Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

A-level
STATISTICS

Unit Statistics 6

Monday 25 June 2018 Morning Time allowed: 1 hour 30 minutes

Materials
For this paper you must have:
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

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 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.

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
TOTAL	

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Answer **all** questions.

Answer each question in the space provided for that question.

1 Bags of cement, of nominal weight $25\ \text{kg}$, are delivered to a builder's merchant in large batches.

The builder's merchant uses an acceptance sampling scheme to determine whether it will accept delivery of a batch of such bags.

The current sampling scheme used by the builder's merchant is given below.

- Select a random sample of 8 bags from the batch.
- Accept the batch if the mean weight of these 8 bags exceeds $25.3\ \text{kg}$, otherwise reject the batch.

It may be assumed that the weights of bags of cement are normally distributed with a standard deviation of $0.75\ \text{kg}$.

(a) Calculate the probability that a batch will be accepted if the mean weight, in kilograms, of a bag of cement in a batch is:

(i) 24.75;

(ii) 25.50 .

[4 marks]

(b) Aled is the new purchasing manager at the builder's merchant. He is reviewing the sampling scheme used for batches of bags of cement.

(i) Aled requires that the sampling scheme used should have a probability of at least 0.95 of **rejecting** a batch with a mean weight of $24.75\ \text{kg}$, and a probability of at most 0.01 of **rejecting** a batch with mean weight $25.75\ \text{kg}$.

He suggests that the sample size should be increased to 10 and that a batch should now be accepted if the mean weight of bags in the sample exceeds $25.25\ \text{kg}$.

Carry out calculations to demonstrate that Aled's new suggested sampling scheme satisfies only one of his two requirements.

(ii) Advise Aled how he should change the sample size for his suggested sampling scheme in order to meet his requirements.

No further calculations are required.

[4 marks]

(c) Operating an acceptance sampling plan may be regarded as equivalent to carrying out a hypothesis test with

$$H_0\text{: Batch is satisfactory}$$

Explain the meaning of a Type II error in the context of acceptance sampling.

[2 marks]

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QUESTION PART REFERENCE	Answer space for Question 1

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2 An environmental protection agency decided to investigate the bioaccumulation of mercury in otters.

Otter carcasses were obtained from three areas of Scotland during 2014.

The concentration of mercury, in milligrams per kilogram, was measured in the livers of otters obtained from random selections of otter carcasses found in each of the three areas.

The results are summarised in the table.

Area of Scotland		
Shetland	**Argyll**	**North Central**
9.16	13.86	9.02
12.14	14.76	9.85
11.40	16.98	8.13
9.55	14.74	10.40
10.47	13.74	8.10
11.51		9.13
		10.22

Carry out a one-factor analysis of variance, using the 5% level of significance, to investigate for a difference between the mean concentrations of mercury in otters for the three different areas of Scotland.

You should interpret your conclusion fully in the context of the question.

[11 marks]

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

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3 Rupal, the Human Resources manager of a large chain of optician stores, was investigating absenteeism and job satisfaction of employees.

Rupal was concerned that the level of absenteeism was too high. In order to try to reduce absenteeism, Rupal introduced a new bonus scheme for employees.

(a) Rupal measured the percentage absenteeism in each of a random sample of 10 stores during a three-month period before the bonus scheme was introduced and also during a three-month period after it was introduced.

The results are given in **Table 1**.

Table 1

	Store									
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Before	5.2	6.1	3.4	6.5	6.8	8.2	6.1	4.8	4.9	3.5
After	4.4	6.4	2.8	4.6	6.5	5.6	5.2	5.7	5.6	1.9

(i) Carry out a t-test, using the 5% level of significance, to investigate whether mean percentage absenteeism reduced following the introduction of the bonus scheme.

[9 marks]

(ii) State any necessary assumption for the test in part **(a)(i)** to be valid.

[1 mark]

QUESTION PART REFERENCE	**Answer space for Question 3(a)**

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QUESTION PART REFERENCE	Answer space for Question 3(a)

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(b) Rupal also selected a random sample of 16 employees and asked them to complete a 'satisfaction' survey after the bonus scheme was introduced.

The survey result provided an employee satisfaction score, on a scale from 0 to 10, where 0 represented an employee who was completely unhappy and 10 represented an employee who was completely happy with all aspects of working in a store.

The scores are given in **Table 2**.

Table 2

Employee	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Score	5.0	5.6	9.4	9.6	8.5	6.8	7.4	4.6	7.8	9.0

Employee	**11**	**12**	**13**	**14**	**15**	**16**
Score	6.2	5.2	3.4	2.8	8.8	7.2

Rupal knew that the median satisfaction score before the bonus scheme was introduced was 5.2 . He claimed that the bonus scheme resulted in a higher median satisfaction score.

Carry out a sign test, using the 5% level of significance, to investigate Rupal's claim.

[6 marks]

QUESTION PART REFERENCE	**Answer space for Question 3(b)**

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QUESTION PART REFERENCE	Answer space for Question 3(b)

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4 Mariam, an ecologist, is interested in the effect of the local environment on the growth of pine saplings.

She wishes to study the effect of 3 different environments, E_1 , E_2 and E_3 on the mean growth of pine saplings.

