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Examiners' report

FURTHER MATHEMATICS B (MEI)

H635

For first teaching in 2017

Y412/01 Summer 2022 series

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate answers is also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Advance Information for Summer 2022 assessments

To support student revision, advance information was published about the focus of exams for Summer 2022 assessments. Advance information was available for most GCSE, AS and A Level subjects, Core Maths, FSMQ, and Cambridge Nationals Information Technologies. You can find more information on our website.

Paper Y412/01 series overview

This is a calculator paper in which situations are modelled by discrete random variables; the suitability of models is tested using chi-squared tests. Bivariate data are investigated, with tests for correlation and association, and modelling using regression.

In general, candidates performed well on this paper. Very few extremely low marks were seen. Most of the candidates achieved over half of the available marks and demonstrated a good understanding of the content of this option. Candidates appeared well prepared for all of the questions apart from Question 5 (d). It was pleasing to see evidence of working, when appropriate, from the majority of candidates.

Candidates who did well on this paper generally did the following:	Candidates who did less well on this paper generally did the following:
• demonstrated good knowledge of probability models • gave clear, unambiguous comments when required • provided all relevant detail in hypothesis tests, using suitable wording • demonstrated the ability to select then apply an appropriate probability model to a given situation.	• demonstrated limited knowledge of probability models and the conditions under which they apply • demonstrated some understanding of hypothesis testing but chose incorrect critical values and/or gave inappropriate conclusions • could apply routine probability calculations.

Question 1 (a)

1 A fair five-sided spinner has sectors labelled 1, 2, 3, 4, 5. In a game at a stall at a charity event, the spinner is spun twice. The random variable X represents the lower of the two scores. The probability distribution of X is given by the formula

$$P(X = r) = k(11 - 2r) \text{ for } r = 1, 2, 3, 4, 5,$$

where k is a constant.

(a) Complete the copy of this table in the Printed Answer Booklet. **[1]**

r	1	2	3	4	5
$P(X = r)$		$7k$		$3k$	

Question 1 (b)

(b) Determine the value of k. **[1]**

Question 1 (c)

(c) Find each of the following.

- $E(X)$
- $Var(X)$ **[2]**

Question 1 (d)

(d) The stall-holder charges a player C pence to play the game, and then pays the player $50X$ pence, where X is the player's score.

Given that the average profit that the stall-holder makes on one game is 25 pence, find the value of C. **[2]**

Most candidates multiplied their $E(X)$ by 50 but many subtracted 25 rather than adding.

Question 2 (a)

2 On a car assembly line, a robot is used for a particular task.

(a) State the conditions under which a Poisson distribution is an appropriate model for the number of breakdowns of the robot in a week. **[2]**

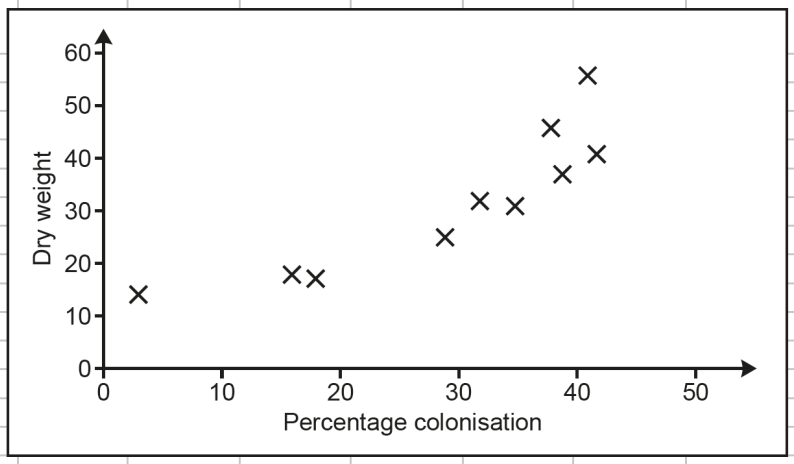
Many candidates found it difficult to relate the conditions of 'randomness', 'independence' and 'uniform average rate' to the context, 'breakdowns', typically referring to 'events' or avoiding any reference to context. Many candidates' responses were either muddled, incomplete or contained additional words which changed the meaning sufficiently enough for marks not to be given.

