Edexcel Maths S2

Mark Scheme Pack

2005-2015

EDEXCEL FOUNDATION - LONDON EXAMINATIONS

Stewart House 32 Russell Square London WC1B 5DN

June 2001

Advanced Supplementary/Advanced Level

General Certificate of Education

Subject **STATISTICS 6684** Paper No. **S2**

Question number	Scheme	Marks
1. (a)	(i) small village so use census	B1
	e.g. use electoral register or some other suitable list	B1
	(ii) Sample survey	B1
	eg. list of times and days when no. of vehicle travelling through can be counted. (some suitable list of time periods)*	B1 (4)
(b)	eg. X = no. of vehicle passing through in a 10min period	B1
	X could have a Poisson distribution	B1 (2)
	* time period must be specified e.g. 10mins, 1hour, 7am-7pm but < 1day.	⑥
2. (a)	X = no. of accidents in the next month $X \sim Po(0.9)$	
	$P(X=0) = e^{-0.9} = 0.4065\ldots = \underline{0.407}$ ⊛	B1 c.s.o. (1)
(b)	Y = no. of accidents in next 6 months. $Y \sim Po(\underline{5.4})$	B1
	$P(Y=2) = \frac{e^{-5.4} \times (5.4)^2}{2}, = 0.06585\ldots$ $\underline{0.066}$ or $\underline{0.0658/9}$	M1, A1 (3)
(c)	M = no. of months with no accidents	
	$M \sim B(4, 0.407)$ Identify correct binomial	B1 (√ their (a))
	$P(M=2) = \binom{4}{2}(0.407)^2(0.593)^2, = 0.3495$ AWRT $(0.349 \sim 0.350)$	M1, A1 (3)
		⑦

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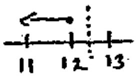
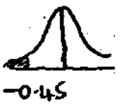
Question number	Scheme	Marks
3.	$H_0: p = \frac{1}{4}$; $H_1: p \neq \frac{1}{4}$	B1 ; B1
	X = no. of gold beads in sample of 20. Under H_0 $X \sim B(20, \frac{1}{4})$	
	Critical Region $P(X \leq 1) = 0.0243$ $P(X \leq 8) = 0.9591$ C.R. $X \leq 1$ or $X \geq 9$ Probability $E(X) = 5$ $P(X \leq 2) = 0.0913$ $P(X \geq 8) = 1 - 0.8982$ $= 0.1018$ OR $2 \times P(X \leq 2)$ $= 2 \times 0.0913$ $= 0.1826$	M1 A1 each value A1
	Not significant (either $x = 2$ not in C.R. or prob > 10%)	M1
	Insufficient evidence of a change in proportion of gold beads	A1√ ⑦
4.	X = no. of letters marked 1st class $X \sim B(10, 0.20)$	
(a)	$P(X \geq 3) = 1 - P(X \leq 2)$, $= 1 - 0.6778 = 0.3222$ or 0.322	M1, A1 (2)
(b)	$P(X < 2) = P(X \leq 1)$, $= 0.3758$ or 0.376	M1, A1 (2)
(c)	F = no. of 1st class stamps in batch of 70 $F \sim B(70, 0.20)$	M1 (Normal approx)
	$F \approx N(14, \sqrt{11.2}^{2})$	A1 μ A1 σ or σ^2
	$P(F \leq 12) \approx P\left(Z \leq \frac{12.5 - 14}{\sqrt{11.2}}\right)$ ± ½ Standardizing	M1 M1
	 $= P(Z \leq -0.4482\ldots)$ AWRT −0.45	A1
	 $= 1 - 0.6736$	
	$= 0.3264$ (AWRT 0.326~0.327)	A1 (7)
(d)	The 70 letters form a random sample or are representative or letters are independent	B1 (1) ⑫

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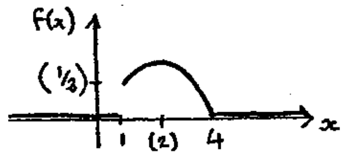
5.	X = no. of requests for bulbs in a week. $X \sim Po(2)$	
(a)	$P(X=4) = \frac{e^{-2}.2^4}{4!}$ or $[P(X \leqslant 4) - P(X \leqslant 3)]$ $0.9473 - 0.8571$ $= \underline{0.0902}$ or $\underline{0.090}$ or $\underline{0.09}$	M1 A1 (2)
(b)	$P(X > 5) = 1 - P(X \leqslant 5), = 1 - 0.9834 = \underline{0.0166}$	M1, A1 (2)
(c)	Y = no. of requests in 3 weeks. $Y \sim Po(\underline{6})$ $P(Y \leqslant 5)$, $= \underline{0.4457}$	B1 M1, A1 (3)
(d)	$H_0 : \lambda = 2$ (or $\mu = 8$) ; $H_1 : \lambda < 2$ (or $\mu < 8$) R = no. of requests in 4 weeks. $R \sim Po(8)$ $P(R \leqslant 3), = 0.0424$ [C.R. $\leqslant 3$ or prob $< 5\%$] sig there is evidence that the rate of requests has decreased	B1 ; B1 M1, A1 A1√ (5) ⑫
6 (a)	$f(x) = \frac{d}{dx}F(x) = \underline{\frac{1}{27}(-3x^2 + 12x)}$ Attempt $\frac{d}{dx}$	M1 A2/1/0 −1 e.e.o.o. (3)
(b)	$\frac{d}{dx}[f(x)] = 0 \Rightarrow -6x + 12 = 0, \Rightarrow x \underline{= 2}$ is mode	M1, A1 (2)
(c)	  x, f(x) axes marked and at least 1, 4	B1 B1 B1 (3)
(d)	$\mu = \int_1^4 \left(\frac{4x^2}{9} - \frac{x^3}{9} \right) dx$ Attempt $\int x f(x) dx$ $= \frac{1}{9}\left[\frac{4x^3}{3} - \frac{x^4}{4}\right]_1^4 = \left(\frac{256}{27} - \frac{256}{36}\right) - \left(\frac{4}{27} - \frac{1}{36}\right)$ Use of correct limits $= \underline{2.25 \text{ or } 9/4}$	M1 some integration attempted M1 A1 (3)
(e)	$F(2.25) = \frac{1}{27}(-2.25^3 + 6 \times 2.25^2 - 5) = 0.517$ (AWRT 0.52)	B1 (1)
(f)	$F(\mu) > 0.5 \Rightarrow \mu > \text{median}$ $F(2) = \frac{1}{27}(-8 + 24 - 5) = 11/27 = 0.407 \Rightarrow \text{mode} < \text{median}$	B1√ (from (e)) B1 ⑭ (2)

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Paper No. **S2**

Question number	Scheme		Marks	
7.	(a) $P(T<0.2) = \underline{0.2}$		B1	(1)
	(b) $\mu = E(T) = \underline{0.5}$		B1	(1)
	(c) $E(T^2) = \int_0^1 1t^2\,dt = \left[t^3/3\right]_0^1$	$\int t^2$	M1	
		[ ]	A1 dep	
		$-\mu^2$	M1	
	$Var(T) = (1/3) - (0) - \mu^2 = \underline{\frac{1}{12}}$	$1/12$	A1	(4)
	(d) X = no. of children with $T<0.2$ $X \sim B(20, 0.2)$	Identify binomial	M1 ($\int$ p from (a))	
	$P(X \leq 4) = \underline{0.6296}$		M1, A1	(3)
	(e) Expect mean to still be close to 0.5 (or <u>no change</u>)		B1	
	Expect variance to be <u>reduced</u>		B1	(2)
	(f) $P(T<0.2) = \int_0^{0.2} 4t\,dt$	Attempt $\int 4t\,dt$ between 0, 0.2	M1	
	$= \left[4t^2/2\right]_0^{0.2}$			
	$= 2\times(0.2)^2 - 0 = \underline{0.08}$ ⊛		A1 c.s.o.	(2)
	(g) Y = no. of players stopping star in under ·2s.			
	$Y \sim B(75, 0.08) \approx P_o(6)$	P_o $\lambda = 6$	M1 A1	
	$P(Y>7) = 1 - P(Y \leq 7)$		M1	
	$\approx 1 - 0.7440$			
	$= \underline{0.256}$		A1	(4)
				⑰
S.C.	<u>Normal Approx</u> $N(6, 5.52)$ $\sqrt{6}, \sqrt{5.52}$	M1 } i.e. 2/4 only		
	$\rightarrow (0.261 \sim 0.262)$	A1		

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Question number	Scheme		Marks
1. (a)	Collection / group / set of individuals or items		**B1** **(1)**
(b)	A r.v. that is a function of known observations from a population		**B1B1** **(2)**
(c)	College students. Mean approval rating of 75%		**B1,B1** **(2)**
(d)	*(Probability) distribution* of all possible mean approval ratings of sample size 50		**B1**
		Dependent	**B1** **(2)** ⑦
2.	$H_0: \lambda = 2.5$; $H_1: \lambda > 2.5$ (Accept $H_0: \lambda = 10$; $H_1: \lambda > 10$)		**B1,B1**
	1 week $X \sim Po(2.5)$, 4 weeks $X \sim Po(10)$	$Po(10)$	**B1**
	$P(X \geq 14) = 1 - 0.8645 = 0.1355$		**M1A1**
	Insufficient evidence to reject H_0		**M1**
	Sales have not increased after appointment of new salesman.	Context	**A1ft**
	[Note; $P(X \leq 14) = 0.9165$, $P(X \leq 15) = 0.9153$ for M1A1]		**(7)** ⑦
3. (a)	X is no of passengers who do not turn up for this flight. $X \sim Bin(200, 0.03)$		**M1**
		both	**A1** **(2)**
(b)	$X \sim Po(6)$		**B1**
	$P(X < 4) = 0.1512$	Strict inequality, 0.1512	**M1A1** **(3)**
(c)	$P(X > 4) = 1 - 0.2851 = 0.7149$		**M1A1** **(2)**
	[Notes: (b)Use of N(6,5.82) B1 $P(X<3.5)$M1A0 (c) $P(X>4.5)$M1A0 (b) Use of N(6,6) B0 (b) Exact Bin no credit.]		⑦

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Question number	Scheme		Marks
4.			
(a)	Continuous Uniform (Rectangular), $X \sim U[0,14]$		**B1,B1** (2)
(b)	$E(X)=\frac{(14+0)}{2}=7$	Form & sub, 7	**M1A1**
	Mean arrival time is 8.02am	8.02am	**A1** (3)
(c)	$P(X \le x)=\int_0^x \frac{1}{14}dt=\frac{x}{14}$	Integral, $\frac{x}{14}$	**M1,A1**
	$F(x)=\begin{cases} 0 & x<0 \\ \frac{x}{14} & 0 \le x \le 14 \\ 1 & x>14 \end{cases}$	Centre Ends	**B1ft** **B1** (4)
(d)	$P(X>10)=1-F(X10)$	Require '1 minus' or valid integral	**M1**
	$=1-\frac{10}{14}=\frac{2}{7}$	$\frac{2}{7}$	**A1** (2)
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Question number	Scheme		Marks
5.(a)	Failed connections occur singly, independently and at a constant rate of 3 per hour, randomly	Any two	**B1,B1**
			(2)
(b) (i)	X is no of failed connections every hour. $P(X=0)=0.0498$		**M1A1**
			(2)
(ii)	$P(X>4)=1-0.8153=0.1847$	Require '1 minus', 0.1847	**M1A1**
			(2)
(c)	$X \sim Po(24)$		**B1**
			(1)
(d)	Y is no of users that fail to connect at their first attempt		
	$Y \sim N(24,24)$	Normal, both	**B1,B1**
	$P(Y \geq 12)=1-P(Z<\frac{11.5-24}{\sqrt{24}})$	From above, all correct	**M1,A1**
	$=P(Z<-2.55)$	-2.55	**A1**
	$=0.9946$		**A1**
			13 **(6)**
6. (a)	$X \sim Bin(20,0.4)$	Bin, 20 & 0.4	**B1,B1**
			(2)
(b)	$P(5<X<15)=0.9984-0.1256$ $=0.8728$	≤14&≤5, Subtract, both correct	**M1,M1(dep)** **A1A1**
			(4)
(c)	$E(X)=20\times0.4=8$	8	**B1**
	$sd=\sqrt{20\times0.4\times0.6}=2.19$	Sub in $\sqrt{npq}$, 2.19	**M1,A1**
			(3)
(d)	$H_0: p=0.4$		
	$H_1: p>0.4$	Both	**B1**
	$P(X \geq 8 \mid n=10, p=0.4)=1-0.9877$	Require '1 minus'	**M1**
	$=0.0123$		**A1**
	Reject H_0		**M1**
	Proportion of diners who prefer to eat organic foods is higher than trade magazine's claim	Context	**A1ft**
	[Note; $P(X \leq 6)=0.9452$, $P(X \leq 7)=0.9877$ M1A1]		**(5)**
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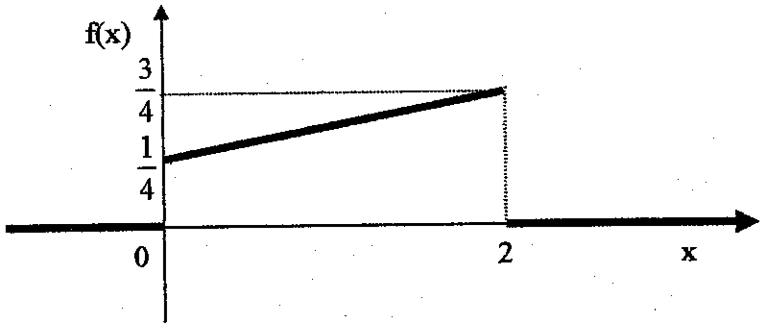
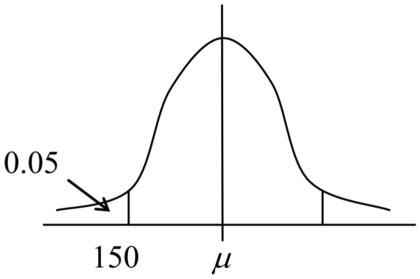
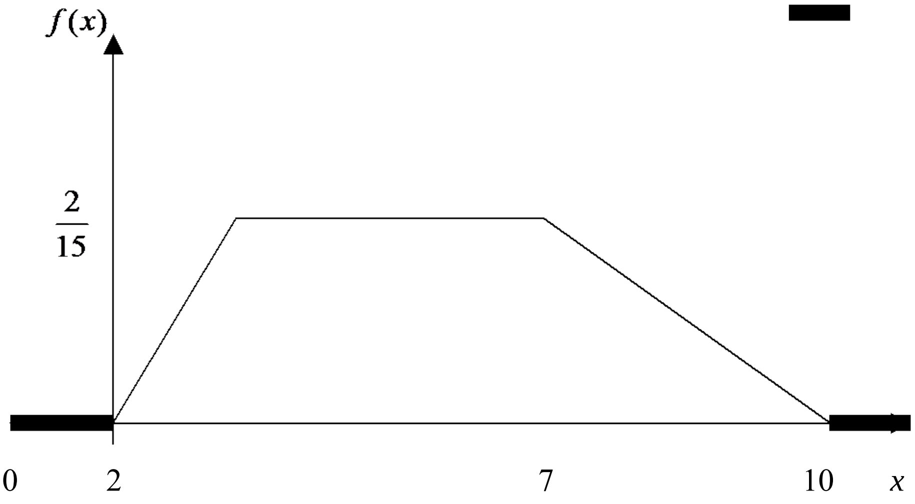
7. (a)	$8k=1, k=\frac{1}{8}$ cso	**B1** **(1)**
(b)	$F(m)=0.5$ $x^2+2x-4=0$ $x=\sqrt{5}-1=1.236$ awrt 1.24	**M1** **A1** **A1** **(3)**
(c)	$f(x)=\frac{1}{4}(x+1), \quad 0\le x\le 2$ Differentiation, all correct $=0,$ otherwise 0 and ranges	**M1A1** **A1** **(3)**
(d)		**B1** vals& labels **B1** slope **B1** f(x)=0 **(3)**
(e)	mode= 2 2	**B1** **(1)**
(f)	$E(X)=\int_0^2 x(\frac{1}{4}(x+1))dx$ Attempt $\int_0^2 xf(x)dx$ $=\left[(\frac{1}{12}x^3+\frac{1}{8}x^2)\right]_0^2$ Expression all correct $=\frac{7}{6}$	**M1** **A1** **A1** **(3)**
(g)	mean<median<mode ⇒ negative skew Comparison, both	**M1A1** **(2)** 16

Question Number		Scheme	Marks	
1.	(*a*)	Survey is less time consuming.	B1	
	(*b*)	It is easier/quicker to analyse the results	B1	**(2)**
	(*c*)	List of members	B1	**(1)**
	(*d*)	The members	B1	**(1)**
				(4 marks)
2.	(*a*)	Y is the random variable consisting of any function of the X_i that involves no other quantities.	B1 B1	**(2)**
	(*b*)	$Y = \bar{X} = \frac{\sum X}{n}$	B1	**(1)**
	(*c*)	When all possible samples are taken and the values of Y found then the values form a probability distribution (known as the sampling distribution of Y)	B1 B1	**(2)**
				(5 marks)
3.	(*a*)	$\mathrm{E}(R) = \frac{\alpha+\beta}{2} = 3, \Rightarrow \alpha+\beta = 6$	M1 A1	
	(*b*)	$\mathrm{Var}(R) = \frac{(\beta-\alpha)^2}{12} = \frac{25}{3}, \Rightarrow (\beta-\alpha)^2 = 100$	M1 A1	
		$\alpha = -2, \beta = 8$	M1 A1 A1	**(7)**
		$\mathrm{P(R < 6.6)} = \frac{1}{10} \times 8.6 = 0.86$	M1 A1	**(2)**
				(9 marks)
4.	(*a*)	$\mathrm{H_0} : \rho = 0.20,\ \mathrm{H_1} : \rho < 0.20$	B1 B1	
		X = number buying single packets, $X \sim \mathrm{B}(25, 0.20)$		
		$\mathrm{P}(X \le 2) = 0.0982$	M1 A1	
		0.0982 > 5%, so not significant (comparison)	M1	
		No reason to suspect the percentage who bought crisps in single packets that day was lower than usual (context)	A1 ft	**(2)**
		$\mathrm{H_0} : \rho = 0.03,\ \mathrm{H_1} : \rho \ne 0.03$	B1 B1	
		Y = number buying bumper packs, $Y \sim \mathrm{B}(300, 0.03) \Rightarrow Y \sim \mathrm{Po}(9)$	M1	
		$\mathrm{P}(Y \le 3) = 0.0212$ and $\mathrm{P}(Y \le 15) = 0.9780 \Rightarrow \mathrm{P}(Y \ge 16) = 0.0220$	M1 A1	
		Critical region $Y \le 3$ and $Y \ge 16$	A1	**(6)**
		Significance level = 0.0212 + 0.0220 = 0.0432	B1 ft	**(1)**
				(13 marks)

Question Number		Scheme	Marks
5.	(*a*)	$L \sim \mathrm{N}(\mu, 0.3^2)$, $\mathrm{P}(L < 150) = 0.05 \Rightarrow \mathrm{P}\left(Z < \frac{150-\mu}{0.3}\right) = 0.05$	
		 $\Rightarrow \frac{150-\mu}{0.3} =, \; -1.6449$	M1 A1, B1
		$\mu = 150.49347 = 150.5$	A1 **(4)**
	(*b*)	X represents number less than 150cm. $X \sim \mathrm{B}(10, 0.05)$	B1
		$\mathrm{P}(X \leq 2) = 0.9885$	M1 A1 **(3)**
	(*c*)	Normal approximation $\mu = 500 \times 0.05 = 25$, $\sigma^2 = 23.75$ or 25	B1, B1
		$\mathrm{P}(X < 35) \approx \mathrm{P}(Z < \frac{34.5-25}{\sqrt{23.75 \text{ or } 25}})$ ±0.5, standardise	M1, M1
		$\approx \mathrm{P}(Z < 1.95 \text{ or } 1.9)$	A1
		≈ 0.9744 or 0.9713	A1 **(6)**
			(13 marks)
6.	(*a*)	X represents number of faults per 25 m $\Rightarrow X \sim \mathrm{Po}(1.5)$	B1
		$\mathrm{P}(X = 4) = 0.0471$	B1 **(2)**
	(*b*)	Y represents number of faults per 100 m $\Rightarrow Y \sim \mathrm{Po}(6.0)$	B1
		$\mathrm{P}(Y < 6) = \mathrm{P}(Y \leq 5) = 0.4457$	B1
		R represents number of 100 m balls containing fewer than 6 faults	
		$R \sim \mathrm{B}(3, 0.4457)$	M1 A1
		$\mathrm{P}(R = 1) = C_1^3 \times 0.4457 \times (1 - 0.4457)^2 = 0.41082$ accept 0.411	M1 A1 **(6)**
	(*c*)	S represents number of faults in a 500 m ball $\Rightarrow S \sim \mathrm{Po}(30)$	B1
		$\mathrm{P}(23 \leq S \leq 33) \approx \mathrm{P}(\frac{22.5\text{-}30}{\sqrt{30}} \leq Z \leq \frac{33.5\text{-}30}{\sqrt{30}})$ ±0.5, standardise	M1, M1 A1
		$\approx \mathrm{P}(-1.37 \leq Z \leq 0.64)$	A1
		≈ 0.6536	A1 **(6)**
			(14 marks)

Question Number	Scheme	Marks
7. (*a*)		B1 (labels) B1 (graph) B1 (axes)
(*b*)	(i) $F(x)=\int_0^x \frac{x}{15}dx=\frac{x^2}{30}$ for $0 \le x \le 2$	B1
	$F(x)=\frac{12}{15}+\int_7^x (\frac{4}{9}-\frac{2x}{45})dx=\frac{4x}{9}-\frac{x^2}{45}-\frac{11}{9}$ for $7 \le x \le 10$	B1 M1 A1
	(ii) $F(x)=\frac{2}{15}+\int_2^x \frac{2}{15}dx=\frac{2x}{15}-\frac{2}{15}$ for $2 \le x \le 7$	B1 M1 A1
	(iii) $F(x)=0, x<0, F(x)=1, x>10$	B1 **(8)**
(*c*)	$\mathrm{P}(X \le 8.2)=F(8.2)=0.928$	M1 A1 **(2)**
(*d*)	$E(X)=\int_0^2 \frac{x^2}{15}dx+\int_2^7 \frac{2x}{15}dx+\int_7^{10} (\frac{4x}{9}-\frac{2x^2}{45})dx$	M1 A1
	$=\left[\frac{x^3}{45}\right]_0^2+\left[\frac{x^2}{15}\right]_2^7+\left[\frac{2x^2}{9}-\frac{2x^3}{125}\right]_7^{10}=4.78$	A1 A1 **(4)**
		(17 marks)

Question Number	Scheme	Marks
1. (*a*)	Continuous uniform (Rectangular) U(–0.5, 0.5)	B1 B1 (2)
(*b*)	P(error within 0. 2 cm) = 2 × 0.2 = 0.4	M1 A1 (2)
(*c*)	P(both within 2 cm) = $0.4^2 = 0.16$	M1 A1 (2)
		(6 marks)
2. (*a*)	$X \sim \text{Po}(7)$	B1
	$P(X \leq 2) = 0.0296$	B1
	$P(X \geq 13) = 1 - 0.9370 = 0.0270$	M1 A1
	Critical region is $(X \leq 2) \cup (X \geq 13)$	A1 (5)
(*b*)	Significance level = 0.0296 + 0.0270 = 0.0566	B1 (1)
(*c*)	$x = 5$ is not the critical region $\Rightarrow$ insufficient evidence to reject H_0	M1 A1 (2)
		(8 marks)
3. (*a*)	Weeds grow independently, singly, randomly and at a constant rate (weeds/m^2) any 2	B1 B1 (2)
(*b*)	Let X represent the number of weeds/m^2	
	$X \sim \text{Po}(0.7)$, so in 4 m^2, $\lambda = 4 \times 0.7 = 2.8$	B1
	$P(Y < 3) = P(Y = 0) + P(Y = 1) + P(Y = 2)$	M1
	$= e^{-2.8}\left(1 + 2.8 + \dfrac{2.8^2}{2}\right)$	A1
	$= 0.46945$	A1 (4)
(*c*)	Let X represent the number of weeds per 100 m^2	
	$X \sim \text{Po}(100 \times 0.7 = 70)$	B1
	$P(X > 66) \approx P(Y > 66.5)$ where $Y \sim N(70, 70)$	M1 M1 A1
	$\approx P\left(Z > \dfrac{66.5 - 70}{\sqrt{70}}\right)$	M1
	$\approx P(Z > -0.41833\ldots) = 0.6628$	A1 (6)
		(12 marks)

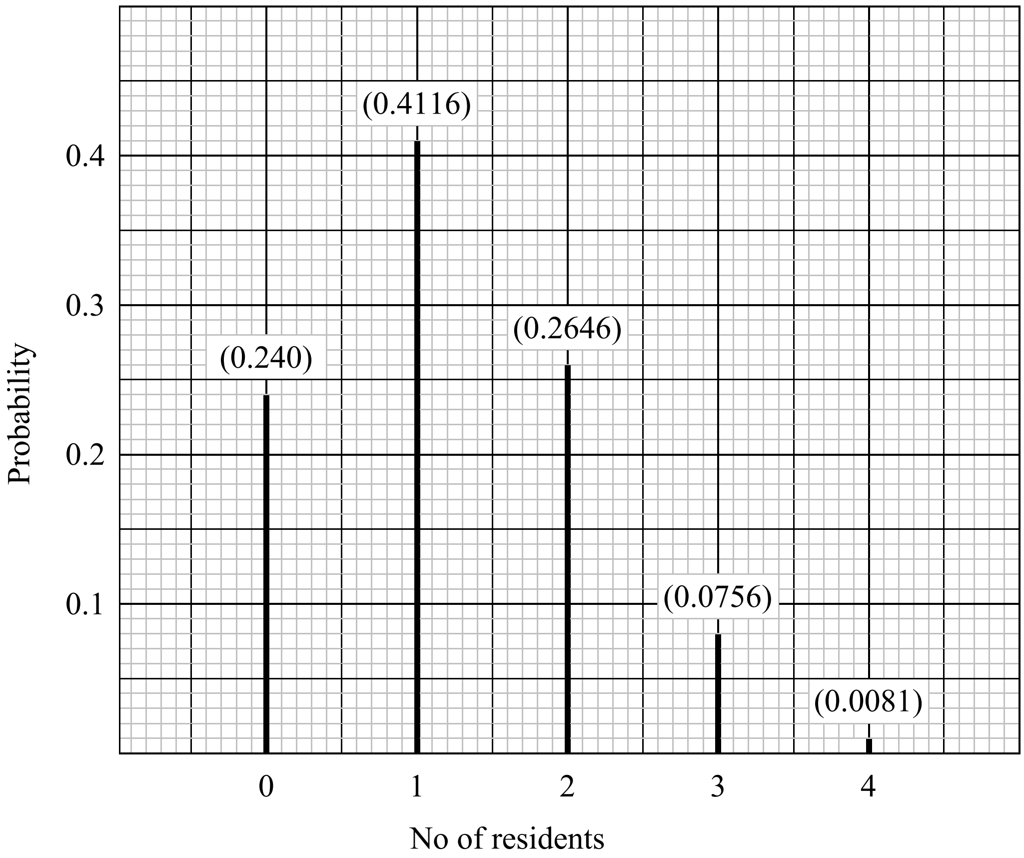
Question Number	Scheme	Marks
4. (*a*)	$P(X > 0.7) = 1 - F(0.7) = 0.4267$	M1 A1 (2)
(*b*)	$f(x) = \frac{d}{dx}F(x) = \frac{4}{3} \times 2x - \frac{4x^2}{3}$	M1
	$= \frac{4x}{3}(2 - x^2)$ for $0 \le x \le 1$	A1 (2)
(*c*)	$E(X) = \int_0^1 \frac{4}{3}(2x^2 - x^4)\,dx = \left[\frac{4}{3}\left(\frac{2x^3}{3} - \frac{x^5}{5}\right)\right]_0^1$	M1 A1
	$= \frac{28}{45} = 0.622$	A1
	$\text{Var}(X) = \int_0^1 \frac{4}{3}(2x^3 - x^5)\,dx - \left(\frac{28}{45}\right)^2$	M1
	$= \left[\frac{4}{3}\left(\frac{2x^4}{4} - \frac{x^6}{6}\right)\right]_0^1 - \left(\frac{28}{45}\right)^2$	A1
	$= \frac{116}{2025} = 0.05728$	A1 (6)
(*d*)	$f(x) = \frac{4}{3}(2 - 3x^2) = 0$	M1
	$\Rightarrow \text{mode} = \sqrt{\frac{2}{3}} = 0.816496$	A1
	$\text{skewness} = \frac{\frac{28}{45} - \sqrt{\frac{2}{3}}}{\sqrt{\frac{116}{2025}}} = -0.81170$	M1 A1 (4)
		(14 marks)

Question Number	Scheme	Marks
5. (*a*)	Let X represent the number of double yolks in a box of eggs	B1
	$\therefore X \sim \text{B}(12, 0.05)$	B1
	$\text{P}(X = 1) = \text{P}(X \leq 1) - \text{P}(X \leq 0) = 0.8816 - 0.5404 = 0.3412$	M1 A1 (3)
(*b*)	$\text{P}(X > 3) = 1 - \text{P}(X \leq 3) = 1 - 0.9978 = 0.0022$	M1 A1 (2)
(*c*)	$\text{P(only 2)} = \text{C}_2^3\,(0.3412)^2(0.6588)^2$	M1 A1
	$= 0.230087$	A1 (3)
(*d*)	Let X represent the number of double yolks in 10 dozen eggs	
	$\therefore X \sim \text{B}(120, 0.05) \Rightarrow X = \text{Po}(6)$	B1
	$\text{P}(X \geq 9) = 1 - \text{P}(X \leq 8) = 1 - 0.8472$	M1 A1
	$= 0.1528$	A1
(*e*)	Let X represent the weight of an egg $\therefore W \sim \text{N}(65, 2.4^2)$	M1
	$\text{P}(X > 68) = \text{P}\left(Z > \frac{68-65}{2.4}\right)$	A1
	$= \text{P}(Z > 1.25)$	A1
	$= 0.1056$	A1 (3)
		(15 marks)

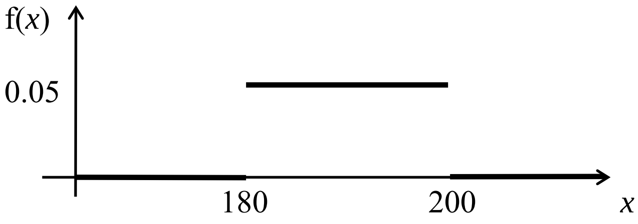
Question Number	Scheme	Marks
6. (*a*)	All subscribers to the magazine	B1 (1)
(*b*)	A list of all members that had paid their subscriptions	B1 (1)
(*c*)	Members who have paid	B1 (1)
(*d*)	Advantage: total accuracy	B1
	Disadvantage: time consyming to obtain data and analyse it	B1 (2)
(*e*)	Let X represent the number agreeing to change the name	
	$\therefore X \sim \text{B}(25, 0.4)$	B1
	$\text{P}(X = 10) = \text{P}(X \leq 10) - \text{P}(X \leq 9) = 0.1612$	M1 A1 (3)
(*f*)	$\text{H}_0\text{: } p = 0.40$, $\text{H}_1\text{: } p < 0.40$	B1, B1
	$\text{P}(X \leq 6) = 0.0736 > 0.05 \Rightarrow$ not significant	M1 A1
	No reason to reject H_0 and conclude % is less than the editor believes	A1 (5)
(*g*)	Let X represent the number agreeing to change the name $\therefore X \sim \text{B}(200, 0.4)$	
	$\text{P}(71 \leq X < 83) \approx \text{P}(70.5 \leq Y < 82.5)$ where $Y \sim \text{N}(80, 48)$	B1 B1
	$\approx \text{P}\left(\frac{70.5-80}{\sqrt{48}} \leq X < \frac{82.5-80}{\sqrt{48}}\right)$	M1 M1
	$\approx \text{P}(-1.37 \leq X < 0.36)$	A1 A1
	$= 0.5533$	A1 (7)
		(20 marks)

Question number	**Mark scheme**	**Marks**
1. (*a*)	A random variable; that is, a function involving no unknown quantities	B1; B1 (2)
(*b*)	If all possible samples are taken; then their values will form a probability distribution called the sampling distribution	B1; B1 (2)
		(4 marks)
2. (*a*)	λ is large or $\lambda > 10$	B1 (1)
(*b*)	$Y \sim \text{N}(30, 30)$ may be implied	B1
	$\text{P}(Y > 28) = 1 - \text{P}(Y \le 28.5)$	M1 A1
	$= 1 - \text{P}\left(Z \le \dfrac{28.5 - 30}{\sqrt{30}}\right)$	M1 A1
	$= 1 - \text{P}(Z \le -0.273)$	
	$= 0.607$	A1 (6)
		(7 marks)

(ft = follow through mark; (*) indicates final line is given on the paper)

Question number	Mark scheme	Marks
3. (*a*)	$X \sim \mathrm{B}(4, 0.3)$	B1 B1 (2)
(*b*)		
	All probabilities correct	B1
	Scales and labels	B1
	Correct diagram	B1 (3)
(*c*)	1 resident	B1 (1)
(*d*)	$\mathrm{E}(X) = np = 1.2$	B1
	$\mathrm{Var}\,(X) = np(1 - p)$	
	$= 4 \times 0.3 \times 0.7$	M1
	$= 0.84$	A1 (3)
		(9 marks)

(ft = follow through mark; (*) indicates final line is given on the paper)

Question number	Mark scheme	Marks
4. (*a*)	*Fixed number* of *independent* trials	B1 B1
	2 outcomes	B1
	Probability of success *constant*	B1 (4)
(*b*)	$P(X = 5) = \frac{2}{7}$; $P(X \neq 5) = \frac{5}{7}$ may be implied	B1; B1 ft
	P(5 on sixth throw) = $\left(\frac{5}{7}\right)^2 \times \left(\frac{2}{7}\right)$ $p^n(1 - p)$	M1 A1 ft
	$= 0.0531$	A1 (5)
(*c*)	P(exactly 3 fives in first eight throws) = $\binom{8}{3}\left(\frac{2}{7}\right)^3\left(\frac{5}{7}\right)^3$ use of ^nC_r needed	M1 A1 ft
	$= 0.243$	A1 (3)
		(12 marks)
5. (*a*)	$f(x) = \begin{cases} 0.05 & 180 \le x \le 200 \\ 0 & \text{otherwise} \end{cases}$	B1 B1
	 labels	B1
	3 parts	B1 (4)
(*b*)(i)	$P(X \le 183) = 3 \times 0.05$	M1
	$= 0.15$	A1
(ii)	$P(X = 183) = 0$	B1 (3)
(*c*)	IQR = 10	B1 (1)
(*d*)	$0.05(200 - x)$; $= 0.05(x - 180) \times 2$	M1; A1
	$200 - x = 2x - 360$	
	$x = 186\frac{2}{3}$	A1 (3)
(*e*)	$\frac{1}{3}$ of all cups of lemonade dispensed contains $186\frac{2}{3}$ ml or less	B1 B1 ft (2)
	(or $\frac{2}{3}$ of all cups of lemonade dispensed contains $186\frac{2}{3}$ ml or more)	
		(13 marks)

(ft = follow through mark; (*) indicates final line is given on the paper)

Question number	Mark scheme	Marks
6. (*a*)	Po(1)	B1 B1
	Each patient seen singly *or* patients with disease seen randomly *or* seen constant rate of once per week *or* each patient assumed independent of the next	B1 (3)
(*b*)	$X \sim \text{Po}(4)$ may be implied	B1
	$\text{P}(X > 3) = 1 - \text{P}(X \leq 3)$	M1
	$= 1 - 0.4335$	A1
	$= 0.5665$	A1 (4)
(*c*)	$\text{H}_0\text{: } \lambda = 6$	B1
	$\text{H}_1\text{: } \lambda < 6$	B1
	$\text{P}(X \leq 2) = 0.0620$ $\alpha = 0.05 \Rightarrow$ critical region $X \leq 1$	M1 A1
	$0.0620 > 0.05$ 2 not in critical region	M1
	The number of patients with the disease seen by the doctor has not been reduced	A1 (6)
(*d*)	This does not support the model as the disease will occur in outbreaks; the patients seen by the doctor are unlikely to be independent of each other/don’t occur singly	B1; B1 (2)
		(15 marks)

(ft = follow through mark; (*) indicates final line is given on the paper)

Question number	Mark scheme	Marks
7. (*a*)	$\int_{-1}^{0} k(x^2 + 2x + 1)\ \mathrm{d}x = 1$ limits needed and =1	M1
	$\left[k\left(\frac{x^3}{3} + x^2 + x\right)\right]_{-1}^{0} = 1$ attempt at integration	M1 A1
	$k = 3$ (*)	A1 (4)
(*b*)	$\mathrm{E}(X) = \int_{-1}^{0} x.\mathrm{f}(x)\ \mathrm{d}x$	M1
	$= \int_{-1}^{0} (3x^3 + 6x^2 + 3x)\ \mathrm{d}x$ limits needed	A1
	$= \left[\frac{3x^4}{4} + 2x^3 + \frac{3x^2}{2}\right]_{-1}^{0}$ integration and substituting limits	M1
	$= -\frac{1}{4}$	A1 (4)
(*c*)	$\int_{-1}^{x_0} (3x^3 + 6x^2 + 3x)\ \mathrm{d}x = \left[x^3 + 3x^2 + 3x\right]_{-1}^{x_0}$	M1
	$= x_0 + 3x_0^2 + 3x_0 + 1$	A1
	$\mathrm{F}(x) = \begin{cases} 0 & x < -1 \\ x^3 + 3x^2 + 3x + 1 & -1 \le x \le 0 \\ 1 & x > 0 \end{cases}$	B1 B1 (4)
(*d*)	$\mathrm{P}(-0.3 < X < 0.3) = \mathrm{F}(0.3) - \mathrm{F}(-0.3)$	M1
	$= 1 - 0.343$	A1
	$= 0.657$	A1 (3)
		(15 marks)

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EDEXCEL FOUNDATION

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January 2004

Advanced Subsidiary/Advanced Level

General Certificate of Education

Subject **STATISTICS 6684** Paper No. **S2**

Question number	Scheme	Marks
1.		
(a)	List of patients registered with the practice. Require 'list' or 'register' or database or similar	**B1**
		(1)
(b)	The patient(s)	**B1**
		(1)
(c)	Adv: Quicker, cheaper, easier, used when testing results in destruction of item, quality of info about each sampling unit is often better. Any one	**B1**
	Disadv: Uncertainty due to natural variation, uncertainty due to bias, possible bias as sampling frame incomplete, bias due to subjective choice of sample, bias due to non-response . Any one	**B1**
		(2)
(d)	Non-response due to patients registered with the practice but who have left the area	**B1**
		(1)
		(Total 5 Marks)
2(a)	$\text{P}(R \geq 4\ ) = 1 - \text{P}(R \leq 3) = 0.6533$ Require 1 minus and correct inequality	**M1A1**
		(2)
(b)	$\text{P}(S \leq 1) = \text{P}(S = 0) + \text{P}(S = 1), = e^{-2.71} + 2.71e^{-2.71}, = 0.2469$ awrt 0.247	**M1,A1,A1**
		(3)
(c)	$\text{P}(\text{T} \leq 18) = \text{P}(\text{Z} \leq \frac{18-25}{5}), = \text{P}(\text{Z} \leq -1.4) = 0.0808$ 4 dp, cc no marks	**M1,A1**
		(2)
		(Total 7 Marks)
3(a)	$p = \frac{1}{2}$	**B1**
		(1)
(b)	Binomial distribution is symmetrical	**B1**
		(1)
(c)	Since n is large and $p \approx 0.5$ then use normal approximation, Can be implied below	**M1**
	$np = 96$ and $npq = 49.92$	**A1A1**
	$\text{P}(90 \leq X < 105) \approx \text{P}(89.5 \leq Y \leq 104.5)$ where $Y \sim \text{N}(96, 49.92)$ ± 0.5 cc on both	**M1,**
	$\approx \text{P}\left(\frac{89.5-96}{\sqrt{49.92}} \leq Z \leq \frac{104.5-96}{\sqrt{49.92}}\right)$ Standardisation of both	**M1**
	$\approx \text{P}\left(-0.92 \leq Z \leq 1.20\right)$ awrt -0.92 & 1.20	**A1**
	$\approx$ 0.7055-0.7070 4dp in range	**A1**
		(7)
		(Total 9 Marks)

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Subject **STATISTICS 6684** Paper No. **S2**

Question number	Scheme	Marks
4		
(a)	*n* large, *p* small	**B1,B1**
		(2)
(b)	Let *X* represent the number of people catching the virus, $X \sim \mathrm{B}\left(12, \frac{1}{150}\right)$ Implied	**B1**
	$\mathrm{P}(X = 2) = \mathrm{C}_2^{12}\left(\frac{1}{150}\right)^2\left(\frac{149}{150}\right)^{10}, = 0.0027$ Use of Bin including C_2^{12}, 0.0027(4) only	**M1A1,A1**
		(4)
(c)	$X \sim \mathrm{Po}(np) = \mathrm{Po}(8)$ Poisson, 8	**B1,B1**
	$\mathrm{P}(X < 7) = \mathrm{P}(X \le 6) = 0.3134$ $X \le 6$ for method, 0.3134	**M1A1**
		(4)
		(Total 10 Marks)
5(a)	Vehicles pass at random / one at a time / independently / at a constant rate Any 2&context	**B1B1**dep
		(2)
(b)	*X* is the number of vehicles passing in a 10 minute interval,	
	$X \sim \mathrm{Po}\left(\frac{51}{60} \times 10\right) = \mathrm{Po}(8.5)$ Implied $\mathrm{Po}(8.5)$	**B1**
	$\mathrm{P}(X{=}6){=}\frac{8.5^6 \mathrm{e}^{-8.5}}{6!}, = 0.1066$ (or 0.2562-0.1496=0.1066) Clear attempt using 6, 4dp	**M1A1**
		(3)
(c)	$\mathrm{P}(X \ge 9) = 1 - \mathrm{P}(X \le 8) = 0.4769$ Require 1 minus and correct inequality	**M1A1**
		(2)
(d)	$\mathrm{H}_0 : \lambda = 8.5,\ \mathrm{H}_1 : \lambda < 8.5$ One tailed test only for alt hyp	**B1ʃ,B1ʃ**
	$\mathrm{P}(X \le 4 \mid \lambda = 8.5) = 0.0744, > 0.05$ $X \le 4$ for method, 0.0744	**M1,A1**
	(Or $\mathrm{P}(X \le 3 \mid \lambda = 8.5) = 0.0301, < 0.05$ so CR $X \le 3$ correct CR	**M1,A1)**
	Insufficient evidence to reject H_0, 'Accept'	**M1**
	so no evidence to suggest number of vehicles has decreased. Context	**A1ʃ**
		(6)
		(Total 13 Marks)

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Subject **STATISTICS 6684** Paper No. **S2**

Question number	Scheme	Marks
6		
(a)	Let *X* represent the number of plant pots with defects, $X \sim \mathrm{B}(25,0.20)$ Implied	**B1**
	$\mathrm{P}(X \le 1) = 0.0274, \mathrm{P}(X \ge 10) = 0.0173$ Clear attempt at both tails required**,** 4dp	**M1A1A1**
	Critical region is $X \le 1, X \ge 10$	**A1**
		(5)
(b)	Significance level = 0.0274+0.0173=0.0447 Accept % 4dp	**B1** cao
		(1)
(c)	$\mathrm{H}_0 : \lambda = 10,\ \mathrm{H}_1 : \lambda > 10 \text{ (or } \mathrm{H}_0 : \lambda = 60,\ \mathrm{H}_1 : \lambda > 60)$	**B1B1**
	Let *Y* represent the number sold in 6 weeks, under $\mathrm{H}_0,\ Y \sim \mathrm{Po}(60)$	
	$\mathrm{P}(Y \ge 74) \approx \mathrm{P}(W > 73.5) \text{ where } W \sim \mathrm{N}(60,60)$ ± 0.5 for cc ,73.5	**M1A1**
	$\approx \mathrm{P}(Z \ge \frac{73.5-60}{\sqrt{60}}) = \mathrm{P}(Z > 1.74) =, 0.0407 - 0.0409$ <0.05 Standardise using 60 $\sqrt{60}$	**M1,A1**
	Evidence that rate of sales per week has increased.	**A1ʃ**
		(7)
		(Total 13 Marks)

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Subject **STATISTICS 6684** Paper No. **S2**

Question number	Scheme	Marks
7 **(a)**	$\int_0^4 kx(5-x)\mathrm{d}x = 1$ Limits required	**M1**
	$k\left[\frac{5x^2}{2}-\frac{x^3}{3}\right]_0^4 = 1$ $\left[\frac{5x^2}{2}-\frac{x^3}{3}\right]$	**A1**
	Sub in limits and solve to give **** $k=\frac{3}{56}$ **** Correct solution	**A1**
		(3)
(b)	$\mathrm{F}(x)=\int_0^{x_0}\mathrm{f}(x)\mathrm{d}x=\int_0^{x_0}\frac{3}{56}x(5-x)\,\mathrm{d}x=\frac{3}{56}\left[\frac{5x^2}{2}-\frac{x^3}{3}\right]_0^{x_0}$ Variable upper limit required	**M1**
	$=\frac{x_0^2}{112}(15-2x_0)$	**A1**
	$\mathrm{F}(x)=\begin{array}{ll} 0 & x<0 \\ \frac{x^2}{112}(15-2x) & 0\le x\le 4 \\ 1 & x>4 \end{array}$ Ends, middle.	**B1,B1∫**
		(4)
(c)	$\mathrm{E}(x)=\int_0^4\frac{3}{56}x^2(5-x)\,\mathrm{d}x=\frac{3}{56}\left[\frac{5x^3}{3}-\frac{x^4}{4}\right]_0^4=2.29$ $\int x\mathrm{f}(x)\mathrm{d}x$, $\left[\frac{5x^3}{3}-\frac{x^4}{4}\right]$, 3sf ($2\frac{2}{7}$)	**M1A1A1**
		(3)
(d)	$\mathrm{f}'(x)=\frac{3}{56}(5-2x)=0 \Rightarrow$ Mode=2.5 Attempt $\mathrm{f}'(x)$, $(5-2x)=0$, 2.5	**M1A1A1**
	(Or Sketch M1, x=0&5 A1, Mode=2.5 A1)	
		(3)
(e)	F(2.3)=0.491, F(2.5)=0.558 Their F, awrt 0.491 & 0.558 or 0.984 & -6.5	**M1,A1**
	F(*m*)=0.5 ⇒ *m* lies between 2.3 and 2.5 cso	**A1**
		(3)
(f)	Mean (2.29)<Median (2.3-2.5)<Mode (2.5)	**B1**
	Negative skew	**B1** dep
		(2)
		(Total 18 Marks)

EDEXCEL STATISTICS S2 (6684) – JUNE 2004 PROVISIONAL MARK SCHEME

Qn no.	Scheme		Marks
1(a)	A list of (all) the members of the population		**B1**
			(1)
(b)	A random variable that is a function of a random sample		**B1**
	that contains no unknown parameters		**B1**
			(2)
			(Total 3 marks)
2(a)	$\mathrm{P}(X < 2.7) = \frac{3.7}{5} = 0.74$	0.74	**B1**
			(1)
(b)	$\mathrm{E}(X) = \frac{4-1}{2} = 1.5$	Require minus or complete attempt at integration, 1.5	**M1A1**
			(2)
(c)	$\mathrm{Var}(X) = \frac{1}{12}(4+1)^2 = \frac{25}{12} = 2.08\dot{3}$	Require plus, $\frac{25}{12} or 2\frac{1}{12} or 2.08\dot{3} or 2.08$	**M1A1**
			(2)
			(Total 5 marks)
3	$\mathrm{H}_0 : p = 0.25,\ \mathrm{H}_1 : p > 0.25$	1 tailed	**B1B1**
	Under H_0, $X \sim \mathrm{Bin}(25,0.25)$	Implied by probability	**B1**
	$\mathrm{P}(X \geq 10) = 1 - \mathrm{P}(X \leq 9) = 0.0713$ >0.05	Correct inequality, 0.0713	**M1A1**
	Do not reject H_0, there is insufficient evidence to support Brad's claim.	DNR, context	**A1A1**
			(7)
			(Total 7 marks)
4(a)	Fixed no of trials/ independent trials/ success & failure/ Probab of success is constant any 2		**B1B1**
			(2)
(b)	*X* is rv 'no of defective components $X \sim \mathrm{Bin}(20,0.1)$	$\mathrm{Bin}(20,0.1)$	**B1**
			(1)
(c)	P(*X* = 0)=0.1216	=0, 0.1216 **M1A1**	
			(2)
(d)	$\mathrm{P}(X > 6) = 1 -\ \mathrm{P}(X \leq 6) = 1 - 0.9976 = 0.0024$	Strict inequality & 1- with 6s, 0.0024	**M1A1**
			(2)
(e)	E(*X*)=20x0.1=2	2	**B1**
	Var(*X*)=20x0.1x0.9=1.8	1.8	**B1**
			(2)
(f)	$X \sim \mathrm{Bin}(100,0.1)$	Implied by approx used	**B1**
	$X \sim \mathrm{P}(10)$		**B1**
	$\mathrm{P}(X > 15) =$ 1-P$(X \leq 15) =$ 1-0.9513=0.0487	Strict inequality and 1- with 15, 0.0487	**M1A1**
	(OR $X \sim \mathrm{N}(10,9)$, *P(X > 15.5) = 1-P(Z<1.83)=0.0336 (0.0334) with 15.5*		*B1**M1A1*****)**
	(OR $X \sim \mathrm{N}(10,10)$, *P(X > 15.5) = 1-P(Z<1.74)=0.0409 (0.0410) with 15.5*		*B1**M1A1*****)**
			(4)
			(Total 13 marks)

Qn no.	Scheme	Marks
5 (a)	A range of values of a test statistic such that if a value of the test statistic obtained from a particular sample lies in the critical region, then the null hypothesis is rejected (or equivalent).	**B1B1**
		(2)
(b)	P(X < 2) =P(X =0) + P(X=1)	both **M1**
	$=e^{-\frac{1}{7}}+\frac{e^{-\frac{1}{7}}}{7}$	both **A1**
	=0.990717599… =0.9907 to 4 sf	awrt 0.991 **A1**
		(3)
(c)	$X \sim \mathrm{P}(14\times\frac{1}{7})=\mathrm{P}(2)$	**B1**
	$\mathrm{P}(X\le 4)=0.9473$	Correct inequality, 0.9473 **M1A1**
		(3)
(d)	$\mathrm{H}_0:\lambda=4,\ \mathrm{H}_1:\lambda<4$ Accept μ & $\mathrm{H}_0:\lambda=\frac{1}{7},\ \mathrm{H}_1:\lambda<\frac{1}{7}$	**B1B1**
	$X \sim \mathrm{P}(4)$	Implied **B1**
	$\mathrm{P}(X\le 1)=0.0916>0.05$,	Inequality 0.0916 **M1A1**
	So insufficient evidence to reject null hypothesis	**A1**
	Number of breakdowns has not significantly decreased	**A1**
		(7)
		(Total 15 marks)
6 (a)	No of defects in carpet area a sq m is distributed $\mathrm{Po}(0.05a)$	Poisson, 0.05a **B1B1**
	Defects occur at a constant rate, independent, singly, randomly	Any 1 **B1**
		(3)
(b)	$X \sim \mathrm{P}(30\times 0.05)=\mathrm{P}(1.5)$	P(1.5) **B1**
	P(X = 2)=$\frac{e^{-1.5}\times 1.5^2}{2}$=0.2510	Tables or calc 0.251(0) **M1A1**
		(3)
(c)	$\mathrm{P}(X>5)=1-\ \mathrm{P}(X\le 5)=1-0.9955=0.0045$	Strict inequality, 1-0.9955, 0.0045 **M1M1A1**
		(3)
(d)	$X \sim \mathrm{P}(17.75)$	Implied **B1**
	$X \sim \mathrm{N}(17.75,17.75)$	Normal, 17.75 **B1**
	$\mathrm{P}(X\ge 22)=\mathrm{P}\left(Z>\frac{21.5-17.75}{\sqrt{17.75}}\right)$	Standardise, accept 22 or ± 0.5 **M1M1**
	=P(Z > 0.89)	awrt 0.89 **A1**
	=0.1867	0.1867, **A1**
		(6)
		(Total 15 marks)

Qn no.	Scheme	Marks
7(a)	$\mathrm{E}(X)=\int_0^1 \frac{1}{3}x\mathrm{d}x+\int_1^2 \frac{8x^4}{45}\mathrm{d}x$	$\int x\mathrm{f}(x)\mathrm{d}x$, 2 terms added **M1M1**
	$=\left[\frac{1}{6}x^2\right]_0^1+\left[\frac{8x^5}{225}\right]_1^2$	Expressions, limits **A1A1**
	$=1.26\dot{8}=1.27$ to 3 sf or $\frac{571}{450}$ or $1\frac{121}{450}$	awrt1.27 **A1**
		(5)
(b)	$\mathrm{F}(x_0)=\int_0^{x_0} \frac{1}{3}\mathrm{d}x=\frac{1}{3}x_0$ for $0 \le x < 1$	variable upper limit on $\int \mathrm{f}(x)\mathrm{d}x$, $\frac{1}{3}x_0$ **M1A1**
	$\mathrm{F}(x_0)=\frac{1}{3}+\int_1^{x_0} \frac{8x^3}{45}\mathrm{d}x$ for $1 \le x \le 2$	their fraction + v.u.l on $\int \mathrm{f}(x)\mathrm{d}x$ &2 terms **M1**
	$=\frac{1}{3}+\left[\frac{8x^4}{180}\right]_1^{x_0}$	$\frac{8x^4}{180}$ **A1**
	$=\frac{1}{45}\left(2x_0^4+13\right)$	**A1**
	$$\mathrm{F}(x)=\begin{cases} 0 & x<0 \\ \frac{1}{3}x & 0 \le x < 1 \\ \frac{1}{45}\left(2x^4+13\right) & 1 \le x \le 2 \\ 1 & x>2 \end{cases}$$	middle pair, ends **B1,B1**
		(7)
(c)	$\mathrm{F}(m)=0.5$	
	$\frac{1}{45}\left(2x^4+13\right)=\frac{1}{2}$	Their function=0.5 **M1A1ft**
	$m^4=4.75$	
	$m=1.48$ to 3 sf	awrt1.48 **A1**
		(3)
(d)	mean<median	**B1**
	Negative Skew	dep **B1**
		(2)
		(Total 17 marks)

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190 High Holborn London WC1V 7BH

January 2005

Advanced Subsidiary/Advanced Level

General Certificate of Education

FINAL
28/01/05

Subject: **Statistics** **Paper: S2**

Question Number	Scheme	Marks
1.	(a) $P(R=5)=P(R\le 5)-P(R\le 4)=0.7216-0.5155$	Can be implied M1
	$=0.2061$	AWRT 0·2061 A1 (2)
	(OR: $^{15}C_5(0.3)^5(0.7)^{10}=0.206130\ldots$)	
	(b) $P(S=5)=0.2414-0.1321=0.1093$	Accept 0·1093 or 0·1094 AWRT AWRT B1 (1)
	(OR: $\frac{7.5^5e^{-7.5}}{5!}=0.10937459\ldots$)	
	(c) $P(T=5)=0$	cao B1 (1)
2.	(a) (i) A collection of individuals or items	B1
	(ii) A list of all sampling units in the population	B1 (2)
	(b) Not always possible to keep this list up to date	B1 (1)
	(c) (i) eg:- Pupils in year 12 – small easily listed ~~sample~~ population	B1
	Population known & easily accessed	B1
	(ii) Students in a University – Large not easily listed population	B1
	Population known but too time consuming/expensive to interview all of them.	B1 (4)
	(c) SR (i) Definition of census by example	B1
	(ii) " " sample " "	B1

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General Certificate of Education

Subject: **Statistics** **Paper: S2**

Question Number	Scheme	Marks
3.	(a) Continuous uniform/Rectangular	B1
	$f(x)=\begin{cases} 1/l, & 0\le x\le l \\ 0 & \text{otherwise}\end{cases}$	B1 B1 (3)
	(b) $P(X<\frac{1}{3}l)=\frac{1}{l}\times\frac{l}{3}=\frac{1}{3}$ Their $\frac{1}{l}\times\frac{l}{3}$	M1A1 (2)
	(c) $E(X)=\frac{1}{2}l$	B1 (1)
	(d) $P(\text{Both}<\frac{1}{3}l)=(\frac{1}{3})^2=\frac{1}{9}$ $(b)^2$	M1 A1√(2)
4.	(a) Probability of success/failure is constant Trials are independent	B1 B1 (2)
	(b) Let p represent proportion of students who can distinguish between brands	
	$H_0: p=0.1$; $H_1: p>0.1$ (both)	B1
	$\alpha=0.01$; CR: $z>2.3263$ 2.3263	B1
	$np=25$; $npq=22.5$ both Can be implied	B1
	$z=\frac{39.5-25}{\sqrt{22.5}}=3.0568....$ Standardisation with ±0.5 & their $\sqrt{npq}$	M1
	AWRT 3.06	A1
	Reject H_0: claim cannot be accepted Based on clear evidence from z or p	A1√ (6)
	(c) eg:- np, nq both >5 — true so acceptable p close to 0.5 — not true, assumption not met success/failure not clear cut necessarily independence — one student influences another	B1 (2) B1

(b) Aliter $z=3.06 \Rightarrow p=0.9989>0.99$ or $p=0.0011<0.01$ } B1 equiv to 2.3263

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General Certificate of Education

Subject: **Statistics** **Paper: S2**

Question Number	Scheme	Marks
5.	Let X represent the number of defective articles	
	$\therefore X \sim B(10, 0.032)$	
	(a) $P(X=2) = \cancel{{}^{10}C_2}^{45}(0.032)^2(1-0.032)^8$	Use of ${}^nC_r p^r q^{n-r}$ M1
		All correct A1
	$= \underline{0.0355274....}$	AWRT 0.0355 A1 (3)
	(b) Large n, small $p \Rightarrow$ Poisson approximation	Seen or implied B1
	with $\lambda = 100 \times 0.032 = 3.2$	
	$P(X<4) = P(X \leq 3) = P(0)+P(1)+P(2)+P(3)$	$P(X\leq3)$ stated or implied M1
	$= e^{-3.2}\left\{1+3.2+\frac{(3.2)^2}{2}+\frac{(3.2)^3}{6}\right\}$ **NB** Normal Approx $\Rightarrow$ 0/4	All correct A1
	$= \underline{0.602519....}$	AWRT 0.603 A1 (4)
	(c) np & nq both $>5 \Rightarrow$ Normal approximation	N approx M1
	with $np = 32$ and $npq = 30.976$	both A1
	$P(X>42) \approx P(Y>42.5)$ where $Y \sim N(32, 30.976)$	Standardise M1 their np, $\sqrt{npq}$
	$= P\left(Z > \frac{42.5-32}{\sqrt{30.976}}\right)$	All correct A1
	$= P(Z > 1.8865....)$	AWRT 1.89 A1
	$= \underline{0.0294}$	0.0294–0.0297 A1 (6)

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Advanced Subsidiary/Advanced Level

