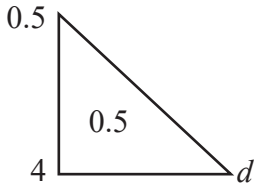


Question Number	Scheme		Marks	
1 (a) (i)	$X \sim B(14, 0.2)$			
	$[P(X = 2)] = {}^{14}C_2 \times 0.2^2 \times 0.8^{12}$		M1	
	$= 0.2501$		awrt 0.2501	
	(ii)	$X \sim B(25, 0.2)$		
		$P(X > 3) = 1 - P(X \leq 3) = 1 - 0.2340$ or $1 - (0.0038 + 0.0236 + 0.0708 + 0.1358)$		M1
		$= 0.7660$		awrt 0.766
			(4)	
(b)(i)	$[np = 6 \Rightarrow] n = \frac{6}{0.2}$		M1	
	$= 30$		A1	
				(2)
(ii)	$Y \sim B(n, 0.2)$ we require $P(Y \geq 1) > 0.95$			
	$1 - P(Y = 0) > 0.95 \Rightarrow P(Y = 0) < 0.05$		M1	
	$[{}^n C_0 \times 0.2^0] \times 0.8^n < 0.05$		M1	
	$0.8^{14} = 0.04398... [< 0.05]$	$n > \frac{\ln 0.05}{\ln 0.8} \Rightarrow n > 13.425$	dM1	
	$n = 14$		A1	
				(4)
Notes			Total 10	
(a) (i)	M1	For writing or using ${}^{14}C_2 \times 0.2^2 \times 0.8^{12}$ (Allow 91 for ${}^{14}C_2$)		
	A1	awrt 0.2501 NB 0.2501 with no working scores M1A1		
(ii)	M1	For writing or using $1 - P(X \leq 3)$		
	A1	awrt 0.766 NB awrt 0.766 with no working scores M1A1		
(b)(i)	M1	For use of $np = 6$ e.g. $0.2n = 6$ (Allow \geq)		
	A1	Cao		
(ii)	M1	For writing or using $P(Y \geq 1) = 1 - P(Y = 0)$ (Allow $P(Y \geq 1) = 1 - P(Y \leq 0)$)		
	M1	For $0.8^n < 0.05$ oe (Allow $=$ or \leq)		
	dM1	Dependant on previous M1 For substitution of n (allow $0.8^{13} = 0.05497...$) or rearranging to $n > ...$ (Allow $=$ or \geq) If using logs allow any base e.g. $n > \log_{0.8} 0.05$		
	A1	Cao		

Question Number	Scheme		Marks
2 (a)	[Mode =] 4		B1 (1)
(b)	$\left[a \int_0^4 x^3 dx = \frac{1}{2} \Rightarrow \right] a \left[\frac{x^4}{4} \right]_0^4 = \frac{1}{2}$		M1
	$64a = \frac{1}{2} \Rightarrow a = \frac{1}{128} *$		A1* (2)
(c)		$\frac{1}{2} \times \frac{1}{2} \times (d-4) = \frac{1}{2}$ or $\frac{1}{2} \times \frac{1}{2} \times (d-4) + \int_0^4 ax^3 dx = 1$	M1
	$d = 6$		A1 (2)
(d)	$b = \frac{-\frac{1}{2}}{6-4} \left[= -\frac{1}{4} \right]$	$4b + c = 0.5$ oe	M1
	$0 = -\frac{1}{4} \times 6 + c$ or $\frac{1}{2} = -\frac{1}{4} \times 4 + c$	$10b + 2c = 0.5$ oe or $6b + c = 0$ oe	M1
	$b = -\frac{1}{4}$ and $c = \frac{3}{2}$		A1 (3)
Notes			Total 8
(a)	B1	Cao	
(b)	M1	For integrating the 1 st line of the pdf and setting = 0.5 Ignore limits	
	A1*	Answer is given so a correct solution must be seen with no errors. There must be at least one line of correct working from the M mark to the final answer.	
		Mark parts c and d together	
(c)	M1	For setting the area of the triangle = 0.5	
	A1	Cao	
(d)	M1	A correct method for finding b ft their d value or $4b + c = 0.5$ oe (this may be seen any part of this question) Allow $4b + c = 64a$	
	M1	A correct method for finding c ft their b and d value or $10b + 2c = 0.5$ oe or $6b + c = 0$ oe (these may be seen any part of this question) Allow $6b + c = 0$	
	A1	For both b and c correct NB $b = -0.25$ oe and $c = 1.5$ oe will score 3/3	

