Mark Scheme (Results)

October 2020

Pearson Edexcel International A Level in Statistics S2 (WST02/01)

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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.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL 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
- $\lfloor$ 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. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme	Marks
1 (a)	$\int_1^2 k\left(\frac{1}{2}x^3-3x^2+ax+1\right)\mathrm{d}x[=1]$	M1
	$k\left[\frac{1}{8}x^4-x^3+\frac{1}{2}ax^2+x\right]_1^2[=1]$	A1
	$k\left(2-8+2a+2\right)-k\left(\frac{1}{8}-1+\frac{1}{2}a+1\right)=1$ **or** $k\left(2a-4\right)-k\left(\frac{1}{8}+\frac{1}{2}a\right)=1$	dM1
	$-\frac{33}{8}k+\frac{3}{2}ka=1 \quad \therefore k\left(12a-33\right)=8$ *	A1 *
		(4)
(b)	$\frac{\mathrm{d}f(x)}{\mathrm{d}x}=k\left(\frac{3}{2}x^2-6x+a\right)$	M1
	$\frac{3}{2}x^2-6x+5=0$ **or** $\frac{4}{9}x^2-\frac{16}{9}x+\frac{40}{27}=0$	dM1
	$x=\frac{6\pm\sqrt{6^2-4\times1.5\times5}}{3}$	M1
	$x=2-\frac{\sqrt{6}}{3}$ oe or 1.183... awrt 1.18	A1
		(4)

		Notes	Total 8
1(a)	**M1**	Attempting to integrate f(x), (at least one term $x^n \to x^{n+1}$). Ignore limits. No Need to equate to 1	
	A1	Fully correct integration. Allow not simplified. Ignore limits and accept any letters. Allow + C No Need to equate to 1	
	dM1	Dep on 1st M1. Subst in correct limits, subtracting results and equate to 1 Allow if they have + C the use of F(2) = 1 and F(1) = 0 to form 2 equations and solve to eliminate + C	
	A1*	Answer is given. Correct solution only. At least one correct line of working required between $k\left(2a-4\right)-k\left(\frac{1}{8}+\frac{1}{2}a\right)=1$ and the final given answer.	
(b)	**M1**	Attempting to differentiate f(x), (at least one term $x^n \to x^{n-1}$). Condone missing k or incorrect value for k	
	dM1	Dependent on first Method mark being awarded. Putting their differential (or multiple of) = 0 May be implied by awrt 1.18 or awrt 2.82	
	M1	Correct method for solving their 3 term quadratic equation. May be implied by awrt 1.18 or awrt 2.82 Minimum for method if final answer is incorrect is of the form $\frac{6\pm\sqrt{6}}{3}$	
	A1	Allow equivalent exact answer. awrt 1.18 Must eliminate the 2.816… or clearly indicate which of the 2 solutions is their answer	

Question Number	Scheme	Marks
2(a)	$\mathrm{f}(w)=\begin{cases}\frac{1}{8} & -1.4<w<6.6\\ 0 & \text{otherwise}\end{cases}$	M1 A1
		(2)
(b)	$\mathrm{E}(W)=2.6$ oe	B1
		(1)
(c)	$(1.6-\alpha)\times"\frac{1}{8}"=0.35$	M1
	$\alpha=-1.2$ oe	A1cso
		(2)
(d)	$\mathrm{P}(1.2<W<2.4)=(2.4-1.2)\times"\frac{1}{8}"$	M1
	$=\frac{3}{20}$ or 0.15 oe	A1ft
		(2)
(e)	$\mathrm{P}(W>2 \mid 1.2<W<2.4)=\frac{0.4\times"1/8"}{"0.15"}$	M1
	$=\frac{1}{3}$ awrt 0.333	A1
		(2)
(f)	The random variable Y is the number of days the train is between 1.2 minutes and 2.4 minutes late $Y\sim \mathrm{B}(40,"0.15")$	M1
	$\mathrm{P}(Y\geq 10)=1-\mathrm{P}(Y\leq 9)$ or $1-0.9328$	M1
	$=0.0672$ awrt 0.0672	A1 (3)