General Certificate of Education

Subject: **Statistics** **Paper: S2**

Question Number	Scheme	Marks
6.	Let X represent number of accidents/month $\therefore X \sim Po(3)$	B1
	(a) $P(X>4) = 1 - P(X \le 4)$; $= 1 - 0.8513 = \underline{0.1847}$	M1; A1 (3)
	(b) Let Y represent number of accidents in 3 months $\therefore Y \sim Po(3\times3 = 9)$	Can be implied B1
	$P(Y>4) = 1 - 0.0550 = \underline{0.9450}$	B1 (2)
	(c) $H_0: \lambda = 3$; $H_1: \lambda < 3$ $\alpha = 0.05$ 2 tailed; allow B0 B1 M1 (0.025) A0	both B1
	$P(X \le 1 \mid \lambda=3) = 0.1991$; > 0.05	B1; M1
	$\therefore$ Insufficient evidence to support the claim that the mean number of accidents has been reduced.	A1√ (4)
	(NB: CR: $X \le 0$; $X=1$ not in CR; same conclusion $\Rightarrow$ B1, M1, A1)	
	(d) $H_0: \lambda = 24\times3 = 72$; $H_1: \lambda < 72$	Can be implied $\lambda = 72$ B1 both H_0 & H_1 B1
	$\alpha = 0.05 \Rightarrow$ CR: $z < -1.6449$	−1.6449 B1
	Using Normal approximation with $\mu = \sigma^2 = 72$	Can be implied B1
	$z = \dfrac{55.5 - 72}{\sqrt{72}} = -1.94454\ldots$	Stand^n with ±0.5, μ & σ M1 AWRT −1.94/5 A1
	Since −1.944.... is in the CR, H_0 is rejected. There is evidence that the restriction has reduced the number of accidents.	Context & clear evidence A1√ (7)
	Alitar (d) $p = 0.0262 < 0.05$ AWRT 0.026 B1 equiv to −1.6449	

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General Certificate of Education

Subject: **Statistics** **Paper: S2**

Question Number	Scheme		Marks
7.	(a) $k\int_1^4(-x^2+5x-4)\,dx=1$	Us^{ng} of $\int f(x)dx=1$	M1
	$\therefore\ k\left[-\frac{x^3}{3}+\frac{5x^2}{2}-4x\right]_1^4=1$	All correct integ^n with limits	A1
	$* \Rightarrow \underset{\sim\sim\sim}{k=2/9}\ *$	c.s.o	A1 (3)
	(b) $E(X)=\int_1^4 2/9(-x^3+5x^2-4x)\,dx$	Us^{ng} of $\int xf(x)dx$	M1
	$=2/9\left[-\frac{x^4}{4}+\frac{5x^3}{3}-\frac{4x^2}{2}\right]_1^4$	Correct integ^n with limits	A1
	$=\underset{\sim\sim\sim}{5/2}$	cao	A1 (3)
	(c) $\frac{d}{dx}f(x)=2/9(-2x+5)=0$; $\Rightarrow$ Mode $=5/2$ SC: 5/2 only; no working B1	Diff^n of $f(x)$ & $=0$	M1; A1 (2)
	(d) $F(x)=\int_1^{x_0}2/9(-x^2+5x-4)\,dx$	Us^{ng} of $\int f(x)dx$	M1
	$=\left[2/9\left(-x^3/3+\frac{5x^2}{2}-4x\right]_1^{x_0}\right.$	Integ^n with limits 1 & symbol	A1
	$=2/9\left\{-\frac{x_0^3}{3}+\frac{5x_0^2}{2}-4x_0+\frac{11}{6}\right\}$	aef	A1
	$\therefore\ F(x)=\begin{cases}0 & x<1\\ 2/9\left\{-\frac{x^3}{3}+\frac{5x^2}{2}-4x+\frac{11}{6}\right\} & 1\le x\le 4\\ 1 & x>4\end{cases}$	$x<1$; $x>4$ $1\le x\le 4$	B1 B1 (5)
	(e) $P(X\le 2.5)=F(2.5)=0.5$	F(2.5) or integral etc	M1 A1 (2)
	(f) Median $=2.5$; Distribution is symmetrical		B1;B1 (2) cao cao

GCE

Edexcel GCE

Statistics S2 (6684)

Summer 2005

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Mark Scheme (Results)

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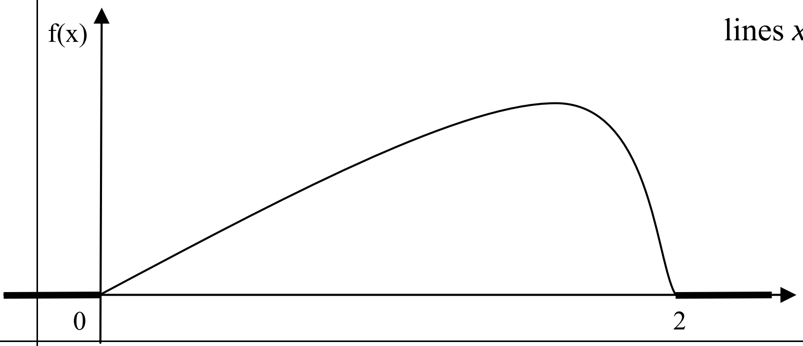
Statistics S2 (6684)

June 2005
6684 Statistics S2
Mark Scheme

Question Number	Scheme		Marks
1(a)	$X \sim B(n, 0.04)$	Implied	B1
	$E(X) = np$		M1
		Use of $np = 5$	
	$5 = 0.04n$		
	$n = 125$	125	A1
			(3)
(b)	$E(X) = 3$		
	$np = 3$	$np = 3$	B1
	$\text{sd} = \sqrt{npq} = \sqrt{3(1-0.04)}$	Use of npq	M1
	$= \sqrt{2.88}$	$\sqrt{3(1-0.04)}$	A1
	$= 1.70$	awrt 1.70	A1
			(4) **Total 7**
2(a)	$f(x) = \frac{1}{4}$, $2 \le x \le 6$	$\frac{1}{4}$ and range	B1
	$= 0$, otherwise	0 and range	B1
			(2)
(b)	E(X) = 4 by symmetry or formula	4	B1
			(1)
(c)	$\text{Var}(X) = \frac{(6-2)^2}{12}$	Use of formula	M1
	$= \frac{4}{3}$	$1.\dot{3}$ or $1\frac{1}{3}$ or $\frac{4}{3}$ or 1.33	A1
			(2)
(d)	$F(x) = \int_2^x \frac{1}{4}\,dt = \left[\frac{1}{4}t\right]_2^x$	Use of $\int f(x)\,dx$	M1
	$= \frac{1}{4}(x-2)$	$\frac{1}{4}(x-2)$ or equiv.	A1
	$F(x) = \frac{1}{4}(x-2)$, $2 \le x \le 6$	$\frac{1}{4}(x-2)$ and range	B1ft
	$= 1$, $x > 6$	ends and ranges	B1
	$= 0$, $x < 2$		
			(4)
(e)	$P(2.3 < X < 3.4) = \frac{1}{4}(3.4-2.3)$	Use of area or F(x)	M1
	$= 0.275$	0.275 or $\frac{11}{40}$	A1
			(2) **Total 11**

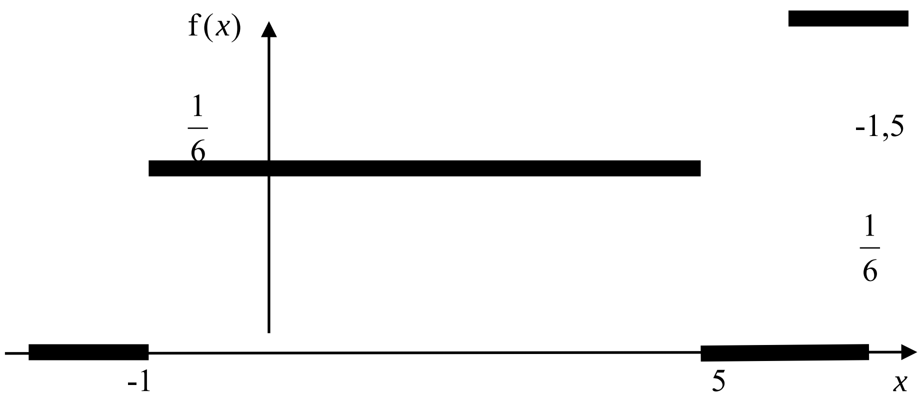
Question Number	Scheme	Marks
3(a)	Misprints are random / independent, occur singly in space and at a constant rate — Context, any 2	B1, B1 (2)
(b)	$P(X = 0) = e^{-2.5}$ — Po (2.5)	M1
	$= 0.08208\ldots\ldots = 0.0821$ — 0.0821	A1 (2)
(c)	Y ~ Po (5) for 2 pages — Implied	B1
	$P(Y > 7) = 1 - P(X \leq 7)$ — Use of 1 – and correct inequality	M1
	$= 1 - 0.8666 \quad = 0.1334$ — 0.1334	A1 (3)
(d)	For 20 pages, $Y \sim P_o\ (50)$ — $P_o\ (50)$	B1
	$Y \sim N(50\ ,\ 50)$ approx — N(50, 50)	B1
	$P(Y < 40) = P(Y \leq 39.5)$ — cc ± 0.5	M1
	$= P\left(Z \leq \dfrac{39.5 - 50}{\sqrt{50}}\right)$ — standardise above	M1
	all correct	A1
	$= P\ (Z \leq -1.4849)$ — awrt – 1.48	A1
	$= 1 - 0.93 = 0.07$ — 0.07	A1 (7)
		Total 14
4(a)	Individual member or element of the population or sampling frame	B1 (1)
(b)	A list of all sampling units or all the population	B1 (1)
(c)	All possible samples are chosen from a population; the values of a statistic and the associated probabilities is a sampling distribution	B1 B1 (2)
		Total 4

Question Number	Scheme		Marks
5(a)	$X \sim B(200, 0.02)$	Implied	B1
	n large, P small so $X \sim Po(np) = Po(4)$	conditions, $P_0(4)$	B1, B1
	$P(X = 5) = \frac{e^{-4}4^5}{5!}$	$P(X \le 5) - P(X \le 4)$	M1
	$= 0.1563$	0.1563	A1
			(5)
(b)	$P(X < 5) = P(X \le 4)$	$P(X \le 4)$	M1
	$= 0.6288$	0.6288	A1
			(2) **Total 7**
6(a)	$\int_0^2 k(4x - x^3)\,dx = 1$	$\int f(x)dx = 1$, all correct	M1 A1
	$k\left[2x^2 - \frac{1}{4}x^4\right]_0^2 = 1$	[*]	A1
	$k(8 - 4) = 1$	cso	A1
	$k = \frac{1}{4}$		(4)
(b)	$E(X) = \int_0^2 x.\frac{1}{4}(4x - x^3)\,dx$	$\int xf(x)dx$	M1
	$= \left[\frac{1}{3}x^3 - \frac{1}{20}x^5\right]_0^2$	[*]	A1
	$= \frac{16}{15}$	1.07 or $1\frac{1}{15}$ or $\frac{16}{15}$ or $1.0\dot{6}$	A1 (3)
(c)	At mode, $f'(x) = 0$	Implied	M1
	$4 - 3x^2 = 0$	Attempt to differentiate	M1
	$x = \frac{2}{\sqrt{3}}$	$\sqrt{\frac{4}{3}}$ or 1.15 or $\frac{2}{\sqrt{3}}$ or $\frac{2\sqrt{3}}{3}$	A1 (3)
(d)	At median, $\int_0^x \frac{1}{4}\left(4t - t^3\right)dt = \frac{1}{2}$	$F(x) = \frac{1}{2}$ or $\int f(x)dx = \frac{1}{2}$	M1
	$\frac{1}{4}\left(2x^2 - \frac{1}{4}x^4\right) = \frac{1}{2}$	Attempt to integrate	M1
	$x^4 - 8x^2 + 8 = 0$		
	$x^2 = 4 \pm 2\sqrt{2}$	Attempt to solve quadratic	M1
	$x = 1.08$	Awrt 1.08	A1 (4)

(e)	mean (1.07) $<$ median (1.08) $<$ mode (1.15)	any pair	M1
	$\Rightarrow$ negative skew	cao	A1
			(2)
(f)		lines $x<0$ and $x>2$, labels, 0 and 2	B1
		negative skew between 0 and 2	B1 (2)
			Total 18
7 (a)	$X \sim B(10, p)$	Binomial (10, 0.75)	B1, B1 (2)
(b)	$P(X = 6) = 0.9219 - 0.7759$	$P(X \le 6) - P(X \le 5)$	M1
	$= 0.1460$	0.1460	A1 (2)
(c)	H_0: $p = 0.75$ (or $p = 0.25$)	Correct H_0	B1
	H_1: $p < 0.75$ (or $p > 0.25$)	One tailed H_1	B1
	Under H_0, $X \sim B(20, 0.75)$ (or $Y \sim B(20,0.25)$)	Implied	B1
	$P(X \le 13) = 1 - 0.7858 = 0.2142$ (or $P(Y \ge 7)$)	$P(X \le 13)$ and 1 - , 0.2142	M1, A1
	Insufficient evidence to reject H_0 as $0.2412 > 0.05$		
	Doctor's belief is not supported by the sample	Context	A1
	(OR CR $P(X \le 12) = 1 - 0.8982 = 0.1018$ (or $P(Y \ge 8)$)		(6)
	$P(X \le 11) = 1 - 0.9591 = 0.0409$ (or $P(Y \ge 9)$)	*either*	(*M1 A1*)
	13 outside critical region (or 7))		
(d)	$P(X \le c) \le 0.01$ for $p=0.75$		
	(or $P(Y \ge 20-c) \le 0.01$ for $p=0.25$)		M1 A1
	$P(X \le 9) = 1 - 0.9961 = 0.0039$ (or $P(Y \ge 11)$	0.9961 or 0.9981	B1
	$P(X \le 10) = 1 - 0.9861 = 0.0139$ (or $P(Y \ge 10)$	9	B1
	C. R. is [0,9], so greatest no. of patients is 9.		(4)
			Total 14

Question Number	Scheme		Marks
1.(a)	Let X be the random variable the number of heads.		
	$X \sim \text{Bin}(4, 0.5)$		
	$\text{P}(X = 2) = C_2^4 0.5^2 0.5^2$	Use of Binomial including ^nCr	M1
	$=0.375$	or equivalent	A1 (2)
(b)	$\text{P}(X = 4)$ or $\text{P}(X = 0)$		B1
	$= 2 \times 0.5^4$	$(0.5)^4$	M1
	$= 0.125$	or equivalent	A1 (3)
(c)	$\text{P(HHT)} = 0.5^3$	no ^nCr	M1
	$= 0.125$	or equivalent	A1 (2)
	or		
	P(HHTT) + P (HHTH) $= 2 \times 0.5^4$ $= 0.125$		
			Total 7 marks
	1a) 2,4,6 acceptable as use of binomial.		

Question Number	Scheme	Marks
2.(a)	Let X be the random variable the no. of accidents per week	
	X ~Po(1.5) — λ need poisson and must be in part (a)	B1 (1)
(b)	$P(X=2) = \frac{e^{-1.5}1.5^2}{2}$ — $\frac{e^{\mu}\mu^2}{2}$ or P(X≤ 2) - P(X≤ 1)	M1
	$= 0.2510$ — awrt 0.251	A1 (2)
(c)	$P(X \geq 1) = 1 - P(X=0) = 1 - e^{-1.5}$ — correct exp awrt 0.777	B1
	$= 0.7769$	
	P(at least 1 accident per week for 3 weeks)	
	$= 0.7769^3$ — $(p)^3$	M1
	$= 0.4689$ — awrt 0.469	A1 (3)
(d)	X ~ Po(3) — may be implied	B1
	$P(X > 4) = 1 - P(X \leq 4)$	M1
	$= 0.1847$ — awrt 0.1847	A1 (3)
		Total 9 marks
	c) The 0.7769 may be implied	

3.(a)	 -1,5 $\frac{1}{6}$	B1 B1 B1 (3)
(b)	$\mathrm{E}(X) = 2$ by symmetry	B1 (1)
(c)	$\mathrm{Var}(X) = \frac{1}{12}(5+1)^2$ or $\int \frac{x^2}{6}\,\mathrm{d}x - 4 = \left[\frac{x^3}{18}\right]_{-1}^{5} - 4$ $= 3$	M1 A1 (2)
(d)	$\mathrm{P}(-0.3 < X < 3.3) = \frac{3.6}{6}$ or $\int_{-0.3}^{3.3} \frac{1}{6}\mathrm{d}x = \left[\frac{x}{6}\right]_{-0.3}^{3.3}$ full correct method for the correct area $= 0.6$	M1 A1 (2)
		Total 8 marks

Question Number	Scheme	Marks
4.	X = Po (150 × 0.02) = Po (3) po,3	B1,B1(dep)
	$P(X > 7) = 1 - P(X \le 7)$	M1
	$= 0.0119$ awrt 0.0119	A1
	Use of normal approximation max awards B0 B0 M1 A0 in the use 1- p(x < 7.5)	
	$z = \frac{7.5-3}{\sqrt{2.94}}$ =2.62 $p(x>7) = 1 - p(x<7.5)$ $= 1 - 0.9953$ $= 0.0047$	**Total 4 marks**
5.(a)	$\int_2^3 kx(x-2)\mathrm{d}x = 1$ $\int f(x) = 1$	M1
	$\left[\frac{1}{3}kx^3 - kx^2\right]_2^3 = 1$ attempt $\int$ need either x^3 or x^2	M1
	correct $\int$	A1
	$(9k - 9k) - (\frac{8k}{3} - 4k) = 1$	
	$k = \frac{3}{4} = 0.75$ * cso	A1 (4)

Question Number	Scheme	Marks
(b)	$\mathrm{E}(X)=\int_2^3 \frac{3}{4}x^2(x-2)\mathrm{d}x$ attempt $\int xf\left(x\right)$	M1
	$=\left[\frac{3}{16}x^4-\frac{1}{2}x^3\right]_2^3$ correct $\int$	A1
	$=2.6875=2\frac{11}{16}=2.69$ (3sf) awrt 2.69	A1 (3)
(c)	$\mathrm{F}(x)=\int_2^x \frac{3}{4}(t^2-2t)\mathrm{d}t$ $\int \mathrm{f}(x)$ with variable limit or +C	M1
	$=\left[\frac{3}{4}\left(\frac{1}{3}t^3-t^2\right)\right]_2^x$ correct integral	A1
	lower limit of 2 or F(2) = 0 or F(3) =1	A1
	$=\frac{1}{4}(x^3-3x^2+4)$	A1
	$\mathrm{F}(x)=\begin{cases}0 & x\le 2\\ \frac{1}{4}(x^3-3x^2+4) & 2<x<3\\ 1 & x\ge 3\end{cases}$ middle, ends	B1✓,B1 (6)
(d)	$\mathrm{F}(x)=\frac{1}{2}$ $\frac{1}{4}(x^3-3x^2+4)=\frac{1}{2}$ their F(x) =1/2	M1
	$x^3-3x^2+2=0$ $x=2.75,\ x^3-3x^2+2>0$ $x=2.70,\ x^3-3x^2+2<0\Rightarrow$ root between 2.70 and 2.75 (or F(2.7)=0.453, F(2.75)=0.527 $\Rightarrow$ median between 2.70 and 2.75	M1 (2)
		Total 15 marks

6.(a)

X	1	2	5
P($X = x$)	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{6}$

Mean $= 1\times\frac{1}{2}+2\times\frac{1}{3}+5\times\frac{1}{6}=2$ or 0.02 $\Sigma\, x.p(x)$ need ½ and 1/3 M1A1

For M

Variance= $= 1^2\times\frac{1}{2}+2^2\times\frac{1}{3}+5^2\times\frac{1}{6}-2^2=2$ or 0.0002 M1A1

(4)

(b) $\Sigma x^2.p(x)-\lambda^2$

(1,1) B2
(1,2) and (2,1)
(1,5) and (5,1) LHS -1 B1
e.e. (3)
(2,2)
(2,5) and (5,2) repeat of "theirs" on RHS B1
(5,5)

(c)

$\bar{x}$	1	1.5	2	3	3.5	5
P($\bar{X} = \bar{x}$)	$\frac{1}{2}\times\frac{1}{2}=\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{3}\times\frac{1}{3}=\frac{1}{9}$	$\frac{1}{6}$	$2\times\frac{1}{3}\times\frac{1}{6}=\frac{1}{9}$	$\frac{1}{36}$

¼ M1A1

1.5+,-1ee M1A2

(6)

Total 13 marks

Two tail

7.(a)(i)	$H_0 : p = 0.2, H_1 : p \neq 0.2$ $p =$	B1B1
	$P(X \geq 9) = 1 - P(X \leq 8)$ or attempt critical value/region	M1
	$= 1 - 0.9900 = 0.01$ CR $X \geq 9$	
	0.01 < 0.025 or 9 ≥ 9 or 0.99 > 0.975 or 0.02 < 0.05 or lies in interval with correct interval stated.	A1
	Evidence that the percentage of pupils that read Deano is not 20%	A1
(ii)	X ~ Bin (20, 0.2) may be implied or seen in (i) or (ii)	B1
	So 0 or [9,20] make test significant. 0,9,between “their 9” and 20	B1B1B1 (9)
(b)	$H_0 : p = 0.2, H_1 : p \neq 0.2$	B1
	$W \sim$ Bin (100, 0.2)	
	$W \sim$ N (20, 16) normal; 20 and 16	B1; B1
	$P(X \leq 18) = P(Z \leq \frac{18.5 - 20}{4})$ or $\frac{x(+\frac{1}{2}) - 20}{4} = \pm 1.96$ ± cc, standardise or use z value, standardise	M1M1A1
	$= P(Z \leq -0.375)$	
	$= 0.352 - 0.354$ CR $X < 12.16$ or 11.66 for ½	A1
	[0.352 >0.025 or 18 > 12.16 therefore insufficient evidence to reject H_0]	
	Combined numbers of Deano readers suggests 20% of pupils read Deano	A1 (8)
(c)	Conclusion that they are different.	B1
	Either large sample size gives better result Or Looks as though they are not all drawn from the same population.	B1 (2)
		Total 19 marks
	One tail	
7(a)(i)	$H_0 : p = 0.2, \quad H_1 : p > 0.2$	B1B0

	$P(X \ge 9) = 1 - P(X \le 8)$ or attempt critical value/region	M1
	$= 1 - 0.9900 = 0.01$ CR $X \ge 8$	A0
	0.01 < 0.05 or 9 $\ge$ 8 (therefore Reject H_0,)evidence that the percentage of pupils that read Deano is not 20%	A1
(ii)	X ~ Bin (20, 0.2) may be implied or seen in (i) or (ii)	B1
	So 0 or [8,20] make test significant. 0,9,between “their 8” and 20	B1B0B1 (9)
(b)	$H_0 : p = 0.2$, $H_1 : p < 0.2$	B1 √
	$W \sim \text{Bin}(100, 0.2)$	
	$W \sim N(20, 16)$ normal; 20 and 16	B1; B1
	$P(X \le 18) = P(Z \le \frac{18.5 - 20}{4})$ or $\frac{x - 20}{4} = -1.6449$ ± cc, standardise or standardise, use z value	M1M1A1
	$= P(Z \le -0.375)$	
	$= 0.3520$ CR $X < 13.4$ or 12.9 awrt 0.352	A1
	[0.352 >0.05 or 18 > 13.4 therefore insufficient evidence to reject H_0]	
	Combined numbers of Deano readers suggests 20% of pupils read Deano	A1 (8)
(c)	Conclusion that they are different.	B1
	Either large sample size gives better result Or Looks as though they are not all drawn from the same population.	B1 (2)
		Total 19 marks

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GCE

Edexcel GCE

Statistics S2 (6684)

June 2006

advancing learning, changing lives

Mark Scheme

(Results)

Edexcel GCE
Statistics S2 (6684)

June
6684 Statistics S2
Mark Scheme

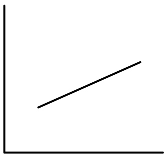
Question Number	Scheme	Marks
1.(a)	Saves time / cheaper / easier any one or A census/asking all members takes a long time or is expensive or difficult to carry out	B1 (1)
(b)	List, register or database of all club members/golfers or Full membership list	B1 (1)
(c)	Club member(s)	B1 (1)
2.(a)	$P(L < -2.6) = 1.4 \times \frac{1}{8} = \frac{7}{40}$ or 0.175 or equivalent	B1 (1)
(b)	$P(L < -3.0 \text{ or } L > 3.0) = 2 \times \left(1 \times \frac{1}{8}\right) = \frac{1}{4}$ M1 for 1/8 seen	M1;A1 (2)
(c)	$P(\text{within 3mm}) = 1 - \frac{1}{4} = 0.75$ B(20,0.75) recognises binomial	B1
	Using B(20,p)	M1
	Let X represent number of rods within 3mm	
	$P(X \le 9 / p = 0.25)$ or $1 - P(X \le 10 / p = 0.75)$	M1
	$= 0.9861$ awrt 0.9861	A1 (4)

Question Number	Scheme	Marks
3.	Let X represent the number of properties sold in a week	
a)	$\therefore\ X \sim \text{P}_o(7)$ must be in part a	B1
	Sales occur independently/randomly, singly, at a constant rate context needed once	B1 B1 (3)
b)	$\text{P}\ (\ X = 5\ ) = \text{P}(X\ \le\ 5)\ -\ \text{P}(X \le 4)$ or $\dfrac{7^5 \text{e}^{-7}}{5!}$	M1
	$=\ \ 0.3007 - 0.1730$ $= 0.1277$ awrt 0.128	A1 (2)
c)	$\text{P}\ (\ X > 181\ ) \approx \text{P}\ (\ Y \ge\ 181.5\ )$ where $Y \sim \text{N}\ (\ 168,\ 168)$ N (168, 168)	B1
	$= \ \text{P}\left(\text{z} \ge \dfrac{181.5-168}{\sqrt{168}}\right)$ $\pm\,0.5$ stand with μ and σ	M1 M1
	Give A1 for 1.04 or correct expression $= \text{P}\ \left(\text{z} \ge 1.04\right)$	A1
	$= 1 - 0.8508$ attempt correct area 1-p where $p > 0.5$	M1
	$= 0.1492$ awrt 0.149	A1 (6)

Question Number	Scheme	Marks
4.	Let X represent the number of breakdowns in a week.	
a)	$X \sim \mathrm{P_o}\,(1.25)$ implied	B1
	$\mathrm{P}\,(X < 3) = \mathrm{P}\,(0) + \mathrm{P}(1) + \mathrm{P}(2)$ or $\mathrm{P}\,(X \leq 2)$	M1
	$= \mathrm{e}^{-1.25}\left(1+1.25+\frac{(1.25)^2}{2!}\right)$	A1
	$= 0.868467$……. awrt 0.868 or 0.8685	A1 (4)
b)	$\mathrm{H_0}: \lambda = 1.25$; $\mathrm{H_1}: \lambda \neq 1.25$ (or $\mathrm{H_0}: \lambda = 5$; $\mathrm{H_1}: \lambda \neq 5$) λ or μ	B1 B1
	Let Y represent the number of breakdowns in 4 weeks	
	Under $\mathrm{H_0}$, $Y \sim \mathrm{P_0}(5)$ may be implied	B1
	$\mathrm{P}\,(Y \geq 11) = 1 - \mathrm{P}(Y \leq 10)$ or $\mathrm{P}(X \geq 11) = 0.0137$ One needed for M $\mathrm{P}(X \geq 10) = 0.0318$	M1
	$= 0.0137$ CR $X \geq 11$	A1
	$0.0137 < 0.025$, $0.0274 < 0.05$, $0.9863 > 0.975$, $0.9726 > 0.95$ or $11 \geq 11$ any .allow %	M1
	Evidence that the rate of breakdowns has changed /decreased √ from $\mathrm{H_1}$ context From their p	B1√ (7)

Question Number	Scheme	Marks
5. (a)	Binomial	B1 (1)
	Let X represent the number of green mugs in a sample	
(b)	$X \sim B(10, 0.06)$ may be implied or seen in part a	B1
	$P(X = 3) = {}^{10}C_3(0.06)^3(0.94)^7$ ${}^{10}C_3(p)^3(1-p)^7$	M1
	$= 0.016808\ldots$ awrt 0.0168	A1 (3)
(c)	Let X represent number of green mugs in a sample of size 125	
(i)	$X \sim P_0(125 \times 0.06 = 7.5)$ may be implied	B1
	$P(10 \le X \le 13) = P(X \le 13) - P(X \le 9)$	M1
	$= 0.9784 - 0.7764$	
	$= 0.2020$ awrt 0.202	A1 (3)
(ii)	$P(10 \le X \le 13) \approx P(9.5 \le Y \le 13.5)$ where $Y \sqcup N(7.5, 7.05)$ 7.05	B1
	9.5, 13.5	B1
	$= P\left(\frac{9.5-7.5}{\sqrt{7.05}} \le z \le \frac{13.5-7.5}{\sqrt{7.05}}\right)$ ± 0.5 stand.	M1 M1
	both values or both correct expressions.	
	$= P(0.75 \le z \le 2.26)$ awrt 0.75 and 2.26	A1
	$= 0.2147$ awrt 0.214or 0.215	A1 (6)

Question Number	Scheme		Marks	
6a)	$\int_1^4 \frac{1+x}{k}dx = 1$	$\int f(x)=1$ Area = 1	M1	
	$\therefore \left[\frac{x}{k}+\frac{x^2}{2k}\right]_1^4 = 1$	correct integral/correct expression	A1	
	$k=\frac{21}{2}$ *	cso	A1	
				(3)
(b)	$P(X \le x_0) = \int_1^{x_0} \frac{2}{21}(1+x)$	$\int f(x)$ variable limit or +C	M1	
	$=\left[\frac{2x}{21}+\frac{x^2}{21}\right]_1^{x_0}$	correct integral + limit of 1 May have k in	A1	
	$=\frac{2x_0+x_0{}^2-3}{21}$ or $\frac{(3+x)(x-1)}{21}$		A1	
	$F(x) = \begin{cases} 0, & x<1 \\ \frac{x^2+2x-3}{21} & 1 \le x < 4 \\ 1 & x \ge 4 \end{cases}$	middle; ends	B1√; B1	
				(5)
(c)	$E(X) = \int_1^4 \frac{2x}{21}(1+x)dx$	valid attempt $\int xf(x)$	M1	
		x^2 and x^3		
	$=\left[\frac{x^2}{21}+\frac{2x^3}{63}\right]_1^4$	correct integration	A1	
	$=\frac{171}{63}=2\frac{5}{7}=\frac{19}{7}=2.7142....$	awrt 2.71	A1	
				(3)

Question Number	Scheme	Marks
(d)	$F(m) = 0.5 \;\Rightarrow \frac{x^2+2x-3}{21} = \frac{1}{2}$ putting their F(x) = 0.5	M1
	$\therefore 2x^2+4x\text{-}27=0$ or equiv	
	$\therefore x = \frac{-4\pm\sqrt{16-4.2(-27)}}{4}$ attempt their 3 term quadratic	M1
	$\therefore x = -1 \pm 3.8078...$	
	i.e. $x = 2.8078…$ awrt 2.81	A1 (3)
e)	Mode = 4	B1 (1)
f)	Mean < median < mode (⇒ negative skew) allow numbers in place of words Or Mean < median	B1 (1)
	 w diagram but line must not cross y axis	

Question Number	Scheme	Marks
7.a)	Let X represent the number of bowls with minor defects.	
	$\therefore X \sim B;(25, 0.20)$ may be implied	B1; B1
	$P\left(X \le 1\right) = 0.0274$ or $P(X = 0) = 0.0038$ need to see at least one. prob for $X \le$ no For M1	M1A1
	$P\left(X \le 9\right) = 0.9827; \Rightarrow P\left(X \ge 10\right) = 0.0173$ either	A1
	$\therefore$ CR is $\left\{X \le 1 \cup X \ge 10\right\}$	A1 (6)
b)	Significance level = 0.0274 + 0.0173	
	= 0.0447 or 4.477% awrt 0.0447	B1 (1)
c)	$H_0 : p = 0.20$; $H_1 : p < 0.20$;	B1 B1
	Let Y represent number of bowls with minor defects	
	Under H_0 $Y \sim B$ (20, 0.20) may be implied	B1
	$P (Y \le 2)$ or $P(Y \le 2) = 0.2061$ $P(Y \le 1) = 0.0692$ either	M1
	= 0.2061 CR $Y \le 1$	A1
	$0.2061 > 0.10$ or $0.7939 < 0.9$ or $2 > 1$ their p	M1
	Insufficient evidence to suggest that the proportion of defective bowls has decreased.	B1√ (7)

Mark Scheme (Results)
January 2007

GCE

GCE Mathematics

Statistics S2 (6684)

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January 2007
6684 Statistics S2
Mark Scheme

Question Number	Scheme	Marks
1. (a)	A random variable; function of known observations (from a population). data OK	B1 B1 (2)
(b) (i)	Yes	B1 (1)
(ii)	No	B1 (1)
		Total 4
2. (a)	$P(J \geq 10) = 1 - P(J \leq 9)$ or $=1-P(J<10)$	M1
	$= 1 - 0.9919$ implies method	
	$= 0.0081$ awrt 0.0081	A1 (2)
(b)	$P(K \leq 1) = P(K = 0) + P(K = 1)$ both, implied below even with '25' missing	M1
	$= (0.73)^{25} + 25(0.73)^{24}(0.27)$ clear attempt at '25' required	M1
	$= 0.00392$ awrt 0.0039 implies M	A1 (3)
		Total 5

Question Number	Scheme	Marks
3.		
(a)	Let W represent the number of white plants.	
	$W \sim B(12,0.45)$ use of	**B1**
	$P(W = 5) = P(W\le 5) - P(W\le 4)$ ${}^{12}C_5 0.45^5 0.55^7$ or equivalent award B1M1	**M1**
	$= 0.5269 - 0.3044$ values from correct table implies B	
	$= 0.2225$ awrt 0.222(5)	**A1**
		(3)
(b)	$P(W \ge 7) = 1 - P(W \le 6)$ or $=1-P(W<7)$	**M1**
	$= 1 - 0.7393$ implies method	
	$= 0.2607$ awrt 0.261	**A1**
		(2)
(c)	P(3 contain more white than coloured)$=\frac{10!}{3!7!}(0.2607)^3(1-0.2607)^7$ use of B,n=10	**M1A1∫**
	$= 0.256654\ldots$ awrt 0.257	**A1**
		(3)
(d)	mean = np = 22.5 ; var = npq = 12.375	**B1B1**
	$P(W > 25) \approx P\left(Z > \frac{25.5 - 22.5}{\sqrt{12.375}}\right)$ ± standardise with σ and μ; ±0.5 c.c.	**M1;M1**
	$\approx P(Z > 0.8528..)$ awrt 0.85	**A1**
	$\approx 1 - 0.8023$ ‘one minus‘	**M1**
	≈ 0.1977 awrt 0.197 or 0.198	**A1**
		(7)
		Total 15

Question Number	Scheme		Marks
4. (a)	$\lambda > 10$ or large	μ ok	**B1** **(1)**
(b)	The Poisson is discrete and the normal is continuous.		**B1** **(1)**
(c)	Let *Y* represent the number of yachts hired in winter		
	$P(Y<3) = P(Y \leqslant 2)$	$P(Y \leqslant 2)$ & Po(5)	**M1**
	$= 0.1247$	awrt 0.125	**A1** **(2)**
(d)	Let *X* represent the number of yachts hired in summer X~Po(25).		
	N(25,25)	all correct, can be implied by standardisation below	**B1**
	$P(X > 30) \approx P\left(Z > \frac{30.5 - 25}{5}\right)$	± standardise with 25 & 5; ±0.5 c.c.	**M1;M1**
	$\approx P(Z > 1.1)$	1.1	**A1**
	$\approx 1 - 0.8643$	'one minus'	**M1**
	≈ 0.1357	awrt 0.136	**A1** **(6)**
(e)	no. of weeks $= 0.1357 \times 16$	ANS (d)x16	**M1**
	$= 2.17$ or 2 or 3	ans>16 M0A0	**A1∫** **(2)**
			Total 12

Question Number	Scheme	Marks
5.		
(a)	f(x) = $\begin{cases}\dfrac{1}{\beta-\alpha}, & \alpha<x<\beta,\\ 0, & \text{otherwise.}\end{cases}$ function including inequality, 0 otherwise	**B1,B1**
		(2)
(b)	$\dfrac{\alpha+\beta}{2}=2$, $\dfrac{3-\alpha}{\beta-\alpha}=\dfrac{5}{8}$ or equivalent	**B1,B1**
	$\alpha+\beta=4$ $3\alpha+5\beta=24$	
	$3(4-\beta)+5\beta=24$ $2\beta=12$ $\beta=6$ attempt to solve 2 eqns	**M1**
	α = -2 both	**A1** **(4)**
(c)	E(X) = $\dfrac{150+0}{2}=75\,\text{cm}$ 75	**B1** **(1)**
(d)	Standard deviation = $\sqrt{\dfrac{1}{12}(150-0)^2}$	**M1**
	= 43.30127…cm $25\sqrt{3}$ or awrt 43.3	**A1** **(2)**
(e)	P$(X<30)$ + P$(X>120)$ = $\dfrac{30}{150}+\dfrac{30}{150}$ 1st or at least one fraction, + or double	**M1,M1**
	$=\dfrac{60}{150}$ or $\dfrac{2}{5}$ or 0.4 or equivalent fraction	**A1**
		(3)
		Total 12

Question Number	Scheme	Marks
6. (a)	$H_0 : p = 0.20$, $H_1 : p < 0.20$	**B1,B1**
	Let X represent the number of people buying family size bar. $X \sim B(30, 0.20)$	
	$P(X \leqslant 2) = 0.0442$ or $P(X \leqslant 2) = 0.0442$ awrt 0.044 $P(X \leqslant 3) = 0.1227$ CR $X \leqslant 2$	**M1A1**
	0.0442 < 5%, so significant. Significant	**M1**
	There is evidence that the no. of family size bars sold is lower than usual.	**A1** **(6)**
(b)	$H_0 : p = 0.02$, $H_1 : p \neq 0.02$ $\lambda = 4$ etc ok both	**B1**
	Let Y represent the number of gigantic bars sold.	
	$Y \sim B(200, 0.02) \Rightarrow Y \sim Po(4)$ can be implied below	**M1**
	$P(Y = 0) = \mathbf{0.0183}$ and $P(Y \leqslant 8) = \mathbf{0.9786} \Rightarrow P(Y \geqslant 9) = \mathbf{0.0214}$ first, either	**B1,B1**
	Critical region $Y = 0 \cup Y \geqslant 9$ $Y \leq 0$ ok	**B1,B1**
	N.B. Accept exact Bin: 0.0176 and 0.0202	
(c)	Significance level = 0.0183 + 0.0214 = 0.0397 awrt 0.04	**B1** **(1)**
		Total 13

Question Number	Scheme	Marks
7. (a)	$1 - \text{F}(0.3) = 1 - (2 \times 0.3^2 - 0.3^3)$ ‘one minus’ required	**M1**
	$= 0.847$	**A1** **(2)**
(b)	$\text{F}(0.60) = 0.5040$ $\text{F}(0.59) = 0.4908$ both required awrt 0.5, 0.49	**M1A1**
	0.5 lies between therefore median value lies between 0.59 and 0.60.	**B1** **(3)**
(c)	$\text{f}(x) = \begin{cases} -3x^2 + 4x, & 0 \le x \le 1, \\ 0\ , & \text{otherwise.} \end{cases}$ attempt to differentiate, all correct	**M1A1** **(2)**
(d)	$\int_0^1 x\text{f}(x)\text{d}x = \int_0^1 -3x^3 + 4x^2 \text{d}x$ attempt to integrate $x\text{f}(x)$	**M1**
	$= \left[\frac{-3x^4}{4} + \frac{4x^3}{3} \right]_0^1$ sub in limits	**M1**
	$= \frac{7}{12}$ or $0.58\dot{3}$ or 0.583 or equivalent fraction	**A1** **(3)**
(e)	$\frac{\text{df}(x)}{\text{d}x} = -6x + 4 = 0$ attempt to differentiate f(x) and equate to 0	**M1**
	$x = \frac{2}{3}$ or $0.\dot{6}$ or 0.667	**A1** **(2)**
(f)	mean < median < mode, therefore negative skew. Any pair, cao	**B1,B1** **(2)**
		Total 14

Mark Scheme (Results)

Summer 2007

GCE

GCE Mathematics

Statistics S2 (6684)

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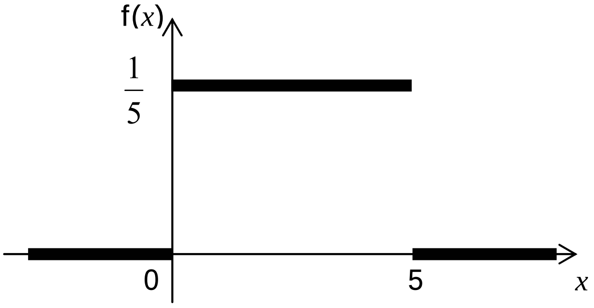
June 2007
6684 Statistics S2
Mark Scheme

Question Number	Scheme	Marks
1(a)	Continuous uniform distribution *or* rectangular distribution.	B1
	 1/5,(0),5 0 may be implied by start at y axis	B1
		B1
		(3)
(b)	$\text{E}(X) = 2.5$ ft from their a and b, must be a number	B1ft
	$\text{Var}(X) = \frac{1}{12}(5-0)^2$ or attempt to use $\int_0^5 \text{f}(x)x^2\text{d}x - \mu^2$ use their f(x)	M1
	$= \frac{25}{12}$ or 2.08 o.e awrt 2.08	A1
		(3)
(c)	$\text{P}(X > 3) = \frac{2}{5} = 0.4$ 2 times their 1/5 from diagram	B1ft (1)
(d)	$\text{P}(X = 3) = 0$	B1 (1)
		(Total 8)

Question Number	Scheme			Marks
2	<u>One tail test</u> <u>Method 1</u>			
	$H_o : \lambda = 5$ ($\lambda = 2.5$)		may use λ or μ	B1
	$H_1 : \lambda > 5$ ($\lambda > 2.5$)			B1
	$X \sim \text{Po}(2.5)$		may be implied	M1
	$P(X \geq 7) = 1 - P(X \leq 6)$ $= 1 - 0.9858$	[$P(X \geq 5) = 1 - 0.8912 = 0.1088$] $P(X \geq 6) = 1 - 0.9580 = 0.0420$	att $P(X \geq 7)$ $P(X \geq 6)$	M1
	$= 0.0142$	CR $X \geq 6$	awrt 0.0142	A1
	$0.0142 < 0.05$	$7 \geq 6$ or 7 is in critical region or 7 is significant		M1
	(Reject H_0.) There is significant evidence at the 5% significance level that the factory <u>is polluting the river</u> with bacteria. **<u>or</u>** The scientists claim is justified			B1 (7) Total 7
	<u>Method 2</u>			
	$H_o : \lambda = 5$ ($\lambda = 2.5$)		may use λ or μ	B1
	$H_1 : \lambda > 5$ ($\lambda > 2.5$)			B1
	$X \sim \text{Po}(2.5)$		may be implied	M1
	$P(X < 7)$	[$P(X < 5) = 0.8912$] $P(X < 6) = 0.9580$	att $P(X < 7)$ $P(X < 6)$	
	$= 0.9858$	CR $X \geq 6$	wrt 0.986	M1 A1
	$0.9858 > 0.95$	$7 \geq 6$ or 7 is in critical region or 7 is significant		M1
	(Reject H_0.) There is significant evidence at the 5% significance level that the factory <u>is polluting the river</u> with bacteria. **<u>or</u>** The scientists claim is justified			B1 (7)

	Two tail test Method 1				
					B1
	$H_o : \lambda = 5$ ($\lambda = 2.5$)		may use λ or μ		B0
	$H_1 : \lambda \neq 5$ ($\lambda \neq 2.5$)				
					M1
	$X \sim \text{Po}(2.5)$				
					M1
	$P(X \geq 7) = 1 - P(X \leq 6)$	[$P(X \geq 6) = 1 - 0.9580 = 0.0420$]	att $P(X \geq 7)$	$P(X \geq 7)$	
	$= 1 - 0.9858$	$P(X \geq 7) = 1 - 0.9858 = 0.0142$			
					A1
	$= 0.0142$	CR $X \geq 7$	awrt 0.0142		
					M1
	$0.0142 < 0.025$	$7 \geq 7$ or 7 is in critical region or 7 is significant			
					B1
	(Reject H_0.) There is significant evidence at the 5% significance level that the factory is polluting the river with bacteria. **or** The scientists claim is justified				(7)
	Method 2				B1
	$H_o : \lambda = 5$ ($\lambda = 2.5$)		may use λ or μ		B0
	$H_1 : \lambda \neq 5$ ($\lambda \neq 2.5$)				
					M1
	$X \sim \text{Po}(2.5)$				
	$P(X < 7)$	[$P(X < 6) = 0.9580$]	att $P(X < 7)$	$P(X < 7)$	
		$P(X < 7) = 0.9858$			
					M1A1
	$= 0.9858$	CR $X \geq 7$	awrt 0.986		
					M1
	$0.9858 > 0.975$	$7 \geq 7$ or 7 is in critical region or 7 is significant			
					B1
	(Reject H_0.) There is significant evidence at the 5% significance level that the factory is polluting the river with bacteria. **or** The scientists claim is justified				(7)

Question Number	Scheme		Marks
3(a)	$X \sim \text{Po}\ (1.5)$	need Po and 1.5	B1 (1)
(b)	<u>Faulty</u> components occur at a constant rate. <u>Faulty</u> components occur independently or randomly. <u>Faulty</u> components occur singly.	any two of the 3 only need faulty once	B1 B1 (2)
(c)	$\text{P}(X = 2) = \ \text{P}(X \leq 2) - \text{P}(X \leq 1)$ or $\dfrac{\text{e}^{-1.5}(1.5)^2}{2}$		M1
	$= 0.8088 - 0.5578$		
	$= 0.251$	awrt 0.251	A1 (2)
(d)	$X \sim \text{Po}(4.5)$	4.5 may be implied	B1
	$\text{P}(X \geq 1) = \ 1 - \text{P}(X = 0)$		M1
	$= \ 1 - \text{e}^{-4.5}$		
	$= \ 1 - 0.0111$		
	$= \ 0.9889$	awrt 0.989	A1 (3)
			Total 8

Question Number	Scheme	Marks
4	Attempt to write down combinations at least one seen	M1
	(5,5,5), (5,5,10) any order (10,10,5) any order, (10,10,10)	A1
	(5,10,5), (10,5,5), (10,5,10), (5,10,10), all 8 cases considered. May be implied by 3 * (10,5,10) and 3 * (5,5,10)	A1
	median 5 and 10	B1
	Median = 5 P(M = m) = $\left(\frac{1}{4}\right)^3 + 3\left(\frac{1}{4}\right)^2\left(\frac{3}{4}\right) = \frac{10}{64}$ = 0.15625 add at least two prob using ¼ and ¾. identified by having same median of 5 or 10 Allow no 3 for M	M1 A1
	Median = 10 P(M = m) = $\left(\frac{3}{4}\right)^3 + 3\left(\frac{3}{4}\right)^2\left(\frac{1}{4}\right) = \frac{54}{64}$ = 0.84375	A1
		(7) Total 7

Question Number	Scheme	Marks
5(a)	If $X \sim B(n,p)$ and	
	n is large, $n > 50$	B1
	p is small, $p < 0.2$	B1
	then X can be approximated by $Po(np)$	
		(2)
(b)	P(2 consecutive calls) $= 0.01^2$	M1
	$= 0.0001$	A1
		(2)
(c)	$X \sim B(5, 0.01)$ may be implied	B1
	$P(X > 1) = 1 - P(X = 1) - P(X = 0)$	M1
	$= 1 - 5(0.01)(0.99)^4 - (0.99)^5$	
	$= 1 - 0.0480298\ldots - 0.95099\ldots$	
	$= 0.00098$ awrt 0.00098	A1
		(3)
(d)	$X \sim B(1000, 0.01)$ may be implied by correct mean and variance	B1
	Mean $= np = 10$	B1
	Variance $= np(1 - p) = 9.9$	B1
		(3)
(e)	$X \sim Po(10)$	
	$P(X > 6) = 1 - P(X \leq 6)$	M1
	$= 1 - 0.1301$	
	$= 0.8699$ awrt 0.870	A1
		(2)
		Total 12

Question Number	Scheme			Marks
6	One tail test Method 1			
	$H_o : p = 0.2$			B1
	$H_1 : p > 0.2$			B1
	$X \sim B(5, 0.2)$		may be implied	M1
	$P(X \geq 3) = 1 - P(X \leq 2)$ $= 1 - 0.9421$	$[P(X \geq 3) = 1 - 0.9421 = 0.0579]$ $P(X \geq 4) = 1 - 0.9933 = 0.0067$	att $P(X \geq 3)$ $P(X \geq 4)$	M1
	$= 0.0579$	CR $X \geq 4$	awrt 0.0579	A1
	$0.0579 > 0.05$	$3 \leq 4$ or 3 is not in critical region or 3 is not significant		M1
	(Do not reject H_0.) There is insufficient evidence at the 5% significance level that there is an increase in the number of times the taxi/driver is late. **Or** Linda's claim is not justified			B1 (7) Total 7
	Method 2			
	$H_o : p = 0.2$			B1
	$H_1 : p > 0.2$			B1
	$X \sim B(5, 0.2)$		may be implied	M1
	$P(X < 3) =$	$[P(X < 3) = 0.9421]$ $P(X < 4) = 0.9933$	att $P(X < 3)$ $P(X < 4)$	
	0.9421	CR $X \geq 4$	awrt 0.942	M1A1
	$0.9421 < 0.95$	$3 \leq 4$ or 3 is not in critical region or 3 is not significant		M1
	(Do not reject H_0.) There is insufficient evidence at the 5% significance level that there is an increase in the number of times the taxi/driver is late. **Or** Linda's claim is not justified			B1 (7)

Two tail test

Method 1 B1

$H_o : p = 0.2$ B0

$H_1 : p \neq 0.2$

M1

$X \sim X \sim B(5, 0.2)$ may be implied

M1

$P(X \geq 3) = 1 - P(X \leq 2)$	$[P(X \geq 3) = 1 - 0.9421 = 0.0579]$	att $P(X \geq 3)$ | $P(X \geq 4)$
$= 1 - 0.9421$	$P(X \geq 4) = 1 - 0.9933 = 0.0067$	
$= 0.0579$	CR $X \geq 4$	awrt 0.0579
$0.0579 > 0.025$	$3 \leq 4$ or 3 is not in critical region or 3 is not significant	

A1

M1

B1

(Do not reject H_0.) There is insufficient evidence at the 5% significance level that there is an increase in the number of times the taxi/driver is late.
Or Linda's claim is not justified (7)

B1

Method 2 B0

$H_o : p = 0.2$

$H_1 : p \neq 0.2$ M1

$X \sim X \sim B(5, 0.2)$ may be implied

$P(X < 3) =$	$[P(X < 3) = 0.9421]$	att $P(X < 3)$ | $P(X < 4)$
	$P(X < 4) = 0.9933$	
0.9421	CR $X \geq 4$	awrt 0.942
$0.9421 < 0.975$	$3 \leq 4$ or 3 is not in critical region or 3 is not significant	

M1A1

M1

B1

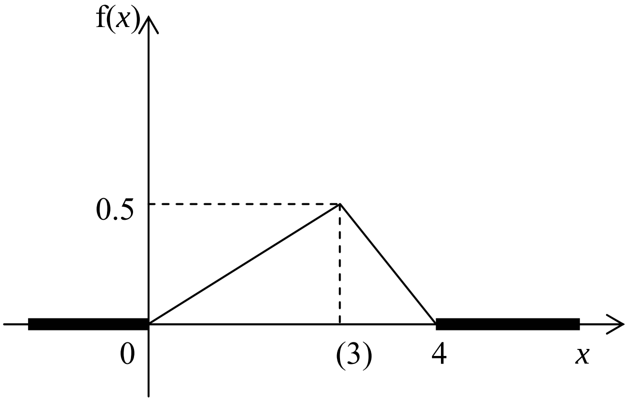
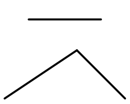
Do not reject H_0. There is insufficient evidence at the 5% significance level that there is an increase in the number of times the taxi/driver is late.
Or Linda's claim is not justified (7)

Special Case

If they use a probability of $\frac{1}{7}$ throughout the question they may gain B1 B1 M0 M1 A0 M1 B1.

NB they must attempt to work out the probabilities using $\frac{1}{7}$

Question Number	Scheme	Marks
7(a) i	If $X \sim \mathrm{B}(n,p)$ and	
	n is large or $n > 10$ **or** $np > 5$ **or** $nq > 5$	B1
	p is close to 0.5 **or** $nq > 5$ and $np > 5$	B1
	then X can be approximated by $\mathrm{N}(np, np(1-p))$	
		(2)
ii	mean = np	B1
	variance = $np(1-p)$ must be in terms of p	B1
		(2)
(b)	$X \sim \mathrm{N}(60, 58.2)$ or $X \sim \mathrm{N}(60, 7.63^2)$ 60, 58.2	B1, B1
	$\mathrm{P}(X \geq 40) = \mathrm{P}(X > 39.5)$ using 39.5 or 40.5	M1
	$= 1 - \mathrm{P}\left(z < \pm\left(\dfrac{39.5-60}{\sqrt{58.2}}\right)\right)$ standardising 39.5 or 40 or 40.5 and their μ and σ	M1
	$= 1 - \mathrm{P}(z < -2.68715\ldots)$	
	$= 0.9965$ allow answers in range 0.996 – 0.997	A1dep on both M
		(5)
(c)	$\mathrm{E}(X) = 60$ may be implied or ft from part (b)	B1ft
	Expected profit = $(2000 - 60) \times 11 - 2000 \times 0.70$	M1
	= £19 940.	A1
		(3) Total 12

Question Number	Scheme		Marks
8(a)		(0), 4, 0.5 0 may be implied by start at y axis	B1
		both patio  must be straight	B1 B1
			(3)
(b)	Mode is $x = 3$		B1
			(1)
(c)	$F(x) = \int_0^x \frac{1}{6}t \text{ dt}$ (for $0 \le x \le 3$)	ignore limits for M	M1
	$= \frac{1}{12}x^2$	must use limit of 0	A1
	$F(x) = \int_3^x 2 - \frac{1}{2}t \text{ dt}; + \int_0^3 \frac{1}{6}t \text{ dt}$ (for $3 < x \le 4$)	need limit of 3 and variable upper limit; need limit 0 and 3	M1; M1
	$= 2x - \frac{1}{4}x^2 - 3$		A1
	$$F(x)\begin{cases} 0 & x < 0 \\ \frac{1}{12}x^2 & 0 \le x \le 3 \\ 2x - \frac{1}{4}x^2 - 3 & 3 < x \le 4 \\ 1 & x > 4 \end{cases}$$	middle pair ends	B1 ft B1
(d)			(7)
	F(m) = 0.5	either eq	M1
	$\frac{1}{12}x^2 = 0.5$	eq for their $0 \le x \le 3$	A1ft
	$x = \sqrt{6} = 2.45$	$\sqrt{6}$ or awrt 2.45	A1
			(3) Total 14

Mark Scheme (Results)
January 2008

GCE

GCE Mathematics (6684/01)

January 2008
Statistics S2
Mark Scheme

Question Number	Scheme	Marks
1. (a)	A census is when <u>every member</u> of the <u>population</u> is investigated.	B1
(b)	There would be no cookers left to sell.	B1
(c)	A list of the unique identification numbers of the cookers.	B1
(d)	A cooker	B1
		(4)
Notes		
1. (a)	**B1** Need one word from each group (1) <u>Every member /all items / entire /oe</u> (2) <u>population/collection of individuals/sampling frame/oe</u> enumerating the population on its own gets B0	
(b)	**B1** Idea of Tests to destruction. Do not accept cheap or quick	
(c)	**B1** Idea of list/ register/database of cookers/serial numbers	
(d)	**B1** cooker(s) / serial number(s) The sample of 5 cookers or every 400th cooker gets B1	

2 (a)	Let X be the random variable the number of faulty bolts	M1
	$P(X \leq 2)$ - $P(X \leq 1) = 0.0355 - 0.0076$ or $(0.3)^2(0.7)^{18}\frac{20!}{18!2!}$	A1 (2)
	$= 0.0279$ $= 0.0278$	M1 A1
(b)	$1 - P(X \leq 3) = 1 - 0.1071$ $= 0.8929$	(2)
	or $1-(0.3)^3(0.7)^{17}\frac{20!}{17!3!}-(0.3)^2(0.7)^{18}\frac{20!}{18!2!}-(0.3)(0.7.)^{19}\frac{20!}{19!1!}-(0.7)^{20}$	M1A1√A1
(c)	$\frac{10!}{4!6!}(0.8929)^6(0.1071)^4 = 0.0140.$	(3)
Notes:		
2. (a)	**M1** Either attempting to use P ($X \leq 2$) – P ($X \leq 1$) or attempt to use binomial and find p(X = 2). Must have $(p)^2(1-p)^{18}\frac{20!}{18!2!}$, with a value of p	
	A1 awrt 0.0278 or 0.0279.	
(b)	**M1** Attempting to find $1 - P(X \leq 3)$	
	A1 awrt 0.893	
(c)	**M1** for $k\ (p)^6(1-p)^4$. They may use any value for p and k can be any number or ${}^{n}C_{6}p^{6}(1-p)^{n-6}$	
	A1√ $\frac{10!}{4!6!}(their\ part\ b)^6(1-their\ part\ b)^4$ may write ${}^{10}C_6$or ${}^{10}C_4$	
	A1 awrt 0.014	
		B1 B1 (2)

3. (a)		
	Events occur at a constant rate. any two of the 3	
	Events occur independently or randomly.	B1
	Events occur singly.	
(b)		M1
	Let X be the random variable the number of cars passing the observation point.	A1
(i)		
	Po(6)	M1
	$P(X \le 4) - P(X \le 3) = 0.2851 - 0.1512$ or $\frac{e^{-6}6^4}{4!}$	A1
	$= 0.1339$	
		(5)
		B1
(ii)	$1 - P(X \le 4) = 1 - 0.2851$ or $1 - e^{-6}\left(\frac{6^4}{4!}+\frac{6^3}{3!}+\frac{6^2}{2!}+\frac{6}{1!}+1\right)$	M1 A1
	$= 0.7149$	
(c)		A1
	P (0 car and 1 others) + P (1 cars and 0 other)	(4)
	$= e^{-1} \text{ x } 2e^{-2} + 1e^{-1} \text{ x } e^{-2}$	
	$= 0.3679 \text{ x } 0.2707 + 0.3674 \text{ x } 0.1353$	
	$= 0.0996 + 0.0498$	
	$= 0.149$	
	alternative	
	$P_o(1+2) = P_o(3)$ B1	
	$P(X=1) = 3e^{-3}$ M1 A1	
	$= 0.149$ A1	
Notes 3(a)	**B1 B1** Need the word events at least once.	
	Independently and randomly are the same reason.	
	Award the first B1 if they only gain 1 mark	
	Special case. If they have 2 of the 3 lines without the word events they get B0 B1	
	B1 Using Po(6) in (i) or (ii)	
(b) (i)	**M1** Attempting to find $P(X \le 4) - P(X \le 3)$ or $\frac{e^{-\lambda}\lambda^4}{4!}$	

(ii) (c)	**A1** awrt 0.134 **M1** Attempting to find $1 - P(X \leq 4)$ **A1** awrt 0.715 **B1** Attempting to find both possibilities. May be implied by doing $e^{-\lambda_1} \times \lambda_2 e^{-\lambda_2} +$ $e^{-\lambda_2} \times \lambda_1 e^{-\lambda_1}$ any values of λ_1 and λ_2 **M1** finding one pair of form $e^{-\lambda_1} \times \lambda_2 e^{-\lambda_2}$ any values of λ_1 and λ_2 **A1** one pair correct **A1** awrt 0.149 Alternative. B1 for Po(3) M1 for attempting to find $P(X=1)$ with Po(3) A1 $3e^{-3}$ A1 awrt 0.149	

4. (a)	$K(2^4 + 2^2 - 2) = 1$ $K = 1/18$	M1 A1 (2)
(b)	$1 - F(1.5) = 1 - \frac{1}{18}(1.5^4 + 1.5^2 - 2)$ $= 0.705 \quad \text{or} \quad \frac{203}{288}$	M1 A1 (2)
(c)	$f(y) = \begin{cases} \frac{1}{9}(2y^3 + y) & 1 \le y \le 2 \\ 0 & otherwise \end{cases}$	M1 A1 B1 (3)
Notes		
4. (a)	**M1** putting F(2) = 1 or F(2) – F(1) = 1 **A1** cso. Must show substituting $y = 2$ and the 1/18	
(b)	**M1** either attempting to find 1 – F(1.5) may write and use F(2) – F (1.5) **A1** awrt 0.705	
(c)	**M1** attempting to differentiate. Must see either a $y^n \rightarrow y^{n-1}$ at least once **A1** for getting $\frac{1}{9}(2y^3 + y)$ o.e and $1 \le y \le 2$ allow $1 < y < 2$ **B1** for the 0 *otherwise.* Allow 0 for y <1 and 0 for y >2 Allow them to use any letter	

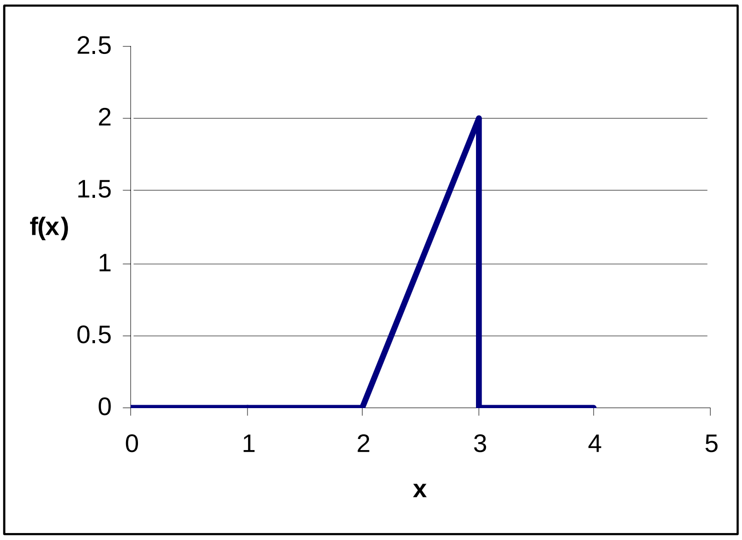
5	$H_0 : p = 0.3$; $H_1 : p > 0.3$	B1 B1
	Let X represent the number of tomatoes greater than 4 cm : $X \sim B(40, 0.3)$	B1
	$P(X \geq 18) = 1 - P(X \leq 17)$ $\quad$ $P(X \geq 18)\ 1 - P(X \leq 17) = 0.0320$ $P(X \geq 17) = 1 - P(X \leq 16) = 0.0633$	M1
	$= 0.0320$ $\quad$ CR $X \geq 18$	A1
	$0.0320 < 0.05$ $\quad$ $18 \geq 18$ or 18 in the critical region	
	no evidence to Reject H_0 or it is significant	M1
	New fertiliser has increased the probability of a tomato being greater than 4 cm **Or** Dhriti's claim is true	B1d cao (7)
5	**B1** for correct H_0. must use p or pi **B1** for correct H_1 must use p and be one tail. **B1** using B(40, 0.3). This may be implied by their calculation **M1** attempt to find $1 - P(X \leq 17)$ or get a correct probability. For CR method must attempt to find $P(X \geq 18)$ or give the correct critical region **A1** awrt 0.032 or correct CR. **M1** correct statement based on their probability , H_1 and 0.05 or a correct contextualised statement that implies that. **B1** this is not a follow through .conclusion in context. Must use the words increased, tomato and some reference to size or diameter. This is dependent on them getting the previous M1 If they do a **two tail test** they may get B1 B0 B1 M1 A1 M1 B0 For the second M1 they must have accept Ho or it is not significant or a correct contextualised statement that implies that. .	