Question Number	Scheme		Marks
3 (a)(i)	$3 + [0] + 29 = 32^*$		B1*
(ii)	$3 + 15 + 29 = 47^*$		B1*
			(2)
(b)	$f(t) = \begin{cases} \frac{1}{15} & 32 \leq t \leq 47 \\ 0 & \text{otherwise} \end{cases}$		M1 A1
			(2)
(c) (i)	[E(T) =] 39.5 oe		B1
(ii)	[Var(T) =] $\frac{(47-32)^2}{12}$		M1
	$\frac{75}{4} = 18.75$		A1
			(3)
(d)	$(40-32) \times \frac{1}{15}$		M1
	$= \frac{8}{15}$		A1
			(2)
Notes			Total 9
(a)(i)	B1*	For $3 + [0] + 29$	
(ii)	B1*	For $3 + 15 + 29$ Allow $32 + 15$	
(b)	M1	For $f(t) = \frac{1}{15} \quad 32 \leq t \leq 47$ Allow use of $<$ instead of one/both \leq signs. Allow the use of any letter for $f(t)$ and t (Condone inconsistent use of letters) but we must have $f(t)$ and an inequality	
	A1	Fully correct pdf $f(t) = \begin{cases} \frac{1}{15} & 32 \leq t \leq 42 \\ 0 & \text{otherwise} \end{cases}$ Must be $f(t)$ and t . Condone $f(T)$ and T Allow use of $<$ instead of one/both \leq signs Allow equivalent for the 0 otherwise.	
(c)(i)	B1	For 39.5 oe	
(ii)	M1	For use of $\text{Var}(T) = \frac{(\beta - \alpha)^2}{12}$	
	A1	For 18.75 oe	
(d)	M1	For use of $(40 - \alpha) \times \frac{1}{\beta - \alpha}$	
	A1	For $\frac{8}{15}$ oe Allow awrt 0.533	

Question Number	Scheme			Marks								
4 (a)	$0.2 \times £10 + 0.3 \times £12 + 0.5 \times £15$			M1								
	$= [£]13.10$			A1								
				(2)								
(b)	10 10 10	12 12 12	15 15 15	B1 B1								
	10 10 12 ($\times 3$)	12 12 15 ($\times 3$)	12 15 15 ($\times 3$)									
	10 10 15 ($\times 3$)	10 12 12 ($\times 3$)	10 15 15 ($\times 3$)									
	10 12 15 ($\times 6$)			(2)								
(c)	$P(10) = 0.2$	$P(12) = 0.3$	$P(15) = 0.5$	B1								
	Median can be 10, 12 or 15			B1								
	$P(M = 10) = 0.2^3 + 0.2^2 \times 0.3 \times 3 + 0.2^2 \times 0.5 \times 3$ or $1 - 0.8^3 - 3 \times 0.8^2 \times 0.2$			M1								
	$P(M = 12) = 0.3^3 + 0.3^2 \times 0.5 \times 3 + 0.3^2 \times 0.2 \times 3 + 0.2 \times 0.3 \times 0.5 \times 6$			M1								
	$P(M = 15) = 0.5^3 + 0.5^2 \times 0.3 \times 3 + 0.5^2 \times 0.2 \times 3$ or $1 - 0.5^3 - 3 \times 0.5^2 \times 0.5$			M1								
	<table border="1" style="width: 100%; text-align: center;"> <tr> <td>M</td> <td>10</td> <td>12</td> <td>15</td> </tr> <tr> <td>$P(M = m)$</td> <td>$\frac{13}{125} = 0.104$</td> <td>$\frac{99}{250} = 0.396$</td> <td>$\frac{1}{2} = 0.5$</td> </tr> </table>			M	10	12	15	$P(M = m)$	$\frac{13}{125} = 0.104$	$\frac{99}{250} = 0.396$	$\frac{1}{2} = 0.5$	A1
	M	10	12	15								
$P(M = m)$	$\frac{13}{125} = 0.104$	$\frac{99}{250} = 0.396$	$\frac{1}{2} = 0.5$									
			(6)									
Notes				Total 10								
(a)	M1	For $0.2 \times 10 + 0.3 \times 12 + 0.5 \times 15$ May be implied by a correct answer										
	A1	Cao Allow 13.1										
(b)	B1	B1 for at least 5 possible combinations. Ignore repeats. May be seen in part c										
	B1	For all 10 possible combinations. Ignore repeats. May be seen in part c										
(c)	B1	Correct probabilities – may be seen in an equation or implied by a correct probability										
	B1	All 3 medians and no extras										
	M1	A correct method for one of the probabilities (May be implied by a correct probability)										
	M1	A correct method for two of the probabilities (May be implied by 2 correct probabilities)										
	M1	A correct method for all three probabilities (May be implied by 3 correct probabilities) or 3 probabilities that add to 1										
	A1	Cao Need not be in a table but probabilities must be attached to the correct median										

