Question Number	Scheme	Marks
5 (a)	$\bar{x} \pm 1.6449 \times \frac{5}{\sqrt{10}}$	M1 B1
	$\bar{x} \pm 2.60 \Rightarrow (\bar{x} - 2.60,\ \bar{x} + 2.60)$ *	A1*
		(3)
(b)	$\bar{y} \pm 1.96 \times \frac{3}{\sqrt{20}}$	M1 B1
	$\bar{y} \pm 1.31 \Rightarrow (\bar{y} - 1.31,\ \bar{y} + 1.31)$	A1
		(3)
(c)(i)	$\bar{X} - \bar{Y} \sim \mathrm{N}\left(\mu - \mu,\ \frac{5^2}{10} + \frac{3^2}{20}\right) \Rightarrow \bar{X} - \bar{Y} \sim \mathrm{N}(0,\ 2.95)$	M1 A1
(ii)	Do not overlap when either	
	$\bar{x} - 2.60 > \bar{y} + '1.31'$ or $\bar{x} + 2.60 < \bar{y} - '1.31'$	M1
	$\bar{x} - \bar{y} > 3.91$ or $\bar{x} - \bar{y} < -3.91$	A1ft
	$2 \times \mathrm{P}(\bar{X} - \bar{Y} > 3.91) = 2 \times \mathrm{P}\left(Z > \frac{'3.91' - '0'}{'\sqrt{2.95}'}\right) = [2 \times \mathrm{P}(Z > 2.276\ldots)]$	M1 M1
	$[2 \times 0.0113] = 0.0226$ (calculator gives $[2 \times 0.0114\ldots] = 0.0228$)	A1
		(7)
	Notes	**Total 3**

Question Number	Scheme	Marks
7 (a)	$W = S_1 + S_2 + S_3 + L_1 + L_2 + L_3 + L_4$	
	$W \sim \mathrm{N}(3 \times 7.7 + 4 \times 20,\ 3 \times 0.01^2 + 4 \times 0.02^2)$ So $W \sim \mathrm{N}(103.1,\ 0.0019)$	M1 A1
	$[\mathrm{P}(W > 103.15) =] \mathrm{P}\left(Z > \frac{103.15 - '103.1'}{'\sqrt{0.0019}'}\right) [= \mathrm{P}(Z > 1.1470\ldots)]$	M1
	$[1 - 0.8749] = 0.1251$ (Calculator gives 0.12567…) awrt 0.13	A1
		(4)
(b)	Let $Y = L_1 - L_2$	
	$Y \sim \mathrm{N}(0,\ 2 \times 0.02^2)$ So $Y \sim \mathrm{N}(0,\ 0.0008)$	M1 A1
	$\mathrm{P}\left(Z > \frac{0.01 - '0'}{'\sqrt{0.0008}'}\right)$ or $\mathrm{P}\left(Z < \frac{-0.01 - '0'}{'\sqrt{0.0008}'}\right)$	M1
	$2 \times (1 - 0.6368) = 0.7264$ (Calculator gives $2 \times 0.36183\ldots$) awrt 0.724 → 0.726	M1 A1
		(5)
(c)	$T \sim \mathrm{N}(\mu, \sigma^2)$	
	$\mu = 7.7n - 7.7n [= 0]$	M1
	$\sigma^2 = 0.0001n^2 + 0.0001n$	M1
	$\frac{2 - '0'}{\sqrt{'0.0001n^2 + 0.0001n'}} = 1.99$	M1 B1
	$0.0001n^2 + 0.0001n - 1.01[00755\ldots] = 0$	dM1
	$n = 100$	A1
		(6)
	Notes	**Total 15**