6a (i) ii) b)	Let X represent the number of sunflower plants more than 1.5m high $X \sim \text{Po}(10)$ $\mu=10$ $\text{P}(8 \le X \le 13) = \text{P}(X \le 13) - \text{P}(X \le 7)$ $= 0.8645 - 0.2202$ $= 0.6443$ awrt 0.644 $X \sim \text{N}(10,7.5)$ $\text{P}(7.5 \le X \le 13.5) = \text{P}\left(\frac{7.5-10}{\sqrt{7.5}} \le X \le \frac{13.5-10}{\sqrt{7.5}}\right)$ $= \text{P}\ (-0.913 \le \text{X} \le 1.278)$ $= 0.8997\ - (1 - 0.8186)$ $= 0.7183$ awrt 0.718 or 0.719 Normal approx /not Poisson since (n is large) and p close to half. **or** (np = 10 npq = 7.5) mean $\neq$ variance **or** np (= 10) and nq (= 30) both >5. or exact binomial = 0.7148	B1 M1 A1 B1 M1 M1 A1 A1 M1 A1 (10) B1 B1dep (2)
6a (i) ii)	**B1** mean = 10 May be implied in (i) or (ii) **M1** Attempting to find $\text{P}(X \le 13) - \text{P}(X \le 7)$ **A1** awrt 0.644 **B1** $\sigma^2 = 7.5$ May be implied by being correct in standardised formula **M1** using 7.5 or 8.5 or 12.5 or 13.5. **M1** standardising using 7.5 or 8 or 8.5 **or** 12.5 or13 or 13.5 and their mean and standard deviation.	

	A1 award for either $\frac{7.5-10}{\sqrt{7.5}}$ or awrt -0.91 **A1** award for either $\frac{13.5-10}{\sqrt{7.5}}$ or awrt 1.28 **M1** Finding the correct area. Following on from their 7.5 and 13.5. Need to do a Prob >0.5 – prob <0.5 or prob <0.5 + prob< 0.5 **A1** awrt 0.718 or 0.719 only. Dependent on them getting all three method marks. No working but correct answer will gain all the marks first **B1** normal	
b)	second **B1** p close to half, or mean $\neq$ variance or np and nq both > 5.They may use a number bigger than 5 or they may work out the exact value 0.7148 using the binomial distribution. **Do not allow np> 5 and npq>5**	

7 ai)	A hypothesis test is a mathematical procedure to examine a value of a population parameter proposed by the null hypothesis compared with an alternative hypothesis.	B1
ii)	The critical region is the range of values **or** a test statistic or region where the test is significant that would lead to the rejection of H_0.	B1g B1h (3)
(b)	Let X represent the number of incoming calls : $X \sim Po(9)$	B1
	From table $P(X \geq 16) = 0.0220$	M1 A1
	$P(x \leq 3) = 0.0212$	A1
	Critical region ($x \leq 3$ or $x \geq 16$)	B1 (5)
(c)	Significance level = 0.0220 + 0.0212 = 0.0432 or4.32%	B1 (1)
(d)	$H_o : \lambda = 0.45$; $H_1 : \lambda < 0.45$ (accept : $H_o : \lambda = 4.5$; $H_1 : \lambda < 4.5$)	B1
	Using $X \sim Po(4.5)$	M1
	$P(X \leq 1) = 0.0611$ CR $X \leq 0$ awrt 0.0611	A1 M1
	$0.0611 > 0.05$. $1 \geq 0$ or 1not in the critical region There is evidence to Accept H_0 or it is not significant There is no evidence that there are less calls during school holidays.	B1cao (5)
Notes 7 ai)	B1 Method for deciding between 2 hypothesis.	
ii)	B1 range of values. This may be implied by other words. Not region on its own B1 which lead you to reject H_0	

	Give the first B1 if only one mark awarded.	
(b)	B1 using $P_o(9)$ M1 attempting to find $P(X \geq 16)$ or $P(x \leq 3)$ A1 0.0220 or $P(X \geq 16)$ A1 0.0212 or $P(x \leq 3)$ These 3 marks may be gained by seeing the numbers in part c B1 correct critical region A completely correct critical region will get all 5 marks. Half of the correct critical region eg $x \leq 3$ or $x \geq 17$ say would get B1 M1 A0 A1 B0 if the M1 A1 A1 not already awarded.	
(c)	B1 cao awrt 0.0432	
(d)	B1 may use λ or μ. Needs both H_0 and H_1 M1 using $P_o(4.5)$ A1 correct probability or CR only M1 correct statement based on their probability , H_1 and 0.05 or a correct contextualised statement that implies that. **B1** this is not a follow through .Conclusion in context. Must see the word **calls** in conclusion If they get the correct CR with no evidence of using $P_o(4.5)$ they will get M0 A0 SC If they get the critical region $X \leq 1$ they score M1 for rejecting H_0 and B1 for concluding the rate of calls in the holiday is lower.	

8. a)	 Max height of 2 labelled and goes through(2,0)	B1
	shape must be between 2 and 3 and no other lines drawn (accept patios drawn)	B1
	/ correct shape	B1
	3	(3)
		B1 (1)
b)	$\int_2^3 2x(x-2)\,dx = \left[\frac{2x^3}{3} - 2x^2\right]_2^3$	
		M1A1
c)	$= 2\frac{2}{3}$	A1 (3)
	$\int_2^m 2(x-2)\,dx = 0.5$	
	$\left[x^2 - 4x\right]_2^m = 0.5$	M1
d)	$m^2 - 4m + 4 = 0.5$	
	$m^2 - 4m + 3.5 = 0$	A1
	$m = \frac{4 \pm \sqrt{2}}{2}$	M1
	$m = 2.71$	A1 (4)
	Negative skew. mean < median < mode .	B1 B1dep
e)		(2)

Notes 8. (a)	**B1** the graph must have a maximum of 2 which must be labelled **B1** the line must be between 2 and 3 with not other line drawn except patios. They can get this mark even if the patio cannot be seen. **B1** the line must be straight and the right shape.	
(b)	**B1** Only accept 3	
(c)	**M1** attempt to find $\int x\mathrm{f}(x)\mathrm{d}x$ for attempt we need to see $x^{\mathrm{n}} \rightarrow x^{\mathrm{n}+1}$. ignore limits **A1** correct integration ignore limits **A1** accept $2\frac{2}{3}$ or awrt 2.67 or $2.\dot{6}$	
(d)	**M1** using $\int \mathrm{f}(x)\mathrm{d}x = 0.5$ **A1** $m^2 - 4m + 4 = 0.5$ oe **M1** attempting to solve quadratic. **A1** awrt 2.71 or $\frac{4+\sqrt{2}}{2}$ or $2+\frac{\sqrt{2}}{2}$ oe	
(e)	First **B1** for negative Second **B1** for mean < median< mode. Need all 3 or may explain using diagram.	

Mark Scheme (Results)

June 2008

GCE

GCE Mathematics (6684/01)

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June 2008
6684 Statistics S2
Mark Scheme

Question Number	Scheme	Marks
1(a)	E(X) = 5	B1
	Var(X) = $\frac{1}{12}(10-0)^2$ or attempt to use $\int \frac{x^2}{10}dx - \mu^2$	M1
	$= \frac{100}{12} = \frac{25}{3} = 8\frac{1}{3} = 8.\dot{3}$ awrt 8.33	A1
		(3)
(b)	P($X \leq 2$) = $(2-0)\times\frac{1}{10} = \frac{1}{5}$ or $\frac{2}{10}$ or 0.2	M1 A1 (2)
(c)	$\left(\frac{1}{5}\right)^5$ = 0.00032 or $\frac{1}{3125}$ or 3.2×10^{-4} o.e.	M1 A1 (2)
(d)	P(X $\geq$ 8) or P(X > 8)	M1
	P($X \geq 8 \mid X \geq 5$) = $\frac{\text{P}(X \geq 8)}{\text{P}(X \geq 5)}$	M1
	$= \frac{2/10}{5/10}$	
	$= \frac{2}{5}$	A1 (3)
	alternative	
	remaining time ~ U[0,5] or U[5,10] P(X $\geq$ 3 or 8) = $\frac{2}{5}$	M1 M1 A1 (Total 10)
	<u>Notes</u> (a) B1 cao M1 using the correct formula $\frac{(a-b)^2}{12}$ and subst in 10 or 0 **or** for an attempt at the integration they must increase the power of x by 1 and subtract their E(X) squared. A1 cao (b) M1 for P($X \leq 2$) or P(X < 2) A1 cao (c) M1 (their b) ^{5}. If the answer is incorrect we must see this. No need to check with your calculator A1 cao (d) writing P($X \geq 8$) (may use > sign). If they do not write P($X \geq 8$) then it must be clear from their working that they are finding it. 0.2 on its own with no working gets M0 M1 For attempting to use a correct conditional probability.	

A1 2/5

Full marks for 2/5 on its own with no incorrect working

Alternative

M1 for P($X \geq 3$) or P($X \geq 8$) may use > sign

M1 using either U[0,5] or U[5,10]

A1 2/5

Question Number	Scheme	Marks
2	X ~B(100,0.58)	
	Y ~ N (58, 24.36)	B1 B1 B1
	[P($X > 50$) = P($X \geq 51$)]	
	using 50.5 or 51.5 or 49.5 or 48.5	M1
	$= \text{P}\left(z \geq \pm\left(\frac{50.5-58}{\sqrt{24.36}}\right)\right)$ standardising 50.5, 51, 51.5 ,48.5,49, 49.5 and their μ and σ for M1	M1
	= P(z $\geq$ -1.52…)	A1
	= 0.9357	A1
	alternative	(7)
	X ~B(100,0.42)	
	Y ~ N (42, 24.36)	B1 B1 B1
	[P($X < 50$) = P($X \leq 49$)]	
	using 50.5 or 51.5 or 49.5 or 48.5	M1
	$= \text{P}\left(z \leq \pm\left(\frac{49.5-42}{\sqrt{24.36}}\right)\right)$ standardising 50.5, 51, 51.5 ,48.5,49, 49.5 and their μ and σ for M1	M1 A1
	= P(z $\leq$ 1.52…)	
	= 0.9357	A1
		(Total 7)
	Notes	
	The first 3 marks may be given if the following figures are seen in the standardisation formula :- 58 or 42, 24.36 or √24.36 or √24.4 or awrt 4.94.	
	Otherwise	
	B1 normal	
	B1 58 or 42	
	B1 24.36	
	M1 using 50.5 or 51.5 or 49.5 or 48.5. ignore the direction of the inequality.	
	M1 standardising 50.5, 51, 51.5 ,48.5, 49, 49.5 and their μ and σ . They may use √ 24 or √24.36 or √24.4 or awrt 4.94 for σ or the √of their variance.	
	A1 ± 1.52. may be awarded for $\pm\left(\frac{50.5-58}{\sqrt{24.36}}\right)$ or $\pm\left(\frac{49.5-42}{\sqrt{24.36}}\right)$ o.e.	
	A1 awrt 0.936	

Question Number	Scheme	Marks
3(a)	$X \sim$ Po (9) may be implied by calculations in part a or b	M1
	P($X \le 3$) = 0.0212 P($X \ge 16$) = 0.0220	
	CR $X \le 3$; $\cup$ $X \ge 16$	A1; A1 (3)
(b)	P(rejecting Ho) = 0.0212 + 0.0220	M1
	= 0.0432 or 0.0433	A1 cao
		(2)
		Total 5

Notes

(a) M1 for using Po (9) – other values you might see which imply Po (9) are 0.0550, 0.0415, 0.9780, 0.9585, 0.9889,0.0111,0.0062 or may be assumed by at least one correct region.

A1 for $X \le 3$ or $X < 4$ condone c1 or CR instead of X

A1 for $X \ge 16$ or $X > 15$

They must identify the critical regions at the end and not just have them as part of their working. Do not accept P($X \le 3$) etc gets A0

(b) if they use 0.0212 and 0.0220 they can gain these marks regardless of the critical regions in part a. If they have not got the correct numbers they must be adding the values for their critical regions.(both smaller than 0.05) You may need to look these up. The most common table values for lambda = 9 are in this table

x	2	3	4	5	14	15	16	17	18
	0.0062	0.0212	0.0550	0.1157	0.9585	0.9780	0.9889	0.9947	0.9976

A1 awrt 0.0432 or 0.0433

Special case

If you see 0.0432 / 0.0433 and then they go and do something else with it eg 1 – 0.0432 award M1 A0

Question Number	Scheme	Marks
4(a)	$X \sim \mathrm{B}(11000, 0.0005)$	M1 A1 (2)
(b)	$\mathrm{E}(X) = 11000 \times 0.0005 = 5.5$	B1
	$\mathrm{Var}(X) = 11000 \times 0.0005 \times (1 - 0.0005)$ $= 5.49725$	B1 (2)
(c)	$X \sim \mathrm{Po}(5.5)$	M1 A1
	$\mathrm{P}(X \leq 2) = 0.0884$	dM1 A1 (4)
		Total 8
	Notes (a) M1 for Binomial, A1 fully correct These cannot be awarded unless seen in part a (b)B1 cao B1 also allow 5.50, 5.497, 5.4973, do **not** allow 5.5 (c) M1 for Poisson A1 for **using** Po (5.5) M1 this is dependent on the previous M mark. It is for attempting to find $\mathrm{P}(X \leq 2)$ A1 awrt 0.0884 Special case If they use normal approximation they could get M0 A0 M1 A0 if they use 2.5 in their standardisation. NB exact binomial is 0.0883	

Question Number	Scheme	Marks
5(a)	$X \sim \mathrm{B}(15, 0.5)$	B1 B1 (2)
(b)	$\mathrm{P}(X = 8) = \mathrm{P}(X \leq 8) - \mathrm{P}(X \leq 7)$ or $\left(\frac{15!}{8!7!}(p)^8(1-p)^7\right)$ $= 0.6964 - 0.5$ $= 0.1964$ awrt 0.196	M1 A1 (2)
(c)	$\mathrm{P}(X \geq 4) = 1 - \mathrm{P}(X \leq 3)$ $= 1 - 0.0176$ $= 0.9824$	M1 A1 (2)
(d)	$\mathrm{H}_0 : p = 0.5$ $\mathrm{H}_1 : p > 0.5$ $X \sim \mathrm{B}(15, 0.5)$ $\mathrm{P}(X \geq 13) = 1 - \mathrm{P}(X \leq 12)$ | $[\mathrm{P}(X \geq 12) = 1 - 0.9824 = 0.0176]$ att $\mathrm{P}(X \geq 13)$ $= 1 - 0.9963$ | $\mathrm{P}(X \geq 13) = 1 - 0.9963 = 0.0037$ $= 0.0037$ | CR $X \geq 13$ awrt 0.0037/ CR $X \geq 13$ $0.0037 < 0.01$ | $13 \geq 13$ Reject H_0 or it is significant or a correct statement in context from their values There is sufficient evidence at the 1% significance level that the coin is <u>biased in favour of heads</u> Or There is evidence that Sues belief is correct	B1 B1 M1 A1 M1 A1 (6)
	<u>Notes</u> (a) B1 for Binomial B1 for 15 and 0.5 must be in part a This need not be in the form written (b) M1 attempt to find P ($X = 8$) any method. Any value of p A1 awrt 0.196 Answer only full marks (c) M1 for 1 - P ($X \leq 3$). A1 awrt 0.982	

(d) B1 for correct H_0. must use p or π

B1 for correct H_1 must be one tail must use p or π

M1 attempt to find $P(X \geq 13)$ correctly. E.g. $1 - P(X \leq 12)$

A1 correct probability or CR

To get the next 2 marks the null hypothesis must state or imply that $(p) = 0.5$

M1 for correct statement based on their probability or critical region or a correct contextualised statement that implies that. not just 13 is in the critical region.

A1 This depends on their M1 being awarded for rejecting H_0. Conclusion in context. Must use the words biased in favour of heads or biased against tails or sues belief is correct .
NB this is a B mark on EPEN.

They may also attempt to find $P(X < 13) = 0.9963$ and compare with 0.99

Question Number	Scheme	Marks
6(a)	Calls occur singly Calls occur at a constant rate Calls occur independently or randomly. any two of the 3 only need calls once	B1 B1 (2)
(b) (i)	X~ Po(4.5) used or seen in (i) or (ii) $P(X = 5) = P(X \le 5) - P(X \le 4)$ $= 0.7029 - 0.5321$ $= 0.1708$	M1 M1 A1 (3)
(ii)	$P(X > 8) = 1 - P(X \le 8)$ $= 1 - 0.9597$ $= 0.0403$	M1 A1 (2)
(c)	$H_o : \lambda = 9\ (\lambda = 18)$ may use λor μ $H_1 : \lambda > 9\ (\lambda > 18)$ $X \sim Po(9)$ may be implied $P(X \ge 14) = 1 - P(X \le 13) = 1 - 0.9261 = 0.0739$ | $[P(X \ge 14) = 1 - 0.9261 = 0.0739]$ att $P(X \ge 14)$ | $P(X \ge 15)$ $P(X \ge 15) = 1 - 0.9585 = 0.0415$ CR $X \ge 15$ awrt 0.0739 $0.0739 > 0.05$ | $14 \le 15$ Accept H_0. or it is not significant or a correct statement in context from their values There is insufficient evidence to say that the number of calls per hour handled by the agent has increased.	B1 B1 M1 A1 M1 A1 (6)
	Notes (a) B1 B1 They must use calls at least once. Independently and randomly are the same reason. Award the first B1 if they only gain 1 mark. Special case if they don't put in the word calls but write two correct statements award B0B1 (b) correct answers only score full marks (i) M1 Po (4.5) may be implied by them using it in their calculations in (i) or (ii) M1 for $P(X \le 5) - P(X \le 4)$ **or** $\frac{e^{-\lambda}\lambda^5}{5!}$ A1 only awrt 0.171	

(ii) M1 for $1 - \text{P}(X \leq 8)$
A1 only awrt 0.0403

(c) B1 both . Must be one tail test. They may use λ or μ and either 9 or 18 and match H_0 and H_1

M1 Po (9) may be implied by them using it in their calculations.
M1 attempt to find $\text{P}(X \geq 14)$ eg $1 - \text{P}(X \leq 13)$ or $1 - \text{P}(X < 14)$
A1 correct probability or CR

To get the next2 marks the null hypothesis must state or imply that $(\lambda) = 9$ or 18

M1 for a correct statement based on their probability or critical region
or a correct contextualised statement that implies that.

A1. This depends on their M1 being awarded for accepting H_0. Conclusion in context. Must have calls per hour has not increased. Or the rate of calls has not increased.
Any statement that has the word **calls** in and implies the **rate not increasing**
e.g. no evidence that the rate of calls handled has increased
Saying the number of calls has not increased gains A0 as it does not imply rate
NB this is an A mark on EPEN

They may also attempt to find $\text{P}(X < 14) = 0.9261$ and compare with 0.95

Question Number	Scheme	Marks
7(a)		
	$\int_0^1 \frac{1}{2}x\ \mathrm{d}x = \left[\frac{1}{4}x^2\right]_0^1 = \frac{1}{4}$ oe attempt to integrate both parts	M1
	$\int_1^2 kx^3\ \mathrm{d}x \left[\frac{1}{4}kx^4\right]_1^2 = 4k - \frac{1}{4}k$ oe both answer correct	A1
	$\frac{1}{4} + 4k - \frac{1}{4}k = 1$ adding two answers and putting = 1	dM1dep on previous M
	$\frac{15k}{4} = \frac{3}{4}$	
	$k = \frac{1}{5}$ *	A1 (4)
(b)	$\int_0^1 \frac{1}{2}x^2\ \mathrm{d}x = \left[\frac{1}{6}x^3\right]_0^1 = \frac{1}{6}$ attempt to integrate $x\mathrm{f}(x)$ for one part	M1
	1/6	A1
	$\int_1^2 \frac{1}{5}x^4\ \mathrm{d}x = \left[\frac{1}{25}x^5\right]_1^2 = \frac{32}{25} - \frac{1}{25}$	
	$= \frac{31}{25}$ or 1.24	A1
	$\mathrm{E}(X) = \frac{1}{6} + \frac{31}{25}$	
	$= \frac{211}{150} = 1\frac{61}{150} = 1.40\dot{6}$	A1 (4)
(c)		
	$\mathrm{F}(x) = \int_0^x \frac{1}{2}t\ \mathrm{d}t$ (for $0 \le x \le 1$) ignore limits for M	M1
	$= \frac{1}{4}x^2$ must use limit of 0	A1
	$\mathrm{F}(x) = \int_1^x \frac{1}{5}t^3\ \mathrm{d}t; + \int_0^1 \frac{1}{2}t\ \mathrm{d}t$ (for $1 < x \le 2$) need limit of 1 and variable upper limit; need limit 0 and 1	M1; M1
	$= \frac{1}{20}x^4 + \frac{1}{5}$	A1

$$\mathrm{F}(x)\begin{cases} 0 & x<0 \\ \frac{1}{4}x^2 & 0 \le x \le 1 \\ \frac{1}{20}x^4 + \frac{1}{5} & 1<x \le 2 \\ 1 & x>2 \end{cases}$$

middle pair B1 ft

ends B1

(7)

(d)

F(m) = 0.5 either eq M1

$\frac{1}{20}m^4 + \frac{1}{5} = 0.5$ eq for their $1 \le x \le 2$ A1ft

$m = \sqrt[4]{6}$ or 1.57 or awrt 1.57 A1

(3)

(e)

negative skew B1

This depends on the previous B1 being awarded. One of the following statements which must be compatible with negative skew and their figures. If they use mode then they must have found a value for it dB1

(2)

Mean < Median

Mean < mode

Mean < median (< mode)

Median < mode

Sketch of the pdf.

Notes

(a) M1 attempting to integrate both parts

A1 both answers correct

M1 dependent on the previous M being awarded.. adding the two answers together

A1 cso

(b) M1 attempting to use integral of x f(x) on one part

A1 1/6

A1 31/25

A1 awrt 1.41

(c) M1 Att to integrate $\frac{1}{2}$t (they need to increase the power by 1). Ignore limits for method mark

A1 $\frac{1}{4}x^2$ allow use of t. must have used/implied use of limit of 0. This must be on its own without anything else added

M1 att to integrate $\int_1^x \frac{1}{5}t^3$ dt and correct limits.

M1 $\int_0^1 \frac{1}{2}t \text{ dt} +$ Att to integrate using limits 0 and 1. no need to see them put 0 in .

they must add this to their $\int_1^x \frac{1}{5}t^3 \text{ dt}$. may be given if they add 1/4

$$\left(\begin{array}{l}\text{Alternative method for these last two M marks} \\ \text{M1 for att to } \int \frac{1}{5}\boldsymbol{t^3} \text{ dt and putting } + \text{ C} \\ \text{M1 use of F(2) = 1 to find C} \\ \end{array}\right)$$

A1 $\frac{1}{20}x^4 + \frac{1}{5}$ must be correct

B1 middle pair followed through from their answers. condone them using < or ≤ incorrectly they do not need to match up

B1 end pairs. condone them using < or ≤. They do not need to match up

NB if they show no working and just write down the distribution. If it is correct they get full marks. If it is incorrect then they cannot get marks for any incorrect part. So if $0<x<1$ is correct they can get M1 A1 otherwise M0 A0. if $3<x<4$ is correct they can get M1 A1A1 otherwise M0 A0A0. you cannot award B1ft if they show no working unless the middle parts are correct.

(d) M1 either of their $\frac{1}{4}x^2$ or $\frac{1}{20}x^4 + \frac{1}{5}$=0.5

A1 for their F(X) $1<x<2$ = 0.5

A1 cao

If they add both their parts together and put = 0.5 they get M0

I they work out both parts separately and do not make the answer clear they can get M1 A1 A0

(e) B1 negative skew only

B1 Dependent on getting the previous B1. their reason must follow through from their figures.

Mark Scheme (Results)

January 2009

GCE

GCE Mathematics (6684/01)

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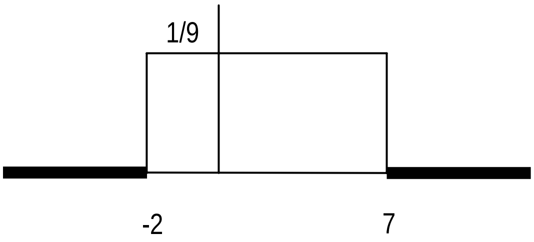
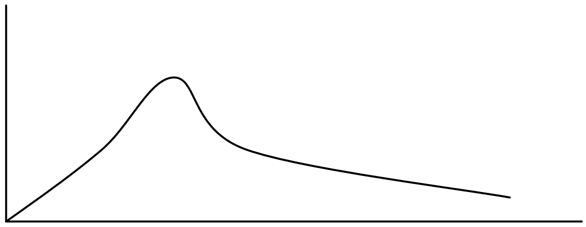
January 2009
6684 Statistics S2
Mark Scheme

Question Number	Scheme	Marks
1	The random variable *X* is the number of daisies in a square.	
	Poisson(3)	B1
(a)	$1 - P(X \le 2) = 1 - 0.4232$ $\quad 1 - e^{-3}(1+3+\frac{3^2}{2!})$	M1
	$= 0.5768$	A1
		(3)
(b)	$P(X \le 6) - P(X \le 4) = 0.9665 - 0.8153$ $\quad e^{-3}\left(\frac{3^5}{5!}+\frac{3^6}{6!}\right)$	M1
	$= 0.1512$	A1
		(2)
(c)	$\mu = 3.69$	B1
	$\text{Var}(X) = \frac{1386}{80} - \left(\frac{295}{80}\right)^2$	M1
	$= 3.73/3.72/3.71$ $\quad$ accept $s^2 = 3.77$	A1
		(3)
(d)	For a Poisson model , Mean = Variance ; For these data $3.69 \approx 3.73$	
	$\Rightarrow$ Poisson model	B1
		(1)
(e)	$\frac{e^{-3.6875}3.6875^4}{4!} = 0.193$ $\quad$ allow their mean or var	M1
	Awrt 0.193 or 0.194	A1 ft
		(2)

Question Number	Scheme	Marks
2 (a)	$\mathrm{f}(x)=\begin{cases}\frac{1}{9} & -2\le x\le 7\\ 0 & otherwise\end{cases}$	B1 B1 (2)
(b)		B1 B1 (2)
(c)	$\mathrm{E}(X)=\underline{2.5}$ Var $(X)=\frac{1}{12}(7+2)^2$ or $\underline{6.75}$ both	B1
	$\mathrm{E}(X^2)=\mathrm{Var}(X)+\mathrm{E}(X)^2$	M1
	$= 6.75 + 2.5^2$ $= 13$	A1
	alternative	(3)
	$\int_{-2}^{7} x^2 f(x)dx = \left[\frac{x^3}{27}\right]_{-2}^{7}$ $\int$ x^2"f(x)" attempt to integrate and use limits of -2 and 7	B1 M1
	$= 13$	A1
(d)	P($-0.2 < X < 0.6) = \frac{1}{9}\times 0.8$	M1
	$= \frac{4}{45}$ or 0.0889 0r equiv awrt 0.089	A1
		(2)

Question Number	Scheme	Marks
3 (a)	$X \sim \mathrm{B}(20, 0.3)$	M1
	$\mathrm{P}\,(X \leq 2) = 0.0355$	
	$\mathrm{P}(X \geq 11) = 1 - 0.9829 = 0.0171$	
	Critical region is $(X \leq 2) \cup (X \geq 11)$	A1 A1 (3)
(b)	Significance level = 0.0355 + 0.0171, = 0.0526 or 5.26%	M1 A1 (2)
(c)	Insufficient evidence to reject H_0 **Or** sufficient evidence to accept H_0 /not significant	B1 ft
	$x = 3$ (or the value) is not in the critical region or 0.1071> 0.025	B1 ft (2)
	Do not allow inconsistent comments	

Question Number	Scheme	Marks
4 (a)	$\int_0^{10} kt\mathrm{d}t = 1$ or Area of triangle = 1	M1
	$\left[\frac{kt^2}{2}\right]_0^{10} = 1$ or 10 x0.5 x 10k =1 or linear equation in k	M1
	$50k = 1$	
	$k = \frac{1}{50}$ cso	A1
		(3)
(b)	$\int_6^{10} ktdt = \left[\frac{\mathrm{kt}^2}{2}\right]_6^{10}$	M1
	$= \frac{16}{25}$	A1
		(2)
(c)	$\mathrm{E}(T) = \int_0^{10} kt^2dt = \left[\frac{\mathrm{kt}^3}{3}\right]_0^{10}$	M1
	$= 6\frac{2}{3}$	A1
	$\text{Var (T)} = \int_0^{10} kt^3dt - \left(6\frac{2}{3}\right)^2 = \left[\frac{kt^4}{4}\right]_0^{10}; - \left(6\frac{2}{3}\right)^2$	M1;M1dep
	$= 50 - \left(6\frac{2}{3}\right)^2$	
	$= 5\frac{5}{9}$	A1
		(5)
(d)	10	B1
		(1)
(e)		B1
		(1)

Question Number	Scheme	Marks
5 (a)	X represents the number of defective components.	
	P ($X = 1$) = $\left(0.99\right)^9\left(0.01\right)\times 10$ = 0.0914	M1A1
		(2)
(b)	P ($X \geq 2$) = 1 – P($X \leq 1$)	M1
	= 1 – $(p)^{10}$ – (a)	A1√
	= 0.0043	A1
		(3)
(c)	$X \sim$ Po(2.5)	B1B1
	P(1 $\leq X \leq$ 4) = P($X \leq$ 4) - P(X = 0)	M1
	= 0.8912 – 0.0821	
	= 0.809	A1
		(4)
	Normal distribution used. B1for mean only	
	Special case for parts a and b If they use 0.1 do not treat as misread as it makes it easier. (a) M1 A0 if they have 0.3874 (b) M1 A1ft A0 they will get 0.2639 (c) Could get B1 B0 M1 A0	
	For any other values of p which are in the table do not use misread. Check using the tables. They could get (a) M1 A0 (b) M1 A1ft A0 (c) B1 B0 M1 A0	

Question Number	Scheme	Marks
6 (a)(i)	$H_0 : \lambda = 7$ $\quad H_1 : \lambda > 7$	B1
	X = number of visits. $X \sim \text{Po}(7)$	B1
	$P(X \geq 10) = 1 - P(X \leq 9)$ $\qquad 1 - P(X \leq 10) = 0.0985$	M1
	$= 0.1695$ $\qquad 1 - P(X \leq 9) = 0.1695$	
	CR $X \geq 11$	A1
	$0.1695 > 0.10$, $\qquad$ CR $X \geq 11$	
	Not significant or it is not in the critical region or do not reject H_0	M1
	The rate of visits on a Saturday is not greater/ is unchanged	A1 no ft
(ii)	$X = 11$	B1 (7)
(b)	(The visits occur) randomly/ independently or singly or constant rate	B1 (1)
(c)	$[H_0 : \lambda = 7 \quad H_1 : \lambda > 7 \quad (\text{ or } H_0 : \lambda = 14 \quad H_1 : \lambda > 14)]$	
	X ~N;(14,14)	B1;B1
	$P(X \geq 20) = P\left(z \geq \frac{19.5 - 14}{\sqrt{14}}\right)$ $\qquad$ +/- 0.5, stand	M1 M1
	$= P(z \geq 1.47)$	
	$= 0.0708$ $\qquad$ or $z = 1.2816$	A1dep both M
	$0.0708 < 0.10$ therefore significant. The rate of visits is greater on a Saturday	A1dep 2nd M (6)

Question Number	Scheme	Marks
7 (a)	$F(x_0) = \int_1^x -\frac{2}{9}x + \frac{8}{9}\,\mathrm{dx} = \left[-\frac{1}{9}x^2 + \frac{8}{9}x\right]_1^x$	M1A1
	$= \left[-\frac{1}{9}x^2 + \frac{8}{9}x\right] - \left[-\frac{1}{9} + \frac{8}{9}\right]$	
	$= -\frac{1}{9}x^2 + \frac{8}{9}x - \frac{7}{9}$	A1
		(3)
(b)	$F(x) = \begin{cases} 0 & x < 1 \\ -\frac{1}{9}x^2 + \frac{8}{9}x - \frac{7}{9} & 1 \le x \le 4 \\ 1 & x > 4 \end{cases}$	B1B1√
		(2)
(c)	$F(x) = 0.75$; or $F(2.5) = -\frac{1}{9}\times 2.5^2 + \frac{8}{9}\times 2.5 - \frac{7}{9}$	M1;
	$-\frac{1}{9}x^2 + \frac{8}{9}x - \frac{7}{9} = 0.75$	
	$4x^2 - 32^x + 55 = 0$	
	$-x^2 + 8x - 13.75 = 0$	
	$x = 2.5$ $= 0.75$ cso	A1
	and $F(x) = 0.25$	
	$-\frac{1}{9}x^2 + \frac{8}{9}x - \frac{7}{9} = 0.25$	M1
	$-x^2 + 8x - 7 = 2.25$	
	$-x^2 + 8x - 9.25 = 0$ quadratic 3 terms =0	M1 dep
	$x = \frac{-8 \pm \sqrt{8^2 - 4\times -1 \times -9.25}}{2\times -1}$	M1 dep
	$x = 1.40$	A1
		(6)
(d)	$Q_3 - Q_2 > Q_2 - Q_1$	M1
	Or mode = 1 and mode < median	
	Or mean = 2 and median < mode	
	Sketch of pdf here or be referred to if in a different part of the question	
	Box plot with Q_1, Q_2, Q_3 values marked on	
	Positive skew	A1
		(2)

Mark Scheme (Results)

Summer 2009

GCE

GCE Mathematics (6684/01)

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June 2009
6684 Statistics S2
Mark Scheme

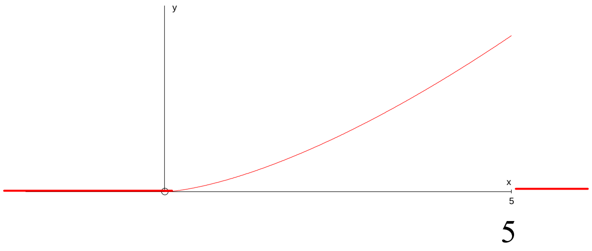
Question Number	Scheme	Marks
Q1 (a)	$[X \sim B(30, 0.15)]$	
	$P(X \leq 6)$, = 0.8474 awrt 0.847	M1, A1 (2)
(b)	$Y \sim B(60, 0.15) \quad \approx \quad Po(9)$ for using Po(9)	B1
	$P(Y \leq 12)$, = 0.8758 awrt 0.876	M1, A1 (3)
		[5]
	[N.B. normal approximation gives 0.897, exact binomial gives 0.894]	
(a)	M1 for a correct probability statement $P(X \leq 6)$ or $P(X < 7)$ or P (X =0) + P (X = 1)+ P (X = 2)+ P (X =4) + P (X =5) + P (X =6). (may be implied by long calculation) Correct answer gets M1 A1. allow 84.74%	
(b)	B1 may be implied by using Po(9). Common incorrect answer which implies this is 0.9261 M1 for a correct probability statement $P(X \leq 12)$ or $P(X < 13)$ or P (X =0)+ P (X = 1)+…+ P (X = 12) (may be implied by long calculation) and attempt to evaluate this probability using their Poisson distribution. Condone P ($X \leq 13$) = 0.8758 for B1 M1 A1 Correct answer gets B1 M1 A1 Use of normal or exact binomial get B0 M0 A0	

Question Number	Scheme	Marks
Q2	H_0: $\lambda = 2.5$ (or $\lambda = 5$) H1: $\lambda < 2.5$ (or $\lambda < 5$) λ or μ	B1B1
	$X \sim \text{Po}(5)$	M1
	$P(X \leq 1) = 0.0404$ or CR $X \leq 1$	A1
	[0.0404<0.05] this is significant or reject H_0 or it is in the critical region	M1
	There is evidence of a decrease in the (mean) number/rate of deformed blood cells	A1 (6) **[6]**
	1st B1 for H_0 must use lambda or mu; 5 or 2.5. 2nd B1 for H_1 must use lambda or mu; 5 or 2.5 1st M1 for use of Po(5) may be implied by probability(must be used not just seen) eg. P (X = 1) = 0.0404 - … would score M1 A0 1st A1 for 0.0404 seen or correct CR 2nd M1 for a correct statement (this may be contextual) comparing their probability and 0.05 (or comparing 1 with their critical region). Do not allow conflicting statements. 2nd A1 is not a follow through. Need the word decrease, number or rate and deformed blood cells for contextual mark. If they have used $\neq$ in H_1 they could get B1 B0 M1 A1 M1A0 mark as above except they gain the 1st A1 for $P(X \leq 1) = 0.0404$ or CR $X \leq 0$ 2nd M1 for a correct statement (this may be contextual) comparing their probability and 0.025 (or comparing 1 with their critical region) They may compare with 0.95 (one tail method) or 0.975 (one tail method) Probability is 0.9596.	

Question Number	Scheme	Marks
Q3 (a)	*A statistic* is a function of $X_1, X_2, ...X_n$ that does not contain any unknown parameters	B1 B1 (2)
(b)	The probability distribution of Y or the distribution of all possible values of Y (o.e.)	B1 (1)
(c)	Identify (ii) as not a statistic Since it contains unknown parameters μ and σ.	B1 dB1 (2) **[5]**
(a)	Examples of other acceptable wording: B1 e.g. is a function of the sample or the data / is a quantity calculated from the sample or the data / is a random variable calculated from the sample or the data B1 e.g. does not contain any unknown parameters/quantities contains only known parameters/quantities only contains values of the sample Y is a function of $X_1, X_2, ...X_n$ that does not contain any unknown parameters B1B1 is a function of the values of a sample with no unknowns B1B1 is a function of the sample values B1B0 is a function of all the data values B1B0 A random variable calculated from the sample B1B0 A random variable consisting of any function B0B0 A function of a value of the sample B1B0 A function of the sample which contains no other values/ parameters B1B0	
(b)	Examples of other acceptable wording All possible values of the statistic together with their associated probabilities	
(c)	1st B1 for selecting only (ii) 2nd B1 for a reason. This is dependent upon the first B1. Need to mention at least one of mu (mean) or sigma (standard deviation or variance) or unknown parameters. Examples since it contains mu B1 since it contains sigma B1 since it contains unknown parameters/quantities B1 since it contains unknowns B0	

Question Number	Scheme	Marks
Q4 (a)	$X \sim \mathrm{B}(20, 0.3)$ $\mathrm{P}(X \le 2) = 0.0355$ $\mathrm{P}(X \le 9) = 0.9520$ so $\mathrm{P}(X \ge 10) = 0.0480$ Therefore the critical region is $\{X \le 2\} \cup \{X \ge 10\}$	M1 A1 A1 A1A1 (5)
(b)	$0.0355 + 0.0480 = 0.0835$ awrt (0.083 or 0.084)	B1 (1)
(c)	11 is in the critical region there is evidence of a <u>change/ increase</u> in the <u>proportion/number</u> of <u>customers buying single tins</u>	B1ft B1ft (2) **[8]**
(a)	M1 for B(20,0.3) seen or used 1st A1 for 0.0355 2nd A1 for 0.048 3rd A1 for $(X) \le 2$ or $(X) < 3$ or [0,2] They get **A0** if they write $\mathrm{P}(X \le 2/ X < 3)$ 4th A1 $(X) \ge 10$ or $(X) > 9$ or [10,20] They get **A0** if they write $\mathrm{P}(X \ge 10/ X > 9)$ **10** $\le X \le 2$ etc is accepted To describe the critical regions they can use any letter or no letter at all. It does not have to be X.	
(b)	B1 correct answer only	
(c)	1st B1 for a correct statement about 11 and their critical region. 2nd B1 for a correct comment in context consistent with their CR and the value 11 Alternative solution 1st B0 $P(X \ge 11) = 1 - 0.9829 = 0.0171$ since no comment about the critical region 2nd B1 a correct contextual statement.	

Question Number	Scheme	Marks
Q5 (a)	X = the number of errors in 2000 words so $X \sim \text{Po}(6)$	B1
	$\text{P}(X \geq 4) = 1 - \text{P}(X \leq 3)$	M1
	$= 1 - 0.1512 \quad = 0.8488$ awrt 0.849	A1 (3)
(b)	Y = the number of errors in 8000 words. $Y \sim \text{Po}(24)$ so use a Normal approx	M1
	$Y \approx\sim \text{N}(24, \sqrt{24}^2)$	A1
	Require $\text{P}(Y \leq 20) = \text{P}\left(Z < \frac{20.5 - 24}{\sqrt{24}}\right)$	M1 M1
	$= \text{P}(Z < -0.714\ldots)$	A1
	$= 1 - 0.7611$	M1
	$= 0.2389$ awrt (0.237~0.239)	A1 (7)
	[N.B. Exact Po gives 0.242 and no ± 0.5 gives 0.207]	**[10]**
(a)	B1 for seeing or using Po(6) M1 for $1 - \text{P}(X \leq 3)$ or $1 - [\text{P}(X = 0) + \text{P}(X = 1) + \text{P}(X = 2) + \text{P}(X = 3)]$ A1 awrt 0.849	
SC	If B(2000, 0.003) is used and leads to awrt 0.849 allow B0 M1 A1 If no distribution indicated awrt 0.8488 scores B1M1A1 but any other awrt 0.849 scores B0M1A1	
(b)	1st M1 for identifying the normal approximation 1st A1 for [mean = 24] **and** [sd = $\sqrt{24}$ or var = 24] These first two marks may be given if the following are seen in the standardisation formula : 24 $\sqrt{24}$ or awrt 4.90 2nd M1 for attempting a continuity correction (20/ 28 ± 0.5 is acceptable) 3rd M1 for standardising using their mean and their standard deviation. 2nd A1 correct z value awrt ±0.71 **or** this may be awarded if see $\frac{20.5 - 24}{\sqrt{24}}$ or $\frac{27.5 - 24}{\sqrt{24}}$ 4th M1 for 1 - a probability from tables (must have an answer of < 0.5) 3rd A1 answer awrt 3 sig fig in range 0.237 – 0.239	

Question Number	Scheme	Marks
Q6 (a)	$P(A>3)=\frac{2}{5}=0.4$	B1 (1)
(b)	$(0.4)^3$,= 0.064 or $\frac{8}{125}$	M1, A1 (2)
(c)	$f(y)=\frac{d}{dy}(F(y))=\begin{cases}\frac{3y^2}{125} & 0\le y\le 5\\ 0 & \textit{otherwise}\end{cases}$	M1A1 (2)
(d)	 Shape of curve and start at (0,0) Point (5, 0) labelled and curve between 0 and 5 and pdf ≥ 0	B1 B1 (2)
(e)	Mode = 5	B1 (1)
(f)	$E(Y)=\int_0^5\left(\frac{3y^3}{125}\right)dy=\left[\frac{3y^4}{500}\right]_0^5=\frac{15}{4}$ or 3.75	M1M1A1 (3)
(g)	$P(Y>3)=\begin{cases}\int_3^5\frac{3y^2}{125}\,dy\\ \text{or } 1-F(3)\end{cases}=1-\frac{27}{125}=\frac{98}{125}=0.784$	M1A1 (2) **[13]**
(a)	B1 correct answer only(cao). Do not ignore subsequent working	
(b)	M1 for cubing their answer to part (a) A1 cao	
(c)	M1 for attempt to differentiate the cdf. They must decrease the power by 1 A1 fully correct answer including 0 otherwise. Condone < signs	
(d)	B1 for shape. Must curve the correct way and start at (0,0). No need for y = 0 (patios) lines B1 for point (5,0) labelled and pdf only existing between 0 and 5, may have y=0 (patios) for other values	
(e)	B1 cao	
(f)	1st M1 for attempt to integrate their $yf(y)$ $y^n\to y^{n+1}$. 2nd M1 for attempt to use correct limits A1 cao	
(g)	M1 for attempt to find $P(Y>3)$. e.g. writing $\int_3^5 \textit{their } f(y)$ must have correct limits or writing 1 – F(3)	

Question Number	Scheme	Marks
Q7 (a)	E(X) = 2 (by symmetry)	B1 (1)
(b)	$0\le x < 2$, gradient = $\frac{\frac{1}{2}}{2}=\frac{1}{4}$ and equation is $y=\frac{1}{4}x$ so $a=\frac{1}{4}$	B1
	b - $\frac{1}{4}x$ passes through (4, 0) so b = 1	B1 (2)
(c)	$\text{E}(X^2)=\int_0^2\left(\frac{1}{4}x^3\right)\,\text{d}x+\int_2^4\left(x^2-\frac{1}{4}x^3\right)\,\text{d}x$	M1M1
	$=\left[\frac{x^4}{16}\right]_0^2+\left[\frac{x^3}{3}-\frac{x^4}{16}\right]_2^4$	A1
	$=1+\frac{64-8}{3}-\frac{256-16}{16} \quad = \quad 4\frac{2}{3}$ or $\frac{14}{3}$	M1A1
	$\text{Var}(X)=\text{E}(X^2)-\left[\text{E}(X)\right]^2=\frac{14}{3}-2^2$, $=\frac{2}{3}$ (so $\sigma=\sqrt{\frac{2}{3}}=0.816$) (*)	M1 A1cso (7)
(d)	$\text{P}(X\le q)=\int_0^q\frac{1}{4}x\,\text{d}x=\frac{1}{4}$, $\quad\frac{q^2}{2}=1$ so $q=\sqrt{2}=1.414$ awrt 1.41	M1A1,A1 (3)
(e)	2- σ= 1.184 so 2 - σ, 2 + σ is wider than IQR, therefore greater than 0.5	M1,A1 (2) **[15]**
(a)	B1 cao	
(b)	B1 for value of a. B1 for value of b	
(c)	1st M1 for attempt at $\int ax^3$ using their a. For attempt they need x^4. Ignore limits. 2nd M1 for attempt at $\int bx^2-ax^3$ use their a and b. For attempt need to have either x^3 or x^4. Ignore limits 1st A1 correct integration for both parts 3rd M1 for use of the correct limits on each part 2nd A1 for either getting 1 and $3\frac{2}{3}$ or awrt 3.67 somewhere or $4\frac{2}{3}$ or awrt 4.67 4th M1 for use of $\text{E}(X^2)-\left[\text{E}(X)\right]^2$ must add both parts for E (X^2) and only have subtracted the mean^2 once. You must see this working 3rd A1 $\sigma=\sqrt{\frac{2}{3}}$ or $\sqrt{0.66667}$ or better with no incorrect working seen.	
(d)	M1 for attempting to find LQ, integral of either part of f(x) with their 'a' and 'b' = 0.25 Or their F(x) = 0.25 i.e. $\frac{ax^2}{2}=0.25$ or $bx-\frac{ax^2}{2}+4a-2b=0.25$ with their a and b If they add both parts of their F(x), then they will get M0. 1st A1 for a correct equation/expression using their 'a' 2nd A1 for $\sqrt{2}$ or awrt 1.41	
(e)	M1 for a reason based on their quartiles • Possible reasons are P(2 - σ<X< 2 + σ)= 0.6498 allow awrt 0.65 • 1.184 < LQ(1.414) A1 for correct answer > 0.5 NB you must check the reason and award the method mark. A correct answer without a correct reason gets M0 A0	

Question Number	Scheme	Marks
Q8 (a)	$X \sim \text{Po}(2)$ $\quad$ $\text{P}(X = 4) = \frac{e^{-2}\times 2^4}{4!} = 0.0902$ $\quad$ awrt 0.09	M1 A1 (2)
(b)	$Y \sim \text{Po}(8)$ $\text{P}(Y > 10) = 1 - \text{P}(Y \le 10) = 1 - 0.8159 = 0.18411\ldots$ $\quad$ awrt 0.184	B1 M1A1 (3)
(c)	F = no. of faults in a piece of cloth of length x $\quad$ $F \sim \text{Po}(x\times\frac{2}{15})$ $e^{-\frac{2x}{15}} = 0.80$ $e^{-\frac{2}{15}\times 1.65} = 0.8025...,\quad e^{-\frac{2}{15}\times 1.75} = 0.791...$ These values are either side of 0.80 therefore x = 1.7 to 2 sf	M1A1 M1 A1 (4)
(d)	Expected number with no faults $= 1200\times 0.8 = 960$ Expected number with some faults $= 1200\times 0.2 = 240$ So expected profit $= 960\times 0.60 - 240\times 1.50, \quad = £216$	M1 A1 M1, A1 (4) **[13]**
(a)	M1 for use of Po(2) may be implied A1 awrt 0.09	
(b)	B1 for Po(8) seen or used M1 for 1 - $\text{P}(Y \le 10)$ oe A1 awrt 0.184	
(c)	1st M1 for forming a suitable Poisson distribution of the form $e^{-\lambda} = 0.8$ 1st A1 for use of lambda as $\frac{2x}{15}$ (this may appear after taking logs) 2nd M1 for attempt to consider a range of values that will prove 1.7 is correct **OR** for use of logs to show lambda = … 2nd A1 correct solution only. Either get 1.7 from using logs or stating values either side	
S.C	for $e^{-\frac{2}{15}\times 1.7} = 0.797... \approx 0.80 \quad \therefore x = 1.7$ to 2 sf allow 2nd M1A0	
(d)	1st M1 for one of the following 1200 p or 1200 (1 – p) where p = 0.8 or 2/15. 1st A1 for both expected values being correct or two correct expressions. 2nd M1 for an attempt to find expected profit, must consider with and without faults 2nd A1 correct answer only.	

Mark Scheme (Results)
January 2010

GCE

Statistics S2 (6684)

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6684 Statistics S2
Mark Scheme

Question Number	Scheme	Marks
Q1 (a)	$X \sim B(20,0.05)$	B1 B1 (2)
(b)	P(X = 0) = 0.95^{20} = 0.3584859… or 0.3585 using tables .	M1 A1 (2)
(c)	$P(X > 4) \quad =1 - P(X \le 4)$ $=1-0.9974$ $=0.0026$	M1 A1 (2)
(d)	Mean $=20\times0.05=1$ Variance $=20\times0.05\times0.95=0.95$	B1 B1 (2) **Total [8]**
	Notes	
Q1 (a)	**1st B1** for binomial **2nd B1** for 20 and 0.05 o.e These must be in part (a)	
(b)	**M1** for finding $(p)^{20}$ $0< p <1$ this working needs to be seen if answer incorrect to gain the M1 **A1** awrt 0.358 or 0.359.	
(c)	**M1** for writing $1 - P(X \le 4)$ or 1 – [P(X = 0) + P(X = 1) + P(X = 2) + P(X = 3) + P(X = 4)] or 1 – 0.9974 or 1 – 0.9568 **A1** awrt 0.0026 or 2.6×10^{-3}, do not accept a fraction e.g. 26/10000	
(d)	**1st B1** for 1 **2nd B1** for 0.95 NB In parts b, c and d correct answers with no working gain full marks	

Question Number	Scheme	Marks
Q2 (a)	$P(X < 0) \qquad = F(0)$	M1
	$= \frac{2}{6} = \frac{1}{3}$	A1 (2)
(b)	$f(x) \quad = \frac{dF(x)}{dx}$	M1
	$f(x) = \begin{cases} \frac{1}{6} & -2 \le x \le 4 \\ 0 & \text{otherwise} \end{cases}$	A1 B1 (3)
(c)	Continuous Uniform (Rectangular) distribution	B1 (1)
(d)	Mean $= 1$	B1
	Variance is $\frac{(4--2)^2}{12} = 3$	M1 A1 (3)
(e)	$P(X = 1) = 0$	B1 (1) **Total [10]**
	Notes	
Q2 (a)	**M1** for attempting to find F(0) by a correct method eg subst 0 into F(x) or $\int_{-2}^{0} \frac{1}{6} dx$ Do **NOT** award M1 for $\int_{-2}^{0} \frac{x+2}{6} dx$ or $\frac{1}{2} \times \frac{1}{3} \times 2$ both of which give the correct answer by using F(x) as the pdf **A1** 1/3 o.e or awrt 0.333 Correct answer only with no incorrect working gets M1 A1	
(b)	**M1** for attempting to differentiate F(x). (for attempt it must have no xs in) **A1** for the first line. Condone < signs **B1** for the second line. – They must have 0 $x < -2$ and $x > 4$ only.	
(c)	**B1** must have "continuous" and "uniform" **or** "Rectangular"	
(d)	**B1** for mean = 1 **M1** for attempt to use $\frac{[\pm(b-a)]^2}{12}$, they must subst in values and not just quote the formula, or using $\int_{-2}^{4} x^2 (\textit{their } f(x)) - (\textit{their mean})^2$, including limits. Must get x^3 **when they integrate.** **A1** cao .	
(e)	**B1** cao	

Question Number	Scheme	Marks
Q3 (a)	$Y \sim \text{Po}(0.25)$	B1
	$\text{P}(Y=0) \quad = \text{e}^{-0.25}$	M1
	$= 0.7788$	A1
		(3)
(b)	$X \sim \text{Po}(0.4)$	B1
	P(Robot will break down) $= 1 - \text{P}(X = 0)$	
	$= 1 - e^{-0.4}$	M1
	$= 1 - 0.067032$	
	$= 0.3297$	A1
		(3)
(c)	$\text{P}(X = 2) \quad = \dfrac{e^{-0.4}(0.4)^2}{2}$	M1
	$= 0.0536$	A1
		(2)
(d)	0.3297 or answer to part (b)	B1ft
	as Poisson events are independent	B1 dep
		(2)
		Total [10]
	Notes	
Q3 (a)	**B1** for seeing or using Po(0.25) **M1** for finding P(*Y*=0) either by e^{-a}, where *a* is positive (*a* needn't equal their λ) or using tables if their value of λ is in them Beware common Binomial error using, $p = 0.05$ gives 0.7738 but scores B0 M0 A0 **A1** awrt 0.779	
(b)	**B1** for **stating or a clear use of** Po(0.4) in part (b) or (c) **M1** for writing or finding 1 – P(*X* =0) **A1** awrt 0.33	
(c)	**M1** for finding P(*X* =2) e.g $\dfrac{\text{e}^{-\lambda}\lambda^2}{2!}$ with their value of λ in or if their λ is in the table for writing $\text{P}(X \leq 2)$ - $\text{P}(X \leq 1)$ **A1** awrt 0.0536	
(d)	1st **B1** their answer to part(b) correct to 2 sf or awrt 0.33 2nd **B1** need the word independent. This is dependent on them gaining the first B1 **SC** **Use of Binomial.** **Mark parts a and b as scheme. They could get (a) B0,M0,A0 (b) B0 M1 A0** **In part c allow M1 for** ${}^{n}C_2\,(p)^2(1-p)^{n-2}$ **with "their n" and "their *p*". They could get (c) M1,A0** **DO NOT GIVE for** $p(x \leq 2) - p(x \leq 1)$ **In (d) they can get the first B1 only. They could get (d) B1B0**	

Question Number	Scheme	Marks
Q4 (a)	$\int_0^3 k(x^2-2x+2)\mathrm{d}x+\int_3^4 3k\mathrm{d}x \quad =1$	M1
	$k\left[\frac{1}{3}x^3-x^2+2x\right]_0^3+\left[3kx\right]_3^4 \quad (=1)$ or $k\left[\frac{1}{3}x^3-x^2+2x\right]_0^3+3k \quad (=1)$	A1 M1 dep
	$9k \quad =1$	
	$k \quad =\frac{1}{9}$ **given** cso	A1
		(4)
(b)	For $0<x\le 3,\ \mathrm{F}(x) \quad =\int_0^x \frac{1}{9}(t^2-2t+2)\mathrm{d}t$	M1
	$=\frac{1}{9}\left(\frac{1}{3}x^3-x^2+2x\right)$	A1
	For $3<x\le 4,\ \mathrm{F}(x) \quad =\int_3^x 3k\mathrm{d}t+\frac{2}{3}$	M1
	$=\frac{x}{3}-\frac{1}{3}$	A1
	$\mathrm{F}(x)=\begin{cases} 0 & x\le 0 \\ \frac{1}{27}(x^3-3x^2+6x) & 0<x\le 3 \\ \frac{x}{3}-\frac{1}{3} & 3<x\le 4 \\ 1 & x>4 \end{cases}$	B1 ft B1
		(6)
(c)	$\mathrm{E}(X) \quad =\int_0^3 \frac{x}{9}(x^2-2x+2)\mathrm{d}t+\int_3^4 \frac{x}{3}\mathrm{d}x$	M1
	$=\frac{1}{9}\left[\frac{1}{4}x^4-\frac{2}{3}x^3+x^2\right]_0^3+\left[\frac{1}{6}x^2\right]_3^4$	A1
	$=\frac{29}{12}$ or 2.416 or awrt 2.42	A1
		(3)
(d)	F(m) = 0.5	M1
	$\mathrm{F}(2.6) = \frac{1}{27}(2.6^3-3\times 2.6^2+6\times 2.6)=\text{awrt } 0.48$	M1
	$\mathrm{F}(2.7) = \frac{1}{27}(2.7^3-3\times 2.7^2+6\times 2.7)=\text{awrt } 0.52$	A1
	Hence median lies between 2.6 and 2.7	A1 dA
		(4)
		Total [17]

Notes

Q4 (a)

1st M1 attempting to integrate **at least one** part (at least one $x^n \to x^{n+1}$) (ignore limits)
1st A1 Correct integration. Limits not needed.
2nd M1 dependent on the previous M being awarded. Adding the two answers together, putting equal to 1 and have the correct limits.
2nd A1 cso

(b)

1st M1 Att to integrate $\frac{1}{9}\left(t^2 - 2t + 2\right)$ (at least one $x^n \to x^{n+1}$). Ignore limits for method mark

1st A1 $\frac{1}{9}\left(\frac{x^3}{3} - x^2 + 2x\right)$ allow use of *t*. Must have used/implied use of limit of 0. This must be on its own without anything else added

2nd M1 attempting to find $\int_3^x 3k + \ldots$ (must get $3kt$ or $3kx$)
and they must use the correct limits and add $\int_0^3 \frac{1}{9}\left(t^2 - 2t + 2\right)$ or $\frac{2}{3}$
or use $+\text{C}$ and use $\text{F}(4) = 1$

2nd A1 $\frac{x}{3} - \frac{1}{3}$ must be correct

1st B1 middle pair followed through from their answers. condone them using < or ≤ incorrectly they do not need to match up
2nd B1 end pairs. condone them using < or ≤. They do not need to match up

NB if they show no working and just write down the distribution. If it is correct they get full marks. If it is incorrect then they cannot get marks for any incorrect part. So if $0<x\leq 3$ is correct they can get M1 A1 otherwise M0 A0. If $3<x\leq 4$ is correct they can get M1 A1 otherwise M0 A0. you cannot award B1ft if they show no working unless the middle parts are correct.