Question Number	Scheme		Marks
5 (a)	Complaints received are independent or occurring at a constant rate or singly		B1 (1)
(b)(i)	$P(X < 3 X \sim \text{Po}(6)) =]0.0620$	awrt 0.062	B1
(ii)	$P(X \dots 6) =]1 - P(X \dots 5)$ or $1 - 0.4457 = 0.5543$	awrt 0.554	M1A1 (3)
(c)	$H_0 : \lambda = 6$ $H_1 : \lambda > 6$		B1
	$P(X \dots 12) = 1 - P(X \dots 21) = [1 - 0.9799]$ or $P(X \dots 11) = 1 - P(X \dots 20) = [1 - 0.9574]$		M1
	$= 0.0201$ or CR ...11		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 6 per week		A1ft
			(5)
(d)	$H_0 : \lambda = 6$ $H_1 : \lambda < 6$		B1
	6 week period is $\text{Po}(36) \Rightarrow N(36, 36)$		B1
	$P(Y \dots 26) \approx P(Y < 26.5) = P\left(Z < \frac{26.5 - 36}{6}\right)$ or $\frac{x + 0.5 - 36}{\sqrt{36}} < -1.6449$		M1 M1
	$[P(Z < -1.583\dots)] = 0.0571$ (Calculator 0.05667...) or $x < 25.63\dots$		A1
	awrt 0.057	awrt 25.6	
	Do not reject H_0 /Not in the CR/Not significant		M1
	There is insufficient evidence to suggest that the mean number of complaints received after the changes made is less than 6 per week		A1ft
			(7)
Notes			Total 16
(a)	B1	A correct assumption. Must be in context so need 'complaints' and then independent/random or constant rate or singly	
(b)(i)	B1	awrt 0.062	
(ii)	M1	For writing or using $1 - P(X \dots 5)$ May be implied by awrt 0.554	
	A1	awrt 0.554	
(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 $1 - P(X \dots 21)$ or $1 - P(X \dots 20)$	
	A1	For 0.0201 or CR ...11	
	M1	A correct statement – no context needed but do not allow contradicting non contextual comments	
	A1ft	Correct conclusion in context with the words highlighted in bold	
(d)	B1	Both hypotheses correct. Must be attached to H_0 and H_1 in terms of λ or μ Allow use of 36 rather than 6	
	B1	For writing or using $N(36, 36)$	
	M1	For standardising using 25.5/26/26.5, their mean and their standard deviation or standardising using $x - 0.5/x/x + 0.5$, their mean and their standard deviation and setting equal to -1.6449	
	M1	For a correct continuity correction written or used e.g. 26.5 or $x + 0.5$	
	A1	awrt 0.057 (NB Poisson used gives 0.0512685... and scores M0M0A0) or CR < awrt 25.6 (Allow \leq)	
	M1	A correct statement – no context needed but do not allow contradicting non contextual comments	
	A1ft	Correct conclusion in context with the words in bold (Allow The mean number of complaints has stayed the same/not changed oe)	