Question 3 (a)

3 A biology student is doing an experiment in which plants are inoculated with a particular microorganism in an attempt to help them grow. She is investigating whether there is any association between the percentage of roots which have been colonised by the microorganism and the dry weight of the plant shoots. After the plants have grown for a few weeks, the student takes a random sample of 10 plants and measures the percentage of roots which have been colonised by the microorganism and the dry weight of the plant shoots.

The spreadsheet output shows the data, together with a scatter diagram to illustrate the data.

	A	B
1	Percentage colonisation	Dry weight
2	3	14
3	18	17
4	16	18
5	29	25
6	35	31
7	32	32
8	39	37
9	42	41
10	38	46
11	41	56



(a) The student decides that a test based on Pearson's product moment correlation coefficient may not be valid.

Explain why she comes to this conclusion. **[2]**

Candidates were required to explain that the points in the scatter diagram did not suggest a linear association due to them not being distributed within an elliptical shape and thus bringing into question the requirement of the underlying population having a bivariate Normal distribution. For many of the candidates who showed awareness of these terms, a common misunderstanding was to refer to 'the data' having a bivariate Normal distribution.

Question 3 (b)

(b) Calculate the value of Spearman's rank correlation coefficient. **[3]**

This was well answered by most candidates. The vast majority realised that data needed to be ranked; few errors in ranking were seen. Candidates who slipped up when calculating the correlation coefficient could still earn most of the marks provided that correct ranking was seen.

Question 3 (c)

(c) Carry out a test based on this coefficient, at the 5% significance level, to investigate whether there is any association between percentage colonisation and shoot dry weight. **[5]**

Many candidates earned 4/5 marks, the missing mark being due to not referencing 'population' in their hypotheses. An incorrect critical value was used by some, most commonly values for a 1-tail test or from the table for the product moment correlation coefficient.

Question 4 (a)

4 A random number generator generates integers between 1 and 50 inclusive, with each number having an equal probability of being generated.

(a) State the probability distribution of the numbers generated. **[2]**

Although most candidates recognised that the Uniform distribution was appropriate, many omitted stating the associated values or were unclear in their wording.

Question 4 (b)

(b) Determine the probability that a number generated is within one standard deviation of the mean. **[4]**

Most candidates calculated mean and standard deviation correctly. Many fully correct answers were seen. A common mistake was for those stating that $P(12 \leq X \leq 39)$ was needed but giving the final answer as 27/50.

Question 5 (a)

5 A researcher is investigating whether there is any relationship between the overall performance of a student at GCSE and their grade in A Level Mathematics. Their A Level Mathematics grade is classified as A* or A, B, C or lower, and their overall performance at GCSE is classified as Low, Middle, High.

Data are collected for a sample of 80 students in a particular area. The researcher carries out a chi-squared test. The screenshot below shows part of a spreadsheet used to analyse the data. Some values in the spreadsheet have been deliberately omitted.

	A	B	C	D	E
1		**Observed frequency**			
2		**A* or A**	**B**	**C or lower**	**Totals**
3	**Low**	6	13	9	28
4	**Middle**	10	6	8	24
5	**High**	15	10	3	28
6	**Totals**	31	29	20	80
7					
8		**Expected frequency**			
9		**A* or A**	**B**	**C or lower**	
10	**Low**	10.85			
11	**Middle**	9.30			
12	**High**	10.85	10.15	7.00	
13					
14		**Contribution to the test statistic**			
15		**A* or A**	**B**	**C or lower**	
16	**Low**	2.1680	0.8002	0.5714	
17	**Middle**	0.0527	0.8379	0.6667	
18	**High**	1.5873		2.2857	
19					

(a) State what needs to be known about the sample for the test to be valid. **[1]**

Many candidates did not state the need for the sample to be randomly chosen.

Question 5 (b)

For the remainder of this question, you should assume that the test is valid.

(b) Determine the missing values in each of the following cells.

- C11
- C18

[3]

Many correct answers were seen. In such questions, candidates should use the provided table as a guide to an appropriate level of accuracy.

