

Question Number	Scheme		Marks
1(a)	List of all the members [of the sports club]		B1
			(1)
(b)	Individual members [of the sports club]		B1
			(1)
(c)	Advantage: Less time consuming to obtain and analyse it/Less expensive		B1
	Disadvantage: May not be representative of the entire population		B1
			(2)
			Total 4
	Notes		
(a)	B1	Idea of a list e.g. database/register of all members. All can be implied but do not allow a partial list e.g. A list of 50 members.	
(b)	B1	Allow member. Do not allow member's opinions.	
(c)	B1	A correct advantage of taking a sample. If not labelled, assume the response refers to sample (rather than a census).	
	B1	A correct disadvantage of taking a sample. If not labelled, assume the response refers to sample (rather than a census).	

Question Number	Scheme		Marks
2 (a)	Mean = 1.98		B1
	Variance = 1.95		B1
	Mean and variance are similar [no reason to doubt the manager's belief]		B1
			(3)
(b)(i)	$P(X \geq 4) = 1 - P(X \leq 3) = 1 - 0.8571$		M1
	$= 0.1429$ (Calc 0.1428765...)	awrt 0.143	A1
(ii)	$P(X \leq 6) - P(X \leq 2) = 0.9955 - 0.6767$		M1
	$= 0.3188$ (Calc 0.318789...)	awrt 0.319	A1
			(4)
(c)	$H_0 : \lambda = 2 \quad H_1 : \lambda > 2$ Allow $H_0 : \lambda = 10 \quad H_1 : \lambda > 10$		B1
	$P(X \geq 17 \text{Po}(10)) = 1 - P(X \leq 16) = 1 - 0.9730$ or $P(X \geq 16 \text{Po}(10)) = 1 - P(X \leq 15) = 1 - 0.9513$		M1
	$= 0.0270$ (Calc 0.027041....) or $\text{CR} \geq 16$		A1
	Reject H_0 /In the CR/Significant		M1
	There is sufficient evidence to suggest that the mean number of complaints received is greater than 2 per day		A1
			(5)
			Total 12
	Notes		
(a)	B1	cao do not allow fraction	
	B1	cao	
	B1	Allow mean = variance ignore extraneous non-contradictory comments	
(b)(i)	M1	For $1 - P(X \leq 3)$ or $1 - 0.8571$	
	A1	awrt 0.143 correct answer scores 2/2	
(ii)	M1	For $P(X \leq 6) - P(X \leq 2)$ or $0.9955 - 0.6767$	
	A1	awrt 0.319 correct answer scores 2/2	
(c)	B1	Both hypotheses correct. Must be attached to H_0 and H_1 in terms of λ or μ	
	M1	For writing or using $\text{Po}(10)$ and $1 - P(X \leq 16)$ or CR: $1 - P(X \leq 15)$ implied by awrt 0.0487 from a CR method	
	A1	awrt 0.027 or $\text{CR} \geq 16$	
	M1	A correct statement consistent with their p -value and 0.05 or 17 and their CR – no context needed but do not allow contradicting non contextual comments	
	A1	(Dep on both M marks) Correct conclusion in context with bold	

