

CANDIDATE
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MATHEMATICS

9709/71

Paper 7 Probability & Statistics 2 **(S2)**

May/June 2018

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: List of Formulae (MF9)

READ THESE INSTRUCTIONS FIRST

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Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

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Answer **all** the questions in the space provided. If additional space is required, you should use the lined page at the end of this booklet. The question number(s) must be clearly shown.

Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.

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You are reminded of the need for clear presentation in your answers.

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The number of marks is given in brackets [] at the end of each question or part question.

The total number of marks for this paper is 50.

This document consists of **12** printed pages.



- 1 A random sample of 75 values of a variable X gave the following results.

$$n = 75 \qquad \Sigma x = 153.2 \qquad \Sigma x^2 = 340.24$$

Find unbiased estimates for the population mean and variance of X . [3]

[illegible]

- 2 A six-sided die is suspected of bias. The die is thrown 100 times and it is found that the score is 2 on 20 throws. It is given that the probability of obtaining a score of 2 on any throw is p .

(i) Find an approximate 94% confidence interval for p . [3]

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(ii) Use your answer to part (i) to comment on whether the die may be biased. [1]

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- 3** The number of e-readers sold in a 10-day period in a shop is modelled by the distribution $\text{Po}(5.1)$. Use an approximating distribution to find the probability that fewer than 140 e-readers are sold in a 300-day period. [4]

[illegible]

- 4 The volume, in millilitres, of a small cup of coffee has the distribution $N(103.4, 10.2)$. The volume of a large cup of coffee is 1.5 times the volume of a small cup of coffee.

(i) Find the mean and standard deviation of the volume of a large cup of coffee. [3]

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(ii) Find the probability that the total volume of a randomly chosen small cup of coffee and a randomly chosen large cup of coffee is greater than 250 ml. [4]

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- 5** The mass, in kilograms, of rocks in a certain area has mean 14.2 and standard deviation 3.1.

- (i) Find the probability that the mean mass of a random sample of 50 of these rocks is less than 14.0 kg. [3]

[illegible]

- (ii) Explain whether it was necessary to assume that the population of the masses of these rocks is normally distributed. [1]

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- (iii) A geologist suspects that rocks in another area have a mean mass which is less than 14.2 kg. A random sample of 100 rocks in this area has sample mean 13.5 kg. Assuming that the standard deviation for rocks in this area is also 3.1 kg, test at the 2% significance level whether the geologist is correct. [5]

[illegible]

- 6 The time, in minutes, taken by people to complete a test is modelled by the continuous random variable X with probability density function given by

$$f(x) = \begin{cases} \frac{k}{x^2} & 5 \leq x \leq 10, \\ 0 & \text{otherwise,} \end{cases}$$

where k is a constant.

- (i) Show that $k = 10$. [3]

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- (ii) Show that $E(X) = 10 \ln 2$. [2]

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(iii) Find $P(X > 9)$.

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(iv) Given that $P(X < a) = 0.6$, find a .

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- 7 The number of absences by girls from a certain class on any day is modelled by a random variable with distribution $Po(0.2)$. The number of absences by boys from the same class on any day is modelled by an independent random variable with distribution $Po(0.3)$.

- (i) Find the probability that, during a randomly chosen 2-day period, the total number of absences is less than 3. [3]

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- (ii) Find the probability that, during a randomly chosen 5-day period, the number of absences by boys is more than 3. [2]

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- (iii) The teacher claims that, during the football season, there are more absences by boys than usual. In order to test this claim at the 5% significance level, he notes the number of absences by boys during a randomly chosen 5-day period during the football season.

(a) State what is meant by a Type I error in this context. [1]

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(b) State appropriate null and alternative hypotheses and find the probability of a Type I error. [3]

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(c) In fact there were 4 absences by boys during this period. Test the teacher's claim at the 5% significance level. [3]

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[illegible]

Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

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- 1 The numbers of alpha, beta and gamma particles emitted per minute by a certain piece of rock have independent distributions $\text{Po}(0.2)$, $\text{Po}(0.3)$ and $\text{Po}(0.6)$ respectively. Find the probability that the total number of particles emitted during a 4-minute period is less than 4. [3]

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- 2 The random variable X has the distribution $N(3, 1.2)$. The random variable A is defined by $A = 2X$. The random variable B is defined by $B = X_1 + X_2$, where X_1 and X_2 are independent random values of X . Describe fully the distribution of A and the distribution of B . [3]

Distribution of A :

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Distribution of B :

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- 3 The management of a factory wished to find a range within which the time taken to complete a particular task generally lies. It is given that the times, in minutes, have a normal distribution with mean μ and standard deviation 6.5. A random sample of 15 employees was chosen and the mean time taken by these employees was found to be 52 minutes.

(i) Calculate a 95% confidence interval for μ .

[3]

[illegible]

Later another 95% confidence interval for μ was found, based on a random sample of 30 employees.

- (ii) State, with a reason, whether the width of this confidence interval was less than, equal to or greater than the width of the previous interval. [1]

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- 4 The mean mass of packets of sugar is supposed to be 505 g. A random sample of 10 packets filled by a certain machine was taken and the masses, in grams, were found to be as follows.

500 499 496 495 498 490 492 501 494 494

- (i) Find unbiased estimates of the population mean and variance. [3]

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The mean mass of packets produced by this machine was found to be less than 505 g, so the machine was adjusted. Following the adjustment, the masses of a random sample of 150 packets from the machine were measured and the total mass was found to be 75 660 g.