Question Number	Scheme		Marks
6(a)	$\left[P\left(Y < \frac{1}{4}k \mid Y < k\right) \right] = \frac{F\left(\frac{1}{4}k\right)}{F(k)} = \frac{\frac{1}{21}\left(\frac{k}{4}\right)^2}{\frac{1}{21}k^2} = \frac{1}{16} \text{ oe}$		M1 A1 (2)
(b)	$\frac{1}{21}k^2 = -\frac{1}{15}k^2 + \frac{4}{5}k - \frac{7}{5}$	$\frac{d}{dy}\left(\frac{1}{21}y^2\right) = \frac{2}{21}y \text{ or } \frac{d}{dy}\left(\frac{2}{15}\left(6y - \frac{y^2}{2}\right) - \frac{7}{5}\right) = \frac{2}{15}(6-y)$	M1
	$\Rightarrow 4k^2 - 28k + 49 = 0 \text{ oe}$	$\frac{d}{dy}\left(\frac{1}{21}y^2\right) = \frac{2}{21}y \text{ \& } \frac{d}{dy}\left(\frac{2}{15}\left(6y - \frac{y^2}{2}\right) - \frac{7}{5}\right) = \frac{2}{15}(6-y)$	A1
	$\Rightarrow (2k - 7)^2 = 0$	$\frac{2}{21}k = \frac{2}{15}(6-k)$	M1
	$k = \frac{7}{2} \text{ oe}$		A1
			(4)
(c)	$f(y) = \begin{cases} \frac{2}{21}y & 0 \leq y \leq 3.5 \\ \frac{2}{15}(6-y) & 3.5 < y \leq 6 \\ [0] & [\text{otherwise}] \end{cases}$		M1 M1
	$E(Y) = \frac{2}{21} \int_0^{3.5} y^2 dy + \frac{2}{15} \int_{3.5}^6 (6y - y^2) dy \Rightarrow \frac{2}{21} \left[\frac{y^3}{3} \right]_0^{3.5} + \frac{2}{15} \left[3y^2 - \frac{y^3}{3} \right]_{3.5}^6$		M1 M1
	$\frac{2}{21} \left(\frac{343}{24} \right) + \frac{2}{15} \left(\frac{325}{24} \right) = \frac{19}{6} = 3.166\dots$		awrt 3.17 dM1 dA1
			(6)
Total 12			
(a)	M1	For a correct probability statement or a correct ratio of probabilities	
	A1	For = $\frac{1}{16}$ oe or 0.0625	
(b)	M1	For setting the two lines of the cdf = to each other or $\frac{2}{21}y$ or $\frac{2}{15}(6-y)$ (Implied by a correct 3TQ)	
	A1	For a correct 3TQ or $\frac{2}{21}y$ and $\frac{2}{15}(6-y)$	
	M1	For solving their 3TQ. If the 3TQ is not correct, then a correct method must be shown or setting their 2 lines of the pdf = to each other	
	A1	$k = 3.5$ oe NB $k = 3.5$ with no incorrect working scores 4/4	
(c)	M1	Attempting to differentiate 1 of the functions. May be seen in part (b) or in an attempt to find $E(Y)$	
	M1	Attempting to differentiate both with one correct. May be seen in part (b) or in an attempt to find $E(Y)$	
	M1	For writing or using $E(Y) = \int_0^{3.5} y f(y) dy + \int_{3.5}^6 y f(y) dy$ Ignore limits	
	M1	For attempting to integrate	
	dM1	Dependent on previous M1. For substitution of limits, must be 0 or 6 and fit their 3.5. May be implied by $\frac{49}{36}$ oe or $\frac{65}{36}$ oe or $\frac{19}{6}$ oe. If the integral is not correct, then we must see evidence of substitution.	
	dA1	Dependent on previous M1. For $\frac{19}{6}$ or awrt 3.17	

Question Number	Scheme		Marks
7(a)	$\frac{97.5 - \mu}{\sigma} = 1.25$	$\frac{85.5 - \mu}{\sigma} = -0.75$	M1 M1 M1 M1 M1
	$2\sigma = 12$		M1
	$\sigma = 6^* \quad [\mu = 90]$		dA1*
			(7)
(b)	$np = 90$ and $np(1-p) = 36$		M1
	$1-p = 0.4$		M1
	$p = 0.6$ and $n = 150$		A1
			(3)
Notes			Total 10
NB Condone use of np for μ and $\sqrt{np(1-p)}$ for σ			
(a)	M1	For standardising using 96.5/97/97.5 and = z value, where $1 < z < 1.5$	
	M1	For standardising using 85.5/86/86.5 and = z value, where $-1 < z < -0.5$	
	M1	For use of a correct continuity correction in either equation	
	M1	For a correct z value used in either equation	
	M1	An attempt at both equations with one fully correct	
	M1	For solving simultaneously eliminating μ or σ As this is a show that question then working must be seen.	
	dA1	Dependent on all previous M marks being awarded $\sigma = 6^*$	
(b)	M1	For $np = \mu$ and $np(1-p) = \sigma^2$ Follow through their μ (Condone $npq = \sigma^2$)	
	M1	For solving simultaneously. May be implied by a correct value for p and n	
	A1	Both $p = 0.6$ and $n = 150$	