equal to a $\pm$ z value]	
	A1 correct z value awrt $\pm$ 1.83 **or** $\pm\frac{134.5-121}{\sqrt{54.45}}$ $\left(\frac{85.5-99}{\sqrt{54.45}}\right)$ or $\pm\frac{x-0.5-121}{\sqrt{54.45}} = 1.96$	
	$\left(\pm\frac{x+0.5-99}{\sqrt{54.45}} = 1.96\right)$ or(allow 1.6449 if 1 tail test in (c))	
	A1 awrt 0.0336/0.0337 **or** awrt 136 (allow 126 if one tail test in (c)) or a comparison of awrt1.83 with 1.96 (1.6449)	
	M1 A correct statement. Accept H_0, oe if a 2-tailed test in (c), reject H_0, oe if a 1-tailed test in (c). Allow for a correct contextual statement. Do not allow contradictions of non-contextual statements.	
	A1 A correct contextual statement to include words in bold/underlined for a 2-tailed test. This is not a follow through mark.	
	NB if finding P(X =135) they can get B1 M1 M1 A0 A0 M0 A0	

Question Number	Scheme	Marks
6. **(a)**	$\mathrm{E}(X)=\int_0^1 \frac{2x^2}{9}\mathrm{d}x+\int_1^4 \frac{2x}{9}\mathrm{d}x+\int_4^6 \frac{2x}{3}-\frac{x^2}{9}\mathrm{d}x$ $=\left[\frac{2x^3}{27}\right]_0^1+\left[\frac{2x^2}{18}\right]_1^4+\left[\frac{x^2}{3}-\frac{x^3}{27}\right]_4^6$ $=\left[\frac{2}{27}\right]+\left[\frac{32}{18}-\frac{2}{18}\right]+\left[4-\frac{80}{27}\right]$ $=2\frac{7}{9}$ or awrt 2.78	M1 A1 M1d A1 (4)
(b)	$\mathrm{F}(x)=\begin{cases} 0 & x<0 \\ \frac{x^2}{9} & 0\le x\le 1 \\ \frac{2x}{9}-\frac{1}{9} & 1<x<4 \\ \frac{2x}{3}-\frac{x^2}{18}-1 & 4\le x\le 6 \\ 1 & x>6 \end{cases}$ 1st M1 For $1 < x < 4$, $\mathrm{F}(x)=\int_1^x \frac{2}{9}\mathrm{d}x+\frac{1}{9}$ 2nd M1 For $4\le x\le 6$, $\mathrm{F}(x)=\int_4^x \frac{2}{3}-\frac{x}{9}\mathrm{d}x+\frac{7}{9}$ or use +C and F(6) =1	B1 M1A1 M1 A1 B1 (6)
(c)	F(x) = 0.5 $\frac{2m}{9}-\frac{1}{9}=0.5$ m = 2.75	M1 A1ft A1 (3)
(d)	Median < mean therefore positive skew **Or** Mean ≈ median therefore no skewness	M1A1cao (2) [15]

	Notes	
(a)	M1 using $\int xf(x)dx$ ignore limits. Must have at least one $x^n \rightarrow x^{n+1}$ They must add the 3 parts together. Do not allow division by 3. A1 all integration correct; ignore limits M1 dependent on previous M being awarded. Subst in correct limits – no need to see zero substituted. A1 $2\frac{7}{9}$ oe or awrt 2.78	
(b)	B1 for 2nd line- allow use of < instead of ≤ M1 For $1 < x < 4$, $F(x) = \int_1^x \frac{2}{9}dx + \frac{1}{9}$. Limits are needed. **or** use $F(x) = \int_1^x \frac{2}{9}dx +$ their F(1) need limits **or** use "their $F(1)" = \int \frac{2}{9}dx + C$ and subst $x = 1$ into RHS **or** use "their $F(4)" = \int \frac{2}{9}dx + C$ and subst $x = 4$ into RHS A1 for 3rd line allow use of ≤ instead of < M1 For $4 \le x \le 6$, $F(x) = \int_4^x \frac{2}{3} - \frac{x}{9}dx + \frac{7}{9}$. Limits are needed. **or** use $F(x) = \int_4^x \frac{2}{3} - \frac{x}{9}dx +$ their F(4) . Limits are needed. **or** use "their $F(4)" = \int \frac{2}{3} - \frac{x}{9}dx + C$ and subst $x = 4$ into RHS **or** use $1 = \int \frac{2}{3} - \frac{x}{9}dx + C$ and subst $x = 6$ into RHS A1 for 4th line allow use of < instead of ≤ B1 for first and last line - allow use of ≤ instead of < and ≥ instead of > and "otherwise" for one of $x < 0$ and $x > 6$	
(c)	M1 putting any one of their lines = 0.5 A1their 3rd line = 0.5 A1 2.75	
(d)	M1 reason must match their values / a correctly shaped and labelled sketch. Must compare the median and mean, ignore references to mode A1 no ft Correct answer only from correct values of the mean and median or a correct and fully labelled sketch.	

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