General Certificate of Education
June 2004
Advanced Level Examination

MATHEMATICS AND STATISTICS   **MBS8**
(SPECIFICATION B)
Unit Statistics 8

Friday 25 June 2004   Morning Session

In addition to this paper you will require:
  • an 8-page answer book;
  • the AQA booklet of formulae and statistical tables;
  • an insert for use in Question 4 (enclosed).
You may use a graphics calculator.

Time allowed: 1 hour 15 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 MBS8.
• Answer **all** questions.
• All necessary working should be shown; 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. Make sure that you attach this insert to your answer book.

Information
• The maximum mark for this paper is 60.
• Mark allocations are shown in brackets.

Advice
• Unless stated otherwise, formulae may be quoted, without proof, from the booklet.

MBS8

Answer **all** questions.

1 The diameters, in millimetres, of soft playballs manufactured by a particular machine may be assumed to be normally distributed with mean μ and standard deviation σ.

The target value for μ is 100 and a value for σ of 4 is considered satisfactory.

(a) For samples of size 6, calculate to one decimal place, upper and lower warning (95%) and action (99.8%) control limits for:

(i) sample means;   *(4 marks)*

(ii) sample standard deviations.   *(3 marks)*

(b) State with reasons the action you would advise, if any, given that a sample of 6 playballs has diameters, in millimetres, of:

(i) 100, 102, 101, 97, 101 and 102;

(ii) 107, 94, 102, 93, 108 and 96.   *(5 marks)*

2 It is claimed that a particular diet programme for gradual weight reduction results in a mean weight loss for participants during the first three months of more than 5 kilograms.

The table below shows, for a random sample of 10 participants, their weights, in kilograms, on joining the programme and after three months.

Participant	Weight on joining	Weight after three months
1	67.7	62.2
2	83.6	77.4
3	102.7	95.3
4	114.7	105.0
5	75.4	70.7
6	93.4	86.1
7	83.2	76.6
8	74.2	71.1
9	111.5	102.6
10	93.2	86.6

(a) Stating the necessary distributional assumption, use a paired *t*-test to investigate the claim at the 1% level of significance. *(11 marks)*

(b) Indicate, with a reason, the benefit in using paired samples to investigate the claim. *(2 marks)*

TURN OVER FOR THE NEXT QUESTION

3 Naomi, a biologist, wishes to compare the effects of 4 different environments, labelled A, B, C and D, on the growth of lettuce seedlings. She has available 20 seedlings, numbered 1, 2, . . ., 20.

(a) (i) Copy and complete the following table to show a suitable experimental design.

Environment			
A	**B**	**C**	**D**
1			
		2	
			3
4			

(1 mark)

(ii) Write down the name of your design and the name of the technique you would then use to analyse the data collected. *(2 marks)*

(b) Naomi is then informed that seedlings numbered 1 to 4 are of Variety I, those numbered 5 to 8 are of Variety II, those numbered 9 to 12 are of Variety III, those numbered 13 to 16 are of Variety IV and those numbered 17 to 20 are of Variety V.

(i) Construct a table to show a suitable experimental design. *(2 marks)*

(ii) Write down the name of your design and the name of the technique you would then use to analyse the data collected. *(2 marks)*

(c) Given the additional information in part (b), state **one** advantage of your design in part (b) over your design in part (a). *(1 mark)*

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

Before a producer delivers 10 kg bags of charcoal for barbecues to retail outlets, bags are chosen at random from large batches and the charcoal in each bag is weighed. These weights, X kilograms, are known to be normally distributed with mean μ and standard deviation 0.2.

A proposed sampling scheme is that a batch is accepted when the mean weight, $\overline{X}$ kilograms, of charcoal from a random sample of 4 bags exceeds 10.1.

(a) Show that the probability that a batch is accepted by this scheme, P(A), is given by:

$$P(A) = P\left(Z > \left(\frac{10.1 - \mu}{0.1}\right)\right) \quad \text{where} \ \ Z \sim N(0, 1). \qquad \textit{(2 marks)}$$

(b) Hence copy and complete the following table.

μ	9.8	9.9	10.0	10.1	10.2	10.3	10.4
P(A)		0.023		0.500			

(3 marks)

(c) Draw the associated operating characteristic curve on **Figure 1**. *(2 marks)*

(d) Using your graph in part (c), or otherwise, comment on the proposed sampling scheme's ability to meet **both** of the following requirements.

- Batches containing bags with a mean weight of 9.95 kg should have at most a 10% probability of acceptance.

- Batches containing bags with a mean weight of 10.25 kg should have at most a 10% probability of rejection. *(3 marks)*

TURN OVER FOR THE NEXT QUESTION

5 As part of an investigation into vehicle hire rates in Mediterranean countries during high season, a 5×5 Latin square design was used.

The factors were as follows.

- Country   1, 2, 3, 4 and 5

- Vehicle group   A, B, C, D and E

- Hire company   a, b, c, d and e

The actual design used is shown in the table. The responses, in €, for all-inclusive 7-day rates, excluding fuel, are also shown.

