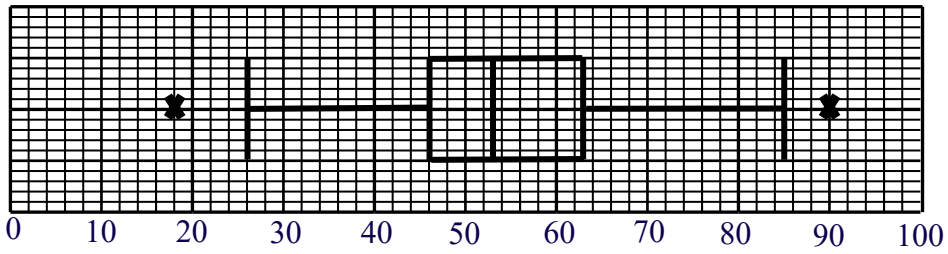
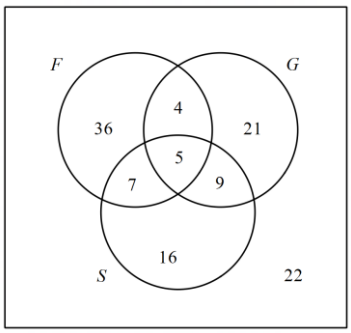
Question Number	Scheme	Marks
1 (a)	Median = 53	B1
	IQR = 63 – 46	M1
	= 17	A1
		(3)
(b)	'46' – 1.5 × '17' or '63' + 1.5 × '17'	M1
	20.5 and 88.5	A1
		M1 A1ft B1
		(5)
(c)	Lower Quartile changes from 46 to 43	B1
	Lower outlier boundary is now 13 **or** upper outlier bounday is now 93	M1
	So, X removed at 18 **and** lower whisker extended to 18 oe	A1
	X at 90 moved to 94	A1
	[All other points remain the same]	
		(4)

	Notes	Total 12
(a)	**B1**	Cao
	M1	For an attempt at IQR. Either Q_1 or Q_3 must be correct.
	A1	Cao
(b)	**M1**	For use of either LQ – 1.5 × IQR or UQ + 1.5 × IQR ft their LQ/UQ and their IQR May be implied by 20.5 or 88.5 or a fully correct box plot with outliers plotted correctly
	A1	Cao May be implied by a fully correct box plot with outliers plotted correctly
	M1	For a box with an upper and lower whisker
	A1ft	For a box with an upper and lower whisker and the LQ, median and UQ plotted correctly ft their values [Allow ½ square tolerance]
	B1	For lower whisker plotted at 26 or their 20.5 **and** upper whisker plotted at 85 or their 88.5 **and** only 2 outliers marked at 18 and 90
(c)	**B1**	For LQ changes to 43
	M1	For 13 or 93 identified as the new outlier boundaries
	A1	Dep on 13 being identified as the new outlier boundary. For outlier removed at 18 **and** lower whisker extended to 18 (Do not accept the lower whisker is extended to 13)
	A1	Dep on 93 being identified as the new outlier boundary. For outlier at 90 moved to 94 [and whisker extended to 93 – Ignore any reference to the upper whisker]

Question Number	Scheme	Marks
2 (a)	$S_{ff} = 25.5 - \frac{15^2}{10}$ $S_{df} = 433.5 - \frac{(25.7\times10)\times15}{10}$	M1
	$S_{ff} = 3$ $S_{df} = 48$	A1 A1
		(3)
(b)	f since the frequency depends on the depth (d) oe	B1
		(1)
(c)	$\frac{'48'}{\sqrt{1090.6\times'3'}} = 0.8391...$ awrt 0.839	M1 A1
		(2)
(d)	As the depth (d) increases the frequency (f) increases	B1ft
		(1)
(e)	$\beta = \frac{'48'}{1090.6}[= 0.04401...]$	M1
	$\alpha = \frac{15}{10} - '\beta'\times25.7[= 0.3688...]$	M1
	$f = 0.369 + 0.0440d$	A1
		(3)
(f) (i)	For every extra metre of depth, the frequency increases by '0.044' [kHz] oe	B1ft
(ii)	[Assuming the model is valid,] the frequency at the surface would be '0.369' [kHz] oe	B1ft
		(2)

