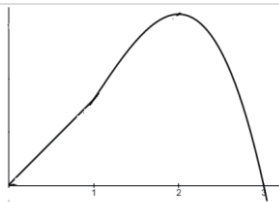| Question Number	Scheme	Marks
	Throughout the paper the candidates may use different letters to the ones given in the mark scheme.	
1(a)	$P(F \geq 12) = 1 - P(F \leq 11)$	M1
	$= 0.34517\ldots$ awrt 0.345	A1
		(2)
(b)	$P(8 \leq F < 15) = P(F \leq 14) - P(F \leq 7)$	M1
	$= 0.81104\ldots$ awrt 0.811	A1
		(2)
(c)	$3(30-F)+F < 70$ or $F > 10$ $\qquad$ $3(R) + 30 - R < 70$ or $R < 20$	M1
	$P(F > 10) = 1 - P(F \leq 10)$ $\qquad\qquad$ $P(R < 20) = P(R \leq 19)$	M1
	$= 0.4922\ldots$ awrt 0.492	A1
		(3)
(d)	$H_0: p = 0.35$ $\quad H_1: p > 0.35$	B1
	Let Y be the number of customers who do **not** buy free range eggs. $Y \sim N(70, 45.5)$	M1
	$P(Y \geq 86) \approx P\left(Z > \dfrac{85.5 - 70}{\sqrt{45.5}}\right)$ $\quad$ or $\pm \dfrac{x - 0.5 - 70}{\sqrt{45.5}} = 1.6449$	M1 M1
	$\approx 0.01078\ldots$ $\qquad$ or $\quad 81.595\ldots$	A1
	There is evidence to reject H_0. In the critical region	dM1
	There is evidence to support the **manager's** belief /There is evidence to support the proportion of customers who do **not** buy free range eggs is more than 35% (o.e)	A1
		(7)
		Total 14
(a)	**M1**	Writing or using $1 - P(F \leq 11)$
	A1	awrt 0.345
(b)	**M1**	$P(F \leq 14) - P(F \leq 7)$
	A1	awrt 0.811
(c)	**M1**	Allow equation instead of inequality (may be implied by 2nd M1)
	M1	Writing or using $1 - P(F \leq 10)$ ft their 10 but must be finding the correct tail.
	A1	awrt 0.492
(d)	**B1**	Both hypotheses in terms of p or π
	M1	Writing or using a normal distribution with a mean of 70
	M1	Standardising using 85.5/86/86.5, their mean and their sd
	M1	Using a continuity correction 86 ± 0.5
	A1	Correct probability awrt 0.0108 or awrt 0.0107 or x value of awrt 82 or allow awrt 2.29… and 1.6449 seen **NB** exact Binomial 0.01156 Po approx. awrt 0.0352
	dM1	(dep on 1st M1) A correct statement based on comparing 86 with their CR or their prob with 0.05 [condone 0.989 > 0.95]– contradicting non-contextual comments M0
	A1	A correct statement in context. **NB** award M1A1 for a correct contextual statement on its own.

Question Number	Scheme	Marks
2(i)(a)	$P(X > 14) = \dfrac{2}{5}$ oe	B1
		(1)
(b)	$a = 8 - 2(14 - 8) \, [= -4]$	M1
	$b = 14 + 2(14 - 8) \, [= 26]$	M1
	$P(6X > a + b) = \left(\dfrac{26 - \dfrac{26 - 4}{6}}{26 + 4} \right)$ oe	M1
	$= \dfrac{67}{90}$ oe awrt 0.744	A1
		(4)
(ii)(a)	$S \sim U[0, 22.5]$ or $f(s) = \begin{cases} \dfrac{2}{45} & 0 \leqslant s \leqslant 22.5 \\ 0 & \text{otherwise} \end{cases}$	B1
		(1)
(b)	$P(S < 12) = \dfrac{12}{\text{"22.5"}}$	M1
	$= \dfrac{8}{15}$ awrt 0.533	A1
		(2)
(c)	$P(T = 6) = {}^{20}C_6 \left(\dfrac{"8"}{15} \right)^6 \left(1 - \dfrac{"8"}{15} \right)^{14}$	M1M1
	$= 0.02072\ldots$ awrt 0.0207	A1
		(3)
		Total 11

		Notes
(i)(a)	**B1**	Allow 0.4
(b)	**M1**	A correct method to find the value of a or $\dfrac{a+b}{2} = 11$ May be awarded in part(a)
	M1	A correct method to find the value of b or a second correct equation ft their (a) eg $\dfrac{b - 14}{b - a} = \dfrac{2}{5}$ May be awarded in part(a)
	M1	A correct probability expression using their value for a and their value for b
	A1	Correct answer
(ii)(a)	**B1**	Correct distribution stated allow in words. Condone $<$
(b)	**M1**	Correct method ft their value of $(b - a)$ if positive. Condone 45 in the denominator for this mark
	A1	Awrt 0.533
(c)	**M1**	For $\left("\dfrac{8}{15}" \right)^6 \left("1 - \dfrac{8}{15}" \right)^{14}$
	M1	Fully correct probability ft their 8/15
	A1	awrt 0.0207

