

General Certificate of Education
June 2007
Advanced Level Examination



STATISTICS
Unit Statistics 6

SS06

Tuesday 26 June 2007 1.30 pm to 3.00 pm

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 blue or black ink or 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 pharmaceutical company manufactures tablets with a nominal potency of 6.0. The units are mg cm^{-3} . The process is to be controlled by taking samples of size 5 at regular intervals and measuring the potency of the tablets. The potency may be assumed to be normally distributed.

The means and ranges of the last eight samples are given in the table.

| Sample | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|--------|------|------|------|------|------|------|------|------|
| Mean | 5.95 | 5.99 | 5.96 | 6.03 | 5.99 | 6.05 | 6.01 | 6.03 |
| Range | 0.12 | 0.04 | 0.17 | 0.09 | 0.11 | 0.05 | 0.14 | 0.12 |

- (a) Use the ranges to show that an estimate of the current standard deviation of the process is 0.045, correct to three decimal places. *(3 marks)*
- (b) Using 0.045 as the standard deviation, calculate upper and lower warning (95%) and action (99.8%) control limits for charts for:
- means;
 - ranges.

You are not required to draw the charts. *(6 marks)*

- (c) The potencies of tablets in the next sample are:

5.96 6.09 5.99 6.16 6.08

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

- (d) A customer specifies tolerances of 6.00 ± 0.15 .

Find the proportion of tablets outside these tolerances if the current mean is 6.06 and the current standard deviation is 0.045. *(2 marks)*

2 (a) Explain the meaning and purpose of blind trials. (3 marks)

(b) A spokesman for a cosmetics company was quoted in an interview as saying, “Carrying out a placebo-controlled test does not make much sense in our industry. A cosmetic product is a balanced and precise mixture of cosmetic ingredients and its effectiveness relies on this specific combination of ingredients.”

Comment on the validity of this statement. (2 marks)

3 To make it easier for customers to find the items that they require, a supermarket chain employed a consultant to redesign the layout of its stores. The new layout was introduced in the Guildford store. Ahmed was asked to evaluate the effectiveness of the new layout in enabling customers to collect items more quickly.

He compiled 12 lists, each of 15 items available in all branches of the supermarket. He then obtained 12 volunteers and took them in a minibus to the Woking store, which still had the old layout. Each volunteer was given one of the lists and asked to collect their 15 items from the shelves. Ahmed then drove the volunteers to the Guildford store. He asked each volunteer to collect their 15 items from the shelves of the Guildford store. The times, in seconds, taken by the volunteers to collect their items were as follows.

| Volunteer | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Woking | 344 | 390 | 205 | 399 | 240 | 422 | 399 | 189 | 402 | 354 | 278 | 349 |
| Guildford | 312 | 288 | 198 | 345 | 244 | 378 | 308 | 183 | 355 | 306 | 260 | 390 |

(a) Use a paired t -test and the 5% significance level to examine whether items can be collected more quickly at the Guildford store than at the Woking store. (10 marks)

(b) Identify one source of possible bias in Ahmed’s design and suggest how it could have been removed. (2 marks)

Turn over for the next question

Turn over ►

- 4 A garden centre sells bags of compost. They are delivered to the garden centre in large batches. When a batch of bags is delivered, the following acceptance sampling scheme is used.

Select a random sample of 10 bags.

Accept the batch if the mean weight of these bags exceeds 25.2 kg.

Otherwise reject the batch.

The weights of the bags may be assumed to be normally distributed with a standard deviation of 0.65 kg.

- (a) By carrying out suitable calculations, determine whether or not this scheme will satisfy the requirement that there is:
- (i) a probability of at least 0.9 of **rejecting** a batch with mean weight 24.6 kg;
 - (ii) a probability of at least 0.95 of **accepting** a batch with mean weight 25.7 kg. *(6 marks)*
- (b) Comment on the suggestion that it would be possible to reduce the sample size and still meet both the requirements in part (a). Further calculation is not required. *(2 marks)*

5 [Figure 1, printed on the insert, is provided for use in this question.]

A firm, which assembles personal computers, buys components in large batches.

