



Answer **all** the questions.

- 1 A geography student chose a certain point in a stream and took measurements of the speed of flow,  $v \text{ ms}^{-1}$ , of water at various depths,  $d \text{ m}$ , below the surface at that point. The results are shown in the table.

$d$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5
$v$	0.8	0.5	0.7	1.2	1.1	1.3	1.6	1.4	0.4

$$n = 9 \quad \Sigma d = 2.7 \quad \Sigma v = 9.0 \quad \Sigma d^2 = 0.96 \quad \Sigma v^2 = 10.4 \quad \Sigma dv = 2.85$$

- (a) (i) Explain why  $d$  is an example of an independent, controlled variable. [1]  
 (ii) Use **two** relevant terms to describe the variable  $v$  in a similar way. [1]

A statistician believes that the point (0.5, 0.4) may be an anomaly.

- (b) Calculate the equation of the least squares regression line of  $v$  on  $d$  for all the points in the table **apart from** (0.5, 0.4). [2]  
 (c) Use the equation of the line found in part (b) to estimate the value of  $v$  when  $d = 0.5$ . [1]  
 (d) Use your answer to part (c) to comment on the statistician's belief. [1]  
 (e) Use the diagram in the Printed Answer Booklet (which does **not** illustrate the data in this question) to explain what is meant by "least squares regression line". [2]
- 2 Eight runners took part in two races. The positions in which the runners finished in the two races are shown in the table.

Runner	A	B	C	D	E	F	G	H
First race	3	1	5	6	2	8	7	4
Second race	4	3	8	7	2	5	6	1

Test at the 5% significance level whether those runners who do better in one race tend to do better in the other. [7]

- 3 A discrete random variable  $X$  has the following probability distribution.

$x$	1	2	3	4
$P(X = x)$	$p$	0.31	0.3	$p^2$

- (a) Determine the value of  $p$ . [3]  
 (b) It is given that  $E(aX + b) = \text{Var}(aX + b) = 23.19$ , where  $a$  and  $b$  are positive constants. Determine the value of  $a$  and the value of  $b$ . [6]

- 4 A school pupil keeps a note of whether her journeys to school and from school are delayed. The results for a random sample of journeys are shown in the table.

	Direction of journey	
	To school	From school
Delayed	64	56
Not delayed	74	106

Test at the 10% significance level whether there is association between delays and the direction of the journey. [7]

- 5 The manager of an emergency response hotline believes that calls are made to the hotline independently and at constant average rate throughout the day. From a small random sample of the population, the manager finds that the mean number of calls made in a 1-hour period is 14.4.

Let  $R$  denote the number of calls made in a randomly chosen 1-hour period.

- (a) Using evidence from the small sample, state a suitable distribution with which to model  $R$ . You should give the value(s) of any parameter(s). [1]
- (b) In this part of the question, use the distribution and value(s) of the parameter(s) from your answer to part (a).
- (i) Find  $P(R > 20)$ . [2]
- (ii) Given that  $P(R = r) > P(R = r + 1)$ , show algebraically that  $r > 13.4$ . [2]
- (iii) Hence write down the mode of the distribution. [1]

The manager also finds, from records over many years, that the modal value of  $R$  is 10.

- (c) Use this result to comment on the validity of the distribution used in part (b). [1]
- (d) Assume now that the type of distribution used in part (b) is valid. Find the range(s) of values of the parameter(s) of this distribution that would correspond to the modal value of  $R$  being 10. [2]

- 6 A teacher has 10 different mathematics books. Of these books, 5 are on Algebra, 3 are on Calculus and 2 are on Trigonometry.

The teacher chooses 5 of the books at random.

- (a) Find the probability that 3 of the books are on Algebra. [3]

The teacher now arranges all 10 books in random order on a shelf.

- (b) Find the probability that the Calculus books are next to each other and the Trigonometry books are next to each other. [3]

**In this question you must show detailed reasoning.**

- (c) Find the probability that 2 of the Calculus books are next to each other but the third Calculus book is separated from the other 2 by at least 1 other book. [4]

- 7 Each of three students, X, Y and Z, was given an identical pack of 48 cards, of which 12 cards were red and 36 were blue. They were each told to carry out a different experiment, as follows:

Student X: Choose a card from the pack, at random, 20 times altogether, **with** replacement.  
Record how many times you obtain a red card.

Student Y: Choose a card from the pack, at random, 20 times altogether, **without** replacement.  
Record how many times you obtain a red card.

Student Z: Choose single cards from the pack at random, **with** replacement, until you obtain the first red card. Record how many cards you have chosen, including the first red card.

- (a) Find the probability that student Z has to choose more than 8 cards in order to obtain the first red card. [3]

Each student carries out their experiment 30 times.

The frequencies of the results recorded by each student are shown in the following table, but **not** necessarily with the rows in the order X, Y, Z:

	Number recorded	0	1	2	3	4	5	6	7	8	$\geq 9$	Observed Mean	Observed Variance
Observed Frequencies	Student 1	0	0	1	3	7	8	6	4	1	0	5.03	1.97
	Student 2	0	8	5	4	2	3	3	2	1	2	4.03	11.57
	Student 3	0	1	2	5	4	6	5	3	4	0	4.97	3.70

- (b) **In this question you must show detailed reasoning.**

Two other students make the following statements about the results. For each of the statements, explain whether you agree with the statement. Do **not** carry out any hypothesis tests, but in each case you should give **two** justifications for your answer.

- (i) “The second row is a good match with the expected results for student Z.” [4]
- (ii) “The third row is definitely student X’s results.” [3]

**END OF QUESTION PAPER**





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