Question Number	Scheme	Marks
3(a)	$4a = a(b) \Rightarrow b = 4$ *	B1*cso
		(1)
(b)	$a(27b - 81 + 1) = 1$	M1
	$a = \dfrac{1}{28}$	A1
		(2)
(c)	$P(X > 2.25) = 1 - F(2.25)$	M1
	$= 0.25237\ldots.$ awrt 0.252	A1
		(2)
(d)(i)	$f(x) = \frac{3}{7}x^2 - \frac{1}{7}x^3$ or $\frac{2}{7}x$	M1
	  Sketch	B1
(ii)	$f'(x) = \frac{6}{7}x - \frac{3}{7}x^2$	dM1
	$\frac{6}{7}x - \frac{3}{7}x^2 = 0$	dM1
	Mode = 2	A1
		(5)
		Total 10
	Notes	
	In this question award mark all parts together	
(a)	**B1***	Answer given so need to see $4a = a(b)$ allow $4a(1) = a(b(1) - 1 + 1)$ followed by $b = 4$
(b)	**M1**	For a correct equation
	A1	1/28 o.e.
(c)	**M1**	For $1 - F(2.25)$ or $F(3) - F(2.25)$ Implied by a correct answer
	A1	awrt 0.252
(d)(i)	**M1**	Differentiating to find f(x), one term correct or correct follow through. Condone missing a Differentiation may be seen anywhere in the question. $f(x) = a(12x^2 - 4x^3)$ or $8ax$
	B1	Sketch of pdf. Straight line followed by smooth curve with mode near the middle of the curve. Must be connected (no gap). Values not required, but must begin and end on horizontal axis.
(ii)	**dM1**	Dep on 1st M being awarded. Differentiating their f(x) (for $1 < x \le 3$) to find $f'(x)$ $x^n \to x^{n-1}$ Condone missing a $f'(x) = a(24x - 12x^2)$
	dM1	Dep on previous M being awarded. Putting their $f'(x) = 0$
	A1	All but the B1 mark must be awarded

Question Number	Scheme		Marks
4(a)	$P(X=8) = \dfrac{e^{-6}6^8}{8!}$ or $0.8472 - 0.7440$		M1
	$= 0.10325\ldots$	awrt 0.103	A1
			(2)
(b)	$[\,X\sim\text{Po}(6)\,\ldots\,]\ P(X\ ?\ n)<0.05$ ıor $P(X\ ?\ n-1)>0.95$ ı		M1
	$n=11$		A1cao
			(2)
(c)	$K\sim\text{Po}(0.6m)$ **and** $P(K=0)<0.05$ ı⁄ $e^{-0.6m}<0.05$ / $-0.6m<\ln 0.05$ oe $\quad$ <u>or</u> $\ \lambda=3$		M1
	$m=5$		A1cao
			(2)
(d)	$Y\sim\text{Po}(3)$		B1
	$P(Y?..) = 1\ ?\ P(Y=0)$		M1
	$= 0.9502$		A1
			(3)
(e)	$[\,W\sim\text{Po}(18)\,]\quad P(W=15) = \dfrac{e^{-18}18^{15}}{15!}\ [=0.078575\ldots\,]$	$Y\sim\text{B}(15,\tfrac{5}{30})$	M1
	$\dfrac{P\big(Y=1\big[\,|\,Y\sim\text{Po}(3)\big]\big)\mathbf{x}P\big(T=14\big[\,|\,T\sim\text{Po}(15)\big]\big)}{\text{"0.078575..."}}$	$P(Y=1)$	dM1
	$= \dfrac{\big(e^{-3}\times 3\big)[=0.149...]\times\left(\dfrac{e^{-15}15^{14}}{14!}\right)[=0.102...]}{\text{"0.078575..."}}$	$=15(\tfrac{1}{6})(\tfrac{5}{6})^{14}$	dM1
	$= 0.1947\ldots$	awrt 0.195	A1
			(4)
(f)	$J\sim\text{Po}(9)$		M1
	$P(J\leq 13)=0.9261$		
	$P(J\leq 14)=0.9585$		
	So critical region is $J\geq 15$		A1
			(2)
			Total 15

