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Mark Scheme (Results)

Summer 2013

GCE Statistics 4 (6686/01R)

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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.

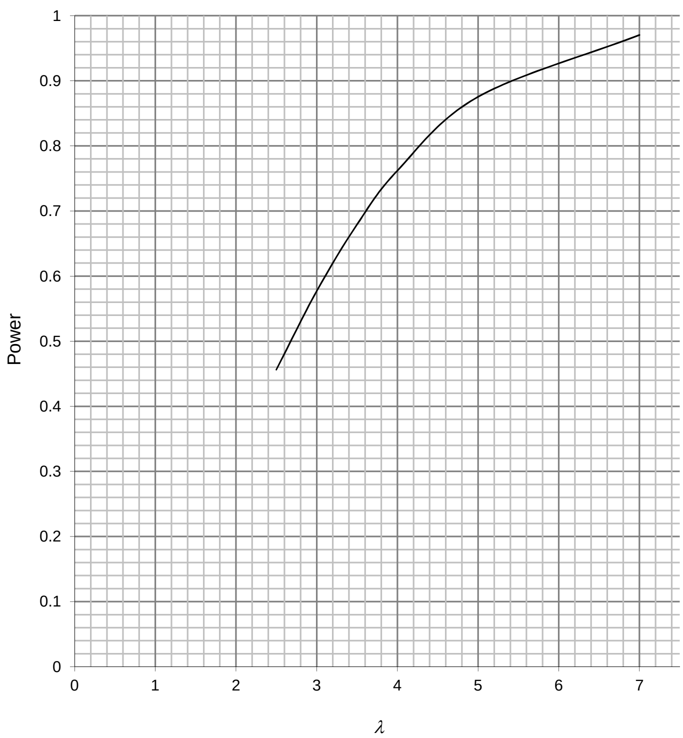
6. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
    - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

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

8. 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.

Question Number	Scheme	Marks
1.(a)	P(X > 1.690) = 0.975	
	P(X > a) = 0.025	M1
	a = 16.013	A1
		(2)
(b)	Upper critical value of $F_{6,4}$ = 15.21	B1
	Lower critical value of $F_{6,4} = \frac{1}{9.15} = 0.109$	B1
		(2)
		[4]
	Notes	
(a)	M1 for using 0.025	
(b)	2nd B1 either $\frac{1}{9.15}$ or awrt 0.109	

Question Number	Scheme	Marks
2.		
(a)	$\frac{29\times 0.36}{45.722} < \sigma^2 < \frac{29\times 0.36}{16.047}$	M1B1,B1
	$0.228 < \sigma^2 < 0.651$	M1 A1
		(5)
(b)	Since 0.495 lies in the interval or $0.228 < 0.495 < 0.651$ yes	B1ft B1ftd
		(2)
		[7]
	Notes	
(a)	1st M1 use of $\frac{29\times s^2}{\chi^2}$ $\left(\text{May use } \frac{s^2}{F_{29,\infty}} \text{ or } s^2\times F_{29,\infty}\right)$ $\left(\text{Based on } \frac{s^2}{\sigma^2} = F_{29,\infty}\right)$ 1st B1 45.722 $\left(\text{using } \frac{s^2}{F_{29,\infty}} \text{ and } s^2\times F_{29,\infty}\right)$ 2nd B1 16.047 (may use $F_{29,\infty} = 1.4686$) 2nd M1 correct answer using their χ^2 value (correct using their $F_{29,\infty}$) A1 awrt 0.228 and awrt 0.651 (awrt 0.245 and awrt 0.529)	
(b)	ft their interval	

Question Number	Scheme	Marks
3. (a)	$X \sim \text{Po}(2)$	
	Size = P($X \geq 3 / \lambda = 2$)	
	$= 1 - 0.6767$	M1
	$= 0.3233$ awrt 0.323	A1 **(2)**
(b)	Power = 1 – P(0) – P(1) – P(2)	M1
	$= 1 - e^{-\lambda} - \lambda e^{-\lambda} - \frac{\lambda^2 e^{-\lambda}}{2!}$	A1
	$= 1 - \frac{1}{2} e^{-\lambda}\left(2 + 2\lambda + \lambda^2\right)$	A1 cso **(3)**
(c)	$r = 0.58$ $s = 0.76$	B1, B1 **(2)**
(d)		B1ft points B1ft curve **(2)**
(e)	$\lambda > 3.1$ allow numbers in range 3.1-3.2	B1 **(1)**
		[10]
	Notes	
(a)	M1 for correct expression for size using Po(2)	
(b)	1st M1 for a correct expression in terms of probabilities. Allow 1- P($X \leq 2$) or 1- P($X < 3$)	
	1st A1 for correct equation in λ	
	2nd A1 cso	
(c)	SC if both correct but not to 2dp award B1B0	
(d)	1st B1ft points	
	2nd B1ft curve (or straight lines) through points	

