Mark Scheme (Final)

Summer 2019

Pearson Edexcel GCE In Statistics 2
Paper 6684/01

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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.

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)
- 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.

Statistics S2 (6684) June 2019 Final

Question Number	Scheme	Marks
1 (a)	Customers arrive at the bank independently/randomly Customers arrive one at a time (accept "singly") The rate of arrival at the bank is constant ("fixed rate" is B0)	B1 B1
		(2)
(b)	Po(2)	B1
	(i) $P(X=2)=\frac{e^{-2}2^2}{2}$	M1
	$=0.2707$ awrt **0.271**	A1
	(ii) $P(X>4)=1-P(X\leq 4)$	M1
	$=0.0527\ldots..$ awrt **0.0527**	A1
		(5)
(c)	$H_0:\mu=8$ (or $\lambda=10$) $H_1:\mu>8$ (or $\lambda>10$)	B1
	X ~Po(8) and $P(X\geq 9)=1-P(X\leq 8)$ or $P(X\leq 13)=0.9658$ $P(X\leq 12)=0.9362$	M1
	$=0.40745\ldots$ CR: $X\geq 14$	A1
	so not significant/ do not reject H_0/ accept H_0/ Not in CR	dM1
	he does not have evidence to open up another service **till**	A1cso
		(5)
(d)	Writing or using of Po(2)	B1
	$P(X\leq 6)=0.9955$ so $P(X\geq 7)=0.004533...$	M1
	so needs 7 Customers	A1
		(3)
		Total 15

Notes

(a)

B1: any assumption in context ("customers arrive/come" [allow "people"] or "bank" mentioned)
B1: 2 assumptions with context in at least 1

(b)

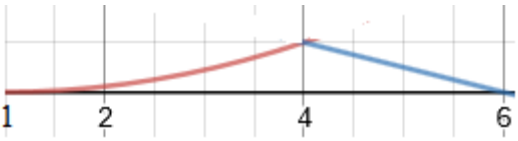
B1: Stating or using Po(2) may be implied by either correct answer
1st M1: $\frac{e^{-\lambda}\lambda^2}{2}$ or $P(X\leq 2)-P(X\leq 1)$
1st A1: awrt 0.271 (correct answer implies M1)
2nd M1: writing or using $1-P(X\leq 4)$ oe
2nd A1: awrt 0.0527 (correct answer implies M1)

(c)

B1: both hypotheses in terms of λ or μ (accept $\lambda = 8$ etc)
1st M1: Stating or using Po(8) and $1-P(X\leq 8)$ or $P(X\leq 13)=0.9658$ or $P(X\leq 12) = 0.9362$
1st A1: awrt 0.407 or $X\geq 14$ (correct answer implies the M1)
2nd dM1: dependent on the previous method mark being awarded. Correct (non contextual) comment. May be implied by a correct contextual comment.
2nd A1cso: correct contextual comment with word **till** (dep on all other marks scored)

(d)

B1: Writing or using Po(2)[may be implied by the correct answer or a correct probability see M1]
M1: either $P(X\leq 6)=$ awrt $0.995/0.996$ or $P(X\geq 7)=$ awrt 0.0045 or $P(X\leq 7) = 0.9989$
Correct probability seen with appropriate label
A1: 7 (correct answer only with no incorrect working seen is 3/3)

Qu No	Scheme	Marks
2 (a)	$\int_{(1)}^{(4)} \frac{1}{18}\left(x^4-2x^3+x^2\right)\mathrm{d}x+\int_{(4)}^{(6)}\left(\frac{3}{2}x^2-\frac{x^3}{4}\right)\mathrm{d}x=\frac{1}{18}\left[\frac{x^5}{5}-\frac{x^4}{2}+\frac{x^3}{3}\right]_{(1)}^{(4)}+\left[\frac{x^3}{2}-\frac{x^4}{16}\right]_{(4)}^{(6)}$	M1A1
	$=\frac{1}{18}\left[\frac{1472}{15}-\frac{1}{30}\right]+[27-16]$ or $\frac{109}{20}+11$; $=\frac{329}{20}$ *	dM1 ; A1cso
		(4)
(b)(i)	$\mathrm{Var}(x)=\frac{329}{20}-\left(\frac{95}{24}\right)^2$ allow $\frac{2251}{2880}$; σ = awrt **0.884**	M1; A1 (2)
(ii)	Mode = 4 > mean or diagram 	M1
	Negative skew or Mode = 4 ≈ mean [or mode = 4 = median] therefore no skew	A1 (2)
(c)	$[\mathrm{F}(x)]=\begin{cases}0 & x<1\\ \frac{1}{54}(x^3-3x^2+3x-1) \text{ or } \frac{1}{54}(x-1)^3 & 1\le x<4\\ \frac{3}{2}x-\frac{x^2}{8}-\frac{7}{2} & 4\le x\le 6\\ 1 & \text{otherwise}\end{cases}$ Allow < or ≤ throughout, allow overlaps too.	M1A1 M1A1 B1 (5)
(d)	F(5) – F(2) = $\frac{7}{8}-\frac{1}{54}$; = $\frac{185}{216}$ or awrt **0.856**	M1; A1 (2)
		Total 15

