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Examiners' report

MATHEMATICS A

H230

For first teaching in 2017

H230/01 Summer 2022 series

Version 1

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 are 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.

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Paper 1 series overview

The overall standard was similar to that in 2019 (i.e., the last "normal" year), with a range of marks from very high to fairly low. Very few candidates scored below 20%. The questions requiring verbal answers (8 (a), 9 (c), 10 (b), 10 (c), 10 (d) and 11 (b)) were fairly well answered on the whole, although most candidates wrote far more than was necessary to gain the mark(s). Centres are referred to the published mark scheme to see the kind of verbal answers that are acceptable.

Some candidates resorted to trial and improvement methods. These are usually not given full credit, even if the correct answers are obtained.

Some candidates did not show sufficient working, and so lost marks. Candidates need to be made aware of the significance of command words such as "Detailed reasoning" and "Determine", as explained on the next page.

Candidates who did well on this paper generally did the following:	Candidates who did less well on this paper generally did the following:
• They understood hypothesis testing well. • Their algebraic skills were good. • They were able to interpret a statistical table. • They were able to break a problem down into its constituent parts. • They understood when to use calculator functions and when to show detailed working.	• Their algebraic skills were less successful. • They lacked understanding of hypothesis testing. • They were unable to relate the algebraic aspects of a problem with the graphical or geometrical aspects.

How much working needs to be shown to gain full marks?

Some candidates seemed unsure as to how much working was required for any given question. This problem arises from what might seem a dilemma. On the one hand, candidates are expected to be able to use calculator functions that "short cut" techniques such as definite integration, solution of quadratic and cubic equations, mean and standard deviation. On the other hand, candidates are also expected to show understanding of precisely the techniques that these functions make unnecessary. This dilemma is resolved by the careful use, in questions, of certain command words, whose definitions are found on pages 10 to 15 of the specification. This can be illustrated by comparing Questions 4 (b) and 8 (b) on this paper.

Question 4 contains the instruction **In this question you must show detailed reasoning**. This means that, when solving the quadratic equation that arises in the solution of part (b), candidates are expected to show a method (either factorisation, or the formula, or completing the square) for obtaining the solutions. Candidates who obtained the quadratic equation and then just wrote down the correct solutions lost one method mark. In contrast to this, Question 8 (b) starts with the word "Find". This command indicates that, while working may be necessary to answer the question, there is no requirement to show all the working. A solution could be obtained from the efficient use of a calculator instead. A further clue is that there are only two marks available for two answers. In fact, it was expected that candidates would use the statistical functions on the calculator to write down the two answers without explanation. Many candidates did this successfully. Many other candidates, however, showed working and in some cases made arithmetical errors and lost the relevant mark. Of course, candidates are free to show working if they wish to.

When using one of the "short cut" functions in questions like 8 (b), candidates would be well advised to carry out the technique twice as a check.

The command word "Determine" also implies that each stage of the working must be shown. Thus, for example, in Question 11 (a) (i), candidates who gave the correct answer without working scored only one mark out of two. And in Question 11 (a) (ii), candidates who gave the correct answer with no working, or inadequate working, scored two marks out of three.

OCR support

A student guide and a classroom poster to help reinforce the A Level Maths command words can be downloaded from the qualification website:

Exam hints for students and the A Level Maths command words poster A4 size

Section A overview

Candidates generally answered Questions 1, 2 and 4 well although, for many, their algebraic skills required improvement. Use of graphical methods in Questions 3 and 6 was less good on the whole.

Question 1

1 Find the term in x^3 in the binomial expansion of $(3-2x)^5$. **[2]**

Some candidates lost the minus sign. Many candidates wrote out all the terms. Others wrote just the terms up to x^3. Many candidates wrote the correct term, $-720x^3$ but then gave, as their answer, just the coefficient -720. Some did not cube the 2. A few seemed unfamiliar with the binomial expansion and attempted to find $(3-2x)^5$ by repeated multiplication of brackets.

Question 2 (a)

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

The cubic polynomial $f(x)$ is defined by $f(x) = 5x^3 - 4x^2 + ax - 2$, where a is a constant.

You are given that $(x-2)$ is a factor of $f(x)$.

(a) Find the value of a. **[2]**

Most candidates answered this question successfully. A few lost the minus sign. Some chose the much longer method of dividing $f(x)$ by $(x - 2)$ and equating coefficients. Many of these candidates made errors.

Question 2 (b)

(b) Find all the factors of $f(x)$. **[3]**

Most candidates found the quadratic factor by long division. Some did it by inspection. Any method was acceptable, so long as the relevant method was shown. Some candidates wrote down, without working, the solutions to the equation $f(x) = 0$ and derived the factors from these. Because of the "**detailed reasoning**" instruction, these candidates scored no marks.

