Question	Answer	Marks	Guidance
1(i)	$176 \pm z \times \frac{7.2}{\sqrt{200}}$	M1	need correct form must be z
	<i>z</i> = 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)	$H_0: p = \frac{1}{3}$ $H_1: p < \frac{1}{3}$	<b>B</b> 1	
		1	
2(ii)	0.0084 < 0.01	B1	Allow P( N ≤ 36 ) < 0.01 or 1%
	There is evidence that <i>p</i> 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)	$\lambda = 10 \times 0.25 + 10 \times 0.36$ (= 6.1)	B1	
	$1 - e^{-6.1} \left(1 + 6.1 + \frac{6.1^2}{2} + \frac{6.1^3}{3!}\right)$	M1	$1 - P(X \le 3)$ , any $\lambda$ 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 $\lambda$ . May be implied
	$\frac{59.5-61}{\sqrt{61'}}$ (= -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 )
	$\frac{6-5}{\sqrt{0.41'}}$ (= 1.562)	M1	Allow cc
	Φ('1.562')	M1	Correct area consistent with their working
	= 0.941	A1	
		4	
5(ii)	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.
	$\frac{0-0.16'}{\sqrt{0.4804'}}  (=-0.231)$	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	

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Question	Answer	Marks	Guidance
6(i)	$k\int_2^6 x^{-1} \mathrm{d}x = 1$	M1	Attempt integrate $f(x) \& = 1$ . Ignore limits
	$k[\ln x]_{2}^{6} = 1$ $k(\ln 6 - \ln 2) = 1 \text{ or } k \ln 3 = 1$ $k = \frac{1}{\ln 3}$ 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)	$P(X < E(X)) = \frac{1}{\ln 3} \int_{2}^{3.64} x^{-1} dx$	M1	Attempt integ f(x) from 2 to $\frac{4}{\ln 3}$ or 3.64 oe
	$= \frac{1}{\ln 3} \left[ \ln x \right] \frac{3.64}{2}$ = $\frac{1}{\ln 3} \left( \ln 3.64 - \ln 2 \right)  (= 0.545)$	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	

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Question	Answer	Marks	Guidance
7(i)	$H_0: \mu = 51$ $H_1: \mu < 51$	B1	Or popn mean
	$\overline{x} = \frac{7480}{150} = 49.8667 = 49.9$	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
	$\frac{49.8667-51}{\sqrt{\frac{146.962^{\circ}}{150}}} \text{ allow } \frac{49.9-51}{\sqrt{\frac{1477}{150}}}$	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
	$\operatorname{comp} z = 1.96$	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
	$\overline{x} = 51 - 1.097 = 49.9$ Rejection region is $\overline{x} < 49.9$	A1	This may have been found in part (i)
	$\frac{\frac{49.9-49}{6.856}}{\frac{1}{\sqrt{150}}}  (= 1.608 \text{ to } 1.614)$	M1	Need 49 and sqrt 150 and correct form
	$P(\bar{x} > 49.9   \mu = 49) = 1 - \Phi(`1.608')$	M1	
	P(Type II error) = 0.0539	A1	Allow 0.0533 to 0.0539
		5	