

General Certificate of Education  
June 2005  
Advanced Subsidiary Examination



**MATHEMATICS AND STATISTICS  
(SPECIFICATION B)  
Unit Statistics 2**

**MBS2**

Tuesday 7 June 2005 Afternoon Session

**In addition to this paper you will require:**

- an 8-page answer book;
- the AQA booklet of formulae and statistical tables.

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 MBS2.
- 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.

**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.

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Answer **all** questions.

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- 1 A manager of a mail order department claims that 85 per cent of orders are dispatched within two days of receipt. A random sample of 130 orders was taken and it was found that 113 of the orders were dispatched within two days of receipt.
- (a) Calculate an approximate 95% confidence interval for the proportion of orders dispatched within two days of receipt. (6 marks)
- (b) State, with a reason, whether your confidence interval supports the manager's claim. (2 marks)
- 2 An airport control centre handles 350 flight departures each day. The probability that a flight will be delayed for more than one hour, for any reason, is 0.008. A *Q-day* occurs when more than five flights suffer such delays in any one day.
- (a) (i) Use a Poisson approximation to show that the probability that any particular day is a *Q-day* is approximately 0.0651. (4 marks)
- (ii) Hence calculate the probability that exactly 2 *Q-days* occur in a particular week (7 days). (3 marks)
- (iii) Use a distributional approximation to find the probability that more than 30 *Q-days* occur in a particular year (365 days). (6 marks)
- (b) What assumption has been made about flight delays? (1 mark)
- 3 A project can be broken down into several activities. The duration of each activity is usually subject to uncertainty.

Program Evaluation and Review Technique (PERT) is used by management to determine the most probable time for each activity and to obtain some measure of the earliest completion time for a project.

PERT uses three estimates for the duration of each activity:

- $P$  = Pessimistic duration estimate;  
 $M$  = Most likely duration estimate;  
 $O$  = Optimistic duration estimate.

For each activity:

$\frac{P + 4M + O}{6}$  is used to estimate the mean duration;

$\frac{P - O}{6}$  is used to estimate the standard deviation of the duration.

The following information, in days, was collected during a team project meeting for the installation of an automated system in a factory.

Activity		<i>P</i>	<i>M</i>	<i>O</i>
A	Obtain equipment	7	5	3
B	Hire contractors	5	4	3
C	Develop system	30	15	12
D	Develop training programme	9	3	3
E	Complete documentation	14	6	4
F	Install system	18	9	6

- (a) Calculate estimates of the mean and standard deviation for the duration of **each** of the six activities. (4 marks)
- (b) Critical activities are those activities which must be completed on time for the whole project to achieve its earliest completion time.

For the whole project:

$\sum_{\text{critical activities}} \left( \frac{P + 4M + O}{6} \right)$  is used to estimate the mean duration;

$\sum_{\text{critical activities}} \left( \frac{P - O}{6} \right)^2$  is used to estimate the variance of the duration.

- (i) Given that the critical activities in the above table are A, C, E and F, calculate estimates of the mean and variance for the duration of the project. (4 marks)
- (ii) Hence, assuming the duration of a project to be normally distributed, calculate the probability that the installation of the automated system will be completed in at most 45 days. (4 marks)

Turn over ►

- 4 Jenny, who manages a confectionery shop, has noticed that the sales of a brand of chocolate have a marked seasonal pattern. The sales figures are given below for each quarter of the last three years.

Quarter	$x$	Sales	Moving average	Centred moving average, $y$	
2002 Q1	1	298			
	Q2	2	302		
				335.25	
Q3	3	342		343.875	
			352.5		
2002 Q4	4	399		362.25	
			372		
	2003 Q1	5	367		380.5
				$p$	
Q2	6	380		$r$	
			$q$		
2003 Q3	7	410		416.5	
			426.5		
	Q4	8	469		433.75
				441	
2004 Q1	9	447		450.75	
			460.5		
	Q2	10	438		470.25
				480	
Q3	11	488			
Q4	12	547			

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- (a) (i) Calculate the values of the moving averages  $p$  and  $q$ . (3 marks)
- (ii) Hence calculate the value of the centred moving average  $r$ . (2 marks)
- (b) The equation of the regression line of the centred moving averages,  $y$ , may be written in the form  $y = a + 17.92x$ , with values of  $x$  as shown in the table opposite. Find the value of  $a$  to one decimal place. (3 marks)
- (c) Use your equation to calculate an estimate of the first quarter seasonal effect. (4 marks)
- (d) An estimate of the fourth quarter seasonal effect is 37.8.

Jenny is considering using the following rule for detecting whether the trend of sales is rising or falling in future first quarters.

Denoting the sales in a fourth quarter and the following first quarter by  $S_4$  and  $S_1$  respectively, then sales are falling when the difference,  $S_4 - S_1$ , is greater than some quantity  $d$ . Explain which of the following values is most suitable for  $d$ :

−80    −60    −40    −20    0    20    40    60    80    (3 marks)

**TURN OVER FOR THE NEXT QUESTION**

**Turn over ►**

- 5 As part of an annual audit process, Julian has to take a sample from the 200 companies on a database. Details of the companies, such as name, location, annual turnover, etc., are kept on the database.

Julian has decided on a sample size of 25 and is considering the following four sampling methods.

Method A: The companies are classified by location into eight equal-sized groups. One location is selected at random and all the companies in that location are included in his sample.

Method B: The companies are classified by annual turnover into five groups. The companies are selected at random from each group, the number from each group being proportional to the number of companies in that group.

Method C: The company names are listed alphabetically. There is at least one company name starting with each letter of the alphabet apart from X. One company is selected at random for each letter of the alphabet (excluding X).

Method D: Systematic sampling.

- (a) Name the type of sampling described in:

(i) Method A;

(ii) Method B. *(2 marks)*

- (b) Write down a set of instructions for Julian to follow, in order to obtain a sample of size 25 by Method D. Julian knows how to select random numbers. *(3 marks)*

- (c) For **each** of the four sampling methods, state, with a reason, whether or not all the companies on the database have an equal chance of being included in the sample. *(4 marks)*

- (d) State, with a reason, which of the four sampling methods is best from a statistical point of view. *(2 marks)*

**END OF QUESTIONS**

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