		Notes	
(a)	**M1**	Correct formula or correct use of tables	
	A1	awrt 0.103	
(b)	**M1**	A correct probability statement. Implied by correct answer	
	A1	cao	
(c)	**M1**	Forming an equation or inequality or identifying $\lambda=3$	
	A1	cao	
(d)	**B1**	Writing Po(3) [implied by 0.0498… or correct answer]	
	M1	Writing or using $1\ ?\ P(Y=0)$	
	A1	Allow 0.95 or better	
(e)	**M1**	Using Po(18) to find $P(W=15)$	
	dM1	(dep on 1ˢᵗ M1) Attempt at conditional probability with $P(Y=1)\times P(T=14)$ (any value of λ) on num. and their $P(W=15)$ on denom. (may be implied)	
	dM1	(dep on 2ⁿᵈ M1) Correct ratio of probabilities	
	A1	awrt 0.195	
ALT:		Use of Binomial: 1ˢᵗ M1 correct distribution, 2ⁿᵈ dM1 $P(Y=1)$, 3ʳᵈ dM1 correct expression	
(f)	**M1**	Writing or using Po(9) Implied by correct CR	
	A1	Cao . Allow $J>14$. Do not allow as part of a probability statement.	

uestion Number	Scheme	Marks
5(a)	P(score 8) = $0.25 \times 0.35 = 0.0875$	B1
		(1)
(b)		B1 M1 M1 M1

sample	Score (y)	calculation	P($Y = y$)
(1,3)	–2	0.4×0.25	0.1
(1,2)	0	0.4×0.35	0.14
(1,1) (2,3)	2	$0.4^2 + 0.35 \times 0.25$	0.2475
(2,2)	4	0.35^2	0.1225
(2,1) (3,3)	6	$0.35 \times 0.4 + 0.25^2$	0.2025
(3,1)	10	0.25×0.4	0.1

Y	–2	0	2	4	6	8	10
P($Y = y$)	0.1 $\left[\frac{1}{10}\right]$	0.14 $\left[\frac{7}{50}\right]$	0.2475 $\left[\frac{99}{400}\right]$	0.1225 $\left[\frac{49}{400}\right]$	0.2025 $\left[\frac{81}{400}\right]$	0.0875 $\left[\frac{7}{80}\right]$	0.1 $\left[\frac{1}{10}\right]$

A1

(5)

(c)	$E(Y) = -2 \times "0.1" + [0 \times "0.14"] + 2 \times "0.2475" + 4 \times "0.1225" + 6 \times "0.2025"$ $+ 8 \times 0.0875 + 10 \times "0.1"$	M1
	$= 3.7$	A1
		(2)

Total 8

		Notes
(a)	**B1**	A correct calculation shown followed by 0.0875
(b)	**B1**	For identifying the correct set of y values. Any extras must have a probability of 0 May be split eg 2 may appear twice
	M1	For at least two correct calculations **or** probs from P(Y = –2), P(Y = 0) , P(Y = 4) or P(Y = 10)
	M1	For at least one correct calculation **or** prob for P(Y = 2) or P(Y = 6)
	M1	For at least four correct calculations **or** probs attached to the correct value of y or sample
	A1	A fully correct answer
(c)	**M1**	Correct expression ft their table
	A1	3.7 or exact equivalent
		Alternative for (c) M1 $E(X) = 0.4 + 2 \times 0.35 + 3 \times 0.25 [= 1.85]$ and $E(Y) = 4 \times "1.85" - 2 \times "1.85"$