(c)

1st M1 attempting to use integral of x f(x) on one part
1st A1 Correct Integration for both parts added together. Ignore limits.
2nd A1 cao or awrt 2.42

(d)

1st M1 for using F(X) = 0.5. This may be implied by subst into F(X) and comparing answers with 0.5.
2nd M1 for substituting both 2.6 and 2.7 into "their F(X)" – 0.5 or "their F(X)"
1st A1 awrt 0.48 and 0.52 if using "their F(X)" .
and awrt -0.02 and 0.02 or if using "their F(X)" 0.5
Other values possible. You may need to check their values for their **correct** equation
NB these last two marks are B1 B1 on ePEN but mark as M1 A1
2nd A1 for conclusion but only award if it follows from their numbers. Dependent on previous A mark being awarded
SC using calculators
M1 for sign of a suitable equation
M1 A1 for awrt 2.66 provided equation is correct
A1 correct comment

Question Number	Scheme	Marks
Q5 (a)	$X \sim \text{Po}(10)$	B1
	$\text{P}(X < 9) \quad = \text{P}(X \le 8)$	M1
	$= 0.3328$	A1 (3)
(b)	$Y \sim \text{Po}(40)$	
	Y is approximately N(40,40)	M1 A1
	$\text{P}(Y > 50) \quad = 1 - \text{P}(Y \le 50)$	
	$= 1 - \text{P}\left(Z < \frac{50.5 - 40}{\sqrt{40}}\right)$	M1 M1 A1
	$= 1 - \text{P}(Z < 1.660..)$	
	$= 1 - 0.9515$	
	$= 0.0485$	A1 (6) **Total [9]**
	N.B. Calculator gives 0.048437. Poisson gives 0.0526 (but scores nothing)	
	Notes	
Q5 (a)	**B1** for using Po(10) **M1** for attempting to find $\text{P}(X \le 8)$: useful values $\text{P}(X \le 9)$ is 0.4579(M0), using Po(6) gives 0.8472, (M1). **A1** awrt 0.333 but do not accept $\frac{1}{3}$	
(b)	1^{st} **M1** for identifying the normal approximation 1^{st} **A1** for [mean = 40] and [sd = $\sqrt{40}$ or var = 40] **NB These two marks are B1 M1 on ePEN** These first two marks may be given if the following are seen in the standardisation formula : 40 and $\sqrt{40}$ or awrt 6.32 2^{nd} **M1** for attempting a continuity correction (50 or 30 $\pm$ 0.5 is acceptable) 3^{rd} **M1** for standardising using their mean and their standard deviation and using either 49.5, 50 or 50.5. (29.5, 30, 30.5) accept $\pm$ 2^{nd} **A1** correct z value awrt ± 1.66 **or** this may be awarded if see $\pm\frac{50.5 - 40}{\sqrt{40}}$ or $\pm\frac{29.5 - 40}{\sqrt{40}}$ 3^{rd} **A1** awrt 3 sig fig in range 0.0484 – 0.0485	

Question Number	Scheme	Marks
Q6 (a)	The set of values of the test statistic for which	B1
	the null hypothesis is rejected in a hypothesis test.	B1
		(2)
(b)	X~B(30,0.3)	M1
	$\text{P}(X \le 3) = 0.0093$	
	$\text{P}(X \le 2) = 0.0021$	A1
	$\text{P}(X \ge 16) = 1 - 0.9936 = 0.0064$	
	$\text{P}(X \ge 17) = 1 - 0.9979 = 0.0021$	A1
	Critical region is $(0 \le) x \le 2$ or $16 \le x (\le 30)$	A1A1
		(5)
(c)	Actual significance level 0.0021+0.0064=0.0085 or 0.85%	B1
		(1)
(d)	15 (it) is not in the critical region	Bft 2, 1, 0
	not significant	
	No significant evidence of a change in $p = 0.3$	
	accept H_0, (reject H_1)	
	$\text{P}(x \ge 15) = 0.0169$	(2)
		Total [10]
	Notes	
Q6 (a)	1st **B1** for "**values/ numbers**"	
	2nd **B1** for "reject the null hypothesis" o.e or the test is significant	
(b)	**M1** for using B(30,0.3)	
	1st **A1** $\text{P}(x \le 2) = 0.0021$	
	2nd **A1** 0.0064	
	3rd **A1** for $(X) \le 2$ or $(X) < 3$ They get **A0** if they write **P**($X \le 2/ X < 3$)	
	4th **A1** $(X) \ge 16$ or $(X) > 15$ They get **A0** if they write **P**($X \ge 16$ $X > 15$	
	NB these are B1 B1 but mark as A1 A1	
	$16 \le X \le 2$ etc is accepted	
	To describe the critical regions they can use any letter or no letter at all. It does not have to be X.	
(c)	**B1** correct answer only	
(d)	Follow through 15 and their critical region	
	B1 for any one of the 5 correct statements up to a maximum of B2	
	– **B1** for any incorrect statements	

Question Number | Scheme | Marks

Q7 (a)

x	1p	2p
$\mathrm{P}(X = x)$	$\frac{1}{4}$	$\frac{3}{4}$

$\mu = 1\times\frac{1}{4} + 2\times\frac{3}{4} = \frac{7}{4}$ or $1\frac{3}{4}$ or 1.75 B1

$\sigma^2 \quad = 1^2\times\frac{1}{4} + 2^2\times\frac{3}{4} - \left(\frac{7}{4}\right)^2$ M1

$= \frac{3}{16}$ or 0.1875 A1

(3)

(b) (1,1,1) , (1,1,2) any order, (1,2,2) any order, (2,2,2) B1

(1,2,1) (2,1,1) (2,1,2) (2,2,1) all 8 cases considered. May be implied by 3 * (1,1,2) and 3*(1,2,2) B1

(2)

(c)

$\bar{x}$	1	$\frac{4}{3}$	$\frac{5}{3}$	2
$\mathrm{P}(\bar{X} = \bar{x})$	$\frac{1}{4}\times\frac{1}{4}\times\frac{1}{4}=\frac{1}{64}$	$3\times\frac{1}{4}\times\frac{1}{4}\times\frac{3}{4}=\frac{9}{64}$	$3\times\frac{1}{4}\times\frac{3}{4}\times\frac{3}{4}=\frac{27}{64}$	$\frac{3}{4}\times\frac{3}{4}\times\frac{3}{4}=\frac{27}{64}$

B1
M1 A1
M1 A1A1

(6)

Total [11]

Notes

Q7 (a) B1 1.75 oe
M1 for using $\sum\left(x^2 p\right) - \mu^2$
A1 0.1875 oe

(b) ignore repeats

(c) 1$^{\text{st}}$ B1 4 correct means (allow repeats)
1$^{\text{st}}$ M1 for p^3 for either of the ends
1st A1 for 1/64or awrt 0.016 **and** 27/64 or awrt 0.422
2$^{\text{nd}}$ M1 $3\times p^2(1-p)$ for either of the middle two $0 < p < 1$
May be awarded for finding the probability of the 3 samples with mean of either 4/3 or 5/3 .
2$^{\text{nd}}$ A1 for 9/64 (or 3/64 three times) and 27/64 (or 9/64 three times) accept awrt 3dp.
3$^{\text{rd}}$ A1 fully correct table, accept awrt 3dp.

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Mark Scheme (Results)

Summer 2010

GCE

GCE Statistics S2 (6684/01)

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Summer 2010

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June 2010
Statistics S2 6684
Mark Scheme

Question Number	Scheme	Marks
Q1 (a)	A population is collection of all items	B1 (1)
(b)	(A random variable) that is a function of the sample which contains no unknown quantities/parameters.	B1 (1)
(c)	The voters in the town Percentage/proportion voting for Dr Smith	B1 B1 (2)
(d)	Probability Distribution of those voting for Dr Smith from all possible samples (of size 100)	B1 (1) **[5]**

Notes

(a) **B1** – collection/group **all** items – need to have /imply all eg entire/complete/every

(b) **B1** – needs function/calculation(o.e.) of the sample/random variables/observations **and** no unknown quantities/parameters(o.e.) NB do not allow unknown variables

e.g. "A calculation based solely on observations from a given sample." B1
"A calculation based only on known data from a sample" B1
"A calculation based on known observations from a sample" B0

Solely/only imply no unknown quantities

(c) **B1** – Voters

Do not allow 100 voters.

B1 – percentage/ proportion voting (for Dr Smith)
the **number** of people voting (for Dr Smith)
Allow 35% of people voting (for Dr Smith)
Allow 35 people voting (for Dr Smith)
Do **not** allow 35% or 35 alone

(d) **B1** – answers must include all three of these features
- (i) All possible samples,
- (ii) their associated probabilities,
- (iii) context of voting for Dr Smith.

e.g "It is all possible values of the percentage and their associated probabilities." B0 no context

Question Number	Scheme	Marks
Q2 (a)	Let X be the random variable the number of games Bhim loses. X ~B(9, 0.2)	B1
	$P(X \le 3) - P(X \le 2) = 0.9144 - 0.7382$ or $(0.2)^3(0.8)^6\frac{9!}{3!6!}$	M1
	$= 0.1762$ $= 0.1762$ awrt 0.176	A1 (3)
(b)	$P(X \le 4) = 0.9804$ awrt 0.98	M1A1 (2)
(c)	Mean = 3 variance = 2.85, $\frac{57}{20}$	B1 B1 (2)
(d)	Po(3) poisson	M1
	$P(X > 4) = 1 - P(X \le 4)$	M1
	$= 1 - 0.8153$	
	$= 0.1847$	A1 (3)
		[10]
	Notes	
(a)	B1 – writing or use of B(9, 0.2)	
	M1 for writing/ using $P(X \le 3) - P(X \le 2)$ or $(p)^3(1-p)^6\frac{9!}{3!6!}$	
	A1 awrt 0.176	
(b)	**M1** for writing or using $P(X \le 4)$ **A1** awrt 0.98	
(c)	**B1** 3 **B1** 2.85, or exact equivalent	
(d)	**M1** for using Poisson **M1** for writing or using $1 - P(X \le 4)$ NB $P(X \le 4)$ is 0.7254 Po(3.5) and 0.8912 Po(2.5) **A1** awrt 0.185	
	Special case :Use of Po(1.8) in (a) and (b)	
	(a) can get B1 M1 A0 – B1 if written B(9, 0.2), M1 for $\frac{e^{-1.8}1.8^3}{3!}$ **or** awrt to 0.161 If B(9, 0.2) is not seen then the only mark available for using Poisson is M1. (b) can get M1 A0 - M1 for writing or using $P(X \le 4)$ or may be implied by awrt 0.964	
	Use of Normal in (d) Can get M0 M1 A0.- for M1 they must write $1 - P(X \le 4)$ or get awrt 0.187	

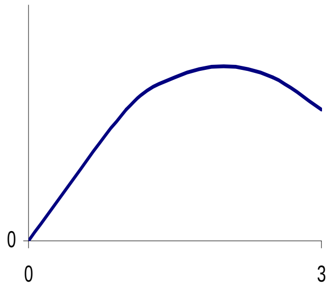
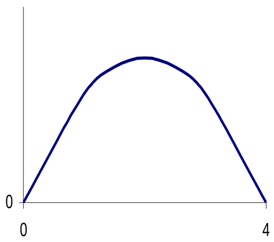
Question Number	Scheme			Marks
Q3	Method 1	Method 2	Method 3	
	P $(X > 6) = \frac{1}{6}$	$\text{P}(4 < X < 6) = \frac{1}{3}$	P $(X > 6) = \frac{1}{6}$	B1 M1
	$\text{P}(X < 4) = \frac{1}{2}$		Y~U[3,9] P $(Y > 6) = \frac{1}{2}$	A1
	total = $\frac{1}{6} + \frac{1}{2} = \frac{2}{3}$	$1 - \frac{1}{3} = \frac{2}{3}$	total = $\frac{1}{6} + \frac{1}{2} = \frac{2}{3}$	M1dep B A1 (5) **[5]**
	Notes **Methods 1 and 2** B1 for 6 and 4 (allow if seen on a diagram on x-axis) **M1** for $\text{P}(X > 6)$ or $\text{P}(6 < X < 7)$; or $\text{P}(X < 4)$ or $\text{P}(1 < X < 4)$; or $\text{P}(4 < X < 6)$ Allow $\leq$ *and* $\geq$ signs **A1** $\frac{1}{6}; or \frac{1}{2}; \frac{1}{3}$ must match the probability statement **M1** for adding their " $\text{P}(X > 6)$" and their "$\text{P}(X < 4)$" or 1 - their "$\text{P}(4 < X < 6)$" dep on getting first B mark **A1** cao $\frac{2}{3}$ **Method 3 Y~U[3, 9]** **B1** for 6 with U[1,7]and 6 with U[3,9] **M1** for $\text{P}(X > 6)$ or $\text{P}(6 < X < 7)$ or $\text{P}(6 < Y < 9)$ **A1** $\frac{1}{6}; or \frac{1}{2};$ must match the probability statement **M1** for adding their " $\text{P}(X > 6)$" and their "$\text{P}(Y >6)$" dep on getting first B mark **A1** cao $\frac{2}{3}$			

Question Number	Scheme	Marks
Q4 (a)	$\frac{4}{9}\left(m^2+2m-3\right)=0.5$	M1
	$m^2 + 2m - 4.125 = 0$	
	$m=\frac{-2\pm\sqrt{4+16.5}}{2}$	M1
	m =1.26, -3.264	
	(median =) 1.26	A1 (3)
(b)	Differentiating $\frac{\mathrm{d}\left(\frac{4}{9}\left(x^2+2x-3\right)\right)}{\mathrm{d}x}=\frac{4}{9}\left(2x+2\right)$	M1 A1
	$\mathrm{f}(x)=\begin{cases}\frac{8}{9}\left(x+1\right) & 1\leq x\leq 1.5\\ 0 & \text{otherwise}\end{cases}$	B1ft (3)
(c)	P($X \geq$ 1.2) = 1 – F(1.2)	M1
	= 1 – 0.3733	
	$=\frac{47}{75}$, 0.6267 awrt 0.627	A1 (2)
(d)	$(0.6267)^4$= 0.154 awrt 0.154 or 0.155	M1 A1 (2)
		[10]
	<u>Notes</u>	
(a)	**M1** putting F(x) = 0.5 **M1** using correct quadratic formula. If use calc need to get 1.26 (384...) **A1** cao 1.26 must reject the other root. If they use Trial and improvement they have to get the correct answer to gain the second M mark.	
(b)	**M1** attempt to differentiate. At least one $x^n \rightarrow x^{n-1}$ **A1** correct differentiation **B1** must have both parts- follow through their $\mathrm{F}'(x)$ Condone <	
(c)	**M1** finding/writing 1 – F(1.2) may use/write $\int_{1.2}^{1.5}\frac{8}{9}(x+1)\mathrm{d}x$ or 1 - $\int_{1}^{1.2}\frac{8}{9}(x+1)\mathrm{d}x$ or $\int_{1.2}^{1.5}$"their f(x)" dx. Condone missing dx **A1** awrt 0.627	
(d)	**M1** (c)^4 If expressions are not given you need to check the calculation is correct to 2sf. **A1** awrt 0.154 or 0.155	

Question Number	Scheme		Marks
Q5 (a)	Connecting occurs at random/independently, singly or at a constant rate		B1 (1)
(b)	Po (8)		B1
(i)	$P(X = 0) = 0.0003$		M1A1
(ii)	$P(X \geq 4) = 1 - P(X \leq 3)$		M1
	$= 1 - 0.0424$		A1 (5)
	$= 0.9576$		
(c)	$H_0: \lambda = 4\ (48)\quad H_1: \lambda > 4\ (48)$		B1
	N(48,48)		M1 A1
	Method 1	Method 2	
	$P(X \geq 59.5) = P\left(Z \geq \frac{59.5 - 48}{\sqrt{48}}\right)$	$\frac{x - 0.5 - 48}{\sqrt{48}} = 1.6449$	M1 M1 A1
	$= P(Z \geq 1.66)$		
	$= 1 - 0.9515$		
	$= 0.0485$	$x = 59.9$	A1
	$0.0485 < 0.05$		
	Reject H_0. Significant. 60 lies in the Critical region		M1
	The number of failed connections at the first attempt has increased.		A1 ft (9)
			[15]
	Notes		
(a)	**B1** Any one of randomly/independently/singly/constant rate. Must have context of connection/logging on/fail		
(b)	**B1** Writing or using Po(8) in (i) or (ii)		
(i)	**M1** for writing or finding $P(X = 0)$		
	A1 awrt 0.0003		
(ii)	**M1** for writing or finding $1 - P(X \leq 3)$		
	A1 awrt 0.958		
(c)	**B1** both hypotheses correct. Must use λ or μ		
	M1 identifying normal		
	A1 using or seeing mean and variance of 48		
	These first two marks may be given if the following are seen in the standardisation formula : 48 and $\sqrt{48}$ or awrt 6.93		
	M1 for attempting a continuity correction (Method 1: 60 ± 0.5 / Method 2: $x \pm 0.5$)		
	M1 for standardising using their mean and their standard deviation and using either Method 1 [59.5, 60 or 60.5. accept $\pm$ z.] Method 2 [($x \pm 0.5$) and equal to a $\pm z$ value)		
	A1 correct z value awrt ± 1.66 **or** $\pm \frac{59.5 - 48}{\sqrt{48}}$, or $\frac{x - 0.5 - 48}{\sqrt{48}} = 1.6449$		
	A1 awrt 3 sig fig in range 0.0484 – 0.0485, awrt 59.9		
	M1 for "reject H_0" or "significant" maybe implied by "correct contextual comment" If one tail hypotheses given follow through "their prob" and 0.05 , $p < 0.5$ If two tail hypotheses given follow through "their prob" with 0.025, $p < 0.5$ If one tail hypotheses given follow through "their prob" and 0.95 , $p > 0.5$ If two tail hypotheses given follow through "their prob" with 0.975, $p > 0.5$ If no H_1 given they get M0		
	A1 ft correct contextual statement followed through from their prob and H_1. need the words <u>number</u> of <u>failed connections/log ons</u> has <u>increased</u> o.e. Allow "there are more failed connections" NB A correct contextual statement **<u>alone</u>** followed through from their prob and H_1 gets M1 A1		

Question Number	Scheme	Marks
Q6 (a)	2 outcomes/faulty or not faulty/success or fail A constant probability Independence Fixed number of trials (fixed n)	B1 B1 (2)
(b)	$X \sim B(50,0.25)$ $P(X \le 6) = 0.0194$ $P(X \le 7) = 0.0453$ $P(X \ge 18) = 0.0551$ $P(X \ge 19) = 0.0287$ CR $X \le 6$ and $X \ge 19$	M1 A1 A1 (3)
(c)	$0.0194 + 0.0287 = 0.0481$	M1A1 (2)
(d)	8(It) is not in the Critical region or 8(It) is not significant or $0.0916 > 0.025$; There is evidence that the probability of a faulty bolt is 0.25 or the company's claim is correct.	M1; A1ft (2)
(e)	$H_0 : p = 0.25 \quad H_1 : p < 0.25$ $P(X \le 5) = 0.0070$ or CR $X \le 5$ $0.007 < 0.01$, 5 is in the critical region, reject H_0, significant. There is evidence that the probability of faulty bolts has decreased	B1B1 M1A1 M1 A1ft 6) **[15]**
	Notes	
(a)	**B1 B1** one mark for each of any of the four statements. Give first B1 if only one correct statement given. No context needed.	
(b)	**M1** for writing or using B(50,0.25) also may be implied by both CR being correct. Condone use of P in critical region for the method mark. **A1** $(X) \le 6$ o.e. [0,6] DO NOT accept $P(X \le 6)$ **A1** $(X) \ge 19$ o.e. [19,50] DO NOT accept $P(X \ge 19)$	
(c)	**M1** Adding two probabilities for two tails. Both probabilities must be less than 0.5 **A1** awrt 0.0481	
(d)	**M1** one of the given statements followed through from their CR. **A1** contextual comment followed through from their CR. NB A correct contextual comment **alone** followed through from their CR.will get M1 A1	
(e)	**B1** for H_0 must use p or π (pi) **B1** for H_1 must use p or π (pi) **M1** for finding or writing $P(X \le 5)$ or attempting to find a critical region or a correct critical region **A1** awrt 0.007/CR $X \le 5$ **M1** correct statement using their Probability and 0.01 if one tail test or a correct statement using their Probability and 0.005 if two tail test. The 0.01 or 0.005 needn't be explicitly seen but implied by correct statement compatible with their H_1. If no H_1 given M0 **A1** correct contextual statement follow through from their prob and H_1. Need faulty bolts and decreased. NB A correct contextual statement **alone** followed through from their prob and H_1 get M1 A1	

Question Number	Scheme	Marks
Q7 (ai)	$f(y) \geq 0$ or $f(3) \geq 0$	M1
	$ky\left(a-y\right) \geq 0$ or $3k(a-3) \geq 0$ or $(a-y) \geq 0$ or $(a-3) \geq 0$	
	$a \geq 3$	A1 cso
(ii)	$\int_0^3 k(ay-y^2)dy = 1$ integration	M1
	$\left[k\left(\frac{ay^2}{2}-\frac{y^3}{3}\right)\right]_0^3 = 1$ answer correct	A1
	$k\left(\frac{9a}{2}-9\right) = 1$ answer = 1	M1
	$k\left[\frac{9a-18}{2}\right] = 1$	
	$k = \frac{2}{9\left(a-2\right)}$ *	A1 cso 6)
(b)	$\int_0^3 k(ay^2 - y^3)\mathrm{d}y = 1.75$ Int $\int xf(x)$	M1
	$\left[k\left(\frac{ay^3}{3}-\frac{y^4}{4}\right)\right]_0^3 = 1.75$ Correct integration	A1
	$\int xf(x) = 1.75$ and limits 0,3	M1dep
	$k\left(9a-\frac{81}{4}\right) = 1.75$	
	$2\left(9a-\frac{81}{4}\right) = 15.75(a-2)$ subst k	M1dep
	$2.25a = -31.5 + \frac{81}{2}$	
	a = 4 *	A1cso
	$k = \frac{1}{9}$	B1 (6)

Question Number	Scheme	Marks
(c)		B1 B1 (2)
(d)	mode = 2	B1 (1) **[15]**
	Notes	
(a) (i)	**M1** for putting f(y) $\geq$ 0 or f(3) $\geq$ 0 or $ky\left(a-y\right)\geq 0$ or $3k(a-3)\geq 0$ or $(a-y)\geq 0$ or $(a-3)\geq 0$ or state in words the probability can not be negative o.e. **A1** need one of $ky\left(a-y\right)\geq 0$ or $3k(a-3)\geq 0$ or $(a-y)\geq 0$ or $(a-3)\geq 0$ **and** $a\geq 3$	
(ii)	**M1** attempting to integrate (at least one $y^n \to y^{n+1}$) (ignore limits) **A1 Correct integration.** Limits not needed. And equals 1 not needed. **M1** dependent on the previous M being awarded. Putting equal to 1 and have the correct limits. Limits do not need to be substituted. **A1** cso	
(b)	**M1** for attempting to find $\int y\mathrm{f}(y)\,\mathrm{d}y$ (at least one $y^n \to y^{n+1}$) (ignore limits) **A1** correct Integration **M1** $\int y\mathrm{f}(y) = 1.75$ and limits 0,3 dependent on previous M being awarded **M1** subst in for k. dependent on previous M being awarded **A1** cso 4 **B1** cao 1/9	
(c)	**B1** correct shape. No straight lines. No need for patios. **B1** completely correct graph. Needs to go through origin and the curve ends at 3. <u>Special case</u>: If draw full parabola from 0 to 4 get B1 B0 Allow full marks if the portion between x = 3 and x = 4 is dotted and the rest of the curve solid. 	
(d)	**B1** cao 2	

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Mark Scheme (Results)

January 2011

GCE

GCE Statistics S2 (6684) Paper 1

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January 2011

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    - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
    - **B** marks are unconditional accuracy marks (independent of M marks)
    - Marks should not be subdivided.

3. Abbreviations

    These are some of the traditional marking abbreviations that will appear in the mark schemes.

    - bod – benefit of doubt
    - ft – follow through
    - the symbol √ will be used for correct ft
    - cao – correct answer only
    - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
    - isw – ignore subsequent working
    - awrt – answers which round to
    - SC: special case
    - oe – or equivalent (and appropriate)
    - dep – dependent
    - indep – independent
    - dp decimal places
    - sf significant figures
    - * The answer is printed on the paper
    - ⎣ The second mark is dependent on gaining the first mark

January 2011
Statistics S2 6684
Mark Scheme

Question Number	Scheme	Marks
1. **(a)**	Occurrences of the disease are independent The probability of catching the disease remains constant.	B1 B1 (2)
(b)	$X \sim \text{Bin}(10,0.03)$ $\text{P}(X=2)=\frac{10\times 9}{2}(0.03)^2(0.97)^8=0.0317$	B1 M1A1 (3)
(c)	$\text{E}(X)=100\times 0.03=3$ $\text{Var}(X)=100\times 0.03\times 0.97=2.91$	B1cao B1cao (2)
(d)	$\lambda=100\times 0.03=3$ $Y \sim \text{Po}(3)$ $\text{P}(Y>5) \quad =1-\text{P}(Y\le 5)$ $= 1 - 0.9161$ $= 0.0839$	B1 (use of) dM1 A1 (3) **[10]**
	Notes	
(a)	B1 independent B1 probability remains constant. One of these must have the context of disease. No context only one correct B0B0 If only one mark awarded give the first B1 SC if they are both correct without context award B1B0	
(b)	B1 for writing or using B(10,0.03) M1 for writing or using $(p)^2\,(1-p)^8\ \frac{10!}{2!8!}$ allow ${}^{10}\text{C}_2, \binom{10}{2}$ etc Allow P(X≤2) – P(X≤1) A1 awrt 0.0317	
(d)	B1 for using Poisson. Any mean. Common values which imply Poisson used are 0.9665 and 0.8153 dM1 for writing or using $1-\text{P}(X\le 5)$ - use of binomial gets M0. This is dependent on them being awarded the previous B mark. A1 awrt 0.0839 **SC: Use of Normal in (d)** Can get B0 M1 A0.- for M1 we must see $1-\text{P}(X\le 5)$ or $1-\text{P}(X\le 5.5)$ oe or get awrt 0.071	

Question Number	Scheme	Marks
2.	$H_0 : p = 0.2$ $H_1 : p > 0.2$	B1
	Under H_0, $X \sim \text{Bin}(10,0.2)$	B1
	$P(X \geq 4) = 1 - P(X \leq 3)$ OR $P(X \leq 4) = 0.9672$	M1
	$= 1 - 0.8791$ $P(X \geq 5) = 0.0328$	
	$= 0.1209$ CR $X \geq 5$	A1
	0.1209>0.05. Insufficient evidence to reject H_0 so teacher's claim is supported.	M1A1ft
		[6]
	Notes	
	B1 for both H_0 and H_1 correct. Must use p or π (pi) B1 for writing or using Bin(10,0.2) M1 for finding or writing $1 - P(X \leq 3)$ or $P(X \leq 4) = 0.9672$ $P(X \geq 5) = 0.0328$ oe or a correct critical region A1 awrt 0.121 or CR $X \geq 5$ M1 need p<0.5 and: correct statement using their Probability and 0.05 if one tail test or correct statement using their Probability and 0.025 if two tail test (condone a comparison with 0.05 instead of 0.025 for a two tail test). Do not allow non-contextual conflicting statements eg "significant" and "accept H_0" A1ft correct contextual statement followed through from "their prob". Either a comment on whether the teacher's claim was correct or on whether the student was guessing the answers. NB if a correct contextual statement only is given for their probability then award M1 A1 If p>0.5 They may compare with 0.95 (one tail method) or 0.975 (two tail method) Probability is 0.8791.	

Question Number	Scheme	Marks
3. **(a)**	$\mathrm{E}(X)=\frac{3-1}{2}=1$	B1 cao (1)
(b)	$\mathrm{Var}(X)=\frac{(3+1)^2}{12}=\frac{4}{3}$ oe	M1A1 (2)
(c)	$\mathrm{E}(X^2)=\frac{4}{3}+1,\ =\frac{7}{3}$ oe	M1,A1
(d)	P(X<1.4)=0.6	(2) B1 cao (1)
(e)	$\mathrm{P}\left(X<0\right)=0.25$ Y is number of values less than 0 $Y\sim\mathrm{Bin}\left(40,0.25\right)$ $\mathrm{P}(Y\geq 10)=1-\mathrm{P}(Y\leq 9)$ $=1-0.4395=0.5605$	B1 M1A1 M1 A1 (5) **[11]**
	<u>Notes</u>	
(b)	M1 $\frac{(3-1)^2}{12}$ *or* $\frac{(3+1)^2}{12}$ *or* $\frac{(3--1)^2}{12}$ A1 awrt 1.33	
(c)	M1 "their(b)" + ["their (a)"]^2 or $\int_{-1}^{3}\frac{x^2}{4}\mathrm{d}x$ A1 awrt 2.33	
(e)	B1 For writing or using the probability of a negative = 0.25 M1 Writing or use of B(40, p) A1 Writing or use of B(40, 0.25) M1 Writing or using $1-\mathrm{P}(Y\leq 9)$ A1 awrt 0.561 or 0.560	

Question Number	Scheme	Marks
4.	H$_0$: $\lambda = 8$ or $\mu = 2$ H$_1$: $\lambda < 8$ or $\mu < 2$ Under H_0, $X \sim \text{Po}(8)$ $\text{P}(X \le 3) = 0.0424$ CR $X \le 3$ $0.0424 < 0.05$, Reject H_0. Richard's claim is supported.	B1 B1 M1 A1 M1A1ft **[6]**
	Notes	
	B1 for H$_0$ correct. Must use λ or μ and 8 or 2 B1 for H$_1$ correct. Must use λ or μ and 8 or 2 M1 for writing or using Po(8) – may be implied by correct CR A1 awrt 0.0424 or CR $X \le 3$ M1 need p<0.5 and: correct statement using their Probability and 0.05 if one tail test or correct statement using their Probability and 0.025 if two tail test (condone a comparison with 0.05 instead of 0.025 for a two tail test). Do not allow non-contextual conflicting statements eg "significant" and "accept H$_0$" A1ft correct contextual statement followed through from "their prob". Either a comment on whether Richard's claim was correct or on whether the service has improved. NB if a correct contextual statement only is given for their probability then award M1 A1 p>0.5 They may compare with 0.95 (one tail method) or 0.975 (two tail method) Probability is 0.9576	

Question Number	Scheme	Marks
5. (a)	$m=-\frac{4}{0.5}=-8$	M1
	$\mathrm{f}(x)=4-8x$ (*)	A1cso
	$\mathrm{f}(x)=\begin{cases}-8x+4 & 0\le x\le 0.5\\ 0 & otherwise\end{cases}$	B1 B1 (4)
(b)	$\mathrm{F}(x)\quad=\int_0^x(-8x+4)\mathrm{d}x$	M1
	$=\left[-4x^2+4x\right]_0^x$	M1
	$\mathrm{F}(x)=\begin{cases}0 & x<0\\ -4x^2+4x & 0\le x\le 0.5\\ 1 & x>0.5\end{cases}$	A1 B1 (4)
(c)	$-4x^2+4x=0.5$	M1
	$x=\frac{1}{4}(2-\sqrt{2})=0.146$	M1A1 (3)
(d)	$x=0$	B1 (1)
(e)	Positive Skew as mode<median	B1ft (1) **[13]**

Question Number	Scheme	Marks
	Notes	
(a)	M1 for $\pm\dfrac{4}{0.5}$ or attempt at gradient A1cso for proceeding to given expression with no incorrect working seen B1 for top line. Must have f(x) and { and more than one line. Condone use of <. B1 for 0 otherwise and no other parts.	
(b)	M1 attempting to integrate (at least one $x^n \to x^{n+1}$) (ignore limits) M1 correct limits used or +C and either F(0) = 0 or F(0.5) = 1, may be implied by seeing $4x - 4x^2$ A1 middle line. May write $4x - 4x^2$ B1 top and bottom line	
(c)	M1 Their F(x) = 0.5 M1 attempting to solve – either correct use of quadratic formula or correct completion of the square A1 awrt 0.146 or $\dfrac{2-\sqrt{2}}{4}$ o.e	
(d)	B1 for 0	
(e)	B1 ft their mode and median. Need direction and correct corresponding reason OR B1 positive skew from tail on right hand side in diagram	

Question Number	Scheme	Marks
6.		
(a)	X~Po(2.5)	M1A1 (2)
(b)	<u>Cars arrive</u> at the toll booth <u>independently/randomly</u> <u>Cars arrive</u> <u>one at a time</u> The <u>rate of arrival</u> at a toll booth remains <u>constant</u> at 2.5 per minute	B1 B1 (2)
(c)(i)	$\mathrm{P}\left(X = 0\right) = \mathrm{e}^{-2.5} = 0.0821$	B1 (1)
(c)(ii)	$\mathrm{P}(X > 3) \qquad = 1 - \mathrm{P}(X \le 3)$ $= 0.2424$	M1 A1 (2)
(d)	Use of Po(10) $1 - 0.0487 = 0.9513$ $m = 15$	M1 M1 A1 cao (3)
(e)	$Y \sim \mathrm{N}\left(25, 25\right)$ $\mathrm{P}\left(X < 15\right) = \mathrm{P}(Y \le 14.5)$ $= \mathrm{P}\left(Z \le \frac{14.5 - 25}{5}\right)$ $= \mathrm{P}\left(Z \le -2.1\right)$ $= 0.01786$	B1B1 M1 M1 A1 A1 (6) **[16]**

Question Number	Scheme	Marks
	Notes	
(a)	M1 Poisson A1 2.5	
(b)	Any two of the statements or equivalent. At least one must be in context. Need words that imply "cars arrive" or "rate of arrival." **SC** no context but 2 correct reasons B1B0 No context but 1 correct reason B0B0	
(c) (i) **(ii)**	B1 awrt 0.0821 M1 for writing or finding 1 - P($X \leq 3$)	
(d)	A1 awrt 0.242 M1 writing or using Po(10) M1 for 1- 0.0487 or 0.9513 seen or implied by correct value for *m*	
(e)	B1 use of normal B1 using or seeing mean and variance of 25 These first two marks may be given if the following are seen in the correct places in the standardisation formula : 25 and $\sqrt{25}$ or 5 M1 for attempting a continuity correction (14 $\pm$ 0.5) or (15 $\pm$ 0.5) M1 for standardising using their mean and their standard deviation and using [14.5, 14, 13.5, 15 or 15.5] accept $\pm$ z. A1 correct z value ± 2.1 **or** $\pm\frac{14.5-25}{5}$, A1 awrt 0.0179 NB use of calculator gets full marks if the answer is awrt 0.0179.	

Question Number	Scheme	Marks
7. **(a)**	$\int_0^9 k(81x - x^3)\mathrm{d}x = 1$ $k\left[\frac{81}{2}x^2 - \frac{1}{4}x^4\right]_0^9 = 1$ $k(\frac{6561}{2} - \frac{6561}{4}) = 1$ $k = \frac{4}{6561}$ **ag**	M1 M1 A1 cso (3)
(b)	$\mathrm{E}(X) \quad = \int_0^9 kx^2(81 - x^2)\,\mathrm{d}x$ $= k\left[\frac{81}{3}x^3 - \frac{x^5}{5}\right]_0^9$ $= k(19683 - 11809.8)$ $= 4.8$	 M1A1 dM1 A1 cao (4)
(c)	$\mathrm{P}(X > 5) \qquad = \int_5^9 k(81x - x^3)$ $= k\left[\frac{81}{2}x^2 - \frac{1}{4}x^4\right]_5^9$ $= k\left(\frac{6561}{4} - 856.25\right) = \text{awrt } 0.478 \text{ or } \frac{3136}{6561}$	M1 M1d A1 (3)
(d)	P(At least 2 queue for more than 5 mins) $\quad =3(1\text{-}0.478)(0.478)^2 + 0.478^3$ $= 0.467$	M1A1ft A1 (3) **[13]**

Question Number	Scheme	Marks
	Notes	
(a)	M1 putting integral = 1 ignore limits. =1 must appear at least once in the working. M1 attempting to integrate **at least one** part must have correct power of x (ignore limits) A1cso subst of at least 9. Allow 1/1640.25	
(b)	M1 attempt to use $x\text{f}(x)$ and attempt to multiply out bracket and attempt at integration – must have x^3 and x^5 terms (ignore limits) A1 correct integration (ignore limits) dM1 substituting correct limits (need not explicitly see 0). Dependent on having been awarded the first M1.	
(c)	M1 attempting to integrate **at least one** part must have correct power of x (ignore limits) M1 dep on previous M being awarded, substituting correct limits [may use 1 – $\int_0^5 k(81x - x^3)$ with limits 0 and 5]	
(d)	M1 $3(1-p)p^2 + p^3$ o r $1-(1-p)^3 - 3(1-p)^2 p$ 3 not needed A1 for $\mathbf{3}(1-p)p^2 + p^3$ $1-(1-p)^3 - \mathbf{3}(1-p)^2 p$ where p is their solution to part (c) A1 awrt 0.467	

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GCE Statistics S2 (6684) Paper 1

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3. Abbreviations

   These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN.

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   - awrt – answers which round to
   - SC: special case
   - oe – or equivalent (and appropriate)
   - dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - ∗ The answer is printed on the paper
   - └ The second mark is dependent on gaining the first mark

June 2011
6684 Statistics S2
Mark Scheme

Question Number	Scheme	Marks
1. **(a)**	The <u>list</u> of <u>ID numbers</u>	B1 (1)
(b)	$F \sim \mathrm{B}(50,0.02)$	B1 B1 (2) **3**
Notes: (a) (b)	B1 for idea of list/register/database and identity numbers NB B0 if referring to the sample or 50 or only part of the population. **These must be in part (b) to gain the marks** 1st B1 for Binomial distribution 2nd B1 for $n = 50$ and $p = 0.02$ or (50,0.02) NB (0.02, 50) is B0 Po(1) alone is B0B0 <u>For a probability table</u> 1st B1 Use of B(50,0.02) NB $\mathrm{P}(X = 0) = 0.3642$ 2nd B1 Table must have all 50 values and their probabilities.	

Question Number	Scheme	Marks
2. **(a)**	Poisson	B1 (1)
(b)	$H_0 : \mu = 9$ (or $\lambda = 36$) $H_1 : \mu > 9$ (or $\lambda > 36$) $X \sim Po(9)$ and $P(X \geq 12) = 1 - P(X \leq 11)$ or $P(X \leq 14) = 0.9585$ $P(X \geq 15) = 0.0415$ $= 1 - 0.8030 = 0.197$ CR $X \geq 15$ $(0.197 > 0.05)$ so not significant/ accept H_0/ Not in CR he does not have evidence to switch on the speed restrictions (o.e)	B1 B1 M1 A1 M1d A1ft (6)
(c)	Let Y = the number of vehicles in 10 s then $Y \sim Po(6)$ Tables: $P(Y \leq 10) = 0.9574$ so $P(Y \geq 11) = 0.0426$ so needs 11 vehicles	B1 M1 A1 (3) **10**

Notes:

(a) B1 for Poisson or Po. Ignore their value for the mean.

(b) 1st B1 for $H_0 : \mu / \lambda = 9$ or $\mu / \lambda = 36$

2nd B1 for $H_1 : \mu / \lambda > 9$ or $\mu / \lambda > 36$

One tail

1st M1 for writing or using $1 - P(X \leq 11)$ or writing $P(X \leq 14) = 0.9585$ or $P(X \geq 15) = 0.0415$. May be implied by correct CR.or probability = 0.197

A1 for 0.197 or a correct CR. Allow $X > 14$. NB $P(X \leq 11) = 0.8030$ on its own scores M1A1

2nd M1 dependent on the 1st M1 being awarded. For a correct statement based on the table below. Do not allow non-contextual conflicting statements eg "significant" and "accept H_0". **Ignore comparisons**.

2nd A1 for a correct contextualised statement. NB A correct contextual statement on its own scores M1A1.

	$0.05 < p < 0.95$	$p < 0.05$ or $p > 0.95$
2nd M1	not significant/ accept H_0/ Not in CR	significant/ reject H_0/ In CR
2nd A1	Insufficient evidence to switch on the speed restrictions	Sufficient evidence to switch on the speed restrictions

Two tail

1st M1 for writing or using $1 - P(X \leq 11)$ or writing $P(X \leq 15) = 0.9780$ or $P(X \geq 16) = 0.022$. May be implied by correct CR. or probability = 0.197

A1 for 0.197 or CR $X \geq 16$. Allow $X > 15$. NB $P(X \leq 11) = 0.8030$ on its own scores M1A1

2nd M1 dependent on the 1st M1 being awarded . For a correct statement based on the table below. Do not allow non-contextual conflicting statements eg"significant" and "accept H_0" . **Ignore**

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td></td><td>comparisons.
2nd A1 for a correct contextualised statement. NB A correct contextual statement on its own scores M1A1.
<table><tr><td></td><td>$0.025 < p < 0.975$</td><td>$p < 0.025$ or $p > 0.975$</td></tr><tr><td>2nd M1</td><td>not significant/ accept H_0/ Not in CR</td><td>significant/ reject H_0/ In CR</td></tr><tr><td>2nd A1</td><td>Insufficient evidence to switch on the speed restrictions</td><td>Sufficient evidence to switch on the speed restrictions</td></tr></table></td><td></td></tr>
<tr><td>(c)</td><td>B1 for identifying Po(6) - may be implied by use of correct tables
M1 any one of the probs 0.9574 or 0.0426 or 0.9799 or 0.0201 may be implied by correct answer of 11
A1 cao do not accept $X \geq 11$
NB answer of 11 with no working gains all three marks.</td><td></td></tr>
<tr><td>3.
(a)</td><td>Mode = 3 from graph</td><td>B1
(1)</td></tr>
<tr><td>(b)</td><td>$\int_0^3 kx^2 \, dx = 0.5 \quad \Rightarrow \left[\frac{kx^3}{3}\right]_0^3 = 0.5$
So $\frac{27k}{3} - 0 = 0.5 \quad \Rightarrow k = \frac{1}{18}$ (using median = 3)</td><td>M1 A1
M1d A1
(4)</td></tr>
<tr><td>(c)</td><td>Height of triangle = $\frac{1}{18} \times 3^2 = \frac{1}{2}$
Area of triangle = $\frac{1}{2} \times (a-3) \times \frac{1}{2} = \frac{1}{2}$
so $a = 5$
cao</td><td>B1ft
M1
A1
(3)</td></tr>
<tr><td>(d)</td><td>From graph distribution is negative skew (left tail is longer)
$\mu <$ median for negative skew so E(X) < 3
[N.B. E(X) = $2\frac{23}{24}$]</td><td>B1
B1d
(2)
10</td></tr>
<tr><td>Notes:
(b)

(c)</td><td>1st M1 for attempt to integrate f(x) (need x^3). Integration must be in part (b)
1st A1 for correct integration. Ignore limits for these two marks.
2nd M1 Dependent on the previous M mark being awarded. For use of correct limits and set equal to 0.5 - leading to a linear equation for k. No need to see 0 substituted.
2nd A1 for $k = \frac{1}{18}$ or exact equivalent
NB $k = \frac{1}{18}$ with no working gains M0A0M0A0
k = $\frac{1/2}{9} = \frac{1}{18}$ without sight of integration is M0A0M0A0
B1 for correct height of triangle using their k. ie 9k. May be seen in working for area of triangle.
Or correct gradient of line ie $\frac{9k}{(3-a)}$ o.e.</td><td></td></tr>
</table>

Question Number	Scheme	Marks
	M1 for a correct linear equation for a, in the form $\pm\frac{1}{2}\times(a-3)\times 9k=\frac{1}{2}$ (Must see the halves) NB if they have stated their height and then used their height rather than $9k$ allow M1 A1 cao NB stating a = 5 and then verifying area of the triangle = 0.5 is acceptable. NB a = 5 on its own is B0M0A0 SC Integration of both parts = 1 or Integration of line = 0.5 leading to $a^2-8a+15=0$ gets B1 M1 and if they identify $a=5$ A1	
(d)	1st B1 for identifying negative skew 2nd B1 dependent on previous B mark being awarded. For correct deduction E(X) <3	
4 (a)	$\frac{9.5-7}{10-7}$ $=\frac{5}{6}$ awrt 0.833	M1 A1 (2)
(b)	P(Longest > 9.5) = 1 - P(all < 9.5) = $1-\left(\frac{5}{6}\right)^3$ $=\frac{91}{216}$ or 0.421	M1 A1 (2)
(c)	P(a stick < 7.6) = $\frac{0.6}{3}=0.2$ Let Y = number of sticks (out of 6) <7.6 then Y~B(6, 0.2) P(Y > 4) = 1 - P($Y \le 4$) = 1 - 0.9984 $=0.0016$ or $\frac{1}{625}$	B1 M1 M1 A1 (4) **8**
Notes: (a)	M1 for an expression for the probability e.g. $\int_7^{9.5}\frac{1}{3}\,\mathrm{d}x$	
(b)	M1 for $1-(a)^3$ **or** $(1-a)^3+3(1-a)^2a+3(1-a)a^2$ A1 awrt 0.421	
(c)	B1 0.2 may be implied by at least one correct probability 1st M1 for writing or using B(6, p) may be implied by $np^x(1-p)^{6-x}$ using their p and $n \ge 1$ 2nd M1 for writing or using 1 – P($Y \le 4$) or $np^5(1-p)+p^6$ (n is an integer > 1) A1 cao NB 0.0016 with no working gets B0M0M0A0	
5. **(a)**	X ~Po(5); P($X \le 3$) = 0.2650	M1 A1 (2)

Question Number	Scheme	Marks
(b)	Let Y = the no.of planks with at most 3 defects, Y ~Binomial	M1
	Y~B(6, 0.265)	A1ft
	$P(Y < 2) = P(Y \le 1)$	M1
	$= \left[0.735^6 + 6 \times 0.265 \times 0.735^5\right]$	A1
	= 0.4987…. **awrt 0.499 or 0.498**	A1
		(5)
(c)	Let T = total number of defects on 6 planks, T ~Po(30) so $T \approx S$ ~Normal	M1
	S~N(30, 30)	A1
	$P(T < 18) = P(S < 17.5)$	M1
	$= P\left(z < \frac{17.5-30}{\sqrt{30}}\right)$	M1
	= P(Z < - 2.28…)	A1
	= 0.01123... **awrt 0.0112 or 0.0113**	A1
		(6) **13**
Notes:		
(a)	M1 for identifying Po(5) - it should be clearly seen somewhere or implied A1 for correct probability. Allow 0.265	
(b)	1st M1 for writing or using the binomial - may be implied by use of $nq^x(1-q)^{6-x}$ with $n \ge 1$ 1st A1ft for $n = 6$ and p = their (a) may be implied by $6p(1-p)^5$ or $(1-p)^6$ **NB** if they write B(6,(a)) they get M1 A1 2nd M1 for writing $P(Y \le 1)$ **or** $P(Y = 0) + P(Y = 1)$ **or** $(1-q)^6 + nq(1-q)^5$ with $n \ge 1$ 2nd A1 $(1-p)^6 + 6p(1-p)^5$ where p = their (a) 3rd A1 for awrt 0.499 SC use of a probability in the tables – lose last two marks – could get M1A1M1 M0 A0	
(c)	1st M1 for a normal approx 1st A1 for correct mean and sd 2nd M1 for use of continuity correction, either 17.5 or 18.5 or 42.5 or 41.5 seen 3rd M1 Standardising with their mean and their sd and 17.5 or 18 or 18.5 or 41.5 or 42 or 42.5 NB if they have not written down a mean and sd then they need to be correct in the standardisation to gain this mark. 2nd A1 for $z = \pm 2.28$ or better. May be awarded for $\pm\frac{17.5-30}{\sqrt{30}}$ [NB no continuity correction z = 2.19] 3rd A1 for awrt 0.0112 or 0.0113 [NB no approximation gives 0.00727…] **SC using P(X<18.5) – P(X<17.5) can get M1 A1 M1 M0A0A0**	

Question Number	Scheme	Marks
6. **(a)**	$H_0 : p = 0.15 \quad H_1 : p \neq 0.15$ $X \sim B(30, 0.15)$ $P(X \leq 1) = 0.0480$ or CR: $X = 0$ $(0.0480 > 0.025)$ not a significant result or do not reject H_0 or not in CR there is no evidence of a change in the proportion of customers buying an item from the display.	B1 B1 M1 A1 M1 A1ft (6)
(b) **Notes:**	$H_0 : p = 0.2 \quad H_1 : p > 0.2$ Let S = the number who buy sandwiches, $S \sim B(120, 0.2)$, $S \approx W \sim N\left(24, \sqrt{19.2}^2\right)$ $P(S \geq 31) = P(W \geq 30.5)$ $= P\left(Z > \dfrac{30.5 - 24}{\sqrt{19.2}}\right)$ or $\dfrac{x - 0.5 - 24}{\sqrt{19.2}} = 1.2816$ [= P(Z >1.48..)] = 1 - 0.9306 = 0.0694 $x = 30.1$ < 0.10 so a significant result, there is evidence that more customers are purchasing sandwiches or the shopkeepers claim is correct.	B1 M1 A1 M1 M1 M1 A1 B1ft (8) **14**

(a)

1st B1 for H_0 must use p 2nd B1 for H_1 must use p

1st M1 for writing or using B(30,0.15) – may be implied by correct CR

1st A1 0.0480 or $X = 0$. Allow $X \leq 0$. Ignore upper CR. NB Allow CR $X \leq 1$ if using one tail test.

2nd M1 A correct statement (see table below) Do not allow non-contextual conflicting statements eg"significant" and "accept H_0". **Ignore comparisons**

2nd A1 for a correct statement in context. For context we need idea of change/decrease in number of customers buying from display – may use different words. NB A correct contextual statement on its own scores M1A1

	Two tail $0.025 < p < 0.975$ **or** **One tail** $0.05 < p < 0.95$	**Two tail** $p < 0.025$ or $p > 0.975$ **or** **One tail** $p < 0.05$ or $p > 0.95$
2nd M1	not significant/ accept H_0/ Not in CR or contextual	significant/ reject H_0/ In CR or contextual
2nd A1	There is no evidence of a change/decrease in the proportion of customers buying an item from the display	There is evidence of a change/decrease in the proportion of customers buying an item from the display.

(b)

1st B1 both hypotheses correct – must use p.

1st M1 for a normal approx

1st A1 for correct mean and sd

2nd M1 for use of continuity correction, either 30.5 or 31.5 or $(x \pm 0.5)$ seen

3rd M1 standardising with their mean and their sd and 30.5, 31 or 31.5 or x or $(x \pm 0.5)$)

4th M1 for 1 - tables value or 1.2816

2nd A1 for awrt 0.069 or $x = 30.1$

2nd B1ft For a correct conclusion in context using their probability and 0.1 For context we need idea of more customers buying sandwiches – may use different words

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td></td><td colspan="2">
<table>
<tr><td></td><td>One tail $0.1 < p < 0.9$ or Two tail $0.05 < p < 0.95$</td><td>One tail $p < 0.1$ or $p > 0.9$ or Two tail $p < 0.05$ or $p > 0.95$</td></tr>
<tr><td>2nd M1</td><td>not significant/ accept H_0/ Not in CR or contextual</td><td>significant/ reject H_0/ In CR or contextual</td></tr>
<tr><td>2nd A1</td><td>There is no evidence of an increase in the proportion of customers buying sandwiches</td><td>There is evidence of a change/increase in the proportion of customers buying sandwiches.</td></tr>
</table>
</td></tr>
<tr><td></td><td>SC using P(X<31.5) – P(X<30.5) can get B1M1 A1 M1 M1M0A0B0</td><td></td></tr>
<tr><td>7 (a)</td><td>$\cap$ shape which does not go below the x-axis [condone missing patios]
Graph must end at the points (1,0) and (5,0) and the points labelled at 1 and 5</td><td>B1
B1
(2)</td></tr>
<tr><td>(b)</td><td>E(X) = 3 (by symmetry)</td><td>B1
(1)</td></tr>
<tr><td>(c)</td><td>$\left[E(X^2)\right] = \int x^2 f(x)\mathrm{d}x = \frac{3}{32}\int \left(6x^3 - x^4 - 5x^2\right)\mathrm{d}x$
$= \frac{3}{32}\left[\frac{6x^4}{4} - \frac{x^5}{5} - \frac{5x^3}{3}\right]_1^5$
$= \frac{3}{32}\left(\left[\frac{6\times 625}{4} - 625 - \frac{625}{3}\right] - \left[\frac{6}{4} - \frac{1}{5} - \frac{5}{3}\right]\right) = 9.8$ (*)</td><td>M1
A1
M1
A1 cso
(4)</td></tr>
<tr><td>(d)</td><td>s.d. = $\sqrt{9.8 - E(X)^2}$,
= 0.8944… awrt 0.894</td><td>M1
A1
(2)</td></tr>
<tr><td>(e)</td><td>$F(1) = 0 \Rightarrow \frac{1}{32}(a - 15 + 9 - 1) = 0$, leading to $\underline{a = 7}$</td><td>M1 A1
(2)</td></tr>
<tr><td>(f)</td><td>F(2.29) = 0.2449…, F(2.31) = 0.2515…
Since F(q_1) = 0.25 and these values are either side of 0.25 then 2.29< q_1 < 2.31</td><td>M1 A1
A1
(3)</td></tr>
<tr><td>(g)</td><td>Since the distribution is symmetric q_3 =5-1.3 = $\underline{3.7}$ cao</td><td>B1
(1)</td></tr>
<tr><td>(h)</td><td>We know P(q_1=2.3 < X < 3.7=q_3) = 0.5
so $k\sigma = 0.7$
so $k = \frac{0.7}{0.894...} = 0.7826..$ = awrt 0.78</td><td>M1
A1
(2)
17</td></tr>
</table>

Question Number	Scheme	Marks
Notes:		
(c)	This part is a "show that" therefore we need to see all the steps in the working 1st M1 for showing intention of doing $\int x^2 \mathrm{f}(x)$ and attempt to multiply out bracket 1st A1 for correct integration, cao, ignore limits for this mark. 2nd M1 for use of correct limits. Need to see evidence of subst both 5 and 1. 2nd A1 for cso leading to 9.8. Do not ignore subsequent working for this final A mark.	
(d)	M1 for a correct expression for standard deviation, must include $\sqrt{\ldots}$ A1 allow awrt 0.894, $\sqrt{0.8}$, $\frac{2\sqrt{5}}{5}$ oe	
(e)	M1 for a correct method to find *a*. e.g F(5) = 1 or $\int_1^5 f(x) = 1$	
(f)	M1 for an attempt at F(2.29) or F(2.31) or put F(x) = 0.25 (ft their value of *a*) 1st A1 for both values seen. awrt 0.245 and 0.252 find 3 solutions awrt 6.76/6.75, 2.305, -0.064 2nd A1 for comparison with 0.25 and stating Q_1 state only 2.30 in range and stating Q_1 lies between 2.29 and 2.31 lies between 2.29 and 2.31	
(h)	M1 For $k\sigma$ = awrt 0.7 A1 Allow awrt 0.78 NB a correct awrt 0.78 gains M1 A1	

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Rewarding Learning

Mark Scheme (Results)

January 2012

GCE Statistics S2 (6684) Paper 1

January 2012
Publications Code UA030902

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN.

- bod – benefit of doubt
- ft – follow through
- the symbol √ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- ∗ The answer is printed on the paper
- [The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

General Principals for Core Mathematics Marking

(But note that specific mark schemes may sometimes override these general principles).

