

Mark Scheme (Results) January 2010

GCE

Statistics S2 (6684)

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January 2010
6684 Statistics S2
Mark Scheme

Question Number	Scheme	Marks
Q1	<p>(a) $X \sim B(20, 0.05)$</p> <p>(b) $P(X = 0) = 0.95^{20} = 0.3584859\dots$ or 0.3585 using tables .</p> <p>(c) $P(X > 4) = 1 - P(X \leq 4)$ $= 1 - 0.9974$ $= 0.0026$</p> <p>(d) Mean = $20 \times 0.05 = 1$ Variance = $20 \times 0.05 \times 0.95 = 0.95$</p>	<p>B1 B1 (2)</p> <p>M1 A1 (2)</p> <p>M1</p> <p>A1 (2)</p> <p>B1</p> <p>B1 (2)</p> <p>Total [8]</p>
Q1	<p>Notes</p> <p>(a) 1st B1 for binomial 2nd B1 for 20 and 0.05 o.e These must be in part (a)</p> <p>(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.</p> <p>(c) M1 for writing $1 - P(X \leq 4)$ 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</p> <p>(d) 1st B1 for 1 2nd B1 for 0.95</p> <p>NB In parts b, c and d correct answers with no working gain full marks</p>	

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

Question Number	Scheme	Marks
Q3 (a)	$Y \sim \text{Po}(0.25)$ $P(Y=0) = e^{-0.25}$ $= 0.7788$	B1 M1 A1 (3)
(b)	$X \sim \text{Po}(0.4)$ P(Robot will break down) $= 1 - P(X = 0)$ $= 1 - e^{-0.4}$ $= 1 - 0.067032$ $= 0.3297$	B1 M1 A1 (3)
(c)	$P(X = 2) = \frac{e^{-0.4} (0.4)^2}{2!}$ $= 0.0536$	M1 A1 (2)
(d)	0.3297 or answer to part (b) as Poisson events are <u>independent</u>	B1ft B1 dep (2) Total [10]
Q3 (a)	<p>Notes</p> <p>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</p> <p>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</p> <p>M1 for finding $P(X=2)$ e.g. $\frac{e^{-\lambda} \lambda^2}{2!}$ with their value of λ in or if their λ is in the table for writing $P(X \leq 2) - P(X \leq 1)$ A1 awrt 0.0536</p> <p>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</p>	

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

Notes

- Q4 (a) **1st M1** attempting to integrate **at least one** part (at least one $x^n \rightarrow x^{n+1}$) (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 $\frac{1}{9}(t^2 - 2t + 2)$ (at least one $x^n \rightarrow x^{n+1}$). 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 $\int_3^x 3k + \dots$ (must get $3kt$ or $3kx$)
and they must use the correct limits and add $\int_0^3 \frac{1}{9}(t^2 - 2t + 2)$ or $\frac{2}{3}$
or use $+ C$ and use $F(4) = 1$
2nd A1 $\frac{x}{3} - \frac{1}{3}$ must be correct
1st B1 middle pair followed through from their answers. condone them using $<$ or \leq incorrectly they do not need to match up
2nd B1 end pairs. condone them using $<$ or \leq . 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)	$X \sim \text{Po}(10)$ $P(X < 9) = P(X \leq 8)$ $= 0.3328$	B1 M1 A1 (3)
(b)	$Y \sim \text{Po}(40)$ $Y \text{ is approximately } N(40,40)$ $P(Y > 50) = 1 - P(Y \leq 50)$ $= 1 - P\left(Z < \frac{50.5 - 40}{\sqrt{40}}\right)$ $= 1 - P(Z < 1.660..)$ $= 1 - 0.9515$ $= 0.0485$ <p>N.B. Calculator gives 0.048437. Poisson gives 0.0526 (but scores nothing)</p>	M1 A1 M1 M1 A1 A1 (6) Total [9]
Q5 (a)	<p>Notes</p> <p>B1 for using Po(10) M1 for attempting to find $P(X \leq 8)$: useful values $P(X \leq 9)$ is 0.4579(M0), using Po(6) gives 0.8472, (M1). A1 awrt 0.333 but do not accept $\frac{1}{3}$</p> <p>(b) 1st M1 for identifying the normal approximation 1st A1 for [mean = 40] and [sd = $\sqrt{40}$ or var = 40] NB These two marks are B1 M1 on ePEN</p> <p>These first two marks may be given if the following are seen in the standardisation formula : 40 and $\sqrt{40}$ or awrt 6.32</p> <p>2nd M1 for attempting a continuity correction (50 or 30 ± 0.5 is acceptable) 3rd 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 2nd A1 correct z value awrt ± 1.66 or this may be awarded if see $\pm \frac{50.5 - 40}{\sqrt{40}}$ or $\pm \frac{29.5 - 40}{\sqrt{40}}$</p> <p>3rd A1 awrt 3 sig fig in range 0.0484 – 0.0485</p>	

