Question Number	Scheme	Marks
1 (a)	[Mode =] 137	B1
		(1)
(b)	$a = 106$ $b = 129$ $c = 126$	B1 B1 B1
		(3)
(c) (i)	$\left[\text{mean} = \frac{4016}{31} =\right] 129.5$	B1
(ii)	[Standard deviation =] $\sqrt{\frac{525056}{31} - '\left(\frac{4016}{31}\right)'^2}$ or $\sqrt{\frac{31}{30}\left(\frac{525056}{31} - '\left(\frac{4016}{31}\right)'^2\right)}$	M1
	$= 12.4$ or 12.6	A1
		(3)
(d)	$\frac{'129.5' - '137'}{'12.4'} [= -0.6]$	M1
	Negative [skew]	A1ft
		(2)
(e)	A correct difference of the average or a correct difference of the spread e.g. On average action films **run for longer** than comedy films as the **median** is greater **129 > 117**	B1ft
		(1)

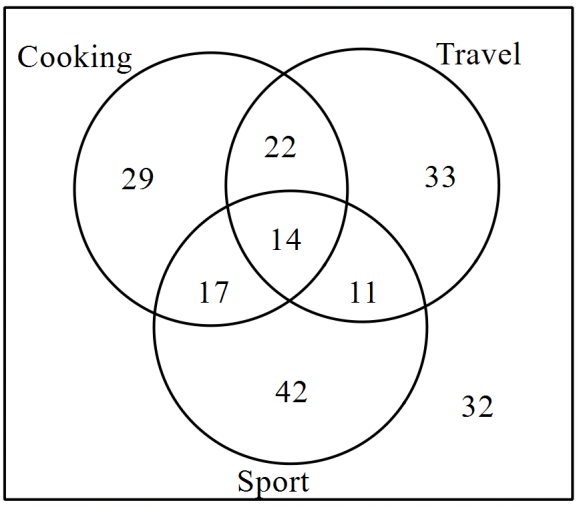
	Notes	**Total 10**
(a)	**B1**	Cao Must be seen in part (a)
(b)	**B1**	$a = 106$ Must be attached to a (Condone Q_1 /lower quartile for a)
	B1	$b = 129$ Must be attached to b (Condone Q_2 /median for b)
	B1	$c = 126$ Must be attached to c (Condone Q_3 /upper quartile for c)
(c) (i)	**B1**	awrt 130
(ii)	**M1**	For a correct method (including the square root) to find the standard deviation. Ft their mean May be implied by awrt 12.4 or awrt 12.9 or awrt 12.6 if sample standard deviation is calculated
	A1	awrt 12.4 or awrt 12.6 if sample standard deviation is calculated Correct answer only scores 2/2
(d)	**M1**	For substitution of the mode, the mean and the standard deviation into the expression. Ft their mode, their mean and their standard deviation. Allow awrt −0.6 if no working shown.
	A1ft	A correct interpretation ft their expression. Ignore any reference to correlation
(e)	**B1ft**	for a correct comment, **referring to length**, with reference to a **correctly named statistic.** Must **include the correct figures** compared. Ft their values. Ignore any reference to skew

The following table may be useful (but not an exhaustive list of possible answers)

Statistic	**A**	**C**	**Comment**
Median	129	117	On average action films **run for longer** as the **median** is greater **129 > 117**
Mean	129.5	114.5	On average action films have a **greater running time** as the **mean** is greater **129.5 > 114.5**
Mode	137	127	On average comedy films are **shorter in length** as the **mode** is less **127 < 137**
IQR	17	20	Comedy films have a **greater spread of running times** as the **IQR** is greater **20 > 17**
Range	57	39	Action films have a **larger variation of running times** as the **range** is greater **57 > 39**
SD	12.4	11.9	Comedy films show **less variability in the length** of films as the **SD** is less **11.9 < 12.4**

