Question	Scheme	Marks
1(a)	The random variable M is such that $M \sim \text{Po}(2)$	
(i)	$[\text{P}(M \text{ ,, } 3) =] 0.8571$ awrt **0.857**	B1
(ii)	$\text{P}(M \ldots 6) = 1 - \text{P}(M \text{ ,, } 5)$	M1
	= 0.0166 (calc 0.016563…) awrt **0.0166**	A1
		(3)
(b)	$Q \sim \text{Po}(6)$	M1
	$\text{P}(4 \text{ ,, } Q \text{ ,, } 7) = \text{P}(Q \text{ ,, } 7) - \text{P}(Q \text{ ,, } 3) [= 0.5928]$	M1
	$X \sim$ B(20, "0.5928") **and** P(X = 15) or ${}^{20}C_{15}("0.5928")^{15}(1-"0.5928")^{5}$	M1
	= 0.06809… awrt **0.068**	A1
		(4)
(c)	H_0: $\lambda = 2$ H_1: $\lambda > 2$	B1
	$R \sim \text{Po}(5)$: $\text{P}(R \ldots 10)$ or $1 - \text{P}(R \text{ ,, } 9)$	M1
	= 0.0318 or CR: $R \ldots 10$	A1
	Reject H_0 or Significant or in the critical region	M1
	There is evidence to support the **manager's belief** / rate of **customers** arriving at the **garage** has **increased**	A1
		(5)
(d)	The number of tyres bought is likely not to occur singly/tyres are not sold independently.	B1
		(1)
	Notes	**Total 13**

(a)	**B1**	awrt 0.857
	M1	for $1 - \text{P}(M \text{ ,, } 5)$ or 1 – 0.9834 Do not allow $1 - \text{P}(M < 6)$ unless $1 - \text{P}(M \text{ ,, } 5)$ **is** used
	A1	awrt 0.0166 correct answer scores 2 out of 2
(b)	**M1**	for writing or using Po(6)
	M1	for $\text{P}(Q \text{ ,, } 7) - \text{P}(Q \text{ ,, } 3)$ or 0.7440 – 0.1512 or awrt 0.593
	M1	For B(20, "0.5928") **and** P(X = 15) or ${}^{20}C_{15}(p)^{15}(1-p)^{5}$ (implied by awrt 0.068)
	A1	awrt 0.068
(c)	**B1**	for correct hypotheses in terms of λ or μ Allow 5 instead of 2. These must be attached to H_0 and H_1 correctly
	M1	for writing or using Po(5) **and** $\text{P}(R \ldots 10)$ or $1 - \text{P}(R \text{ ,, } 9)$ (may be implied by awrt 0.0318 or correct CR)
	A1	awrt 0.0318 allow CR: $[R] \ldots 10$ allow any letter or no letter for CR
	M1	for a correct ft statement consistent with their p-value and 0.05 or with 10 and their CR Need not be contextual but there must be no contradicting non- contextual comments
	A1	dep on 1st and 2nd M1 for a correct conclusion in context which must be rejecting H_0 Must use bold words (oe)
(d)	**B1**	for the idea that tyres may be bought in e.g. pairs oe/the idea that tyre sales are not independent

Question	Scheme	Marks
2(a)	$\frac{3}{10}d-\frac{1}{75}d^2-\frac{2}{3}=1$	M1
	$45d-2d^2-100=150$ **or** $\frac{3}{10}d-\frac{1}{75}d^2-\frac{5}{3}=0 \rightarrow 2d^2-45d+250=0$*	A1*
		(2)
(b)	$\mathrm{P}(1<H<4.5)=\left(\frac{4.5}{6}-\frac{1}{3}\right)-\left(\frac{1}{48}\right)\left[=\frac{19}{48}\text{ or }0.39583...\right]$	M1
	$\mathrm{P}(1<H<1.5)\left[=\left(\frac{1.5^2}{48}\right)-\left(\frac{1}{48}\right)=\frac{5}{192}\text{ or }0.02604...\right]$	M1
	$\mathrm{P}(H<1.5\mid 1<H<4.5)=\frac{"0.02604..."}{"0.3958..."}$	M1
	$=\frac{5}{76}$ or 0.06578… awrt **0.0658**	A1
		(4)
(c)	$[\mathrm{f}(h)=]\begin{cases}\frac{h}{24} & 0<h\text{,,}4\\ \frac{1}{6} & 4<h\text{,,}5\\ \frac{3}{10}-\frac{2}{75}h & 5<h\text{,,}d\\ 0 & \textit{otherwise}\end{cases}$	M1 M1 A1
		(3)