- (ii) Given that the population standard deviation is 3.6 g, test at the 2% significance level whether the machine is still producing packets with mean mass less than 505 g. [5]

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(iii) Explain why the use of the normal distribution is justified in carrying out the test in part **(ii)**. [1]

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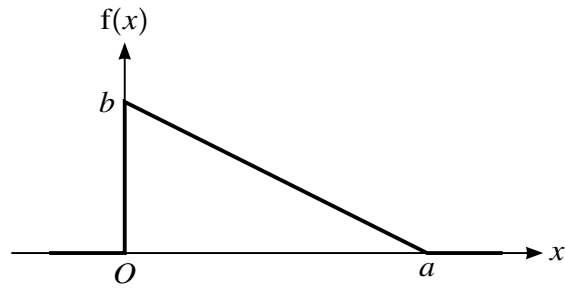
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The diagram shows the probability density function, f , of a random variable X , in terms of the constants a and b .

(i) Find b in terms of a .

[2]

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(ii) Show that $f(x) = \frac{2}{a} - \frac{2}{a^2}x$.

[3]

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(iii) Given that $E(X) = 0.5$, find a .

[4]

[illegible]

6 Accidents on a particular road occur at a constant average rate of 1 every 4.8 weeks.

- (i) State, in context, one condition for the number of accidents in a given period to be modelled by a Poisson distribution. [1]

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Assume now that a Poisson distribution is a suitable model.

- (ii) Find the probability that exactly 4 accidents will occur during a randomly chosen 12-week period. [2]

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- (iii) Find the probability that more than 3 accidents will occur during a randomly chosen 10-week period. [3]

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- (iv) Use a suitable approximating distribution to find the probability that fewer than 30 accidents will occur during a randomly chosen 2-year period ($104\frac{2}{7}$ weeks). [4]

This image shows a full page of white paper with horizontal dotted lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings on the page.

- 7 A ten-sided spinner has edges numbered 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. Sanjeev claims that the spinner is biased so that it lands on the 10 more often than it would if it were unbiased. In an experiment, the spinner landed on the 10 in 3 out of 9 spins.

(i) Test at the 1% significance level whether Sanjeev's claim is justified. [5]

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(ii) Explain why a Type I error cannot have been made. [1]

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In fact the spinner is biased so that the probability that it will land on the 10 on any spin is 0.5.

- (iii)** Another test at the 1% significance level, also based on 9 spins, is carried out. Calculate the probability of a Type II error. [6]

[illegible]

[illegible]

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- 1** A random variable X has the distribution $B(75, 0.03)$.

(i) Use the Poisson approximation to the binomial distribution to calculate $P(X < 3)$. [3]

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

(ii) Justify the use of the Poisson approximation. [1]

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- 2 Amy has to choose a random sample from the 265 students in her year at college. She numbers the students from 1 to 265 and then uses random numbers generated by her calculator. The first two random numbers produced by her calculator are 0.213 165 448 and 0.073 165 196.

(i) Use these figures to find the numbers of the first four students in her sample. [2]

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There were 25 students in Amy's sample. She asked each of them how much money, \$ x , they earned in a week, on average. Her results are summarised below.

$$n = 25$$

$$\Sigma x = 510$$

$$\Sigma x^2 = 13\,225$$

(ii) Find unbiased estimates of the population mean and variance. [3]

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(iii) Explain briefly what is meant by 'population' in this question. [1]

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- 3 A researcher wishes to estimate the proportion, p , of houses in London Road that have only one occupant. He takes a random sample of 64 houses in London Road and finds that 8 houses in the sample have only one occupant. Using this sample, he calculates that an approximate $\alpha\%$ confidence interval for p has width 0.130. Find α correct to the nearest integer. [5]

This image shows a full page of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page, typical of notebook or legal stationery. There are no margins, text, or other markings on the page.

- 4 The numbers, M and F , of male and female students who leave a particular school each year to study engineering have means 3.1 and 0.8 respectively.

(i) State, in context, one condition required for M to have a Poisson distribution. [1]

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Assume that M and F can be modelled by independent Poisson distributions.

(ii) Find the probability that the total number of students who leave to study engineering in a particular year is more than 3. [3]

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(iii) Given that the total number of students who leave to study engineering in a particular year is more than 3, find the probability that no female students leave to study engineering in that year. [3]

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- 5 The time taken for a particular train journey is normally distributed. In the past, the time had mean 2.4 hours and standard deviation 0.3 hours. A new timetable is introduced and on 30 randomly chosen occasions the time for this journey is measured. The mean time for these 30 occasions is found to be 2.3 hours.

(i) Stating any assumption(s), test, at the 5% significance level, whether the mean time for this journey has changed. [6]

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(ii) A similar test at the 5% significance level was carried out using the times from another randomly chosen 30 occasions.

(a) State the probability of a Type I error. [1]

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(b) State what is meant by a Type II error in this context. [1]

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- 6** The times, in minutes, taken to complete the two parts of a task are normally distributed with means 4.5 and 2.3 respectively and standard deviations 1.1 and 0.7 respectively.

(i) Find the probability that the total time taken for the task is less than 8.5 minutes. [4]

This image shows a full page of white paper with horizontal dotted lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings on the page.

This image shows a full page of white paper with horizontal dotted lines, typical of primary school writing paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

- 7 A random variable X has probability density function defined by

$$f(x) = \begin{cases} k \left(\frac{1}{x^2} + \frac{1}{x^3} \right) & 1 \leq x \leq 2, \\ 0 & \text{otherwise,} \end{cases}$$

where k is a constant.

- (i) Show that $k = \frac{8}{7}$. [3]

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- (ii) Find $E(X)$. [3]

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- (iii) Three values of X are chosen at random. Find the probability that one of these values is less than 1.5 and the other two are greater than 1.5. [5]

[illegible]

This image shows a full page of a handwriting practice worksheet. It consists of multiple sets of three horizontal dashed lines spaced evenly down the page, providing a guide for letter height and placement. The background is plain white, and there are no other markings or text present.

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