Notes

(a)

M1: Use of $\int x^2 \mathrm{f}(x)$ in at least one part, multiplied out (unless integration by parts), integ' attempted, both parts added (somewhere) ignore limits

A1: Correct Integration for both parts (ignore limits)
dM1: (dep on 1st M1) Substituting correct limits for each part – must see some evidence
A1*cso: Fully correct solution with no errors and all previous marks awarded($\frac{329}{20}$ seen or allow16.45)

(b)(i)

M1: Using the correct formula for Variance or standard deviation
A1: awrt 0.884

(ii)

M1: for the correct mode being stated and 4 > mean (or median = 4 and 4 > mean)
or sketch (concave LHS, straight line RHS) and at least 1, 4 and 6 seen
A1: negative skew (allow arguments for no skew (see above))

(c)

1st M1: $\left[\frac{1}{18}\left(\frac{t^3}{3}-t^2+t\right)\right]_1^x$ Attempt to integrate 1st line **and** using limits x and 1 **or** + C and F(1) = 0

1st A1: for $\frac{1}{54}(x^3-3x^2+3x-1)$ oe attached to $1\le x<4$ (must use the same variable in range)

2nd M1: $\left[\frac{3}{2}t-\frac{t^2}{8}\right]_4^x$ Attempt to integ' the 2nd line with 4 and x **and** +"their F(4)" **or** + C and use F(6) =1

2nd A1: for $\frac{3}{2}x-\frac{x^2}{8}-\frac{7}{2}$ oe attached to $4\le x\le 6$ (must use the same variable in range)

B1: for the top and bottom lines with correct ranges for x

(d)

M1: for using F(5) – F(2) some evidence of correct sub in each part-condone F(5) or F(2) not in [0,1]
A1: awrt 0.856 (allow 0.8565) [correct answer 2/2]

Question Number	Scheme	Marks
3(a)(i)	B(12, 0.05)	B1
	$P(X=1) = P(X \leq 1) - P(X=0)$	M1
	$= 0.8816 - 0.5404$	
	$= 0.3412\ldots$ awrt **0.341**	A1
(ii)	$P(X>2) = 1 - P(X \leq 2)$	M1
	$[= 1 - 0.9804] = 0.01956\ldots$ awrt **0.0196**	A1
		(5)
(b)	$P(Y=1) = [4\times]("0.341...")(1-"0.341...")^3$	M1
	$= 4\times("0.341...")(1-"0.341...")^3$	M1
	$= 0.390\ldots$ awrt **0.390**	A1
		(3)
(c)	$H_0 : p = 0.04$ $H_1 : p > 0.04$ or $H_0 : \lambda$ or $\mu = 6$ $H_1 : \lambda$ or $\mu > 6$	B1
	Po(6)	M1
	$P(B \geq 10) = 1 - P(B \leq 9)$	M1
	$[= 1 - 0.9161] = 0.0839$ awrt **0.0839**	A1
	Accept H_0, not significant	M1
	There is insufficient evidence that the promotion has been successful	A1cso
		(6)
		Total 14

Notes

(a)(i)	**B1:** for stating or using B(12,0.05) in either part (may be implied by one correct probability) **1st M1:** for writing or using $P(X \leq 1) - P(X = 0)$ or ${}^{12}C_1(0.05)(0.95)^{11}$
(ii)	**2nd M1:** for writing or using $1 - P(X \leq 2)$
(b)	**1st M1:** for ("their (a)(i)") $\times$ (1 – "their (a)(i)")^3 **2nd M1:** for $4\times$("their (a)(i)") $\times$ (1 – "their (a)(i)")^3 or expression of the form $4p(1-p)^3$ with $0 < p < 1$
(c)	**B1:** Both hypotheses correct and in terms of p or correct in terms of λ or μ **1st M1:** Stating or using Po(6) [Must be Po(6) or Poisson (6) but may be implied by a correct Po(6) probability ≤ 9 or ≤ 10] **2nd M1:** stating or using $1 - P(B \leq 9)$ **1st A1:** awrt 0.0839 { NB Binomial gives 0.0797 normal gives 0.07237 may score B1, 2nd M1} **3rd M1:** A correct (contextual or non contextual) conclusion based on comparing their probability (which is < 0.5) with 0.05 (or the 10 sales with their CR) with no contradicting ones **2nd A1cso:** a complete correct method and conclusion in context containing the words **promotion** and **successful oe** or **increase** and **sold oe** [all other marks in (c) scored]
ALT (CR)	2nd M1 for $P(B \geqslant 11) = 1 - P(B \leqslant 10) = 1 - 0.9574 = 0.0426$ 1st A1 for critical region of : $B \geqslant 11$ or $B > 10$ (other letters OK)