Question Number	Scheme	Marks
2 (a) (i)	$S_{yy} = 81938.5 - \frac{2015^2}{50} [= 734]$ *	B1*
(ii)	$r = \frac{219.55}{\sqrt{734 \times 72.25}} = 0.95338...$ awrt 0.953	M1 A1
		(3)
(b)	e.g. [In general] the longer the rabbit the greater the weight	B1ft
		(1)
(c)	Consistent/Yes as *r*/PMCC is close to 1	B1ft
		(1)
(d)	$b = \frac{219.55}{734} = 0.2991...$	M1 A1
	$a = \left(\frac{125}{50}\right) - 'b'\left(\frac{2015}{50}\right) [= -9.554...]$	M1
	$w = -9.55 + 0.299y$	A1
		(4)
(e)	$'-9.55' + '0.299' \times 45 = 3.905$ awrt 3.91	M1 A1ft
		(2)
	Notes	**Total 11**

(a)(i)	**B1***	Answer is given so a correct numerical expression and no incorrect working seen
(ii)	**M1**	For use of $\frac{S_{yw}}{\sqrt{S_{yy} \times S_{ww}}}$ May be implied by awrt 0.953
	A1	awrt 0.953
(b)	**B1ft**	A correct interpretation ft their *r* value (provided that $\lvert r \rvert < 1$) e.g as length/*y* increases the weight/*w* increases Ignore any figures quoted. Do not accept comments about correlation on their own
(c)	**B1ft**	A correct statement with a correct reason ft their *r* value (provided that $\lvert r \rvert < 1$) Allow $0.953 \approx 1$ Allow 'my value' to imply *r*
(d)	**M1**	A correct method to find the gradient (May be implied by awrt 0.299 or $\frac{4391}{14680}$)
	A1	awrt 0.299 (Condone awrt 0.3 if M1 scored) May be implied by a correct gradient in the regression line.
	M1	A correct method to find the intercept ft their *b* (May be implied by awrt –9.55)
	A1	For $w = (\text{awrt}) - 9.55 + (\text{awrt})0.299y$ Must be seen in part (d)
(e)	**M1**	For substitution of 45 into their regression equation
	A1ft	For awrt 3.91 or ft their regression line, provided their final answer is > 0. If regression line is not correct, then you will need to check their answer

Question Number	Scheme	Marks
3 (a)		B1 B1 B1
		(3)
(b) (i)	$\frac{'14'}{200}$	B1ft (1)
(ii)	$\frac{'33'+'11'+'42'+'32'}{200}=\frac{118}{200}$ or $\frac{200-'29'-'22'-'14'-'17'}{200}=\frac{118}{200}$	M1 A1
		(2)
(c)	$\frac{'14'+'11'}{'14'+'11'+'22'+'33'}=\frac{25}{80}$	M1 A1
		(2)

	Notes		Total 8
(a)	**B3**	For a fully correct Venn diagram (B2 for at least 6 numbers in the correct place on the Venn diagram) (B1 for at least 3 numbers in the correct place on the Venn diagram) Treat blanks on the diagram as zero Condone correct probabilities instead of frequencies e.g. $^{22}/_{200}$ oe or 0.11 as 22	
(b) (i)	**B1ft**	For $\frac{'14'}{200}$ oe ft their Venn diagram	
(ii)	**M1**	$\frac{'33'+'11'+'42'+'32'}{200}$ or $\frac{200-'29'-'22'-'14'-'17'}{200}$ ft their Venn diagram. May be implied by $\frac{118}{200}$ oe	
	A1	For $\frac{118}{200}$ oe	
(c)	**M1**	$\frac{n}{'14'+'11'+'22'+'33'}$ provided the answer gives a probability and $0 < n < 80$ ft the Venn diagram for the denominator or $\frac{m}{'0.4'}$ where $0 < m < 0.4$ ft the Venn diagram for the denominator	$\frac{'n'}{80}$ provided $0 < n < 80$ ft the Venn diagram for numerator or $\frac{'m'}{0.4}$ where $0 < m < 0.4$ ft the Venn diagram for numerator
	A1	For $\frac{25}{80}$ oe Allow 0.313	

