Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
TOTAL	

General Certificate of Education
Advanced Level Examination
June 2013

Statistics SS06

Unit Statistics 6

Tuesday 18 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.

Answer **all** questions.

Answer each question in the space provided for that question.

1 A podiatrist wishes to investigate the use of an EMC device for measuring the mobility of the first ray of a patient's foot. The EMC device is to be compared with the currently used K device.

Ten patients at a podiatry clinic each had the mobility of the first ray of one of their feet measured by each device. The order in which the devices were used was random.

The measurements obtained, in degrees, are given in the table.

Patient	1	2	3	4	5	6	7	8	9	10
K device	3.2	4.8	3.7	4.5	5.2	3.8	4.2	4.3	4.2	5.7
EMC device	3.6	4.0	4.1	5.0	5.1	4.6	4.7	4.3	4.8	5.6

(a) (i) Carry out a paired *t*-test, using the 5% level of significance, to investigate for a mean difference between the measurements obtained from the two devices. *(8 marks)*

(ii) State the distributional assumption that it was necessary to make in order to make the test in part **(a)(i)** valid. *(2 marks)*

(b) A double-sampling plan is suggested to monitor the production of the EMC device.

A random sample of 20 EMC devices is taken from a large batch.

The batch is accepted if no non-conforming devices are found in the sample.

The batch is rejected if 2 or more non-conforming devices are found in the sample.

Otherwise, a second random sample of 20 devices is taken and the batch is accepted if a total of 2 or fewer non-conforming devices are found in the 40 devices sampled.

(i) Find the probability of accepting a batch containing 3% non-conforming devices. *(4 marks)*

(ii) Calculate the expected number of devices sampled from a batch containing 3% non-conforming devices. *(2 marks)*

QUESTION PART REFERENCE

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2 Semiconductor wafers are produced in large batches at a manufacturing facility. Individual wafers then receive doses of an implant material in a diffusion process that takes place in a furnace. Engineers are to investigate whether different wafer-implant-material doses have a significant effect on resistivity measurements.

The engineers wish to use four different doses of implant material: D1, D2, D3 and D4.

Twelve wafers, all selected from the same batch, are obtained for this investigation.

As only four wafers can be allowed in any one furnace run, the wafers will have to be tested in three different furnace runs: F1, F2 and F3.

(a) (i) Name the blocking factor.

(ii) Name the treatment factor.

(iii) Give a reason why the 12 wafers should be chosen from the same batch. *(4 marks)*

(b) One engineer, Eric, suggests using a completely randomised design for this experiment. Another engineer, Harriet, suggests using a randomised block design.

(i) Explain why Harriet's suggestion is preferable to Eric's suggestion. *(2 marks)*

(ii) Complete **Table 1** opposite to illustrate Harriet's suggestion for the design of this experiment. *(2 marks)*

(c) Name the technique that you would use in order to analyse data obtained from an experiment using Harriet's suggested design. *(2 marks)*

QUESTION PART REFERENCE	**Answer space for question 2**

QUESTION PART REFERENCE

Answer space for question 2

Table 1

Furnace run		
F1	**F2**	**F3**

3 A treatment for cotton thread is being tested by a large company. The treatment increases the breaking strength of the thread.

The treatment can be applied at three different levels: low, medium and high.

Sixteen lengths of cotton thread are obtained and are randomly assigned to have low level treatment, medium level treatment or high level treatment.

The breaking strengths, in grams, for the 5 lengths of thread assigned to have the low level treatment are

18.5 16.4 16.6 17.3 17.0

The breaking strengths, in grams, for the 6 lengths of thread assigned to have the medium level treatment are

18.3 17.4 18.5 18.3 17.2 18.9

The breaking strengths, in grams, for the 5 lengths of thread assigned to have the high level treatment are

18.1 16.8 17.4 16.3 17.0

Breaking strengths can be assumed to be normally distributed with a common variance.