Question Number	Scheme	Marks
4(a)	$\lambda > n$ where n is at least 10 or λ is large	B1
		(1)
(b)	The Poisson is discrete and the normal is continuous.	B1
		(1)
(c)	Let X represent the number of skis hired $X \sim \text{Po}(205)$	
	$X \sim \text{N}(205, 205)$	B1
	$\text{P}(X > 220) \approx \text{P}\left(Z > \frac{220.5-205}{\sqrt{205}}\right)$	M1 M1
	$\approx \text{P}(Z > 1.08)$	A1
	$\approx 1 - 0.8599$	dM1
	≈ 0.1401 or 0.1395 (calc: 0.139500…)	A1
		(6)
(d)	Number of weekends = 0.1401×20	M1
	= awrt 2.8	A1
		(2)
		Total 10

Notes

(a)	**B1:** allow use of μ (ignore any reference to p etc)
(b)	**B1:** need to have all 4 words: Poisson, discrete, normal, continuous
(c)	**B1:** N(205,205) can be implied by standardisation **1st M1:** sight of or use of a continuity correction either 220.5 or 219.5 or 221.5 **2nd M1:** standardising using either 220.5 or 219.5 or 221.5 or 220 If distribution not stated must use 205 and $\sqrt{205}$ otherwise can ft their mean and st. dev. **1st A1:** correct standardisation or awrt 1.08 [can ignore the inequality sign up to this point] **3rd dM1:** (dep on 2nd M1) for attempting one tail prob (prob <0.5) and $1 - p$ where $0.8 < p < 0.9$ **2nd A1:** awrt 0.14 NB Poisson gives 0.13988...and scores 0/6 **Ans only** of awrt 0.14 is 0/6
(d)	**M1:** their "(c)" ×20 **A1:** awrt 2.8 or (2 or 3 from correct working)

Qu No	Scheme		Marks
5(a)	$\frac{\alpha+\beta}{2}=20.4$	$P(20.4<X<23)=\frac{1}{4}$	B1
	$\frac{23-\alpha}{\beta-\alpha}=\frac{3}{4}$	$[Q_3-Q_2=]2.6$	B1
	$23-40.8+\beta=0.75(\beta-40.8+\beta)$ or $23-\alpha=0.75(40.8-\alpha-\alpha)$	$\beta=23+"2.6"$ or $20.4+2\times"2.6"$ $\alpha=20.4-2\times2.6$	M1
	$\alpha=15.2$ and $\beta=25.6$	$\alpha=15.2$ and $\beta=25.6$	A1
			(4)
(b)	$\sigma=\frac{1}{\sqrt{12}}("25.6"-"15.2")[=3.00022214]$ (o.e.) e.g. $\frac{26\sqrt{3}}{15}$ or $\sqrt{\frac{676}{75}}$ (Allow variance)		M1
	$P(\mu-\sigma<X<\mu+\sigma)=\frac{2\times\sigma}{"25.6"-"15.2"}$ or awrt 0.577		M1
	$=\frac{\sqrt{3}}{3}$ (o.e)		A1
			(3)
(c)	$P(Y>8)\left[=\frac{1}{2}\right]$; $P(Y<7)\left[=\frac{3}{8}\right]$ or M2 for $P(7<Y<8)\left[=\frac{1}{8}\right]$		M1;M1
	One of these three probabilities correct		A1
	Total = $\frac{1}{2}+\frac{3}{8}$ or Total $=1-\frac{1}{8}$		dM1
	$=\frac{7}{8}$ or 0.875		A1cao
			(5)
			Total 12

Notes

(a)

1st B1: Correct equation any form — may be implied by 2.6 seen or correct α or β

2nd B1: 2nd **c**orrect equation any form — 2.6 seen - may be implied by correct α or β

M1: eliminating one variable leading to equation in α or β or correct method for finding α or β