Qu'n Number	Scheme	Marks
6(a)		B1 B1
		(2)
(b)	$E(Y) = 2$	B1
	$\text{Var}(2Y - 3) = 4\text{Var}(Y)$	M1
	$\text{Var}(Y) = \left(\dfrac{131}{21} - 2^2\right)$	M1
	$\text{Var}(2Y - 3) = \dfrac{188}{21}$ awrt 8.95	A1
		(4)
(c)	$\displaystyle\int_{-1}^{t} \frac{1}{14}(y+2)\,dy = \frac{1}{14}\left[\frac{y^2}{2} + 2y\right]_{-1}^{t}$ **or** $\displaystyle\int \frac{1}{14}(y+2)\,dy = \frac{1}{14}\left[\frac{y^2}{2} + 2y\right] + C$ **or** $\displaystyle\int \frac{1}{14}(y+2)\,dy = \frac{1}{28}(y+2)^2 + C$	M1
	$\dfrac{1}{14}\left[\left(\dfrac{t^2}{2} + 2t\right) - \left(\dfrac{1}{2} - 2\right)\right]$ **or** $\dfrac{1}{14}\left[\dfrac{(-1)^2}{2} - 2\right] + C = 0$ & $C = \dfrac{3}{28}$ **or** $\dfrac{1}{28}(-1+2)^2 + C = 0$ & $C = -\dfrac{1}{28}$ leading to $\dfrac{1}{14}\left(\dfrac{y^2}{2} + 2y + \dfrac{3}{2}\right)$ *	A1*cso
		(2)
(d)	$\displaystyle\int_{1}^{t} \frac{3}{14}\,dy + F(1) = \left[\frac{3}{14}y\right]_{1}^{t} + F(1) = \left[\left(\frac{3t}{14}\right) - \left(\frac{3}{14}\right)\right] + F(1)$ or $\displaystyle\int \frac{3}{14}\,dy = \left[\frac{3}{14}y\right] + C$ and use of F(1) = "their F(1)" or F(3) = " their F(3)"	M1
	$\displaystyle\int_{3}^{t} \frac{1}{14}(6-y)\,dy + F(3) = \frac{1}{14}\left[6y - \frac{y^2}{2}\right]_{3}^{t} + F(3) = \frac{1}{14}\left[\left(6t - \frac{t^2}{2}\right) - \left(18 - \frac{9}{2}\right)\right] + F(3)$ or $\displaystyle\int \frac{1}{14}(6-y)\,dx = \frac{1}{14}\left[6y - \frac{y^2}{2}\right] + C$ <u>or</u> $C - \dfrac{(6-y)^2}{28}$ and use F(5) =1	M1
	$F(y) = \begin{cases} 0 & y_{,,}\ -1 \\[2mm] \dfrac{1}{14}\left(\dfrac{y^2}{2} + 2y + \dfrac{3}{2}\right) & -1 < y?\ 1 \\[2mm] \dfrac{3}{14}y + \dfrac{1}{14} & 1 < y_{,,}\ 3 \\[2mm] \dfrac{3}{7}y - \dfrac{1}{28}y^2 - \dfrac{1}{4} & 3 < y?\ 5\ 5 \\[2mm] 1 & y > 5 \end{cases}$	A1 A1 B1
		(5)

(e)	$"\dfrac{3}{14}m+\dfrac{1}{14}"=0.3$	M1
	$m=\dfrac{16}{15}$	A1
		(2)
(f)	$P\left(4Y\le 5 \mid Y\le 3\right)=\dfrac{\left(\dfrac{3}{14}\times\dfrac{5}{4}+\dfrac{1}{14}\right)}{\left(\dfrac{3}{14}\times 3+\dfrac{1}{14}\right)}\left[=\dfrac{19/56}{5/7}\right]$	M1
	$=\dfrac{19}{40}$ or 0.475	A1
		(2)
		Total 17

		Notes
(a)	**B1**	Shape correct – must not touch/cross the *x*-axis
	B1	Fully correct including labels (all *x*-axis and at least one vertical axis label which may be 2/14)
(b)	**B1**	Correct value for E(Y)
	M1	Writing or using 4 Var (Y) on its own
	M1	Correct formula for Var (Y) allow use of their E(Y) if clearly stated
	A1	awrt 8.95
(c)	**M1**	For a correct method for $-1 < y_{,,} 1$ Allow finding the area: attempt at trapezium $\times (y+1)$ $$\frac{1}{2}\left(\frac{1}{14}+\frac{1}{14}(y+2)\right)(y+1)$$
	A1*cso	A fully correct solution with substitution seen or C found leading to $\frac{1}{14}\left(\frac{y^2}{2}+2y+\frac{3}{2}\right)$ Allow any letter
(d)	**M1**	For a correct method for $1<y? \ 3$ Allow finding the area $\left(\frac{1}{14}+\frac{3}{14}\right)+\frac{3}{14}(y-1)$ or $$F(1)+\frac{3}{14}(y-1)$$
	M1	For a correct method for $3<y_{,,} \ 5$ Allow finding the area $$\left(\frac{1}{14}+\frac{3}{14}\right)+\frac{6}{14}+\frac{1}{2}\left(\frac{3}{14}+\frac{1}{14}(6-y)\right)(y-3) \text{ or } F(3)+\frac{1}{2}\left(\frac{3}{14}+\frac{1}{14}(6-y)\right)(y-3)$$
	A1	For a correct expression attached to $1<y? \ 3$
	A1	For a correct expression attached to $3<y_{,,} \ 5$ Allow $\dfrac{29-(6-y)^2}{28}$ oe
	B1	Top, 2nd and bottom line correct plus all in terms of the same letter. Allow $<$ for $_{,,}$ and vice versa
(e)	**M1**	Setting their equation for $1<y? \ 3$ equal to 0.3
	A1	cao
(f)	**M1**	For writing or using $\dfrac{F(\frac{5}{4})}{F(3)}$ Allow use of their expression for $3<y_{,,} \ 5$ for the denominator
	A1	cao