

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
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5	
6	
7	
TOTAL	



General Certificate of Education  
Advanced Level Examination  
June 2013

# Mathematics

# MS04

## Unit Statistics 4

Friday 21 June 2013 9.00 am to 10.30 am

**For this paper you must have:**

- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

### Time allowed

- 1 hour 30 minutes

### Instructions

- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Write the question part reference (eg (a), (b)(i) etc) in the left-hand margin.
- You must answer each question in the space provided for that question. If you require extra space, use an AQA supplementary answer book; do **not** use the space provided for a different question.
- Do not write outside the box around each page.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- The **final** answer to questions requiring the use of tables or calculators should normally be given to three significant figures.

### Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.

### Advice

- Unless stated otherwise, you may quote formulae, without proof, from the booklet.
- You do not necessarily need to use all the space provided.



J U N 1 3 M S 0 4 0 1

Answer **all** questions.

Answer each question in the space provided for that question.

- 1** A gardener decided to compare the variability in the heights of sunflowers grown on the sunny side of her garden with the variability in the heights of those grown on the shady side of her garden.

She selected a sample of 13 sunflowers on the sunny side and a sample of 10 sunflowers on the shady side of her garden. She measured the height of each sunflower, in metres, correct to two decimal places. Each sample may be regarded as a random sample.

The independent random variables  $X$  and  $Y$  denote the height, in metres, of sunflowers grown on the sunny side and on the shady side of her garden respectively. You may assume that  $X$  and  $Y$  are normally distributed with variances  $\sigma_X^2$  and  $\sigma_Y^2$  respectively.

The following results were obtained.

$$\sum(x - \bar{x})^2 = 4.68 \quad \text{and} \quad \sum(y - \bar{y})^2 = 8.10$$

- (a) Calculate unbiased estimates of  $\sigma_X^2$  and  $\sigma_Y^2$ . (1 mark)
- (b) The gardener believed that the height of sunflowers grown on the shady side was more variable than the height of sunflowers grown on the sunny side.

Carry out an  $F$ -test, using a significance level of 5%, to test this belief. (6 marks)

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QUESTION  
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- 7** The conductivity,  $\gamma$ , of metal wire is estimated by observing a related random variable,  $R$ , which has probability density function

$$f(r) = \begin{cases} \frac{2r}{\gamma^2} & 0 \leq r \leq \gamma \\ 0 & \text{otherwise} \end{cases}$$

- (a) (i)** Show that  $\frac{3}{2}R$  is an unbiased estimator of  $\gamma$ . (4 marks)
- (ii)** Given that the variance of  $R$  is  $\frac{1}{18}\gamma^2$ , find, in terms of  $\gamma$ , the variance of  $\frac{3}{2}R$ . (2 marks)
- (b)** The conductivity can also be estimated by making observations of a random variable,  $S$ , which has mean  $\frac{1}{4}\gamma$  and variance  $\frac{1}{16}\gamma^2$ . The random variable  $T$  is defined by  $T = S_1 + S_2 + S_3$ , where  $S_1, S_2$  and  $S_3$  are three independent observations of  $S$ .
- (i)** Find the value of the constant  $k$  such that  $kT$  is an unbiased estimator of  $\gamma$ . (2 marks)
- (ii)** Hence find the relative efficiency of  $\frac{3}{2}R$  with respect to  $kT$ . (4 marks)
- (iii)** State, with justification, which of  $\frac{3}{2}R$  and  $kT$  is a preferred unbiased estimator of  $\gamma$ . (2 marks)

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QUESTION  
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