Mark Scheme (Results)

Summer 2018

Pearson Edexcel GCE Mathematics
Statistics S2 Paper 6684_01

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

Summer 2018
Publications Code 6684_01_1806_MS

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.

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

Question Number	Scheme	Marks
Throughout the paper the candidates may use different letters to the ones given in the mark scheme		
1. (a)	X represents number of telephone calls per min $\Rightarrow X \sim \text{Po}(9)$	
(i)	$\text{P}(X > 5) = 1 - \text{P}(X \leq 5)$	M1
	= 0.8843 awrt 0.884	A1
(ii)	$\text{P}(4 \leq X < 10) = \text{P}(X \leq 9) - \text{P}(X \leq 3)$	M1
	= 0.5874 – 0.0212	
	= 0.5662 awrt 0.566	A1
		(4)
(b)	D represents number of telephone calls per day	
	Normal approximation $\mu = \dfrac{7 \times 60 \times 9}{10} = 378$ and $\sigma^2 = 378$	M1
	$\text{P}(D < 370) \approx \text{P}\left(Z < \dfrac{369.5 - 378}{\sqrt{378}}\right)$ standardise, ± 0.5	M1, M1d A1ft
	$\approx \text{P}(Z < -0.44)$	
	$= 1 - 0.670$	
	= 0.33 or 0.330 or awrt 0.331	A1
		(5)
(c)	W represents number of days which have fewer than 370 telephone calls	
	$W \sim \text{B}(5, "0.33")$ | $W \sim \text{B}(5, "0.67")$	M1
	$\text{P}(W = 4) + \text{P}(W = 5)$ | $\text{P}(W = 0) + \text{P}(W = 1)$	
	$= 5("0.33")^4(1 - "0.33") + ("0.33")^5$ | $= (1 - "0.67")^5 + 5("0.67")("1 - 0.67")^4$	M1
	= 0.0436 awrt 0.044	A1 **(3)**
	Notes	**Total 12**
(a)(i)	M1 for using or writing $1 - \text{P}(X \leq 5)$ or $1 - \text{P}(X < 6)$ may be implied by awrt 0.884	
(ii)	M1 for using or writing $\text{P}(X \leq 9) - \text{P}(X \leq 3)$ **oe** may be implied by awrt 0.566	
(b)	M1 Using normal approximation with mean = variance = 378 or sd = $\sqrt{378}$ (awrt 19.4) or writing N(378,378) May be seen in standardisation.	
	M1 $\pm\left(\dfrac{(369 \text{ or } 370 \text{ or } 369.5 \text{ or } 370.5) - \textit{their mean}}{\textit{their sd}}\right)$ If they have not given a mean and variance they must be correct in here. (allow 1 – standardisation)	
	M1d dep on previous method mark being awarded. Using a continuity correction 370 ± 0.5	
	A1ft standardisation with correct CC ie $\pm\dfrac{369.5 - "\text{their}378"}{\sqrt{"\text{their}378"}}$ or awrt ± 0.44 or implied by 0.330 or 0.331 (allow 1 – standardisation) **(0.33 must be from correct standardisation) NB 0.33 with no working gains NO marks. 0.330 or 0.331 with no working gains full marks.**	
(c)	M1 writing $\text{B}(5, "0.33")$ or $\text{B}(5, 1 - "0.33")$ **or** seeing ${}^5C_n("0.33")^n(1 - "0.33")^{5-n}$ where $1 \leq n \leq 4$ Allow if ${}^nC_r$ calculated or in factorial form	
	M1 $1 - (1 - "0.33")^5 - 5("0.33")^1(1 - "0.33")^4 - 10("0.33")^2(1 - "0.33")^3 - 10("0.33")^3(1 - "0.33")^2$ **oe** Allow if using ${}^nC_r$ form or factorial form	
	NB awrt 0.044 with no incorrect working gains M1M1A1	