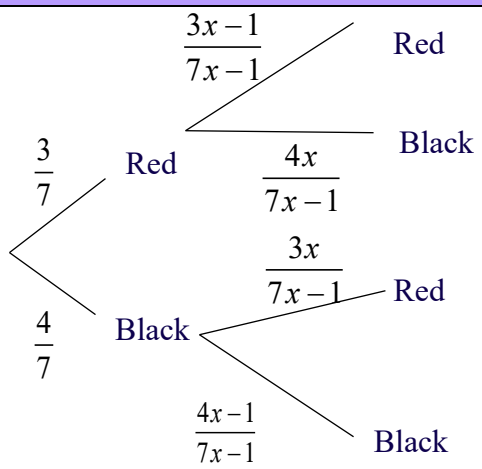
	Notes	Total 12
(a)	**M1**	For a correct method to find either S_{ff} or S_{df} May be implied by a correct anwser
	A1	For $S_{ff} = 3$
	A1	For $S_{df} = 48$
(b)	**B1**	f identified with a correct reason e.g. f **and** is dependent on…/affected by…/changed by…/influenced by… determined by d or f **and** reference to d being controlled e.g. f since d is the variable that is controlled
(c)	**M1**	For a correct method to calculate the PMCC follow through their S_{ff} and S_{df} May be implied by awrt 0.839
	A1	awrt 0.839
(d)	**B1ft**	A correct interpretation follow through their part (c) e.g. As d increases f increases. Ignore any reference to numbers
(e)	**M1**	A correct method to find the gradient ft their S_{df} May be implied by awrt 0.04 or $\frac{240}{5453}$
	M1	A correct method to find the f intercept ft their β May be implied by awrt 0.37 or $\frac{4023}{10906}$
	A1	For a correct equation, with α =awrt 0.369 and β =awrt 0.044 Allow $\alpha = \frac{4023}{10906}$ and $\beta = \frac{240}{5453}$ Must be in terms of f and d only
(f) (i)	**B1ft**	A correct interpretation, follow through their β. Must have the units metre oe
(ii)	**B1ft**	A correct interpretation, follow through their α Allow $d = 0$ to imply 'at the surface'

Question Number	Scheme	Marks
3 (a)(i)	$\frac{7}{120}$	B1
(ii)	$\frac{22}{120}$	B1
		(2)
(b)		B1 M1 A1 B1ft
		(4)
(c)(i)	$\left[\mathrm{P}\left(F' \cap G'\right) = \frac{'16'+22}{120}\right] = \frac{19}{60}$	B1ft
(ii)	$\left[\mathrm{P}\left(F \cap G \middle\| S\right) =\right] \frac{5}{7+5+9+'16'}$	M1
	$= \frac{5}{37}$	A1
		(3)

	Notes	Total 9
(a)(i)	**B1**	Oe Allow 0.058 or better
(ii)	**B1**	Oe Allow 0.183 or better
(b)	**B1**	For 36 and 4 in the correct place on the Venn diagram
	M1	For $2\times41-7-5-9-'36'-'4'$ or $\frac{41}{60}=\frac{'52'}{120}+\frac{'18'+x}{120}-\frac{'9'}{120}$ (May be implied by 21) If $'36'+'4'+'21'=61$ this will imply this mark
	A1	For 21 in the correct place on the Venn diagram
	B1ft	For 16 in the correct place on the Venn diagram or ft their Venn diagram (total = 120)
(c)(i)	**B1ft**	For $\frac{19}{60}$ oe or ft their 16 Allow 0.317 or better
(ii)	**M1**	For a correct method to find the conditional probability ft their 16
	A1	Oe Allow 0.135 or better