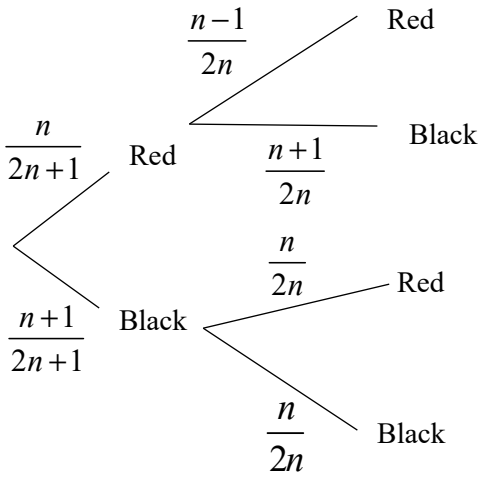
Question Number	Scheme	Marks
4 (a)	$X \sim N(170,16^2)$	
	$P(X>190)=P\left(Z>\frac{190-170}{16}\right)\left[=P(Z>1.25)\right]$	M1
	$[=1-0.8944]=0.1056$ awrt 0.106	A1
		(2)
(b)	$P(X>d)=0.9$	
	$\frac{d-170}{16}=-1.2816$ or $\frac{170-d}{16}=1.2816$ (Calc value ±1.28155…)	M1 A1
	$d=149.494...$ awrt 149	dA1
		(3)
	Notes	**Total 5**
	NB correct answers with no working scores no marks	
(a)	**M1** For standardising using 190, 170 and 16 (May be implied by 1.25)	
	A1 awrt 0.106 Do not ISW	
(b)	**M1** For standardising and setting = z value, where $1 < \|z\| < 2$	
	A1 A fully correct standardisation = a correct compatible z value to 4 dp or better.	
	dA1 Dependent on previous A1 149.5 or awrt 149	

Question Number	Scheme	Marks
5 (a)	[Time is] continuous	B1
		(1)
(b)	16 photographers = 160 small squares or 64 photographers = 640 small squares or $\frac{16}{160}=0.1$ or $\frac{64}{640}=0.1$ or $\frac{160}{16}=10$ or $\frac{640}{64}=10$ Frequency density = 1.6 or Correct scale on the frequency density axis	M1
	$\frac{x}{240}=\frac{16}{160}$ oe or $\frac{(20-12)}{10}\times16+\frac{(24-20)}{5}\times14$	M1
	= 24	A1
		(3)
(c)	**Using *n*** $[Q_2=]20+\frac{(32-21)}{35-21}\times(25-20)$ oe or $25-\frac{35-32}{35-21}\times(25-20)$ oe = awrt 23.9 **Using *n* + 1** $[Q_2=]\ 20+\frac{(32.5-21)}{35-21}\times(25-20)$ oe or $25-\frac{35-32.5}{35-21}\times(25-20)$ oe = awrt 24.1	M1 A1
		(2)
(d)	Mean = Median or Mean ≈ Median	M1
	e.g. Appropriate decision. Consistent with expectation for a normal distribution.	A1ft
		(2)

	Notes	**Total 8**
(a)	**B1**	Allow not discrete
(b)	**M1**	For establishing a ratio between photographers and area or calculating frequency density (may be implied by 2nd M1)
	M1	For a correct ratio or expression using areas for photographers from 12 to 24
	A1	Cao
(c)	**M1**	For a correct method to find median using either n or $n + 1$
	A1	awrt 23.9 or awrt 24.1 if using $n + 1$
(d)	**M1**	For a correct comment about mean and median ft their median Allow mean is close to median to imply mean ≈ median Ignore any comments made about the shape of the histogram
	A1ft	For a correct compatible comment about Charlie's decision ft their median If Mean = Median or Mean ≈ Median, then the decision should be that a normal distribution is suitable [due to symmetry] If Mean < Median or Mean > Median or mean ≠ median, then the decision should be that a normal distribution is not suitable [due to the skew in the data]

