STATISTICS   **SS06**
Unit Statistics 6

Wednesday 17 June 2009   9.00 am to 10.30 am

<div style="border:1px solid">

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 Questions 5 and 6 (enclosed).

You may use a graphics calculator.

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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.

SS06

Answer **all** questions.

1 An investigation is to be carried out into the effects of exercise on pulse rate. Part of the investigation will involve measuring the pulse rates of volunteers after they have spent three minutes stepping on and off a bench. Before proceeding, the investigator wishes to find out whether the height of the bench is a relevant factor. The pulse rates, in beats per minute, of 7 volunteers after they have stepped on and off benches of heights 30 cm and 40 cm are recorded in the table.

		Height of bench	
		30 cm	**40 cm**
	Waheed	124	131
	Sonny	118	126
	Debbie	121	127
Volunteer	**Marian**	124	136
	Dimitri	137	134
	Sajid	129	138
	Maha	142	141

Carry out a paired *t*-test to examine whether the height of the bench affects the mean pulse rate. Use the 10% significance level. *(10 marks)*

2 Each Thursday night a band plays at a jazz club. The bands which have played over the last 19 Thursdays are The Blue River Jazz Band (A), Old Orleans Heat (B), Huddersfield Hot Stompers (C) and The Detroit Teddybears (D).

The attendances at the jazz club for the different bands are summarised below.

Band			
A	**B**	**C**	**D**
43	57	32	69
54	46	59	88
38	39	44	96
58		62	72
61		63	84
72			

(a) Copy and complete the table below, which follows from an analysis of the data.

Source of variation	Sum of squares	Degrees of freedom
Between bands	3369.7	
Error		
Total	5538.5	

(3 marks)

(b) Hence examine whether the average attendance differs according to which band is playing. Use the 1% significance level. Assume that attendances are normally distributed with constant variance. *(5 marks)*

Turn over for the next question

Turn over ▶

3 A road haulage firm frequently undertakes journeys between the firm's depot and a customer's factory. The manager wonders whether it is quicker to use the direct route, D, or a route which is longer but consists mainly of motorway, M.

You are asked to design an experiment to compare these two alternative routes. Six lorries, each with its own driver, are available to you on Wednesday and Thursday, and each will make one journey to the factory each day.

(a) Copy and complete the following table indicating which route, D or M, each driver should use.

		Wednesday	Thursday
Driver	**1**		
	2		
	3		
	4		
	5		
	6		

For example, if you wish driver 1 to travel by the direct route on Wednesday, put a D in the top left hand rectangle of your table. Continue until you have filled in all twelve rectangles. *(3 marks)*

(b) Each driver is to be told to start their journey at the same time on Thursday as they did on Wednesday.

Suggest a further instruction that you might give the drivers which would help to ensure a fair comparison between routes. *(2 marks)*

(c) Suggest an appropriate statistical analysis to be carried out after the journey times have been collected. *(2 marks)*

4 The following double sampling plan is applied to batches of components.

Test a random sample of 30 components.
Accept the batch if no non-conforming components are found.
Reject the batch if 3 or more non-conforming components are found.
Otherwise, test a further random sample of size 30 and accept the batch if a total of 3 or fewer (out of 60) non-conforming components are found.

(a) Calculate the probability of accepting a batch containing 5% non-conforming components. *(5 marks)*

(b) Calculate the expected number of components tested if a batch containing 5% non-conforming components is tested. *(3 marks)*

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

An importer uses an automatic machine to pack brown sugar into bags of nominal weight 1000 grams.

A supermarket chain buys large batches of these bags. When a batch is delivered, each of a random sample of 6 bags is weighed and the batch is rejected if the mean weight is less than 1001 grams. The weights may be assumed to be normally distributed with standard deviation 2.9 grams.

(a) Find the probability of accepting a batch containing bags with mean weight:

  (i) 998 grams;

  (ii) 1004 grams. *(4 marks)*

(b) Using your results from part (a), together with the data in the following table, draw the operating characteristic on **Figure 1**.

Mean weight, grams	999	1000	1001	1002	1003
Probability of acceptance	0.046	0.199	0.500	0.801	0.954

(2 marks)

(c) Find from your operating characteristic, or otherwise, the mean weight of a batch which has a probability of 0.9 of being rejected. *(2 marks)*

(d) It is decided to continue to reject batches if the sample mean weight is less than 1001 grams, but to increase the sample size. The probability of rejecting a batch consisting of bags with mean weight 999.5 grams is to be at least 0.95.

   How large a sample will be necessary in order to achieve this? *(5 marks)*

Turn over for the next question

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

A food factory produces bottles of salad cream. Samples of size 4 are taken at hourly intervals and their contents are checked. The target volume for the contents is 400 ml and a standard deviation of 2.3 ml is considered satisfactory. The volumes may be assumed to be normally distributed.