Question Number	Scheme	Marks
4. (a)(i)	Ardo $s^2 = \frac{1}{6}(1257.78 - 7(13.4)^2)$	M1
	$= 0.143\ldots$ awrt 0.143	A1
(ii)	Bards $0.261 = \dfrac{6\times 0.143... + 8\times s^2}{7+9-2}$	M1
	$s^2 = 0.349\ldots$	A1 (4)
(b)	$\mathrm{H}_0: \sigma_1^2 = \sigma_2^2,\ \mathrm{H}_1: \sigma_1^2 \neq \sigma_2^2$	B1
	critical values $F_{8,6} = 4.15$ $\left(\dfrac{1}{F_{8,6}} = 0.241\right)$	B1
	$\dfrac{s_2^2}{s_1^2} = \dfrac{0.349}{0.143} =$ awrt 2.44 $\left(\dfrac{s_1^2}{s_2^2} = \dfrac{0.143}{.349} = 0.41\right)$	M1; A1
	Since 2.44… (0.424) is not in the critical region we accept H_0 and conclude there is no evidence that the two variances are different	A1cso **(5)**
(c)	H_0: $\mu_B - \mu_A = 0.9$; H_1: $\mu_B - \mu_A > 0.9$ both	B1
	CR: $t_{14}(0.05) > 1.761$ 1.761	B1
	$t = \pm\dfrac{14.8 - 13.4 - 0.9}{\sqrt{0.261\left(\frac{1}{7}+\frac{1}{9}\right)}} = \pm 1.94\ldots$	M1 A1
	awrt $\pm$ 1.94	A1
	Since 1.94… is in the critical region we reject H_0 and conclude that the **mean strength** of rods from ***Bards*** **is more than 0.9 kN** than that from ***Ardo***.	A1 ft **(6)**
	Notes	**[15]**
(a)(i)	M1 for attempt to calculate s^2	
(ii)	M1 use of correct formula for s_p^2 A1 awrt 0.349 / 0.3495	
(b)	1st B1 allow $\mathrm{H}_0: \sigma_1 = \sigma_2,\ \mathrm{H}_1: \sigma_1 \neq \sigma_2$ M1 For use of a correct formula	
(c)	B1 must use μ. If not use A and B it must be clear which is which M1 for attempt at correct test statistic – matching their hypotheses 1st A1 correct test statistic for their hypotheses	

Question Number	Scheme	Marks
5.	D = Paper I score – paper II score	
	H$_0$: $\mu_D = 1$ H$_1$: $\mu_D > 1$	B1
	d: 4, 1, 7, 3, -1, 1, 9, 2	M1
	$\bar{d} = 3.25$; $s^2 = \frac{162 - 8\times 3.25^2}{7} = 11.07..$ (s = 3.32)	M1;M1
	$t_7 = \frac{3.25-1}{3.32/\sqrt{8}} = 1.9126\ldots$ awrt 1.91	M1A1
	$t_7(5\%) = 1.895$	B1
	There is evidence to support the **teacher's** belief or the score on **paper I** is more than one mark **higher** than on **paper II**	A1 ft **(8)** **[8]**
	Notes	
(a)	1st M1 for attempting differences 2nd M1 for attempting $\bar{d}$ 3rd M1 for attempting s_d or $s_d{}^2$, correct expression with their $\sum d^2$ and $\bar{d}$ or correct calculation (to 2 sf or better) 4th M1 for use of $\frac{\bar{d}-1}{s/\sqrt{8}}$, ft their values. 1st A1 awrt 1.91 2nd B1 for 1.895 2nd A1 contextual conclusion ft their values. SC if they use a 2 sample test they may get the first B1 for H$_0$: $\mu_{I} - \mu_{II} = 1$ and H$_1$: $\mu_{I} - \mu_{II} > 1$	

Question Number	Scheme	Marks
6.		
(a)	H_0: $\mu = 500$ [accept ≤ 500], H_1: $\mu > 500$	B1
	$t = \dfrac{502-500}{\sqrt{5.6}/\sqrt{12}} = 2.93$	M1A1
	critical value $t_{11}(1\%) = 2.718$	B1
	sufficient evidence that the mean **amount** of **water** is more than **500** ml	A1 ft **(5)**
(b)	H_0: $\sigma^2 = 9$ or (σ =3), H_1: $\sigma^2 < 9$ or . (σ <3)	B1
	test statistic $\dfrac{11s^2}{\sigma^2}$ =, $\dfrac{61.6}{9}$ = 6.84	M1 A1
	critical values $\chi^2_{11}(1\%)\,\text{lower tail} = 3.053$	B1
	Insufficient evidence to suggest that the **standard deviation** of the amount of **water** is less than 3	A1cso **(5)** **[10]**
	Notes	
(a)	M1 attempt at correct statistic	
	1st A1 awrt 2.93	
	2nd A1ft correct contextual comment including amount , water and 500	
(b)	1st B1 Both hypotheses, must use σ	
	2nd B1 for critical value, this should be compatible with their alternative hypothesis	
	3rd A1cso cso. contextual comment, include standard deviation/ variance and water	