Equations must be linear and come from, μ or probs, or quartiles. Use of normal and σ is M0

A1: both values correct e.g. $\alpha=\frac{76}{5}$, $\beta=\frac{128}{5}$ (correct answer with no incorrect working seen 4/4)

(b)

1st M1: ft their α and β in a correct formula for variance or st.dev. e.g. $\sigma=\frac{1}{\sqrt{12}}(\beta-\alpha)$

(decimal or surd form is OK) NB E(X^2) = $\frac{31688}{75}$

2nd M1: $=\frac{2\times"\text{their }\sigma"}{"\text{their }\beta"-"\text{their }\alpha"}$ or a decimal which is awrt 0.577

A1: $=\frac{\sqrt{3}}{3}$ **NB** M1 M1 A0 for awrt 0.577 if answer not given in exact form at all.

(c)

1st M1: for writing or attempting $P(Y>8)$

2nd M1: for writing or attempting $P(Y<7)$ **NB** award M1M1 for attempting to find $P(7<Y<8)$

1st A1: either $P(Y>8)=\frac{1}{2}$ or $P(Y<7)=\frac{3}{8}$ or $P(7<Y<8)=\frac{1}{8}$

3rd dM1: (dep on 1st M1 and 2nd M1) $P(Y<7)+P(Y>8)$ or $1-P(7<Y<8)$ 2nd **A1:** cao

[Correct answer only scores 5/5]

Qu No	Scheme	Marks
6	$\int_{(-b)}^{(b)} \frac{k}{b}\left(1-\frac{x}{b}\right)\mathrm{d}x\,[=1]$	M1
	$\left[\frac{k}{b}\left(x-\frac{x^2}{2b}\right)\right]_{-b}^{b}=1$ or $\frac{k}{b}\left(b-\frac{b^2}{2b}+b+\frac{b^2}{2b}\right)=1$ or $\frac{k}{b}\left(\frac{b}{2}+\frac{3b}{2}\right)=1$	dM1
	[$2k = 1$] $k=\frac{1}{2}$ oe	A1
	$\int_{(-b)}^{(b)} \frac{k}{b}\left(x-\frac{x^2}{b}\right)\mathrm{d}x=\frac{k}{b}\left(\frac{x^2}{2}-\frac{x^3}{3b}\right)_{(-b)}^{(b)}$	M1A1
	$=\frac{k}{b}\left(\frac{b^2}{2}-\frac{b^3}{3b}\right)-\frac{k}{b}\left(\frac{b^2}{2}+\frac{b^3}{3b}\right)$	dM1
	$=-\frac{2kb}{3}$ (o.e.) (allow + if used E(X) = -1)	A1ft
	$-\frac{2"\frac{1}{2}"b}{3}=-1$	dM1
	$\frac{b}{3}=1\therefore b=3$	A1cso
		(9)
		Total 9

Notes

1st M1: method for finding the area (ignore limits and "= 1" for this mark)

eg $\int \frac{k}{b}\left(1-\frac{x}{b}\right)\mathrm{d}x$ with an attempt at integration, at least one $x^n \to x^{n+1}$

or sketch of triangle with $-b$, $+b$ and height = $\frac{2k}{b}$ clearly marked

2nd dM1: use of correct limits and their area or integration = 1 and an attempt to solve to find k

or use of area of triangle formula: $\frac{1}{2}(b--b)\times\frac{2k}{b}$ = 1 and attempt to solve for k

1st A1: $k=\frac{1}{2}$ oe

3rd M1: attempt to integrate xf(x) ignore limits

2nd A1: correct integration

4th dM1: (dep on 3rd M1)substituting in the correct limits (some correct substitution seen)

3rd A1ft: for a correct simplified answer of the form : $\pm\frac{2kb}{3}$ or $\pm\frac{b}{3}$ or $\pm\frac{2"k"b}{3}$ or $\pm\frac{2kb^2}{3b}$ (o.e.)

ft their value for k if answer not given in terms of k

5th dM1: (dep on 1st M1 and 2nd M1) subst their k value into their integral and equating to –1

4th A1cso: correct work leading to the correct statement that b = 3 all other marks scored

SC Assume b=3

Show k = 0.5 Allow 1st M1 and 2nd M1 but **1st A0**

Use b = 3 and k = 0.5 Allow 3rd M1, 2nd A1, 4th M1 and 3rd A1ft (for correct use of limits) and 5th M1 for clearly showing that mean = -1 but **4th A0** (i.e. 5/7 max)

If you see anyone using the centre of gravity of a triangle to show b = 3 please **send to review**

G. B. Attwood 10th July 2019

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