Vehicle group	Country				
	1	**2**	**3**	**4**	**5**
A	b 242	c 231	d 231	e 229	a 217
B	e 247	a 240	b 245	c 241	d 227
C	d 248	e 260	a 245	b 256	c 241
D	a 267	b 271	c 261	d 251	e 250
E	c 281	d 283	e 278	a 283	b 275

You may assume that:

total sum of squares, $SS_T = 8606.0$;

between hire companies sum of squares, $SS_L = 269.2$.

(a) Carry out an analysis of variance to test, at the 5% level of significance, for a difference in vehicle hire rates between the five hire companies. *(13 marks)*

(b) Indicate, with reasons, whether the use of countries and vehicle groups as two blocking factors has proved effective. *(4 marks)*

END OF QUESTIONS

THERE ARE NO QUESTIONS PRINTED ON THIS PAGE

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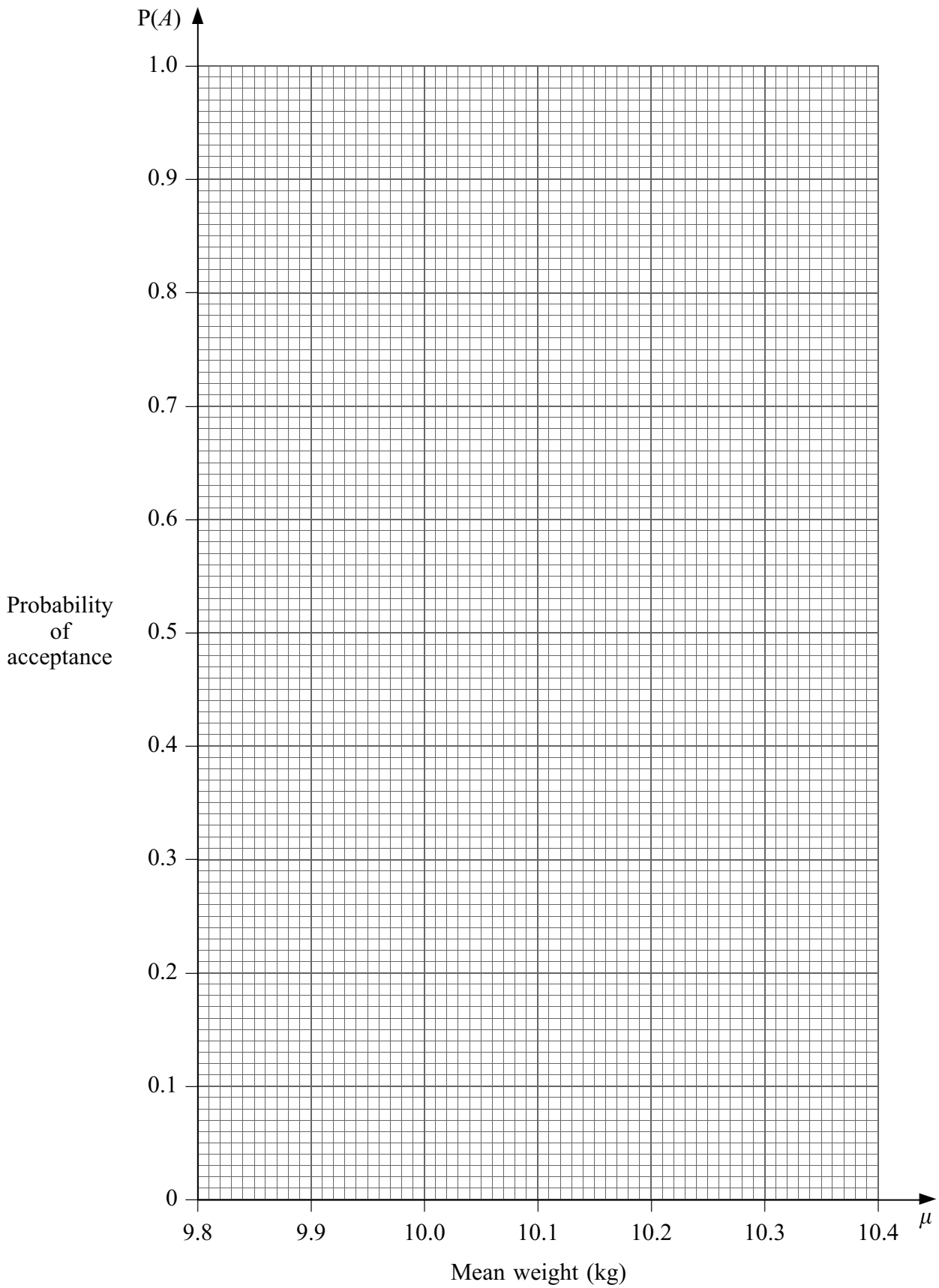**Unit Statistics 8**

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Insert for use in Question 4.

Fill in the boxes at the top of this page.

Attach this insert securely to your answer book.

TURN OVER

Operating Characteristic Curve

Figure 1