		words o.e. Must include the idea of rate so either: mean number or number per day
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Question Number	Scheme			Marks						
3 (a)	If all possible samples are chosen from a population, then <u>all</u> the <u>values</u> of a <u>statistic</u> and their associated <u>probabilities</u> is a sampling distribution <u>or a probability distribution</u> of a <u>statistic</u>			B1						
				(1)						
(b)	111 112 (×3) 122 (×3) 222			B1 B1						
				(2)						
(c)	$\frac{5}{3}$			B1						
				(1)						
(d)	$p^3 = \frac{27}{125}$			M1						
	$p = 0.6$ and $q = 0.4$			A1						
	$\left[b = P\left(\frac{4}{3}\right) \right] = 3 \times p^2 \times q$			M1						
	$\left[c = P\left(\frac{5}{3}\right) \right] = 3 \times p \times q^2$			M1						
	$[d = P(2)] = q^3$			M1						
	$b = \frac{54}{125} = 0.432$ $c = \frac{36}{125} = 0.288$ $d = \frac{8}{125} = 0.064$			A1						
				(6)						
(e)	<table><tr><td>m</td><td>1</td><td>2</td></tr><tr><td>$P(M = m)$</td><td>$\frac{81}{125} = 0.648$</td><td>$\frac{44}{125} = 0.352$</td></tr></table>	m	1	2	$P(M = m)$	$\frac{81}{125} = 0.648$	$\frac{44}{125} = 0.352$			B1 M1 A1
	m	1	2							
$P(M = m)$	$\frac{81}{125} = 0.648$	$\frac{44}{125} = 0.352$								
				(3)						
				Total 13						
Notes										
(a)	B1	A correct explanation including underlined words o.e.								
(b)	B1	For three correct combinations								
	B1	All four combinations (condone permutations) with no additional incorrect ones								
(c)	B1	Allow awrt 1.67								
(d)	M1	For a correct method to find p								
	A1	For $p = 0.6$ and $q = 0.4$ may be implied by a correct calculation								
	M1	A correct method to find $P\left(\frac{4}{3}\right)$ ft their p and q								
	M1	A correct method to find $P\left(\frac{5}{3}\right)$ ft their p and q								
	M1	A correct method to find $P(2)$ ft their p and q								
	A1	cao								
(e)	B1	For $m = 1$ and $m = 2$ only								

	M1	For either $\frac{27}{125} + ' \frac{54}{125} '$ ft their b or $' \frac{36}{125} ' + ' \frac{8}{125} '$, ft their c and d
	A1	cao

Question Number	Scheme		Marks
4(a)	$F(10) = 1 \Rightarrow -k(100 - 200 + 52) = 1$		M1
	<u>or</u> $F(6) = \frac{2}{3} \Rightarrow -k(36 - 120 + 52) = \frac{2}{3}$		
	$48k = 1$ leading to $k = \frac{1}{48}^*$		A1*
			(2)
(b)	$[P(X = 4) =] 0$		B1
			(1)
(c)	$F(4.5) - F(2.5) + F(8.5) - F(5.5)$		M1
	$\frac{1}{6}(4.5 - 2) - \frac{1}{24}(2.5 - 1)^2 - \frac{1}{48}(8.5^2 - 20 \times 8.5 + 52) - \frac{1}{6}(5.5 - 2)$		M1
	$\left[= \frac{5}{12} - \frac{3}{32} + \frac{61}{64} - \frac{7}{12} \right]$		
	$= \frac{133}{192}$		A1
		(3)	
(d)	Attempt to differentiate either function		M1
	$[r(x) =] \frac{1}{12}(x - 1) = \frac{1}{12}x - \frac{1}{12}$		A1
	$[s(x) =] \frac{1}{24}(10 - x) = \frac{5}{12} - \frac{1}{24}x$		A1
			(3)
			Total 9
Notes			
(a)	M1	For using $F(10) = 1$ or $F(6) = \frac{2}{3}$	
	A1*	Fully correct solution with substitution seen leading to $k = \frac{1}{48}$	
(b)	B1	cao	
(c)	M1	For writing or using $F(4.5) - F(2.5)$ implied by $\frac{31}{96}$	
		<u>or</u> $F(8.5) - F(5.5)$ implied by $\frac{71}{192}$	
	M1	For a fully correct method with values substituted into correct part of cdf	
	A1	Allow awrt 0.693	
(d)	M1	Attempt to differentiate either function with $x^n \rightarrow x^{n-1}$ (implied by either correct answer)	
	A1	A correct expression for $r(x)$ oe	
	A1	A correct expression for $s(x)$ oe	

