

# **Mark Scheme for June 2011**

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Mark schemes should be read in conjunction with the published question papers and the Report on the Examination.

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1 (i)	$\sum_{x=0}^n \binom{n}{x} p^x q^{n-x} t^x$ $= \sum_{x=0}^n \binom{n}{x} (pt)^x q^{n-x}$	M1 A1 <b>2</b>	From $E(t^x)$  M1A0 $\sum$ without limits $G_X(t)=q+pt$ M1 then argument A0
(ii)	$G_T(t) = (q+pt)^n (q+pt)^{2n}$ $= (q+pt)^{3n}$ <p>So <math>T \sim B(3n, p)</math></p>	M1 A1 M1 A1 <b>4</b> <b>[6]</b>	Multiplying pgfs  For B For parameters
2 (i)	$H_0: m_d = 0, H_1: m_d > 0$ , (where $d = \text{high} - \text{low}$ ) $D: \quad -4 \ 3 \ 6 \ 1 \ 12 \ 7 \ 14 \ 16 \ 11 \ -9 \ 10$ Rank $-3 \ 2 \ 4 \ 1 \ 9 \ 5 \ 10 \ 11 \ 8 \ -6 \ 7$ $P = 57, Q = 9$ $T = 9$ $CV = 13$ $9 < CV$ so reject $H_0$ There is sufficient evidence at the 5% significance level to support the botanist's belief	B1 M1 A1 B1  B1 M1  A1 ft <b>7</b>	Or $H_0: m_H = m_L$ , etc. Medians  Ranking top down, -9, -10, 8, ..M1A0 $T=15$ B0 [SR last 3 marks: $z=-2;09$ B1 $<-1.96$ etc M1A1] Or equivalent  ft T
(ii)	The rank sum test is for independent samples, the $H$ and $L$ values are correlated	B1 <b>1</b> <b>[8]</b>	Accept data paired
3 (i)	$P(A B') = P(A \cap B') / P(B')$ $\Rightarrow P(A \cap B') = 1/8$ AEF Use $P(A \cap B) = P(A) - P(A \cap B')$ To give $P(A \cap B) = 5/8$ AEF	M1 A1 M1 A1 <b>4</b>	May be implied  Or equivalent
(ii)	$P(A \cap B \cap C) = 5/8 \times 1/4 = 5/32$ AEF	B1 $\checkmark$ <b>1</b>	Ft 5/8
(iii)	$P(B \cap C) = 3\lambda/4$ and $P(C \cap A) = 3\lambda/4$ Use formula for $P(A \cup B \cup C)$ And $P(A \cup B \cup C) = 1$ Sub into formula for $P(A \cup B \cup C)$ and solve for $\lambda$ giving $\lambda = 3/16$ AEF	M1 M1 B1 M1 A1 <b>5</b> <b>[10]</b>	For use of both conditional probs Allow one sign error
4 (i)	$M'(t) = 3(1/4 + 3/4 e^t)^2 \times 3/4 e^t$ $E(X) = M'(0) = 9/4$	M1 A1 A1 <b>3</b>	Allow one error
(ii)	mgf $(1/64 + 9/64 e^t + 27/64 e^{2t} + 27/64 e^{3t})$ $P(X=2) = \text{coefficient of } e^{2t} = 27/64$	M1 A1 A1 <b>3</b>	Or PGF $= (1/4 + 3/4 z)^3$ expand find coefficient of $z^2$ 27/64
(iii)	Sum of 3 obs of $Y$ with mgf $1/4 + 3/4 e^t$ has mgf of $X$ $y: 0 \quad 1$ $p: 1/4 \quad 3/4$ $\text{Var}(Y) = 3/4 - (3/4)^2 = 3/16$	M1*dep  A1 *M1A1 <b>4</b> <b>[10]</b>	OR $B(1, 3/4)$ Using $E(Y^2) - (E(Y))^2$ OR $1 \times 3/4 \times 1/4$ M0 if integration used

5(i)	Does not require a known probability distribution	B1 1	Or equivalent
(ii)	$H_0: m_A = m_B, H_1: m_A \neq m_B$ Ranks: A 1 2 3 5 6 10 B 4 7 8 9 11 12 $R_A = 27, 78 - 27 = 51$ , so $W = 27$ OR: $R_B = 51, 78 - 51 = 27$ 5% CV = 26 $27 > CV$ so do not reject $H_0$ there is insufficient evidence at the 5% SL to indicate a difference in breaking strengths	B1 M1 M1 A1 B1 M1 A1 7	Medians Use N(39,39) with cc B1 $P(W \leq 27.5), Z = -1.84$ or equivalent M1 Not in CR etc A1
(iii)	B would have an extra rank 13 W still 27 but CV now 27 $H_0$ is now rejected	M1 B1 A1 3 [11]	$P(W \leq 27.5) = -2.07$ M1A1 In CR $H_0$ rejected A1
6(i)	$L=0, C=1$ , choose 1C from 14 and 1 from 6 Others $14 \times 6 / {}^{36}C_2 = 2/15$ AG $L=1, C=1$ , choose 1 from 16, 1 from 14 $16 \times 14 / {}^{36}C_2 = 16/45$ AG	M1 A1 M1 A1 4	Or ${}^{14}/_{36} \times {}^6/_35 \times 2$ Or ${}^{14}/_{36} \times {}^{16}/_{35} \times 2$
(ii)	Marginal C probs: 11/30 22/45 13/90 $E(C) = 22/45 + 26/90 = 35/45 = 7/9$	B1 M1 A1 3	AEF
(iii)	EITHER: $2 \times 1/42 + 2/15 + 16/105$ OR: $E(L) = 8/9, E(O) = 2 - 15/9 = 1/3$	M1 A1 A1 3	Other: 0 1 2 M1 p: ${}^{29}/_{42} \quad {}^2/_7 \quad {}^1/_42$ A1 $E(O) = {}^2/_7 + {}^2/_42 = {}^1/_3$ A1
(iv)	EITHER: Argument OR: Use idea that for independence $P(L \cap C) = P(L)P(C)$ Conclude that covariance is non-zero	B2 M1A1 B1 3 [13]	e.g The more Ls the fewer Cs OR Use conditional probability OR $\text{Cov}(L,C) = -136/405$ M1A1 L,C not indep B1
7(i)	$E(S) = \frac{1}{2}(E(\bar{U}_4) + E(\bar{U}_6))$ $= \frac{1}{2}(\mu + \mu) = \mu$ , so S is unbiased $\text{Var}(S) = \frac{1}{4}(\sigma^2/4 + \sigma^2/6)$ $= 5\sigma^2/48$	M1 A1 M1 A1 4	With conclusion
(ii)	$E(T) = (a+b)\mu = \mu, a+b=1$ $\text{Var}(T) = a^2\sigma^2/4 + b^2\sigma^2/6$ Minimise $y = a^2/4 + b^2/6 = a^2/4 + (1-a)^2/6$ EITHER by differentiation OR, completing square, OR from a sketch graph. Giving $a = 2/5, b = 3/5$ Justify minimum value Variance = $\sigma^2/10$	M1 B1 M1 M1 A1 B1 A1 7	Allow from completion of square
(iii)	T is better since (both are unbiased and) $\text{Var}(T) < \text{Var}(S)$	B1 1	From calculated variances
(iv)	Sample mean of 10 observations (is also unbiased) with $\sigma^2/10$ They have the same efficiency	M1 A1 2 [14]	Or show that $T =$ mean of 10 observations

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