Question Number	Scheme		Marks
4 (a)(i)(ii)	$a=\frac{1}{2}$		B1
(ii)	$d=1$		B1
(iii)	$a+3b=1\Rightarrow '\frac{1}{2}'+3b=1\Rightarrow b=\frac{1}{6}$		M1A1
(iv)	$a+2b=c\Rightarrow '\frac{1}{2}'+2\times '\frac{1}{6}'=c$ or $d-b=c\Rightarrow '1'-'\frac{1}{6}'=c$ So $c=\frac{5}{6}$		M1A1
			(6)
(b) (i)	$\mathrm{E}(X)=\left[0\times '\frac{1}{2}'+2\times '\frac{1}{3}'+3\times '\frac{1}{6}'\left[=\frac{7}{6}\right]\right]$	4, 28 and 40 seen	M1
	$\mathrm{E}(12X+4)=12\mathrm{E}(X)+4=12\times '\frac{7}{6}'+4=18$	$4\times '\frac{1}{2}'+28\times '\frac{1}{3}'+40\times '\frac{1}{6}'=18$	M1 A1
			(3)
(ii)	$\mathrm{E}(X^2)=\left[0^2\times '\frac{1}{2}'+2^2\times '\frac{1}{3}'+3^2\times '\frac{1}{6}'\left[=\frac{17}{6}\right]\right]$	16, 784 and 1600 seen oe	M1
	$\mathrm{Var}(X)='\frac{17}{6}'-'\frac{7}{6}'^2\left[=\frac{53}{36}\right]$	$4^2\times '\frac{1}{2}'+28^2\times '\frac{1}{3}'+40^2\times '\frac{1}{6}'[=536]$	M1
	$\mathrm{Var}(12X+4)=12^2\mathrm{Var}(X)=144\times '\frac{53}{36}'=212$	$536-18^2=212$	M1 A1
			(4)

	Notes	Total 13
(a) (i)	**B1**	Cao
(ii)	**B1**	Cao
(iii)	**M1**	For writing or using of $a+3b=1$ ft their a provided $0<a<1$ May be implied by $b=\frac{1}{6}$
	A1	Allow awrt 0.167
(iv)	**M1**	For writing or using of $a+2b=c$ ft their a and their b provided $0<a<1$ and $0<b<1$ or $d-b=c$ ft their d and their b provided $0<d<1$ and $0<b<1$ May be implied by $c=\frac{5}{6}$
	A1	Allow awrt 0.833
(b) (i)	**M1**	For use of $\sum x\mathrm{P}(X=x)$ ft their a and their b provided $0<b<1$ (We do not need to see 0×0.5) Allow $\sum x\mathrm{P}(X=x)=7b$ or writing/using 4, 28 and 40
	M1	For use of $12\mathrm{E}(X)+4$ ft their E(X) Allow E($12X+4$) = $84b+4$ or use of $\sum x\mathrm{P}(X=x)$ if using 4, 28 and 40 ft their a and their b provided $0<a<1$ and $0<b<1$ Allow $\sum x\mathrm{P}(X=x)=4a+96b$
	A1	Cao
(ii)	**M1**	For use of $\sum x^2\mathrm{P}(X=x)$ ft their a and their b, provided $0<b<1$ (We do not need to see $0^2\times 0.5$). Allow $\sum x^2\mathrm{P}(X=x)=17b$ or writing/using 16, 784 and 1600 May be implied by the 2nd M mark
	M1	For use of $\mathrm{Var}(X)=\mathrm{E}(X^2)-\mathrm{E}(X)^2$ ft their $\mathrm{E}(X^2)$ and their $\mathrm{E}(X)$ Allow $\mathrm{Var}(X)=17b-49b^2$ or use of $\sum x^2\mathrm{P}(X=x)$ if using 16, 784 and 1600 ft their a and their b provided $0<a<1$ and $0<b<1$ Allow $\sum x^2\mathrm{P}(X=x)=16a-3168b$
	M1	For use of $12^2\mathrm{Var}(X)$ ft their Var(X) Allow $2448b-7056b^2$ or $\mathrm{Var}(X)=\mathrm{E}(X^2)-\mathrm{E}(X)^2$ if using 16, 784 and 1600 Allow $16a-3168b-(4a+96b)^2$
	A1	Cao