Question Number	Scheme	Marks
6(a)	$[10k=1\Rightarrow]k=0.1$	B1
		(1)
(b)	e.g. $P(X=1)=0.1$ and $P(X=2)[=F(2)-F(1)]=0.1$	B1
	e.g. $P(X=3)[=F(3)-F(2)]=0.1$	M1
	X | 1 | 2 | 3 | 4 | 5 | 6 $P(X=x)$ | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3	A1
		(3)
(c)	$a+a+a+b+b+b+0.11+0.05=1$ $[3a+3b=0.84]$	M1
	$a+2a+3a+4b+5b+6b+0.77+0.4=4.02$ $[\Rightarrow 6a+15b=2.85]$	M1
	e.g. $9a=1.35\Rightarrow a=0.15$*	A1*
		(3)
(d)	$b=0.13$	
	$E(Y^2)=1^2\times0.15+2^2\times0.15+3^2\times0.15+4^2\times'0.13'+5^2\times'0.13'+6^2\times'0.13'$ $+7^2\times0.11+8^2\times0.05=[20.7]$*	M1 A1*
		(2)
(e)	$[\text{Var}(Y)=]20.7-4.02^2[=4.5396]$	M1
	$\text{Var}(5-2Y)=4\text{Var}(Y)=4\times'4.5396'=18.1584$ awrt 18.2	M1 A1
		(3)
(f)	$'0.1'\times0.15+'0.1'\times0.15=0.03$	M1 A1
		(2)

	Notes	Total 14
(a)	**B1**	For $k=0.1$ oe
(b)	**B1**	For correct use of F(x) to find 2 probabilities May be implied by two correct probabilities
	M1	For correct use of F(x) to find one other probability. May be implied by one other correct probability
	A1	For a fully correct probability distribution. Need not be in a table but probabilities must be attached to the correct X values
(c)	**M1**	For use of the sum of the probabilities = 1 to form a linear equation in a and b (May be implied by $3a+3b=0.84$)
	M1	For use of $\sum y\times P(Y=y)=4.02$ to form a linear equation in a and b (May be implied by $6a+15b=2.85$)
	A1*	Answer is given so there must be a correct line between the 2 equations and the given answer
(d)	**M1**	For finding E(Y^2) with their b (At least 4 correct terms). Values for a and b must be substituted into their expression for E(Y^2)
	A1*	For a fully correct expression (no incorrect working seen) eg. $14\times0.15+77\times0.13+49\times0.11+64\times0.05$ Allow 0.15 + 0.6 + 1.35 + 2.08 + 3.25 + 4.68 + 5.39 + 3.2
(e)	**M1**	For a correct expression for Var(Y). May be implied by awrt 4.54 Allow E(5 – 2Y) = $-{}^{76}\!/_{25}$ oe and E((5 – 2Y)^2) = ${}^{137}\!/_{5}$
	M1	For use of 4Var(Y) ft their Var(Y) provided Var(Y) is not 20.7 or 4.02 Do not allow 5 + 4Var(Y) Allow Var(5 – 2Y) = $\frac{137}{5}-\left(-\frac{76}{25}\right)^2$ ft their E(5 – 2Y) and their E((5 – 2Y)^2)
	A1	awrt 18.2
(f)	**M1**	For use of P(X = 1) × P(Y = 2) + P(X = 2) × P(Y = 1) ft their X distribution probabilities
	A1	Cao

Question Number	Scheme		Marks
7 (a)		$\frac{n}{2n+1}$ and $\frac{n+1}{2n+1}$ in the correct places on the tree diagram	B1
		$\frac{n-1}{2n}$ and $\frac{n+1}{2n}$ in the correct places on the tree diagram	B1
		$\frac{n}{2n}$ and $\frac{n}{2n}$ in the correct places on the tree diagram	B1
			(3)
(b)	$'\frac{n}{2n+1}'\times'\frac{n+1}{2n}'+'\frac{n+1}{2n+1}'\times'\frac{n}{2n}'$		M1
	$=\frac{2n(n+1)}{2n(2n+1)}=\frac{n+1}{2n+1}*$		A1*
			(2)
(c)	$\frac{n+1}{2n+1}=\frac{25}{49}\Rightarrow n=24$	So 49 counters in the box	M1 A1
			(2)
(d)	$\frac{'\frac{25}{49}'\times'\frac{24}{48}'}{\frac{25}{49}}=\frac{1}{2}$		M1 A1
			(2)