Figure 2 shows upper and lower warning (95%) and action (99.8%) limits on a chart for means.

(a) Add to **Figure 3** upper and lower warning and action limits for standard deviations.
(3 marks)

(b) The volumes, in ml, of contents in the last seven samples are shown below.

	Sample						
	1	**2**	**3**	**4**	**5**	**6**	**7**
	399	393	398	401	400	402	395
	401	395	397	402	394	395	397
	401	396	400	398	398	399	400
	397	397	399	397	400	396	404
Mean, $\bar{x}$	399.5	395.25	398.5	399.5	398.0	398.0	
Standard deviation, s	1.91	1.71	1.29	2.38	2.83	3.16	

(i) Calculate the values of $\bar{x}$ and s for sample 7. *(1 mark)*

(ii) Plot the seven values of $\bar{x}$ and s on your charts. *(2 marks)*

(iii) Comment on the performance of the process over the last seven hours. *(3 marks)*

(c) Sample 8 had mean $\bar{x} = 398.0$ and standard deviation $s = 4.55$. State, with a reason, the action, if any, you would advise as a result of this sample. *(2 marks)*

(d) Currently, the mean volume of contents is 396 ml with a standard deviation of 2.3 ml.

(i) Find the proportion of bottles with contents outside tolerances of 392 ml to 408 ml. *(2 marks)*

(ii) State whether or not it would be possible to consistently meet these tolerances. Explain your answer. *(2 marks)*

7 Examiners return scripts to an awarding body using prepaid envelopes. The awarding body is considering new designs for the envelopes and asks four experienced examiners to rate each of three designs by giving them a mark out of 100. A perfect design would score 100.

The results are as follows.

		Design		
		P	**Q**	**R**
Examiner	**John**	23	33	42
	Gill	46	37	79
	Gwen	56	44	80
	Neil	54	60	75

You may assume that $\sum_i \sum_j x_{ij}^2 = 36\,721$.

(a) Carry out a 2-factor analysis of variance and test for a difference between designs of envelope. Use the 5% significance level and proceed on the basis that any necessary assumptions are satisfied. *(11 marks)*

(b) Compare the three designs of envelope, including a recommendation as to which one the awarding body should use. *(3 marks)*

END OF QUESTIONS

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General Certificate of Education
June 2009
Advanced Level Examination