Question Number	Scheme	Marks
7.		
(a)	$\dfrac{CV-202}{2/\sqrt{n}}=-2.3263$	M1 B1
	CR $\le 202-\dfrac{4.6526}{\sqrt{n}}$ or $202-2.3263\sqrt{\dfrac{4}{n}}$	A1
		(3)
(b)	$\dfrac{CV-200}{2/\sqrt{n}}=1.6449$ or $\dfrac{2-\dfrac{4.6526}{\sqrt{n}}}{\dfrac{2}{\sqrt{n}}}>1.6449$	M1 B1
	CV = $200+\dfrac{3.2898}{\sqrt{n}}$	
	Solving simultaneously	
	$2=\dfrac{7.9424}{\sqrt{n}}$ or $\sqrt{n}-\dfrac{4.6526}{2}>1.6449$	M1
	$\sqrt{n}=3.9712$	A1
	n = 15.77	A1
	n = 16	A1
		(6)
		[9]
	Notes	
	Note only lose one B1 for not reading from points table. This should be deducted the first time it is done	
(a)	1st M1 use correct formula equal a z value	
	A1 allow use of <	
(b)	1st M1 use correct formula equal a z value	
	B1 – if B mark lost in part (a) allow 1.64 or 1.65	
	1st A1 awrt 3.97 may be implied by an answer of 15.77 **or** an answer of 16 and using 1.6449	
	2nd A1 awrt 15.8 may be implied by an answer of 16	

Question Number	Scheme	Marks
8.		
(a)	$\mathrm{E}\left(\sum_{i=1}^{n} W_i\right) = n\mu$	B1
	$\mathrm{E}\left(W_i^2\right) = \mathrm{Var}\left(W_i\right) + \left(\mathrm{E}\left(W_i\right)\right)^2$	M1
	$= \sigma^2 + \mu^2$	A1
	$\mathrm{E}\left(\sum_{i=1}^{n} W_i^2\right) = \mathrm{E}(W_1^2 + W_2^2 + \ldots.\ W_n^2)$	
	$= n\left(\sigma^2 + \mu^2\right)$	A1 cso
		(4)
(b)	$\mathrm{E}\left(\frac{1}{n}\sum_{i=1}^{n} W_i\right) = \frac{1}{n}\mathrm{E}\left(\sum_{i=1}^{n} W_i\right)$	
	$= \mu$	B1
	$\mathrm{Var}\left(\frac{1}{n}\sum_{i=1}^{n} W_i\right) = \frac{1}{n^2}\mathrm{Var}\left(W_1 + W_2 + \ldots + W_n\right)$	
	$= \frac{1}{n^2} n\sigma^2$	
	$= \frac{\sigma^2}{n},\ \to 0 \text{ as } n \to \infty$	B1,B1d
		(3)
(c)	$\mathrm{E}\left[\frac{1}{n}\left(\sum w_i^2\right) - \left(\overline{w}\right)^2\right] = \frac{1}{n} \times n\left(\sigma^2 + \mu^2\right) - \mathrm{E}(\overline{w}^2)$	M1
	$\mathrm{Var}\ (\overline{w}) = \mathrm{E}\ (\overline{w}^2) - [\mathrm{E}(\overline{w})]^2 \Rightarrow \mathrm{E}\ (\overline{w}^2) - \mu^2 = \frac{\sigma^2}{n}$	M1
	Hence expected value is $\left(\sigma^2 + \mu^2\right) - \frac{\sigma^2}{n} - \mu^2 = \frac{(n-1)\sigma^2}{n}$	A1
	Bias = $(-)\frac{\sigma^2}{n}$	A1
		(4)
(d)	$\frac{n}{(n-1)} U$	B1
		(1)
		[12]

	Notes	
(a) **(b)** **(c)** **(d)**	1st M1 using $\mathrm{E}\left(W_i^{\ 2}\right) = \mathrm{Var}\left(W_i\right) + \left(\mathrm{E}\left(W_i\right)\right)^2$ 2nd B1 stating $\mathrm{Var}\left(\frac{1}{n}\sum_{i=1}^{n} W_i\right) = \frac{\sigma^2}{n}$ 3rd B1 dependent on 2nd B1, stating $\frac{\sigma^2}{n} \to 0 \text{ as } n \to \infty$ 1st M1 attempting correct method with their answer to part (a) – award for $\left(\sigma^2 + \mu^2\right) - E\left(\frac{1}{n}\sum_{i=1}^{n} w_i\right)^2$ 2nd M1 using Var ($\overline{w}$) = E ($\overline{w}^2$) – [E($\overline{w}$)]^2 Allow $\frac{n}{(n-1)}\sigma^2$	

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