Question Number	Scheme	Marks
2(a)	Only 2 outcomes **Heads** and **Tails oe**	
	Constant probability of **spinning** a **Head/Tail oe**	
	Coin is **spun** a fixed number of times **oe**	
	Each **spin** of the **coin** is independent **oe**	B1 B1
		(2)
(b)	$T \sim B(6, 0.5)$	
	$P(T \le 5) - P(T \le 4) = 0.9844 - 0.8906$ or $6\left(\frac{1}{2}\right)^5\left(\frac{1}{2}\right)$ **oe**	M1
	$= 0.09375$ or $\frac{3}{32}$ oe awrt 0.0938	A1
		(2)
(c)	$P(T = 4,5,6) = 1 - P(T \le 3)$	M1
	$= 1 - 0.6563$	
	$= 0.3437$ or $\frac{11}{32}$ awrt 0.344	A1
		(2)
(d)	$P(H = 3,4,5,6) = 1 - P(H \le 2)$	B1M1d
	$= 1 - 0.8306$	
	$= 0.1694$ or $\frac{347}{2048}$ awrt 0.169	A1
		(3)

	Notes		Total 9
(a)	B1 A correct statement – does not need to be in context B1 A second correct statement in context include coin or heads or tails(do not allow H and T) or spins/flip oe.		
(b)	M1 [writing or using B(6, 0.5) **and** writing or using $P(T \le 5) - P(T \le 4)$] **or** $[6\left(\frac{1}{2}\right)^6$ **oe**]		
(c)	M1 for realising they need find $P(T = 4, 5 \text{ or } 6)$ eg $1 - P(T \le 3)$ or $P(T \ge 4)$		
(d)	B1	writing/using B(6, 0.25) **and** $P(H \ge 3)$ **oe**	writing/using B(6, 0.75) **and** $P(T \le 3)$
	M1d	dep on B1 for $1 - P(H \le 2)$	dep on B1 $(0.25)^6 + 6(0.75)(0.25)^5 + 15(0.75)^2(0.25)^4 + 20(0.75)^3(0.25)^3$
	A1	awrt 0.169	awrt 0.169
	NB	Only accept correct use of H and T in the probability statement unless their variable is correctly defined	
	NB	awrt 0.169 with no incorrect working gains B1M1A1	

Question Number	Scheme	Marks
3(a)	$\mathrm{E}(T)=\int_1^2 \frac{1}{2}t(t-1)\mathrm{d}t+\int_2^4 \frac{1}{16}t(14t-3t^2-8)\mathrm{d}t$	M1
	$=\left[\frac{t^3}{6}-\frac{t^2}{4}\right]_1^2+\left[\frac{14t^3}{48}-\frac{3t^4}{64}-\frac{8t^2}{32}\right]_2^4$	A1
	$=\frac{5}{12}+\frac{25}{12}$	M1dep
	$=2.5$ or $\frac{5}{2}$ oe	A1
		(4)
(b)	$\mathrm{Var}(T)=6.675-(2.5)^2$	M1
	$=\frac{17}{40}$ or 0.425	A1
		(2)
(c)	$\mathrm{F}(t)=\begin{cases}0 & t\le 1\\ \frac{1}{4}t^2-\frac{1}{2}t+\frac{1}{4} \text{ or } \frac{(t-1)^2}{4} & 1<t\le 2\\ \frac{1}{16}(7t^2-t^3-8t) & 2<t\le 4\\ 1 & t>4\end{cases}$	M1 A1 M1 A1 B1
		(5)
(d)	$\frac{1}{4}t^2-\frac{1}{2}t+\frac{1}{4}=0.2$	M1
	$t^2-2t+1=0.8$	
	$t^2-2t+0.2=0$	
	$t=\frac{2\pm\sqrt{2^2-4\times1\times0.2}}{2}$ o.e	M1
	$t=1.894...$ awrt 1.89	A1
		(3)
(e)	$1-\mathrm{F}(1.5)=1-\left(\frac{1}{4}\times1.5^2-\frac{1}{2}\times1.5+\frac{1}{4}\right)$	M1
	$=\frac{15}{16}$ or 0.9375 awrt 0.938	A1
		(2)
(f)	$\mathrm{P}(T>3)=0.25$	
	$\mathrm{P}(T>3\mid T>1.5)=\frac{"0.25"}{"0.9375"}$	M1
	$=\frac{4}{15}$ or awrt 0.267	A1
		(2)
		Total 18