(a) (i) Carry out a one-factor analysis of variance, using the 5% level of significance, to investigate for a difference in the mean breaking strength between the three thread treatment levels: low, medium and high. *(10 marks)*

(ii) What advice would you give the company about its choice of treatment level? *(2 marks)*

(b) If the distributional assumption made in order to carry out the test in part **(a)(i)** were found to be incorrect, state, with a reason, an alternative test that could be used to investigate for a difference in the mean breaking strength between the three thread treatments. *(2 marks)*

QUESTION PART REFERENCE

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4 Mischmetal is made into 1 kg ingots by the Fermetall company. The weights of the ingots vary slightly during production, and the quality of the production is monitored by taking a random sample of 4 ingots at regular intervals.

It is known that the standard deviation of the weights of 1 kg ingots produced by Fermetall is 0.015 kg.

(a) Calculate, to three decimal places, upper and lower warning (95%) and action (99.8%) control limits for:

(i) sample means;

(ii) sample standard deviations.

You are **not** required to plot these limits. *(6 marks)*

(b) Eight samples of 4 ingots were taken at regular intervals during a shift at Fermetall. The results, in kilograms, are given in **Table 2** opposite.

(i) Complete **Table 2**. *(3 marks)*

(ii) State what action should have been taken on the basis of the results for sample 5. *(2 marks)*

(iii) Comment on the performance of the process over the eight samples. *(3 marks)*

(c) The production process for the ingots is later found to be operating with a mean of 1.004 kg and a standard deviation of 0.02 kg.

Find the probability that the value of a sample mean will lie between the warning limits. *(3 marks)*

QUESTION PART REFERENCE

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QUESTION PART REFERENCE

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Table 2

Sample	1	2	3	4	5	6	7	8
	1.02	0.97	0.99	1.01	1.03	0.96	1.02	0.97
	1.03	1.01	1.02	0.99	1.04	0.97	0.99	0.97
	0.98	1.02	1.03	1.00	0.95	1.01	0.96	1.02
	0.99	1.01	0.98	0.97	1.02	0.98	1.03	1.02
Mean	1.005	1.003	1.005	0.993	1.010		1.000	
Standard deviation	0.024	0.022	0.024	0.017		0.022	0.032	

QUESTION PART REFERENCE

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QUESTION PART REFERENCE

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5 An oil company compared four different blends of petrol, A, B, C and D, for fuel efficiency. It used four different car drivers, 1, 2, 3 and 4, and four different models of mid-sized family car, I, II, III and IV.

The cars were driven around a standard 50 mile route and the subsequent miles per gallon (mpg) were recorded.

The results are given in **Table 3**.

Table 3

		Car model			
		I	**II**	**III**	**IV**
Driver	**1**	B 32.1	C 23.5	D 33.6	A 29.3
	2	C 28.9	A 27.4	B 36.1	D 36.4
	3	D 30.1	B 34.1	A 30.1	C 31.6
	4	A 34.2	D 24.3	C 30.2	B 34.3

$$\sum\sum x_{ij}^2 = 15606.3 \qquad \sum x_i = 496.2$$

(a) Name the type of experimental design used. *(1 mark)*

(b) (i) Complete **Table 4** opposite. *(7 marks)*

(ii) Hence investigate for a difference between mean fuel efficiency for the four different blends of petrol and for the four different models of car. Use a 5% level of significance. *(5 marks)*

(iii) Comment on your conclusions to the tests that you carried out in part **(b)(ii)** in the context of the question. *(2 marks)*

(c) State all of the assumptions that it was necessary to make in order to make the tests in part **(b)(ii)** valid. *(3 marks)*

QUESTION PART REFERENCE

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QUESTION PART REFERENCE

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Table 4

Source	Sum of squares	Degrees of freedom	Mean square	*F*-ratio
Driver	14.47	3	4.82	
Car model	77.88			
Petrol blend		3		
Error				
Total				

QUESTION PART REFERENCE

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END OF QUESTIONS

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