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2+bx+c)=(x+p)(x+q),\text{ where}\left|pq\right|=\left|c\right|$, leading to x = ...

$(ax^2+bx+c)=(mx+p)(nx+q),\text{ where}\left|pq\right|=\left|c\right|\text{ and }\left|mn\right|=\left|a\right|$, leading to x = …

2. Formula

Attempt to use correct formula (with values for a, b and c), leading to x = …

3. Completing the square

Solving $x^2+bx+c=0$: $\left(x\pm\frac{b}{2}\right)^2\pm q\pm c,\quad q\neq 0$, leading to x = …

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1. ($x^n \rightarrow x^{n-1}$)

2. Integration

Power of at least one term increased by 1. ($x^n \rightarrow x^{n+1}$)

Use of a formula

Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first.

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are mistakes in the substitution of values.

Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but may be lost if there is any mistake in the working.

January 2012
6684 Statistics S2
Mark Scheme

Question Number	Scheme	Marks
1 (a)	$\mathrm{E}(X)=\frac{9+3}{2}=6$	B1 (1)
(b)	$\mathrm{Var}(X)=\frac{(9-3)^2}{12}=3$	M1A1 (2)
(c)	$\mathrm{P}(X>7)=(9-7)\times\frac{1}{6}=\frac{1}{3}$	M1A1 (2)
(d)	$\mathrm{P}(X<6 \mid X>4)=\frac{\mathrm{P}(4<X<6)}{\mathrm{P}(X>4)}$ $=\frac{\frac{2}{6}}{\frac{5}{6}}=\frac{2}{5}$	M1A1 A1 (3) **8**
	Notes	
(b)	M1 $\frac{(9-3)^2}{12}$ or $\frac{(9+3)^2}{12}$	
(c)	M1 $\frac{(9-7)}{6}$ or $1-\frac{(7-3)}{6}$ or $\int_7^9\frac{1}{6}\,\mathrm{d}x$ or $1-\int_3^7\frac{1}{6}\,\mathrm{d}x$ A1 Also acceptable $0.\dot{3}$, $0.3\dot{3}$ and awrt 0.333	
(d)	M1 $\frac{\mathrm{P}(4<X<6)}{P(X>4)}$ or $\frac{\mathrm{P}(X<6)}{P(X>4)}$ or $\frac{2/6}{5/6}$ or $\frac{3/6}{5/6}$ or $1-\frac{\mathrm{P}(X>6)}{P(X>4)}$ or $\frac{6-4}{9-4}$ or $\frac{3}{5}$ A1 $\frac{\mathrm{P}(4<X<6)}{P(X>4)}$ or $\frac{2/6}{5/6}$ or $1-\frac{\mathrm{P}(X>6)}{P(X>4)}$ or $\frac{6-4}{9-4}$ An answer of $\frac{2}{5}$ gains all 3 marks. NB $\leq$ and $\geq$ are accepted in the above formulae	

Question Number	Scheme	Marks
2	$H_0 : p = 0.5$	B1
	$H_1 : p > 0.5$	B1
	X~B(30,0.5) Using correct Bin	M1
	P($X \geq$ 21) = 1 - P($X \leq$20) or P($X \leq$19) = 0.9506 P($X \geq$20) = 0.0494	M1
	= 1 - 0.9786	
	= 0.0214 CR $X \geq$20	A1
	so significant/reject H_0 /in Critical region	M1 dep
	Evidence to suggest **<u>David’s claim is incorrect</u>**	A1
	or The weather **<u>forecast</u>** produced by the local **<u>radio</u>** is better than those achieved by **<u>tossing/flipping a coin</u>**	(7)
		7

Notes

1st B1 for $H_0 : p = 0.5$
2nd B1 for $H_1 : p > 0.5$
SC If both hypotheses are correct but a different letter to p is used they get B1 B0. If no letter is used they get B0 B0.

1st M1 writing or using B(30,0.5)

<u>One tail</u>
2nd M1 for writing or using 1 - P($X \leq$ 20) or writing P($X \leq$19) = 0.9506 or P($X \geq$20) = 0.0494. May be implied by correct CR.or probability = 0.0214
A1 for 0.0214 or CR $X \geq$20/ X >19. **NB** P($X \leq$20) = 0.9786 on its own scores M1A1
3rd M1 dependent on the 2nd M1 being awarded. For a correct statement based on the table below. Do not allow non-contextual conflicting statements eg “significant” and “accept H_0”. **Ignore comparisons**.
2nd A1 for a correct contextualised statement. NB A correct contextual statement on its own scores M1A1.

	$0.05 < p < 0.95$	$p < 0.05$ or $p > 0.95$
3rd M1	not significant/ accept H_0/ Not in CR	significant/ reject H_0/ In CR
2nd A1	David's claim is correct weather **<u>forecast</u>** produced by the local **<u>radio</u>** is no better than those achieved by **<u>tossing/flipping a coin</u>**	David's claim incorrect weather **<u>forecast</u>** produced by the local **<u>radio</u>** is better than those achieved by **<u>tossing/flipping a coin</u>**

<u>Two tail</u>
1st M1 for writing or using 1 - P($X \leq$ 20) or writing P($X \leq$20)= 0.9786 or P($X \geq$21) = 0.0214. May be implied by correct CR. or probability = 0.197
A1 for 0.0214 or CR $X \geq$21/ X >20. **NB** P($X \leq$ 20) = 0.9786 on its own scores M1A1
3rd M1 dependent on the 2nd M1 being awarded . For a correct statement based on the table below. Do not allow non-contextual conflicting statements eg“significant” and “accept H_0” . **Ignore comparisons**.
2nd A1 for a correct contextualised statement. NB A correct contextual statement on its own scores M1A1.

	$0.025 < p < 0.975$	$p < 0.025$ or $p > 0.975$
3rd M1	not significant/ accept H_0/ Not in CR	significant/ reject H_0/ In CR
2nd A1	David's .claim is correct weather **<u>forecast</u>** produced by the local **<u>radio</u>** is no better than those achieved by **<u>tossing/flipping a coin</u>**	David's claim incorrect weather **<u>forecast</u>** produced by the local **<u>radio</u>** is better than those achieved by **<u>tossing/flipping a coin</u>**

Question	Scheme	Marks

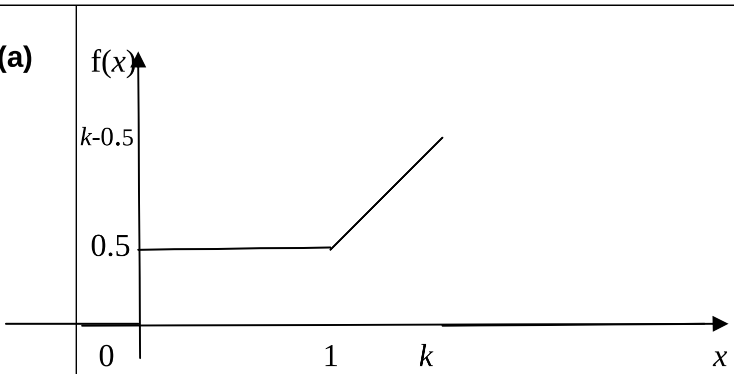
Number		
3 (a)	$P(X=0)=0.85^{10}$ or from tables	M1
	$=0.1969$ awrt 0.197	A1 (2)
(b)	$P(X>3)=1-P(X\le 3)$	M1
	$=1-0.6477$ $=0.3523$ awrt 0.352	A1 (2)
(c)	$n\times 0.15=5$	M1
	$n=33$ or 34	A1 (2)
(d)	1 - P(X = 0) > 0.95	M1
	$1-(0.85)^n>0.95.$ $0.85^n<0.05$	A1
	$n>18.4$	
	$n=19$	A1 (3) **9**
	Notes	
(a)	M1 $(p)^{10}$ with $0<p<1$	
(b)	M1writing or using 1 - P($X\le 3$)	
(c)	M1 $np=5$ $0<p<1$	
(d)	M1 writing or using 1 - P(X = 0) > 0.95 or P(X = 0) < 0.05 (also accepted are = or $\geq$ instead of > and = or $\le$ instead of or <) P(X $\le$ 0) is equivalent to P(X =0) A1 writing or using 1 - $(0.85)^n>0.95$ or $(0.85)^n<0.05$ (also accepted are $\geq$ instead of > and $\le$ instead of or <). Any value of n may be used A1 cao NB an answer of 18.4 gets M1 A1 A0 An answer of 19 gets M1 A1 A1 unless it follows from clearly incorrect working.	

Question Number	Scheme	Marks
4 (a)	Poisson	B1 (1)
(b)	Hits occur **singly** in time Hits are **independent** **or** Hits occur **randomly** Hits occur at a **constant rate**	B1B1 (2)
(c)	X~ Po(5)	B1
	$P(X=10) = \mathrm{P}(X \le 10) - \mathrm{P}(X \le 9)$ or $\frac{e^{-5}5^{10}}{10!}$	M1
	= 0.9863 - 0.9682 = 0.0181 awrt 0.0181	A1 (3)
(d)	X~ Po(10)	B1
	$\mathrm{P}(X \ge 15) = 1 - \mathrm{P}(X \le 14)$	M1
	$= 1 - 0.9165$ $= 0.0835$ awrt 0 .0835	A1 (3)
(e)	X~ Po(50) Approximated by N(50,50)	B1B1
	$\mathrm{P}(X > 70) = \mathrm{P}\left(Z > \frac{70.5 - 50}{\sqrt{50}}\right)$	M1M1
	$= \mathrm{P}(Z > 2.899...)$	A1
	$= 1 - 0.9981$	M1
	$= 0.0019$ awrt 0.0019	A1 (7) **16**
	Notes	
(b)	1st B1 Any one of the 3 statements - no context required. NB It must be a constant (mean) rate and not a constant probability or a constant mean. 2nd B1 A different statement with context of **hits.** NB random and independent are the same statement. If only one mark awarded give the 1st B1. Never award B0 B1	
(c)	B1 writing or using Po(5) M1 writing or using P($X \le 10$) - P($X \le 9$) or $\frac{e^{-5}5^{10}}{10!}$	
(d)	B1 writing or using Po(10) M1 writing or using 1- P($X \le 14$)	
(e)	1st B1 for a normal approximation 2nd B1 for correct mean and sd (may be seen in standardisation formula 1st M1 for attempting a continuity correction (71 ± 0.5) 2nd M1 Standardising using their mean and their sd and using [69.5, 70, 70.5, 71 or 71.5] allow ± z NB if they have not written down a mean and sd then they need to be correct in the standardisation to gain this mark. 1st A1 for $z = \pm$ awrt 2.9 or better. May be awarded for $\pm\frac{70.5 - 50}{\sqrt{50}}$ 3rd M1 for 1 - tables value	
	SC using P(X< 70.5/71.5) – P(X<69.5/70.5) can get B1B1 M0M1A0 M0A0	

Question Number	Scheme	Marks
5 (a)	$X \sim \text{B}(120,0.075)$	B1
	Approximated by Po(9)	M1A1
	$\text{P}(X > 3) = 1 - \text{P}(X \le 3)$	M1
	$= 1 - 0.0212$	
	$= 0.9788$ awrt 0.979	A1
		(5)
(b)	P(At least 4 defective components in each box)	
	$=\text{P}(X>3)\times\text{P}(X>3)$	M1
	$= 0.9788^2$	
	$= 0.95804944$ awrt 0.958	A1
		(2)
		7
	Notes	
(a)	B1 Writing or use of B(120,0.075) may be implied by using Po(9) or N(9,8.325) 1st M1 writing or use of Poisson 1st A1 writing or use of Po(9) 2nd M1 for writing or using 1- P($X \le 3$) or this may be implied by an awrt 0.972 using normal approximation.	
(b)	M1 ((their (a))^2 or 0.979^2 or 0.9788^2 or 0.98^2	

Question Number	Scheme	Marks

6 (a)



shape B1

labels B1

(2)

(b)

$$\int_1^k \left(x-\frac{1}{2}\right)\mathrm{d}x=\frac{1}{2}$$ M1

$$\left[\frac{1}{2}x^2-\frac{1}{2}x\right]_1^k=\frac{1}{2}$$

$k^2-k-1=0$ o.e. A1

$k=\frac{1}{2}\left(1+\sqrt{5}\right)$ M1A1 cso

(4)

(c)

$$F(x)=\begin{cases}0, & x<0\\ \frac{1}{2}x, & 0\le x<1\\ \frac{1}{2}x^2-\frac{1}{2}x+\frac{1}{2}, & 1\le x\le k\\ 1, & x>k\end{cases}$$

B1

M1A1A1B1

B1 1st and last

(6)

Note: Working for the M1A1A1

$\int_1^k x-\frac{1}{2}\,\mathrm{d}x + \text{C} \;=\frac{1}{2}x^2-\frac{1}{2}x\;;+\frac{1}{2}$ (M1A1;A1)

(d)

$\text{P}(0.5<X<1.5)=\text{F}(1.5)-\text{F}(0.5)$

$= 0.875 - 0.25$ M1

$=0.625$ A1

(2)

(e)

Median is $x=1$ B1

Mode is $x=k$ or $\frac{1}{2}(1+\sqrt{5})$ or awrt1.62 B1

(2)

(f)

Negative skew B1

Median<mode or from graph more values are to the right. B1d

(2)

18

Notes

(a)

1st B1 Correct shape with straight lines. Must all be above the *x*-axis

2nd B1 A fully correct graph with the labels 1, *k*, 0.5, *k* - 0.5 seen in the correct places.

Allow the use of $\frac{1}{2}(1+\sqrt{5})$ /awrt 1.62 instead of *k*.

(b)	1st M1 $\int_1^k x-\frac{1}{2}\,\mathrm{d}x = 0.5$ or $\int_1^k x-\frac{1}{2}\,\mathrm{d}x + 0.5 = 1$ ignore limits or $\int_1^k x-\frac{1}{2}\,\mathrm{d}x + \int_1^k \frac{1}{2}\,\mathrm{d}x = 1$ or $\frac{1}{2}(k-0.5+0.5)(k-1) = 0.5$ or any correct method of finding the area 1st A1 for a quadratic equation in the form $a(k^2 - k - 1) = 0$ or $ak^2 - ak = a$. where a is a constant. 2nd M1 correct method for solving a quadratic of the form $ak^2 - bk + c = 0$ where $a,b,c \neq 0$. There must be at least one correct step before the final answer. Allow substituting in k into a quadratic of the form $ak^2 - bk + c = 0$. 2nd A1 cso for $k = \frac{1}{2}\left(1+\sqrt{5}\right)$	
(c)	1st B1 for second line. Do not penalise the use of < instead of $\leq$ and vice versa M1 for use of $\int_1^k x-\frac{1}{2}\,\mathrm{d}x$ + C ignore limits. For use they must have $x \to x^2$ 1st A1 correct integration $\frac{1}{2}x^2 - \frac{1}{2}x$ 2nd A1 C = $\frac{1}{2}$ NB M1A1A1 may be implied by correct 3rd line in F(x) 2nd B1 for 3rd line. Statement of the form $\frac{1}{2}x^2 - \frac{1}{2}x \pm C$. Do not penalise the use of < instead of $\leq$ and vice versa. Allow k or value of k. C may equal 0. 3rd B1 for first and last line. Do not penalise the use of $\leq$ instead of < and $\geq$ instead of > . Allow k or value of k	
(d)	M1 **Using** F(1.5) - F(0.5) . 1.5 must be put into the third line of the c.d.f. and 0.5 must be put into the second line of the c.d.f.. or $\int_{0.5}^1 \frac{1}{2}x\mathrm{d}x + \int_1^{1.5} x-\frac{1}{2}\,\mathrm{d}x$ need to attempt integration, at least one $x^n \to x^{n+1}$ or seeing 0.25 + 0.375 or any correct method of finding the area.. (NB if they have not used + C or C = 0 they will get 0.125. This will get M1A0). An answer of 0.125 from an incorrect method gains M0 A0.	
(e)	If it is not clear which one is the mode and which one is the median assume the median is the first answer and mode the second.	
(f)	B1 negative/negative skew(ness). Do not allow negative correlation. B1 dependent on previous B mark being awarded. Reason must follow from their values or diagram.	

Question Number	Scheme	Marks
7 (a) (i)	The **range of values/region/area/set of values** of the test statistic that would lead you to **reject H_0**	B1
(a) (ii)	The probability of incorrectly rejecting H_0 or Probability of rejecting H_0 when H_0 is true	B1 (2)

(b) (i)	X ~Po(8)	M1	
	$\mathrm{P}(X \le 4) = 0.0996$ $\mathrm{P}(X \le 3) = 0.0424$		
	Critical region [0,3]	A1	
(b) (ii)	awrt 0.0424	B1	(3)
(c)	$\mathrm{H}_0 : \lambda = 8$ (or μ =8)	B1	
	$\mathrm{H}_1 : \lambda > 8$ (or μ >8)		
	P($X \ge 13$) = 1 - P($X \le 12$) or P($X \le 13$) = 0.9658 or P($X \ge 14$) = 0.0342	M1	
	= 1 - 0.9362		
	= 0.0638 CR $X \ge 14$	A1	
	so insufficient evidence to reject H_0 /not significant/ not in critical region	M1 dep	
	There in insufficient evidence of an increase/change in the **rate/number** of sales per month **or** the estate **agents** claim is incorrect	A1	(5)
Notes			**10**

(a)(i) Allow accept H_1 instead of reject H_0. It must be clear which hypothesis gets rejected/accepted.

(ii) Allow equivalent wording.

(b) M1 Writing or using Po(8). May be implied by correct critical region.

A1 allow $0 \le X \le 3$ or CR ≤ 3 or $X \le 3$. Any letter may be used but not P($X \le 3$). This must be on its own.

(c) B1 both hypotheses correct. Must use λ or μ.

One tail

1st M1 for writing or using 1 - P($X \le 12$) or writing P($X \le 13$) = 0.9658 or P($X \ge 14$) = 0.0342. May be implied by correct CR.or probability = 0.0638

A1 for 0.0638 or $X \ge 14$. Allow X >13. NB P($X \le 12$) = 0.9362 on its own scores M1A1

2nd M1 dependent on the 1st M1 being awarded. For a correct statement based on the table below. Do not allow non-contextual conflicting statements eg "not significant" and "reject H_0". **Ignore comparisons**.

2nd A1 for a correct contextualised statement. NB A correct contextual statement on its own scores M1A1.

	$0.05 < p < 0.95$	$p < 0.05$ or $p > 0.95$
2nd M1	not significant/ accept H_0/ Not in CR	significant/ reject H_0/ In CR
2nd A1	Insufficient evidence of an increase/change in the **rate/number** of sales per month	Sufficient evidence of an increase/change in the **rate/number** of sales per month

Two tail

1st M1 for writing or using 1 - P($X \le 12$) or writing P($X \le 14$) = 0.9827 or P($X \ge 15$) = 0.0173. May be implied by correct CR.or probability = 0.0638

A1 for 0.0638 or $X \ge 15$. Allow X >14. NB P($X \le 12$) = 0.9362 on its own scores M1A1

2nd M1 dependent on the 1st M1 being awarded . For a correct statement based on the table below. Do not allow non-contextual conflicting statements eg "not significant" and "reject H_0".**Ignore comparisons**.

2nd A1 for a correct contextualised statement. NB A correct contextual statement on its own scores M1A1.

	$0.025 < p < 0.975$	$p < 0.025$ or $p > 0.975$
2nd M1	not significant/ accept H_0/ Not in CR	significant/ reject H_0/ In CR
2nd A1	Insufficient evidence of an increase/change in the **rate/number** of sales per month	Sufficient evidence of an increase/change in the **rate/number** of sales per month

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Rewarding Learning

Mark Scheme (Results)

Summer 2012

GCE Statistics S2
(6684) Paper 1

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Summer 2012
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Summer 2012
6684 Statistics 2
S2 Mark Scheme

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN.

- bod – benefit of doubt
- ft – follow through
- the symbol $\sqrt{}$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- ∗ The answer is printed on the paper
- ⌐ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

Summer 2012
6684 Statistics S2
Mark Scheme

Question Number	Scheme	Marks
1(a)	P(L>24) = $\frac{1}{15}\times 6$	M1
	= $\frac{2}{5}$ or 0.4 oe	A1 (2)
(b)	Let X represent the number of sweets with $L > 24$	
	X~B(20, 0.4)	M1
	P($X \geq 8$) = 1 – P($X \leq 7$)	M1dep
	= 1 – 0.4159	
	= 0.5841 awrt 0.584	A1
		(3)
(c)	P(both $X \geq 8$) = $(0.5841)^2$	M1
	= 0.341…	A1 ft
		(2)
		Total 7
	notes	
1(a)	M1 $\frac{1}{15}\times$(6 or 5.5 or 6.5 or (30 – 24)) or 1 - $\frac{1}{15}$ ((24 – 15) or (23.5 – 15) or (24.5 – 15))	
(b)	M1 using B(20, "their (a))	
	M1 dependent on 1st M1. Writing or use of 1 – P($X \leq 7$)	
	NB Use of normal/normal approximation/ Poisson/uniform gets M0 M0 A0	
(c)	M1 $(\text{their(b)})^2$ or $(0.58)^2$ or $(0.5841)^2$ or $(0.584)^2$	
	A1ft –either awrt 0.34 or follow through their answer to part (b) must be to 2sf or better.	
	Note you will have to check this.	

Question Number	Scheme	Marks
2.(a)	$X \sim B(25,0.5)$ may be implied by calculations in part a or b	M1
	$P(X \le 7) = 0.0216$	
	$P(X \ge 18) = 0.0216$	
	CR $X \le 7$; $\cup$ $X \ge 18$	A1,A1 (3)
(b)	P(rejecting H_0) = 0.0216 + 0.0216	M1
	= 0.0432 awrt 0.0432/0.0433	A1 (2) Total 5
	Notes	
2(a)	M1 - Using B(25,0.5) – may be implied by a correct critical region or by calculations in part a or b Note Just seeing either $P(X \le 7)$ or $P(X \ge 18)$ scores M1 A0 A0. You may need to check their probabilities in the tables for values other than 7 or 18. 1st A1 – also allow $X < 8$ or [0,7] or $0 \le X \le 7$ or $0 \le X < 8$ oe e.g. [0, 8) or a full list **DO NOT** allow CRs given as $P(X \le 7)$ or 7 – 0 for the A mark. 2nd A1 – also allow $X > 17$ or [18,25] or $18 \le X \le 25$ or $17 < X \le 25$ oe e.g. (17, 25] or a full list **DO NOT** allow CRs given as $P(X \ge 18)$ or 18 - 25 for the A mark. **SC** $7 \ge X \ge 18$ gains M1 A1 A0.	
(b)	M1 – adding their two critical regions' probabilities together or may be awarded for awrt 0.0432 If they add their critical regions' probabilities and then go on and get a different probability as their answer then it is M0A0 e.g. 0.0216 + 0.0216 = 0.0432 then 0.05 – 0.0432 = 0.0068 gets M0 A0 e.g. 0.0216 + 0.0216 = 0.0432 < 0.05 reject H_0 gets M1 A1 e.g. 0.0216 + 0.0216 = 0.0432 so probability of rejecting H_0 is 1 – 0.0432 = 0.9568 gets M0 A0	

Question Number	Scheme	Marks
3(a)	n – large/high/big/ n >50	B1
	p – small/close to 0 / $p < 0.2$	B1
		(2)
(b)	$H_0 : p = 0.03$ $H_1 : p > 0.03$	B1,B1
	Po(6)	B1
	$P(X \geq 12) = 1 - P(X \leq 11)$ or $P(X \leq 10) = 0.9574$	M1
	$= 1 - 0.9799$ $P(X \geq 11) = 0.0426$	
	$= 0.0201$ CR $X \geq 11$	A1
	$(0.0201 < 0.05)$	
	Reject H_0 or Significant or 12 lies in the Critical region.	M1 dep.
	There is evidence that the proportion of defective bolts has increased.	A1 ft
		(7)
		Total 9

(b) Notes

1st B1 for $H_0 : p = 0.03$

2nd B1 for $H_1 : p > 0.03$

SC If both hypotheses are correct but a different letter to p is used they get B1 B0

Also allow B1 B0 for $H_0 : \lambda = 6$ and $H_1 : \lambda > 6$

B1 writing or using Po(6)

One tail

1st M1 for writing or using 1 - $P(X \leq 11)$ or giving $P(X \leq 10) = 0.9574$ or giving $P(X \geq 11) = 0.0426$. May be implied by correct CR or probability = 0.0201

1st A1 for 0.0201 or CR $X \geq 11$/ $X > 10$. **NB** $P(X \leq 11) = 0.9799$ on its own scores M1A1

2nd M1 dependent on the 1st M1 being awarded. For a correct statement based on the table below. Do not allow non-contextual conflicting statements eg “significant” and “accept H_0”. **Ignore comparisons**.

2nd A1 ft for a correct contextualised statement. NB A correct contextual statement on its own scores M1A1.

	$0.05 < p < 0.95$	$p < 0.05$ or $p > 0.95$
2nd M1	not significant/ accept H_0/ Not in CR	significant/ reject H_0/ In CR
2nd A1	The **proportion/number/amount/percentage oe** of **defective bolts** has **not increased/is not higher/oe**	The **proportion/number/amount/percentage oe** of **defective bolts** has **increased/is higher/oe**

Two tail

1st M1 for writing or using 1 - $P(X \leq 11)$ or giving $P(X \geq 12) = 0.0201$ or giving $P(X \leq 11) = 0.9799$. May be implied by correct CR or probability = 0.0201

1st A1 for 0.0201 or CR $X \geq 12$/ $X > 11$. **NB** $P(X \leq 11) = 0.9799$ on its own scores M1A1

2nd M1 dependent on the 1st M1 being awarded. For a correct statement based on the table below. Do not allow non-contextual conflicting statements eg “significant” and “accept H_0”. **Ignore comparisons**.

2nd A1 ft for a correct contextualised statement. NB A correct contextual statement on its own scores M1A1.

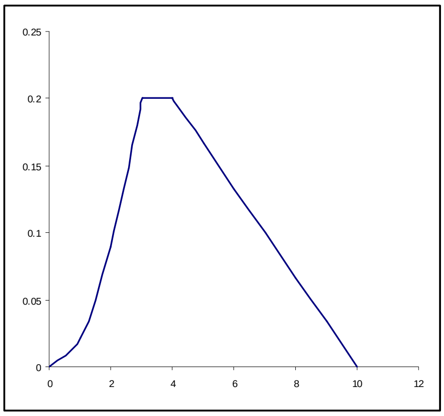
	$0.025 < p < 0.975$	$p < 0.025$ or $p > 0.975$
2nd M1	not significant/ accept H_0/ Not in CR	significant/ reject H_0/ In CR
2nd A1	The **proportion/number/amount/percentage oe** of **defective bolts** has **not increased/is not higher/oe**	The **proportion/number/amount/percentage oe** of **defective bolts** has **increased/is higher/oe**

Use of N(6,5.82) May get B1 B1 B0 M1 (must use 11.5)A0 M1dep A1 ft

Question Number	Scheme	Marks
4(a)	Let X be the random variable the number of houses sold.	
	X ~Po(8)	B1
(i)	$P(X \le 3) - P(X \le 2) = 0.0424 - 0.0138$ or $\frac{e^{-8}8^3}{3!}$	M1
	$= 0.0286$ awrt 0.0286	A1
(ii)	$P(X > 5) = 1 - P(X \le 5)$	M1
	$= 1 - 0.1912$	
	$= 0.8088$ awrt 0.809	A1
		(5)
(b)	Let Y be the random variable = the number of periods where more than 5 houses are sold	
	Y~ B(12,0.8088)	M1
	$P(Y = 9) = (0.8088)^9(1 - 0.8088)^3\frac{12!}{9!3!}$	M1
	$= 0.228$ awrt 0.228	A1
		(3)
(c)	N(20,20)	M1A1
	$P(X > 25) = 1 - P\left(Z \le \frac{25.5 - 20}{\sqrt{20}}\right)$	M1,M1,A1
	$= 1 - P(Z \le 1.23)$	
	$= 1 - 0.8907$	
	$= 0.1093 / 0.1094$ awrt 0.109	A1
		(6)
		Total 14
	Notes	
(a)	1st B1 for writing or using Po(8) in either (i) or (ii)	
(i)	M1 writing or using $P(X \le 3) - P(X \le 2)$ or $\frac{e^{-8}8^3}{3!}$	
(ii)	M1 writing or using $1 - P(X \le 5)$	
(b)	M1 writing or attempting to use B(12,their (a(ii))) NB ft their a(ii) to at least 2sf	
	M1 $\frac{12!}{9!3!}$ $(a(ii))^9(1 - a(ii))^3$ allow ${}^{12}C_3$ or ${}^{12}C_9$ or 220 instead of $\frac{12!}{9!3!}$ NB ft their a(ii) to at least 1sf but an expression must be seen (No use of tables)	
(c)	1st M1 for writing or using a normal approximation 1st A1 for correct mean and sd (may be given if correct in standardisation formula) 2nd M1 Standardising using their mean and their sd and using [24.5, 25, 25.5, 26 or 26.5] and for finding correct area by doing 1 – P(Z≤ "their 1.23") NB if they have not written down a mean and sd then they need to be correct in the standardisation to gain this mark. 3rd M1 for attempting a continuity correction (26 ± 0.5) 2nd A1 for $\pm\frac{25.5 - 20}{\sqrt{20}}$ or $\pm$ awrt 1.2 or better. **SC using P(X< 26.5/25.5) – P(X<25.5/24.5) can get M1A1 M0M1A0A0**	

Question Number	Scheme	Marks
5(a)	$\int_0^k \frac{3}{32}x(k-x)=1$	M1
	$\frac{3}{32}\left[\frac{kx^2}{2}-\frac{x^3}{3}\right]_0^k=1$	A1
	$\frac{3k^3}{64}-\frac{3k^3}{96}=1$	M1 dep
	$3k^3-2k^3=64$	
	$k^3=64$	
	$k=4$	A1cso **(4)**
b	[E(X) =] 2	B1 **(1)**
c	E(X^2) = $\int_0^4 \frac{3}{32}x^3(4-x)$	M1
	$=\left[\frac{3x^4}{32}-\frac{3x^5}{160}\right]_0^4$	
	$=\left[\frac{3\times4^4}{32}-\frac{3\times4^5}{160}\right]$	
	$= 4.8$	A1
	Var (X) = 4.8 – 4	M1
	= 0.8	A1 **(4)**
d	$\int_{1.5}^{2.5}\frac{3}{32}x(4-x)=\left[\frac{3x^2}{16}-\frac{x^3}{32}\right]_{1.5}^{2.5}$ or $\int_0^{1.5}\frac{3}{32}x(4-x)=\left[\frac{3x^2}{16}-\frac{x^3}{32}\right]_0^{1.5}$	M1
	$=\frac{47}{128}=0.3671875$ $=\frac{81}{256}=0.31640625$	
	$1-\frac{47}{128}=\frac{81}{128}$ awrt 0.633 $2\times\frac{81}{256}=\frac{81}{128}$ awrt 0.633	M1depA1 **(3)**
	Notes	**Total 12**
(a)	1st M1 for an attempt to multiply out bracket and for attempting to integrate f(x). Both $x^n \rightarrow x^{n+1}$	
	1st A1 for correct integration. Ignore limits for these two marks. Need $\frac{3}{32}\left(\frac{kx^2}{2}-\frac{x^3}{3}\right)$ oe	
	2nd M1 Dependent on the previous M mark being awarded. For correct use of correct limits and set equal to 1. No need to see 0 substituted in. For verifying they must have $\frac{3}{32}\left(\frac{4^3}{2}-\frac{4^3}{3}\right)$	
	2nd A1 cso or for verifying $\frac{3}{32}\left(\frac{4^3}{2}-\frac{4^3}{3}\right)$ = 1 **oe** eg $3(4)^3-2(4)^3=64$ and a correct comment "so k = 4"	
(c)	1st M1 attempt to multiply out bracket and attempting $\int x^2 \mathrm{f}(x)$ Limits not needed. Both $x^n \rightarrow x^{n+1}$	
	2nd M1 for their E(X^2) – (their mean)^2	
(d)	1st M1 Multiply out brackets, attempting to integrate (both $x^n \rightarrow x^{n+1}$), with either limits (their(b) ± 0.5) or (their (b) – 0.5 and 0) Accept 2 sf for their limits.	
	2nd M1dep on gaining 1st M1. 1 – (using limits (their(b) ±0.5)) or 2 × (using limits (their(b) – 0.5 and 0)	

Question Number	Scheme	Marks
6	Attempt to write down combinations at least one seen	**M1**
	(1,1,1), (1,1,2) any order (1,2,2) any order, (2,2,2) no extra combinations	**A1**
	Range 0 and 1 0 and 1 only	**B1**
	[P(range = 0) =] $(0.65)^3 + (0.35)^3$ either range $= 0.3175$ or $\frac{127}{400}$	**M1** **A1cao**
	[P(range = 1) =] $(0.35)^2(0.65) \times 3 + (0.65)^2(0.35) \times 3$ $= 0.6825$ or $\frac{273}{400}$	**A1cao**
		(6)
		Total 6
	Notes First M1 may be implied by either $(0.65)^3$ or $(0.35)^3$or $(0.65)^2(0.35)$ or $(0.35)^2(0.65)$ First A1 may be implied by $(0.65)^3$ **and** $(0.35)^3$ **and** $(0.65)^2(0.35)$ **and** $(0.35)^2(0.65)$ No need for x3 2nd M1 $(p)^3 + (1-p)^3$ or $(1-p)^2(p) \times 3 + (p)^2(1-p) \times 3$ A1 for 0.3175 cao or exact equivalent e.g $\frac{254}{800}$ A1 for 0.6825 cao or exact equivalent e.g $\frac{546}{800}$ NB These probabilities do not need to be associated with the correct range	

Question Number	Scheme	Marks
7(a)		**B1** **B1** **B1** **B1dep** **0.2,3,4,10** **(4)**
(b)	$F(x) = \begin{cases} 0 & x<0 \\ \frac{x^3}{135} & 0\le x\le 3 \\ \frac{x}{5}-\frac{2}{5} & 3<x<4 \\ \frac{x}{3}-\frac{x^2}{60}-\frac{2}{3} & 4\le x\le 10 \\ 1 & x>10 \end{cases}$	**M1A1** **M1A1** **M1A1**
	1st M1 For $0\le x\le 3$, $F(x) = \int_0^x \frac{t^2}{45}dt$ $= \left[\frac{t^3}{135}\right]_0^x$ 2nd M1 For $3 < x < 4$, $F(x) = \int_3^x \frac{1}{5}dt + \frac{1}{5}$ or $F(x) = \int \frac{1}{5}dx + C$ and uses $F(3) = \frac{1}{5}$ $= \left[\frac{t}{5}\right]_3^x + \frac{1}{5}$ $\frac{1}{5} = \left[\frac{3}{5}\right] + C$ 3rd M1 For $4\le x\le 10$, $F(x) = \int_4^x \frac{1}{3} - \frac{x}{30} dt + \frac{2}{5}$ or $F(x) = \int \frac{1}{3}-\frac{x}{30}dx + C$ and uses $F(4) = \frac{2}{5}$ or $F(10) = 1$ $F(x) = \left[\frac{t}{3}-\frac{t^2}{60}\right]_4^x + \frac{2}{5}$ $\frac{2}{5} = \frac{4}{3}-\frac{4^2}{60}+C$ or $1 = \frac{10}{3}-\frac{10^2}{60}+C$	
	Top line of F(x) ie 0 $x < 0$ Bottom line of F(x) ie 1 $x > 10$	**B1** **B1** **(8)**
(c)	$F(8) = \frac{8}{3}-\frac{8^2}{60}-\frac{2}{3}$ $= \frac{14}{15} = 0.933$	**M1** **A1 cso** **(2)** **Total 14**

Notes

(a) 1st B1 for a curve. It must start at (0, 0) and have the correct curvature.

2nd B1 for a horizontal line that joins the first section of the graph (not by a dotted line)

3rd B1 for a straight line with negative gradient that joins the horizontal line and stops on the positive x axis.

4th B1 dependent on first 3 marks being gained. Fully correct graph with labels 0.2, 3,4,10 in correct places

(b) For all the M marks, the attempt to integrate must have at least one $x^n \rightarrow x^{n+1}$

All A marks are for the correct expressions and ranges.

Do not penalise the use of $\leq$ instead of $<$ and $\geq$ instead of $>$.

1st M1 for attempt to integrate $\int_0^x \frac{t^2}{45}\,\mathrm{d}t$ ignore limits

2nd M1

for attempt to integrate $\int_3^x \frac{1}{5}\,\mathrm{d}t + \text{their } \mathrm{F}(3)$ using correct limits.

or

for attempt to integrate $\int \frac{1}{5}\,\mathrm{d}x + \mathrm{C}$ and substituting in 3 and putting = to their F(3) or substituting in 4 and putting = to their F(4) from their $4 \leq x \leq 10$ line

3rd M1

for attempt to integrate $\int_4^x \frac{1}{3} - \frac{x}{30}\,\mathrm{d}t + \text{their F}(4)$ using correct limits.

or

for attempt to integrate $\int \frac{1}{3} - \frac{x}{30}\,\mathrm{d}t + \mathrm{C}$ and substituting in 4 and putting = to their F(4) or substituting in 10 and putting = 1

(c) M1 substituting 8 into the 4th line of their cdf **or** F(3) + F(4) – F(3) + F(8) – F(4) or $1 - \int_8^{10} \frac{1}{3} - \frac{x}{30}$ (attempt to integrate needed) or use areas e.g $1 - \frac{1`}{2} \times 2 \times \frac{1}{15}$ or $1 - \frac{1}{15}$

A1 14/15 awrt 0.933 from correct working.

NB If using F(3) + F(4) – F(3) + F(8) – F(4) then F(x) must be correct.

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>8(a)</td><td>Let X be the random variable the number of customers asking for water.</td><td></td></tr>
<tr><td>(i)</td><td><table>
<tr><td>X ~B(10,0.6)</td><td>Y ~B(10,0.4)</td><td></td></tr>
<tr><td>$P(X = 6) = (0.6)^6(0.4)^4\frac{10!}{6!4!}$</td><td>$P(Y = 4) = (0.4)^4(0.6)^6\frac{10!}{6!4!}$</td><td></td></tr>
<tr><td>= 0.2508…</td><td>= 0.2508</td><td>awrt 0.251</td></tr>
</table></td><td>B1
M1
A1</td></tr>
<tr><td>(ii)</td><td><table>
<tr><td>X ~B(10,0.6)</td><td>Y ~B(10,0.4)</td><td></td></tr>
<tr><td>$P(X < 9) = 1 – (P(X = 10) + P(X = 9))$
$= 1 - (0.6)^{10} - (0.6)^9(0.4)^1\frac{10!}{9!1!}$</td><td>$P(X < 9) = 1 - P(Y \le 1)$
$= 1 – 0.0464$</td><td></td></tr>
<tr><td>= 0.9536…</td><td>= 0.9536…</td><td>awrt 0.954</td></tr>
</table></td><td>M1
A1
(5)</td></tr>
<tr><td>(b)</td><td>X ~B(50,0.6)
Y ~B(50,0.4)
$P(X < n) \ge 0.9$
$P(Y > 50 – n) \ge 0.9$ or $P(X < 34) = 0.8439$ awrt 0.844
$P(Y \le 50 – n) \le 0.1$ $P(X < 35) = 0.9045$ awrt 0.904/0.905
$50 – n \le 15$
$n \ge 35$
$n = 35$</td><td>M1
M1
A1
(3)
Total 8</td></tr>
<tr><td>
(a)
(i)

(ii)

(b)</td><td>Notes
B1 writing or using B(10,0.6) / B(10,0.4) in either part(i) or (ii)
M1 $(0.6)^6(1-0.6)^4\frac{10!}{6!4!}$ Allow $^{10}C_6$ oe
or writing or using $P(X \le 6)$ - $P(X \le 5)$ if using B(10,0.6)
or $P(X \le 4)$ - $P(X \le 3)$ if using B(10,0.4)
NB use of Poisson will gain M0A0
M1 writing or using $1 – (P(X = 10) + P(X = 9))$ if using B(10,0.6)
or
$1 - P(Y \le 1)$ if using B(10,0.4)
NB use of Poisson will gain M0A0
1st M1 for writing or using either B(50,0.6) or B(50,0.4)
2nd M1 $P(Y > 50 – n) \ge 0.9$ or $P(Y \le 50 – n) \le 0.1$ or $P(X < 34)$ = awrt 0.844 or $P(X < 35)$ = awrt 0.904/0.905 or $50 – n = 15$ or $50 – n = 16$ or $50 – n \le 15$ or $50 – n \le 16$ – allow different letters
A1 cao 35. Do not accept $n \ge 35$ for final A1.

SC use of normal.
M1 M0 A0 for use of N(30,12) leading to an answer of 35</td><td></td></tr>
</table>

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cea
Rewarding Learning

Mark Scheme (Results)

January 2013

GCE Statistics S2 (6684/01)

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January 2013
Publications Code UA034852

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Unless indicated in the mark scheme a correct answer with no working should gain full marks for that part of the question.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for ‘knowing a method and attempting to apply it’, unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

In some instances, the mark distributions (e.g. M1, B1 and A1) printed on the candidate’s response may differ from the final mark scheme.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used.

- bod – benefit of doubt
- ft – follow through
- the symbol √ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- ∗ The answer is printed on the paper
- ⎣ The second mark is dependent on gaining the first mark

4. All A marks are ‘correct answer only’ (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but incorrect answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

8. The maximum mark allocation for each question/part question(item) is set out in the marking grid and you should allocate a score of ‘0’ or ‘1’ for each mark, or “trait”, as shown:

	0	1
aM		●
aA	●	
bM1		●
bA1	●	
bB	●	
bM2		●
bA2		●

January 2013
6684 Statistics S2
Mark Scheme

Question Number	Scheme	Marks
1(a)	n large	B1
	p small	B1
		(2)
(b)	Let X be the random variable the number of letters delivered to the wrong house	
	X~B(1000,0.01)	
	Po(10)	B1
	$\mathrm{P}(X \geq 4) = 1 - \mathrm{P}(X \leq 3)$	M1
	$= 1 - 0.0103$	
	$= 0.9897$	A1
		(3)
		Total 5
	Notes	
(a)	B1 Accept n (the number of trials) large / high / big / $n > 50$ (accept any number larger than 50) B1 Accept p (the probability) small / close to 0 / $p < 0.2$ (accept any number less than 0.2). Do not accept low. These must appear in part (a).	
(b)	B1 writing or using Po(10) M1 using a Poisson (λ need not equal 10) and for writing or using $1 - \mathrm{P}(X \leq 3)$. (Do not accept writing $1 - \mathrm{P}(X < 4)$ unless they have used $1 - \mathrm{P}(X \leq 3)$). A1 0.9897 cao must be 4 dp **NB** **An awrt 0.990 on its own gains B0M0A0 unless there is evidence that Po(10) is used. In which case it gets B1M1A0** **Using B(1000,0.01) gives 0.989927…. and gains B0M0A0**	

Question Number	Scheme	Marks
2 (a)	Let X be the random variable the number power cuts.	
	$X \sim \text{Po}(3)$	B1
(i)	$\text{P}(X = 7) = \text{P}(X \le 7) - \text{P}(X \le 6)$ or $\frac{e^{-3}3^{7}}{7!}$	M1
	$= 0.9881 - 0.9665$	
	$= 0.0216$ awrt 0.0216	A1
(ii)	$\text{P}(X \ge 4) = 1 - \text{P}(X \le 3)$	M1
	$= 1 - 0.6472$	
	$= 0.3528$ awrt 0.353	A1
		(5)
(b)	$X \sim \text{Po}(30)$	
	N(30,30)	M1A1
	$\text{P}(X < 20) = \text{P}\left(Z < \frac{19.5 - 30}{\sqrt{30}}\right)$	M1M1 A1
	$= \text{P}(Z < -1.92)$	
	$= 1 - 0.9726$	
	$= 0.0274 - 0.0276$	A1
		(6)
	Notes	**Total 11**
(a)	B1 Writing or using Po(3) in either (i) or (ii)	
(i)	M1 writing or using $\text{P}(X \le 7) - \text{P}(X \le 6)$ or $\frac{e^{-\lambda}\lambda^{7}}{7!}$	
(ii)	M1 writing or using $1 - \text{P}(X \le 3)$. (Do not accept writing $1 - \text{P}(X < 4)$ unless they have used $1 - \text{P}(X \le 3)$).	
(b)	1st M1 for writing or using a normal approximation 1st A1 for correct mean and sd (may be given if correct in standardisation formula) 2nd M1 Standardising using their mean and their sd **and** using [18.5, 19, 19.5, 20 or 20.5] **and** for finding correct area by doing **1 – P(*Z* ≤ "their 1.92")** If they have not written down a mean and sd then these need to be correct here to award the mark 3rd M1 for attempting a continuity correction (19 ± 0.5) i.e. 18.5 or 19.5 **only**. 2nd A1 for $\pm\frac{19.5 - 30}{\sqrt{30}}$ or $\pm$ awrt 1.9 or better. 3rd A1 awrt 0.0274, 0.0275 or 0.0276 **SC using P(*X*< 20.5/19.5) – P(*X*< 19.5/18.5) can get M1A1 M0M1A0A0**	

Question Number	Scheme	Marks
3(a) (i)	$P(X < 5) = 0.8424$ awrt 0.842	B1
(ii)	$P(X \geq 7) = 1 - P(X \leq 6)$	M1
	$= 1 - 0.9857$	
	$= 0.0143$ awrt 0.0143	A1
		(3)
(b)	$P(X = 0) = (1-p)^{12}$	
	$(1-p)^{12} = 0.05$	M1
	$(1-p) = \sqrt[12]{0.05}$	M1
	$p = 0.221$ awrt 0.221	A1
		(3)
(c)	Variance $= 12p(1-p)$	
	$12p(1-p) = 1.92$	M1
	$12p - 12p^2 = 1.92$	
	$12p^2 - 12p + 1.92 = 0$ or $p^2 - p + 0.16 = 0$ $25p^2 - 25p + 4 = 0$	
	$p = \dfrac{12 \pm \sqrt{12^2 - 4\times 12\times 1.92}}{24}$ $(5p-1)(5p-4) = 0$	M1
	$p = 0.2$ or 0.8	A1,A1
		(4)
	Notes	**Total 10**
(a) (ii)	M1writing or using $1 - P(X \leq 6)$ Do not accept $1 - P(X < 7)$ unless $1 - P(X \leq 6)$ has been used	
(b)	1st M1 $(1-p)^n = 0.05$ 2nd M1 taking *n*th root. If they have used logs they need to get to a correct expression for $1 - p$ for their equation.	
(c)	1st M1 $12p(1 - p) = 1.92$ o.e. 2nd M1 solving a quadratic either by factorising / completing the square / or formula. Working must either be correct for **their** quadratic (they may use a quadratic from an incorrect rearrangement) **or** they must have written the appropriate formula down correctly and only made 1 error substituting into it. May be implied by a correct value of *p*. 1st A1 for 0.2 2nd A1 for 0.8	

Question Number	Scheme	Marks
4 (a)	Mean = 1	B1 **(1)**
(b)	$P(X \le 2.4) = (2.4 - -4)\times\frac{1}{10}$ $= 0.64$ or $\frac{16}{25}$	M1 A1 **(2)**
(c)	P(-3 < X – 5 <3) = P(2 < X < 6) = 0.4	M1 A1 **(2)**
(d)	$\int_a^{4a}\frac{y^2}{4a-a}dy = \left[\frac{y^3}{9a}\right]_a^{4a}$ $= \frac{64a^3 - a^3}{9a}$ $= 7a^2$ *AG	M1 M1 dep A1 A1cso **(4)**
(e)	$\text{Var}(Y) = \frac{1}{12}(4a-a)^2$ or $\text{Var}(Y) = 7a^2 - \left(\frac{5}{2}a\right)^2$ $= \frac{3}{4}a^2$	M1 A1cso **(2)**
(f)	$\frac{2}{3} = \frac{1}{3a}\left(\frac{8}{3} - a\right)$ $a = \frac{8}{9}$	M1 A1 A1 **(3)**
		Total 14
	Notes	
(b)	M1 $(2.4 - -4)\times\frac{1}{10}$ or $1-(6-2.4)\times\frac{1}{10}$ o.e	
(c)	M1 finding P(2 < X < 6) or P(X > 2) or 1 - P(X < 2). May be implied by a correct answer if there is no incorrect working. Do not ignore subsequent incorrect working. **NB** if they change the distribution to U[-9,1] then M1 is for finding P(-3 < X < 1) or P(X > -3) or 1 - P(X < -3). May be implied by a correct answer if there is no incorrect working. Do not ignore subsequent incorrect working.	
(d)	**NB remember the answer is given (AG) so they must show their working** 1st M1 writing or using $\int_a^{4a} y^2 f(y)dy$ with correct limits used at some point. Condone omission of dy. f(y) does not need to be correct. 2nd M1 dependent on previous M being awarded. Attempting to integrate at $y^n \to \frac{y^{n+1}}{n+1}$ 1st A1 correct expression - the correct limits must be substituted. 2nd A1 cso	

(e)	M1 either use of $\frac{(b-a)^2}{12}$ or E(Y^2) – [E(Y)]^2:- they may use their part (d) for E(Y^2)	
(f)	M1 using $\frac{1}{3a}\left(\frac{8}{3}-a\right)=$ a probability **or** $\frac{1}{3a}\left(4a-\frac{8}{3}\right)=$ a probability An answer of $\frac{8}{9}$ **with no incorrect working gains M1A1A1**	

Question Number	Scheme	Marks
5(a)	$P(T > t) = \frac{225}{(t+15)^2}$ $P(T \le t) = 1 - P(T > t)$ $= 1 - \frac{225}{(t+15)^2}$	
	$F(t) = \begin{cases} 1-\frac{225}{(t+15)^2} & t \ge 0 \\ 0 & \text{otherwise.} \end{cases}$	B1
		(1)
(b)	$P(T < 3) = 1 - \frac{225}{(3+15)^2}$	M1
	$= \frac{11}{36}$ or 0.30555…	A1
	awrt 0.306	
		(2)
(c)	$P(T > 8 \mid T > 3) = \frac{P(T > 8)}{P(T > 3)}$	M1 M1
	$= \frac{\frac{225}{23^2}}{\frac{225}{18^2}}$	
	$= \frac{324}{529}$ or 0.612.. awrt 0.612 / 0.6125	A1
		(3)
(d)	$1 - F(t) = 0.1$	M1
	$\frac{225}{(t+15)^2} = 0.1$ or $1 - \frac{225}{(t+15)^2} = 0.9$	A1
	$\frac{225}{0.1} = (t+15)^2$	
	$t = \sqrt{\frac{225}{0.1}} - 15$	M1
	$t = 32.4$, also accept 32/33	A1
		(4) **Total 10**

Notes

(a) B1 The line P($T \le t$) = 1 – P($T > t$) or F(t) = 1 – P($T > t$) or both of the following statements P($T > t$) = $\frac{225}{(t+15)^2}$ and P($T \le t$) /F(t) = 1 – $\frac{225}{(t+15)^2}$ must be seen and no errors. Allow equivalent in words.

Condone use of < instead of $\le$ or > instead of $\ge$ and vice versa.

The cdf must be given. Allow $t > 0$

(b) M1 substituting 3 into F(t)

(c) 1st M1 The conditional probability must,

- be a quotient and
- have P($T > 3$) or 'their numerical equivalent' for the denominator and
- have P($T > 8$) or P($T > 5$) or P($T > 8 \cap T > 3$) or P($T > 5 \cap T > 3$) or 'their numerical equivalent' for the numerator.

Allow $\ge$ in place of >

2nd M1 writing or using P($T > 8$) or P($T \ge 8$).

NB This is independent of the first M mark.

(d) 1st M1 writing or using 1 – F(t) = 0.1 or P($T \ge t$) = 0.1 May be implied by $\frac{225}{(t+15)^2} = 0.1$ o.e.

2nd M1 either square rooting or solving a quadratic either by factorising / completing the square / using the formula - must be correct for their quadratic.

A1 awrt 32.4 or 32 or 33. Do not accept $15\sqrt{10} - 15$

Question Number	Scheme	Marks
6(a)	A statement concerning a **population parameter**	B1
(b)	A critical region is the range / set of values / answers **or** a test statistic **or** region/area **or** values (where the test is significant)	B1
	that would lead to the rejection of H0 / acceptance of H_1	B1
		(3)
(c)	$H_0 : p = 0.45$ $H_1 : p < 0.45$ (or $p \neq 0.45$)	
	$X \sim B(20, 0.45)$	M1
	$P(X \le 5) = 0.0553$ CR $X \le 4$	A1
	Accept H_0. Not significant. 5 does not lie in the Critical region.	M1d
	There is no evidence that the proportion who voted for Mrs George is not 45% or there is evidence to support Mrs George's claim	A1cso
		(4)
(d)	B(8, 0.45): P(0) = 0.0084	M1
	B(7, 0.45): P(0) = 0.0152	A1
	Hence smallest value of n is **8**	B1
		(3)
	Alternative	
	$(0.55)^n < 0.01$	M1
	$n\log 0.55 < \log 0.01$	
	$n > 7.7\ldots$	A1
	Hence smallest value of n is **8**	B1cso
	Notes	**Total 10**
(a)	It must be a statement including the words **population parameter**.	
(c)	1st M1 using B(20, 0.45) and finding $P(X \le 5)$ or $P(X \ge 6)$ Using the normal approximation to the binomial is M0 A1 0.0553 (allow 0.9447) if not using CR or CR $X \le 4$ or $X < 5$ 2nd M1 dependent on previous M being awarded. A correct statement (do not allow if there are contradicting non contextual statements **nor** award if 2 probabilities are given which would result in different conclusions) A1cso Conclusion must contain the words **Mrs George**. There must be no incorrect working seen. If there are no hypotheses you cannot award this mark. **NB** A correct contextual statement on it's own will score M1 A1.	
(d)	M1 Attempt to find P(0) from B(n, 0.45) or $(0.55)^n < 0.01$ or $(0.55)^n = 0.01$ or $(0.55)^n > 0.01$ A1 P(0) = 0.0084 and P(0) = 0.0152 or getting 7.7 May be implied by correct answer. B1 cso. $n = 8$ should not come from incorrect working. NB An answer of 8 on its own with no working gains M1A1B1	

Question Number	Scheme	Marks
7(a)	$\int_0^5 a+bx\ \mathrm{d}x = 1$	M1
	$\left[ax+\frac{bx^2}{2}\right]_0^5 = 1$	A1
	$5a + \frac{25b}{2} = 1$	M1dep
	$10a + 25b = 2$	A1cso
		(4)
(b)	$\int_0^5 ax+bx^2\ \mathrm{d}x = \frac{35}{12}$	M1
	$\left[\frac{ax^2}{2}+\frac{bx^3}{3}\right]_0^5 = \frac{35}{12}$	A1
	$\frac{25a}{2}+\frac{125b}{3} = \frac{35}{12}$	A1
	$30a+100b=7$	**(3)**
(c)	$30a + 100b = 7$	M1
	$10a + 25b = 2$	
	$a = 0.1 \quad b = 0.04$	A1,A1
		(3)
(d)	$\int_0^m 0.1+0.04x\ \mathrm{d}x = 0.5$	M1
	$\left[0.1x+\frac{0.04x^2}{2}\right]_0^m = 0.5$	A1ft
	$0.1m + 0.02m^2 - 0.5 = 0$	
	$m = \frac{-0.1 \pm \sqrt{0.1^2 + 4\times 0.02\times 0.5}}{2\times 0.02}$	
	m = 3.09, -8.09 therefore 3.09	A1
		(3)
(e)	mean < median (< mode)	B1ft
	negatively skewed	B1 dep ft
		(2)
		Toal 15
	Notes	
(a)	1st M1 Attempting to integrate with correct limits or for an attempt to find area $0.5(a+b)h$ or Attempting to integrate and using F(5) = 1	
	1st A1 Correct integration or correct area	
	2nd M1 for using =1. This is dependent on the first M1 being awarded.	
	2nd A1 cso condone missing dx	
(b)	M1 using or writing (limits not needed) $\int_0^5 ax+bx^2\ \mathrm{d}x = \frac{35}{12}$	
	1st A1 correct integration	
	2nd A1 may be awarded for an unsimplified version $\frac{25a}{2}+\frac{125b}{3} = \frac{35}{12}$	

(c)	M1 attempting to solve "their equations" simultaneously – either using rearranging and substitution **or** making one of the coefficients the 'same' (ignore sign) and either adding or subtracting. May be implied by correct values for *a* and *b* 1st A1 for 0.1 2nd A1 for 0.04
(d)	M1 writing or using $\int_0^m "their\ a"+"their\ b"x\ \mathrm{d}x = 0.5$: limits not needed 1st A1 correct integration for their "*a*" and "*b*" **NB** the correct equation simplifies to $m^2 + m - 25 = 0$ A1 3.09 only. If they have both roots then they must select 3.09
(e)	1st B1ft. They must compare their values for mean and median correctly. They only need to compare 2 of mean, median and mode. If they compare either the median or mean with the **mode only** then the value of the mode must be stated. They may draw a sketch that matches their values of '*a*' and '*b*' for $0 \le x \le 5$. It must not go below the *x*-axis This may be seen in part (a). 2nd B1 dependent f.t. on the previous B being awarded.

