

General Certificate of Education  
June 2008  
Advanced Level Examination



**MATHEMATICS**  
**Unit Statistics 3**

**MS03**

Friday 23 May 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.
- 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 MS03.
- 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.

**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.

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Answer **all** questions.

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- 1 The best performances of a random sample of 20 junior athletes in the long jump,  $x$  metres, and in the high jump,  $y$  metres, were recorded. The following statistics were calculated from the results.

$$S_{xx} = 7.0036 \quad S_{yy} = 0.8464 \quad S_{xy} = 1.3781$$

- (a) Calculate the value of the product moment correlation coefficient between  $x$  and  $y$ .  
(2 marks)
- (b) Assuming that these data come from a bivariate normal distribution, investigate, at the 1% level of significance, the claim that for junior athletes there is a positive correlation between  $x$  and  $y$ .  
(4 marks)
- (c) Interpret your conclusion in the context of this question.  
(1 mark)
- 2 A survey of a random sample of 200 passengers on UK internal flights revealed that 132 of them were on business trips.
- (a) Construct an approximate 98% confidence interval for the proportion of passengers on UK internal flights that are on business trips.  
(6 marks)
- (b) Hence comment on the claim that more than 60 per cent of passengers on UK internal flights are on business trips.  
(2 marks)
- 3 Pitted black olives in brine are sold in jars labelled “340 grams net weight”. Two machines, A and B, independently fill these jars with olives before the brine is added.

The weight,  $X$  grams, of olives delivered by machine A may be modelled by a normal distribution with mean  $\mu_X$  and standard deviation 4.5.

The weight,  $Y$  grams, of olives delivered by machine B may be modelled by a normal distribution with mean  $\mu_Y$  and standard deviation 5.7.

The mean weight of olives from a random sample of 10 jars filled by machine A is found to be 157 grams, whereas that from a random sample of 15 jars filled by machine B is found to be 162 grams.

Test, at the 1% level of significance, the hypothesis that  $\mu_X = \mu_Y$ .  
(6 marks)

- 4 A manufacturer produces three models of washing machine: basic, standard and deluxe. An analysis of warranty records shows that 25% of faults are on basic machines, 60% are on standard machines and 15% are on deluxe machines.

For basic machines, 30% of faults reported during the warranty period are electrical, 50% are mechanical and 20% are water-related.

For standard machines, 40% of faults reported during the warranty period are electrical, 45% are mechanical and 15% are water-related.

For deluxe machines, 55% of faults reported during the warranty period are electrical, 35% are mechanical and 10% are water-related.

- (a) Draw a tree diagram to represent the above information. (3 marks)
- (b) Hence, or otherwise, determine the probability that a fault reported during the warranty period:
  - (i) is electrical; (2 marks)
  - (ii) is on a deluxe machine, given that it is electrical. (2 marks)
- (c) A random sample of 10 electrical faults reported during the warranty period is selected. Calculate the probability that exactly 4 of them are on deluxe machines. (3 marks)

- 5 The daily number of emergency calls received from district A may be modelled by a Poisson distribution with a mean of  $\lambda_A$ .

The daily number of emergency calls received from district B may be modelled by a Poisson distribution with a mean of  $\lambda_B$ .

During a period of 184 days, the number of emergency calls received from district A was 3312, whilst the number received from district B was 2760.

- (a) Construct an approximate 95% confidence interval for  $\lambda_A - \lambda_B$ . (6 marks)
- (b) State one assumption that is necessary in order to construct the confidence interval in part (a). (1 mark)

- 6 An aircraft, based at airport A, flies regularly to and from airport B.

The aircraft's flying time,  $X$  minutes, from A to B has a mean of 128 and a variance of 50.

The aircraft's flying time,  $Y$  minutes, on the return flight from B to A is such that

$$E(Y) = 112, \quad \text{Var}(Y) = 50 \quad \text{and} \quad \rho_{XY} = -0.4$$

- (a) Given that  $F = X + Y$ :

(i) find the mean of  $F$ ;

(ii) show that the variance of  $F$  is 60. (4 marks)

- (b) At airport B, the stopover time,  $S$  minutes, is independent of  $F$  and has a mean of 75 and a variance of 36.

Find values for the mean and the variance of:

(i)  $T = F + S$ ; (2 marks)

(ii)  $M = F - 3S$ . (3 marks)

- (c) Hence, assuming that  $T$  and  $M$  are normally distributed, determine the probability that, on a particular round trip of the aircraft from A to B and back to A:

(i) the time from leaving A to returning to A exceeds 300 minutes; (3 marks)

(ii) the stopover time is greater than one third of the total flying time. (6 marks)

7 (a) The random variable  $X$  has a Poisson distribution with  $E(X) = \lambda$ .

(i) Prove, from first principles, that  $E(X(X - 1)) = \lambda^2$ . (4 marks)

(ii) Hence deduce that  $\text{Var}(X) = \lambda$ . (2 marks)

(b) The independent Poisson random variables  $X_1$  and  $X_2$  are such that  $E(X_1) = 5$  and  $E(X_2) = 2$ .

The random variables  $D$  and  $F$  are defined by

$$D = X_1 - X_2 \quad \text{and} \quad F = 2X_1 + 10$$

(i) Determine the mean and the variance of  $D$ . (2 marks)

(ii) Determine the mean and the variance of  $F$ . (3 marks)

(iii) For **each** of the variables  $D$  and  $F$ , give a reason why the distribution is **not** Poisson. (2 marks)

(c) The daily number of black printer cartridges sold by a shop may be modelled by a Poisson distribution with a mean of 5.

Independently, the daily number of colour printer cartridges sold by the same shop may be modelled by a Poisson distribution with a mean of 2.

Use a distributional approximation to estimate the probability that the total number of black and colour printer cartridges sold by the shop during a 4-week period (24 days) exceeds 175. (6 marks)

**END OF QUESTIONS**

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