	Notes		Total 9
(a)	**B1**	For $\frac{n}{2n+1}$ and $\frac{n+1}{2n+1}$ in the correct places on the tree diagram	
	B1	For $\frac{n-1}{2n}$ and $\frac{n+1}{2n}$ in the correct places on the tree diagram	
	B1	For $\frac{n}{2n}$ and $\frac{n}{2n}$ in the correct places on the tree diagram. Allow $\frac{1}{2}$ for $\frac{n}{2n}$ in both places	
(b)	**M1**	For use of P(Red) × P(Black) + P(Black) × P(Red) ft their tree diagram	
	A1*	Answer is given so no incorrect working can be seen. Must have at least one correct line of working between M1 and the given answer.	
(c)	**M1**	For solving to find $n = 24$	
	A1	Cao	
(d)	**M1**	For a correct ratio ft their n and their tree diagram Allow a correct ratio in terms of n e.g. $\frac{\frac{n+1}{2n+1}\times\frac{n}{2n}}{\frac{n+1}{2n+1}}$ oe ft their tree diagram for the numerator	
	A1	For 0.5 (Working must be seen)	

Question Number	Scheme	Marks
8 (a)	$\frac{162-\mu}{\sigma}=-1.2816$ (Calculator gives –1.28155…) or $\frac{175-\mu}{\sigma}=1.04$ (Calculator gives 1.03987…)	M1 A1 A1
	$\mu-1.2816\sigma=162$	
	$\mu+1.04\sigma=175$	
	$2.3216\sigma=13$	dM1
	$\sigma=5.5995...$ awrt 5.6 $\mu=169.1764...$ awrt 169	A1
		(5)
(b)	$Q_1=208.26$ or $Q_3-Q_1=13.48$	B1
	$221.74+1.5(221.74-'Q_1')[=241.96]$ or $'Q_1'-1.5(221.74-'Q_1')[=188.04]$	M1
	Probability of an outlier / **1 – Probability of not an outlier**	
	$\left[\mathrm{P}(B>'241.96')=\right]$ $\mathrm{P}\left(Z>\frac{'241.96'-215}{10}\right)[=\mathrm{P}(Z>2.70)]$ or $\left[\mathrm{P}(B<'188.04')=\right]$ $\mathrm{P}\left(Z<\frac{'188.04'-215}{10}\right)[=\mathrm{P}(Z<-2.70)]$ or	$\left[\mathrm{P}('188.04'<B<'241.96')=\right]$ $\mathrm{P}\left(\frac{'188.04'-215}{10}<Z<\frac{'241.96'-215}{10}\right)$ $[=\mathrm{P}(-2.70)<Z<\mathrm{P}(2.70)]$	dM1
	$=0.0035$ (Calculator gives 0.0034883…)	$=0.993$ (Calculator gives 0.99298…)	
	$\mathrm{P(Outlier)}=2\times'0.0035'$	$\mathrm{P(Outlier)}=1-'0.993'$	M1
	$=0.007$ (Calculator gives 0.006976…) awrt 0.007	$=0.007$ (Calculator gives 0.007017…) awrt 0.007	A1
			(5)

	Notes		Total 10
(a)	**M1**	For standardising with μ and σ and setting = to a z value with $\lvert z\rvert>1$	
	A1	For one correct equation in any form with correct z value as given or better	
	A1	For a 2nd correct equation in any form allow 2dp or better for the z value	
	dM1	Dependent on previous M1. For solving their 2 linear simultaneous equations (Can be implied by both correct answers) If answers are incorrect then we need to see evidence of correct working	
	A1	For $\mu=$ awrt 169 and $\sigma=$ awrt 5.6	
(b)	**B1**	For $Q_1=208.26$ or $Q_3-Q_1=13.48$ Do not accept rounded values	
	M1	For a correct method for finding 1 outlier limit, ft their Q_1 or their IQR. You will need to check that these are correct if no working shown.	
	dM1	Dependent on previous M1. For standardising using their limit(s), 215 and 10 (allow ±) May be implied by ± awrt 2.70 or awrt 0.0035 or awrt 0.993 or final answer of awrt 0.007	
	M1	If using the LHS of the MS: for multiplying their probability by 2 or If using the RHS of the MS: for 1 – their probability May be implied by awrt 0.007	
	A1	awrt 0.007	