A random sample of 50 components is taken from each batch and the batch is accepted if the sample contains 2 or fewer non-conforming components.

- (a) (i) Find the probability of accepting batches containing 1%, 3%, 5%, 7%, 10% and 15% non-conforming components. *(3 marks)*
- (ii) Hence draw the operating characteristic on **Figure 1**. *(2 marks)*
- (b) Frank, the managing director, complains that some batches with a low percentage of non-conforming components are being rejected and some batches with a high percentage of non-conforming components are being accepted.

He asks Sally, the quality control manager, to change the sampling plan. She introduces the following double sampling plan.

Take a random sample of size 40 and accept the batch if 1 or fewer non-conforming components are found; reject the batch if 4 or more non-conforming components are found.

If 2 or 3 non-conforming components are found, take a further random sample of size 40 and accept the batch if a total of 3 or fewer (out of 80) non-conforming components are found; otherwise reject the batch.

The following table shows the probability of accepting batches containing various percentages of non-conforming components.

| % non-conforming | 1 | 3 | 5 | 7 | 10 | 15 |
|-------------------|-------|-------|-----|-------|-------|-------|
| P (accept) | 0.994 | 0.833 | x | 0.286 | 0.095 | 0.013 |

- (i) Calculate the value of x . *(5 marks)*
- (ii) Add the operating characteristic for this double sampling plan to **Figure 1**. *(2 marks)*
- (c) Compare the two sampling plans. Include in your answer a comment on Frank's complaint in part (b). *(3 marks)*

- 6 (a) A researcher, investigating the effect of drinking alcohol on mental dexterity, obtained 12 volunteers and divided them randomly into three groups of four. Thirty minutes before solving a simple Sudoku puzzle, the volunteers in Group 2 each drank one measure of whisky and those in Group 3 each drank three measures of whisky. The volunteers in Group 1 had no alcohol. The time, in seconds, that it took each volunteer to solve the puzzle was recorded.

| Group 1 (no alcohol) | Group 2 (1 measure) | Group 3 (3 measures) |
|---------------------------------|--------------------------------|---------------------------------|
| 184 | 196 | 262 |
| 126 | 98 | 168 |
| 108 | 222 | 240 |
| 204 | 144 | 190 |

Carry out a one-factor analysis of variance to test for differences between the effects of different amounts of alcohol. Use the 5% significance level. *(11 marks)*

- (b) It was pointed out that the time taken to solve a Sudoku puzzle may also depend on the weight and the sex of the subject. Twelve new female volunteers were obtained. They were ranked by weight and divided into four groups.

Volunteers ranked 1, 2, 3 formed the first group;
 4, 5, 6 formed the second group;
 7, 8, 9 formed the third group;
 10, 11, 12 formed the fourth group.

One member of each group was randomly chosen to drink no alcohol, one to drink one measure of whisky and one to drink three measures of whisky. They were timed to solve the same simple Sudoku puzzle.

Copy and complete the following analysis of variance table which arose from this second experiment. Test for differences between the effects of different weights and of different amounts of alcohol, using the 5% significance level.

| Source | Sum of squares | Degrees of freedom | Mean square |
|-----------------------------------|-----------------------|---------------------------|--------------------|
| Between amounts of alcohol | 9 348 | | |
| Between weights | 7 980 | | |
| Residual | | | |
| Total | 20 542 | | |

(6 marks)

- (c) In the light of your results, comment on the effectiveness of the experiment in part (b) compared to that in part (a). *(2 marks)*
- (d) The analysis of variance undertaken in part (b) assumes that there is no interaction between weight and amount of alcohol consumed. Explain, in the context of this experiment, the meaning of this assumption. *(2 marks)*

END OF QUESTIONS

There are no questions printed on this page

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|---------------------|--|--|--|--|--|------------------|--|--|--|--|--|
| Surname | | | | | | Other Names | | | | | |
| Centre Number | | | | | | Candidate Number | | | | | |
| Candidate Signature | | | | | | | | | | | |

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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

Turn over ►

Figure 1 (for use in Question 5)