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Mark Scheme (Results)

Summer 2013

GCE Statistics 2 (6684/01R)

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Summer 2013
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(b)	r : 0 and 4 $\text{P}(R=0)=\frac{9}{27}$ or $\frac{1}{3}$ $\qquad \text{P}(R=4)=\frac{18}{27}$ or $\frac{2}{3}$	B1 M1d A1 **(3)** **[5]**
	Notes	
(a)	1st B1 for any two of the triples 2nd B1 for all 8 cases. No incorrect extras – condone repeats. Allow (1, 5, 5) (x 3) and (1, 1, 5) (x 3) instead of writing all three cases down	
(b)	B1 for both values of r M1 d dependent on previous B1. For an attempt to evaluate one of the probabilities for r correctly e.g. for $r = 0$; $\left(\frac{2}{3}\right)^3+\left(\frac{1}{3}\right)^3$ and for $r = 4$; $3\times\left(\frac{1}{3}\right)^2\times\left(\frac{2}{3}\right)+3\times\left(\frac{1}{3}\right)\times\left(\frac{2}{3}\right)^2$ **Working must be shown.** A1 for both values of r and their correct corresponding probabilities. Allow awrt 0.333 and 0.667 **NB** Correct answer with no working will gain B1M0A0	

Question Number	Scheme	Marks
2.		
(a)	F(2) = 1 gives: $\frac{1}{4}\left(2^3-4\times 2^2+2k\right)=1$	M1
	***k* = 6**	A1
		(2)
(b)	f(y) = $\frac{\mathrm{d}}{\mathrm{d}y}\left(\mathrm{F}(y)\right)=\frac{1}{4}\left(3y^2-8y+\text{"6"}\right)$	M1A1ft
	$\mathrm{f}(y)=\begin{cases}\frac{1}{4}\left(3y^2-8y+6\right) & 0\le y\le 2\\ 0 & \text{otherwise}\end{cases}$	A1
		(3)
(c)	P(Y > 1) = 1 – F(1) = $1-\frac{1}{4}\left(1^3-4\times 1^2+k\right)$	M1
	$=\frac{1}{4}$ (o.e.)	A1
		(2) **[7]**
	Notes	
(a)	M1 for an attempt to use F(2) = 1. Clear attempt to form a linear equation for *k*	
(b)	M1 for some correct differentiation $y^n \to y^{n-1}$ 1st A1ft for $3y^2-8y+\text{"6"}$, follow through their value of *k* or even *k* as a letter 2nd A1 for a fully correct solution including the 0 otherwise.	
(c)	M1 for clear use of 1 – F(y) or attempt at integrating f(y); at least one correct term with correct coefficient, and using limit of 1 and 2 A1 for $\frac{1}{4}$ or any exact equivalent	

Question Number	Scheme	Marks
3.		
(a)	$\frac{1}{2}(a+b)=23$ and $\frac{1}{12}(b-a)^2=75$	B1B1
	$a+b=46$ and $b-a=\sqrt{12\times 75}\,(=30)$	M1
	Adding gives $2b = 76$	M1
	$\underline{\mathbf{b = 38}}$ and $\underline{\mathbf{a = 8}}$	A1 A1
		(6)
	<u>alternative</u>	
	$\frac{1}{2}(a+b)=23$ and $\frac{1}{12}(b-a)^2=75$	B1B1
	$a+b=46$ and hence $(46-2a)^2=900$ oe	M1
	$a^2-46a+304=0$	
	$(a-8)(a-38)=0$	M1
	$\underline{\mathbf{b = 38}}$ and $\underline{\mathbf{a = 8}}$	A1 A1
		(6)
(b)	P($23 < X < c$) = 0.5 – 0.32 or $c=28.4$ and prob $=\frac{5.4}{30}$	M1
	= <u>**0.18**</u>	A1
		(2) **[8]**
	Notes	
(a)	1st B1 for at least one correct equation using given formulae	
	2nd B1 for any 2 correct equations for *a* and *b* using both 23 and 75	
	1st M1 for rearranging to get two linear equations in *a* and *b* *or* rearranging and substituting linear equation into quadratic.	
	2nd M1 for solving i.e. eliminating one variable leading to a linear equation in one variable *or* solving their quadratic correctly by any method.	
	1st A1 for *b* = 38	
	2nd A1 for *a* = 8	
	SC If they get *b* = 8 and *a* = 38 or they give two sets of values and do not eliminate one then they can get B1B1M1M1A1A0	
(b)	M1 for a correct method, e.g. a correct expression or seeing calculation for *c* and calculation for probability	
	A1 for 0.18 only	

Question Number	**Scheme**	**Marks**
4.		
(a)	$\int f(x)\ dx = k\left[3x + x^2 - \frac{x^3}{3}\right]$	M1
	$\int_0^3 f(x)\ dx = 1$ gives $k\left[\left(9+9-\frac{27}{3}\right)-(0)\right] = 1$	M1
	So $k = \frac{1}{9}$ (*)	A1cso
		(3)
(b)	$f'(x) = k(2-2x)$	M1
	$f'(x) = 0$ implies $x = 1$ so **mode = 1**	A1
		(2)
(c)	$E(X) = \int_0^3 \tfrac{1}{9}\left(3x + 2x^2 - x^3\right)\ dx$	M1
	$= \frac{1}{9}\left[\frac{3x^2}{2} + \frac{2x^3}{3} - \frac{x^4}{4}\right]_0^3$	M1dA1
	$= \left\{\frac{1}{9}\left[\left(\frac{3}{2}\times 9 + \frac{2}{3}\times 27 - \frac{81}{4}\right) - 0\right]\right\} = \frac{5}{4}$	A1
		(4)
(d)	Mean > mode	M1
	So **positive skew**	A1
		(2) **[11]**
	Notes	
(a)	**NB** This is a 'Show that so working must be seen' 1st M1 for some correct integration $x^n \to x^{n+1}$ for at least one term 2nd M1 for some correct use of the limit 3 and at least implied use of limit 0 and put =1 A1cso for correct solution with no incorrect working seen.	
(b)	M1 for attempt to differentiate and putting = 0. At least one correctly differentiated *x* term. or for an alternative method for finding the maximum such as completing the square and selecting the corresponding *x* value or using a sketch and symmetry. A1 for mode = 1	
(c)	1st M1 for clear attempt to use $xf(x)$ with an intention of integrating (Integral sign enough) Ignore limits. Must substitute in f(*x*) 2nd M1d dependent on 1st M being awarded. For some correct integration...at least one correct term with the correct coefficient. 1st A1 for fully correct (possibly un-simplified) integration. Ignore limits 2nd A1 for answer of 5/4 or 1.25 or some other exact equivalent	
(d)	M1 for a comparison of mean and mode (ft their values of mode and mean). Do **not** allow median. A1 for positive skew only (provided this is compatible with their values and comparison)	
Question Number	**Scheme**	**Marks**
5.	[X = number of customers joining the queue in the next 10 mins ~Po(3)]	

Question Number	Scheme	Marks
(a)	$P(X = 4) = P(X \le 4) - P(X \le 3)$ or $\frac{e^{-3}3^4}{4!}$	M1
	$0.8153 - 0.6472 = 0.1681$ or $0.1680313...$ (awrt **<u>0.168</u>**)	A1
		(2)
(b)	Y [= number of customers joining the queue in the next 20 mins] ~ Po(6)	B1
	$P(Y > 10) = 1 - P(Y \le 10)$	M1
	$= 1 - 0.9574 = 0.0426(209...)$ (awrt **<u>0.0426</u>**)	A1
		(3)
(c)	$P(T > 3.5) =$ **<u>0.3</u>**	B1
		(1)
(d)	$C \sim B(5, 0.3)$	M1
	$P(C \ge 3) = 1 - P(C \le 2)$	M1
	$= 1 - 0.8369 = 0.1631$ (0r 0.16308..) (awrt **<u>0.163</u>**)	A1
		(3)
(e)	P(Bethan is served in < 4 minutes) = 0.8 (o.e.)	B1
	J = number joining the queue in 4 mins has $J \sim$ Po(1.2)	M1
	$P(J = 0) = e^{-1.2} = 0.30119...$	A1
	P(Bethan is served and $J = 0$) = $0.8 \times e^{-1.2} = 0.240955...$ (awrt **<u>0.241</u>**)	A1
		(4) **[13]**
	Notes	
(a)	M1 for a correct method. May use incorrect λ A1 for awrt 0.168	
(b)	B1 for writing or using Po(6) M1 for writing or using $1 - P(Y \le 10)$ A1 for awrt 0.0426	
(d)	1st M1 for identifying that $C \sim B(5, 0.3)$. Follow through their 0.3. May be implied 2nd M1 for writing or using $1 - P(C \le 2)$ A1 for awrt 0.163 SC if they use normal distribution they may get M0 M1 A0 if they find $P(C \ge 2.5)$	
(e)	B1 for 0.8 for P(Bethan is served in the next 4 minutes) M1 for identifying Po(1.2) A1 for $e^{-1.2}$ or awrt 0.301... A1 for awrt 0.241	

Question Number	Scheme	Marks
6.	[X = the number of raisins in a mini-muffin]	
(a)	$X \sim \text{Po}(8)$	B1
	e.g. $\text{P}(X \le 3) = 0.0424$, $\text{P}(X \le 13) = 0.9658$ so $\text{P}(X \ge 14) = 0.0342$	M1
	So Critical Region is $X \le 3$ or $X \ge 14$	A1 A1
		(4)
(b)	0.0424 + 0.0342	M1
	= **0.0766** (or better)	A1
		(2)
(c)	$\text{H}_o : \lambda = 8$ (or μ=80) $\text{H}_1 : \lambda > 8$ (or $\mu > 80$)	B1
	[R = no. of raisins in 10 muffins. $R \sim \text{Po}(80)$.] Use $Y \sim \text{N}(80, 80)$	M1A1
	$\text{P}(R \ge 95) \simeq \text{P}(Y \ge 94.5)$	M1
	$= \text{P}\left(Z > \dfrac{94.5-80}{\sqrt{80}}\right)$	M1
	$= \text{P}(Z > 1.62...) = 1 - 0.9474 =$ awrt **0.053**	A1
	Probability is greater than 0.05 so not significant (accept H_0)	M1
	Insufficient evidence to support the bakery's claim Or insufficient evidence of an increase in the (mean) number of raisins per muffin	A1cso
		(8)
		[14]
	Notes	
(a)	B1 for Po(8) seen or implied by use M1 for clear evidence of use of Po(8), may be implied by a correct CR (allow written as a probability statement) or a probability seen in part(b). If they give 3 and 14 1st A1 for $X \le 3$ or $0 \le X \le 3$ or 0,1,2,3 or [0,3] Allow any letter 2nd A1 for $X \ge 14$ or $[14, \infty)$ condone $[14, \infty]$ Allow any letter These A marks must be for statements with X only – not in prob statements	
(b)	M1 for showing they are adding together the two probabilities that correspond to their CR **or** allow M1 A1for correct answer	
(c)	B1 for both hypotheses. Must be in terms of λ or μ, 8 or 80 can be swapped 1st M1 for normal approx 1st A1 E(Y) = 80 and Var(Y) = 80 (or correct st. dev seen somewhere) 2nd M1 for use of a continuity correction 94.5 or 95.5 3rd M1 Standardising using their mean and their sd, If they have not written down a mean and sd then these need to be correct here to award the mark. They must also use 94.5, 95.5 or 95 and find the correct area ie using 1 - P(Z ≤ "their 1.62") 2nd A1 for awrt 0.053 or awrt 0.947 4th M1 for a correct statement based on their probability and 0.05 3rd A1 cso for a correct contextualised statement and a fully correct solution with no errors seen. Need either bakery's claim or Raisins and muffin **NB** If Found P(X=95) they can get B1 M1 A1 M0M0A0M0A0	

Question Number	Scheme	Marks
7.		

Question Number	**Scheme**	**Marks**
(a)	$X \sim \mathrm{B}(20, 0.2)$	M1 A1
		(2)
(b)	$S = 4X - 1(20 - X)$	M1
	$S = 5X - 20$	A1cso
		(2)
(c)	$\mathrm{E}(X) = 4, \quad \mathrm{Var}(X) = 3.2$	B1, B1
	$\mathrm{E}(S) = 5 \times 4 - 20 = 0, \quad \mathrm{Var}(S) = 5^2\,\mathrm{Var}(X) = 80$	M1 A1
		(4)
(d)	$S \geq 20$ implies $5X - 20 \geq 20$	M1
	[So $5X \geq 40$] $X \geq 8$	A1
	$\mathrm{P}(S \geq 20) = \mathrm{P}(X \geq 8) = 1 - \mathrm{P}(X \leq 7)$	M1
	$= 1 - 0.9679 = \underline{\mathbf{0.0321}}$	A1
		(4)
(e)	[Let C = no. Cameron gets correct. $C \sim \mathrm{B}(100, 0.4)$] $Y \sim \mathrm{N}(40, \sqrt{24}^2)$	M1A1
	$\mathrm{P}(C > 50) \simeq \mathrm{P}(Y > 50.5)$	
	$= \mathrm{P}\left(Z > \dfrac{50.5 - 40}{\sqrt{24}}\right)$	M1 M1
	$= \mathrm{P}(Z > 2.14...) = 1 - 0.9838 = 0.0162$ or 0.016044.. (awrt **<u>0.016</u>**)	A1
	N.B. exact Bin (0.01676...) Poisson approx (0.0526...)	**(5)**
		[17]
	Notes	
(a)	M1 for "binomial" or B(... A1 for $n = 20$ and $p = 0.2$	
(b)	**NB** this is a 'show that' so working must be shown M1 for attempt at any correct expression for S that uses 4 and – 1 (1 may not be seen) A1cso for correct expression derived. No incorrect working seen and M1 scored.	
(c)	1st B1 for E(X) = 4 seen. Condone E(S) = 4. May be implied by correct E(S) or be seen in the calculation for E(S) 2nd B1 for Var(X) = 3.2 seen. Condone Var(S) = 3.2. May be implied by correct Var(S) or be seen in the calculation for Var(S) M1 for a correct formula for E(S) or Var(S) – follow through their E(X) and Var(X) may be implied by either answer being correct A1 for 0 and 80 correctly assigned.	
(d)	1st M1 for an attempt to solve the inequality for X 2nd M1 for $1 - \mathrm{P}(X \leq 7)$	
(e)	1st M1 for use of normal approx. and mean = 40 1st A1 for Var = 24 or st. dev = $\sqrt{24}$ May be implied by later work 2nd M1 49.5 or 50.5 3rd M1 Standardising using their mean and their sd, If they have not written down a mean and sd then these need to be correct here to award the mark. They must also use 50.5, 49.5 or 50 and find the correct area ie using 1 - P(Z ≤ "their 2.14"), 2nd A1 for awrt 0.016	

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Mark Scheme (Results)

Summer 2013

GCE Statistics S2 (6684/01)

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(5,5,5) (5,5,1) (5,1,5) (1,5,5) (5,5,2) (5,2,5) (2,5,5)
or (5,5,5) and (5,5,1) ($\times$ 3) and (5,5,2) ($\times$ 3)</td><td>B1
B1
(2)</td></tr>
<tr><td>1(b)</td><td>(5,5,5) $\left(\frac{3}{10}\right)^3 = \frac{27}{1000} = 0.027$
(5,5,1) $3\times\frac{1}{2}\times\left(\frac{3}{10}\right)^2 = \frac{135}{1000}\ or\ \frac{27}{200} = 0.135$
(5,5,2) $3\times\frac{1}{5}\times\left(\frac{3}{10}\right)^2 = \frac{54}{1000} = \frac{27}{500} = 0.054$
$\text{P}(M = 5) = \left(\frac{3}{10}\right)^3 + 3\times\frac{1}{2}\times\left(\frac{3}{10}\right)^2 + 3\times\frac{1}{5}\times\left(\frac{3}{10}\right)^2 = \frac{27}{125}$ = 0.216 oe</td><td>B1
M1

A1A1
(4)</td></tr>
<tr><td>1(c)</td><td>$\text{P}(M = 1) = (0.5)^3 + 3(0.5)^2(0.2) + 3(0.5)^2(0.3)$
$= 0.5$
$\text{P}\ (M = 2) = \left(\frac{1}{5}\right)^3 + 3\times\left(\frac{1}{5}\right)^2\times\frac{1}{2} + 3\times\left(\frac{1}{5}\right)^2\times\frac{3}{10} + 6\times\frac{1}{2}\times\frac{1}{5}\times\frac{3}{10}$
$= 0.284$ or $\frac{71}{250}$ oe
<table>
<tr><td><i>m</i></td><td>1</td><td>2</td><td>5</td></tr>
<tr><td>P(<i>M</i> = <i>m</i>)</td><td>0.5</td><td>0.284</td><td>0.216</td></tr>
</table></td><td>M1
A1
M1
A1
A1
(5)
Total 11 marks</td></tr>
<tr><td></td><td>Notes</td><td></td></tr>
<tr><td>1(a)

1(b)

1(c)</td><td colspan="2">1st B1 for two of the given triples, any order
2nd B1 for all 7 cases. no incorrect extras
B1 $\left(\frac{3}{10}\right)^3$ <i>or</i> 0.027 oe. This can be a single term in a summation
M1 either "3" $\times\frac{1}{2}\times\left(\frac{3}{10}\right)^2$ or "3" $\times\frac{1}{5}\times\left(\frac{3}{10}\right)^2$ oe. May omit the 3 × or have another positive integer in place of the 3. These may be seen as a single term in a summation
A1 $\left(\frac{3}{10}\right)^3 + 3\times\frac{1}{2}\times\left(\frac{3}{10}\right)^2 + 3\times\frac{1}{5}\times\left(\frac{3}{10}\right)^2$ oe
A1 0.216 oe
1st M1 correct calculation for P(<i>M</i> = 1) or P(<i>M</i> = 2), working must be shown and not implied by a correct answer.
1st A1 either P(<i>M</i> = 1) or P(<i>M</i> = 2) correct
2nd M1 correct calculation for both P(<i>M</i> = 1) and P(<i>M</i> = 2), or their probabilities adding up to 1, but do not allow probabilities of 0.5, 0.2 and 0.3
2nd A1 both P(<i>M</i> = 1) and P(<i>M</i> = 2) correct
3rd A1dep on both M marks awarded. All three values written down with their correct probabilities. They must be in part (c) but they do not need to be in a table.
NB A fully correct table with no working will get M0 A0 M1 A1 A0.</td></tr>
</table>

Question Number	Scheme	Marks

2(a)	$P(X = 1) = 0.25e^{-0.25} = 0.1947$ awrt 0.195	M1A1 (2)
2(b)	$X \sim Po(1.5)$ $P(X > 2) = 1 - P(X \leq 2)$ $= 1 - 0.8088$ $= 0.1912$ awrt 0.191	B1 M1 A1 (3)
2(c)	$[\lambda = 300 \times 0.25 = 75]$ $X \sim N(75,75)$ $P(X < 90) = P(X \leq \frac{89.5-75}{\sqrt{75}})$ $= P(Z \leq 1.6743..)$ = awrt 0.953 or 0.952	 B1 B1 M1M1 A1 (5) Total 10 marks
	Notes	
2(a) **2(b)** **2(c)**	M1 $0.25e^{-0.25}$ o.e B1 stating or using Po(1.5) M1 stating or using $1 - P(X \leq 2)$ 1st B1 for normal approximation and correct mean 2nd B1 Var (X) = 75or sd = $\sqrt{75}$ or awrt 8.66 (may be given if correct in standardisation formula) 1st M1 using either 89.5 or 88.5 2nd M1 Standardising using their mean and their sd, using [89.5, 88.5 or 89] and for finding correct area **NB** use of Poisson gives an answer of 0.9498 and gains no marks	

Question Number	Scheme	Marks
3(a)	$X \sim \text{Po}(7)$ $\text{P}(X > 10) = 1 - \text{P}(X \le 10)$ $= 1 - 0.9015$ $= 0.0985$ awrt 0.0985	B1 M1 A1 (3)
3(b)	$\text{P}(X > d) < 0.05$ **Or** $\text{P}(X \ge d) < 0.05$ $\text{P}(X \le d) > 0.95$ $\text{P}(X < d) > 0.95$ $\text{P}(X \le 11) = 0.9467$ $\text{P}(X < 12) = 0.9467$ $\text{P}(X \le 12) = 0.9730$ $\text{P}(X < 13) = 0.9730$ Least number of games =12 Least number of games 13	 M1 A1 A1 (3)
3(c)	$\text{H}_0\text{: } \lambda = 1, \left(\mu = 28\right)$ $\text{H}_1\text{: } \lambda > 1\left(\mu > 28\right)$ $Y \sim \text{Po}(28)$ approximated by N(28,28) $\text{P}(Y \ge 36) = \text{P}(Z \ge \frac{35.5-28}{\sqrt{28}})$ $1.6449 = \frac{x - 0.5 - 28}{\sqrt{28}}$ $= \text{P}(Z \ge 1.42)$ $= 0.0778$ or $1.42 < 1.6449$ CR $X \ge 37.2$ 0.0778 > 0.05 so do not reject H_0/not significant. Not in CR There is no evidence that the average **rate** of **sales** per day has **increased**.	B1 B1 M1M1 A1 M1 A1cso (7) Total 13 marks
	Notes	
3(a)	B1 stating or using Po(7) M1 stating or using 1 - $\text{P}(X \le 10)$	
3(b)	M1 using or writing $\text{P}(X > d) < 0.05$ or $\text{P}(X < d) > 0.95$ (condone ≥ instead of > and ≤ instead of <) May be implied by correct answer. Different letters may be used. 1st A1 $\text{P}(X \le 12)$/ $\text{P}(X < 13)$ = awrt 0.973 **or** $\text{P}(X \le 11)$ / $\text{P}(X < 12)$ = awrt 0.947 May be implied by a correct answer 2nd A1 12 or 13 **NB** An answer of 12/13 on its own with no working gains M1A1A1	
3(c)	1st B1 both hypotheses correct using λ or μ, **and** 1 or 28 2nd B1 for writing or using a normal approximation with correct mean and Var (may be given if sd correct in standardisation formula) 1st M1 for use of a continuity correction 35.5 or 36.5 or $x \pm 0.5$ 2nd M1 Standardising using their mean and their sd. If they have not written down a mean and sd then these need to be correct here to award the mark. They must use [35.5, 36.5, 36, x or $x \pm 0.5$] For CR must have = awrt 1.64 or 1.65 1st A1 awrt 0.0778 or 0.9222 or the statement 1.42 < awrt 1.65/1.64 or CR $X \ge 37.2$ / $X > 37.2$ 3rd M1 a correct conclusion for their probability. May be implied by a correct contextual conclusion. NB Non contextual contradicting statements gets M0 2nd A1 a correct contextual conclusion for their hypotheses and a fully correct solution with no errors seen. Need the words **"rate/average number"**, **"sales"** and **"increased"**oe NB If found $\text{P}(X = 36)$ they can get B1B10M0A0M0A0	

Question Number	Scheme	Marks

4(a)	E(X) = $\frac{5b}{2}$	B1 (1)
4(b)	Var(X) = E(X^2) - (E(X))^2 $= \int_b^{4b} \frac{x^2}{3b}\mathrm{d}x - (\frac{5b}{2})^2$ $=\left[\frac{x^3}{9b}\right]_b^{4b} - \frac{25b^2}{4}$ $=\frac{63b^3}{9b} - \frac{25b^2}{4}$ $=\frac{3b^2}{4}$	M1 M1d A1cso (3)
4(c)	Var(3 - 2X) = 4Var(X) $= 3b^2$	M1 A1 (2)
4(d)	$\mathrm{F}(x) = \begin{cases} 0 & x < 1 \\ \frac{x-1}{3} & 1 \le x \le 4 \\ 1 & x > 4 \end{cases}$	B1B1 (2)
4(e)	$\frac{x-1}{3} = 0.5$ so $x = 2.5$	B1 (1)
Alt 4(b)	Var(X) $= \int_a^b \frac{(x-\bar{x})^2}{b-a}\mathrm{d}x$ $= \int_b^{4b} \frac{4x^2-20bx+25b^2}{12b}\mathrm{d}x$ $= \left[\frac{\frac{4x^3}{3}-10bx^2+25b^2x}{12b}\right]_b^{4b}$ $= \frac{9b^3}{12b}$ $= \frac{3b^2}{4}$	Total 9 marks M1 M1 A1cso(3)
	Notes	
4(b)	**NB remember the answer is given (AG) so they must show their working** 1st M1 for using $\int \frac{x^2}{3b}$ dx - (their (a))^2 limits not needed and condone missing dx. NB need not use the letter x but if they use b instead do not award if they cancel down to $\frac{b}{3}$ NB Check they have subtracted (their(a))^2 2nd M1 dependent on previous M being awarded. For some correct integration $x^n \to x^{n+1}$ and correct limits substituted at some point. condone 4b^3 instead of (4b)^3 A1 for correct solution with no incorrect working seen.	
4(c)	M1 for writing or using 4Var(X)	
4(d)	1st B1 top **and** bottom line. Allow use of $\le$ instead of < and $\ge$ instead of > 2nd B1 middle row. Allow use of < instead of $\le$	

Question Number	**Scheme**	**Marks**
5(a)	F(1) = 0, $\frac{4}{10} + a + b = 0$	M1 A1

	$a=-\frac{3}{5}$ *or* $b=\frac{1}{5}$ F(2) = 1, $2+2a+b=1$ Solving gives $a=-\frac{3}{5}, b=\frac{1}{5}$ **Alt** F(2) - F(1) = 1, $2+2a+b-\frac{4}{10}-a-b=1$ $a=-\frac{3}{5}$ F(2) =1 **or** F(1) = 0 $2-\frac{6}{5}+b=1$ **or** $\frac{4}{10}-\frac{3}{5}+b=0$ $b=\frac{1}{5}$	 M1 A1 (4) M1 A1 M1 A1 (4)
5(b)	Differentiating cdf gives f(x) = $\frac{3}{10}x^2+\frac{6}{10}x+a, \quad 1\le x\le 2$ $=\frac{3}{10}(x^2+2x-2)$	B1 cso (1)
5(c)	$\mathrm{E}(X)=\int_1^2\frac{3}{10}(x^3+2x^2-2x)\mathrm{d}x$ $=\frac{3}{10}\left[\frac{1}{4}x^4+\frac{2}{3}x^3-x^2\right]_1^2$ $=\frac{13}{8}$	M1 M1d A1 A1 (4)
5(d)	F(1.425) = 0.24355, F(1.435) = 0.25227 0.25 lies between F(1.425)and F(1.435) hence result.	M1A1 A1 (3)
	Notes	Total 12 marks
5(a)	1st M1 using F(1) = 0. Clear attempt to form a linear equation for *a* and *b* 1stA1 either *a* = -0.6 or *b* = 0.2 Previous M must be awarded 2nd M1 using F(2) = 1. Clear attempt to form a second linear equation for *a* and *b* 2nd A1 if 1st A1 awarded then both *a* and *b* must be correct otherwise award if either *a* = -0.6 or *b* = 0.2 **alt** 1st M1 F(2) - F(1) = 1. Leading to a value for *a:* 1st A1 *a* = -0.6 2nd M1 using F(2) = 1 or F(1) = 0. Leading to a value for *b:* 2nd A1 *b* = 0.2 NB correct values for *a* and *b* with no working scores no marks.	
5(b)	B1 They must differentiate and then factorise. cso	
5(c)	1st M1 for clear attempt to use *x*f(*x*) with an intention of integrating (Integral sign enough) Ignore limits. Must substitute in f(*x*) or "their f(*x*)". 2nd M1d dependent on previous M being awarded for some correct integration… at least one correct term with the correct coefficient. 1st A1 for fully correct (possibly unsimplified) integration. Ignore limits 2nd A1 Accept 1.63 and 1.625 or some other exact equivalent	
5(d)	M1 expression showing substitution of 1.425 or 1.435 into F(*x*) [**or** into F(*x*) – 0.25] [or putting their F(*x*) = 0.25 and attempting to solve leading to *x* = ...] May be implied by either pair of the correct answers as given below for the 1st A1 1st A1 awrt 0.244 and awrt 0.252 [**or** awrt -0.00645 and awrt 0.00227] [or *x* = awrt 1.432] 2nd A1 0.25 lies between F(1.425)and F(1.435) [**or** change in sign therefore root between] [**or** "1.432" lies between 1.425 and 1.435 therefore root between]. Statement must be true for their method	

Question Number	**Scheme**	**Marks**
6(a)	X~B(20,0.25) $\mathrm{P}(X\ge 10)=1-0.9861=0.0139$ $\mathrm{P}(X\le 1)=0.0243$	M1 A1 A1

	$(0 \leq)X \leq 1 \cup 10 \leq X(\leq 20)$	A1A1 (5)
6(b)	$\text{H}_0: p = 0.25$ $\text{H}_1: p < 0.25$ $X \sim \text{B}(20,0.25)$ $\text{P}(X \leq 3) = 0.2252$ or CR $X \leq 1$ Insufficient evidence to reject H_0, Accept H_0, Not significant. 3 does not lie in the Critical region. No evidence that the **changes** to the process have **reduced** the **percentage** of **defective articles (oe)**	 B1 M1A1 M1d A1cso (5) Total 10 marks
	Notes	
6(a)	M1 using B(20,0.25) may be implied by a correct CR (allow written as a probability statement) 1st A1 awrt 0.0139 2nd A1 awrt 0.0243 3rd A1 $X \leq 1$ or $0 \leq X \leq 1$ or [0,1] or 0,1 or equivalent statements 4th A1 $X \geq 10$ or $10 \leq X \leq 20$ or 10,11,12,13,14,15,16,17,18,19,20 or [10,20] or equivalent statements **NB** These two A marks must be for statements with X (any letter) only – not in probability statements and **SC** for CR written as $1 \geq X \geq 10$ gets A1 A0	
6(b)	B1 both hypotheses with p 1st M1 using B(20, 0.25) and finding $\text{P}(X \leq 3)$ or $\text{P}(X \geq 4)$ may be implied by a correct CR 1st A1 0.2252 (allow 0.7748) if not using CR or CR $X \leq 1$ or $X < 2$ 2nd M1dependent on previous M being awarded. A correct statement (do not allow if there are contradicting non contextual statements) A1cso Conclusion must contain the words **changes/new process oe**, **reduced oe number/percentage oe** , and **defective articles/defectives**. There must be no incorrect working seen.	

Question Number	Scheme	Marks
7(a)	Distribution $X \sim \mathrm{B}(n, 0.1)$	B1
		(1)
7(b)	$Y \sim \mathrm{B}(10, 0.1)$	B1
	$\mathrm{P}(Y \geq 4) \quad = 1 - \mathrm{P}(Y \leq 3)$	M1
	$= 1 - 0.9872$	
	$= 0.0128$	A1
		(3)
7(c)		
	$0.9^n < 0.05$ or $1 - (0.9)^n > 0.95$	M1
	$n > 28.4$	A1
	$n = 29$	A1
	alternative	
	B(28,0.1): P(0) = 0.0523	M1
	B(29,0.1): P(0) = 0.0471	A1
	$n = 29$	A1cao
		(3)
7(d)	$C \sim \mathrm{Po}(5)$	B1
	$\mathrm{P}(C > 10) = 1 - \mathrm{P}(C \leq 10)$	M1
	$= 1 - 0.9863$	
	$= 0.0137$	A1
		(3)
		Total marks 10
	Notes	
7(a)	B1 for “binomial” or B(…	
7(b)	B1 writing or using B(10,0.1)	
	M1 writing or using $1 - \mathrm{P}(Y \leq 3)$	
	A1 awrt 0.0128	
7(c)	M1 $(0.9)^n < 0.05$,oe, or $(0.9)^n = 0.05$,oe, or $(0.9)^n > 0.05$, oe, or seeing 0.0523 or seeing 0.0471	
	1st A1 [P(0)] = 0.0471 or getting awrt 28.4 May be implied by correct answer.	
	2nd A1 cao $n = 29$ should not come from incorrect working.	
	NB An answer of 29 on its own with no working gains M1A1A1	
7(d)	B1 writing or using Po(5)	
	M1 writing or using $1 - \mathrm{P}(C \leq 10)$	
	A1 awrt 0.0137	

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS
General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\sqrt{}$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- ∗ The answer is printed on the paper
- ⌐ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme	Marks
1(a)	Let X = the number of leaf cuttings successfully taking root	
	$X \sim \text{B}(10,0.05)$	B1
(i)	$\text{P}(X = 1) = \text{P}(X \leqslant 1) - \text{P}(X = 0)$ or ${}^{10}C_1 \times 0.05 \times 0.95^9$	M1
	$= 0.9139 - 0.5987$	
	$= 0.3152$ awrt 0.315	A1
(ii)	$\text{P}(X > 2) = 1 - \text{P}(X \leqslant 2)$	M1
	$= 1 - 0.9885$	
	$= 0.0115$ awrt 0.0115	A1
		(5)
1(b)	$Y \sim \text{Po}(8)$	B1
	$\text{P}(Y \geqslant 10) = 1 - \text{P}(Y \leqslant 9)$	M1
	$= 1 - 0.7166$	
	$= 0.2834$ awrt 0.283	A1
		(3)
		Total (8)

Notes

(a)	B1 use of B(10,0.05). May appear in (i) or (ii) or may be implied	
(i)	M1 writing or using $\text{P}(X \leqslant 1) - \text{P}(X = 0)$ or ${}^{n}C_1 \times p \times (1-p)^{n-1}$ $(0 < p < 1)$	
(ii)	M1 writing or using $1 - \text{P}(X \leqslant 2)$	
(b)	B1 writing or using Po(8) or writing or using N(8,7.6)	
	M1 writing or using $1 - \text{P}(Y \leqslant 9)$ or for M1 for $\text{P}\left(Z > \frac{9.5-8}{\sqrt{7.6}}\right)$	
	A1 for awrt 0.283 from poisson or an answer in the range (0.293,0.295) from normal	
	NB using binomial, $\text{P}(X \geqslant 10) = 0.280125...$scores B0M0A0	
	Answer only 0.28 or awrt 0.280 scores B0M0A0	
	Answer only awrt 0.283 scores B1M1A1	
	Answer only in the range (0.293,0.295) B1M1A1	

Question Number	Scheme	Marks
2(a)	**<u>List</u>** of all the **<u>customers</u>** (who eat in the restaurant)	B1 (1)
(b)	**<u>Customer(s)</u>** (who ate in the restaurant)	B1 (1)
(c)	Advantage: more/total accuracy, unbiased	B1
	Disadvantage: time consuming to obtain data and analyse it, expensive, difficult to ensure entire population is included	B1 (2)
(d)	Let X = the number of customers who would like more choice on the menu.	
	$H_0: p = 0.3 \quad H_1: p > 0.3$	B1
	$X \sim B(50,0.3)$	M1
	$P(X \geqslant 20) = 1 - P(X \leqslant 19)$ or CR $P(X \leqslant 20) = 0.9522$	M1
	$= 1 - 0.9152$ $P(X \geqslant 21) = 0.0478$	
	$= 0.0848$ $X \geqslant 21$	A1
	Do not reject H_0/ not significant/20 is not in critical region	M1
	The percentage of <u>customers</u> who would like more <u>choice</u> on the menu is not more than Bill believes. or There is no evidence to reject <u>Bill's</u> <u>belief</u>.	A1cso
		(6)
		Total (10)

Notes

(a)	B1 Need the idea of list/register/database and 'customer(s)' Do not allow customer's opinions. 'All' may be implied. Do not allow a partial list e.g. 'A list of 50 customers'
(b)	B1 customer(s)
(c)	If not labelled, assume the response refers to a census. 1st B1 is for the advantage and 2nd B1 is for the disadvantage.
(d)	B1 need both hypotheses with p M1 using B(50,0.3) M1 for $1 - P(X \leqslant 19)$ or $P(X \leqslant 20) = 0.9522$ or $P(X \geqslant 21) = 0.0478$ leading to a **critical region** $X > k$ or $X \geq k$ A1 awrt 0.0848 or critical region $X \geqslant 21$ or $X > 20$ M1 a correct conclusion for their probability. May be implied by a correct contextual conclusion. A1 a correct contextual conclusion for their hypotheses and a fully correct solution with no errors seen. Must mention 'customers' and 'choice' <u>or</u> 'Bill' and 'belief'. NB $P(X=20)$ can score B1M1M0A0M0A0 NB normal approximation gives 0.082(457…) and loses all A marks

Question Number	Scheme	Marks
3(a)	$\frac{1}{6}a(a+1)=0.6$	M1
	$a^2+a-3.6=0$	
	$a=\frac{-1\pm\sqrt{1+4\times 3.6}}{2}$	M1
	$=1.462\ldots$ a = 1.46 only	A1
		(3)
3(b)	$\mathrm{f}(x)=\frac{\mathrm{d}}{\mathrm{d}x}\mathrm{F}(x)=\frac{1}{3}x+\frac{1}{6}$	M1A1
(i)	$\mathrm{E}(X)=\int_0^2 x\left(\frac{1}{3}x+\frac{1}{6}\right)\mathrm{d}x$	M1
	$=\left[\frac{x^3}{9}+\frac{x^2}{12}\right]_0^2$	A1
	$=\frac{11}{9}$ awrt 1 .22	A1
(ii)	$\mathrm{Var}(X)=\int_0^2 x^2\left(\frac{1}{3}x+\frac{1}{6}\right)\mathrm{d}x-\left(\frac{11}{9}\right)^2$	M1
	$=\left[\frac{x^4}{12}+\frac{x^3}{18}\right]_0^2-\left(\frac{11}{9}\right)^2$	A1ft
	$=\frac{23}{81}$ awrt 0.284	A1
		(8)
		Total (11)

Notes

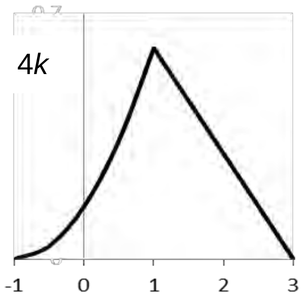
(a)	M1 putting F(x) = 0.6 or 1 – 0.4 M1 attempting either completing the square or quadratic formula (one slip allowed) (condone + instead of $\pm$) Must set f(a) = 0.6 or f(a) = 0.4 to score this mark. May be implied by implied by awrt 1.46 or awrt -2.46 A1 for 1.46 only (must reject other root if stated) (condone awrt 1.46)
(b) (i)	1st M1 attempting to differentiate F(x) at least one $x^n \to x^{n-1}$ 2nd M1 for intention to use $\int_0^2 x\mathrm{f}(x)\,\mathrm{d}x$ using their f(x) which must be a changed function from F(x). No need for limits 2nd A1 correct integration (may be unsimplified)
(ii)	3rd M1 for intention to use $\int x^2\mathrm{f}(x)\,\mathrm{d}x-\mu^2$ using their f(x) which must be a changed function from F(x). No need for limits. This may be seen on separate lines. Must substitute their value of μ/E(X) 4th A1ft correct integration. Ft their E(X).

Question Number	Scheme	Marks
4(a)	(H_1:) $\lambda > 1.5$	B1 (1)
4(b)	C~Po(6)	B1
	$P(C > 10) = 1 - P(X \le 10)$	M1
	$= 1 - 0.9574$	
	$= 0.0426$ awrt 0.0426	A1
		(3)
4(c)	$P(X \le 10 \mid \mu = 7) = 0.9015$	M1
	$P(X \le 10 \mid \mu = 7.5) = 0.8622$	
	Parameter $\mu = 7$	A1
	$\lambda = \frac{7}{4}$, 1.75	A1
		(3)
		Total (7)

Notes

(a)	B1 Must use λ	
(b)	B1 writing or using Po(6) M1 writing or using $1 - P(X \le 10)$ A1 do not isw. e.g. If the response goes on to state the level of significance is 5%, withhold the A mark. NB $P(X \leqslant 9) = 0.9161$ $P(X \le 11) = 0.9799$ can imply B1	
(c)	M1 either $P(X \le 10 \mid \mu = 7) = 0.9015$ or $P(X \le 10 \mid \mu = 7.5) = 0.8622$ award for sight of 0.9015 (or 0.0985) <u>or</u> 0.8622 (or 0.1378) NB $\lambda = 7$ scores M1A1A0 allow awrt 1.76 from calculator to score M1A1A1	

Question Number	Scheme	Marks
5(a)	Let X = the number of break downs per month	
	$X \sim \text{Po}\left(\frac{15}{12}\right)$	B1
	$\text{P}(X=3) = \frac{e^{-1.25}1.25^3}{3!}$	M1
	$= 0.0933$ awrt 0.0933	A1
		(3)
(b)	$\text{P}(X \geqslant 2) = 1 - \text{P}(X=0) - \text{P}(X=1)$	
	$= 1 - e^{-1.25}(1 + 1.25)$	M1
	$= 0.35536\ldots$	
	$= 0.355$ **AG	A1cso
		(2)
(c)	$(0.355)^4 = 0.0159$ awrt 0.016	M1A1
		(2)
(d)	$Y \sim$ number of months the photocopier does break down at least twice.	
	$Y \sim \text{B}(12, 0.355)$	M1A1
	$\text{P}(Y \geq 2) = 1 - \text{P}(Y=0) - \text{P}(Y=1)$	dM1
	$= 1 - (1-0.355)^{12} - 12(1-0.355)^{11}(0.355)$	A1
	$= 0.961$	A1
		(5)
		Total (12)
	Notes	
(a)	B1 writing or using Po(1.25)	
	M1 $\frac{e^{-\lambda}\lambda^3}{3!}$	
(b)	**NB remember the answer is given (AG) so they must show their working**	
	M1 $1 - \text{P}(X=0) - \text{P}(X=1)$ or $1 - \text{P}(X \leqslant 1)$ **and** a correct expression using their λ	
	Condone 0.3554 or better	
(c)	M1 Their $[(\text{b})]^4$	
(d)	M1 for identifying Binomial	
	1st A1 B(12, their (b))	
	dM1 $1 - \text{P}(Y=0) - \text{P}(Y=1)$ or $1 - \text{P}(X \leqslant 1)$ dependent on 1st M1	
	2nd A1 for a correct expression	
	3rd A1 for awrt 0.961	

Question Number	Scheme	Marks
6(a)		B1 B1
		(2)
(b)	$\int_{-1}^{1} k(x+1)^2\,dx + \int_{1}^{3} k(6-2x)\,dx = 1$	M1
	$\int_{-1}^{1} k(x^2+2x+1)\,dx + \int_{1}^{3} k(6-2x)\,dx = 1$	
	$k\left[\frac{x^3}{3}+x^2+x\right]_{-1}^{1} + k\left[6x-x^2\right]_{1}^{3} = 1$	M1A1
	$k\left[2\frac{1}{3}+\frac{1}{3}\right]+k\left[9-5\right]=1$	dM1
	$6\frac{2}{3}k=1$	
	$k=\frac{3}{20}$ **AG	A1cso
		(5)
(c)	$\int_{-1}^{x} k(x^2+2x+1)\,dx = k\left[\frac{x^3}{3}+x^2+x\right]_{-1}^{x}$ or $\left[\frac{k}{3}(x+1)^3\right]_{-1}^{x}$	M1
	$= \frac{3}{20}\left(\frac{x^3}{3}+x^2+x+\frac{1}{3}\right)$ or $\frac{1}{20}(x+1)^3$	
	$\int_{1}^{x} k(6-2x)\,dx + \int_{-1}^{1} k(x^2+2x+1)\,dx = k\left[6x-x^2\right]_{1}^{x}+\frac{2}{5}$	M1
	$=\frac{3}{20}(6x-x^2-5)+\frac{2}{5}$	
	$=\frac{9}{10}x-\frac{3}{20}x^2-\frac{7}{20}$	
	$$\mathrm{F}(x)=\begin{cases}0 & x<-1\\ \frac{3}{20}\left(\frac{x^3}{3}+x^2+x+\frac{1}{3}\right) & -1\le x\le 1\\ \left(\frac{9}{10}x-\frac{3}{20}x^2-\frac{7}{20}\right) & 1<x\le 3\\ 1 & x>3\end{cases}$$	B1 A1 A1
		(5)

Question Number	Scheme	Marks
6. cont. (d)	$\frac{9}{10}x-\frac{3}{20}x^2-\frac{7}{20}=0.5$	M1
	$3x^2-18x+17=0$	
	$x=\frac{18\pm\sqrt{18^2-4\times3\times17}}{6}$	dM1
	$x = 1.17$ only	A1
		(3)
		Total (15)

Notes

(a)	B1 correct shape with correct curvature and straight line with negative gradient. Must start and end on the *x*-axis. B1 –1, 1, 3 and 4*k* (or 0.6) labelled in the correct place
(b)	M1 adding two areas and putting equal to 1 eg $\int_{-1}^{1} k(x+1)^2 dx + 4k = 1$ M1 attempting to integrate (at least one $x^n \to x^{n+1}$) or finding area of triangle A1 correct integration $k\left(\frac{x^3}{3}+x^2+x\right)$ and $k(6x-x^2)$ <u>or</u> $k\left(\frac{x^3}{3}+x^2+x\right)$ and $4k$ <u>or</u> $k\left(\frac{(x+1)^3}{3}\right)$ and $k\left(\frac{(6-2x)^2}{-4}\right)$ M1 dependent on previous two M marks. For using correct limits A1 correct solution with no incorrect working seen
(c)	For both M marks, attempt to integrate at least one $x^n \to x^{n+1}$ M1 for attempt to integrate line 1 of f(*x*) with correct limits <u>or</u> with + c and substituting in –1 and setting = 0 M1 for attempt to integrate line 2 of f(*x*) with correct limits and adding $\frac{2}{5}$ oe or their F(1) <u>or</u> with + c and substituting in 3 and setting = 1 B1 top and bottom row correct 1st A1 for 2nd line of F(*x*) with correct range 2nd A1 for 3rd line of F(*x*) with correct range Do not penalise the use of ≤ instead of < and ≥ instead of >
(d)	M1 for setting their 2nd line or 3rd line of F(*x*) = 0.5 dM1 for solving a 3 term quadratic dependent on first M1 (must be using their 3rd line of F(*x*)) A1 for 1.17only (condone awrt 1.17) must reject other solution (4.825….)

Question Number	Scheme	Marks
7	$\frac{64.5-\mu}{\sigma}=0.75$	B1 M1 M1 A1
	$\frac{52.5-\mu}{\sigma}=-1.25$	A1
	$64.5-\mu=0.75\sigma$	dM1
	$52.5-\mu=-1.25\sigma$	
	$\sigma = 6$	A1
	$\mu = 60$	A1
	$np = 60$	M1
	$np(1-p) = 36$	M1
	$1-p = 0.6$	
	$p = 0.4$	A1
	$n = 150$	A1
		(12)
		Total (12)

Notes

B1 ± 0.75 and ± 1.25 (or better) seen

1st M1 64 ± 0.5 or 52 ± 0.5

2nd M1 standardising either using 64, 65 or 64 ± 0.5 or $52, 53$ or 52 ± 0.5 with μ and σ <u>or</u> *np* and $\sqrt{np(1-p)}$ (need not be set equal to a z-value)

1st A1 for $\frac{64.5-\mu}{\sigma}=0.75$ (with compatible signs)
2nd A1 for $\frac{52.5-\mu}{\sigma}=-1.25$ (with compatible signs)

3rd M1 solving simultaneous equations dependent on 2nd M1. Must attempt to eliminate μ or σ <u>or</u> *np* or $\sqrt{np(1-p)}$

3rd A1 $\sigma = 6$
4th A1 $\mu = 60$
4th M1 using $\mu = np$ (may be awarded at any stage in the working)

5th M1 using $\sigma = \sqrt{np(1-p)}$ (may be awarded at any stage in the working)

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Mark Scheme (Results)

Summer 2014

Pearson Edexcel GCE in Statistics 2 (6684/01)

Summer 2014
Publications Code UA040123

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

PEARSON EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: Method marks are awarded for ‘knowing a method and attempting to apply it’, unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol √ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- d… or dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- ∗ The answer is printed on the paper or ag- answer given
- ⌊ or d… The second mark is dependent on gaining the first mark

4. All A marks are ‘correct answer only’ (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
    - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme	Marks
1. **(a)**	Po(9)	B1
(i)	$\mathrm{P}(X \le 7) - \mathrm{P}(X \le 6)$ = 0.3239 – 0.2068 $\quad \dfrac{e^{-9}9^7}{7!}$	M1
	= 0.1171	A1
(ii)	$\mathrm{P}(X \ge 10) = 1 - \mathrm{P}(X \le 9)$	M1
	= 1 – 0.5874 = 0.4126	A1 (5)
(b)	Po(1.5) P(next patient before 11:45) = 1- P(0) = 1 - $e^{-1.5}$ = 0.7769	B1 M1 A1 (3) [8]
	Notes	
(a) (i)	B1 Po(9) written or used in either (i) or (ii) M1 writing $\mathrm{P}(X \le 7) - \mathrm{P}(X \le 6)$ or $\dfrac{e^{-\lambda}\lambda^7}{7!}$ This may be implied by 0.3239 – 0.2068 A1 awrt 0.117	
(ii)	M1 writing $1 - \mathrm{P}(X \le 9)$ This may be implied by 1 – 0.5874. A1 awrt 0.413	
(b)	B1 Po(1.5) written or used M1 writing or using 1 – P(0) or 1 - $e^{-\lambda}$. This may be implied by 1 – 0.2231 A1 awrt 0.777	

Question Number	Scheme	Marks
2.		
(a)	$\int_0^9 c\left(81-t^2\right)\mathrm{d}t = 1$	M1
	$c\left[81t-\frac{t^3}{3}\right]_0^9 = 1$	A1
	$c\left[81\times 9-\frac{9^3}{3}\right] = 1$	M1d
	$486c = 1$	
	$c = \frac{1}{486}$	A1cso
		(4)
(b)	$\mathrm{F}(t) = \frac{1}{486}\int_0^t 81-x^2\mathrm{d}x$	M1
	$= \frac{1}{486}\left[81t-\frac{x^3}{3}\right]_0^t$	
	$= \frac{t}{6}-\frac{t^3}{1458}$	
	$\mathrm{F}(t) = \begin{cases} 0 & t < 0 \\ \frac{t}{6}-\frac{t^3}{1458} & 0 \le t \le 9 \\ 1 & t > 9 \end{cases}$	A1cso
		(2)
(c)	$\mathrm{P}(T > 3) = 1-\left(\frac{3}{6}-\frac{3^3}{1458}\right)$	M1
	$= \frac{14}{27}$ or awrt 0.519	A1
		(2)
(d)	$\mathrm{P}(T > 7 \mid T > 3) = \frac{0.068587}{0.5185}$	M1A1ft
	$= \frac{25}{189}$ or awrt 0.132	A1
		(3)
(e)	${}^3C_2\left(0.5185\right)^2\left(1-0.5185\right) = \frac{2548}{6561}$ or awrt 0.388/ 0.387	M1A1ftA1
		(3) [14]

	Notes	
(a)	1st M1 Attempting to integrate, For attempt $x^n \rightarrow x^{n+1}$ and c must remain as c or 1/486. Ignore limits 1st A1 Correct integration. Ignore limits. 2nd M1 dependent on previous M being awarded. Putting = 1 and substitution of 9 as a limit seen. Need at least one intermediate step before getting 486 or substitution of 1/486 and 9 seen and leading to an answer of 1 A1 $c = \frac{1}{486}$ cso or if verifying, the statement $c = \frac{1}{486}$	
(b)	M1 Attempting to integrate with correct limits **or** $\int \mathrm{f}(t)\mathrm{d}t$ + C and F(0) = 0 or F(9) = 1. Subst in c at some point A1 F(t) must be stated and cso. Condone use of < instead of ≤ etc.	
(c)	M1 using or writing 1 – F(3) or $\frac{1}{486}\int_3^9 81 - x^2 \mathrm{d}x$ or 1 – P($X \le 3$) A1 awrt 0.519	
(d)	M1 $\frac{a\ probability}{their\ (\mathrm{c})}$ where 0 < *a probability* < *their (c)* < 1. If *a probability* ≥ *their (c)*, give M0. A1ft $\frac{\frac{50}{729}}{their\ (\mathrm{c})}$ or $\frac{awrt 0.0686}{their\ (\mathrm{c})}$ A1 $\frac{25}{189}$ or awrt 0.132	
(e)	M1 Allow $\left(their\ '0.5185'\right)^2\left(1 - their\ '0.5185'\right)$ A1ft Allow $^3C_2$ (*their* ‘0.5185’)^2(1 – *their* ‘0.5185’) A1 awrt 0.388 or 0.387	

Question Number	Scheme	Marks
3. **(a)**	Any two of • Emails are independent/occur at random • Emails occur singly • Emails occur at a constant rate	B1B1d (2)
(b)	$X \sim \text{Po}(4)$ $\text{P}(X = 0) = 0.0183$ $\text{P}(X \geq 9) = 0.0214$ CR $X = 0$; $X \geq 9$	B1B1 (2)
(c)	$0.0183 + 0.0214 = 0.0397$ or 3.97%	M1A1 (2)
(d)	8 is not in the critical region **or** $\text{P}(X \geq 8) = 0.0511$ therefore there is evidence that the company's **<u>claim</u>** is true	M1 A1ft (2)
(e)	$\text{H}_0 : \lambda = 6$ (or $\lambda = 2$) $\text{H}_1 : \lambda < 6$ (or $\lambda = 2$) allow λ or μ Po(6) $\text{P}(X \leq 2) = 0.0620$ CR $X \leq 2$ $0.0620 < 0.10$ Reject H_0 or Significant. There is evidence at the 10% level of significance that the mean **<u>rate/number/amount</u>** of **<u>emails</u>** received **<u>is lower/ has decreased/is less</u>**. Or **<u>fewer emails</u>** are received	B1 M1 A1 M1 dep. A1 cso (5) [13]
	Notes	
(a)	B1 any correct statement with context of emails in B1d Dependent on previous B1. Any correct statement, need not have context **SC** for 2 correct statements without context B1 B0	
(b)	B1 $X = 0$ or $X \leq 0$ Allow any letter. B1 $X \geq 9$ or $X > 8$ Allow any letter. **SC** if write correct CR's as probability statements award B1 B0 For these 2 marks ignore any union sign ($\cup$) or intersection sign ($\cap$)	
(c)	M1 adding their probabilities of 'their' critical regions if sum gives a probability less than 1 or award if a correct answer given A1 awrt 0.0397	
(d)	M1 correct reason ft their CR. Do not allow non-contextual contradictions. A1 correct conclusion for their CR. Allow conclusion in context of **<u>emails</u>** are **<u>received</u>** at a rate of 2 every 5 mins	
(e)	B1 both hypotheses correct, must have λ or μ and either 2 or 6. M1 using Po(6) may be implied by correct answer. A1 0.062 or $X \leq 2$ M1 dependent on previous method being awarded. Do not allow conflicting non-contextual statements. Follow through their hypotheses.	

Question Number	Scheme	Marks
4. (a)	X is the random variable the Number of successes, $X \sim \mathrm{B}(10, 0.75)$	B1
(i)	$\mathrm{P}(X = 6) = (0.75)^6 (0.25)^4\ {}^{10}C_6$ or $\mathrm{P}(X \le 6) - \mathrm{P}(X \le 5)$	M1
	$= 0.145998$ awrt 0.146	A1
(ii)	Using $X \sim \mathrm{B}(10, 0.75)$	
	$\mathrm{P}(X \ge 8) = \mathrm{P}(X = 8) + \mathrm{P}(X = 9) + \mathrm{P}(X = 10)$	M1
	$= (0.75)^8 (0.25)^2\ {}^{10}C_8 + (0.75)^9 (0.25)^1\ {}^{10}C_9 + (0.75)^{10}$	
	$= 0.52559$ awrt 0.526	A1
	Or	
	Using $Y \sim \mathrm{B}(10, 0.25)$ and $\mathrm{P}(Y \le 2) = 0.5256$	(5)
(b)	$1 - \mathrm{P}(0) = 0.8$ or $\mathrm{P}(0) = 0.2$	M1
	$(1-p)^{20} = 0.2$	
	$1 - p = 0.9227$	
	$p = 0.0773$	A1
	$\frac{3}{200}(90 - x) = 0.0773$	M1
	$x = 84.84$	
	$x = 85$	A1cao (4)
(c)	X – successes $\sim \mathrm{B}(100, 0.975)$	B1
	Y – not successes $\sim \mathrm{B}(100, 0.025)$	
	$Y \sim \mathrm{Po}(2.5)$	M1A1
	$\mathrm{P}(Y \le 5) = 0.958$	M1A1 (5)
	Notes	[14]
(a)	B1 writing or using $p = 0.75$ or $p = 0.25$ anywhere in (a)(i) or (a)(ii)	
(i)	M1 writing or using $(p)^6 (1-p)^4\ {}^{10}C_6$ **or** writing for $p = 0.75$, $\mathrm{P}(X \le 6) - (X \le 5)$ **or** for $p = 0.25$, $\mathrm{P}(X \le 4) - \mathrm{P}(X \le 3)$ **or** correct answer.	
(ii)	M1 writing B(10, 0.75) and writing or using $\mathrm{P}(X = 8) + \mathrm{P}(X = 9) + \mathrm{P}(X = 10)$ oe **or** writing B(10, 0.25) and writing or using $\mathrm{P}(Y \le 2)$.	
	Using correct Binomial must be shown by $(0.75)^n (0.25)^{10-n}$ or a correct answer.	
(b)	M1 for writing or using 1 – P(0) = 0.8 or P(0) = 0.2 or $(1-p)^{20} = 0.2$. Allow any inequality sign.	
	A1 awrt 0.0773 or awrt 0.923.	
	M1 subst in $\frac{3}{200}(90 - x)$ for p **NB** this may be substituted in earlier for p.	
	Allow for $\frac{3}{200}(90 - x) = k$ where $0 < k < 1$ $k \ne 0.8$ or 0.2 Allow any inequality sign	
	A1 condone $x \ge 85$. Do not allow $x \le 85$.	
(c)	B1 writing or using 0.975 or 0.025, may be implied by Po(2.5)	
	M1 using Po approximation	
	A1 Po(2.5)	
	M1 writing or using $\mathrm{P}(Y \le 5)$	
	A1 awrt 0.958	
	SC use of normal approximation can get B1 M0A0M1A0	
	B1 writing or using 0.975 or 0.025 implied by normal with mean 97.5 or answer of 0.973	
	M1 for awrt 0.973	

Question Number	Scheme	Marks
5.(a)	n is large and p close to 0.5	B1B1 (2)
(b)	There would be no pea seeds left	B1 (1)
(c)	H_0: $p = 0.55$ H_1 : $p \neq 0.55$	B1 (1)
(d)	X~N(121, 54.45)	B1
	$P(X \geq 134.5) = P\left(Z \geq \frac{134.5-121}{\sqrt{54.45}}\right)$ or $\pm\frac{x-0.5-121}{\sqrt{54.45}} = 1.96$	M1M1A1
	$= P(Z \geq 1.8295..)$ $= 1 - 0.9664$ $= 0.0336/0.0337$ $x = 135.96$	A1
	Accept H_0 not in CR, not significant	M1
	The **company's claim** is justified **or** 55% of its pea **seeds germinate**	A1cso (7)
	Alternative	
	X~N(99, 54.45)	B1
	$P(X \leq 85) = P\left(Z \leq \frac{85.5-99}{\sqrt{54.45}}\right)$ or $\pm\frac{x+0.5-99}{\sqrt{54.45}} = 1.96$	M1 M1 A1
	$= P(Z \geq 1.8295..)$ $= 1 - 0.9664$ $= 0.0336/0.0337$ $x = 107.5$	
	Accept H_0 not in CR, not significant	M1
	The **company's claim** is justified **or** 55% of its pea **seeds germinate**	A1cso [11]
	Notes	
(a)	B1 accept $n > 50$ (or any number bigger than 50) B1 p close to 0.5 NB Do not accept $np > 5$, $nq > 5$.	
(b)	Must have the idea of no peas left. They must mention either **pea** or **seeds**.	
(c)	B1 both hypotheses correct. Must use p or π and 0.55 oe. Accept the hypotheses in part (d).	
(d)	B1 correct mean and Var, may be seen in the standardiation formula as 121 and $\sqrt{54.45}$ or 7.38 to 2dp or implied by a correct answer M1 for attempting a continuity correction (Method 1:135/85 ± 0.5 / Method 2:$x \pm 0.5$) M1 for standardising using their mean and their standard deviation and using either Method 1 [134.5, 135, 135.5, 85, 85.5 or 84.5 accept $\pm z$.] Method 2 [$(x \pm 0.5)$ and equal to a $\pm$ z value] A1 correct z value awrt ± 1.83 **or** $\pm\frac{134.5-121}{\sqrt{54.45}}$ $\left(\frac{85.5-99}{\sqrt{54.45}}\right)$ or $\pm\frac{x-0.5-121}{\sqrt{54.45}} = 1.96$ $\left(\pm\frac{x+0.5-99}{\sqrt{54.45}} = 1.96\right)$ or(allow 1.6449 if 1 tail test in (c)) A1 awrt 0.0336/0.0337 **or** awrt 136 (allow 126 if one tail test in (c)) or a comparison of awrt1.83 with 1.96 (1.6449) M1 A correct statement. Accept H_0, oe if a 2-tailed test in (c), reject H_0, oe if a 1-tailed test in (c). Allow for a correct contextual statement. Do not allow contradictions of non-contextual statements. A1 A correct contextual statement to include words in bold/underlined for a 2-tailed test. This is not a follow through mark. **NB** if finding $P(X = 135)$ they can get B1 M1 M1 A0 A0 M0 A0	

Question Number	Scheme	Marks
6.		
(a)	$\mathrm{E}(X)=\int_0^1 \frac{2x^2}{9}\mathrm{d}x+\int_1^4 \frac{2x}{9}\mathrm{d}x+\int_4^6 \frac{2x}{3}-\frac{x^2}{9}\mathrm{d}x$	M1
	$=\left[\frac{2x^3}{27}\right]_0^1+\left[\frac{2x^2}{18}\right]_1^4+\left[\frac{x^2}{3}-\frac{x^3}{27}\right]_4^6$	A1
	$=\left[\frac{2}{27}\right]+\left[\frac{32}{18}-\frac{2}{18}\right]+\left[4-\frac{80}{27}\right]$	M1d
	$=2\frac{7}{9}$ or awrt 2.78	A1 (4)
(b)	$\mathrm{F}(x)=\begin{cases} 0 & x<0 \\ \frac{x^2}{9} & 0\le x\le 1 \\ \frac{2x}{9}-\frac{1}{9} & 1<x<4 \\ \frac{2x}{3}-\frac{x^2}{18}-1 & 4\le x\le 6 \\ 1 & x>6 \end{cases}$	B1 M1A1 M1 A1 B1
	1st M1 For $1<x<4$, $\mathrm{F}(x)=\int_1^x \frac{2}{9}\mathrm{d}x+\frac{1}{9}$ 2nd M1 For $4\le x\le 6$, $\mathrm{F}(x)=\int_4^x \frac{2}{3}-\frac{x}{9}\mathrm{d}x+\frac{7}{9}$ or use +C and F(6) =1	(6)
(c)	$\mathrm{F}(x)=0.5$	M1
	$\frac{2m}{9}-\frac{1}{9}=0.5$	A1ft
	$m=2.75$	A1 (3)
(d)	Median < mean therefore positive skew **Or** Mean $\approx$ median therefore no skewness	M1A1cao (2) [15]

	Notes	
(a)	M1 using $\int x\mathrm{f}(x)\mathrm{d}x$ ignore limits. Must have at least one $x^n \to x^{n+1}$ They must add the 3 parts together. Do not allow division by 3. A1 all integration correct; ignore limits M1 dependent on previous M being awarded. Subst in correct limits – no need to see zero substituted. A1 $2\frac{7}{9}$ oe or awrt 2.78	
(b)	B1 for 2nd line- allow use of $<$ instead of $\le$ M1 For $1 < x < 4$, $\mathrm{F}(x)=\int_1^x \frac{2}{9}\mathrm{d}x+\frac{1}{9}$. Limits are needed. **or** use $\mathrm{F}(x)=\int_1^x \frac{2}{9}\mathrm{d}x+$ their F(1) need limits **or** use “their $\mathrm{F}(1)\text{"}=\int \frac{2}{9}\mathrm{d}x+C$ and subst $x = 1$ into RHS **or** use “their $\mathrm{F}(4)\text{"}=\int \frac{2}{9}\mathrm{d}x+C$ and subst $x = 4$ into RHS A1 for 3rd line allow use of $\le$ instead of $<$ M1 For $4 \le x \le 6$, $\mathrm{F}(x)=\int_4^x \frac{2}{3}-\frac{x}{9}\mathrm{d}x+\frac{7}{9}$. Limits are needed. **or** use $\mathrm{F}(x)=\int_4^x \frac{2}{3}-\frac{x}{9}\mathrm{d}x+$ their F(4) . Limits are needed. **or** use “their $\mathrm{F}(4)\text{"}=\int \frac{2}{3}-\frac{x}{9}\mathrm{d}x+C$ and subst $x = 4$ into RHS **or** use $1=\int \frac{2}{3}-\frac{x}{9}\mathrm{d}x+C$ and subst $x = 6$ into RHS A1 for 4th line allow use of $<$ instead of $\le$ B1 for first and last line - allow use of $\le$ instead of $<$ and $\ge$ instead of $>$ and “otherwise” for one of $x < 0$ and $x > 6$	
(c)	M1 putting any one of their lines = 0.5 A1their 3rd line = 0.5 A1 2.75	
(d)	M1 reason must match their values / a correctly shaped and labelled sketch. Must compare the median and mean, ignore references to mode A1 no ft Correct answer only from correct values of the mean and median or a correct and fully labelled sketch.	