		Notes	Total 12
2(a)	**M1**	pdf of the form $[\mathrm{f}(w)=]\begin{cases}p & -1.4<w<6.6\\ 0 & \text{otherwise}\end{cases}$	where p is a probability allow use of $\leq$ instead of one/both < signs. Allow equivalent for the 0 otherwise. Allow any letter/mix of letters
	A1	Fully correct allow use of $\leq$ instead of one/both < signs. Allow any letter but must be consistent.	
(b)	**B1**	2.6 oe	
(c)	**M1**	setting up equation $(1.6-\alpha)\times"\text{their } p"=0.35$ with $0<p<1$ or $\frac{7}{20}=\frac{2.8}{8}$ and $\alpha=1.6-"2.8"$ or F(1.6) – F(α) = 0.35 using their F(w) in the form $bw+c$ where $0<b<1$ Allow for $\int_{\alpha}^{1.6}"\text{their f}(w)"\mathrm{d}w=0.35$ oe with an attempt to integrate (at least one term correct).	
	A1 cso	If using F(1.6) – F(α) = 0.35 then F(w) must be correct. Allow different letters	
(d)	**M1**	$(2.4-1.2)\times"\text{their } p"$ where "their $\frac{1}{8}$" is a probability or F(2.4) – F(1.2) using their F(w) in the form $bw+c$ where $0<b<1$ Implied by 0.15 Allow for $\int_{1.2}^{2.4}"\text{their f}(w)"\mathrm{d}w$ with an attempt to integrate (at least one term correct).	
	A1ft	Ft their p as long as the answer is a probability	
(e)	**M1**	$\frac{0.4\times"\text{their } 1/8"}{"\text{their (d)}"}$ or $\frac{0.4}{"1.2"}$ implied by $\frac{1}{3}$ Allow for $\int_{2}^{2.4}"\text{their f}(w)"\mathrm{d}w$ with an attempt to integrate (at least one term correct) for numerator	
	A1	Allow $0.\dot{3}$ or $0.3\dot{3}$	
(f)	**M1**	Writing or using B(40, " their 0.15") Implied by mean of $40\times"\text{their (d)}"$	
	M1	Writing or using $1-\mathrm{P}(Y\leq 9)$ Allow for $1-\mathrm{P}\left(z\leqslant\frac{9.5 \text{ or } 9-"\text{their mean}"}{"\text{their sd}"}\right)$	
	A1	awrt 0.0672	

Question Number	Scheme	Marks
3(a)(i)	$X \sim \text{B}(10,\ 0.45)$	M1
	$\text{P}(X \leq 1) = 0.0233$ awrt 0.0233	A1
(ii)	$\text{P}(X \geq 6) = 1 - \text{P}(X \leq 5)$ or $1 - 0.7384$	M1
	$= 0.2616\ldots$ awrt 0.262	A1
		(4)
(b)	$F \sim \text{N}(54,\ 29.7)$	M1A1
	$\frac{c + 0.5 - 54}{\sqrt{29.7}} \leq -1.6449$ **or** $\frac{d - 0.5 - 54}{\sqrt{29.7}} \geq 1.6449$	M1M1B1 A1
	$c = 44$ and $d = 64$	A1cso
		(7)
(c)	H_0: $p = 0.45$ H_1: $p < 0.45$	B1
	$Y \sim \text{B}(30, 0.45)$ therefore $\text{P}(Y \leq 8) = 0.03...$ or CR $Y \leq 8$	B1
	8 is in the critical region or Reject H_0 oe or significant	dM1
	therefore the data collected supports the **manufacturer's claim**.	A1
		(4)

