

1. (a)	$P(C') = \frac{103}{120}$ oe	awrt 0.858	B1 (1)
(b)	$P(A \cap B \cap C') = 0$		B1 (1)
(c)	$P(A \cup B \cup C') = \frac{9+3+2+5+1+93}{120}$ or $P(A \cup B \cup C') = 1 - \frac{7}{120}$ $= \frac{113}{120}$ oe	awrt 0.942	M1 A1 (2)
(d)	$P(\text{At most 1}) = P(0 \text{ or } 1) = \frac{93+9+7+1}{120}$ or $\frac{120-2-5-3}{120}$ $= \frac{110}{120}$ oe	awrt 0.917	M1 A1 (2)
(e)	$P(A \text{At most 1}) = \frac{\frac{9}{120}}{\frac{110}{120}}$ $= \frac{9}{110}$ oe	awrt 0.0818	M1 A1 (2)
(f)	$\left[P(X=0) = \frac{93}{120} \right] P(X=1) = \frac{17}{120} P(X=2) = \frac{8}{120} P(X=3) = \frac{2}{120}$ $E(X) = \left[\frac{93}{120} \times 0 \right] + \frac{17}{120} \times 1 + \frac{8}{120} \times 2 + \frac{2}{120} \times 3$ $= \frac{13}{40}$ or 0.325 oe		M1 M1 A1 (3)
Notes			[11]
(a)	B1 (allow awrt 0.858)		
(b)	B1 cao condone 0/120 but do not allow other denominators		
(c)	M1 for either correct expression for $P(A \cup B \cup C')$ A1 o.e. (allow awrt 0.942)		
(d)	M1 correct expression A1 $\frac{11}{12}$ o.e. (allow awrt 0.917)		
(e)	M1 follow through their part (d) if num < denom eg $\frac{m/120}{\text{"110/120"}}$ or if the fraction in (d) has denominator of 120 $\frac{m}{\text{"their 110"}}$ where $0 < m < 110$ Allow $\frac{n}{120-3-2-5}$ or $\frac{n}{110}$ where $0 < n < 110$ A1 o.e. (allow awrt 0.0818)		
(f)	1 st M1 for the probability distribution of X (condone missing $P(X=0)$) awrt 0.14 awrt 0.067 and awrt 0.017 May be implied by a correct expression for $E(X)$. At least 2 correct must be associated with the correct x value 2 nd M1 correct follow through expression for $E(X)$ fit their probabilities and X values A1 Dep on both previous method marks being awarded. Working must be checked. A correct answer with no working scores 3/3 SC $P(X=17) = 17/120$ (awrt 0.14) $P(X=8) = 8/120$ (awrt 0.067) $P(X=14) = 14/120$ (awrt 0.12) leading to awrt 4.58 or 183/40 gains M0M1A0		

Question Number	Scheme	Marks
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2. (a)	$S_{dp} = 5240.8 - \frac{1029 \times 50.8}{10} [= 13.48]$ $r = \frac{'13.48'}{\sqrt{344.9 \times 0.576}}$ $= 0.9563834526.... \quad \text{awrt } \underline{0.956}$	M1 M1 A1 (3)
(b)(i)	$w = 50 - p$	B1
(ii)	-1	B1 (2)
(c)	-0.956	B1ft (1)
Notes		
(a)	1 st M1 correct expression for S_{dp} 2 nd M1 valid attempt at r with their S_{dp} not equal to 5240.8 and the correct denominator A1 awrt 0.956 (b)(i) B1 allow equivalent rearrangements (ii) B1 - 1 cao (c) B1ft follow through $-1 \times$ their(a) providing $-1 <$ their (a) < 1	