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Mark Scheme (Results)

Summer 2014

Pearson Edexcel GCE in Statistics S2R (6684/01R)

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Summer 2014
Publications Code UA040126

General Marking Guidance

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PEARSON EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75

2. The Edexcel Mathematics mark schemes use the following types of marks:

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3. Abbreviations

   These are some of the traditional marking abbreviations that will appear in the mark schemes.

   - bod – benefit of doubt
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   - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which round to
   - SC: special case
   - oe – or equivalent (and appropriate)
   - d… or dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - $\ast$ The answer is printed on the paper or ag- answer given
   - └ or d… The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

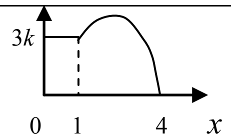
6. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
    - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

Question	Scheme	Marks
1.	$\text{H}_0 : p = 0.2 \qquad \text{H}_1 : p < 0.2$	B1
	$\left[X \sim \text{B}(40, 0.2)\right] \qquad \text{P}(X \leq 3) = 0.0285$ or CR of $X \leq 3$	M1A1
	[0.0285 < 0.05] significant, reject H_0	M1dep
	There is evidence to support the supplier's **<u>claim</u>** or The probability of a **<u>ball</u>** failing the bounce **<u>test</u>** is **<u>less</u>** than **<u>0.2</u>**	A1cso **(5)**
	Notes	
	1st B1 for both H_0 and H_1 must use p or π 1st M1 for writing or using B(40, 0.2) , may be implied by correct answer 1st A1 awrt 0.0285 or CR of $X \leq 3$ as their final answer 2nd M1 dependent on the previous method mark being awarded. A correct statement (this may be contextual) comparing "their probability" and 0.05 (or comparing 3 with their critical region). Do not allow conflicting statements. 2nd A1cso This is cso so can only be awarded for a fully correct solution. A correct contextualised conclusion (to include the words underlined in bold)	

Question	Scheme	Marks
2. (a)	(i) *S* <u>is</u> a statistic, (ii) *D* is <u>not</u> a statistic , (iii) *F* <u>is</u> a statistic	B1, B1, B1 (3)
(b)	$T \sim \text{B}(10, 0.4)$	M1A1 (2)
(c)	P($2'$ $2'$ 2) or P(5 5 2, 5 >5 2, >5 >5 2) $= 0.6^2 \times 0.4$ = $(0.25)^2(0.4) + 2\times(0.25)(0.35)(0.4) + (0.35)^2(0.4)$ $= 0.144$	M1 A1 (2) **(7)**
	Notes	
(a)	B1 for each variable. Accept "yes, no, yes" o.e.	
(b)	M1 for binomial A1 for $n = 10$ and $p = 0.4$ NB If they give 2 options then unless they select the correct one they gain M0A0	
(c)	M1 for identifying the correct possibilities $2'$ $2'$ 2 <u>**or**</u> 5 5 2 and 5 >5 2 and >5 5 2 and >5 >5 2 **or** a correct probability statement. The possibilities must be in the correct order. Condone 2× (5 >5 2) or 2× (>5 5 2). Implied a correct answer. A1 for 0.144 or exact equivalent e.g. $\frac{18}{125}$	

Question	Scheme	Marks
3. (a)	$X \sim \text{Po}(9)$	M1A1
		(2)
(b)	$\text{P}(X > 7) = 1 - \text{P}(X \le 7)$	M1
	$= \left[1 - 0.3239\right] = 0.6761$	A1
		(2)
(c)	[Y = no. of accidents in a month] $Y \sim \text{Po}(1.5)$	B1
	$\text{P}(Y \ge 1) = 1 - \text{P}(Y = 0)$	M1
	$= \left[1 - 0.2231\right] = 0.7769$ (= 0.777 (3dp))*	A1cso
		(3)
(d)	[A = no. of months with at least one accident] $A \sim \text{B}(6,\ 0.777)$	M1
	$\text{P}(A = 4) = \binom{6}{4}(0.777)^4(0.223)^2$	M1
	= 0.2719… awrt **0.272**	A1
		(3)
		(10)
	Notes	
(a)	M1 for Poisson (accept Po). Condone P(9) A1 for mean of 9	
(b)	M1 for writing $1 - \text{P}(X \le 7)$. This may be implied by $1 - 0.3239$ or a correct answer A1 for awrt 0.676	
(c)	B1 Po(1.5) written or used M1 writing or using $1 - \text{P}(Y = 0)$ or $1 - \text{P}(Y \le 0)$ or 1- $e^{-\lambda}$ [may not be Y] A1 for at least (1 – 0.223) or better. No need for final comment.* answer given so 0.777 does not imply all three marks	
(d)	1st M1 for identifying binomial with n = 6 and p = 0.777 or better. Condone use of p = 0.223. May be implied by $(p)^4(1 - p)^2$ p = awrt 0.777 or awrt 0.223 2nd M1 Must have $^6C_4\ (0.777)^4(1 - 0.777)^2$ A1 for awrt 0.272	

Question	Scheme	Marks
4. (a)		B1B1B1 (3)
(b)	Mode = 2	B1 (1)
(c)	Mean < mode, so negative skew	B1, dB1 (2)
(d)	$3k\times 1+\int_{1}^{4}\left(4kx-kx^2\right)\ \mathrm{d}x=1$	M1, B1
	$3k+\left[2kx^2-\frac{kx^3}{3}\right]_1^4\ \{=1\}$	M1
	$3k+\left(32k-\frac{64k}{3}\right)-\left(2k-\frac{k}{3}\right)=1$	M1d
	$12k=1$ so $k=\frac{1}{12}$	A1 (5)
(e)	Lower Quartile = 1	B1 (1)
(f)	P(1 < X < 2) = P(2 < X < 3) by symmetry	M1
	So P(X > 3) = $1-3k-\frac{22}{36}=\frac{5}{36}$	A1 (2)
		(14)

	Notes
(a)	1st B1 for horizontal line $y = 3k$ and $3k$ marked on y-axis 2nd B1 for correct shape for $1 < x < 4$, meeting x-axis at (4, 0) and not extending below x-axis. Must be a curve 3rd B1 for $x = 1$ marked and graphs meeting at the point (1, $3k$)
(b)	B1 for 2
(c)	1st B1 for a suitable reason which matches their mode. The mode must be a number. Must use mean. 2nd dB1 not ft, dependent on 1st B1. Correct answer from correct value of Mode.
(d)	1st M1 for attempting the sum of both areas = 1, ignore limits B1 for $3k$ seen added to integral 2nd M1 For some correct integration, at least one $kx^n \rightarrow kx^{n+1}$ 3rd M1d Dependent on 1st M1 being awarded. For use of correct limits. A1 for $k = \frac{1}{12}$
(e)	B1 for 1
(f)	M1 for identifying the symmetry. May be implied by P(1< x <2) $=\frac{11}{36}$ found by any method or writing down a correct equation (ft their k). e.g $0.75-2\times\frac{11}{36}$ or $\int_3^4 kx(4-x)\ \mathrm{d}x$ or $1-3k-\frac{11}{36}-\int_1^2 4kx-kx^2$ with their k subst in A1 for $\frac{5}{36}$ or exact equivalent

Question	Scheme	Marks
5. (a)	$H_0 : \lambda = \frac{1}{8}$ (or λ=5) $H_1 : \lambda \ne \frac{1}{8}$ (or $\lambda \ne 5$) allow λ or μ	B1
	X ~Po(5), $P(X \le 1) = 0.0404$ or $P(X \ge 10) = 0.0318$ or $P(X \ge 9) = 0.0681$	M1
	Critical Regions: $X \le 1$ or $X \ge 10$	A1, A1 (4)
(b)	0.0404 + 0.0318 = 0.0722 (or 7.22% significance level)	M1A1 (2)
(c)	$H_0 : \lambda = \frac{1}{8}$ (or $\lambda = 25$) $H_1 : \lambda < \frac{1}{8}$ (or $\lambda < 25$) allow λ or μ	B1
	[Y= no. of defects in 200m of wallpaper] Y~Po(25) $Y \approx\sim N(25, \sqrt{25}^2)$	M1A1
	$P(Y \le 19) \approx P\left(Z < \frac{19.5 - 25}{\sqrt{25}}\right)$ or $\pm \frac{x - 0.5 - 25}{5} = 1.96$	M1M1
	$= [P(Z < -1.1)] = 0.1357$ (or 0.13566… from calc) $x = 35.3$	A1
	[> 0.05] not significant, there is insufficient evidence to support **<u>Thomas' claim.</u>** Or The **<u>number/rate/amount</u>** of **<u>defects</u>** is not **<u>decreased/less/reduced</u>**	A1cso (7) **(13)**
	Notes	
(a)	B1 for suitable hypotheses M1 for correct use of Po(5). Award if one relevant probability is seen or a correct CR. Allow if a correct CR written as a Probability statement 1st A1 for $X \le 1$ or $X < 2$ or $0 < X < 2$ or $0 \le X < 2$ or $0 < X \le 1$ oe. Allow any letter 2nd A1 for $X \ge 10$ or $X > 9$ or $10 \le x \le 40$ or $9 < x \le 40$ oe. Allow any letter Ignore any $\cup$ or $\cap$ signs Do not allow CR written as probability statements	
(b)	M1 for adding their probabilities of 'their' critical regions if sum gives a probability less than 1 or award if a correct answer given A1 for awrt 0.0722 (o.e)	
(c)	B1 for suitable hypotheses 1st M1 for normal approximation 1st A1 for mean =25 and variance = 25 or sd = 5 may be seen in the standardiation formula or implied by a correct answer 2nd M1 for attempting a continuity correction (Method 1:19 ± 0.5 / Method 2:x ± 0.5) 3rd M1 for standardising using their mean and their standard deviation and using either Method 1 [19.5, 19, 18.5 accept $\pm z$.] Method 2 [($x \pm 0.5$) and equal to a $\pm$ z value] 2nd A1 for awrt 0.136 or 35.3 or -1.1 > -1.96 3rd A1 for a correct contextualised conclusion. cao for a one tailed test, must come from correct working . Condone incorrect hypotheses. **NB** if finding $P(X=19)$ ie $P(X \le 19.5)$ - $P(X \le 18.5)$they can get B1 M1 A1M1 M1 A0 A0	

Question	**Scheme**	**Marks**
6. (a)	$\frac{d^2}{2}-\frac{d^4}{16}=\frac{1}{2}$	M1
	$\left[d^4-8d^2+8=0\Rightarrow\right]8=\left(d^2-4\right)^2$ or $d^2=\frac{8\pm\sqrt{64-32}}{2}$	M1
	$d^2=4-\sqrt{8}$	M1d
	$d=\sqrt{4-\sqrt{8}}=1.08239...$ awrt 1.08	A1 (4)
(b)	$\text{f}(d)=d-\frac{d^3}{4}$	M1
	$\left[\text{f}'(d)=0\Rightarrow\right]\ 1-\frac{3d^2}{4}=0$	M1A1
	$\left[d^2=\frac{4}{3}\text{ so}\right]d=1.154...$	A1
	$\text{f}''(d)=-\frac{6d}{4}<0$ so max	B1 (5)
(c)	$\text{P}(D<1)=\left[\frac{1}{2}-\frac{1}{16}\right]=\frac{7}{16}$	B1
	Number of children = $80\times\frac{7}{16}$, = 35	M1, A1
		(3) **(12)**
	Notes	
(a)	1st M1 for forming this equation based on F(d) = 0.5 oe 2nd M1 for attempting to solve (complete the square or use formula) –must be correct for their equation d3rd M1 for square rooting to get d = …. Do not award for d = awrt1.17 Dependent on previous M being awarded. A1 for awrt 1.08 Must reject any negative answers	
(b)	1st M1 for attempting to find f(d). Some correct differentiation. $x^n \rightarrow x^{n-1}$ 2nd M1 for attempting $\text{f}'(d)$ and setting it =0 Some correct differentiation x^n to x^{n+1} 1st A1 for a correct equation for d 2nd A1 for awrt 1.15 or 1.155 or $\sqrt{\frac{4}{3}}$ or $\frac{2\sqrt{3}}{3}$ or $\frac{2}{\sqrt{3}}$ oe B1 for a method confirming that their value gives a max not a min	
(c)	M1 for $80\times p$, $0<p<1$ A1 for 35 only	

Question	Scheme	Marks
7. (a)	$X \sim \mathrm{U}[0, 9]$	B1
		(1)
(b)	$[\mathrm{P}(X > 6) =]\ \frac{1}{3}$ oe allow awrt 0.333	B1
		(1)
(c)	$R = X\left(9 - X\right),\ = 9X - X^2$	M1, A1
		(2)
(d)	$\mathrm{E}(X) = 4.5$	B1
	$\mathrm{Var}(X) = \frac{81}{12} = \frac{27}{4}$ **or** $\mathrm{E}(X^2) = \int_0^9 \frac{x^2}{9}\,\mathrm{d}x$	B1
	$\mathrm{E}(X^2) = \mathrm{Var}(X) + [\mathrm{E}(X)]^2$ **or** $= \left[\frac{x^3}{27}\right]_0^9$	M1
	$\mathrm{E}(X^2) = 27$	A1
	So $\mathrm{E}(R) = 9 \times 4.5 - 27 = 13.5$	dM1A1
		(6)
	Alternative method	
	$\int_0^9 \frac{\left(9x - x^2\right)}{9}\,\mathrm{d}x = \left[\frac{9x^2}{18} - \frac{x^3}{27}\right]_0^9$	B1 B1 M1A1
	$= \frac{81}{2} - \frac{81}{3}$	dM1
	$= 13.5$	A1
(e)	$R > 2X^2$ or $9X - X^2 > 2X^2$	M1
	$9X > 3X^2$	A1
	So $\mathrm{P}(X < 3)$	M1
	$= \frac{1}{3}$	A1
		(4)
		(14)

	Notes	
(a)	B1 for X~U[0, 9] or "continuous uniform"/"rectangular" distribution with correct range Or allow the pdf $\mathrm{f}(x)=\begin{cases}\frac{1}{9} & 0\le x\le 9\\ 0 & \text{otherwise}\end{cases}$	
(c)	M1 for $X(9-X)$ or $9X-X^2$ may be implied by a correct answer A1 for $9X-X^2$ or $a=-1$ and $b=9$	
(d)	1st B1 for 4.5 or may be implied 2nd B1 for $\frac{81}{12}\,or\,\frac{27}{4}$ **or** $\int_0^9 \frac{x^2}{9}$ ignore limits 1st M1 for full method for $\mathrm{E}(X^2)$ using their Var (X) and E(X) or attempt to integrate $x^n \to x^{n+1}$ leading to a value for E(X^2). Need to be using $\int_0^9 \frac{x^2}{9}$ ignore limits. 1st A1 for $\mathrm{E}(X^2)$=27, may be implied. d2nd M1 for using 9E(X) – $\mathrm{E}(X^2)$. With their E(X) and $\mathrm{E}(X^2)$.This may be implied by a correct answer. Dep on first M Alternative B1 $\int_0^9 \frac{(9x-x^2)}{9}$ dx ignore limits , ft their (c) whch must be of the form aX^2 + b B1 $\int_0^9 \frac{(9x-x^2)}{9}$ dx with correct limits, ft their (c) M1 attempt to integrate at least one $x^n \to x^{n+1}$. Need to be using their $\int_0^9 \frac{(9x-x^2)}{9}$ dx condone limits missing A1 Correct Integration dM1 subst in limits, need to see 9 substituted. Condone missing 0	
(e)	Allow $\le$ instead of < and $\ge$ instead of > in this part 1st M1 for forming a suitable inequality in R and X or just X. May be implied by a correct probability in X. 1st A1 for simplifying to $9X>3X^2$ or $3>X$. May be implied by a correct probability in X 2nd M1 for forming a correct probability in X 2nd A1 for $\frac{1}{3}$ or exact equivalent	

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Mark Scheme (Results)

Summer 2014

Pearson Edexcel International A Level in Statistics 2
(WST02/01)

Summer 2014
Publications Code IA040144

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EDEXCEL IAL MATHEMATICS

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- sf significant figures
- ∗ The answer is printed on the paper
- ⎣ The second mark is dependent on gaining the first mark

4. All A marks are ‘correct answer only’ (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. Ignore wrong working or incorrect statements following a correct answer.

Question Number	**Scheme**	**Marks**
1. **(a)**	n- large (allow $n > 50$ or any number greater than 50) ["too" large is OK] p – small (allow $p < 0.2$ or a probability less than 0.2)	**B1**
		(1)
(b)	$H_0 : p = 0.009$ $H_1 : p > 0.009$	**B1**
		(1)
(c)	Po(4.5)	**B1**
	Probability $P(X \geq 9) = 1 - P(X \leq 8)$ $= 1 - 0.9597$ $= 0.0403$ **Critical Region (CR)** $P(X \leq 7) = 0.9134$ $P(X \leq 8) = 0.9597$ CR $X \geq 9$	**M1** **A1**
	Reject H_0 or Significant or 9 is in the Critical region. There is evidence that the farmer's claim is true. Or There is evidence that the proportion of eggs with a double yolk is > 0.009	**M1d** **A1cso**
		(5)
		[7]
	Notes	
(b)	B1 both hypotheses correct. Must mention p (or π). Words only is B0	
(c)	B1 writing or using Po(4.5)(Check their probs using tables if Po(4.5) is not seen) 1st M1 writing $1 - P(X \leq 8)$ May be implied by sight of $1 - 0.9597$ or for CR method: $P(X \leq 7) = 0.9134$ or $P(X \leq 8) = 0.9597$ (NB may see $P(X \leq 9) = 0.9829$ Allow this if trying a two-tail test and CR approach) They can score M1 for writing $1 - P(X \leq 8)$ even if they later go on to use another distribution such as B(500, 0.009). Exact binomial gives 0.039526... but scores A0 1st A1 for probability awrt 0.0403 or CR of $X > 8$ or $X \geq 9$ Allow awrt 0.9597 if accompanied by a correct comparison with 0.95 2nd dM1 correct statement that must agree with hypotheses. Dependent on B1 Contradictory non-contextual ststements such as "not significant" so "reject H_0" score M0 2nd A1cso correct contextual statement. Depends on all other marks in (c) being scored. Must mention "farmer" and "claim" or "eggs" and "double yolk" NB A correct calculation followed only by a correct contextual comment scores the final M1(implied) and A1	
2-tail	If 2-tail hypotheses in (b) Score B0 in (b) Could score B1 M1A1and M1 for a correct non contextual comment but A0 since they should not be rejecting H_0 in this case (or they have scored A0 earlier so not cso)	

Question Number	**Scheme**	**Marks**
2. (a)	$\int_0^2 k\left(4-y^2\right)\mathrm{d}y\,[=1]$ <u>or</u> attempt F(y)	**M1**
	$k\left[4y-\frac{y^3}{3}\right]_0^2\,[=1]$ F(y) = $k\left[4y-\frac{y^3}{3}\right]$	**A1**
	$k\left[4\times2-\frac{2^3}{3}\right]=1$ <u>or</u> must use F(2) = 1	**M1d**
	$k=\frac{3}{16}$ **(*)**	**A1cso** **(4)**
(b)	E(Y) = $\frac{3}{16}\int_0^2\left(4y-y^3\right)\mathrm{d}y$	**M1**
	$=\frac{3}{16}\left[2y^2-\frac{y^4}{4}\right]_0^2$, $=\frac{12}{16}$ or 0.75	**A1, A1**
	= 750 (kg)	**A1cao (4)**
(c)	E (Y^2) = $\frac{3}{16}\int_0^2 4y^2-y^4\mathrm{d}y$	**M1**
	$=\frac{3}{16}\left[\frac{4y^3}{3}-\frac{y^5}{5}\right]_0^2$ (= 0.8)	**A1**
	Var(Y) = 0.8 – 0.75^2	**M1**
	= 0.2375	**A1**
	Standard deviation = 0.48734... or 487 (kg)	**A1 (5)**
(d)	P(Y>1.5) = $\frac{3}{16}\int_{1.5}^2\left(4-y^2\right)\mathrm{d}y$ <u>or</u> $1-\frac{3}{16}\left[4y-\frac{y^3}{3}\right]_0^{1.5}$	**B1** **M1**
	$=\frac{3}{16}\left[4y-\frac{y^3}{3}\right]_{1.5}^2$ <u>or</u> $1-\frac{3}{16}\left[4y-\frac{y^3}{3}\right]_0^{1.5}$ = 0.0859 or $\frac{11}{128}$	**A1** **(3)**
		[16]
	Notes	
(a)	1st M1 attempting to integrate f(y), (at least one term $y^n \to y^{n+1}$). Ignore limits. 1st A1 fully correct integration. Ignore limits and accept any letters. 2nd dM1 dep on 1st M1. Subst in correct limits – condone not seeing 0 substituted. 2nd A1 cso – no incorrect working seen. "Verifying" requires statement "so k = …" here NB An "= 1" must appear somewhere <u>before</u> the line $\frac{16k}{3}=1$	
(b)	1st M1 Attempting to integrate yf(y), (at least one term $y^n \to y^{n+1}$). Ignore limits 1st A1 correct integration which must be shown. **No integration loses all 4 marks** 2nd A1 0.75 or any exact equivalent. May be implied by a correct ans. of 750 (kg) 3rd A1cao 750 only. Condone missing "kg"	
(c)	1st M1 Attempting to integrate y^2f(y) (at least one term $y^n \to y^{n+1}$). Ignore limits. Condone in $\sqrt{\ }$ 1st A1 correct integration. Condone inside $\sqrt{\ }$. May be implied by sight of 0.8 2nd M1 using E(Y^2) – [E(Y)]^2 follow through their E(Y^2) and E(Y)^2 Must see values <u>used</u> 2nd A1 0.2375 may be implied by correct sd. Allow $\frac{19}{80}$ or exact equivalent 3rd A1 awrt 0.487 or awrt 487. (no fractions)	
(d)	B1 using 1.5 in an integral or 1 – F(1.5). Must be part of a correct expression. M1 Correct integration and at least intention to use correct limits so 1.5, 2 or 0, 1.5 seen A1 awrt 0.0859 or $\frac{11}{128}$ or exact equivalent	

Question Number	**Scheme**	**Marks**
3. (a)	$\left[\mathrm{E}(T)=\frac{\alpha+\beta}{2}=2\right],\Rightarrow \alpha+\beta=4$	**, B1**
	$\left[\mathrm{Var}(T)=\frac{(\beta-\alpha)^2}{12}=\frac{16}{3}\right],\Rightarrow (\beta-\alpha)^2=64$	**, B1**
	$\alpha=-2,\beta=6$	**M1 A1 A1**
		(5)
(b)	$\mathrm{P}(T<3.4)=\frac{1}{8}\times(5.4)$	**M1**
	$=0.675$	**A1**
		(2)
		[7]

	Notes	
(a)	1st B1	$\alpha+\beta=4$ oe
	2nd B1	$(\beta-\alpha)^2=64$ oe allow $(\beta-\alpha)=+8$ or $(\beta-\alpha)=-8$ or $3(\beta-\alpha)^2=192$ May be implied by a correct equation in one variable
	M1	Correct processes to obtain a correct equation in one variable. Allow one slip. e.g. $(\beta-[4-\beta])^2=64$ <u>or</u> $2\beta=12$ <u>or</u> $4\alpha^2-16\alpha-48=0$ <u>or</u> $(2-\alpha)^2=16$
	1st A1	$\alpha=-2,$
	2nd A1	$\beta=6$ If both correct answers only appear then this implies all 5 marks.
(b)	M1	$\frac{1}{\pm \text{ their } "(\beta-\alpha)"}\times(3.4-\text{'their }\alpha\text{'})$ If their nexpression is –ve or > 1 then M0
	A1	0.675 or exact equivalent e.g. $\frac{27}{40}$

Question Number	Scheme	Marks
4. (a)	$\text{P}(L > 100) = \text{P}\left(Z > \dfrac{100-\mu}{0.5}\right) = 0.3$	
	$\Rightarrow \dfrac{100-\mu}{0.5} =, \ 0.5244$	**M1 B1**
	$\mu = 99.7378...$ cm awrt 99.7	**A1**
		(3)
(b)	X represents number more than 100cm. $X \sim \text{B}(12, 0.3)$	**B1**
	$\text{P}(X \le 2) = 0.2528$ awrt 0.253	**M1A1**
		(3)
(c)	Normal approximation $\mu = 400 \times 0.3 = 120, \ \sigma^2 = 84$	**M1, A1**
	$\text{P}(X > 127) \approx 1 - \text{P}(Z < \dfrac{127.5-120}{\sqrt{84}})$ ± 0.5, standardise	**M1, M1, A1**
	$\approx 1 - \text{P}(Z < 0.818\ )$	
	$= 1 - 0.7939$	
	$= 0.206$ or 0.207	**A1** **(6)**
		[12]

	Notes
(a)	M1 standardising (±) with 100, μ and 0.5 and setting equal to a z value. $0.5 < z < 0.7$ NB Use of $z = 0.7$ scores M0B0A0 B1 $z = \pm\ 0.5244$ or better (Calc. Gives 0.5244005...). Must be used in an equation for μ. A1 awrt 99.7. Answer only is 0/3 NB M1 + answer only of awrt 99.7 scores M1B0A1 but allow B1 for $99.7376 \le \mu \le 99.7379$
(b)	B1 writing B(12, 0.3) M1 writing $\text{P}(X \le 2)$ May be implied by sight of 0.252 or 0.253. NB $\text{P}(X < 3)$ alone is M0 unless they show that $\text{P}(X < 3) = \text{P}(X = 0) + \text{P}(X = 1) + \text{P}(X = 2)$ A1 awrt 0.253. Answer only scores 3/3
(c)	1st M1 attempting to use a Normal approx. State $\text{N}(\mu, \sigma^2)$ with μ or σ correct 1st A1 correct mean and var/sd 2nd M1 continuity correction used: either 127.5 or 126.5 seen 3rd M1 standardising with their μ and σ and finding correct area. Must lead to $\text{P}(Z > +\text{ve})$ (o.e.) 2nd A1 $\dfrac{127.5-120}{\sqrt{84}}$ or awrt 0.82 3rd A1 for awrt 0.206 or 0.207

Question Number	Scheme	Marks
5. (a)(i)	$H_0 : p = 0.35 \quad H_1 : p \neq 0.35$	**B1**
(ii)	B(15,0.35)	**M1**
	CR $X \leq 1 \cup X \geq 10$ (Allow any letter)	**A1A1**
		(4)
(b)	8 is not in CR	**M1**
	There is evidence that the Company's claim is true	**A1ft**
		(2)
(c)	0.0142 + 0.0124 = 0.0266	**B1**
		(1)
		[7]

	Notes
(a) (i)	B1 both hypotheses correct. Must mention p (or π). Words only is B0
(ii)	M1 Writing B(15,0.35) May be implied by e.g. P($X \leq 1$) =0.0142 or P($X \leq 9$) = 0.9876
	1st A1 $X \leq 1$ (accept $X < 2$) Allow $0 \leq X \leq 1$ but P($X \leq 1$) is A0
	2nd A1 $X \geq 10$ (accept $X > 9$) Allow $10 \leq X \leq 15$ but P($X \geq 10$) is A0
	Either correct answer will imply M1
(b)	M1 for a reason that matches their CR. "Interpret" their CR of P($X \geq 10$) as $X \geq 10$ etc
	Allow calculation of P($X \geq 8$) = 1 – 0.8868 = 0.1132 and "not sig" comment
	Do not allow contradictory remarks e.g. 8 is not in CR so significant (this gets M0)
	A1ft for a conclusion correct for their CR in context
	Must mention "claim" or "peas" and "germinating"
	NB A correct contextual claim on its own scores M1A1
(c)	B1 for 0.0266 or awrt 0.0266 (calc gives 0.02662196...)

Question Number	Scheme	Marks
6. (a)	F(1.23) = awrt 0.495	**M1**
	F(1.24) = awrt 0.501	**A1**
	0.5 lies between therefore median value lies between 1.23 and 1.24	**A1**
		(3)
(b)	$[\mathrm{f}(x)=]\begin{cases}\frac{9x}{10}-\frac{3x^2}{10} & 0\le x\le 2\\ 0 & \text{otherwise}\end{cases}$	**M1A1** **B1**
		(3)
(c)	$\frac{18}{20}-\frac{12x}{20}=0$ <u>or</u> completeing square so: $\frac{3}{10}\left[\frac{9}{4}-\left(x-\frac{3}{2}\right)^2\right]$	**M1**
	$x = 1.5$	**A1**
		(2)
(d)	Median < mode, negative skew	**M1,A1**
		(2)
		[10]

	Notes
(a)	M1 attempt at both F(1.23) and F(1.24) and at least one correct <u>or</u> $\frac{x^2}{20}(9-2x)=0.5$ 1st A1 both awrt 0.495 and awrt 0.501 <u>or</u> 1.238 2nd A1 correct comment about the value of the <u>median</u> (not just $0.495 < \mathrm{F}(m) < 0.501$)
(b)	M1 attempting to differentiate. Multiply out and at least one term $x^n \to x^{n-1}$ A1 correct differentiation. Allow $\frac{18x}{20}-\frac{6x^2}{20}$ or $\frac{3}{10}x(3-x)$ or any exact equivalent. B1 correct pdf, including 0 otherwise and $0 \le x \le 2$
(c)	M1 for an attempt to differentiate pdf and put = 0 or complete the square or a sketch Sketch should have the correct shape and show some positive values on x – axis. An attempt at completing the square should get to $p \pm q(x-1.5)^2$ Answer only scores M1A1
(d)	M1 reason must match their values/ sketch (NB mean = 1.2) . Their values must be in [0, 2] No mode or median will score M0 unless their reason is based on their sketch A1 no ft correct answer only e.g. If their mode = 1 and they say “mode < median” score M1 for a correct reason but A0 even if they say “positive skew” since there is no ft and “negative skew” would follow incorrect working.

Question Number	Scheme	Marks
7. (a)	F represents number of flaws per 50 m $\Rightarrow F \sim \text{Po}(2)$	
	$\text{P}(F=5)=0.9834-0.9473$ or $\frac{\text{e}^{-2}2^5}{5!}$	**M1**
	$=0.0361$	**A1 (2)**
(b)	G represents number of flaws per 200 m $\Rightarrow G \sim \text{Po}(8)$	**B1**
	$\text{P}(G<7)=\text{P}(G\le 6)=0.3134$	**B1**
	[R = number of 200 m rolls containing fewer than 7 flaws.] $R \sim \text{B}(4, 0.3134)$	**M1A1ft**
	$\text{P}(R=1)=C_1^4\times 0.3134\times(1-0.3134)^3=0.40576...$ awrt 0.406	**M1 A1 (6)**
(c)	N represents number of flaws in a x m roll $\Rightarrow N \sim \text{Po}(\lambda)$	
	$\text{P}(N<26)=\text{P}(\frac{25.5-\lambda}{\sqrt{\lambda}})$ ± 0.5, standardise	**M1, M1 A1**
	$\frac{25.5-\lambda}{\sqrt{\lambda}}=0.1$ gives $\lambda+0.1\sqrt{\lambda}-25.5=0$	**B1**
	$\sqrt{\lambda}=\frac{-0.1\pm\sqrt{0.1^2+4\times 25.5}}{2}$	**dM1**
	$\left[\sqrt{\lambda}=5\right]$ so $\lambda=25$	**A1**
	$x=\frac{25}{2}\times 50$, so $x=625$ m	**dM1** **A1 (8)**
		[16]
	Notes	
(a)	M1 Writing $\text{P}(X\le 5)-\text{P}(X\le 4)$ or $\frac{\text{e}^{-\lambda}\lambda^5}{5!}$ (any value of λ) A1 awrt 0.0361	
(b)	1st B1 Writing or using Po(8) 2nd B1 awrt 0.313 (calc gives 0.3133742...) 1st M1 Recognize Binomial 1st A1ft writing B(4, 'their 0.313') May be $\Rightarrow$ by next line 2nd dM1 (dep. on 1st M1) $C_1^4\times\text{'their }0.3134\text{'}\times(1-\text{'their }0.3134\text{'})^3$ 2nd A1 awrt 0.406	
(c)	1st M1 continuity correction used. Either 25.5 or 26.5 2nd M1 standardising using their λ and $\sqrt{\lambda}$ for mean and sd. Any letter may be used or $\frac{x}{25}$ etc 1st A1 $\frac{25.5-\lambda}{\sqrt{\lambda}}=z$ where $0<z<0.5$ May be implied by their correct quadratic (25.5 req'd) B1 0.1 (calc 0.09992..) used as their z value in an equation. Allow e.g. $\frac{26-\mu}{\sigma}=0.1$ 3rd dM1 (dep on 2nd M1) some attempt at solving their 3TQ $\frac{-b\pm\sqrt{+ve}}{2a}$ 2nd A1 25 (o.e.) 4th dM1 (dep on 3rd M1) $\frac{\text{their }25}{2}\times 50$ (If using $\frac{x}{25}$ award when $x=$..) 3rd A1 awrt 625	

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Mark Scheme (Results)

January 2015

Pearson Edexcel International A Level in Statistics 2
(WST02/01)

January 2015
Publications Code IA040682

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate’s response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for ‘knowing a method and attempting to apply it’, unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\sqrt{}$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- **∗** The answer is printed on the paper
- ⎣ The second mark is dependent on gaining the first mark

4. All A marks are ‘correct answer only’ (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. Ignore wrong working or incorrect statements following a correct answer.

January 2015
WST02 Statistics S2
Mark Scheme

Question Number	Scheme	Marks
1(a)	$X \sim \text{Po}(3.2)$	B1
	$\text{P}(X = 3) = \frac{\text{e}^{-3.2}3.2^3}{3!}$	M1
	$= 0.2226$ awrt 0.223	A1 (3)
(b)	$Y \sim \text{Po}(1.6)$	B1
	$\text{P}(Y \geq 1) = 1 - \text{P}(Y = 0)$	M1
	$= 1 - \text{e}^{-1.6}$	
	$= 0.7981$ awrt 0.798	A1 (3)
(c)	$X \sim \text{Po}(0.8)$	
	$\frac{\text{P}(X = 1) \times \text{P}(X = 3)}{\text{P}(Y = 4)} = \frac{\left(\text{e}^{-0.8} \times 0.8\right) \times \left(\frac{\text{e}^{-0.8}0.8^3}{3!}\right)}{\frac{\text{e}^{-1.6}1.6^4}{4!}}$	M1 M1 M1 A1
	$= \frac{0.3594 \times 0.0383}{0.05513}$	
	$= 0.25$	A1 (5)
(d)	$A \sim \text{Po}(72)$ approximated by $\text{N}(72,72)$	B1
	$\frac{5000}{60} = 83.33$	M1
	$\text{P}(A \geq 84) = \text{P}\left(Z \geq \frac{83.5 - 72}{\sqrt{72}}\right)$	M1 M1
	$= \text{P}(Z \geq 1.355\ldots)$	
	$= 0.0869$ awrt 0.087/0.088	A1 (5)
	Notes	
(a)	B1 for writing or using Po(3.2) M1 $\frac{\text{e}^{-\lambda}\lambda^3}{3!}$	
(b)	B1 for writing or using Po(1.6) M1 $1 - \text{P}(Y = 0)$ or $1 - \text{e}^{-\lambda}$	
(c)	1st M1 using Po(0.8) with X=1 or X=3 (may be implied by 0.359... or 0.0383...) 2nd M1 $\left(\text{e}^{-\lambda} \times \lambda\right) \times \left(\frac{\text{e}^{-\lambda}\lambda^3}{3!}\right)$ (consistent lambda) awrt 0.0138 implies 1st 2 M marks 3rd M1 correct use of conditional probability with denominator $= \frac{\text{e}^{-1.6}1.6^4}{4!}$ 1st A1 fully correct expression 2nd A1 0.25 (allow awrt 0.250)	
(d)	B1 Writing or using N(72,72) 1st M1 for exact fraction **or** awrt 83.3 (may be implied by 84) (Note: Use of N(4320,4320) can score B1 and 1st M1) 2nd M1 Using 84 +/– 0.5 3rd M1 standardising using 82.5, 83, $83.\dot{3}$ (awrt 83.3), 83.5, 83.8, 84 or 84.5, 'their mean' **and** 'their sd'	

Question Number	Scheme	Marks
2(a)	P(X > 4) = 1 – F(4) $= 1-\frac{3}{5}$ $= \frac{2}{5}$ oe	M1 A1 (2)
(b)	1	B1 (1)
(c)	$\mathrm{f}(x)=\frac{\mathrm{dF}(x)}{\mathrm{d}x}=\frac{1}{5}$ $\mathrm{f}(x)=\begin{cases}\frac{1}{5} & 1\le x\le 6\\ 0 & \text{otherwise}\end{cases}$	M1 A1 (2)
(d)	E(X) = 3.5	B1 (1)
(e)	Variance = $\frac{(6-1)^2}{12}$ or $\int_1^6 \frac{1}{5}x^2\ \mathrm{d}x-(3.5)^2$ $=\frac{25}{12}$ awrt 2.08	M1 A1 (2)
(f)	$\mathrm{E}(X^2)=\mathrm{Var}(X)+[\mathrm{E}(X)]^2$ $=\frac{25}{12}+3.5^2$ or $\int_1^6 \frac{1}{5}x^2\ \mathrm{d}x$ or $\int_1^6 \frac{1}{5}(3x^2+1)\ \mathrm{d}x$ $=\frac{43}{3}$ $\mathrm{E}(3X^2+1)=3\,\mathrm{E}(X^2)+1$ $=\left[\frac{3x^3}{15}+\frac{x}{5}\right]_1^6$ = 44 = 44	M1 dM1 A1cao (3)
	Notes	
(a)	M1 writing or using 1 – F(4) oe	
(c)	M1 for differentiating to get 1/5 A1 both lines correct with ranges	
(e)	M1 $\frac{(6-1)^2}{12}$ or $\int_1^6 \frac{1}{5}x^2\ \mathrm{d}x$ – 'their 3.5'^{2}	
(f)	1st M1 "their Var(X)" + ["their E(X)"]^2 (which must follow from the 1st method in (e)) **or** $\int_1^6 \frac{1}{5}x^2\ \mathrm{d}x$ **and** integrating $x^n \to \frac{x^{n+1}}{n+1}$ (may be seen in (e)) **or** writing $\int_1^6 \frac{1}{5}(3x^2+1)\ \mathrm{d}x$ (May be implied by $\frac{43}{3}$ seen) 2nd M1 (dependent on previous M1) **using** 3 × 'their E(X^2)' + 1 **or** $\int_1^6 \frac{1}{5}(3x^2+1)\ \mathrm{d}x$ and integrating $x^n \to \frac{x^{n+1}}{n+1}$	

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>3(a)</td><td>(A random variable) that is a function of a (random) sample involving no unknown quantities/parameters
or
A quantity calculated solely from a random sample</td><td>B1
(1)</td></tr>
<tr><td>(b)</td><td>If all possible samples are chosen from a population;
then the values of a statistic and the associated probabilities is a sampling distribution
or a probability distribution of a statistic</td><td>B1
(1)</td></tr>
<tr><td>(c)</td><td>$\text{Mean} = 100\times\frac{4}{7}+200\times\frac{3}{7}$
$=\frac{1000}{7}$ awrt 143
$\text{Variance} = 100^2\times\frac{4}{7}+200^2\times\frac{3}{7}-\left(\frac{1000}{7}\right)^2$
$=\frac{120000}{49}$ awrt 2450 (to 3sf)</td><td>B1
M1
A1
(3)</td></tr>
<tr><td>(d)</td><td>(100,100,100)
(100,100,200) (100,200,100) (200,100,100) or 3 x (100,100,200)
(100,200,200) (200,100,200) (200,200,100) or 3 x (100,200,200)
(200,200,200)</td><td>B2
(2)</td></tr>
<tr><td>(e)</td><td>(100,100,100) $\left(\frac{4}{7}\right)^3=\frac{64}{343}$ awrt 0.187
(200,200,200) $\left(\frac{3}{7}\right)^3=\frac{27}{343}$ awrt 0.0787
(100,100,200) $3\times\left(\frac{4}{7}\right)^2\times\left(\frac{3}{7}\right)=\frac{144}{343}$ awrt 0.420 (allow 0.42)
(100,200,200) $3\times\left(\frac{4}{7}\right)\times\left(\frac{3}{7}\right)^2=\frac{108}{343}$ awrt 0.315
<table>
<tr><td><i>m</i></td><td>100</td><td>$400/3$
awrt 133</td><td>$500/3$
awrt 167</td><td>200</td></tr>
<tr><td>P(<i>M</i> = <i>m</i>)</td><td>$\frac{64}{343}$ or
awrt 0.187</td><td>$\frac{144}{343}$ or
awrt 0.420
(allow 0.42)</td><td>$\frac{108}{343}$ or
awrt 0.315</td><td>$\frac{27}{343}$ or
awrt 0.0787</td></tr>
</table>
</td><td>B1 both
M1
A1
A1
(4)</td></tr>
</table>

Question Number	Scheme	Marks
	Notes	
(a)	B1 for a definition which includes each of the following 3 aspects A **function**[1] of a (random) **sample**[2] involving **no unknown quantities/parameters**[3] 1. function/quantity/calculation/value/random variable 2. sample/observations/data 3. no unknown parameters/no unknown values/solely (from a sample)	
(b)	B1 requires all underlined words: <u>All</u> <u>values</u> of a <u>statistic</u> with their associated <u>probabilities</u> **or** <u>probability distribution</u> of a <u>statistic</u>	
(c)	M1 $100^2\times\frac{4}{7}+200^2\times\frac{3}{7}-\left(\text{their mean}\right)^2$	
(d)	B1 any 2 of (100,100,100), (100,100,200) any order, (100,200,200) any order, (200,200,200) B1 all correct, allow 3 × (100,100,200) and 3 × (100,200,200) and (100,100,100) and (200,200,200) Note: Allow other notation for 100 and 200 e.g. Small and Large	
(e)	B1 Both probabilities for (100,100,100) and (200,200,200) correct M1 $3\times p^2\times(1-p)$ A1 either correct A1 all means correct **and** all probabilities correct (table not required but means must be associated with correct probabilities)	

Question Number	Scheme	Marks
4(a)	$X \sim \text{Po}(6)$ $\text{P}(5 \le X < 7) = \text{P}(X \le 6) - \text{P}(X \le 4)$ or $\dfrac{e^{-6}6^5}{5!} + \dfrac{e^{-6}6^6}{6!}$ $= 0.6063 - 0.2851$ $= 0.3212$ awrt 0.321	M1 M1 A1 (3)
(b)	$\text{H}_0: \lambda = 9 \qquad \text{H}_1: \lambda < 9$ $X \sim \text{Po}(9)$ therefore $\text{P}(X \le 4) = 0.05496...$ or CR $X \le 3$ Insufficient evidence to reject H_0 **or** Not Significant **or** 4 does not lie in the critical region. There is no evidence that the mean number of accidents at the crossroads has reduced/decreased.	B1 B1 dM1 A1cso (4)
(a) (b)	**Notes** M1 writing or using Po(6) M1 either $\text{P}(X \le 6) - \text{P}(X \le 4)$ or $\dfrac{e^{-\lambda}\lambda^5}{5!} + \dfrac{e^{-\lambda}\lambda^6}{6!}$ 1st B1 both hypotheses correct (λ or μ) allow 0.5 instead of 9 2nd B1 either awrt 0.055 **or** critical region $X \le 3$ dM1 for a correct comment (dependent on previous B1) Contradictory non-contextual statements such as "not significant" so "reject H_0" score M0 (May be implied by a correct contextual statement) A1 cso requires correct contextual conclusion with underlined words and all previous marks in (b) to be scored.	

Question Number	Scheme	Marks
5(a)	$\int_{-1}^{2} k(x^2+a)\mathrm{d}x + \int_{2}^{3} 3k\ \mathrm{d}x = 1$	M1
	$\left[k\left(\frac{x^3}{3}+ax\right)\right]_{-1}^{2} + \left[3kx\right]_2^3 = 1$	dM1
	$k\left(\frac{8}{3}+2a+\frac{1}{3}+a\right)+9k-6k=1$	A1
	$6k+3ak=1$	
	$\int_{-1}^{2} k(x^3+ax)\mathrm{d}x + \int_{2}^{3} 3kx\ \mathrm{d}x \left[=\frac{17}{12}\right]$	M1
	$\left[k\left(\frac{x^4}{4}+\frac{ax^2}{2}\right)\right]_{-1}^{2} + \left[\frac{3kx^2}{2}\right]_2^3 = \frac{17}{12}$	dM1
	$k\left(4+2a-\frac{1}{4}-\frac{a}{2}\right)+\frac{27k}{2}-6k=\frac{17}{12}$	A1
	$\frac{45k}{4}+\frac{3ak}{2}=\frac{17}{12}$ $135k+18ak=17$	
	$99k = 11$	ddM1
	$a=1, k=\frac{1}{9}$	A1 (8)
(b)	2	B1 (1)
(a)	Notes 1st M1 writing or using $\int_{-1}^{2} k(x^2+a)\mathrm{d}x + \int_{2}^{3} 3k\ \mathrm{d}x = 1$ ignore limits 2nd dM1 attempting to integrate at least one $x^n \to \frac{x^{n+1}}{n+1}$ **and** sight of correct limits (dependent on previous M1) 1st A1 a correct equation – need not be simplified 3rd M1 $\int_{-1}^{2} k(x^3+ax)\mathrm{d}x + \int_{2}^{3} 3kx\ \mathrm{d}x$ ignore limits 4th dM1 setting $=\frac{17}{12}$ **and** attempting to integrate at least one $x^n \to \frac{x^{n+1}}{n+1}$ **and** sight of correct limits (dependent on previous M1) 2nd A1 a correct equation – need not be simplified 5th ddM1 attempting to solve two simultaneous equations in *a* and *k* by eliminating 1 variable (dependent on 1st and 3rd M1s) 3rd A1 both *a* and *k* correct	

Question Number	Scheme	Marks
6. (a)	$P(X=5) = {}^{20}C_5(0.3)^5(0.7)^{15}$ or 0.4164 – 0.2375 $= 0.17886\ldots$ awrt 0.179	M1 A1 (2)
(b)	Mean = 6 sd = $\sqrt{20\times0.7\times0.3}$ $= 2.049\ldots$ awrt 2.05	B1 M1 A1 (3)
(c)	$H_0: p = 0.3$ $H_1: p > 0.3$ $X \sim B(20,0.3)$ $P(X \geq 8) = 0.2277$ or $P(X \geq 10) = 0.0480$, so CR $X \geq 10$ Insufficient evidence to reject H_0 **or** Not Significant **or** 8 does not lie in the critical region. There is no evidence to support the Director (of Studies') belief/There is no evidence that the proportion of parents that do not support the new curriculum is greater than 30%	B1 M1 A1 dM1 A1cso (5)
(d)	$X \sim B(2n, 0.25)$ $X \sim B(8, 0.25)$ $P(X \geq 4) = 0.1138$ $X \sim B(10, 0.25)$ $P(X \geq 5) = 0.0781$ $2n = 10$ $n = 5$	M1 A1 A1 (3)
	Notes	
(a)	M1 ${}^{20}C_5(p)^5(1-p)^{15}$ or using $P(X \leq 5) - P(X \leq 4)$	
(b)	M1 use of $20\times0.7\times0.3$ (with or without the square root)	
(c)	B1 both hypotheses correct (p or π) M1 using $X \sim B(20,0.3)$ (may be implied by 0.7723, 0.2277, 0.8867 or 0.1133) A1 awrt 0.228 **or** CR $X \geq 10$ dM1 a correct comment (dependent on previous M1) A1 cso requires correct contextual conclusion with underlined words and all previous marks in (c) to be scored.	
(d)	M1 for 0.1138 or 0.0781 or 0.8862 or 0.9219 seen 1st A1 B(10, 0.25) selected (may be implied by $n = 10$ or $2n = 10$ or $n = 5$) An answer of 5 with no incorrect working seen scores 3 out of 3 Special Case: Use of a normal approximation, M1 for $\frac{(n-0.5)-\frac{n}{2}}{\sqrt{\frac{3}{8}n}} = z$ with $1.28 \leq z \leq 1.29$, 1st A1 for n=4.2/4.3, 2nd A1 for n=5	

Question Number	Scheme	Marks
7.	$Y \sim \mathrm{N}\left(\frac{n}{5}, \frac{4n}{25}\right)$	B1
	$\mathrm{P}(Y \geq 30) = \mathrm{P}\left(Z > \frac{29.5 - n/5}{\frac{2}{5}\sqrt{n}}\right)$	M1 M1A1
	$\frac{29.5 - n/5}{\frac{2}{5}\sqrt{n}} = 2$	B1
	$n + 4\sqrt{n} - 147.5 = 0$ or $0.04n^2 - 12.44n + 870.25 = 0$	dM1
	$\sqrt{n} = 10.3...$ $n = 106.26\ldots$ or $n = 204.73\ldots$	A1
	$n = 106$	A1 cao (8)
	Notes 1st B1 writing or using $\mathrm{N}\left(\frac{n}{5}, \frac{4n}{25}\right)$ 1st M1 writing or using 30 +/– 0.5 2nd M1 standardising using 29, 29.5, 30 or 30.5 and their mean and their sd 1st A1 fully correct standardisation (allow +/-) 2nd B1 for z = +/– 2 or awrt 2.00 must be compatible with their standardisation 3rd dM1 (dependent on 2nd M1) getting quadratic equation **and** solving leading to a value of $\sqrt{n}$ or n 2nd A1 awrt 10.3 **or** awrt (106 **or** 107 **or** 204 **or** 205) 3rd A1 for 106 only (must reject other solutions if stated) Note: $\frac{29.5 - n/5}{\frac{2}{5}\sqrt{n}} = -2$ leading to an answer of 106 may score B1M1M1A1B0M1A1A1	

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Mark Scheme (Results)

June 2015

Pearson Edexcel International A Level
in Statistics 2 (WST02/01)

Edexcel and BTEC Qualifications

Pearson: helping people progress, everywhere

Summer 2015
Publications Code IA042723

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

PEARSON EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

   These are some of the traditional marking abbreviations that will appear in the mark schemes.