	Notes	**Total 15**
(a)(i)	**M1**	Writing or using B(10, 0.45) in (i) or (ii) implied by a correct answer to (i) or (ii)
	A1	awrt 0.0233
(ii)	**M1**	For writing or using $1 - \text{P}(X \leq 5)$ oe
	A1	awrt 0.262
(b)	**M1**	For writing or using N(54,…)
	A1	For writing or using N(54, 29.7)
	M1	For standardising (allow $\pm$) using their "54" and "29.7" and putting = to z value where $1 < \lvert z \rvert < 2$ Condone missing ± 0.5
	M1	M1 for using a continuity correction $\pm$ 0.5 in standardisation. No need to put = to z value
	B1	For using 1.6449 or better (calc gives) 1.64485… Allow if written then gone on to use 1.65 or1.64 or better in equation
	A1	One correct inequality. Allow written as an equation. Allow with 1.65/1.64 or better
	A1cso	All previous marks awarded. Both c and d correct integers
		NB: c and d correct with no working can be awarded full marks
(c)	**B1**	Both hypotheses correct in terms of p or π Must be attached to H_0 and H_1
	B1	0.03 or better (0.03120…) or CR stated as $Y \leq 8$ oe do not accept $\text{P}(Y \leq 8) = ...$ for CR Condone 0.97 or better (0.96879…)
	dM1	Dep on 2nd B1 A correct statement – need not be contextual but do not allow contradicting non contextual comments. Allow opposite conclusion if 2-tail hypotheses given.
	A1	Correct conclusion for their H_1. If H_1 is 2- tail the opposite conclusion must be given. No hypotheses or H_1 $p > 0.45$ is A0. Allow belief instead of claim. Allow the data collected supports that the **proportion/percentage/probability/number/amount oe** of flawed **plates** has **decreased/reduced/is not 0.45/has changed oe**

Question Number	Scheme	Marks
4(a)	Common Spotted-orchids occur singly/randomly/independently	B1
		(1)
(b)(i)	$S \sim \text{Po}(4.5)$	
	$\text{P}(S=6)=\frac{\text{e}^{-4.5}4.5^6}{6!}$ or $\text{P}(S\leq 6)-\text{P}(S\leq 5)$	M1
	$=0.1281\ldots$ awrt 0.128	A1
(ii)	$\text{P}(4<S<10)=\text{P}(S\leq 9)-\text{P}(S\leq 4)$ or $0.9829-0.5321$	M1
	$=0.4508$ awrt 0.451	A1
		(4)
(c)	$\text{H}_0: \lambda=9$ $\text{H}_1: \lambda>9$	B1
	$M \sim \text{Po}(9)$ $\text{P}(M\geq 11)=1-\text{P}(M\leq 10)$ or $\text{P}(M\geq 15)=0.0415$	M1
	$=0.294$ or CR $M\geq 15$	A1
	Accept H_0 or insignificant or 11 does not lie in the critical region	dM1
	There is insufficient evidence to support **Juan's belief**	A1
		(5)
(d)	$T \sim \text{N}(90, 90)$	B1
	$\text{P}(T<70)=\text{P}\left(Z<\pm\left(\frac{69.5-90}{\sqrt{90}}\right)\right)$ or $\text{P}(Z<\pm 2.160\ldots\ldots)$ awrt 2.16	M1
	$=0.0154$ awrt 0.0154	A1
		(3)
(e)	$V\sim \text{Po}(200\times 0.012)=\text{Po}(2.4)$ $V\sim=\text{Po}(2.4)$	M1
	$\text{P}(V=0)+\text{P}(V=1)=\text{e}^{-2.4}(1+2.4)$	dM1
	$=0.30844\ldots$ awrt 0.308	A1
		(3)
	Notes	**Total 16**
4(a)	**B1**	One of the given reasons. No context needed
(b)(i)	**M1**	For $\frac{\text{e}^{-\lambda}\lambda^6}{6!}$ with any value for λ or writing or using $\text{P}(S\leq 6)-\text{P}(S\leq 5)$
	A1	awrt 0.128
(ii)	**M1**	Writing or using $\text{P}(S\leq 9)-\text{P}(S\leq 4)$
	A1	awrt 0.451
(c)	**B1**	Both hypotheses correct. Must be attached to H_0 and H_1 in terms of λ or μ. Allow 4.5 instead of 9.
	M1	Writing or using Po(9) and $1-\text{P}(M\leq 10)$ or $\text{P}(M\geq 15)=0.0415$ oe Implied by correct CR or awrt 0.3 or 0.29… or better (0.2940…)
	A1	0.3 or 0.29… or better (0.2940…) or $M\geq 15$ oe SC: Condone $\text{P}(X\leqslant 10)=0.7$ or better (0.705988....) for M1A1
	dM1	Dep on M1 A1. A correct statement– no context needed but do not allow contradicting non contextual comments. Allow opposite conclusion if 2-tail hypotheses given.
	A1	Correct conclusion. If H_0 is 2- tail the opposite conclusion must be given. No hypotheses or H_0 $\lambda<9$ gets A0. Allow claim instead of belief. Alternative: There is insufficient evidence to support hat the number of Common Spotted-**orchids** has **increased/ /is not 9/has changed oe** (with the bold words included).
(d)	**B1**	Writing or using N(90, 90)
	M1	Standardising with 68.5 or 69.5 or 70.5 and their mean and sd
	A1	awrt 0.0154 **NB** Poisson gives 0.01275…
(e)	**M1**	Writing or using $\text{Po}(200\times 0.012)$ Allow $\text{Po}(200\times$"their d")
	dM1	Dependent on using Poison. For using / writing $\text{P}(V=0)+\text{P}(V=1)$ or $\text{e}^{-\lambda}(1+\lambda)$ or $\text{P}(V\leqslant 1)$ oe
	A1	awrt 0.308 **NB** Binomial gives 0.3066