Question Number	Scheme		Marks
5 (a)		$\frac{3}{7}$ in the correct place on the tree diagram	B1
		$\frac{3x-1}{7x-1}$ in the correct place on the tree diagram	B1
		$\frac{3x}{7x-1}$ and $\frac{4x-1}{7x-1}$ in the correct place on the tree diagram	B1
			(3)
(b)	$'\frac{3}{7}'\times\frac{4x}{7x-1}+\frac{4}{7}\times'\frac{3x}{7x-1}'=\frac{32}{63}$	$'\frac{3}{7}'\times\frac{4x}{7x-1}=\frac{16}{63}$	$\frac{4}{7}\times'\frac{3x}{7x-1}'=\frac{16}{63}$ M1
	$\frac{24x}{7x-1}=\frac{32}{9}\Rightarrow x=4$	$\frac{12x}{7x-1}=\frac{16}{9}\Rightarrow x=4$	$\frac{12x}{7x-1}=\frac{16}{9}\Rightarrow x=4$ dM1 A1
	[So $7\times'4'=$]28 counters in total		dA1ft
			(4)
(c)	$\text{P}(B \text{ and } R)=\frac{4}{7}\times'\frac{12}{27}'\left[=\frac{16}{63}\right]$ or $\text{P}(BR \text{ and } RR)=\frac{4}{7}\times'\frac{12}{27}'+'\frac{3}{7}'\times'\frac{11}{27}'\left[=\frac{3}{7}\right]$		M1
	$\text{P}(1\text{stblack}\mid 2\text{ndRed})=\frac{\frac{4}{7}\times'\frac{12}{27}'}{\frac{4}{7}\times'\frac{12}{27}'+'\frac{3}{7}'\times'\frac{11}{27}'}=\frac{16}{27}$		M1 A1
			(3)

	Notes	Total 10
(a)	**B1**	for $\frac{3}{7}$ in the correct place on the tree diagram. Allow $\frac{3x}{7x}$
	B1	for $\frac{3x-1}{7x-1}$ in the correct place on the tree diagram Allow equivalent expresions e.g. $1-\frac{4x}{7x-1}$
	B1	both $\frac{3x}{7x-1}$ and $\frac{4x-1}{7x-1}$ in the correct place on the tree diagram. Allow equivalent expressions
(b)	**M1**	for setting their P(two counters are different colours) = $\frac{32}{63}$ or P(R and B) = $\frac{16}{63}$ or P(B and R) = $\frac{16}{63}$ ft their tree diagram
	dM1	Dependent on previous M mark. For an attempt to simplify the probability expression leading to x = … (At least one correct step needed) May be implied by $x = 4$
	A1	for $x = 4$
	dA1ft	Dep on 2nd M mark. Ft their x provided x is a positive integer
(c)	**M1**	For a correct probability expression for either P(B and R) or P(BR and RR) ft their tree diagram and their x, provided that x is an integer Allow expressions given in terms of x e.g. $\frac{4}{7}\times\frac{3x}{7x-1}$ or $\frac{4}{7}\times\frac{3x}{7x-1}+\frac{3}{7}\times\frac{3x-1}{7x-1}$ ft their tree diagram
	M1	For a correct ratio of probabilities ft their tree diagram and their x, provided that x is an integer Allow expressions given in terms of x e.g. $\frac{\frac{4}{7}\times\frac{3x}{7x-1}}{\frac{4}{7}\times\frac{3x}{7x-1}+\frac{3}{7}\times\frac{3x-1}{7x-1}}$ ft their tree diagram
	A1	Allow awrt 0.593