Question Number	Scheme	Marks
Q6	<p>(a) The set of values of the test statistic for which the null hypothesis is rejected in a hypothesis test.</p> <p>(b) $X \sim B(30, 0.3)$ $P(X \leq 3) = 0.0093$ $P(X \leq 2) = 0.0021$ $P(X \geq 16) = 1 - 0.9936 = 0.0064$ $P(X \geq 17) = 1 - 0.9979 = 0.0021$ Critical region is $(0 \leq) x \leq 2$ or $16 \leq x (\leq 30)$</p> <p>(c) Actual significance level $0.0021 + 0.0064 = 0.0085$ or 0.85%</p> <p>(d) 15 (it) is not in the critical region not significant No significant evidence of a change in $p = 0.3$ accept H_0, (reject H_1) $P(x \geq 15) = 0.0169$</p>	<p>B1 B1 (2)</p> <p>M1</p> <p>A1</p> <p>A1 A1A1 (5)</p> <p>B1 (1)</p> <p>Bft 2, 1, 0 (2)</p> <p>Total [10]</p>
Q6	<p>Notes</p> <p>(a) 1st B1 for “values/ numbers” 2nd B1 for “reject the null hypothesis” o.e or the test is significant</p> <p>(b) M1 for using $B(30, 0.3)$ 1st A1 $P(x \leq 2) = 0.0021$ 2nd A1 0.0064</p> <p>3rd A1 for $(X) \leq 2$ or $(X) < 3$ They get A0 if they write $P(X \leq 2 / X < 3)$ 4th A1 $(X) \geq 16$ or $(X) > 15$ They get A0 if they write $P(X \geq 16 X > 15)$ NB these are B1 B1 but mark as A1 A1</p> <p>$16 \leq X \leq 2$ 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.</p> <p>(c) B1 correct answer only</p> <p>(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</p>	

Question Number	Scheme	Marks																
Q7 (a)	<table border="1" data-bbox="223 268 970 392"> <tr> <td>x</td> <td>$1p$</td> <td>$2p$</td> </tr> <tr> <td>$P(X = x)$</td> <td>$\frac{1}{4}$</td> <td>$\frac{3}{4}$</td> </tr> </table> <p data-bbox="223 398 678 470">$\mu = 1 \times \frac{1}{4} + 2 \times \frac{3}{4} = \frac{7}{4}$ or $1\frac{3}{4}$ or 1.75</p> <p data-bbox="223 481 622 649">$\sigma^2 = 1^2 \times \frac{1}{4} + 2^2 \times \frac{3}{4} - \left(\frac{7}{4}\right)^2$ $= \frac{3}{16}$ or 0.1875</p> <p data-bbox="223 672 901 716">(b) (1,1,1), (1,1,2) any order, (1,2,2) any order, (2,2,2)</p> <p data-bbox="223 750 1332 828">(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 $3*(1,2,2)$</p> <p data-bbox="223 862 191 907">(c)</p> <table border="1" data-bbox="223 884 1189 1064"> <tr> <td>\bar{x}</td> <td>1</td> <td>$\frac{4}{3}$</td> <td>$\frac{5}{3}$</td> <td>2</td> </tr> <tr> <td>$P(\bar{X} = \bar{x})$</td> <td>$\frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} = \frac{1}{64}$</td> <td>$3 \times \frac{1}{4} \times \frac{1}{4} \times \frac{3}{4} = \frac{9}{64}$</td> <td>$3 \times \frac{1}{4} \times \frac{3}{4} \times \frac{3}{4} = \frac{27}{64}$</td> <td>$\frac{3}{4} \times \frac{3}{4} \times \frac{3}{4} = \frac{27}{64}$</td> </tr> </table>	x	$1p$	$2p$	$P(X = x)$	$\frac{1}{4}$	$\frac{3}{4}$	\bar{x}	1	$\frac{4}{3}$	$\frac{5}{3}$	2	$P(\bar{X} = \bar{x})$	$\frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} = \frac{1}{64}$	$3 \times \frac{1}{4} \times \frac{1}{4} \times \frac{3}{4} = \frac{9}{64}$	$3 \times \frac{1}{4} \times \frac{3}{4} \times \frac{3}{4} = \frac{27}{64}$	$\frac{3}{4} \times \frac{3}{4} \times \frac{3}{4} = \frac{27}{64}$	<p data-bbox="1364 414 1396 448">B1</p> <p data-bbox="1364 504 1396 537">M1</p> <p data-bbox="1364 604 1396 638">A1</p> <p data-bbox="1476 638 1524 683">(3)</p> <p data-bbox="1364 683 1396 716">B1</p> <p data-bbox="1364 750 1396 784">B1</p> <p data-bbox="1476 817 1524 862">(2)</p> <p data-bbox="1364 907 1396 940">B1</p> <p data-bbox="1364 940 1444 974">M1 A1</p> <p data-bbox="1364 974 1476 1008">M1 A1A1</p> <p data-bbox="1476 1086 1524 1131">(6)</p> <p data-bbox="1380 1153 1524 1198">Total [11]</p>
x	$1p$	$2p$																
$P(X = x)$	$\frac{1}{4}$	$\frac{3}{4}$																
\bar{x}	1	$\frac{4}{3}$	$\frac{5}{3}$	2														
$P(\bar{X} = \bar{x})$	$\frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} = \frac{1}{64}$	$3 \times \frac{1}{4} \times \frac{1}{4} \times \frac{3}{4} = \frac{9}{64}$	$3 \times \frac{1}{4} \times \frac{3}{4} \times \frac{3}{4} = \frac{27}{64}$	$\frac{3}{4} \times \frac{3}{4} \times \frac{3}{4} = \frac{27}{64}$														
Q7 (a)	<p data-bbox="223 1232 303 1265">Notes</p> <p data-bbox="223 1288 574 1411">B1 1.75 oe M1 for using $\sum(x^2 p) - \mu^2$ A1 0.1875 oe</p> <p data-bbox="223 1444 406 1489">(b) ignore repeats</p> <p data-bbox="223 1523 1324 1825">(c) 1st B1 4 correct means (allow repeats) 1st M1 for p^3 for either of the ends 1st A1 for $1/64$ or awrt 0.016 and $27/64$ or awrt 0.422 2nd 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 $5/3$. 2nd A1 for $9/64$ (or $3/64$ three times) and $27/64$ (or $9/64$ three times) accept awrt 3dp. 3rd A1 fully correct table, accept awrt 3dp.</p>																	

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