Question Number	Scheme	Marks
7. (a)	$A = \frac{X_1 + X_2 + X_3 + Y_1 + Y_2}{5}$, $X \sim N(30, 4.5^2)$, $Y \sim N(20, 3.5^2)$; X, Y are independent.	
	$E(A) = \frac{3(30) + 2(20)}{5}$ or $Var(A) = \frac{3(4.5)^2 + 2(3.5)^2}{25}$ — A correct method for finding $E(A)$ or $Var(A)$	M1
	$E(A) = 26$ or $Var(A) = 3.41$ — At least one of either $E(A) = 26$ or $Var(A) = 3.41$	A1
	Both $E(A) = 26$ and $Var(A) = 3.41$	A1
	{So $A \sim N(26, 3.41)$}	
	$\{P(A < 24) =\}\ P\left(Z < \frac{24 - 26}{\sqrt{3.41}}\right)$ — Standardising $(\pm)$ with their mean and their standard deviation	M1
	$= P(Z < -1.08306...)$	
	$= 1 - 0.8599$	M1
	$= 0.1401$ (or 0.139391...) — **0.14** or awrt **0.140** or awrt **0.139**	A1
		[6]
(b)	$W \sim N(m, 2.8^2)$; $P(W - X < 4) = 0.1$ W, X are independent.	
	$\{E(W - X) = E(W) - E(X) = m - 30\} \Rightarrow E(W - X) = m - 30$ — $E(W - X) = m - 30$	B1
	$\{Var(W - X) =\}\ 2.8^2 + 4.5^2\ \{= 28.09\}$ — $2.8^2 + 4.5^2$	M1
	{So $W - X$ $N(m - 30, 28.09)$} $\{P(W - X < 4) = 0.1\} \Rightarrow P\left(Z < \frac{4 - (m - 30)}{\sqrt{2.8^2 + 4.5^2}}\right) = 0.1$	
	$\frac{4 - (m - 30)}{\sqrt{2.8^2 + 4.5^2}} = k\ (= -1.2816)$ — Standardising $(\pm)$ with their mean which is in terms of m and their standard deviation and setting the result equal to k, where $\lvert k \rvert$ is in the interval [1.28, 1.29].	M1
	± 1.2816 or awrt ± 1.2816	B1
	Correct equation . See notes	A1
	$\{m = 34 + 1.2816(5.3) \Rightarrow\}\ m = 40.792...$ (= 40.784 from using -1.28) — awrt **40.8**	A1
		[6]
		12

Question Number	Scheme	Marks
7(a)	$\mathrm{E}(B_1 - B_2) = 0$	B1
	$\mathrm{Var}(B_1 - B_2) = 0.006$	B1
	$\mathrm{P}(\lvert B_1 - B_2 \rvert > 0.1) = 2\mathrm{P}(B_1 - B_2 > 0.1)$	M1
	$= 2\times\mathrm{P}\left(Z > \dfrac{0.1}{\sqrt{"0.006"}}\right)\left[= 2\times\mathrm{P}(Z > 1.2909\ldots)\right]$	M1
	$= 0.1967\ldots$ awrt 0.197	A1
		(5)
(b)	$\overline{B} \sim \mathrm{N}\left(1.96, \dfrac{0.003}{n}\right)$	B1
	$\mathrm{P}(\overline{B} > 2) = \mathrm{P}\left(Z > \dfrac{2-1.96}{\sqrt{0.003/n}}\right)$ [< 0.01]	M1
	$\dfrac{2-1.96}{\sqrt{\dfrac{0.003}{n}}} > 2.3263$	B1 dM1
	$n = 11$	A1
		(5)
(c)	$\mu_M = 21.8 + 500\times 1.96\left[= 1001.8\right]$; $\sigma_M{}^2 = 0.6 + 500\times 0.003\left[= 2.1\right]$	M1 ; M1
	Let $X = 4T - 3M$	M1
	$\mu_X = 4\times 774 - 3\times "1001.8"\left[= 90.6\right]$; $\sigma_X{}^2 = 16\times 1.8 + 9\times "2.1"\left[= 47.7\right]$	M1 ; M1
	$\mathrm{P}(4T - 3M > 100) = \mathrm{P}\left(Z > \dfrac{100 - "90.6"}{\sqrt{"47.7"}}\right)\left[= \mathrm{P}(Z > 1.361\ldots)\right]$	M1
	$= 0.0869$ (table) or $0.08675\ldots$ (calc)	A1
		(7)
		Total 17

(a)	**B1**	For expected value being 0 written or used
	B1	For 0.006 being written or used for Variance
	M1	Realising they need to consider both
	M1	Correct standardisation using their 0.1 and 0.006 If the expected value and/or standard deviation not stated then they must be correct
	A1	awrt 0.197
(b)	**B1**	The correct distribution written or used
	M1	Correct standardisation. Allow using their distribution if stated but must contain $\sqrt{n}$ for sd
	B1	Using awrt 2.3263
	dM1	Dep on previous M being awarded using a z value, $2 < z < 3$
	A1	11
(c)	**M1**	Correct method for finding the mean of M
	M1	Correct method for finding the var of M
	M1	Realising the need to find $4T - 3M$ or $4T - 3M - 100$ or $100 + 3M - 4T$
	M1	Correct method for finding the mean of X (using $4T - 3M - 100 = -9.4$ or $100 + 3M - 4T = 9.4$)
	M1	Correct method for finding the var of X
	M1	Correct standardisation using their mean of X and their standard deviation of X If these are not stated then they must be correct
	A1	awrt 0.0869 or 0.0868