Mariam's colleague, Paolo, obtains 9 saplings, S_1, S_2 ….. S_9, for her study.

(a) (i) Construct a fully labelled table to illustrate a suitable experimental design for Mariam to use in her study.

(ii) State the name of the experimental design indicated by your table in part **(a)(i)**.

(iii) State the name of the technique that Mariam would need to use to analyse the data collected using the experimental design that you stated in part **(a)(ii)**.

[5 marks]

(b) Paolo later informs Mariam that the pine saplings he obtained for her study were of three different varieties.

- Saplings S_1, S_2 and S_3 were of variety V_1 .
- Saplings S_4, S_5 and S_6 were of variety V_2 .
- Saplings S_7, S_8 and S_9 were of variety V_3 .

(i) Construct a new fully labelled table to illustrate a different experimental design for Mariam to use, following Paolo's information about the saplings.

(ii) State the name of the experimental design indicated by your table in part **(b)(i)**.

(iii) State the name of the technique that Mariam would need to use to analyse the data collected using the experimental design that you stated in part **(b)(ii)**.

[4 marks]

(c) In light of Paolo's information regarding the pine saplings, state **one** advantage of the design that you stated in part **(b)(ii)** over the design that you stated in part **(a)(ii)**.

[2 marks]

QUESTION PART REFERENCE	**Answer space for Question 4**

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5 *Gretan Plastics* is a company that manufactures polycarbonate sheets for use in canopies.

Canopy sheets have a target width of 500 mm. When production is satisfactory, the widths of these sheets are approximately normally distributed with a standard deviation of 2.1 mm.

The production of these sheets is controlled by taking a sample of 6 sheets at regular intervals and measuring their widths.

(a) (i) Calculate upper and lower 95% warning limits and upper and lower 99.8% action limits for a control chart for means of sheet widths. You are not required to draw this chart.

[3 marks]

(ii) Calculate the corresponding upper warning limit and the upper action limit for a control chart for ranges of sheet widths.

[2 marks]

(iii) State the action, if any, that you would recommend *Gretan Plastics* to take regarding the production process for sheets for **each** of the following samples:

Sample 1	498.6	499.5	500.2	496.2	489.9	500.6
Sample 2	497.8	502.6	501.6	498.3	500.1	499.8

[4 marks]

QUESTION PART REFERENCE	**Answer space for Question 5(a)**

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QUESTION PART REFERENCE	Answer space for Question 5(a)

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(b) The quality control manager, Ava, at *Gretan Plastics* decides to introduce a new scheme for controlling the production of these sheets.

She decides to select a sample of 40 sheets from the production at regular intervals. Any sheet with a width outside the interval $500 \pm w$, where w is a value yet to be determined, is to be classed as non-conforming.

(i) Ava decides to select the value for w so that, when the mean width of sheets is 500 mm and the standard deviation is 2.1 mm, the probability of a randomly selected sheet being non-conforming is 0.15 .

Find the value of w .

[2 marks]

(ii) Calculate the upper warning limit and the upper action limit for a control chart for the proportion non-conforming to be used for Ava's new production control scheme.

[4 marks]

(iii) The following numbers of non-conforming sheets were found in the next two samples:
Sample 3: 11
Sample 4: 18
For **each** of these samples, comment on the state of control of the production process and suggest any resulting action that may need to be taken.

[3 marks]

QUESTION PART REFERENCE	**Answer space for Question 5(b)**

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QUESTION PART REFERENCE	Answer space for Question 5(b)

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6 An investigation is carried out by the company *Ecomest* into the effects of a fuel additive on the reduction of emissions of nitrogen oxides by car engines.

The analyst at *Ecomest* wants to use a Latin Square Design and then carry out an analysis of variance to investigate for a difference in mean emission reduction.

Ecomest is investigating the effectiveness of 4 different fuel additives, V, W, X and Y, on emission reduction.

There are 4 different drivers, 1, 2 ,3 and 4, involved in the investigation and 4 different makes of car are used.

All of the cars are of medium size and have the same size petrol engine.

The summarised results from the investigation by the analyst at *Ecomest* are given in **Table 3**.

Table 3

Driver	Car make	Additive	Emission reduction (grams per 100 miles)
1	Audi	V	21
1	Mercedes	W	26
1	Toyota	Y	20
1	Chrysler	X	25
2	Audi	Y	23
2	Mercedes	X	26
2	Toyota	V	20
2	Chrysler	W	27
3	Audi	W	15
3	Mercedes	Y	13
3	Toyota	X	16
3	Chrysler	V	16
4	Audi	X	17
4	Mercedes	V	15
4	Toyota	W	20
4	Chrysler	Y	20

(a) The partially completed ANOVA table, which arises from the analysis of the results in **Table 3**, is given in **Table 4** on the page opposite.

Complete **Table 4**.

[5 marks]

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(b) Hence, carry out an analysis of variance to test, at the 1% level of significance, for a difference between mean emission reductions of nitrogen oxides for the four different additives.

[4 marks]

QUESTION PART REFERENCE

Answer space for Question 6

Table 4

Source	Sums of squares	Degrees of freedom	Mean square
Between drivers	216	3	72
Between car makes	24		
Between additives			
Error			
Total	296	15	

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QUESTION PART REFERENCE	Answer space for Question 6

END OF QUESTIONS

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