Question	Answer	Marks	Guidance
1(i)	$176 \pm z \times \frac{7.2}{\sqrt{200}}$	**M1**	need correct form must be z
	$z = 2.24$	**B1**	allow 2.241 and 2.242
	175 to 177	**A1**	cwo
		3	
1(ii)	Sample random	**B1**	oe. both words essential
		1	

Question	Answer	Marks	Guidance
2(i)	$H_0: p = \frac{1}{3}$ $H_1: p < \frac{1}{3}$	**B1**	
		1	
2(ii)	$0.0084 < 0.01$	**B1**	Allow P(N $\leqslant$ 36) < 0.01 or 1%
	There is evidence that p has decreased	**B1 dep**	Allow 'p has decreased' or $p < \frac{1}{3}$
		2	
2(iii)	150	**B1**	
		1	

Question	Answer	Marks	Guidance
3	$\frac{12.2 - 12}{2.5 / \sqrt{n}}$	**M1**	Standardisation. Allow cc. need correct form incl sqrt
	(=) 1.96	**B1**	Correct z
	$\sqrt{n} = 1.96 \times 2.5 \div 0.2$	**M1**	Rearrange equation in n or sqrt n with numerical z to the stage n= or sqrt n = allow arithmetical slips only
	$n = 600$	**A1**	accept 601 SR whole number ans from 595 to 605 can score full marks if fully justified
		4	

Question	Answer	Marks	Guidance
4(i)	$\lambda = 10\times0.25 + 10\times0.36 \quad (= 6.1)$	**B1**	
	$1 - e^{-6.1}\left(1 + 6.1 + \frac{6.1^2}{2} + \frac{6.1^3}{3!}\right)$	**M1**	$1 - P(X \leqslant 3)$, any λ Allow one end error
	$= 0.857$	**A1**	Allow 0.858
		3	
4(ii)	$\lambda = 61$	**B1 ft**	Ft from (i)
	N('61', '61')	**M1**	N with $\mu = \lambda$, any λ. May be implied
	$\frac{59.5-61}{\sqrt{'61'}} \quad (= -0.192)$	**M1**	Standardise with their mean and variance Allow no or wrong cc. not 61/100
	$\Phi('-0.192') = 1 - \Phi('0.192')$	**M1**	Correct area consistent with their working
	$= 0.424$	**A1**	
		5	

Question	Answer	Marks	Guidance
5(i)	$T_1 + T_2 \sim N(5, 0.4^2 + 0.5^2)$	**B1**	or N(5, 0.41)
	$\frac{6-5}{\sqrt{'0.41'}} \quad (= 1.562)$	**M1**	Allow cc
	$\Phi('1.562')$	**M1**	Correct area consistent with their working
	$= 0.941$	**A1**	
		4	
5(ii)	$\text{Var}(T_2 - 1.2T_1) = 0.5^2 + 1.2^2 \times 0.4^2$ $(= 0.4804)$	**B1**	Or similar using $1.2T_1 - T_2$
	$T_2 - 1.2T_1 - N(0.16, 0.4804)$	**B1 ft**	Only ft attempt at combination. no ft for neg var.
	$\frac{0-'0.16'}{\sqrt{'0.4804'}} \quad (= -0.231)$	**M1**	Standardise with their mean and variance. Allow cc
	$P(T_2 - 1.2T_1) > 0$		
	$= \Phi('0.231')$	**M1**	Correct area consistent with their working
	$= 0.591$ (3 sfs)	**A1**	
		5	

Question	Answer	Marks	Guidance
6(i)	$k\int_2^6 x^{-1}\mathrm{d}x = 1$	**M1**	Attempt integrate f(x) & = 1. Ignore limits
	$k\left[\ln x\right]_2^6 = 1$ $k(\ln 6 - \ln 2) = 1$ or $k\ln 3 = 1$ $k = \frac{1}{\ln 3}$ **AG**	**A1**	correct sub of correct limits in correct integral leading to correct ans. No errors seen.
		2	
6(ii)	$\frac{1}{\ln 3}\int_2^6 1\,\mathrm{d}x$	**M1**	Attempt integ xf(x). Ignore limits
	$= \frac{1}{\ln 3}\left[x\right]_2^6$ $(= \frac{1}{\ln 3}(6-2))$	**A1**	Correct integral and limits
	$= \frac{4}{\ln 3} = 3.64$ **AG**	**A1**	No errors seen
		3	
6(iii)	$\mathrm{P}(X < \mathrm{E}(X)) = \frac{1}{\ln 3}\int_2^{3.64} x^{-1}\mathrm{d}x$	**M1**	Attempt integ f(x) from 2 to $\frac{4}{\ln 3}$ or 3.64 oe
	$= \frac{1}{\ln 3}\left[\ln x\right]_2^{3.64}$ $= \frac{1}{\ln 3}(\ln 3.64 - \ln 2)$ $(= 0.545)$	**A1**	Correct sub correct limits into correct integral
	P(m < X < E(X)) = "0.545" – 0.5	**M1**	Subt 0.5 from their P(X < E(X)) art 0.045 . ft their P(X < E(X) (> 0.5)
	= 0.045 (2 sfs)	**A1**	equivalent method M1 method for median-need 0.5 and limits 2 to m or m to 6 A1 sqrt 12 or 3.464 M1 calc area from "3.464" to 3.64 A1 0.045 or better, not 0.046
		4	

Question	Answer	Marks	Guidance
7(i)	$H_0: \mu = 51$ $H_1: \mu < 51$	**B1**	Or popn mean …
	$\bar{x} = \frac{7480}{150} = 49.8667 = 49.9$	**B1**	
	$s^2 = \frac{150}{149}\left(\frac{380000}{150} - \left(\frac{748}{15}\right)^2\right)$ $= 46.9620 = 47.0$ or $s = 6.85$	**M1**	Correct subst in s^2 or $\sqrt{s^2}$ formula Biased var scores M0
	$\frac{49.8667-51}{\sqrt{\frac{'46.962'}{150}}}$ allow $\frac{49.9-51}{\sqrt{\frac{'47'}{150}}}$	**M1**	Allow 49.8667 to 49.9 in numerator Need sqrt 150
	$= (-)\ 2.025 = (-)\ 1.965$	**A1**	Accept 2.02 or 2.03 Accept –2.0264 –1.9651 provided correct working
	comp $z = 1.96$	**M1**	or comp $1 - \phi(2.025)$ with 0.025
	There is evidence that $\mu < 51$	**A1 ft**	no contradictions biased var B1B1M0M1A0M1A1ft (max 5/7) accept cv method $x_{crit} = 49.9028$ M1A1 49 867 < 49.9… M1A1
		7	
7(ii)	$\frac{\bar{x}-51}{\frac{6.856}{\sqrt{150}}} = -1.96$	**M1**	Need 51 and sqrt 150 and correct form
	$\bar{x} = 51 - 1.097 = 49.9$ Rejection region is $\bar{x} < 49.9$	**A1**	This may have been found in part (i)
	$\frac{49.9-49}{\frac{6.856}{\sqrt{150}}}$ (= 1.608 to 1.614)	**M1**	Need 49 and sqrt 150 and correct form
	$P(\bar{x} > 49.9 \mid \mu = 49) = 1 - \Phi('1.608')$	**M1**	
	P(Type II error) = 0.0539	**A1**	Allow 0.0533 to 0.0539
		5	