	Notes	
(a)	M1: Using $\int tf(t)$ for both parts, attempt to multiply out and an attempt at integration. $x^n \to x^{n+1}$ Ignore limits. A1: correct integration for both parts M1dep : dep on previous method being awarded. For adding the 2 parts together and substituting the correct limits in to each part. A1:2.5 do not ISW. You will need to check that they have used Algebriac integration	
(b)	M1: $\frac{267}{40}$ – ["their E(T)"]^2, NB must see -1^2 if their E(T) = 1 A1: 0.425	
(c)	M1: $\int_1^t \frac{1}{2}(x-1)\mathrm{d}x$ with correct limits **or** $\int \frac{1}{2}(x-1)\mathrm{d}x$ and F(1) = 0 There must be an attempt to integrate for either method; $x^n \to x^{n+1}$ A1: 2nd line **oe** allow in terms of x. Must be in the cdf M1: $\int_2^t \frac{1}{16}(14x-3x^2-8)\mathrm{d}x +$ using "their F(2)" or $\int \frac{1}{16}(14x-3x^2-8)$ and using F(4) = 1 There must be an attempt to integrate for either method; $x^n \to x^{n+1}$ A1: 3rd line **oe** allow in terms of x. **Correct Method must be shown to award the A1** Must be in the cdf B1: fully correct all in terms of t (allow < instead of $\leq$ and vice versa ditto > and $\geq$) **NB fully correct answer with no working can gain M1A1M0A0B1**	
(d)	M1: their cdf for $1 < t \leq 2$ = 0.2 or $\int_1^t \frac{1}{2}(t-1)\mathrm{d}t$ = 0.2 and attempt at integration $x^n \to x^{n+1}$ M1: Correct method for solving their **3 term quadratic equation** ie correct use of formula or correct completion of the square A1:awrt 1.89 allow $\frac{5+2\sqrt{5}}{5}$ or $1+\frac{2}{\sqrt{5}}$ **oe** must be only one answer given.	
(e)	M1: attempt at 1 – F(1.5) must subst 1.5 into their line for $1 < t \leq 2$ **or** $\int_1^{1.5} \frac{1}{2}(t-1)\mathrm{d}t$ and attempt at integration $x^n \to x^{n+1}$ **oe** A1: 0.9375	
(f)	M1: 0.25/ "their (e)" or [1– "their F(3)"]/ "their (e)" **NB** if they have written a value for P(T > 3) allow this as the numerator if 0 < P(T > 3) < 1 A1: 4/15 or awrt 0.267	

Question Number	Scheme	Marks
4.(a)	$\frac{\beta+\alpha}{2}=4$, $\frac{(\beta-\alpha)^2}{12}=12$	B1
	$\beta+\alpha=8$ **and** $(\beta-\alpha)=12$ **or** $\alpha^2-8\alpha-20=0$ **or** $\beta^2-8\beta-20=0$	B1
	$2\beta=20$	M1d
	$\beta=10$	A1
	$\alpha=-2$	A1
		(5)
(b)	P(David late) = $0.05+0.95\times\left(\frac{"10"-5}{"12"}\right)$	M1, B1ft
	= $\frac{107}{240}$ or 0.4458333… awrt 0.446	A1
		(3)
(c)	P(missed train | late) = $\frac{0.05}{0.446}$	M1
	= $\frac{12}{107}$ or 0.1121… awrt 0.112	A1
		(2)
	Notes	**Total 10**
(a)	B1 $\frac{\alpha+\beta}{2}=4$ and $\frac{(\beta-\alpha)^2}{12}=12$ **oe** B1 A pair of correct linear equations or a correct single equation in α or β M1d dep on 1st B mark being awarded. Correct method to solve their simultaneous equations by eliminating α or β or a correct method to solve their quadratic equation. A1 cao must state it is $\beta=10$ not just write 10 or written as […, 10] A1 cao must state it is $\alpha=-2$ not just write -2 or written as [-2, …]	
(b)	M1 $0.05+0.95\times(p)$ $0<p<1$ B1ft $\left(\frac{10-5}{12}\right)$ or $\frac{5}{12}$ or awrt 0.417 or $\frac{"\text{their}\beta"-5}{"\text{their}\beta"-"\text{their}\alpha"}$ A1 awrt 0.446 or $\frac{107}{240}$ NB only award these marks in part(b)	
(c)	M1 $\frac{0.05}{\text{their (b)}}$ A1 awrt 0.112 or $\frac{12}{107}$	