Question 5 (c)

(c) In this question you must show detailed reasoning.

Carry out a hypothesis test at the 10% significance level to investigate whether there is any association between level of performance at GCSE and A Level Mathematics grade. **[6]**

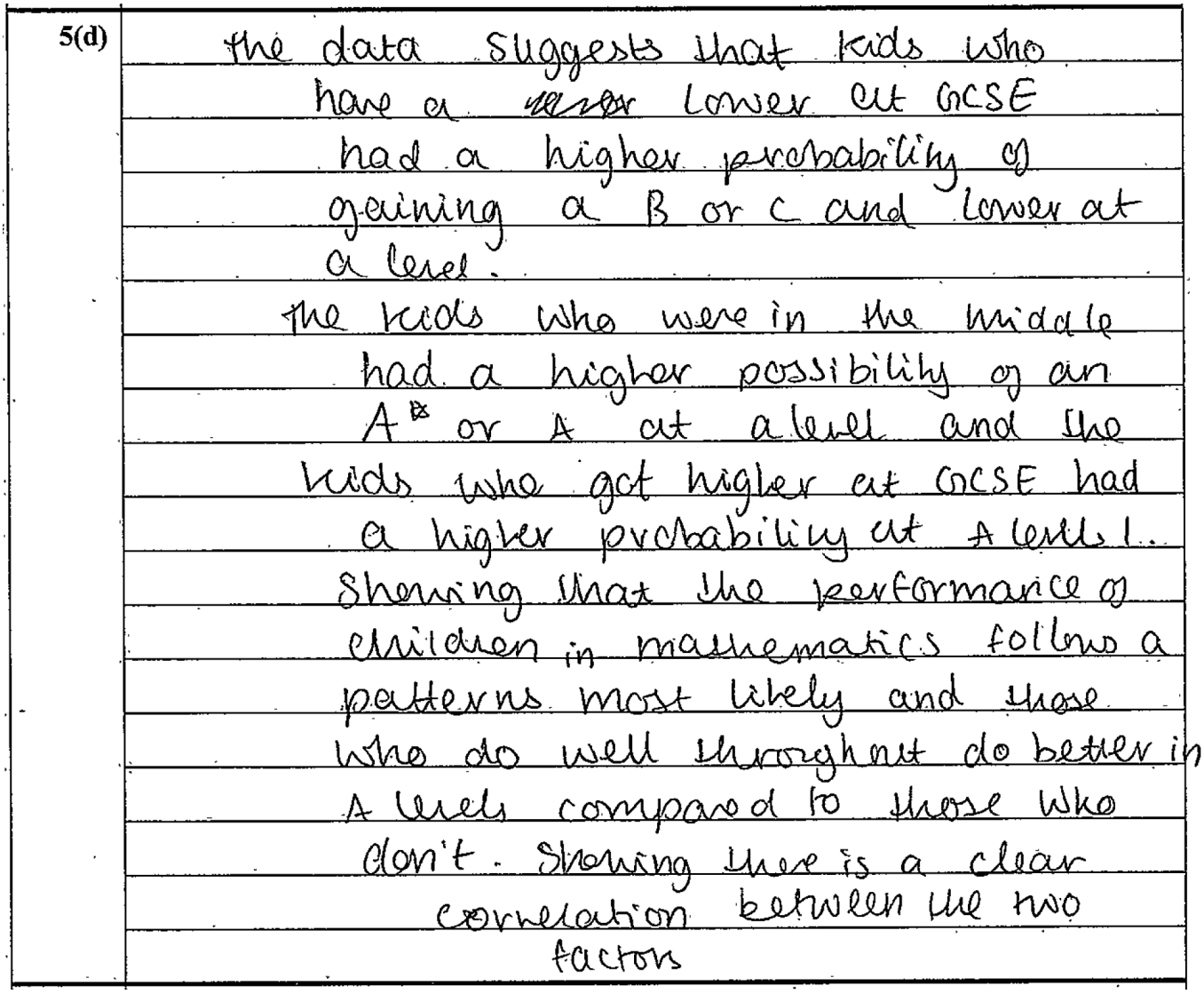
This question was well answered. Some candidates did not state their hypotheses or used 'correlation' in place of 'association'. Common mistakes included errors in addition when finding the test statistic and use of an incorrect critical value. Most candidates managed to compare their test statistic with their critical value and provide a suitably non-assertive conclusion.

