General Certificate of Education
June 2008
Advanced Level Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

STATISTICS **SS06**
Unit Statistics 6

Wednesday 18 June 2008 9.00 am to 10.30 am

For this paper you must have:
- an 8-page answer book
- the blue AQA booklet of formulae and statistical tables
- an insert for use in Question 5 (enclosed).

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.
- Write the information required on the front of your answer book. The *Examining Body* for this paper is AQA. The *Paper Reference* is SS06.
- Answer **all** questions.
- Show all necessary working; otherwise marks for method may be lost.
- The **final** answer to questions requiring the use of tables or calculators should normally be given to three significant figures.
- Fill in the boxes at the top of the insert.

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

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions.

1 A company makes oven doors for use in the manufacture of electric cookers. The width of the doors has a target value of 850 mm. When production is satisfactory, the width of the doors is known to be normally distributed with standard deviation 0.8 mm. The process is to be controlled by taking a sample of four doors, at hourly intervals, and measuring their widths.

(a) Calculate upper and lower warning (95%) and action (99.8%) limits for charts for means. You are **not** required to draw the charts. *(4 marks)*

(b) Calculate upper and lower warning (95%) and action (99.8%) limits for charts for standard deviations. You are **not** required to draw the charts. *(2 marks)*

(c) The widths, in millimetres, of the next sample of oven doors are

851.6 850.4 850.9 849.9

State the action, if any, that you would advise as a result of this sample. *(3 marks)*

2 Sandra, a chemical engineer, wishes to compare four different instrument panels, **A**, **B**, **C** and **D**, for use in controlling a chemical process. Technicians are to be asked to assess the panels for ease of use. Two experimental designs are suggested.

Design 1 Twelve technicians are randomly allocated, three to each instrument panel.

Design 2 Three technicians each assess each instrument panel.

(The order in which they appear in each column is unimportant.)

Design 1

A	B	C	D
T_5	T_2	T_{12}	T_4
T_1	T_6	T_9	T_{11}
T_7	T_{10}	T_8	T_3

Design 2

A	B	C	D
T_1	T_1	T_1	T_1
T_2	T_2	T_2	T_2
T_3	T_3	T_3	T_3

(a) Identify the completely randomised design. *(1 mark)*

(b) Name the other type of experimental design suggested. *(1 mark)*

(c) Assuming that there is no difference in the difficulty of carrying out the two designs, explain why **Design 2** is preferred to **Design 1**. *(2 marks)*

3 An automated process produces chocolate-coated sweets. At regular intervals, a scoop is used to take a sample of the sweets. The chocolate coating of the sweets in the sample is inspected. The process is currently running satisfactorily and the results of the last 10 samples are summarised in the table.

Sample number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Number of sweets in the scoop	72	85	78	74	80	79	82	77	79	86
Number of sweets with an imperfect coating	10	7	9	11	8	8	13	7	11	10

(a) Show that a suitable estimate of:

(i) n, the number of sweets in a typical scoop, is 79;

(ii) p, the proportion of sweets with an imperfect coating when the process is running satisfactorily, is 0.119. *(2 marks)*

(b) Using $n = 79$ and $p = 0.119$, calculate values for upper and lower warning and action limits for charts for the proportion of sweets with an imperfect coating.

You are **not** required to draw the charts. *(4 marks)*

(c) State the action that you would recommend in **each** of the following cases.

(i) The next sample contains 76 sweets, 16 of which have an imperfect coating.

(ii) The next sample contains 13 sweets, 1 of which has an imperfect coating. *(4 marks)*

Turn over for the next question

4 Sidney claims to be an antiques expert. He offers a service advising customers on the price that they can obtain for antique items at auctions. He claims that, on average, his prices are correct and he offers the following supporting data from the 8 antique items which his customers have sold at auctions during the past month.