Question Number	Scheme		Marks
5 (a)	$[X \sim B(15, 0.25) \quad P(X > 4) =] 1 - P(X \leq 4) = 1 - 0.6865$		M1
	$= 0.3135$ (Calc 0.313514...) awrt 0.314		A1
			(2)
(b)	$P(X \geq 1) > 0.95 \Rightarrow 1 - P(X = 0) > 0.95$ so $[{}^nC_0(0.25)^0](0.75)^n < 0.05$		M1
	$n > 10.4(1\dots)$ or $n > \frac{\log(0.05)}{\log(0.75)}$ or $n > \log_{0.75}(0.05)$		M1
	$n = \underline{11}$		A1
			(3)
(c)	$X \sim B(100, 0.25)$ so $N(25, 18.75)$		B1
	$P(21.5 < Y < 30.5) = P(Y < 30.5) - P(Y < 21.5)$		M1
	$P\left(Z < \frac{30.5 - 25}{\sqrt{18.75}}\right) - P\left(Z < \frac{21.5 - 25}{\sqrt{18.75}}\right) = P(Z < 1.27) - P(Z < -0.81)$		M1 M1
	$= 0.8980 - 0.2090 = 0.689$ (Calc 0.688526...) awrt 0.689		A1
			(5)
(d)	$H_0: p = 0.3$ and $H_1: p > 0.3$		B1
	$R \sim B(25, 0.3) \quad P(X \geq 10) = 1 - P(X \leq 9) = 1 - 0.8106$ or CR method: $P(X \geq 11) = 1 - P(X \leq 10) = 1 - 0.9022 = 0.0978$		M1
	$= 0.1894$ or $CR \geq 11$		A1
	Do not reject H_0 /not significant/not in the CR		M1
	There is not significant evidence that the proportion of tulips producing red flowers is greater than 0.3		A1
			(5)
	Notes		Total 15
(a)	M1	For $1 - P(X \leq 4)$ or $1 - 0.6865$	
	A1	awrt 0.314 correct answer 2/2	
(b)	M1	For $1 - P(X = 0) > 0.95$ or $(0.75)^n < 0.05$ (condone =)	
	M1	For $n > 10.41$ or $n > \frac{\log(0.05)}{\log(0.75)}$ or $n > \log_{0.75}(0.05)$ (condone < or =) or for the 2 trials for $n = 10$ and 11	
	A1	cao	
(c)	B1	For writing or using $N(25, 18.75)$ NB: Poisson approximation send to review	
	M1	For writing or using 21.5 or 30.5	
	M1	For either standardisation using their mean and standard deviation. Allow 20.5/21/21.5 29.5/30/30.5	
	M1	For both standardisations using their mean and standard deviation. Allow 20.5/21/21.5 29.5/30/30.5	

	A1	(Dep on all M marks) awrt 0.689 (Exact binomial awrt 0.685 scores 0/5)
(d)	B1	Both hypotheses correct. Must be attached to H_0 and H_1 in terms of p or π
	M1	For writing or using $B(25, 0.3)$ and $1 - P(X \leq 9)$ or for CR : $1 - P(X \leq 10)$
	A1	awrt 0.189 or $CR \geq 11$
	M1	A correct statement – no context needed but do not allow contradicting non contextual comments
	A1	(Dep on both M marks) Correct conclusion in context using bold word o.e.

Question Number	Scheme		Marks
6 (a)	$[A=] X(20 - X) = 20X - X^2$		M1
	$[E(X)=]10$	$[E(A)=] \frac{1}{20} \int_{[0]}^{[20]} 20x - x^2 \, dx$	B1
	$[\text{Var}(X)=] \frac{100}{3}$	$[E(A)=] \frac{1}{20} \left[10x^2 - \frac{1}{3}x^3 \right]_{[0]}^{[20]}$	B1
	$E(X^2) = 10^2 + \frac{100}{3} \left[= \frac{400}{3} \right]$	Correct limits 0 and 20	M1
	$E(A) = 20 \times 10 - \frac{400}{3}$	$E(A) = \frac{1}{20} \left(10(20^2) - \frac{1}{3}(20^3) - 0 \right)$	M1
		$= \frac{200}{3}$	A1
			(6)
(b)	$[P(A > 5X^2) =] P(20X - X^2 > 5X^2)$		M1
	$\Rightarrow P\left(X < \frac{10}{3}\right)$		M1
	$\frac{1}{20} \times \frac{10}{3}$		M1
	$= \frac{1}{6}$		A1
			(4)
			Total 10
	Notes		
(a)	M1	For a correct expression for area	
	B1	For 10 <u>or</u> correct expression for E(A) ignore limits	
	B1	For $\frac{100}{3}$ <u>or</u> fully correct integration	
	M1	For use of $E(X^2) = E(X)^2 + \text{Var}(X)$ ft their E(X) and Var(X) <u>or</u> correct limits seen or used	
	M1	For use of $20E(X) - E(X^2)$ ft their E(X) and $E(X^2)$ <u>or</u> complete numerical expression for E(A)	
	A1	Allow awrt 66.7	
(b)	M1	For " $20X - X^2 > 5X^2$ " Allow = ft their area which must be in terms of X	
	M1	For rearranging and attempting to solve " $20X - X^2 > 5X^2$ " May be implied by $\frac{10}{3}$	
	M1	For correct area $\frac{1}{20} \times \frac{10}{3}$	
	A1	Allow awrt 0.167	