Question 5 (d)

(d) Discuss briefly what the data suggest about A Level Mathematics grade for different levels of performance at GCSE. **[3]**

This question was unsuccessfully answered by many candidates. The question required candidates to make a comment for each of the different levels of performance at GCSE; many did not follow this, instead providing muddled answers. Rather than commenting on how observed performance had compared with what would be expected if there was no association, many candidates commented on likelihood of success.

Exemplar 1



5(d)

the data suggests that kids who have a ~~lower~~ lower at GCSE had a higher probability of gaining a B or C and lower at a level.
the kids who were in the middle had a higher possibility of an A* or A at a level and the kids who got higher at GCSE had a higher probability at A levels I. Showing that the performance of children in mathematics follows a patterns most likely and those who do well throughout do better in A levels compared to those who don't. Showing there is a clear correlation between the two factors

This candidate has used the data provided to discuss the probabilities of different outcomes rather than discussing the data in relation to association between the classification factors.

Assessment for learning

In such questions, candidates are required to state that for the cells containing relatively large contributions the data suggests that observed values are either greater than would be expected or less than would be expected if there were no association, and that for the cells with low contributions the data suggest that observed values are as would be expected if there were no association.

Question 5 (e)

(e) State **one** disadvantage of using a 10% significance level rather than a 5% significance level in a hypothesis test. **[1]**

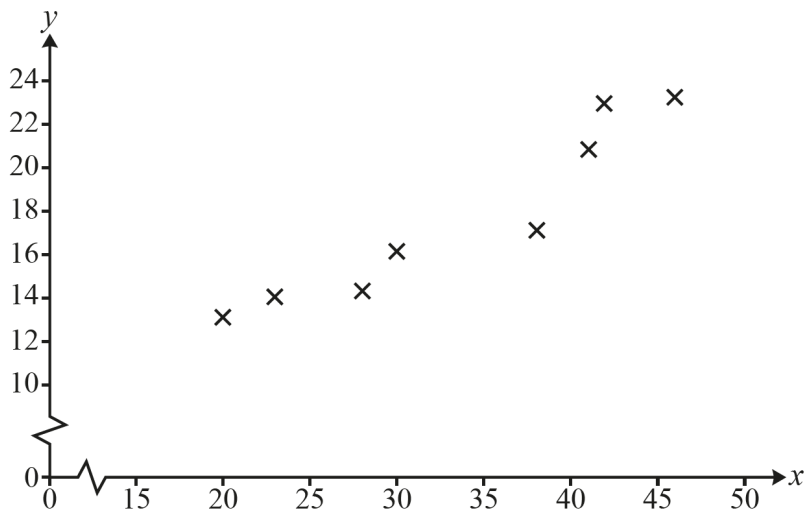
Many correct answers were seen. Common misconceptions included beliefs that the test would be 'less accurate' or 'less precise' at the 10% level.

Question 6 (a)

6 Tom has read in a newspaper that you can tell the air temperature by counting how often a cricket chirps in a period of 20 seconds. (A cricket is a type of insect.) He wants to know exactly how the temperature can be predicted. On 8 randomly selected days, when Tom can hear crickets chirping, he records the number of chirps, x, made by a cricket in a 20-second interval, and also the temperature, $y\,°\text{C}$, at that time. The data are summarised as follows.

$n = 8 \qquad \Sigma x = 268 \qquad \Sigma y = 141.9 \qquad \Sigma x^2 = 9618 \qquad \Sigma y^2 = 2630.55 \qquad \Sigma xy = 5009.1$

These data are illustrated below.



(a) Determine the equation of the regression line of y on x. Give your answer in the form $y = ax + b$, giving the values of a and b correct to **3** significant figures. **[4]**

Many correct answers were seen. Some candidates interchanged coefficients a and b.

Question 6 (b)

(b) Use the equation of the regression line to predict the temperature for the following values of x.