Item	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Price advised by Sidney, £	35	150	65	15	10	170	45	20
Price obtained at auction, £	53	160	22	8	35	115	35	15

(a) By carrying out a paired *t*-test, using the 10% significance level, verify that the data support Sidney's claim. The differences may be regarded as a random sample from a normal distribution. *(9 marks)*

(b) Further investigation reveals that, during the past month, Sidney's customers offered 12 further items for sale at auctions. However, the owners did not sell these 12 items because the only bids received were much lower than the prices advised by Sidney.

Apply a sign test to these 20 items (the 8 which were sold and the 12 which were not sold) offered for sale at auctions during the past month by Sidney's customers. Investigate the claim that, on average, the prices that can be obtained are lower than those advised by Sidney. Use the 1% significance level. *(6 marks)*

(c) Summarise briefly your findings in parts (a) and (b). *(2 marks)*

5 [**Figures 1**, **2 and 3**, printed on the insert, are provided for use in this question.]

A food shop buys organic oats in bags of nominal weight 1000 grams. It is known that the weights of the bags in any batch are normally distributed with standard deviation 6 grams.

When a batch is received, a random sample of five bags are weighed and the batch is accepted if the mean weight exceeds 1003 grams; otherwise it is rejected.

(a) Complete the table on **Figure 1** by calculating the probability of accepting a batch consisting of bags with a mean weight of:

(i) 999 grams;

(ii) 1007 grams. *(5 marks)*

(b) Draw the operating characteristic for this plan on **Figure 2**. *(2 marks)*

(c) The following alternative plan is proposed.

Take a random sample of 25 bags from each batch.
Classify any bags weighing less than 993 grams as non-conforming.
Accept the batch if it includes 5 or fewer non-conforming bags.
Otherwise reject the batch.

(i) Using this alternative plan, find the probability of accepting batches containing 10%, 15%, 25% and 30% non-conforming bags. *(2 marks)*

(ii) Draw the operating characteristic for this plan on **Figure 3**. *(2 marks)*

(d) A batch is submitted containing bags with mean weight 998 grams.

(i) Using your operating characteristic drawn on **Figure 2**, find the probability that this batch will be accepted by the plan based on the sample mean weight. *(1 mark)*

(ii) Show that the probability that a randomly selected bag from this batch weighs less than 993 grams (and hence is classified as non-conforming) is 0.20, correct to two significant figures. *(1 mark)*

(iii) Using your operating characteristic drawn on **Figure 3**, find the probability that this batch would be accepted by the alternative plan. *(1 mark)*

(iv) Find the probability that a randomly selected bag from this batch weighs less than the nominal weight of 1000 grams. Hence comment on the relative performance of the two plans. *(3 marks)*

6 Marian, John and Sajid are cyclists with similar cycling habits. They wished to reduce the amount of money that they spend on batteries for the back lights of their bicycles. They agreed to compare three makes of battery, **P**, **Q** and **R**, and three makes of back light, **A**, **B** and **C**. They would all put new batteries in their back lights on the same day and record the number of days before the batteries needed replacing. When the longest lasting battery needed replacing, they would all start again with new batteries and a different light/battery combination. The process would be repeated until the required data had been collected.

They devised a Latin square design and collected the following data.

		Battery		
		P	**Q**	**R**
Back light	**A**	96 (Marian)	35 (John)	122 (Sajid)
	B	42 (John)	31 (Sajid)	146 (Marian)
	C	131 (Sajid)	54 (Marian)	137 (John)

(Marian used a battery of make **P** in a back light of make **A**. The battery needed replacing after 96 days, etc.)

(a) Carry out an analysis of variance and verify that, at the 5% significance level, there is insufficient evidence to show a difference between makes of battery. *(14 marks)*

(b) After examining the mean times that each make of battery had lasted, Sajid expressed surprise that no significant difference had been detected. He suggested that they should have carried out a larger experiment by including two additional cyclists, makes of battery and makes of back light. They could then have designed and carried out a 5×5 Latin square.

(i) Suggest a possible reason why Sajid was surprised.

(ii) Give **one** advantage and **one** disadvantage of Sajid's suggestion that a 5×5, instead of a 3×3, Latin square should have been used. *(4 marks)*

END OF QUESTIONS

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Surname		Other Names	
Centre Number						Candidate Number				
Candidate Signature										

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Unit Statistics 6

Insert

Insert for use in **Question 5**.