Question Number	Scheme	Marks
5.(a)	$H_0 : p = 0.35$ $H_1 : p > 0.35$	B1
	$V \sim B(40, 0.35)$ $P(V \geq 18) = 1 - P(V \leq 17)$ or $P(V \geq 19) = 0.0699$	M1
	$= 1 - 0.8761$ $P(V \geq 20) = 0.0363$	
	$= 0.1239$ CR $V \geq 20$	A1
	Accept H_0 or not Significant or 18 does not lie in the critical region	M1d
	There is insufficient evidence that the **proportion/amount/number/ percentage** of customers who bought **organic vegetables** has increased.	A1cso (5)
(b)	$E \sim B(50, 0.35)$	M1
	$P(E \leq 10) = 0.0160$ $P(E \geq 25) = 0.0207$	
	$P(E \leq 11) = 0.0342$ $P(E \geq 24) = 0.0396$	
	CR $E \leq 10$ $E \geq 25$	A1A1 (3)
(c)	The **manager's claim** is supported or there is sufficient evidence that the proportion of customers buying organic **eggs** is different from those buying organic **vegetables**.	B1ft (1)
(d)	0.016 + 0.0207 = 0.0367 or 3.67% awrt 0.0367 or 3.67%	B1 (1)
(e)	$F \sim N(40, 32)$	M1 A1
	$P(F < n) = P\left(Z < \frac{n - 0.5 - 40}{\sqrt{32}}\right)$	M1M1d
	$\frac{n - 0.5 - 40}{\sqrt{32}} = -1.68$	B1
	$n = 31$	A1cso (6)
	Notes	**Total 16**
(a)	B1 both hypotheses correct with p or π M1 writing or using $V \sim B(40, 0.35)$ **and** $1 - P(V \leq 17)$ or $P(V \leq 17) = 0.8761$ or awrt 0.124 **OR** writing $P(V \geq 19) = 0.0699$ or $P(V \geq 20) = 0.0363$ **leading to a CR**. Implied by correct CR A1 awrt 0.124 or $V \geq 20$ or $V > 19$ allow any letter M1d dep on previous M being awarded. ft their CR or probability. A correct statement – do not allow contradicting non-contextual comments A1 cso all previous marks must be awarded. A correct statement in context. Need **Bold words. NB** award M1A1 for a correct contextual statement on its own. If there are no hypotheses or they are the wrong way around, then M0A0	
(b)	M1 writing $E \sim B(50, 0.35)$ **or** a correct probability or one tail of the CR correct A1 $E \leq 10$ **oe** A1 $E \geq 25$ **oe**, allow any letter. Condone missing letter **NB** If CR written as probabilities and both are correct or CR written as $10 \geq E \geq 25$ oe award M1A1A0. If just give CV 10 and 25 given award M1A0A0	
(c)	B1 A correct statement including the words **managers claim** or **eggs** and **vegetable(**s) (or **veg**) ft their 2 tail CR. Cannot be awarded if no CR given in (b)	
(e)	M1 writing/using normal approximation with mean = 40 A1 writing/using normal approximation with mean = 40 and var = 32 M1 $\pm\left(\frac{(n \text{ or } n - 0.5 \text{ or } n + 0.5) - \textit{their mean}}{\textit{their sd}}\right)$ if no mean or sd given they must be correct here. M1 dep on previous method mark being awarded. Using continuity correction $n - 0.5$ **B1** ± 1.68 **A1** 31 cso all previous marks must be awarded. **NB** 31 with no working gains no marks	