Question Number	Scheme	Marks
5. (a)	Label beginners 1 – 452, intermediates 1 – 251, professionals 1 – 97	M1
	Use random numbers to select a ...	M1
	Simple random sample of 28 beginners, 16 intermediates and 6 professionals.	A1
		[3]
(b)	**Any one of**	
	• Enables estimation of statistics/sampling errors for each strata.	B1
	• Reduces variability.	
	• More representative of the population/reflects population structure	**[1]**
(c)	$H_0 : m_I - m_B = 3 \quad H_1 : m_I - m_B > 3$	B1; B1
	s.e. $= \sqrt{\frac{38.1}{60} + \frac{57.3}{80}}$ $\{= 1.162432794...\}$	M1
	$z = \frac{36.9 - 31.7 - 3}{"1.1624..."}$; $= 1.89258...$ awrt 1.89	dM1; A1
	One tailed c.v. $Z = 1.6449$ or CR : $Z \geqslant 1.6449$ or p-value = awrt $0.029 < 0.05$	B1
	[in the CR/significant/Reject H_0/"0.029" < 0.05]	
	Conclude either that the	
	• mean score of intermediates is more than 3 greater than the mean score of beginners. (oe)	A1
	• manager's belief is correct.	
		[7]
		11
	Alternative method for "2nd M1, 1st A1, 3rd B1" marks: Let $D = \bar{x}_I - \bar{x}_B$	
	$1.6449 = \frac{D - 3}{1.1624...}$ **dependent upon the 1st M1 for** $\frac{D - 3}{\text{their } "1.1624..."} = 1.6449 / 1.645 / 1.64 / 1.65$	dM1:
	So, $D = 4.912...$ $D =$ awrt 4.91 and $D_{obs} = 5.2$	A1
	$D_{obs} = 36.9 - 31.7 = 5.2$ [1.64, 1.65]	B1

Question Number	Scheme	Marks
6.		
(a)	$\overline{T} \sim N(4, \frac{4}{35})$	M1 A1
		(2)
(b)	$\overline{K} \sim N(\lambda, \frac{\lambda}{40})$	M1
	$2 \times 2.5758 \times \sqrt{\frac{\lambda}{40}} = 2.6$	B1 M1
	$\lambda =$ awrt **<u>10.2</u>**	A1
		(4)
(c)	$2 \times 0.99 \times 0.01$	M1
	$=$ **<u>0.0198</u>**	A1
		(2)
		Total 8
	Notes	
(a)	M1 for Normal distribution A1 for correct mean and variance (allow N(4, awrt 0.114))	
(b)	M1 for use of $\frac{\lambda}{40}$ if $\lambda = \sigma$ is used, then M0 B1 for ±2.5758 (may be implied by sight of 10.188…) M1 for use of $2 \times z \times \frac{'\sigma'}{\sqrt{40}} = 2.6$ with $\lvert z \rvert > 2$ A1 awrt 10.2 (an answer of 10.15…or awrt 10.2 on its own scores M1B0M1A1) **SC:** Use of $\sqrt{\lambda}$ instead of λ leading to an answer of awrt 3.19… scores M0B1M1A0	
(c)	M1 for $2p(1-p)$ for any p $0 < p < 1$ A1 0.0198	

Question Number	Scheme	Marks
7. (a)	$a = 2\times180-330 = 30$	B1
	$b = 4.5^2\times2+6.7^2 = 85.39$	M1 A1
		(3)
(b)	$X = L-1.8S$	
	$\mathrm{E}(X) = 330-1.8\times180 = 6$	M1
	$\mathrm{Var}(X) = 6.7^2+1.8^2\times4.5^2 = 110.5$	M1 A1
	$\mathrm{P}(X>0) = \mathrm{P}\left(Z > \frac{0-6}{\sqrt{110.5}}\right)$	M1
	$\mathrm{P}(Z>-0.57) = 0.7157$	A1
		(5)
(c)	$T = S_1 - \frac{S_1+S_2+S_3}{3} = \frac{2S_1-S_2-S_3}{3}$	M1 A1
	$\mathrm{E}(T) = 0$	M1
	$\mathrm{Var}(T) = \frac{1}{9}\left(2^2\times4.5^2+4.5^2+4.5^2\right) = \frac{6}{9}\left(4.5^2\right) = 13.5$	M1
	$\mathrm{P}(T>5) = \mathrm{P}\left(Z > \frac{5-0}{\sqrt{13.5}}\right)$	M1
	$\mathrm{P}(Z>1.36) = 1-0.9131 = 0.0869$	A1
		(6)
		[14]