Fill in the boxes at the top of this page.

Fasten this insert securely to your answer book.

Turn over for Figure 1

Figure 1 (for use in Question 5)

Mean weight of bags in batch, grams	997	999	1001	1003	1005	1007	1009
Probability of acceptance	0.013		0.228	0.500	0.772		0.987

Figure 2 (for use in Question 5)

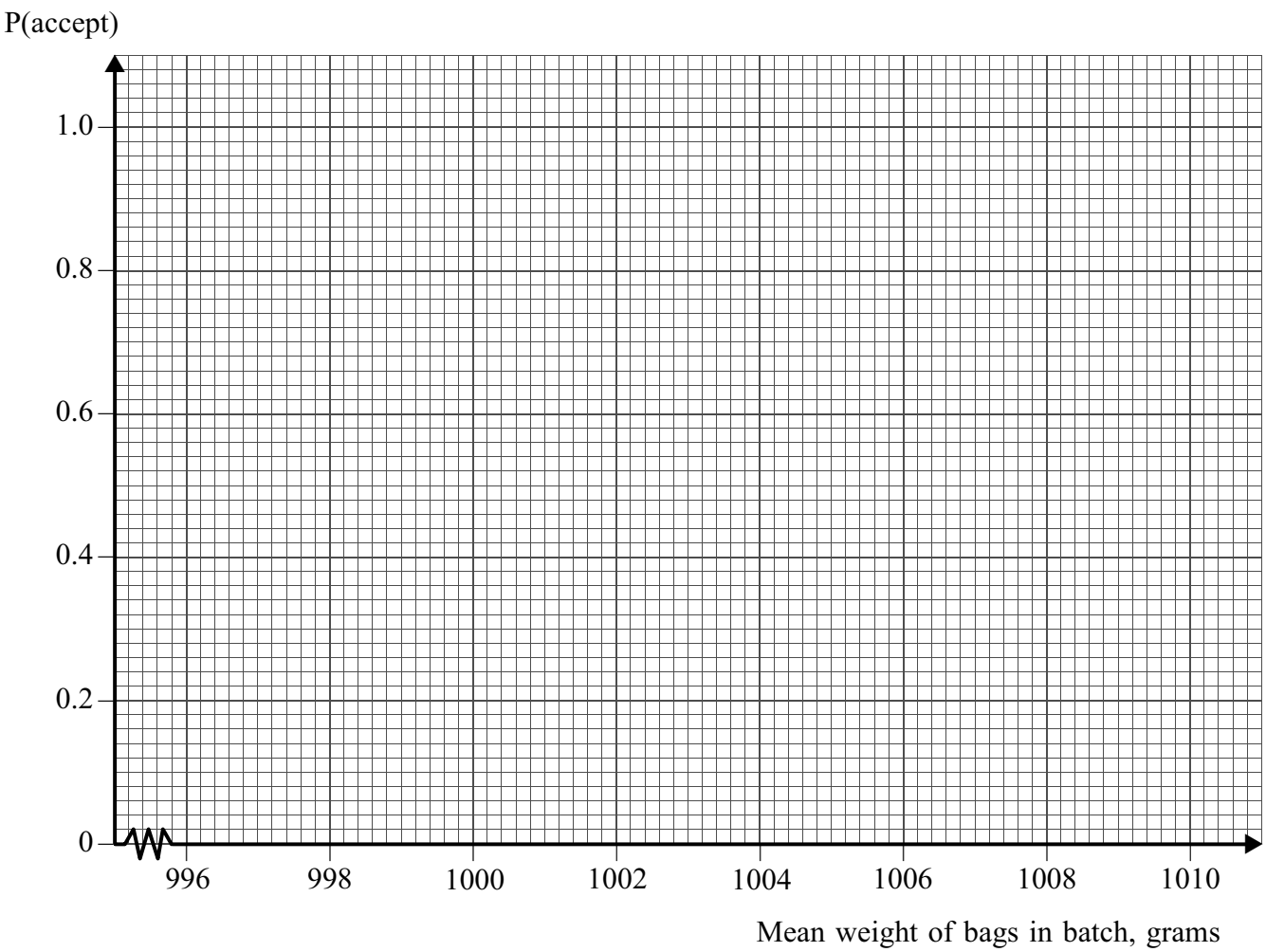
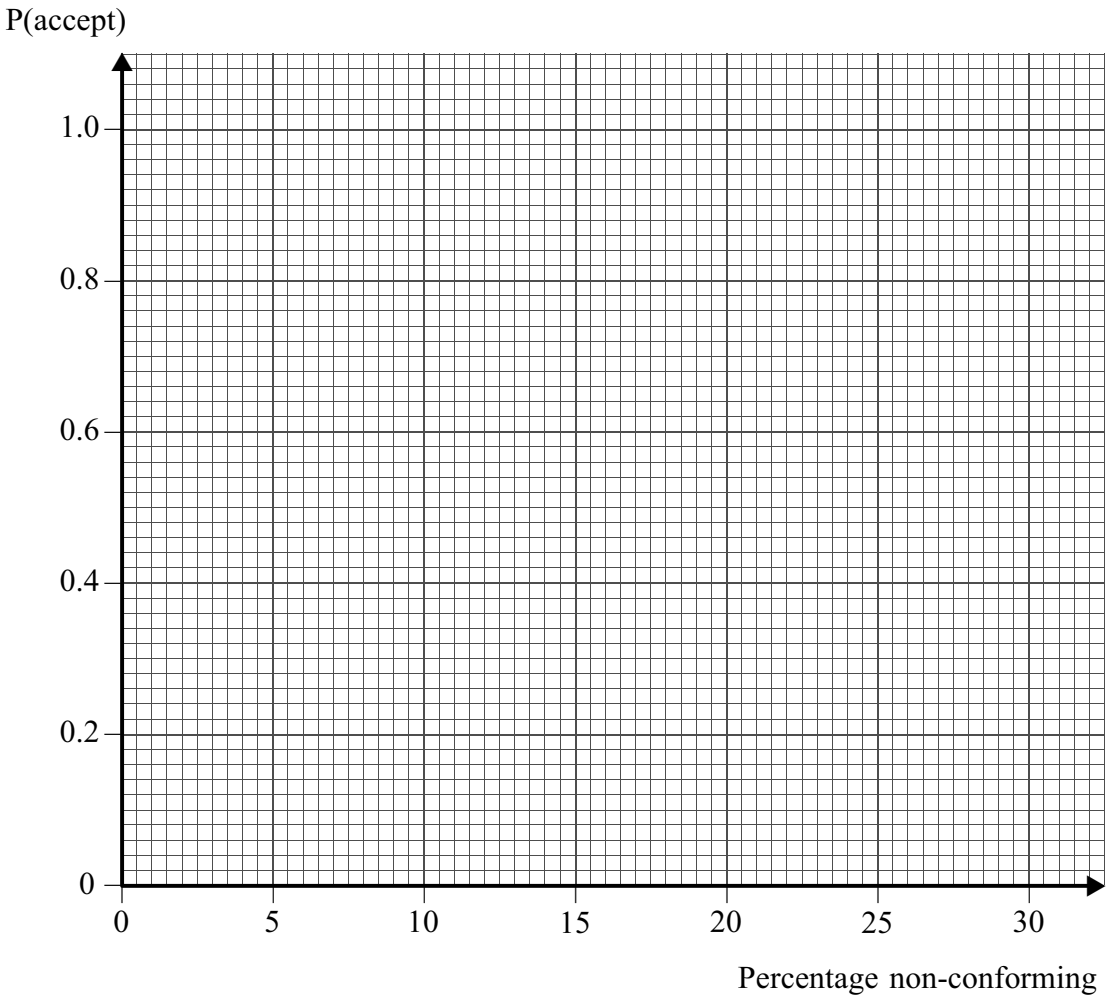


Figure 3 (for use in Question 5)



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