AQA

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Unit Statistics 6

Insert

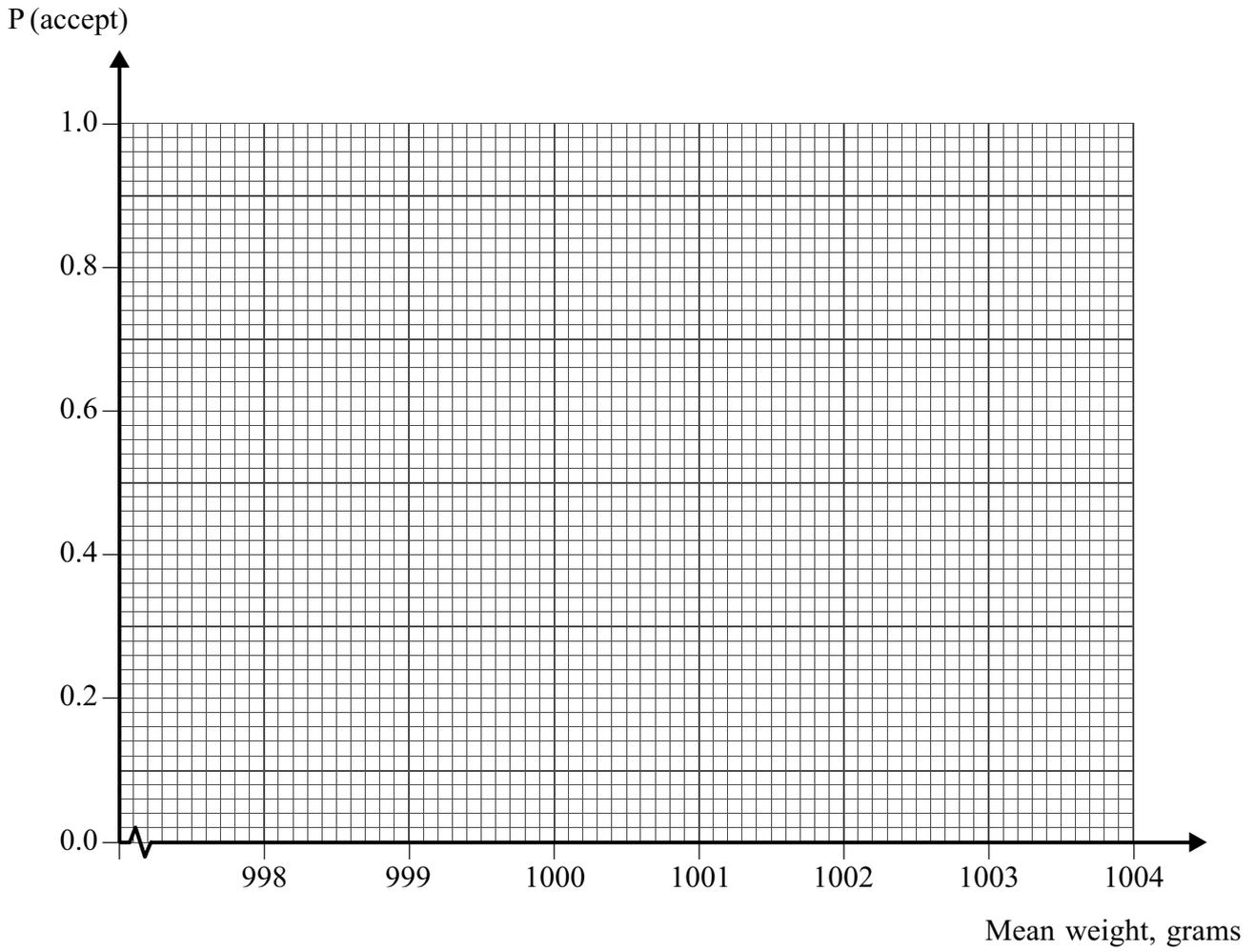Insert for use in **Questions 5 and 6**.
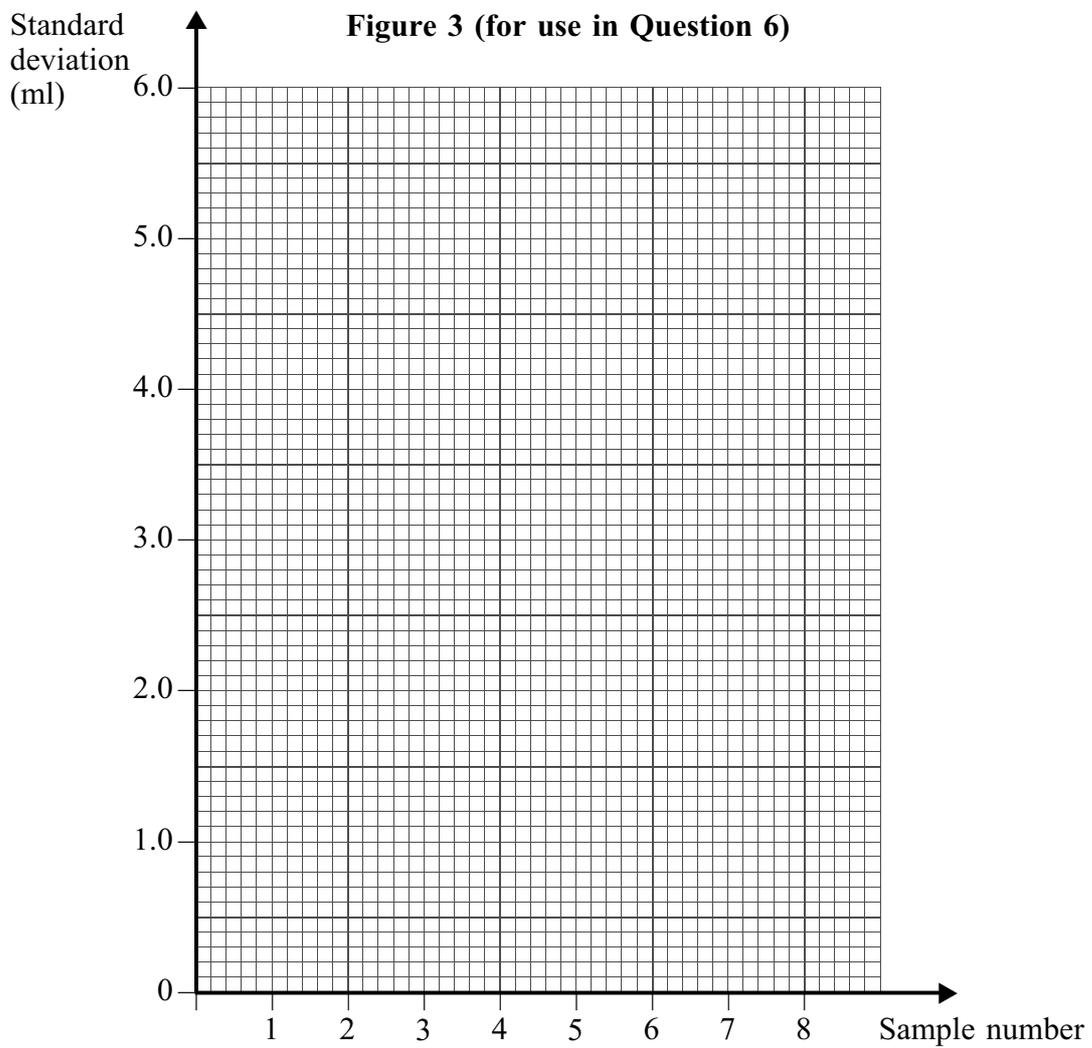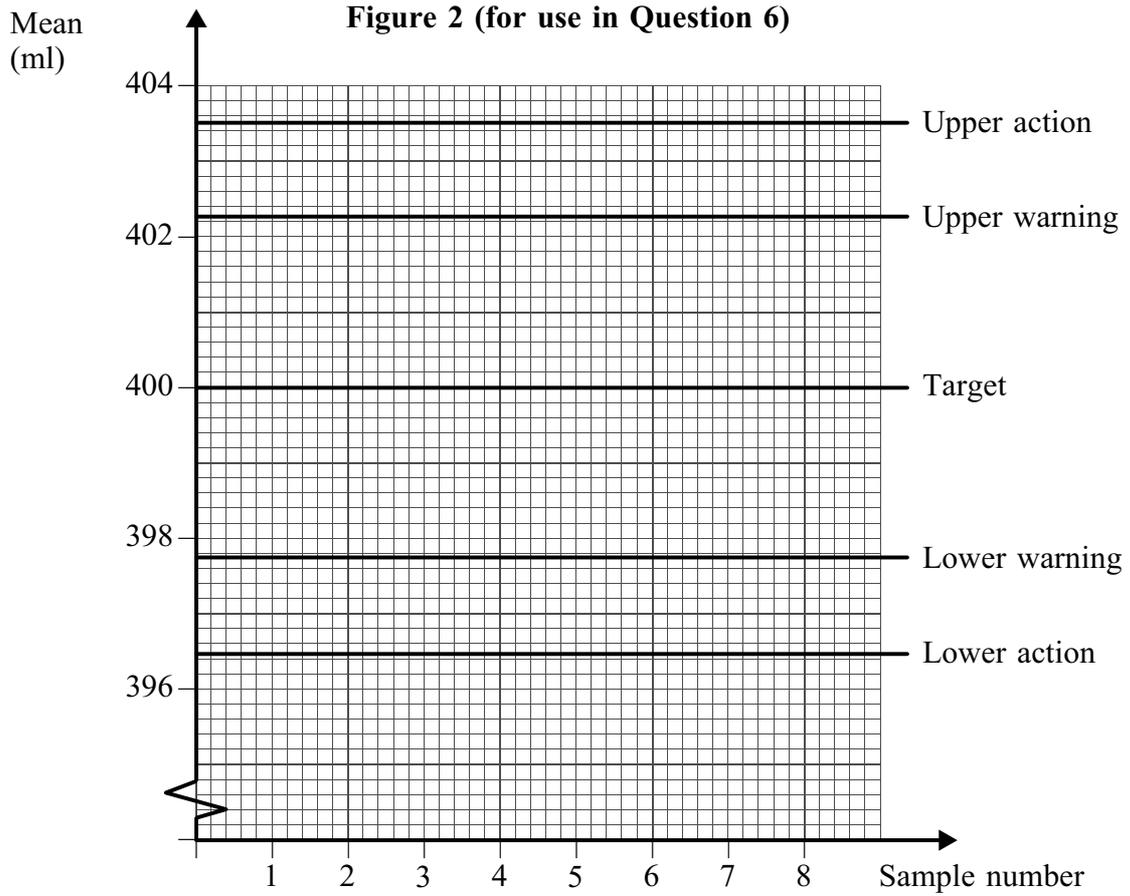
Fill in the boxes at the top of this page.

Fasten this insert securely to your answer book.

Turn over for Figure 1

Turn over ▶

Figure 1 (for use in Question 5)

P (accept)

Mean weight, grams

Figure 2 (for use in Question 6)

Mean (ml)

404 — Upper action

402 — Upper warning

400 — Target

398 — Lower warning

396 — Lower action

1 2 3 4 5 6 7 8 Sample number

Figure 3 (for use in Question 6)

Standard deviation (ml)

6.0

5.0

4.0

3.0

2.0

1.0

0

1 2 3 4 5 6 7 8 Sample number

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