		Notes	Total 9
(a)	**M1**	for $\frac{3}{10}d-\frac{1}{75}d^2-\frac{2}{3}=1$	
	A1*	cso at least one step seen before given answer e.g. removing the denominator or correct 3 term quadratic = 0	
(b)	**M1**	correct method to find $\mathrm{P}(1<H<4.5)$ implied by $\frac{19}{48}$ or awrt 0.396	
	M1	for writing or finding $\mathrm{P}(1<H<1.5)$ implied by $\frac{5}{192}$ or awrt 0.026	
	M1	for $\frac{p}{"0.3958"}$ where $0<p<$ "0.3958"	
	A1	awrt 0.0658	
(c)	**M1**	for one of row 1, 2 or 3 correct. Allow any letters. Condone missing/incorrect range	
	M1	for any two rows correct with ranges. Allow any letters and < for ,, signs	
	A1	Fully correct. all the same letter in rows 1 to 3 Allow < for ,, signs condone $d = 10$ but not $d = 12.5$	

Question	Scheme	Marks
3(a)	A **list** of **all** the **shops**	B1
		(1)
(b)	The shops	B1
		(1)
(c)	Advantage - A sample is quicker/ cheaper / easier to process	B1
	Disadvantage – less accurate/ may be biased / may not be representative	B1
		(2)
(d)	$P(X \leqslant 6) = 0.0172$ or $P(X \geqslant 18) = 0.0212$ or $P(X \leqslant 17) = 0.9788$ or $X \leqslant 6$ or $X \geqslant 18$	M1
	$[P(X \leqslant 6)] = 0.0172$ **and** $[P(X \geqslant 18)] = 0.0212$	A1
	CR: $[0 \leqslant X \leqslant 6, 18 \leqslant X \leqslant 30]$	A1
		(3)
(e)	20 is in the critical region therefore there is evidence that **Jian's belief** is incorrect	B1ft
		(1)
(f)	$H_0 : p = 0.4$ $H_1 : p < 0.4$	B1
	$J \sim B(150, 0.4) \Rightarrow \approx N(60, 36)$	M1A1
	$P(J \leqslant 47) \approx P\left(Z \leqslant \frac{47.5-60}{6} [= -2.08333...]\right)$ $\quad \frac{(n+0.5)-60}{6} = -1.6449$	M1 M1
	= 0.0188 (calc 0.018610…) CR: $J <$ awrt 49.6	A1
	There is sufficient evidence to suggest that the **proportion** of **shops** where the stocktaking system is being used incorrectly **is less than 0.4/decreased**	A1
		(7)

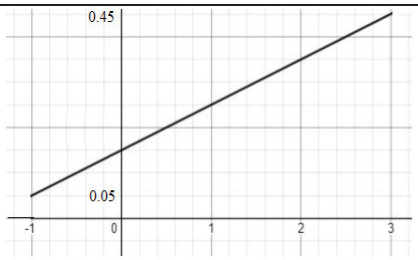
	Notes	**Total 15**
(a)	**B1**	for the idea of a list/database(oe) of **all shops** list of all stocktaking systems is B0
(b)	**B1**	for allow shop or store(s) the number of shops is B0 the stocktaking systems at each shop is B0
(c)	**B1**	for a correct advantage for a sample oe eg allow census take longer than a sample e.g. 'a sample is more uncertain' on its own is B0
	B1	for a correct disadvantage for a sample oe eg a census is more accurate than a sample
		If there is no reference to sample or census assume referring to sample. Ignore extraneous non-contradictory comments
(d)	**M1**	for one of these probability statements correct or awrt 0.017 or awrt 0.021 or awrt 0.98 or one correct CR
	A1	for both probabilities awrt 0.0172 and awrt 0.0212
	A1	for both CR correct oe e.g. $X < 7, X > 17$ ignore any symbol used between the two CR tails allow any or no letter (do not allow CR stated as probabilities)
(e)	**B1ft**	for stating 20 is in the CR **and** give correct statement. Allow the belief in words. Only ft if their CR is in the form $X \leqslant C_1 \cup X \geqslant C_2$ (allow as probability statements)
(f)	**B1**	for both hypotheses correct, using p or π. Must be attached to H_0 and H_1
	M1	for writing or using N(60,…)
	A1	for writing or using N(60, 36)
	M1	for standardising (allow ±) using their "60" and "6" with either 46.5, 47 or 47.5 for CR method n, $n + 0.5$ or $n - 0.5$ and equate to –1.6449 or better
	M1	for using the correct continuity correction 47.5 or $(n + 0.5)$
	A1	for awrt 0.019 or CR: $J <$ awrt 49.6 or $J + 0.5 <$ awrt 50.1 Exact binomial gives 0.01756…and scores M0A0M0M0A0
	A1	dep on previous A1 for a correct conclusion in context using bold word (oe) Do not allow 'number' for 'proportion'

Question	Scheme	Marks
4(a)	$\frac{10}{50}\times\frac{9}{49}\left[=\frac{9}{245}*\right]$	B1cso
		(1)
(b)	number of counters numbered 4 = 10 numbered 7 = 15 numbered 10 = 25	M1
	$M = 4, 5.5, 7, 8.5, 10$	B1
	$\mathrm{P}(M=5.5)=2\times\frac{10}{50}\times\frac{15}{49}\left[=\frac{6}{49}\right]$	M1
	$\mathrm{P}(M=7)=2\times\frac{10}{50}\times\frac{25}{49}+\frac{15}{50}\times\frac{14}{49}\left[=\frac{71}{245}\right]$	M1
	$\mathrm{P}(M=8.5)=2\times\frac{15}{50}\times\frac{25}{49}\left[=\frac{15}{49}\right]$	M1
	$\mathrm{P}(M=10)=\frac{25}{50}\times\frac{24}{49}\left[=\frac{12}{49}\right]$	
	m | 4 | 5.5 | 7 | 8.5 | 10 $\mathrm{P}(M=m)$ | $\frac{9}{245}$ (awrt 0.037) | $\frac{6}{49}$ (awrt 0.122) | $\frac{71}{245}$ (awrt 0.290) | $\frac{15}{49}$ (awrt 0.306) | $\frac{12}{49}$ (awrt 0.245)	A1
		(6)
(c)	$\left(1-\frac{9}{245}\right)^n < 0.15$	M1
	$n = 50.689\ldots$ or $n = 50$ is 0.1539… or $n = 51$ is 0.148… or $[n >]\frac{\log 0.15}{\log(1-\frac{9}{245})}$	M1
	$n = 51$	A1
		(3)

	Notes	Total 10
(a)	**B1**	A correct equivalent expression
(b)	**M1**	For 10, 15 and 25 - may be seen in (a) or may be seen in probability expressions
	B1	all means correct with no incorrect extra unless they have a probability of 0
	M1	One correct probability (not including 9/245)
	M1	Two correct probabilities (not including 9/245)
	M1	Three correct probabilities (not including 9/245)
	A1	fully correct. need not be in a table but must have correct probability associated with correct mean
	SC	**With replacement** using probabilities $\frac{10}{50},\frac{15}{50},\frac{25}{50}$ gives $\frac{3}{25},\frac{29}{100},\frac{3}{10},\frac{1}{4}$ can score maximum M1B1M1(two correct)M1(four correct)M0A0
(c)	**M1**	Setting up a correct inequality (allow any inequality or equal sign here)
	M1	for a value n = awrt 50.7 or awrt 0.154 or awrt 0.148 or correct log expression for n
	A1	51 cao do not allow $n \ldots 51$

Question	Scheme	Marks
5(a)	$D \sim \text{B}(8, 0.05)$	M1
	$\text{P}(D \ldots 2) = 1 - \text{P}(D \,,, 1)$	M1
	= 0.0572 (calc 0.057244…) awrt **0.0572**	A1
		(3)
(b)	$E \sim \text{Po}(50)$	M1
	$\text{P}(E = 45) = \dfrac{\text{e}^{-50} \times 50^{45}}{45!}$	M1
	= 0.0458262… awrt **0.0458**	A1
		(3)
(c)	$\text{P}(T > 16) = \dfrac{50-16}{50-10}$ or $1 - \dfrac{16-10}{50-10}$	M1
	= 0.85	A1
		(2)
(d)	$\text{P}(T < 40) = 0.75$	M1
	F = number of customers ringing in the next 40 seconds has $F \sim \text{Po}(4)$	
	$\text{P}(F = 0)$ [$= \text{e}^{-4}$ = awrt 0.0183]	M1
	P(Jia reaches the correct department and $F = 0$) $= 0.75 \times 0.95 \times \text{e}^{-4}$	dM1
	= 0.013049… awrt **0.013**	A1
		(4)

	Notes		Total 12
(a)	**M1**	for writing or using $\text{B}(8, 0.05)$	
	M1	for writing or using $1 - \text{P}(D \,,, 1)$	
	A1	awrt 0.0572	
(b)	**M1**	for writing or using Po(50)	
	M1	for $\dfrac{\text{e}^{-\lambda} \times \lambda^{45}}{45!}$ with any value of λ (may be implied by awrt 0.046)	
	A1	awrt 0.0458	
(c)	**M1**	for a correct method to find $\text{P}(T > 16)$	
	A1	for 0.85 oe correct answer scores 2 out of 2	
(d)	**M1**	for 0.75 oe	
	M1	for attempting $\text{P}(F = 0)$ from Po (λ) allow any λ	
	dM1	dep on previous M1 "0.75" $\times 0.95 \times$ "e^{-4}"	
	A1	awrt 0.013	

Question	Scheme	Marks
6(a)	$\int_{-1}^{3}(a+bx)\,dx\ [=1]$ or trapezium drawn	M1
	$\left[ax+\frac{bx^2}{2}\right]_{-1}^{3}\ [=1]$ oe or $\frac{3-(-1)}{2}\big((a-b)+(a+3b)\big)\ [=1]$	A1
	$\left[3a+\frac{9b}{2}\right]-\left[-a+\frac{b}{2}\right]=1$ oe or $\frac{4}{2}(2a+2b)=1 \Rightarrow 4a+4b=1$*	A1*
		(3)
(b)(i)	$\int_{-1}^{3} ax^2+bx^3\,dx=\left[\frac{ax^3}{3}+\frac{bx^4}{4}\right]_{-1}^{3}$	M1A1
	$\left[\frac{27a}{3}+\frac{81b}{4}\right]-\left[-\frac{a}{3}+\frac{b}{4}\right]=\frac{17}{5}$	dM1
	$\frac{28}{3}a+20\left(\frac{1-4a}{4}\right)=\frac{17}{5}$	M1 A1
		(5)
(ii)	$-\frac{32}{3}a=-\frac{8}{5}$ oe or $\frac{28}{3}\left(\frac{1-4b}{4}\right)+20b=\frac{17}{5}$	M1
	$b=\frac{1-4\times0.15}{4}\Rightarrow b=0.1$*	A1*
		(2)
(c)		M1 A1
		(2)
(d)	$\left["0.15"k+\frac{0.1k^2}{2}\right]-\left[-"0.15"+\frac{0.1}{2}\right]=0.2$ or $\frac{1}{2}(k+1)(0.05+0.1k+0.15)=0.2$; $\left[0.45+\frac{0.9}{2}\right]-\left["0.15"k+\frac{0.1k^2}{2}\right]=0.8$ or $\frac{1}{2}(3-k)(0.15+0.1k+0.45)=0.8$	M1
	$0.05k^2+0.15k-0.1=0$	A1
	$k=\frac{-0.15\pm\sqrt{0.15^2-4\times0.05\times(-0.1)}}{2\times0.05}$	M1
	$=0.56155\ldots$ awrt **0.562**	A1
		(4)
		Total 16

	Notes	
(a)	**M1**	for an attempt to integrate $a+bx$ with either $a \to ax$ or $x \to x^2$ ignore limits or for trapezium drawn with parallel sides correct in terms of *a* and *b* (may be implied by correct area of trapezium)
	A1	correct integration or correct area of trapezium
	A1*	cso (correct limits seen substituted or correct area) equated to 1 which leads to final given answer
		Mark b(i) and b(ii) together
(b)(i)	**M1**	for an attempt to integrate ax^2+bx^3 with either $x^2 \to x^3$ or $x^3 \to x^4$ ignore limits
	A1	correct integration ignore limits
	dM1	dep on previous M1. Substituting in correct limits and equating to 17/5
	M1	substituting $4b=1-4a$ oe
	A1	a correct equation
(ii)	**M1**	solving their equation in *a* in the form $na=c$ where $n \neq 1$ or a correct equation in terms of *b* M0 for $a=0.15$ without working or for using $b = 0.1$ in $4a + 4b = 1$ to find *a*
	A1*	for a correct un-simplified expression for *b* leading to given answer $b = 0.1$ * which must come from correct working
(c)	**M1**	correct shape (straight line with positive gradient) must be above *x*-axis and must be between –1 and 3 ignore graph before –1 and after 3
	A1	correct with both correct *x*-axis labels –1 and 3 **and** at least 1 correct *y* –axis label from 0.05, 0.15 or 0.45 ignore graph before –1 and after 3
(d)	**M1**	for a correct equation using integration or area need not be simplified. use of limit $k + 1$ instead of *k* in integration is M0
	A1	correct 3 term quadratic (oe)
	M1	correct method seen to solve their 3 term quadratic or awrt 0.562 or awrt – 3.56
	A1	awrt 0.562 with other solutions eliminated if given Allow $\frac{\sqrt{17}-3}{2}$