Question Number	Scheme	Marks
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3. (a)	lower quartile = 116 upper quartile = 125 "125" + 1.5 × ("125" – "116") or "125" + 1.5 × (9) Outlier is greater than 138.5, so $c = 9^*$	B1 M1 A1*cso (3)
(b)	$\bar{x} = \frac{-96}{24} [= -4]$ $\bar{d} = \bar{x} + 125$	$\sum d = 125 \times 24 - 96 [= 2904]$ $\bar{d} = \frac{2904}{24}$ $\bar{d} = 121$ M1 M1 A1 (3)
(c)	$[\sigma_x = \sigma_d] = \sqrt{\frac{1306}{24}}$ $[\sigma_d] = 7.3767\dots$	M1 A1 awrt 7.38 (2)
(d)	$[P(D > 118 X < 0)] = \frac{P(118 < D < 125)}{P(D < 125)}$ or $\frac{P(-7 < X < 0)}{P(X < 0)}$ or $\frac{5/24}{14/24}$ $= \frac{5}{14}$	M1 A1 (2) [10]
Notes		
(a)	B1 both values correct. Both values must be seen either in the calculation or separately. They are not implied by the IQR = 9 M1 use of $Q_3 + 1.5 \times \text{IQR}$ with their values. May be implied by 138.5 if B1 awarded A1*cso for 138.5 and conclusion $c = 9$ (do not accept $c = 139$) with no errors. Answer is given so working must be shown.	
(b)	1 st M1 for correct expression for \bar{x} 2 nd M1 use of $\bar{d} = \bar{x} + 125$ A1 121 NB condone no labelling or incorrect labelling throughout part(b)	1 st M1 for correct expression for $\sum d$ 2 nd M1 use of " $\sum d$ " ÷ 24 must be clear it is their sum
(c)	M1 correct expression $\sqrt{\frac{1306}{24}}$ A1 awrt 7.38 final answer	
(d)	M1 correct probability statement (allow a probability of $\frac{k}{14}$ where $0 < k < 14$ to score M1) A1 allow awrt 0.357	

Question Number	Scheme	Marks												
4. (a)	$\frac{2}{5}$	B1 (1)												
(b)	$E(W) = 3$ $E(5 - 2W) = 5 - 2E(W)$ $E(X) = -1$	B1 M1 A1 (3)												
(c)	$P(X < W) = P(5 - 2W < W) = P(W > \frac{5}{3})$ or $P(W \geq 2)$ $= \frac{4}{5}$	M1 A1 (2)												
(d)(i)	<table border="1"> <tr> <td>[y]</td> <td>1</td> <td>$\frac{1}{2}$</td> <td>$\frac{1}{3}$</td> <td>$\frac{1}{4}$</td> <td>$\frac{1}{5}$</td> </tr> <tr> <td>[p]</td> <td>$\frac{1}{5}$</td> <td>$\frac{1}{5}$</td> <td>$\frac{1}{5}$</td> <td>$\frac{1}{5}$</td> <td>$\frac{1}{5}$</td> </tr> </table>	[y]	1	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{5}$	[p]	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{5}$	B1
[y]	1	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{5}$									
[p]	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{5}$									
(ii)	$E(Y) = \frac{1}{5} \left(1 + \frac{1}{2} \dots + \frac{1}{5} \right)$ or $\frac{1}{5} + \frac{1}{10} + \frac{1}{15} + \frac{1}{20} + \frac{1}{25} \left[= \frac{137}{300} = 0.4566\dots \right]$ $E(Y^2) = \frac{1}{5} \left(1^2 + \left(\frac{1}{2}\right)^2 + \dots + \left(\frac{1}{5}\right)^2 \right)$ or $\frac{1}{5} + \frac{1}{20} + \frac{1}{45} + \frac{1}{80} + \frac{1}{125} \left[= \frac{5269}{18000} = 0.2927\dots \right]$ $\text{Var}(Y) = '0.2927\dots' - ('0.4566\dots')^2$ awrt 0.0842	M1 M1 M1 A1 (5)												
(e)	$\text{Var}(2 - 3Y) = (-3)^2 \text{Var}(Y)$ awrt 0.758	M1 A1ft (2)												
Notes		[13]												
(a)	B1 oe													
(b)	B1 sight of $E(W) = 3$ or the x values 3, 1, -1, -3, -5 (they may be added) M1 use of $E(5 - 2W) = 5 - 2E(W)$ or $\frac{1}{5}(3 + 1 + \dots + -5)$ Condone use of X instead of W A1 cao and labelled $E(X)$													
(c)	M1 for identifying $W > \frac{5}{3}$ or $W \geq 2$ eg $1 - P(W = 1) \geq 2$ or $1 - P(W \leq 1) \geq 2$ A1 oe													
(d)(i)	B1 Correct distribution (probabilities may be implied by correct use). May be seen in any part													
(ii)	M1 attempt at expression for $E(Y)$ using their values of y and p (at least 2 terms seen) or awrt 0.457 (0.45 if have 0.3 rather than 1/3) Condone incorrect labelling M1 attempt at expression for $E(Y^2)$ using their values of y and p (at least 2 terms seen) or awrt 0.293 (0.2885 if have 0.3 rather than 1/3) Condone incorrect labelling M1 For use of " $E(Y^2)$ " - (" $E(Y)$ ") ² ft their values for $E(Y^2)$ and $E(Y)$ A1 awrt 0.0842 or $\frac{947}{11250}$													
(e)	M1 for use of $(-3)^2 \text{Var}(Y)$ with their $\text{Var}(Y) > 0$ condone $(3)^2 \text{Var}(Y)$ A1ft $\frac{947}{1250}$ or $9 \times$ "their part (d) > 0" evaluated correctly to 3sf or exact fraction													