Question Number	Scheme	Marks
6 (a)	$\left[\mathrm{P}\left(X+2<3X-4\right)=\right]\mathrm{P}\left(X>3\right)=\frac{2}{5}$	M1 A1
		(2)
(b)	$\mathrm{E}\left(X^2\right)=\frac{1}{5}\left(1^2+2^2+3^2+4^2+5^2\right)=11$	M1 A1
		(2)
(c)	$\mathrm{E}\left(X\right)=3$	B1
	$\mathrm{Var}\left(X\right)='11'-('3')^2[=2]$ or $\frac{25-1}{12}$ or $\frac{(5+1)(5-1)}{12}$	M1
	$\mathrm{E}\left(aX+5\right)=6\Rightarrow '3'a+5=6$	M1
	$a=\frac{1}{3}$	A1
	$\mathrm{Var}\left(3-aX\right)\Rightarrow\left('\frac{1}{3}'\right)^2\times '2'$	M1
	$=\frac{2}{9}$	A1
		(6)

	Notes	Total 10
(a)	**M1**	For rearranging to $\mathrm{P}\left(X>3\right)$ Allow P(3 < X) or x > 3 or identifying that P(X = 4) and P(X = 5) are needed e.g 6 < 8 and 7 < 11 identified
	A1	For $\frac{2}{5}$ oe **NB** $\frac{2}{5}$ with no incorrect working seen scores M1A1 Watch out for P(X < 3) = $\frac{2}{5}$ which scores M0A0
(b)	**M1**	For a correct method to find $\mathrm{E}\left(X^2\right)$ May be implied by E(X^2) = 11
	A1	Cao
(c)	**B1**	For $\mathrm{E}\left(X\right)=3$ May be seen in an expression for Var(X) or implied by a correct value for Var(X) ft their E(X^2) or implied by a = $\frac{1}{3}$ Allow if seen in part (b)
	M1	For a correct method to find Var (X) ft their E(X^2) and their E(X)
	M1	For writing or using $a\mathrm{E}(X)+5=6$ ft their E(X) May be implied by a = $\frac{1}{3}$
	A1	For $\frac{1}{3}$ oe Allow 0.333
	M1	Use of $\mathrm{Var}\left(3-aX\right)=a^2\mathrm{Var}(X)$ ft their a and their Var (X) May be implied by $\mathrm{Var}\left(3-aX\right)=\frac{2}{9}$
	A1	For $\frac{2}{9}$ oe allow awrt 0.222

Question Number	Scheme	Marks
7 (a)	$\mathrm{P}(X > 210) = \mathrm{P}\left(Z > \dfrac{210-180}{20}\right)$	M1
	$= \mathrm{P}(Z > 1.5) = 1 - 0.9332 = 0.0668$ So 6.68%*	A1*
		(2)
(b)	$\dfrac{n-180}{20} = -1.0364$	M1 B1
	$n = 159.272$ awrt 159	A1
		(3)
(c)(i)	$\mathrm{P}(Y < \mu - 5 \mid Y < \mu) = \dfrac{1-0.7967}{0.5}$	M1
	$= 0.4066$ awrt 0.407	A1
		(2)
(ii)	$\dfrac{5}{\sigma} = 0.83$	M1
	$\sigma = \dfrac{5}{0.83} = 6.02...$ So $\sigma = 6$ *	A1*
		(2)

	Notes	Total 9
(a)	**M1**	For standardising using 210, 180 and 20 (Standardidsation must be seen)
	A1*	Answer is given so no incorrect working can be seen 0.0668 is sufficent for this mark
(b)	**M1**	For standardising using any letter, 180 and 20 = z value, where $1 < \lvert z \rvert < 1.5$
	B1	For –1.0364 or better Allow 1.0364 or better
	A1	awrt 159 **NB** M1B0A1 is possible
(c)(i)	**M1**	For a correct method to find the conditional probability
	A1	awrt 0.407
(ii)	**M1**	For use of 0.83 or better (calc 0.82989…) in an equation with σ only. Allow $\dfrac{\mu+5-\mu}{\sigma} = 0.83$
	A1*	Answer is given so no incorrect working can be seen awrt 6.02 – awrt 6.025 is sufficient for this mark