   - bod – benefit of doubt
   - ft – follow through
   - the symbol √ will be used for correct ft
   - cao – correct answer only
   - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which round to
   - SC: special case
   - oe – or equivalent (and appropriate)
   - d… or dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - ∗ The answer is printed on the paper or ag- answer given
   - └ or d… The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

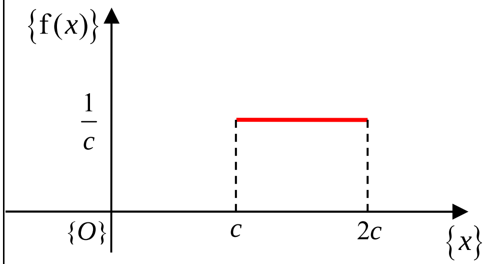
June 2015 WMST02/01
Statistics 2 Mark Scheme

Question Number	Scheme		Marks
1. (a)	$\{\mathrm{P}(X>4)=\}\ 1-\mathrm{F}(4)$	$1-\mathrm{F}(4)$ seen or used	M1
	$\left\{=1-\frac{3}{5}\right\}=\frac{2}{5}$	$\frac{2}{5}$ or 0.4	A1
			[2]
(b)	$\mathrm{P}(3<X<a)=0.642$		
	$\mathrm{F}(a)-\mathrm{F}(3)=0.642$	$\mathrm{F}(a)-\mathrm{F}(3)=0.642$	M1 o.e.
	$\mathrm{F}(a)-\frac{1}{20}(3^2-4)=0.642\ \{\Rightarrow \mathrm{F}(a)=0.892\}$	Correct equation	A1 o.e.
	$\frac{1}{5}(2a-5)-\text{"}\frac{1}{20}(3^2-4)\text{"}=0.642\Rightarrow a=\ldots$	Solving this equation o.e., leading to $a=\ldots$ (or $x=\ldots$). Follow through their F(3)	dM1
	$\left\{\frac{1}{5}(2a-5)=0.892\Rightarrow\right\}\ a=4.73$	$a=4.73$ (or $x=4.73$)	A1 **cao**
			[4]
(b)	**Alternative Method for Part (b)**		
	$\int_3^4\left(\frac{1}{10}x\right)\{\mathrm{d}x\}$	Correct expression for finding the probability between $x=3$ and $x=4$	M1
	$\left\{=\left[\frac{x^2}{20}\right]_3^4\right\}=\frac{4^2}{20}-\frac{3^2}{20}\ \left\{=\frac{7}{20}\right\}$	Correct $\frac{4^2}{20}-\frac{3^2}{20}$, simplified or un-simplified.	A1
	$\int_3^4\left(\frac{1}{10}x\right)\{\mathrm{d}x\}+\int_4^a\left(\frac{2}{5}\right)\{\mathrm{d}x\}=0.642\Rightarrow a=\ldots$	Writes a correct equation and attempts to solve leading to $a=\ldots$ (or $x=\ldots$)	dM1
	$\left\{\frac{7}{20}+\frac{2}{5}a-\frac{8}{5}=0.642\Rightarrow\right\}\ a=4.73$	$a=4.73$ (or $x=4.73$)	A1 **cao**
			[4]
(c)	$\mathrm{f}(x)=\frac{\mathrm{d}}{\mathrm{d}x}\left(\frac{1}{20}(x^2-4)\right)=\frac{1}{10}x$ $\mathrm{f}(x)=\frac{\mathrm{d}}{\mathrm{d}x}\left(\frac{1}{5}(2x-5)\right)=\frac{2}{5}$	Attempt at differentiation. **See notes.**	M1
		At least one of $\frac{1}{10}x$ or $\frac{2}{5}$	A1
		Both $\frac{1}{10}x$ and $\frac{2}{5}$	A1
	$\mathrm{f}(x)=\begin{cases}\frac{1}{10}x, & 2\leqslant x\leqslant 4\\ \frac{2}{5}, & 4<x\leqslant 5\\ 0, & \text{otherwise}\end{cases}$	**This mark is dependent on M1** All three lines with limits correctly followed through from their $\mathrm{F}'(x)$	dB1ft
			[4]
			10

	Question 1 Notes	
1. (a)	**M1**	$1-\text{F}(4)$ seen or used.
	Note	Can be implied by either $1-\frac{3}{5}$ or $1-\frac{1}{5}\left(2(4)-5\right)$ or $1-\frac{1}{20}\left(4^2-4\right)$ The probability statements $1-\text{P}(X \leqslant 4)$ or $1-\text{P}(X < 4)$ are not sufficient for M1
	A1	$\frac{2}{5}$ or 0.4
	Note	Give M1A1 for the correct answer from no working.
(b)	**NOTE**	In part (b), candidates are allowed to write • $\text{F}(a)$ as either $\text{P}(X < a)$ or $\text{P}(X \leqslant a)$. Also condone $\text{F}(a)$ written as $\text{F}(x)$ • $\text{F}(3)$ as either $\text{P}(X < 3)$ or $\text{P}(X \leqslant 3)$
	M1	For writing $\text{F}(a)-\text{F}(3)=0.642$ or equivalent (see NOTE above)
	A1	For an un-simplified $\text{F}(a)-\frac{1}{20}(3^2-4)=0.642$ or equivalent (see NOTE above)
	Note	Give 1st M1 1st A1 for $\text{F}(a)=0.892$ or $\text{P}(X \geqslant a)=0.108$
	SC	Allow SC 1st M1 1st A1 for $\frac{1}{20}(a^2-4)-\frac{1}{20}(3^2-4)=0.642$
	Note	Give 1st M0 for $\text{F}(a-1)-\text{F}(3)=0.642$ o.e. without a correct acceptable statement
	dM1	**dependent on the FIRST method mark being awarded.** Attempts to solve $\frac{1}{5}(2a-5)-\text{"their F(3)"}=0.642$ leading to $a=...$(or $x=...$)
	Note	dM1 can be given for either $\frac{1}{5}(2a-5)=0.892$ or $1-\frac{1}{5}(2a-5)=0.108$ leading to $a=...$(or $x=...$)
	A1	$a=4.73$ (or $x=4.73$) **cao**
	Note	Give M0A0M0A0 for $\text{F}(a)-(1-\text{F}(3))=0.642$ $\left\{\Rightarrow \text{F}(a)=1.392\right\}$
	Note	Give M0A0M0A0 for $\int_3^a \left(\frac{1}{10}x\right)\text{d}x=0.642$ (this solves to give awrt 4.67)
(c)	**M1**	At least one of either $\frac{1}{20}(x^2-4) \rightarrow \pm\alpha x \pm \beta,\ \alpha \neq 0,\ \beta$ can be 0 $\frac{1}{5}(2x-5) \rightarrow \pm\delta,\ \delta \neq 0$
	1st A1	At least one of $\frac{1}{10}x$ or $\frac{2}{5}$. Can be simplified or un-simplified.
	2nd A1	Both $\frac{1}{10}x$ and $\frac{2}{5}$. Can be simplified or un-simplified.
	dB1ft	**dependent on the FIRST method mark being awarded.** All three lines with limits correctly followed through from their $\text{F}'(x)$
	Note	Condone the use of $<$ rather than $\leqslant$ or vice versa.
	Note	0, otherwise is equivalent to 0, $x < 2$ **and** 0, $x > 5$
	Note	In part (c), accept f being expressed consistently in another variable eg. u

Question Number	Scheme		Marks
2. (a)	$X \sim \text{Po}(8)$		
	$\{\text{P}(X \neq 8)\} = 1 - \text{P}(X = 8)$	$1 - \text{P}(X = 8)$, can be implied	M1
	$= 0.860413...$ or 0.8605	0.86 or awrt 0.860 or awrt 0.861	A1
			[2]
(b)	$X \sim \text{Po}(8)$		
	$\{\text{P}(X \geqslant 8)\} = 1 - 0.453$	$1 - 0.453$ or awrt 0.547	B1
	$\left\{\left[\text{P}(X \geqslant 8)\right]^4\right\} = (1 - 0.453)^4 \left\{= (0.547)^4\right\}$	Applying $\left[\text{their P}(X \geqslant 8)\right]^4$	M1
	$= 0.089526...$	0.09 or awrt 0.090	A1
			[3]
(c)	Y = number of chocolate chips in the 9 biscuits		
	$\{Y \sim \text{Po}(72) \approx\} Y \sim \text{N}(72, 72)$	Normal or N	M1
		$(72, 72)$	A1
	$\{\text{P}(Y > 75)\} \approx \text{P}(Y > 75.5)$	For either 74.5 or 75.5	M1
	$= \text{P}\left(Z > \dfrac{75.5 - 72}{\sqrt{72}}\right)$	Standardising $(\pm)$ with their mean, their standard deviation and either 75.5 or 75 or 74.5	M1
	$= \text{P}(Z > 0.41...) = 1 - 0.6591$		
	$= 0.3409$ (from calculator 0.339994…)	awrt 0.341 or awrt 0.340	A1
			[5]
(d)	$\text{H}_0 : \lambda = 1.5$, $\text{H}_1 : \lambda > 1.5$ or $\text{H}_0 : \lambda = 6$, $\text{H}_1 : \lambda > 6$	Both hypotheses are stated correctly	B1
	{Under H_0, for 4 hours} $X \sim \text{Po}(6)$		
	Probability Method $\text{P}(X \geqslant 11) = 1 - \text{P}(X \leqslant 10)$ $= 1 - 0.9574$	**Critical Region Method** $\text{P}(X \leqslant 9) = 0.9161$ or $\text{P}(X \geqslant 10) = 0.0839$ $\text{P}(X \leqslant 10) = 0.9574$ or $\text{P}(X \geqslant 11) = 0.0426$	M1
	Note: Award 1st M1 for the use of $X \sim \text{Po}(6)$		
	$\text{P}(X \geqslant 11) = 0.0426$ $\text{CR} : X \geqslant 11$	Either $\text{P}(X \geqslant 11) = 0.0426$ or $\text{CR} : X \geqslant 11$ or $\text{CR} : X > 10$	A1
	Reject H_0 or significant or 11 lies in the CR	**dependent on previous M** See notes	dM1
	Conclude either • The **rate of sales** of packets of biscuits has **increased**. • The **mean** number of packets of biscuits **sold** has **increased**.	Correct conclusion in context.	A1 **cso**
			[5]
			15

	Question 2 Notes	
2. (a)	**M1**	$1-\mathrm{P}(X=8)$ or $\mathrm{P}(X<8)+\mathrm{P}(X>8)$ or $\mathrm{P}(X\le 7)+\mathrm{P}(X\geqslant 9)$
	Note	Can be implied by either $1-\frac{\mathrm{e}^{-8}8^8}{8!}$ or $1-\left(\mathrm{P}(X\le 8)-\mathrm{P}(X\le 7)\right)$ or $1-\left(0.5925-0.4530\right)$ or $1-0.1395$ or $\mathrm{P}(X\le 7)+1-\mathrm{P}(X\leqslant 8)$
	A1	0.86 or awrt 0.860 or awrt 0.861
(b)	**B1**	$1-0.453$ or awrt 0.547 (**Note:** calculator gives 0.5470391905…)
	M1	Applying $\left[\text{their } \mathrm{P}(X\geqslant 8)\right]^4$
	A1	0.09 or awrt 0.090 (**Note:** calculator gives 0.08955168526…)
(c)	**1st M1** **1st A1** **Note**	For writing N or for using a normal approximation. For a correct mean of 72 and a correct variance of 72 1st M1 and/or 1st A1 may be implied in applying the standardisation formula
	2nd M1 **3rd M1** **Note** **Note**	For either 74.5 or 75.5 (i.e. an attempt at a continuity correction) Standardising $(\pm)$ with their mean, their standard deviation and either 75.5 or 75 or 74.5 Award 2nd M1 3rd M0 for $\frac{75.5-72}{72}$ from a correct $Y\sim \mathrm{N}(72, 72)$ You can recover the 1st A1 in part (c) for $\mathrm{N}\left(72,\sqrt{72}\right)\Rightarrow z=\frac{75.5-72}{\sqrt{72}}$
	2nd A1	awrt 0.341 or awrt 0.340. (**Note:** calculator gives 0.339994…)
(d)	**B1** **Note**	$\mathrm{H}_0:\lambda=1.5,\ \ \mathrm{H}_1:\lambda>1.5$ correctly labelled or $\mathrm{H}_0:\lambda=6,\ \ \mathrm{H}_1:\lambda>6.$ Allow μ used instead of λ
	Note	B0 for either $\mathrm{H}_0=6,\ \ \mathrm{H}_1>6$ or $\mathrm{H}_0:x=6,\ \ \mathrm{H}_1:x>6$ or $\mathrm{H}_0:p=6,\ \ \mathrm{H}_1:p>6$
	1st M1	For use of $X\sim\mathrm{Po}(6)$ (may be implied by 0.9161, 0.9574, 0.9799, 0.0839, 0.0426 or 0.0201). Condone by $\frac{\mathrm{e}^{-6}(6)^{11}}{11!}$. Allow any value off the $\mathrm{Po}(6)$ tables.
	1st A1 **Note** **Note**	For either $\mathrm{P}(X\geqslant 11)=0.0426$ or $\mathrm{CR}:X\geqslant 11$ or $\mathrm{CR}:X>10$ Condone $\mathrm{CR}\geqslant 11$ Award 1st M1 1st A1 for writing down $\mathrm{CR}:X\geqslant 11$ or $\mathrm{CR}:X>10$ from no working. Give A0 stating $\mathrm{CR}:\mathrm{P}(X\geqslant 11)$
	2nd dM1 **Note** **Note** **Note**	**dependent on the FIRST method mark being awarded.** For a correct follow through comparison based on their probability or CR and their significance level compatible with their ***stated*** alternative hypothesis. Do not allow non-contextual conflicting statements. Eg. "significant" and "accept H_0". M1 can be implied by a correct contextual statement. Give final M0A0 for $\mathrm{P}(X=11)=0.9799-0.9574=0.0225\Rightarrow$ Reject H_0, etc. Give final M0A0 for $\mathrm{P}(X\leqslant 11)=0.9799\Rightarrow$ Accept H_0, etc
	2nd A1	Award for a correct solution only with all previous marks in part (d) being scored. Correct conclusion which is in context, using either the words <u>rate of sales</u> and <u>increased</u> **or** <u>mean sold</u> and <u>increased</u>

Question Number	Scheme	Marks
3. (a)	 A horizontal line drawn above the x-axis in the first quadrant	B1
	dependent on the first B mark Labels of c, $2c$ and $\frac{1}{c}$, marked on the graph. Ignore $\{O\}$, $\{x\}$ and $\{f(x)\}$	dB1
		[2]
(b)	$E(X)=\frac{3c}{2}$ $E(X)=\frac{3c}{2}$, simplified or un-simplified.	B1
	$\left\{E(X^2)=\right\}\int_c^{2c}\left(\frac{1}{2c-c}x^2\right)\{dx\}$ $\int_c^{2c}x^2 f(x)\{dx\}$ where $f(x)$ is equivalent to $\frac{1}{c}$. (Limits are required)	M1
	$=\left[\frac{1}{c}\left(\frac{x^3}{3}\right)\right]_{\{c\}}^{\{2c\}}$ $\pm Ag(c)x^2\to\pm Bg(c)x^3,\ A\neq 0,\ B\neq 0$ (Ignore limits for this mark)	M1
	$=\left(\frac{(2c)^3}{3c}-\frac{c^3}{3c}\right)\left\{=\frac{7c^2}{3}\right\}$ **dependent on first M mark.** Applies limits of $2c$ and c to an ***integrated*** function in x and subtracts the correct way round.	dM1
	$\mathrm{Var}(X)=E(X^2)-(E(X))^2$	
	$=\frac{7c^2}{3}-\left(\frac{3c}{2}\right)^2$ **dependent on first M mark.** Applying the variance formula correctly with their $E(X)$	dM1
	$=\frac{c^2}{12}$ ***** Correct proof	A1
		[6]
(c)	$X>2(2c-X)$ Correct un-simplified (or simplified) inequality statement. **Can be implied by** $X>\frac{4c}{3}$	M1
	$\Rightarrow\ X>4c-2X\ \Rightarrow 3X>4c$	
	$\Rightarrow X>\frac{4c}{3}$ **dependent on the first M mark.** Rearranges $X>2(2c-X)$ to give X >… or X <… **See notes**	dM1
	$\left\{P(X>2(2c-X))=P\left(X>\frac{4c}{3}\right)\right\}=\frac{2}{3}$ $\frac{2}{3}$	A1
		[3]
		11
	Note: In (c), give M2 for either $X>\frac{4c}{3}$ or $P\left(X>\frac{4c}{3}\right)$ or $1-P\left(X<\frac{4c}{3}\right)$	

	Question 3 Notes	
3. (a)	**1st B1**	A horizontal line drawn above the x-axis in the first quadrant
	2nd dB1	**dependent on the FIRST B mark being awarded.** Labels of c, $2c$ and $\frac{1}{c}$, marked on the graph.
	Note	Allow the label $\frac{1}{2c-c}$ as an alternative to $\frac{1}{c}$
	Note	Ignore $\{O\}$, $\{x\}$ and $\{\mathrm{f}(x)\}$
(b)	**B1**	$\mathrm{E}(X)=\frac{3c}{2}$, simplified or un-simplified. This mark can be implied.
	Note	B1 can be given for an un-simplified $\left(\frac{(2c)^2}{c}\right)-\left(\frac{c^2}{c}\right)$ or $\frac{3c^2}{2c}$ or $2c-\frac{c}{2}$ etc.
	Note	$\int_c^{2c}\frac{1}{c}x\,\mathrm{d}x$ or $\left[\frac{x^2}{2c}\right]_c^{2c}$ are not sufficient for B1.
	1st M1	Correct $\mathrm{E}(X^2)$ expression of $\int_c^{2c}x^2\mathrm{f}(x)\{\mathrm{d}x\}$ where $\mathrm{f}(x)$ is equivalent to $\frac{1}{c}$.
	Note	Must have limits of $2c$ and c. Note the $\mathrm{d}x$ is not required for this mark.
	2nd M1	$\pm A\mathrm{g}(c)x^2 \to \pm B\mathrm{g}(c)x^3,\ A\neq 0,\ B\neq 0$, where $\mathrm{g}(c)$ is a function of c
	Note	Limits are not required for the second 2nd M1 mark.
	3rd dM1	**dependent on the FIRST method mark being awarded.** Applies limits of $2c$ and c to an integrated function in x and subtracts the correct way round.
	4th M1	**dependent on the FIRST method mark being awarded.** Applying the variance formula correctly with their follow through $\mathrm{E}(X)$.
	Note	Allow 4th M1 for $\{\mathrm{Var}(X)=\}\int_c^{2c}\left(\frac{1}{2c-c}x^2\right)\{\mathrm{d}x\}-\left(\int_c^{2c}\left(\frac{1}{2c-c}x\right)\{\mathrm{d}x\}\right)^2$
	A1	Correctly proves that $\mathrm{Var}(X)=\frac{c^2}{12}$. **Note:** Answer is given
(c)	**1st M1**	For writing down a correctly un-simplified (or simplified) inequality statement. Eg: $X>2(2c-X)$ or $\mathrm{P}(X>2(2c-X))$ (**Note:** "P" is not required for this mark)
	2nd dM1	**dependent on the FIRST method mark being awarded.** Rearranges to give $\mathrm{P}(X>\pm\alpha c)$ or $\mathrm{P}(X<\pm\alpha c)$ or $X>\pm\alpha c$ or $X<\pm\alpha c,\ \alpha\neq 0$
	Note	"P" is not required for these cases above
	Note	Also allow, with P, the statements $1-\mathrm{P}(X<\pm\alpha c)$ or $1-\mathrm{P}(X>\pm\alpha c),\ \alpha\neq 0$
	NOTE	Give M2 for either $X>\frac{4c}{3}$ or $\mathrm{P}\left(X>\frac{4c}{3}\right)$ or $1-\mathrm{P}\left(X<\frac{4c}{3}\right)$
	A1	$\frac{2}{3}$ or $\frac{4}{6}$ or $0.\dot{6}$
	Note	Give M1M1A1 for a final answer of $\frac{2}{3}$ ***from any*** working.

Question Number	Scheme		Marks
3. (b)	**Alternative Method 1 for Part (b)**		
	$\{\mathrm{Var}(X)=\}$		
		Implied $\mathrm{E}(X)=\frac{3c}{2}$	**B1**
	$\int_c^{2c}\left(\frac{1}{2c-c}\left(x-\frac{3}{2}c\right)^2\right)\{\mathrm{d}x\}$	$\int_c^{2c} x^2\mathrm{f}(x)\{\mathrm{d}x\}$ where $\mathrm{f}(x)$ is equivalent to $\frac{1}{c}$. (Limits are required)	**1st M1**
		Applies $\int_c^{2c}\mathrm{f}(x)\left(x-\frac{3c}{2}\right)^2\{\mathrm{d}x\}$ where $\mathrm{f}(x)$ is a is equivalent to $\frac{1}{c}$. (Limits are required)	**4th dM1**
	$=\frac{1}{c}\left[\frac{1}{3}\left(x-\frac{3c}{2}\right)^3\right]_{\{c\}}^{\{2c\}}$	$\pm A\mathrm{g}(c)(x-\delta)^2\rightarrow\pm B\mathrm{g}(c)(x-\delta)^3$, $A,B,\delta\neq 0$ (Ignore limits for this mark)	**2nd M1**
	$=\frac{1}{3c}\left(\left(\frac{c}{2}\right)^3-\left(-\frac{c}{2}\right)^3\right)$	**dependent on first M mark.** Applies limits of $2c$ and c to an integrated function in x and subtracts the correct way round.	**3rd dM1**
	$=\frac{1}{3c}\left(\frac{c^3}{4}\right)=\frac{c^2}{12}$ *	Correct proof	**A1**
			[6]
(b)	**Alternative Method 2 for Part (b)**		
	$\{\mathrm{Var}(X)=\}$		
	$\int_c^{2c}\left(\frac{1}{2c-c}\left(x-\frac{3}{2}c\right)^2\right)\{\mathrm{d}x\}$	**Award as in Alt. Method 1**	**B1** **1st M1** **4th M1**
	$=\frac{1}{c}\int_c^{2c}\left(x^2-3cx+\frac{9}{4}c^2\right)\{\mathrm{d}x\}$		
	$=\frac{1}{c}\left[\frac{1}{3}x^3-\frac{3}{2}cx^2+\frac{9}{4}c^2x\right]_{\{c\}}^{\{2c\}}$	$\pm A\mathrm{g}(c)(x-\delta)^2\rightarrow\pm B\mathrm{g}(c)(\pm\alpha x^3\pm\beta x^2\pm\delta x)^3$, $A,B,\alpha,\beta,\delta\neq 0$ (Ignore limits for this mark)	**2nd M1**
	$=\frac{1}{c}\left(\left(\frac{1}{3}(2c)^3-\frac{3}{2}c(2c)^2+\frac{9}{4}c^2(2c)\right)-\left(\frac{1}{3}(c)^3-\frac{3}{2}c(c)^2+\frac{9}{4}c^2(c)\right)\right)$	As earlier	**3rd dM1**
	$=\frac{1}{c}\left(\left(\frac{8}{3}c^3-6c^3+\frac{9}{2}c^3\right)-\left(\frac{1}{3}c^3-\frac{3}{2}c^3+\frac{9}{4}c^3\right)\right)$		
	$=\frac{1}{c}\left(\left(\frac{7}{6}c^3\right)-\left(\frac{13}{12}c^3\right)\right)=\frac{1}{c}\left(\frac{c^3}{12}\right)$		
	$=\frac{c^2}{12}$ *	Correct proof	**A1**
			[6]

Question Number	Scheme		Marks
4. (a)	$\mathrm{P}(X=0 \mid k=3)=0.0498$ $\mathrm{P}(X=0 \mid k=4)=0.0183$ $\mathrm{P}(X=0 \mid k=5)=0.0067$ $\left\{\mathrm{e}^{-k}<0.025 \Rightarrow k>\right\}$ 3.688...	At least one of these 9 probabilites **or** awrt 3.7 seen in their working.	B1
	$\mathrm{P}(X \leqslant 8 \mid k=3)=0.9962,\ \mathrm{P}(X \geqslant 9 \mid k=3)=0.0038$ $\mathrm{P}(X \leqslant 8 \mid k=4)=0.9786,\ \mathrm{P}(X \geqslant 9 \mid k=4)=0.0214$ $\mathrm{P}(X \leqslant 8 \mid k=5)=0.9319,\ \mathrm{P}(X \geqslant 9 \mid k=5)=0.0681$	**Both** $\mathrm{P}(X=0)=0.0183$ **or** awrt 3.7 **and either** $\mathrm{P}(X \geqslant 9)=0.0214$ **or** $\mathrm{P}(X \leqslant 8)=0.9786$	B1
	Both tails less than 2.5% when $\underline{k=4}$	Final answer given as $\underline{k=4}$	B1
			[3]
(b)	Actual sig. level = 0.0214 + 0.0183	See notes	M1
	= 0.0397	0.0397	A1 **cao**
			[2]
			5

		Question 4 Notes
4. (a)		
	1st B1	For any of 0.0498, 0.0183, 0.0067, 0.9962, 0.9786, 0.9319, 0.0038, 0.0214, 0.0681 or awrt 3.7 seen in their working.
	2nd B1 **Note**	For both $\mathrm{P}(X=0)=0.0183$ **or** awrt 3.7 **and either** $\mathrm{P}(X \geqslant 9)=0.0214$ **or** $\mathrm{P}(X \leqslant 8)=0.9786$ These must be written as probability statements.
	3rd B1	Final answer given as $\underline{k=4}$. Also allow $\lambda=4$
	Note	**Do not recover working for part (a) in part (b)**
(b)	**M1**	For the addition of two probabilities for two tails, where each tail < 0.05
	A1	0.0397 **cao**

Question Number	Scheme		Marks
5.	$Y = \dfrac{2X_1 + X_2}{3}$ where $\begin{array}{\|c\|c\|c\|} \hline x & 6 & 9 \\ \hline \mathrm{P}(X = x) & 0.35 & 0.65 \\ \hline \end{array}$		
	Note: You can mark parts (a) and (b) together for this question.		
(a)	$\dfrac{2(6)+6}{3} = 6 \qquad \dfrac{2(9)+9}{3} = 9$	At least three correct values for y of either 6, 7, 8 or 9	B1
	$\dfrac{2(6)+9}{3} = 7 \qquad \dfrac{2(9)+6}{3} = 8$	Correct values for y of 6, 7 8 and 9 only	B1
			[2]
(b)	$\{(6, 6) \Rightarrow \mathrm{P}(Y = 6)\} = (0.35)^2$ $\{(6, 9) \Rightarrow \mathrm{P}(Y = 7)\} = (0.65)(0.35)$	At least one of either $(0.35)^2$, $(0.65)(0.35), (0.35)(0.65)$ or $(0.65)^2$	M1
	$\{(9, 6) \Rightarrow \mathrm{P}(Y = 8)\} = (0.35)(0.65)$ $\{(9, 9) \Rightarrow \mathrm{P}(Y = 9)\} = (0.65)^2$	At least two of either $(0.35)^2$, $(0.65)(0.35), (0.35)(0.65)$ or $(0.65)^2$	M1
	$\begin{array}{\|c\|c\|c\|c\|c\|} \hline \text{sample} & (6, 6) & (6, 9) & (9, 6) & (9, 9) \\ \hline y & 6 & 7 & 8 & 9 \\ \hline \mathrm{P}(Y = y) & 0.1225 & 0.2275 & 0.2275 & 0.4225 \\ \hline \text{or } \mathrm{P}(Y = y) & \frac{49}{400} & \frac{91}{400} & \frac{91}{400} & \frac{169}{400} \\ \hline \end{array}$	**See notes** At least 3 correct **See notes**	A1 A1 B1ft
			[5]
(c)	$\{\mathrm{E}(Y)\} = 6(0.1225) + 7(0.2275) + 8(0.2275) + 9(0.4225) = 7.95$ or $\dfrac{159}{20}$		M1;A1 **cao**
			[2]
			9
(c)	**<u>Alternative Method for Part (c)</u>**		
	$\left\{\mathrm{E}(Y) = \dfrac{2}{3}\mathrm{E}(X_1) + \dfrac{1}{3}\mathrm{E}(X_2) = \dfrac{2}{3}\mathrm{E}(X) + \dfrac{1}{3}\mathrm{E}(X) = \mathrm{E}(X)\right\}$		
	$= 6(0.35) + 9(0.65); = 7.95$ or $\dfrac{159}{20}$		M1; A1 **cao**
			[2]

		Question 5 Notes
5. (a)	**Note**	**You can mark parts (a) and (b) together for this question.**
	1st B1 **2nd B1**	At least three correct values for *y* of either 6, 7, 8 or 9 Correct values for *y* of 6, 7 8 and 9 only. **Note:** Any extra value(s) given is 2nd B0.
(b)	**1st M1**	At least one of either $(0.35)^2$, $(0.65)(0.35)$, $(0.35)(0.65)$ or $(0.65)^2$. **Can be implied.**
	2nd M1	At least two of either $(0.35)^2$, $(0.65)(0.35)$, $(0.35)(0.65)$ or $(0.65)^2$. **Can be implied.**
	1st A1	At least two correct probabilities given which either must be linked to a correct sample (x_1, x_2) or their followed through *y*-value.
	2nd A1 **B1ft**	At least 3 correct probabilities corresponding to the correct value of *y*. Either • all 4 correct probabilities corresponding to the correct value of *y* • 6, 7, 8 and 9 with two correct probabilities, two other probabilities and $\sum \mathrm{p}(y) = 1$
	Note **Note** **Note**	B1ft is dependent on 1st M1 2nd M1 1st A1. A table is not required but *y*-values must be linked with their probabilities for 2nd A1 B1 Eg: (6, 6) by itself does not count as an acceptable value of *y*
(c)	**M1** **Note**	A correct follow through expression for $\mathrm{E}(Y)$ using their distribution Also allow M1 for a correct expression for $\mathrm{E}(X)$
	A1	7.95 **cao** Allow $\frac{159}{20}$

Question Number	Scheme		Marks
6. (a)	$X \sim B(30, 0.4)$	$X \sim B(30, 0.4)$	B1
			[1]
(b)	Eg: Any one of either • Constant probabilty of buying insurance • Customers buy insurance independently of each other	Any one of these two assumptions in context which refers to insurance.	B1
			[1]
(c)	$P(X < r) < 0.05$		
	$\{P(X \leqslant 8) = P(X < 9)\} = 0.0940$ $\{P(X \leqslant 7) = P(X < 8)\} = 0.0435$	For at least one of either 0.094(0) or 0.0435 seen in part (c)	M1
	So $r = 8$	$r = 8$	A1
			[2]
(d)	$\{Y \sim B(100, 0.4) \approx\} Y \sim N(40, 24)$	Normal or N	M1
		(40, 24)	A1
	$\{P(Y \geqslant t)\} \approx P(Y > t - 0.5)$	For either $t - 0.5$ or $t + 0.5$	M1
	$\left\{= P\left(Z > \frac{(t-0.5)-40}{\sqrt{24}}\right) = 0.938\right\}$		
	$\frac{(t-0.5)-40}{\sqrt{24}} = -1.54$	Standardising $(\pm)$ with their mean and their standard deviation and either $t - 0.5$ or t or $t + 0.5$ or $t - 1.5$	M1
		-1.54 or 1.54 or awrt -1.54 or awrt 1.54	B1
	So, $\{\text{So, } t = 32.955571...\} \Rightarrow t = 33$	$t = 33$	A1 **cao**
			[6]
(e)	$H_0 : p = 0.4,\ H_1 : p < 0.4$	Both hypotheses are stated correctly	B1
	$\{\text{Under } H_0,\ X \sim B(25, 0.4)\}$		
	Probability Method $P(X \leqslant 6);= 0.0736$		
	Critical Region Method $P(X \leqslant 6);= 0.0736$ $\{P(X \leqslant 7)= 0.1536\}$ $\text{CR} : X \leqslant 6$	$P(X \leqslant 6)$	M1
		Either 0.0736 or $\text{CR} : X \leqslant 6$ or $\text{CR} : X < 7$	A1
	$\{0.0736 < 0.10\}$		
	Reject H_0 or significant or 6 lies in the CR	**Dependent on 1st M1** See notes	dM1
	So **percentage** (or **proportion**) who buy **insurance** has **decreased**.		A1 **cso**
			[5]
			15

Question Number	Scheme	Marks
6. (e)	**Alternative Method: Normal approximation to the Binomial Distribution**	
	• Normal Approximation gives 0.0764 (or 0.07652…) and loses all A marks	
	$\mathrm{H}_0 : p = 0.4,\ \ \mathrm{H}_1 : p < 0.4$ Both hypotheses are stated correctly	B1
	$\{Y \sim \mathrm{B}(25, 0.4) \approx Y \sim \mathrm{N}(10, 6)\}$	
	$\mathrm{P}(X \leqslant 6) \approx \mathrm{P}(X < 6.5)$ $\mathrm{P}(X \leqslant 6)$ or $\mathrm{P}(X < 6.5)$	M1
	$= \mathrm{P}\left(Z < \frac{6.5 - 10}{\sqrt{6}}\right)$ $= \mathrm{P}(Z < -1.4288...)$	
	$\{= 1 - 0.9236\} = 0.0764$ ***Award A0 here***	***A0***
	$\{0.0764 < 0.10\}$	
	Reject H_0 or significant As in the main scheme	M1
	So **percentage** (or **proportion**) who buy **insurance** has **decreased**. ***Award A0 here***	***A0***

	Question 6 Notes	
6. (a)	**B1**	$X \sim \mathrm{B}(30, 0.4)$ or $X \sim \mathrm{Bin}(30, 0.4)$. Condone $X \sim \mathrm{b}(30, 0.4)$
	Note	$X \sim \mathrm{B}(30, 0.4)$ o.e. must be seen in part (a) only.
(b)	**B1**	For any one of the two acceptable assumptions listed anywhere in part (b).
	Note	A contextual statement, which refers to insurance, is required for this mark.
(c)	**Note**	Award M1 A1 for $r = 8$ seen from no incorrect working.
(d)	**1st M1**	For writing N or for using a normal approximation.
	1st A1	For a correct mean of 40 and a correct variance of 24
	Note	1st M1 and/or 1st A1 may be implied in applying the standardisation formula
	2nd M1	For either $t - 0.5$ or $t + 0.5$ (i.e. an attempt at a continuity correction)
	3rd M1	As described on the mark scheme.
	B1	-1.54 or 1.54 or awrt -1.54 or awrt 1.54. Note: Calculator gives -1.5382
	2nd A1	$\underline{t = 33}$ **cao** (The integer value is required).
(e)	**B1**	$\mathrm{H}_0 : p = 0.4,\ \ \mathrm{H}_1 : p < 0.4$ corectly labelled. Also allow $\mathrm{H}_0 : \pi = 0.4,\ \ \mathrm{H}_1 : \pi < 0.4$ Also allow $\mathrm{H}_0 : \pi = 0.4,\ \ \mathrm{H}_1 : \pi < 0.4$ or $\mathrm{H}_0 : p(x) = 0.4,\ \ \mathrm{H}_1 : p(x) < 0.4$
	Note	B0 for $\mathrm{H}_0 = 0.4,\ \ \mathrm{H}_1 < 0.4$
	1st M1	**Probability Method & CR Method:** Stating $\mathrm{P}(X \leqslant 6)$
	1st A1	Either 0.0736 or $\mathrm{CR} : X \leqslant 6$ or $\mathrm{CR} : X < 7$ **Note:** Condone $\mathrm{CR} \leqslant 6$
	Note	Award 1st M1 1st A1 for writing down $\mathrm{CR} : X \leqslant 6$ or $\mathrm{CR} : X < 7$ from no working.
	Note	Give A0 for stating $\mathrm{CR} : \mathrm{P}(X \leqslant 6)$
	2nd dM1	**dependent on the FIRST method mark being awarded.** For a correct follow through comparison based on their probability or CR and their significance level compatible with their ***stated*** alternative hypothesis. Do not allow non-contextual conflicting statements. Eg. "significant" and "accept H_0".
	Note	M1 can be implied by a correct contextual statement.
	2nd A1	Award for a correct solution only with all previous marks in part (e) being scored. Correct conclusion which is in context, using the words percentage (or proportion), insurance and decreased (or equivalent words for decreased).

Question Number	Scheme	Marks
7. (a)	$\int_0^k \left(\frac{2x}{15}\right)\{\mathrm{d}x\} + \int_5^k \frac{1}{5}(5-x)\{\mathrm{d}x\} = 1$ Complete method of writing a correct equation for the area ***with correct limits*** and setting the result equal to 1	M1
	$\left[\frac{x^2}{15}\right]_{\{0\}}^{\{k\}} + \left[x-\frac{x^2}{10}\right]_{\{k\}}^{\{5\}} = 1$ Evidence of $x^n \to x^{n+1}$	M1
	Both $\frac{2x}{15} \to \frac{x^2}{15}$ **and** $\frac{1}{5}(5-x) \to x-\frac{x^2}{10}$	A1 o.e.
	$\left(\frac{k^2}{15}\right) + \left(5-\frac{5^2}{10}-\left(k-\frac{k^2}{10}\right)\right) = 1$	
	$2k^2+150-75-30k+3k^2=30$	
	$k^2-6k+9=0$ or $\frac{k^2}{6}-k+\frac{3}{2}=0$	
	$(k-3)(k-3)=0 \Rightarrow k = \ldots$ **Dependent on the 1st M mark** Attempt to solve a 3 term quadratic equation leading to $k = \ldots$	dM1
	$k=3$ $k=3$	A1
		[5]
(b)	{mode =} 3 3 **or** states their k value from part (a)	B1 ft
		[1]
(c)	$\left\{\mathrm{P}\left(X \leqslant \frac{k}{2} \middle\vert X \leqslant k\right) = \frac{\mathrm{P}\left(X \leqslant \frac{k}{2} \cap X \leqslant k\right)}{\mathrm{P}(X \leqslant k)}\right\}$	
	$= \frac{\mathrm{P}\left(X \leqslant \frac{k}{2}\right)}{\mathrm{P}(X \leqslant k)}$ Either $\frac{\mathrm{P}\left(X \leqslant \frac{k}{2}\right)}{\mathrm{P}(X \leqslant k)}$ or $\frac{\mathrm{F}\left(\frac{k}{2}\right)}{\mathrm{F}(k)}$ seen or implied.	M1
	$= \frac{\int_0^{\frac{k}{2}} \left(\frac{2x}{15}\right)\{\mathrm{d}x\}}{\int_0^k \left(\frac{2x}{15}\right)\{\mathrm{d}x\}}$ **see notes**	dM1
	$= \frac{\frac{1}{15}\left(\frac{k}{2}\right)^2}{\frac{k^2}{15}}$ Correct substitution of their limits or their k into conditional probability formula.	A1ft
	$\left\{= \frac{\left(\frac{9}{60}\right)}{\left(\frac{9}{15}\right)} = \frac{0.15}{0.6}\right\} = \frac{1}{4}$ $\frac{1}{4}$ or 0.25	A1 **cao**
		[4]
		10

		Question 7 Notes
7. (a)	**1st M1**	$\int_0^k \left(\frac{2x}{15}\right)\{\mathrm{d}x\} + \int_5^k \frac{1}{5}(5-x)\{\mathrm{d}x\} = 1$. (***with correct limits*** and =1) $\{\mathrm{d}x\}$ not needed.
	2nd M1	Evidence of $x^n \to x^{n+1}$
	1st A1	**Both** $\frac{2x}{15} \to \frac{x^2}{15}$ **and** $\frac{1}{5}(5-x) \to x - \frac{x^2}{10}$
	3rd dM1	**dependent on the FIRST method mark being awarded.** Attempt to solve a **three term** quadratic equation. Please see table on page 20
	2nd A1	$k = 3$ from correct working.
	Note	**WARNING:** $\frac{2x}{15} = \frac{1}{5}(5-x)$ to get $k = 3$ is M0M0A0M0A0.
	Note	It is possible to give M0M1A1M0A0 in part (a).
(b)	**B1 ft**	Mode = 3 or candidate states their *k* value from part (a), where $0 <$ their $k < 5$
(c)	**1st M1**	Either $\frac{\mathrm{P}\left(X \leqslant \frac{k}{2}\right)}{\mathrm{P}(X \leqslant k)}$ or $\frac{\mathrm{F}\left(\frac{k}{2}\right)}{\mathrm{F}(k)}$, seen or implied by their later working.
	Note	Without reference to a correct conditional probability statement give 1st M0 for either $\frac{\mathrm{f}\left(\frac{k}{2}\right)}{\mathrm{f}(k)}$ or $\frac{\mathrm{F}(k) - \mathrm{F}\left(\frac{k}{2}\right)}{\mathrm{F}(k)}$ or $\frac{\mathrm{P}\left(X \leqslant \frac{k}{2}\right) \times \mathrm{P}(X \leqslant k)}{\mathrm{P}(X \leqslant k)}$
	2nd dM1	**dependent on the FIRST method mark being awarded.** **Applies** the conditional probability statement by writing down • $\frac{\int_0^{\frac{k}{2}} \left(\frac{2x}{15}\right)\{\mathrm{d}x\}}{\int_0^k \left(\frac{2x}{15}\right)\{\mathrm{d}x\}}$ with limits. • $\frac{\mathrm{F}\left(\frac{k}{2}\right)}{\mathrm{F}(k)}$ where $\mathrm{F}(x)$ is defined as $\mathrm{F}(x) = \frac{x^2}{15}$ These statements can be implied by later working.
	Note	Finding $\mathrm{P}(X \leqslant 1.5) = 0.15$ and $\mathrm{P}(X \leqslant 3) = 0.6$ without applying $\frac{0.15}{0.6}$ is 2nd M0
	1st A1ft	Correct substitution of their limits or their *k* into conditional probability formula.
	Note	Candidates can work in terms of *k* for this 1st A1 mark.
	2nd A1	$\frac{1}{4}$ or 0.25 **cao**
	Note	Condone giving 2nd A1 for achieving a correct answer of 0.25 where at least one of their stated $\mathrm{P}\left(X \leqslant \frac{k}{2}\right)$ or $\mathrm{P}(X \leqslant k)$ is greater than 1
	Note	Alternative method using similar triangles. Area up to $\frac{k}{2}$ is $\frac{1}{4}$ of the area up to *k*. This can score 4 marks.

7. (a)	**Alternative Method 1 for Part (a) Using the CDF**	
	$0 \leqslant x \leqslant k,\ \mathrm{F}(x) = \int_0^k \frac{2t}{15}\{\mathrm{d}t\} = \left[\frac{2t^2}{\underline{\underline{30}}}\right]_0^x = \frac{x^2}{\underline{\underline{15}}}$ Evidence of $x^n \to x^{n+1}$	**2nd M1**
	$k < x \leqslant 5,\ \mathrm{F}(x) = \mathrm{F}(k) + \int_k^x \frac{1}{5}(5-t)\{\mathrm{d}t\}$ $= \frac{k^2}{15} + \left[\underline{\underline{\frac{1}{5}\left(5t - \frac{t^2}{2}\right)}}\right]_k^x$ **Both** $\frac{2x}{15} \to \frac{x^2}{\underline{\underline{15}}}$ **and** $\frac{1}{5}(5-x) \to x - \frac{x^2}{\underline{\underline{10}}}$	**1st A1** o.e.
	$= \frac{k^2}{15} + \frac{1}{5}\left(\underline{\underline{5x - \frac{x^2}{2}}}\right) - \frac{1}{5}\left(5k - \frac{k^2}{2}\right)$ $= x - \frac{x^2}{10} - k + \frac{k^2}{6}$	
	$\{\mathrm{F}(5) = 1 \Rightarrow\}\ 5 - \frac{5^2}{10} - k + \frac{k^2}{6} = 1$ Complete method of writing a correct equation for the area ***with correct limits*** and setting $\mathrm{F}(5) = 1$	**1st M1**
	then apply the main scheme	
7. (a)	**Alternative Method 2 for Part (a) Use of Area**	
	$\frac{1}{2}k\left(\frac{2k}{15}\right) + \frac{1}{2}\left(\frac{5-k}{5}\right)(5-k) = 1$ Complete area expression put = 1	M1
	At least one term correct on LHS	M1
	Correct LHS	A1 o.e.
	then apply the main scheme	
General	**Note** The c.d.f is defined as $\mathrm{F}(x) = \begin{cases} 0, & x < 0 \\ \frac{x^2}{15}, & 0 \leqslant x \leqslant 3 \\ x - \frac{x^2}{10} - \frac{3}{2}, & 3 < x \leqslant 5 \\ 1, & x > 5 \end{cases}$	
7. (a)	**Method mark for solving a 3 term quadratic of the form** $x^2 + bx + c = 0$ **Factorising/Solving a quadratic equation is tested in Question 7(a).** **1. Factorisation** $(x^2 + bx + c) = (x + p)(x + q)$, where $\lvert pq\rvert = \lvert c\rvert$, leading to $x = \ldots$ $(ax^2 + bx + c) = (mx \pm p)(nx \pm q)$, where $\lvert pq\rvert = \lvert c\rvert$ and $\lvert mn\rvert = \lvert a\rvert$, leading to $x = \ldots$ **2. Formula** Attempt to use correct formula (with values for *a*, *b* and *c*) **3. Completing the square** Solving $x^2 + bx + c = 0$: $\left(x \pm \frac{b}{2}\right)^2 \pm q \pm c = 0$, $q \neq 0$, leading to $x = \ldots$	

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Mark Scheme (Results)

Summer 2015

Pearson Edexcel GCE in Statistics 2 (6684/01)

Summer 2015
Publications Code UA042711

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

PEARSON EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

   These are some of the traditional marking abbreviations that will appear in the mark schemes.

   - bod – benefit of doubt
   - ft – follow through
   - the symbol $\surd$ will be used for correct ft
   - cao – correct answer only
   - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which round to
   - SC: special case
   - oe – or equivalent (and appropriate)
   - d… or dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - ∗ The answer is printed on the paper or ag- answer given
   - ⎣ or d… The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks

affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme		Marks
1. (a)		**notes**	
	$\mathrm{P}(N \geq 10) = 1 - \mathrm{P}(N \leq 9)$	M1: using or writing $1-\mathrm{P}(N \leq 9)$ or $1-\mathrm{P}(N<10)$	M1 A1
	= 0.4126	A1: awrt 0.413	
(b)	Y represents number of owls per 200 km^2 $\Rightarrow$ $Y \sim \mathrm{Po}(1.8)$	B1: using or writing Po(1.8)	B1
	$\mathrm{P}(Y=2) = \dfrac{e^{-1.8}1.8^2}{2!}$	M1 : for a single term of the form $\dfrac{e^{-\lambda}\lambda^2}{2!}$ with any value for λ or $\mathrm{P}(X \leq 2) - P(X \leq 1)$	M1 A1
	= 0.2678	A1: awrt 0.268	
(c)	Normal approximation	M1: Using or writing, normal approximation with mean = 450	M1
	$\mu = 50 \times 9 = 450 \quad \sigma^2 = 450$	M1: Using or writing the mean = variance. Does not need to be 450. May be seen in the standardisation calculation.	M1
	$\mathrm{P}(X \geq 470) \approx 1 - \mathrm{P}\left(Z < \dfrac{469.5-450}{\sqrt{450}}\right)$	M1: $\pm\left(\dfrac{(470 \text{ or } 469.5 \text{ or } 470.5) - \textit{their mean}}{\textit{their sd}}\right)$ May be implied by a correct answer or z = awrt 0.92	M1
		M1: dep on previous method mark being awarded. Using a continuity correction 470 ± 0.5 May be implied by a correct answer or z = awrt 0.92	dM1 A1
		A1: correct standardisation no need to subtract from 1. Award for $\dfrac{469.5-450}{\sqrt{450}}$ or awrt 0.92 or a correct answer	
	= 0.1788	A1: awrt 0.179	A1 **(6)**

Question Number	Scheme		Marks
2(a)		**notes**	
	X ~ B(30, 0.25)	B1: using B(30, 0.25)	B1
	$P(X \le 10) - P(X \le 4) = 0.8943 - 0.0979$	M1: using $P(X \le 10) - P(X \le 4)$ or $P(X \ge 5) - P(X \ge 11)$ oe	M1 A1
	$= 0.7964$	A1: awrt 0.796	
	NB a correct answer gains full marks		

(b)	$H_0 : p = 0.25 \quad H_1 : p < 0.25$	B1: Both hypotheses correct, labelled H_0 or NH or H_n and H_1or AH or H_a , must use p or $p(x)$ or π	B1
	B(15, 0.25)	M1: for using B(15, 0.25)	M1 A1
	$P(X \le 1) = 0.0802$	A1: awrt 0.0802 or CR $X \le 1$ (allow $P(X \ge 2) = 0.9198$)	
	NB: Allow M1 A1 for a correct CR with no incorrect working		
	Reject H_0 or Significant or 1 1ies in the critical region	M1: A correct statement – do not allow contradictory non contextual statements. Follow through their Probability/CR (for 1 or 2 tail test). If no H_1 given then M0. Ignore their comparison. For a probabillity < 0.5, statement must be correct compared to 0.1 for 1 tail test and 0.05 for 2 tailed test or if the probability > 0.5, statement must be correct compared to 0.9 for 1 tail test and 0.95 for 2 tailed test.	dM1 A1cso
	There is evidence that the radio **company's** claim is true. **Or** The new transmitter will reduce the proportion of houses unable to receive **radio**	A1: cso (all previous marks awarded) and a correct statement containing the word **company** if writing about the claim or **radio** if full context.	

Question Number	Scheme		Marks
		Notes	
3(a)	$\int_0^2 kx^2\mathrm{d}x+\int_2^6 k\left(1-\frac{x}{6}\right)\mathrm{d}x=1$	M1: for adding the two integrals, and attempting to integrate, at least one integral $x^n \to x^{n+1}$, ignore limits and does not need to be put equal to 1. Do **not** award if they add before integrating	M1 A1
	$k\left[\frac{x^3}{3}\right]_0^2+k\left[x-\frac{x^2}{12}\right]_2^6=1$	A1: correct integration, ignore limits and does not need to be put equal to 1	
	$k\left[\frac{8}{3}\right]+k\left[3-\frac{5}{3}\right]=1$	M1: dependent on first M being awarded, correct use of limits and putting equal to 1. This may be seen as F(2) $=\frac{8}{3}k$ and using F(6) = 1	dM1 A1cso
	$4k=1$	A1: cso answer given so need $4k=1$ leading to $k=\frac{1}{4}$	
	$k=\frac{1}{4}$ *		
NB Validation – if they substitute in *k* = ¼ you may award the 1st three marks as per scheme. For the Final A mark they must say " therefore *k* = ¼"			
(b)	2	B1: cao	B1
(c)	$\int_0^x kt^2\mathrm{dt}=\frac{kx^3}{3}$	M1: attempting to find $\int_0^x kt^2\mathrm{d}t$ $t^2 \to t^3$, ignore limits, may leave in terms of *k*	M1
	$\int k\left(1-\frac{t}{6}\right)\mathrm{dt}=k\left[t-\frac{t^2}{12}\right]+C$ $=kt-k\frac{t^2}{12}+C$ F(6) =1 $6k-3k+C=1 \quad \therefore\ C=\frac{1}{4}$	M1: attempting to find $\int k(1-\frac{t}{6})\mathrm{d}t$ at least one integral $t^n \to t^{n+1}$ **and** either have + *C* $(C \neq 0)$ and use F(6) =1 **or** have limits 2 and *x* and + "their $\int_0^2 kt^2\mathrm{dt}$ " and attempt to integrate $t^n \to t^{n+1}$ NB: may use any letter, need not be *t* ,condone use of *x*	M1
	$\mathrm{F}(x)\begin{cases} 0 & x<0 \\ \frac{x^3}{12} & 0 \le x \le 2 \\ \frac{x}{4}-\frac{x^2}{48}+\frac{1}{4} & 2<x\le 6 \\ 1 & x>6 \end{cases}$	A1: second line correct A1: third line correct B1: first and fourth line correct they may use "otherwise" instead of *x* < 0 or *x* > 6 but not instead of both	A1 A1 B1
	NB: Condone use of < rather than ≤ and vice versa		

Question Number	Scheme		Marks
(d)	$\frac{x}{4}-\frac{x^2}{48}+\frac{1}{4}=0.75$	M1: putting their line 2 or their line 3 = 0.75	M1 A1
	$x^2-12x+24=0$ oe	A1: The correct quadratic equation – like terms must be collected together	
	$x=\frac{12\pm\sqrt{144-4\times 24}}{2}$	M1d: dep on previous M1 being awarded. A correct method for solving a 3 term quadratic equation = 0 leading to x = …Use either the quadratic formula or completing the square - If they quote a correct formula and attempt to use it, award the method mark if there are small errors. Where the formula is not quoted, the method mark can be implied from correct working with values but is lost if there is a mistake. If they attempt to factorise award M1 if they have $\left(x^2+bx+c\right)=(x+p)(x+q),$ where $\lvert pq\rvert=\lvert c\rvert$ leading to $x=...$ May be implied by a correct value for x	dM1 A1
	= 2.54 or $6-2\sqrt{3}$	A1: awrt 2.54 or $6-2\sqrt{3}$ or $6-\sqrt{12}$. If 2 values for x are given they must eliminate the incorrect one.	

Question Number	Scheme		Notes	Marks
			Notes	
4(a)	0.8		B1: cao	B1
(b)	0.25		B1: cao	B1
(c)	$\frac{(0.5-0)^2}{12}=\frac{1}{48}$ or awrt 0.0208		M1: for $\frac{(0.5\pm 0)^2}{12}$ or for $\int_0^{0.5} 2x^2\mathrm{d}x-(\text{their }(b))^2$ with some integration $x^n \to x^{n+1}$	M1A1
			A1: $\frac{1}{48}$ or awrt 0.0208 or awrt 2.08×10^{-2}	
(d)	P(L > 0.4) = 0.2	P(L < 0.4) = 0.8	An awrt 0.123 award B1 M1 A1	B1 dM1A1
	Y~ B(30, 0.2)	Y~ B(30, 0.8)	B1: using or writing B(30, their P(L < 0.4) or B(30, their P(L > 0.4) . If they have not written these probabilities in this part use answer from part (a) ie P(L < 0.4) = (a) or P(L > 0.4) = 1- (a)	
	P($Y\leq$ 3) = 0.1227	P($Y\geq$ 4) = 0.1227	M1: dependent on previous B mark being awarded. Using B(30,P(L>0.4) with P($Y\leq$ 3) written or used **Or** B(30 P(L<0.4)) with P($Y\geq$ 4) written or used A1: awrt 0.123	
(e)	$1-\left[4\times 0.4-4\times 0.4^2\right]=\frac{1}{25}$ or 0.04		M1: Using 1- F(0.4) or F(0.5) – F(0.4) or $\mathrm{P}(X\leq 0.5)-\mathrm{P}(X\leq 0.4)$. Must see some substitution of 0.4 A1: $\frac{1}{25}$ or 0.04 only	M1A1
(f)	Po(4)		B1ft: using or writing Po(4) **NB** for ft they must either write 100 × “their 0.04” and use Poison or write Po(“their λ ”) Allow P instead of Po	B1ft
	P($X\geq$ 8) = 1- P($X\leq$7)		M1 using or writing 1- P($X\leq$7) If using normal approximation, they must either write this or $\frac{7.5-4}{2}$ or $\frac{7.5-4}{\sqrt{3.84}}$ or $\frac{7.5-4}{\text{awrt } 1.96}$ or $\frac{7.5-20}{\sqrt{16}}$	M1
	= 1 – 0.9489 = 0.0511		A1 awrt 0.0511	A1

Question Number	Scheme		Marks
		Notes	
5(a)	X~Po(4) P(X = 0) = 0.0183 P($X \geq 8$) = 0.0511 P($X \leq 1$) = 0.0916 P($X \geq 9$) = 0.0214	M1: using Po(4), need to see a probability from Po(4), need not be one of the 4 given here. May be implied by a single correct CR	M1 A1 A1
	CR $X = 0$ $X \geq 9$	A1: $X = 0$ or $X \leq 0$ or $X < 1$ A1: $X \geq 9$ or $X > 8$ Any letter(s) may be used instead of X eg CR or Y or in words **SC** candidates who write P(X = 0) and $\mathrm{P}(X \geq 9)$ award M1A1 A0 **NB** Candidates who write $8 < x \leq 0$ oe get M1A0A0	
(b)	$\mathrm{H_0}: \lambda = 4 \quad \mathrm{H_1}: \lambda \neq 4$	B1: both hypotheses correct, labelled $\mathrm{H_0}$ or NH or $\mathrm{H_n}$ and $\mathrm{H_1}$ or AH or $\mathrm{H_a}$ may use λ or μ. These must be seen in part (b)	B1
	There is evidence that ***Liftsforall's*** claim is true **or** There is insufficient evidence to doubt ***Liftforall's*** claim	B1: ft their CR only, Do not ft hypotheses.Needs to include the word ***Liftsforall.*** If no Critical region stated in part (a) award B0 or $\mathrm{P}(X \leq 3) =$ awrt 0.434 and a correct conclusion.	B1ft
(c)	0.0183 + 0.0214 = 0.0397	B1: Awrt 0.0397	B1
(d)	P($B \leq 3$| B ~ Po(6)) = 0.1512	M1: using Po(6) and writing or using P($B \leq 3$) oe. A1: awrt 0.151	M1 A1
	X ~ B(4, 0.1512)	B1ft: dep on M1 being awarded. Using or writing B(4,"their 0.151") for use they need $(1 - p)^4$ or $p\,(1 - p)^3$ or $p^2(1 - p)^2$	dB1ft
	Alternative method for first 3 marks		
	P($B \geq 4$| B ~ Po(6)) = 0.8488	M1: using Po(6) and writing or using P($B \geq 4$) oe A1: awrt 0.849	M1 A1
	Y ~ B(4, 0.849)	B1ft: dep on M1 being awarded. Using or writing B(4,"their 0.849") for use they need $(p)^4$ or $p^3(1 - p)$ or $p^2(1 - p)^2$	dB1ft
	If 0 < p < 0.5		
	P($X \leq 1$) = P(X = 0) + P(X = 1)	M1: using or writing P(X = 0) + P(X = 1) oe	M1
	$(1-0.1512)^4 + 4\times(1-0.1512)^3 \times 0.1512$	M1: $(1-p)^4 + 4\times(1-p)^3 \times p$ oe	dM1
	= 0.889	A1: awrt 0.889	A1
	If 0.5 < p < 1		
	P($Y \geq 3$) = P(Y = 3) + P(Y = 4)	M1: using or writing P(X = 3) + P(X = 4) oe	M1
	$4\times(0.8488)^3 \times 0.1512 + (0.8488)^4$	M1: $(p)^4 + 4\times(p)^3 \times(1-p)$ oe	dM1
	= 0.889	A1: awrt 0.889	A1
NB: a correct answer implies full marks, lose the final A mark if got awrt 0.889 and go on to do more work			

Question Number	Scheme		Marks
	NB: All powers of 1 **must** be simplified for the Accuracy(A) marks		
		notes	
6(a)	$\left[\frac{kx^{n+1}}{n+1}\right]_0^1=1$	M1: attempting to integrate $x^n \to x^{n+1}$ and putting equal to 1, ignore limits A1: correct integration	M1A1
	$k=n+1$	A1: $k = n + 1$ Do **not** accept $\frac{n+1}{1^{n+1}}$	A1
(b)	$\int_0^1 kx^{n+1}\mathrm{d}x=\left[\frac{kx^{n+2}}{n+2}\right]_0^1$	M1: Writing or using $\int_0^1 kx^{n+1}\mathrm{d}x$, ignore limits. Allow $\int_0^1 kx\left(x\right)^n\mathrm{d}x$ Allow substitution of their k A1: correct integration $\frac{kx^{n+2}}{n+2}$	M1A1
	$=\frac{n+1}{n+2}$	A1: correct answer only- must be in terms or n	A1cao
(c)	$\int_0^1 kx^{n+2}\mathrm{d}x=\left[\frac{kx^{n+3}}{n+3}\right]$	M1: Attempting to integrate $\int_0^1 kx^{n+2}\mathrm{d}x$, $x^{n+2}\to x^{n+3}$, ignore limits. Do not allow substitution of k if it has x in it. This must be on its own with no extra bits added on.	M1 A1cao
	$=\frac{n+1}{n+3}$	A1: correct answer only SC if they have $\frac{k}{n+2}$ as answer to part(b) award A1 for $\frac{k}{n+3}$	
(d)	Var (X) = $\frac{3}{5}-\left(\frac{3}{4}\right)^2=\frac{3}{80}$	M1: using "their(c)"– ["their(b)"]^2 with n = 2 or correct Var(X) Using $\int_0^1 kx^4\mathrm{d}x-\left[\int_0^1 kx^3\mathrm{d}x\right]^2$ for Var(X)	M1
	Var (3X) = 9 Var (X)	M1: for writing or using 9 Var (X) or 3^2Var(X)	M1 A1cso
	$=\frac{27}{80}$ oe or 0.3375 or 0.338	A1: cso	

<table>
<tr><th>Question Number</th><th colspan="2">Scheme</th><th>Marks</th></tr>
<tr><td></td><td></td><td>Notes</td><td></td></tr>
<tr><td>7</td><td colspan="2">NB: If there is a fully correct table award full marks.</td><td></td></tr>
<tr><td></td><td>P(10) = 0.2, P(20) = 0.4 and P(50) = 0.4</td><td>B1: using P(10) = 0.2 (<i>p</i>) P(20) = 0.4(<i>q</i>) and P(50) = 0.4(<i>r</i>) may be seen in calculations or implied by a correct probability.</td><td>B1</td></tr>
<tr><td></td><td>Median 10, 20, 50</td><td>B1: three correct medians and no extras.</td><td>B1</td></tr>
<tr><td></td><td>P(Median 10) =
$0.2^3+3\times0.2^2\times0.4+3\times0.2^2\times0.4$
or
$0.2^3+3\times0.2^2\times0.8$</td><td>M1: allow if $(p+q+r)=1$ and use
$p^3+3\times p^2\times q+3\times p^2\times r$
or
$p^3+3\times p^2\times(q+r)$
look for $\frac{1}{125}+\frac{6}{125}+\frac{6}{125}$</td><td rowspan="3">See below for how to award</td></tr>
<tr><td></td><td>P(Median 50) =
$0.4^3+ 3\times0.4^2\times0.2+3\times0.4^2\times0.4$
or
$0.4^3+3\times0.4^2\times0.6$</td><td>M1: allow if $(p+q+r)=1$ and use
$r^3+3\times r^2\times p+3\times r^2\times q$
or
$r^3+3\times r^2\times(p+q)$
Look for $\frac{8}{125}+\frac{12}{125}+\frac{24}{125}$</td></tr>
<tr><td></td><td>P(Median 20) =
$3\times0.2\times0.4^2+6\times0.2\times0.4\times0.4+0.4^3+$
$3\times0.4^2\times0.4$</td><td>M1: allow if $(p+q+r)=1$ and use
$3\times p\times q^2+6\times p\times q\times r+q^3+$
$3\times q^2\times r$
$\frac{12}{125}+\frac{24}{125}+\frac{8}{125}+\frac{24}{125}$</td></tr>
<tr><td></td><td colspan="2"><u>How to award the M marks</u> – Allow the use of 1, 2 and 5 for the medians for the method marks
M1 any correct calculation (implied by correct answer) for P(m = 10) or P(m = 20) or P(m = 50)
M1 any 2 correct calculations (implied by 2 correct answers) P(m = 10) or P(m = 20) or P(m = 50)
M1 any 3 correct calculations (implied by 3 correct answers) for P(m = 10) and P(m = 20) and P(m = 50) or
3 probabilities that add up to 1 providing it is 1 – their 2 other calculated probabilities. Do not allow $\frac{1}{5}\ \frac{2}{5}\ \frac{2}{5}$
NB if they do not have a correct answer their working must be clear including the addition signs.</td><td></td></tr>
<tr><td></td><td><table>
<tr><td>median</td><td>10</td><td>20</td><td>50</td></tr>
<tr><td></td><td>0.104</td><td>0.544</td><td>0.352</td></tr>
<tr><td></td><td>Or $\frac{13}{125}$</td><td>Or $\frac{68}{125}$</td><td>Or $\frac{44}{125}$</td></tr>
</table></td><td>A1: awrt any 1 correct
A2: awrt all 3 correct
These do not need to be in a table as long as the correct probablity is with the correct median(10, 20 & 50)
NB: Do Not allow the use of 1,2 and 5 for the medians for the A marks</td><td>A2</td></tr>
</table>

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