Question Number	Scheme	Marks
5(a)	$\mathrm{E}(T^2)=\int_0^3 \frac{1}{50}\left(18t^2-2t^3\right)\,\mathrm{d}t+\int_3^5 \frac{1}{20}t^2\mathrm{d}t$	M1
	$=\left[\frac{1}{50}\left(6t^3-\frac{t^4}{2}\right)\right]_0^3+\left[\frac{t^3}{60}\right]_3^5$ or $=\left[\frac{3}{25}t^3-\frac{t^4}{100}\right]_0^3+\left[\frac{t^3}{60}\right]_3^5$ oe	A1
	$=\frac{1}{50}\left(6\times3^3-\frac{3^4}{2}\right)+\left(\frac{125}{60}-\frac{27}{60}\right)$ or $=\frac{1}{50}\left(162-\frac{81}{2}\right)+\left(\frac{25}{12}-\frac{9}{20}\right)$ oe	M1d
	$=\frac{1219}{300}=4.063...$	
	$\mathrm{Var}(T)=\text{"}4.063...\text{"}-(1.66)^2$	M1
	= 1.3077… awrt 1.31	A1
		(5)
(b)	$\int_3^t \frac{1}{20}\mathrm{d}x+C$ where $C=0.9$ or $\int_0^3 \frac{1}{50}(18-2t)\,\mathrm{d}t$ **or** using F(5) =1 to find C	M1
	$\left[\mathrm{F}(t)=\right]\begin{cases}0 & t<0\\ \frac{1}{50}\left(18t-t^2\right) \text{ or } 1.62-\frac{(18-2t)^2}{200} & 0\le t\le 3\\ \frac{1}{20}t+0.75 & 3<t\le 5\\ 1 & t>5\end{cases}$	B1 A1 A1
		(4)
(c)	$\mathrm{P}(T>2)=1-\text{"}\frac{1}{50}\left(18\times2-2^2\right)\text{"}$ or $1-\int_0^2 \frac{1}{50}(18-2t)\,\mathrm{d}t$	M1
	$=\frac{9}{25}$ or 0.36	A1
		(2)
(d)	$\mathrm{P}(0<T<3.66)$ = F(3.66)	M1
	= 0.933	A1
		(2)
	Notes	**Total 13**