Question Number	Scheme	Marks
5. (a)	$P(X < 37) = P\left(Z < \frac{37-40}{2.4}\right) = P(Z < -1.25)$ $= 1 - 0.8944 \quad ; = 0.105649... \quad \text{awrt } \underline{0.106}$	M1 M1; A1 (3)
(b)	$P(\text{one value is greater than } 32) = \sqrt{0.16} [=0.4]$ $\frac{32-m}{2.4} = 0.2533$ $m = 31.392... \quad \text{awrt } \underline{31.4}$	M1 M1 B1 A1 (4)
(c)	$P(Y < 0) = P\left(Z < \frac{0-4}{8}\right) = P(Z < -0.5) [= 0.3085]$ <p>Let X be the number of negative values</p> $P(X \geq 1) = 1 - P(X = 0) \text{ oe}$ $= 1 - (0.6915)^5$ $= 0.84188...$ <p style="text-align: right;">awrt 0.842</p>	M1 M1 A1 (4)
Notes		
(a)	<p>1st M1 standardising 37 (or 43) with 40 and 2.4 (allow \pm) 2nd M1 for $1 - p$ (where $0.88 < p < 0.90$) Implied by correct answer. A1 for awrt 0.106 (calc. 0.105649.....)</p> <p>(b) 1st M1 correct expression for one value > 32 (may be implied by sight of 0.2533... Allow any value between 0.25 and 0.26 inclusive) 2nd M1 standardising 32 with m and 2.4 and setting equal to z value $0.2 < z < 0.3$ B1 for $z = \pm 0.2533$ or better (calc gives 0.2533470931.....) used in a linear equation for m A1 awrt 31.4 or better</p> <p>SC [using 0.16] Allow M0M1 B0 A0 for $\frac{32-m}{2.4} = z$ where $0.99 \leq z < 1.04$</p> <p>(c) 1st M1 standardising 0 with 4 and 8 (allow \pm) or seeing 0.3085 or 0.6915 2nd M1 realising they need to find $1 - P(X = 0)$ ie writing or using $1 - P(\text{no negative values})$ oe May be implied by $1 - p^5$ $0 < p < 1$</p> <p>3rd M1 use of $1 - p^5$ where p is $1 - P\left(Z < \frac{0-4}{8}\right)$" A1 awrt 0.842 (tables: 0.8418894... calculator: 0.84193233....)</p> <p>NB If they use Binomial</p> <ul style="list-style-type: none"> ▪ and get 0.842 full marks. ▪ and get 0.125 then award M1M1M0A0 ▪ otherwise send to Review 	