Question Number	Scheme		Marks
7(a)	$\int_0^m \left(\frac{1}{4}x - \frac{1}{64}x^3 \right) dx \left[= \frac{1}{2} \right]$		M1
	$\left[\frac{1}{8}x^2 - \frac{1}{256}x^4 \right]_0^m \left[= \frac{1}{2} \right]$		A1
	$m^4 - 32m^2 + 128 = 0$ or for either F(2.1645) or F(2.1655)		M1
	$m^2 = 16 \pm \sqrt{128}$ (= 4.686... or 27.313...) or both F(2.1645) and F(2.1655)		M1
	$m = \sqrt{16 - \sqrt{128}} = 2.165^*$		A1*
			(5)
(b)	$E\left(\frac{1}{Y}\right) = \frac{4}{255} \int_1^4 (y^{-1}y^3) dy = \frac{4}{255} \int_1^4 (y^2) dy$		M1
	$\frac{4}{255} \left[\frac{y^3}{3} \right]_1^4 = \frac{4}{255} \times \frac{63}{3} \left[= \frac{28}{85} \right]$		dM1
	$E\left(\frac{1}{Y^2}\right) = \frac{4}{255} \int_1^4 (y^{-2}y^3) dy = \int_1^4 \frac{4}{255} y dy$		M1
	$\frac{4}{255} \left[\frac{y^2}{2} \right]_1^4 = \frac{4}{255} \times 7.5 \left[= \frac{2}{17} \right]$		dM1
	$\text{Var}\left(\frac{1}{Y}\right) = \frac{2}{17} - \left(\frac{28}{85}\right)^2 = \frac{66}{7225}^*$		A1*
			(5)
(c)	$\text{Var}\left(4 - \frac{5}{Y}\right) = 25 \times \frac{66}{7225}$		M1
	$= \frac{66}{289} = 0.2283...$ awrt 0.228		A1
			(2)
	Notes		Total 12
(a)	M1	For $\int f(x) dx$ ignore limits and = 0.5	
	A1	For correct integration ignore limits and = 0.5	
	M1	For substitution of limits leading to a correct equation or use of 2.1645 or 2.1655	
	M1	Solving the equation leading to $m^2 = ...$ or substitution of both 2.1645 (= 0.499891) and 2.1655 (= 0.500273)	
	A1*	$m = \sqrt{16 - \sqrt{128}}$ or 0.499... < m < 0.500... leading to the given answer	
(b)	M1	For $\int \frac{1}{y} f(y) dy$ Ignore limits	
	dM1	Dep on previous M1. For substitution of limits into integrated expression	
	M1	For $\int \frac{1}{y^2} f(y) dy$ Ignore limits	

	dM1	Dep on previous M1. For substitution of limits into integrated expression
	A1*	Dep on all M marks. For use of $E\left(\frac{1}{Y^2}\right) - \left(E\left(\frac{1}{Y}\right)\right)^2$ leading to the given answer
(c)	M1	For use of $5^2 \text{Var}\left(\frac{1}{Y}\right)$
	A1	awrt 0.228