(a)	**M1**	Intention to find $\mathrm{E}(T^2)$ correctly. They must add the 2 integrals and attempt to integrate (at least one term $x^n \to x^{n+1}$). Algebraic integration must be seen. Ignore limits. Allow as part of Var(T) condone " – (1.66)^2" occurring twice. If no algebraic integration shown it is M0
	A1	Correct integration
	M1d	dep on previous M being awarded for correct limits and attempt to substitute. If no working shown An attempt may be implied by a correct answer **or** 1219/300 **or** 243/100 **or** 49\30 oe
	M1	For their $\mathrm{E}(T^2)$ – 1.66^2
	A1	awrt 1.31 Allow 2452 / 1875 oe
(b)	**M1**	For a correct method to find the 3rd line including limits unless using F(5) = 1 method.
	B1	2nd line correct – any letter. Ignore missing inequality
	A1	3rd line correct– any letter. Ignore missing inequality
	A1	Fully correct CDF All in terms of the same letter (Ignore LHS). Allow < instead of ≤ and vice versa. Allow "otherwise" for the range on the 1st or last line but not both.
(c)	**M1**	For finding 1 – F(2) using their second line or starting again. Must subst in 2
	A1	cao
(d)	**M1**	For realising they need F(3.66) Allow F(3.66) [– F(0)] allow F("their mean +2") [– F(0)]
	A1	Cao allow answer as a fraction

Question Number	Scheme	Marks
6(a)	A sampling distribution is **all** the **values** of a **statistic** and the associated **probabilities** **or** the **probability distribution** of the **statistic**.	B1
		(1)
(b)	P(small(40)) = 0.5, P(medium(80)) = 0.3, P(large(150)) = 0.2	B1
	Range (R) 0, 40, 70, 110	B1
	$\left[\mathrm{P}(R=0)=\right]"0.5"^3+"0.3"^3+"0.2"^3=0.16$	M1
	(40,40,80) (40,80,80) (80,80,150) (80,150,150) (40,40,150) (40,80,150) (40,150,150)	B1
	$\left[\mathrm{P}(R=40)=\right]3\times("0.5"\times"0.3"^2)+3\times("0.5"^2\times"0.3")$	M1
	$\left[\mathrm{P}(R=70)=\right]3\times("0.3"^2\times"0.2")+3\times("0.3"\times"0.2"^2)=0.09$	M1
	$\left[\mathrm{P}(R=110)=\right]3\times("0.5"^2\times"0.2")+3\times("0.5"+"0.2"^2)+6\times("0.5"\times"0.3"\times"0.2")=0.39$	M1
	R: 0, 40, 70, 110 r: 0.16, 0.36, 0.09, 0.39	A1cao
		(7)
(c)	$(1-"0.09")^n<0.2$ or $("0.91")^n<0.2$	M1
	$[n>]17.065...$	M1
	$n=18$	A1
		(3)
	Notes	**Total 11**

6(a)	**B1**	A correct explanation with the words in bold. Allow equivalent words eg outcomes for values
(b)	**B1**	Correct probabilities – may be seen in an equation or implied by a correct probability for $R = 0$ or for 2 correct probabilities from those for $R=40$, $R=70$, $R=110$
	B1	All four ranges correct with no extra.
	M1	Correct method for finding P($R = 0$)
	B1	All the correct combinations for $R = 40$, 70 and 110. $R= 0$ combinations are not required but no incorrect combinations must be seen (may use bag size rather than numbers in bag) May be implied by a correct probability for P($R = 40$), P($R = 70$) and P($R = 110$) or by correct working seen for each of the 7 combinations (no need for the number of ways of arranging ie $3\times$ or $6\times$) eg $(40,40,80)=0.5^2\times0.3$
	M1	Correct method for one of the probabilities for P($R = 40$), P($R = 70$), P($R = 110$)
	M1	Correct method for a second probability for P($R = 40$), P($R = 70$), P($R = 110$) or the 4 probabilities add up to 1.
	A1	Correct answer only. Allow answers as a fraction. Need not be in a table but probabilities must be attached to the correct range
(c)	**M1**	Setting up a correct inequality using their 0.09 Allow written as an equation.
	M1	For 17.1 or better allow $\frac{\log 0.2}{\log"0.91"}$ or $\log_{"0.91"}0.2$ oe If inequality/equation is incorrect but of the form $(p)^n<0.2$ $(p)^n=0.2$ where $0<p<1$ this mark can be awarded if working is shown
	A1	18 do not accept $n > 18$ or $n < 18$ if final answer

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