Question Number	Scheme	Marks	
6. (a)	$\bar{f} = 10.8 + 0.748\bar{p} = 10.8 + 0.748(62.4)$ awrt 57.5	M1 A1 (2)	
(b)	For each additional mark scored on the pre-test , the average mark on the final exam increases by 0.748	B1 (1)	
(c)	The statement is not reliable as there is no data below 19 (extrapolation).	B1 (1)	
(d)	76	B1 (1)	
(e)	$p < 10.8 + 0.748p$ $0.252p < 10.8$ $p < \text{awrt } \mathbf{42.9}$	M1 M1 A1 (3)	
(f)	[No change to] $S_{pp} = 15\,573.76$		
	$\sum pf = 133486 - 2842 + 9016$ [= 139660]	$\sum pf$ increases by $98(92 - 29)$ [= 6174]	M1
	$\sum f = "57.47" \times 34 + (92 - 29)$ or $\frac{133486 - 11648.35}{2120} \times 34 + (92 - 29)$ [= $1954 + 92 - 29 \approx 2017$]	$\frac{\sum p \sum f}{n}$ increases by $\frac{2120(92 - 29)}{34}$ [= 3928.235...]	M1
	$S_{pf} = "139660" - \frac{2120 \times "2017"}{34}$ [= 13894...]	S_{pf} increases by '6174' - '3928.235' [= 2245.764...]	dM1
	$b = \frac{"13894..."}{15573.76}$ [= 0.89...]	$b = \frac{11648.35 + "2245.764"}{15573.76}$	M1
		awrt 0.9	A1 (5)
	Notes	[13]	
(a)	M1 for substituting 62.4 into the regression equation. Allow answer between 57 and 58 A1 awrt 57.5		
(b)	B1 must include context and reference to 0.748 Needs to refer to each mark being 0.748 or a multiple of eg 10 marks is 7.48 Allow equivalent words eg score/ point for mark, pre or test for pre-test, exam or final for final exam		
(c)	B1 Not reliable with correct supporting reason eg it (10.8) is an outlier, outside the range		
(d)	B1 76 cao		
(e)	1 st M1 for setting up inequality in p only or for drawing the line $f = p$ on the graph. May be implied by $p < n$ (ignore any lower limit) where $40 \leq n < 46$ (allow incorrect inequality sign or =) Allow trial and improvement. 2 nd M1 rearranging to the form $ap < b$ with correct inequality sign. Allow $(1 - 0.748)p < 10.8$ May be implied by $p < n$ (ignore any lower limit) where $42 < n < 44$ A1 $p < \text{awrt } 42.9$ (ignore any lower limit) ISW		
(f)	1 st M1 Correct method to find new $\sum pf$ or change in $\sum pf$ 2 nd M1 Correct method to find new $\sum f$ or change in $\frac{\sum p \sum f}{n}$ Allow 2018 or 2017 3 rd dM1 dep on both previous method marks being awarded. Correct method to find new S_{pf} with their changed $\sum pf$ and $\sum f$ or change in S_{pf} 4 th M1 expression for $b = \frac{S_{pf}}{15573.76}$ with their changed S_{pf} and unchanged S_{pp} A1 awrt 0.9 (from correct working)		

Question Number	Scheme	Marks
7. (a)	$P(X=3) = F(3) - F(2) = \frac{1}{38}$ $P(X=3) = \frac{7}{n} \times \frac{6}{n-1} \times \frac{5}{n-2}$ $\frac{7}{n} \times \frac{6}{n-1} \times \frac{5}{n-2} = \frac{1}{38} \rightarrow n(n-1)(n-2) = 7980 \quad (*)$	M1 M1 M1 A1cso (4)
(b)	$21 \times 20 \times 19 = 7980$	B1cso (1)
(c)	$a = F(0) = P(X=0) = \frac{14}{21} \times \frac{13}{20} \times \frac{12}{19}$ $P(X=1) = 3 \times \frac{14}{21} \times \frac{13}{20} \times \frac{7}{19} \left[= \frac{91}{190} \right] \text{ or } P(X=2) = 3 \times \frac{7}{21} \times \frac{6}{20} \times \frac{14}{19} \left[= \frac{21}{95} \right]$ $b = F(1) = P(X=0) + P(X=1) = \frac{26}{95} + \frac{91}{190} \text{ or } b = \frac{37}{38} - \frac{21}{95}$	M1 $a = \frac{26}{95}$ A1 M1 M1 dM1 $b = \frac{143}{190}$ A1 (6) [11]
Notes		
(a)	1 st M1 for use of $F(3) - F(2)$ Accept $\frac{1}{38}$ 2 nd M1 product of 3 probabilities where the denominators are n , $(n-1)$ and $(n-2)$ and the numerators are decreasing k , $(k-1)$ and $(k-2)$ This may be seen as a single term in a longer expression. 3 rd M1 setting up equation for $P(X=3) =$ product of correct 3 probabilities without replacement A1cso fully correct solution with no errors seen (b) B1cso correctly evaluated product. Allow $21(21-1)(21-2) = 7980$ (c) 1 st M1 product of 3 probabilities for $P(X=0)$ The three probabilities can be in any arrangement May be implied by $\frac{26}{95}$ 1 st A1 $a = \frac{26}{95}$ oe must be clear this is the value for a 2 nd M1 product of 3 probabilities for $P(X=1)$ or $P(X=2)$ or $\frac{91}{190}$ or $\frac{91}{570}$ or $\frac{21}{95}$ or $\frac{7}{95}$ oe seen. Condone incorrect labelling. The three probabilities can be in any arrangement 3 rd M1 $\times 3$ or adding the 3 sets of the 3 fractions or $\frac{91}{190}$ or $\frac{21}{95}$ Condone incorrect labelling 4 th dM1 their $P(X=0) +$ their $P(X=1)$ or $F(2) - P(X=2)$ (dep on 2 nd M1 being scored) 2 nd A1 $b = \frac{143}{190}$ oe must be clear this is the value for b NB if $a = 0.273\dots$ and $b = 0.7526$ implies the method marks.	