Question Number	Scheme	Marks
6.(a)	$\mathrm{F}'(x) = k\left(ax^2 - x^3\right)$ **oe**	M1
	$\mathrm{F}''(x) = k\left(2xa - 3x^2\right)$ **oe**	M1
	$2xka - 3kx^2 = 0$	
	$kx\left(2a - 3x\right) = 0$	
	$a = \frac{3}{2} \times \frac{8}{3}$ or $2 \times 4 - 3 \times \frac{8}{3} = 0$	M1d
	$a = 4$ *	A1cso*
		(4)
(b)	$\mathrm{F}(2) = \frac{4}{15} \Rightarrow k\left(\frac{32}{3} - 4\right) + b = \frac{4}{15}$ or $\frac{20}{3}k + b = \frac{4}{15}$ **oe**	M1
	$\mathrm{F}(4) = 1 \Rightarrow k\left(\frac{256}{3} - 64\right) + b = 1$ or $\frac{64}{3}k + b = 1$ **oe**	M1
	$\frac{44}{3}k = \frac{11}{15}$	M1dd
	$k = \frac{1}{20}$ or $b = -\frac{1}{15}$	A1
	Alternative to find *k*	
	$f(x) = \frac{4}{15}$ $1 < x \leq 2$ $f(x) = k(4x^2 - x^3)$ $2 < x \leq 4$	(M1)
	$\int_1^2 \frac{4}{15}\mathrm{d}x + \int_2^4 "\, k(4x^2 - x^3)"\mathrm{d}x = 1$	(M1)
	$\left[\frac{4}{15}x\right]_1^2 + k\left[\frac{4x^3}{3} - \frac{x^4}{4}\right]_2^4 = 1$ or $k\left[\frac{4x^3}{3} - \frac{x^4}{4}\right]_2^4 = \frac{11}{15}$	(M1dd)
	$\left[\frac{8}{15} - \frac{4}{15}\right] + k\left[\frac{4\times4^3}{3} - \frac{4^4}{4}\right] - k\left[\frac{4\times2^3}{3} - \frac{2^4}{4}\right] = 1$	
	$k = \frac{1}{20}$	(A1)
	$\mathrm{F}(2.5) = "\text{their } k"\left(\frac{4}{3} \times 2.5^3 - \frac{2.5^4}{4}\right) + ("\text{their } b")$	M1
	$= \frac{623}{1280}$ or $0.4867...$ awrt 0.487	A1cso
	Alternative to find F(2.5)	
	$\int_1^2 \frac{4}{15}\mathrm{d}x + \int_2^{2.5} "\, \frac{1}{20}(4x^2 - x^3)"\mathrm{d}x = \left[\frac{4}{15}x\right]_1^2 + k\left[\frac{4x^3}{3} - \frac{x^4}{4}\right]_2^{2.5}$	(M1)
	$= \frac{623}{1280}$ or $0.4867...$	(A1 cso)
		(6)
		Total 10

	Notes
(a)	M1 attempting to find $F'(x)$, $x^n \to x^{n-1}$ condone missing *k*. Implied by correct $F''(x)$ M1 attempting to find $F''(x)$, $x^n \to x^{n-1}$ condone missing *k* M1d dependent on the 2nd M being awarded. Putting "their $2a-3x"=0$ and substituting $x=8/3$ A1* cso fully correct solution with no errors. Must differentiatial including the *k* . Make sure there is no incorrect notation
(b)	M1 Form the correct equation in terms of the two unknowns *k* and *b* using $F(2)=4/15$ M1 Form the correct equation in terms of the two unknowns *k* and *b* using $F(4)=1$ M1dd dependent on first two method marks being awarded. Solving the two equations simultaneously by eliminating either *k* or *b* A1 one of *k* or *b* correct.
	Alternative
	M1 for 4/15 and attempt at differentiating third line $x^n \to x^{n-1}$ and must have *k*. M1 for using their pdf equations with correct limits, adding and setting equal to 1 **NB** these first two marks can be implied by $\left[\frac{4}{15}x\right]_1^2 + k\left[\frac{4x^3}{3}-\frac{x^4}{4}\right]_2^4 = 1$ or $k\left[\frac{4x^3}{3}-\frac{x^4}{4}\right]_2^4 = \frac{11}{15}$ dd M1 dependent of previous method marks being awarded. Correct integration and attempt to substitute limits A1 *k* correct
	M1 correct method for finding F(2.5) using their values for *k* and *b* or allow with the letters *a*(or 4), *k* and *b*. May be implied by a correct answer otherwise working must be shown. A1cso all previous method marks must be awarded $\frac{623}{1280}$ or awrt 0.487
	Alternative M1 correct method for finding F(2.5) using their value for *k* or allow with the letters *a*(or 4) and *k*. May be implied by a correct answer otherwise working must be shown. A1cso all previous method marks must be awarded $\frac{623}{1280}$ or awrt 0.487

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom