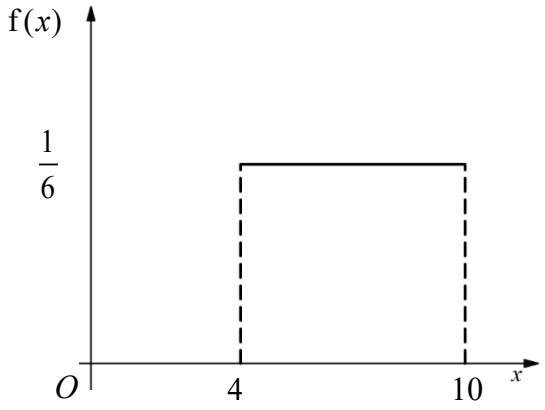
Question Number	Scheme	Marks
1(a)(i)	e.g. A database of **all** the customers	B1
(ii)	e.g. The customer(s)	B1
		(2)
(b)	e.g. It is cheaper	B1
		(1)
(c)	B(50, 0.35)	M1A1
		(2)
(d)	$[\mathrm{P}(X > 20) =] 1 - \mathrm{P}(X \leqslant 20)$ $(= 1 - 0.8139)$	M1
	$= 0.1861$ **awrt 0.186**	A1
		(2)

	Notes		Total 7
(a)(i)	**B1**	for a suitable sampling frame e.g. a list / spreadsheet / register and indicating it contains **all** the customers who have the internet service. All can be implied but not a partial list.	
(ii)	**B1**	for a suitable sampling units e.g. people who pay for the service, subscriber (s), customer (s). Do not allow customer (s) satisfaction o.e.	
(b)	**B1**	for a suitable reason e.g. it is quicker, cheaper, easier to process	
(c)	**M1**	Binomial distribution or B(….) seen	
	A1	B(50, 0.35) or binomial stated with $n = 50,\ p = 0.35$	
(d)	**M1**	For $1 - \mathrm{P}(X \leqslant 20)$, may be implied by $1 - 0.8139$ or $\mathrm{P}(X \geqslant 21)$	
	A1	awrt 0.186 (Calc: 0.186054…) (Correct answer 2/2)	

Question Number	Scheme	Marks
2(a)	$[\mathrm{F}(10)] = k \times 6 = 1 \Rightarrow k = \frac{1}{6}$ *	B1cso
		(1)
(b)	$[\mathrm{P}(X = 5) =]\ 0$	B1
		(1)
(c)	$[\mathrm{P}(5 < X < 7) =]\ \mathrm{F}(7) - \mathrm{F}(5)\ \left(= \frac{1}{6}(3-1)\right)$	M1
	$= \frac{1}{3}$	A1
		(2)
(d)	$\mathrm{f}(x) = \begin{cases} \frac{1}{6} & 4 \leqslant x \leqslant 10 \\ 0 & \text{otherwise} \end{cases}$	M1A1
		(2)
(e)		M1A1ft
		(2)
(f)	$\mathrm{E}(X)\left(= \frac{4+10}{2}\right) = 7$	B1
		(1)
(g)	$[\mathrm{Var}(X)] = \frac{(10-4)^2}{12} = 3$ **or** $[\mathrm{E}(X^2)] = \int_{[4]}^{[10]} \frac{x^2}{6}\,\mathrm{d}x$ **or** $[\mathrm{E}(2X^2-1)] = \int_{[4]}^{[10]} \frac{2x^2-1}{6}\,\mathrm{d}x$	M1
	$\mathrm{E}(2X^2-1) = 2 \times \left("3"+"7"^2\right) - 1$ **or** $2\left[\frac{x^3}{18}\right]_4^{10} - 1 = 2\left(\frac{1000}{18} - \frac{64}{18}\right) - 1$	M1
	$= 103$ $= 103$	A1
		(3)
	Notes	**Total 12**
(a)	**B1*** cso for substituting $x = 10$ into $\mathrm{F}(x)$, setting equal to 1 and rearranging to achieve the given answer. Alternatively, substituting $x = 10$ and $k = \frac{1}{6}$, and achieves an answer of 1 but must state a conclusion confirming that $k = \frac{1}{6}$	

(b)	**B1**	cao
(c)	**M1**	for sight or use of $\mathrm{F}(7)-\mathrm{F}(5)$
	A1	$\frac{1}{3}$ or exact equivalent. (Answer coming from incorrect working (e.g. substituting 6 and 4 o.e. is M0A0)
(d)	**M1**	for $\mathrm{f}(x)=\frac{1}{6}$ with or without the interval
	A1	fully correct with both lines and correct intervals (o.e)
(e)	**M1**	for a horizontal line \ rectangle drawn in the first quadrant
	A1ft	fully correct with 4, 10 and "1/6" labelled (condone missing vertical lines at 4 and 10 and axes labels)
(f)	**B1**	cao
(g)	**M1**	attempts to find Var(X) or attempts to integrate $x^2\times\mathrm{f}(x)$. (Ignore limits and labelling) May be seen as part of $\int_{[4]}^{[10]}\frac{2x^2-1}{6}\,\mathrm{d}x$ Condone omission of dx
	M1	for a full attempt to find $\mathrm{E}(2X^2-1)$ (Implied by $2\times(\text{"52"})-1$). Follow through their $\mathrm{E}(X^2)$ evaluated, even if labelled as $\mathrm{Var}(X)$.
	A1	Cao (Working must be seen)

Question Number	Scheme	Marks
3(a)(i)	$X \sim \text{Po}(5)$ $[[\text{P}(X \geqslant 4)\ (=1-\text{P}(X \leqslant 3))=1-0.2650]$	M1
	$=0.735$ **awrt 0.735**	A1
(ii)	$"0.735"^3 = 0.397065...$ **awrt 0.397**	M1A1
		(4)
(b)	$\text{H}_0 : \lambda = 2.5 \qquad \text{H}_1 : \lambda > 2.5$	B1
		(1)
(c)	$X \sim \text{Po}(10)$ where X is the number of detections in one hour	
	$\text{P}(X \leqslant 15) = 0.9513 \Rightarrow \text{P}(X \geqslant 16) = 0.0487$	M1A1
	Critical region $X \geqslant 16$	A1
		(3)
(d)	13 is not in the critical region (so do not reject H_0) so insufficient evidence to suggest that the **mean rate** (o.e) of **detecting** (o.e) motion has **increased** (o.e).	B1ft
		(1)

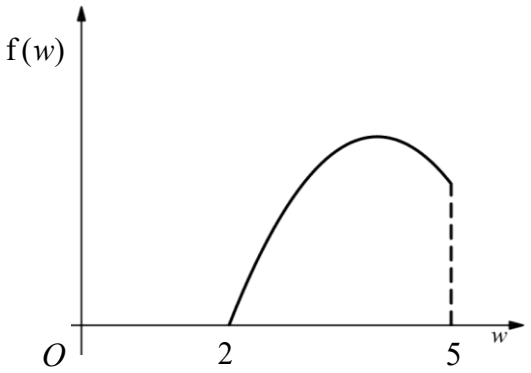
		Notes	Total 9
(a)(i)	**M1**	Sight or use of the correct Poisson distribution. May be implied by awrt 0.265	
	A1	awrt 0.735 Calc: 0.73497…) (Correct answer 2/2)	
(ii)	**M1**	for attempting their (a)(i)^3 or ${}^3\text{c}_3$(a)(i)^3 (1- a(i))^0	
	A1	awrt 0.397	
(b)	**B1**	correct hypotheses in terms of λ or μ (may write 10 instead of 2.5)	
(c)	**M1**	for attempting to use Po(10). May be implied by awrt 0.9513, awrt 0.9730, awrt 0.0487, awrt 0.0270	
	A1	for finding $\text{P}(X \geqslant 16) =$ awrt 0.0487 (or a clear statement that probability is awrt 0.0487).	
	A1	for a correct critical region. Must be expressed as e.g. $X \geqslant 16$ (o.e.) and not a probability statement. Can use a different letter to X and condone $\text{CR} \geqslant 16$	
(d)	**B1ft**	dep on a CR $X \geqslant a$ o.e. such that 13 is not in the critical region (condone a probability statement for a CR) For 13 is not in the critical region **and** a correct conclusion in context that there is insufficient evidence to suggest that the **mean rate** of **detections** has **increased**. (o.e). Withhold this mark if there are contradictory statements or incorrect comparisons.	

Question Number	Scheme	Marks
4(a)(i)	$[P(X=1)] = 0.3389...$ **awrt 0.339**	B1
(ii)	$[P(X \leqslant 2)] = 0.8122$ **awrt 0.812**	B1
		(2)
(b)	$H_0: p = 0.05 \quad H_1: p \neq 0.05$	B1
	$Y \sim Po(7.5)$	M1
	$P(Y \geqslant 13) = 1 - P(Y \leqslant 12)$ or $1 - 0.9573$	M1
	$= 0.0426658...$ **awrt 0.0427**	A1
	"0.0427" > 0.025 (so do not reject H_0) / 13 is not in the critical region. o.e	dM1
	Insufficient evidence to suggest that the **proportion** of patients with the eye **condition** has changed	A1ft
		(6)

	Notes	Total 8
(a)(i)	**B1**	awrt 0.339
(ii)	**B1**	awrt 0.812
(b)	**B1**	for correct hypotheses and attached to H_0 and H_1 in terms of p. Accept $H_0: \lambda = 7.5$, $H_1: \lambda \neq 7.5$
	M1	for a correct Poisson distribution with $\lambda = 7.5$. May be implied by awrt 0.957 or awrt 0.043
	M1	$P(Y \geqslant 13) = 1 - P(Y \leqslant 12)$ or $1 - 0.9573$ or allow for CR: $X \geqslant 14$ **or** CR: $X \leq 2$ o.e
	A1	awrt 0.0427 or allow for fully defined critical region of CR: $X \leqslant 2$, $X \geqslant 14$ o.e
	dM1	dep on 2nd M1 for a correct non-contextual comparison ft on their "0.0427" or a comparison with their critical region
	A1ft	**dependent on all previous method marks**. For a correct contextual conclusion using the bolded words. (o.e) Condone "the optician's claim is incorrect" o.e
	SC	if no approximation (use of B (150,0.05)) is used leading to 0.03851568… then maximum score B1M0M1A0dM1A0ft
	SC	if a normal approximation (N (7.5,7.125)) is used leading to awrt 0.0305 – awrt 0.0307 then maximum score B1M0M1A1dM1A0ft. 2nd M1 is for working out *z*-value of 1.87 or better, 1st A mark for awrt 0.0305 – awrt 0.0307, 3rd M1 (dep) a correct comparison.

Question Number	Scheme	Marks
5(a)	All the possible combinations: *SSW*, *SSP*, *SWW(x2)*, *SWP(x2)*, *WWW*, *WWP*	M1A1
		(2)
(b)	{10,11,12,13}	M1A1
		(2)
(c)	$\left(\mathrm{P}(SSW)=\right)\frac{3}{5}\times\frac{3}{5}\times\frac{1}{2}$ o.e. or $\left(\mathrm{P}(WWP)=\right)\frac{2}{5}\times\frac{2}{5}\times\frac{1}{2}$ o.e.	B1
	$\left(\mathrm{P}(T=11)\right)=2\times\frac{3}{5}\times\frac{2}{5}\times\frac{1}{2}+\frac{3}{5}\times\frac{3}{5}\times\frac{1}{2}$ or $\left(\mathrm{P}(T=12)\right)=2\times\frac{3}{5}\times\frac{2}{5}\times\frac{1}{2}+\frac{2}{5}\times\frac{2}{5}\times\frac{1}{2}$	M1
	t | 10 | 11 | 12 | 13 $\mathrm{P}(T=t)$ | $\frac{9}{50}=0.18$ | $\frac{21}{50}=0.42$ | $\frac{8}{25}=0.32$ | $\frac{2}{25}=0.08$	A1
		(3)
(d)	{0, 1, 2}	B1
	r | 0 | 1 | 2 $\mathrm{P}(R=r)$ | $\frac{2}{25}=0.08$ | $\frac{1}{2}=0.5$ | $\frac{21}{50}=0.42$	M1A1
		(3)

		Notes	Total 10
(a)	**M1**	lists at least 3 valid combinations (do not be concerned if there are any extras). Ignore any reference to *A* and *B* in their combinations, e.g. the use of subscripts. Allow in words.	
	A1	lists all 6 possible combinations (condone permutations) with no additional incorrect ones.	
(b)	**M1**	for at least 2 correct values (ignore any incorrect extra values)	
	A1	for all four values and no others (condone if not ordered). Must be seen in b.	
(c)	**B1**	for finding the probability of the event *SWW* or the event *WWP*. Implied by $\frac{9}{50}$ o.e. or $\frac{2}{25}$ o.e. May be seen in the table.	
	M1	for an attempt at $\mathrm{P}(T=11)$ or $\mathrm{P}(T=12)$. Implied by $\frac{21}{50}$ o.e. or $\frac{8}{25}$ o.e. May be seen in the table	
	A1	for a fully correct table, or all values of *T* correctly paired with their probabilities	
(d)	**B1**	for all three values and no others (may be seen in a table) (If listed condone if not ordered)	
	M1	for at least one correct value for *r* with a correct probability or calculation. Correctly paired in table is fine if not explicitly written down.	
	A1	for a fully correct table, or all values of *R* correctly paired with their probabilities	

Question Number	Scheme	Marks
6(a)		M1 A1
		(2)
(b)	Mode $= 4$	B1
		(1)
(c)	$\mathrm{E}(W) = \frac{1}{9}\int_2^5 w(6-w)(w-2)\ \mathrm{d}w$	M1
	$\mathrm{E}(W) = \frac{1}{9}\int_2^5 \left(-w^3+8w^2-12w\right)\mathrm{d}w = \frac{1}{9}\left[-\frac{w^4}{4}+\frac{8w^3}{3}-6w^2\right]_2^5$	M1
	$= \frac{1}{9}\left(\left(-\frac{5^4}{4}+\frac{8\times5^3}{3}-6\times5^2\right)-\left(-\frac{2^4}{4}+\frac{8\times2^3}{3}-6\times2^2\right)\right)$	dM1
	$= 3.75\,(\mathrm{kg})$	A1
		(4)
(d)	Standard deviation $= \sqrt{\frac{73}{5}-\left("\frac{15}{4}"\right)^2}$	M1
	$= \frac{\sqrt{215}}{20} = 0.73314...\,(\mathrm{kg})$ **awrt 0.733**	A1
		(2)
(e)	$\frac{1}{9}\int\ (-w^2+8w-12)\ \mathrm{d}w = \frac{1}{9}\left(-\frac{w^3}{3}+4w^2-12w\right)$	M1A1
	$\mathrm{F}(3.7) = \frac{1}{9}\int_2^{3.7}(-w^2+8w-12)\ \mathrm{d}w = 0.460...\ (<0.5)$	M1
	$\mathrm{F}(3.8) = \frac{1}{9}\int_2^{3.8}(-w^2+8w-12)\ \mathrm{d}w = 0.504\ (>0.5)$	M1
	3.7 and 3.8 give values either side of 0.5 hence median lies between 3.7 and 3.8	A1
		(5)
(f)	$X \sim \mathrm{N}(30,\ 30)$	B1
	$\mathrm{P}\left(Z < \frac{19.5-"30"}{\sqrt{"30"}}\right) = \mathrm{P}(Z<-1.917...)$	M1M1 A1ft
	= awrt 0.0274 or awrt 0.0276	A1
		(5)
		Total 19

	Notes	
(a)	**M1**	a negative **quadratic** shape which is in the first quadrant
	A1	correct graph with 2 and 5 labelled. Do not be concerned by the value of the maximum labelled. (condone missing axes labels\ missing vertical line at w=5) (If sketch shown for w<2 and w >5, must have f(w) = 0)
(b)	**B1**	Cao (accept $w = 4$)
(c)	**M1**	for attempting $\int w\,\mathrm{f}(w)\,\mathrm{d}w$. Does not require limits. Condone omission of dw or use of another variable.
	M1	for an attempt at integration of wf(w) with correct limits. Look for $w^n \rightarrow w^{n+1}$ for at least one term
	dM1	dependent on both previous method marks. For correct use of limits.
	A1	3.75 (kg) o.e. (Must see evidence of all previous M marks)
(d)	**M1**	for a correct standard deviation calculation using their part (c) including square root. May see $\sqrt{\frac{43}{80}}$ or $\sqrt{0.5375}$ or $\sqrt{\frac{215}{400}}$ (o.e)
	A1	awrt 0.733 (kg)
(e)	**M1**	for an attempt at integration of f(x). Look for $w^n \rightarrow w^{n+1}$ for at least one term Ignore limits. Condone missing 1/9 for this mark
	A1	correct integrated expression, including the 1/9 with or without + c. Limits do not need to be substituted in.
	dM1	dependent on the 1st M1. For one correct evaluation using 2 and 3.7 **or** 2 and 3.8 (Allow equivalent substitution into re-arrangements)
	dM1	dependent on the previous method marks. For two correct evaluations using 2 and 3.7 and 2 and 3.8 (Allow equivalent substitution into re-arrangements)
	A1	correct calculations, reasoning and conclusion (e.g. comparing awrt = 0.46 or awrt 0.504 with 0.5 \ median) o.e
	ALT	**Finding the value of *m***
	M1 A1	See scheme
	dM1	dependent on the 1st M1. Uses $\frac{1}{9}\int_2^m (-w^2+8w-12)\,\mathrm{d}w = 0.5$ must see limits.
	dM1	dependent on the previous method marks. Substituting **both** limits to obtain a cubic $am^3+bm^2+cm+d=0$ where a, b, c and d are constants and solves by any method (including calculator) to obtain m = ..., for at least one root. Allow substitution of 3.7 and 3.8 into the cubic expression.
	A1	All 3 correct roots seen **and** indicates awrt 3.79 **and** give a reason for rejecting the other two roots (other roots awrt 0.65 (condone 0.64) awrt 7.6 (condone 7.5)) Allow substitution of 3.7 and 3.8 into the cubic expression and identifying a sign change.
(f)	**B1**	for a correct normal approximation to a Poisson
	M1	for attempting to use a continuity correction (19.5 or 20.5)
	M1	for attempting to standardise (They can achieve this with 19.5, 20 or 20.5)
	A1ft	Dependent on both previous method marks for correct standardisation following through their mean and variance
	A1	awrt 0.0274 (Calc: 0.027617…) or awrt 0.0276 **NB Use of Poisson distribution gives 0.02187… and scores 0 marks.**

Question Number	Scheme	Marks
7(a)	$X \sim \text{B}(30,\ 0.45) \Rightarrow \text{P}(X > 16) = 1 - \text{P}(X \leqslant 16) = 1 - 0.8644$	M1
	$= 0.1356$ **awrt 0.136**	A1
		(2)
(b)	$Y \sim \text{N}(81, 44.55)$ where Y is the number of trains which arrive no more than 2 minutes late	M1A1
	$\text{P}\left(Y > \dfrac{k + 0.5 - "81"}{\sqrt{"44.55"}}\right) < 0.0427$	M1 M1 A1ft
	$\dfrac{k + 0.5 - "81"}{\sqrt{"44.55"}} > 1.72$	M1B1
	$k > 91.98... \Rightarrow k = 92$	A1
		(8)

	Notes	Total 10
(a)	**M1**	for use of a binomial with $n = 30,\ p = 0.45$ (you may need to check probabilities if no distribution is given.) (e.g. awrt 0.864, awrt 0.769, awrt 0.231, awrt 0.645, awrt 0.355)
	A1	awrt 0.136 (Correct answer scores 2/2)
(b)	**M1**	for attempting the **correct** binomial to normal approximation. Score for sight of N(81,...) o.e.
	A1	correct normal distribution N(81, 44.55)
	M1	for attempting a continuity correction (***k* + 0.5 or *k* - 0.5)**
	M1	for attempting to standardise with their "81" and their $\sqrt{"44.55"}$ or awrt 6.67, with or without a continuity correction.
	A1ft	dependent on both of the previous method marks. For a correct standardisation using ***k* + 0.5** but ft their "81" and their $\sqrt{"44.55"}$ or awrt 6.67
	M1	for setting their standardised expression more than a z-value $1 < \lvert z \rvert < 3$ (Condone equals)
	B1	correct z-value awrt 1.72 (Allow -1.72 if consistent with their standardisation)
	A1	dependent on all the previous marks for 92
	SC	if no continuity correction is used leading to 92.48027526…then maximum score is M1A1M0M1A0ftM1B1A0
	SC	if the incorrect continuity correction (k – 0.5) is used leading to 92.9802… then maximum score is M1A1M1M1A0ftM1B1A0