- 35
- 10 **[2]**

Many candidates did not consider the accuracy of their final answers. Those who gave answers to 3 or more decimal places were penalised.

Question 6 (c)

(c) Comment on the reliability of your predictions in part **(b)**. **[3]**

Most candidates gave suitable comments regarding interpolation and extrapolation.

Question 6 (d)

(d) State the coordinates of the point of intersection of the line whose equation you have calculated with the regression line of x on y. **[1]**

Many correct answers were seen. Those who attempted to calculate the coordinates of this point were mostly unsuccessful.

Question 7 (a)

7 On average one in five packets of a breakfast cereal contains a voucher for a discount on the next packet bought. Whether or not a packet contains a voucher is independent of other packets, and can only be determined by opening the packet.

(a) State the distribution of the number of packets that need to be opened in order to find one which contains a voucher. **[2]**

Question 7 (b)

(b) Determine the probability that exactly 4 packets have to be opened in order to find one which contains a voucher. **[1]**

Question 7 (c)

(c) Determine the probability that exactly 10 packets have to be opened in order to find two which contain a voucher. **[2]**

Many correct answers were seen. Common errors included use of B(10, 0.2) or simply calculating $0.8^8 \times 0.2^2$.

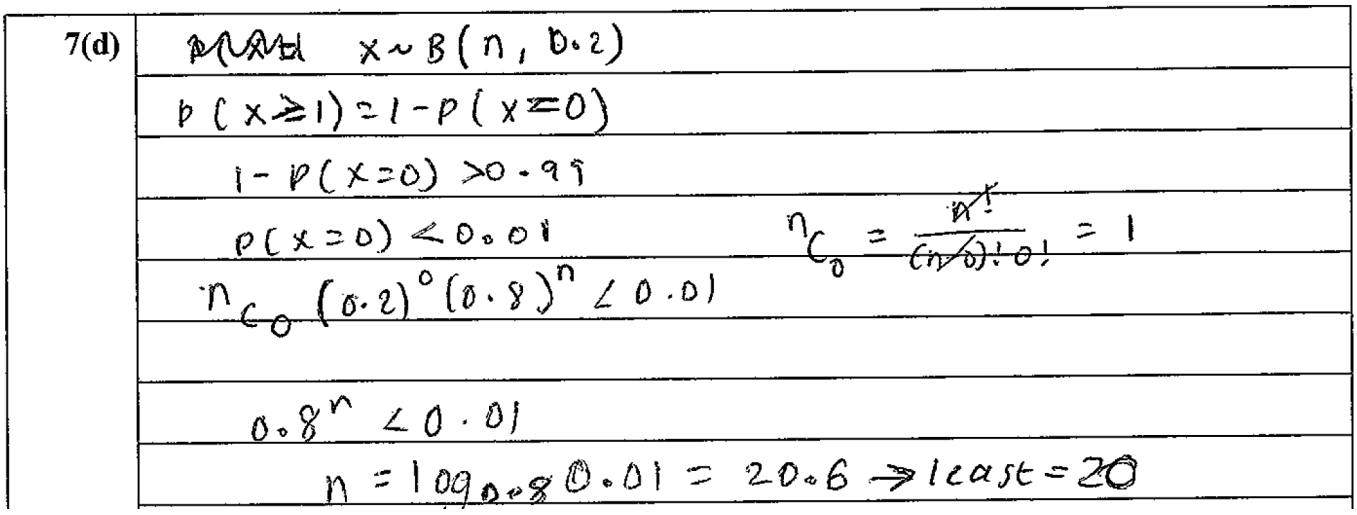
Question 7 (d)

(d) I have n packets, and I open them one by one until I find a voucher or until all the packets are open.

Given that the probability that I find a voucher is greater than 0.99, determine the least possible value of n. **[2]**

Many of the candidates who wrote $0.8n < 0.01$ managed to obtain the correct solution without error. Some candidates slipped up with their handling of inequalities. Incorrect inequalities, involving $0.8n-1$ or $0.8n \times 0.2$, were common.

Exemplar 2



This candidate has stated the correct inequality but perhaps not realised that after taking logarithms a value of n greater than 20.6 is needed.

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