Misconception

The responses given to Question 2 (b) revealed some confusion between "factors" and "solutions". Some candidates found the factors successfully, but then used these to write down the solutions to the equation $f(x) = 0$. They then stated or implied that they thought these solutions were the "factors" of $f(x)$.

Question 3 (a)

3 The diagram in the Printed Answer Booklet shows part of the graph of $y = x^2 - 4x + 3$.

(a) It is required to solve the equation $x^2 - 3x + 1 = 0$ graphically by drawing a straight line with equation $y = mx + c$ on the diagram, where m and c are constants.

Find the values of m and c. **[2]**

Most candidates showed unfamiliarity with this style of question. Some wrote $x^2 - 4x + 3 = x^2 - 3x + 1$ $\Rightarrow$ $x - 2 = 0$, but most did not know how to proceed to obtain the required straight-line equation. Some differentiated and concluded that the required straight-line equation was $y = 2x - 3$.

Question 3 (b)

(b) Use the graph to find approximate values of the roots of the equation $x^2 - 3x + 1 = 0$. **[2]**

Most of the candidates who had obtained a straight line equation (either correct or incorrect) in part (a), knew how to use it to find solutions. Even an incorrect line could lead to one mark on follow-through. A minority of candidates misunderstood the instruction "Use the graph" and drew the graph of $y = x^2 - 3x + 1$. These candidates were (perhaps rather generously) given one mark out of two for the correct solutions. A large number of candidates gave the correct solutions but had drawn either no line or an incorrect line. It was assumed that these candidates had used the calculator function to obtain these solutions and so they scored no marks.

A common incorrect answer was $x = 1$ or 3, which comes from the intersection points of the given curve with the x-axis.

Question 3 (c)

(c) By shading, or otherwise, indicate clearly the regions where **all** of the following inequalities are satisfied. You should use the values of m and c found in part **(a)**.

$x \geqslant 0$ $\quad$ $x \leqslant 4$ $\quad$ $y \leqslant x^2 - 4x + 3$ $\quad$ $y \geqslant mx + c$ **[3]**

Very few candidates answered this correctly. Candidates who had drawn an incorrect line in part (b) could score up to two marks on follow-through. However, many candidates (with either a correct or an incorrect line) made mistakes in indicating the relevant regions. In some cases, their region stopped at the x-axis. In other cases, only one of the two correct regions was shown. In many cases, the region indicated was both above the line and above the curve. A few candidates drew the line $y = 4$ instead of $x = 4$.

Question 4 (a)

4 In this question you must show detailed reasoning.

Solve the following equations, for $0° \leqslant x \leqslant 360°$.

(a) $2\tan x + 1 = 4$ **[3]**

This question was correctly answered by most candidates. Some candidates made a sign error.

Others found $\frac{\tan^{-1}3}{2}$. A few correctly obtained 56.3°, but then either gave no other answer or gave the correct 180 + 56.3° together with the incorrect 180° − 56.3° and/or 360° − 56.3°.

Question 4 (b)

(b) $5\sin x - 1 = 2\cos^2 x$ **[5]**

Many candidates used a correct method, gaining two method marks, but some made arithmetical or algebraic slips and so lost the two accuracy marks. Many candidates lost a mark because they omitted the working for the solution of the relevant quadratic equation. Others lost a mark because they did not indicate why they were rejecting the solution sin x = −3. Some candidates correctly used the identity $\sin^2 x + \cos^2 x = 1$ but appeared not to recognise that the resulting equation was a quadratic equation in sin x.

Two examples of the subsequent incorrect work were as follows: $5\sin x + 2\sin^2 x = 3 \Rightarrow \sin^2 x = \frac{3}{7}$ and $5\sin x - 1 = 2 - 2\sin^2 x \Rightarrow 4 = 2 - 2\sin x$.

A few candidates attempted a solution without the use of the identity $\sin^2 x + \cos^2 x = 1$. These candidates did not make any progress.

Question 5 (a)

5 The gradient of a curve is given by $\frac{dy}{dx} = x^2 - 3x$. The curve passes through the point (6, 20).

(a) Determine the equation of the curve. **[4]**

Most candidates recognised the need to integrate, although a few differentiated. Some omitted the arbitrary constant. Some found the correct polynomial but omitted "*y* = ". A few candidates obtained the correct integral, but then wrote $\frac{x^3}{3} - \frac{3x^2}{2} + 2 = 0$, and stated that this was the required equation of the curve.

An unusual, but interesting, incorrect method was as follows: When $x = 6$, $\frac{dy}{dx} = 18$. The curve passes through (6, 20) hence the equation is $y - 20 = 18(x - 6)$.

Question 5 (b)

(b) Hence determine $\int_1^p y \, dx$ in terms of the constant p. **[4]**

Many candidates did not carry out a second integration but substituted the limits into their answer to part (a). Some of those who used a correct method made an arithmetical error in obtaining the constant term.

It is worth noting that this question required the ability to carry out a definite integral without the use of the relevant calculator function.

Question 6 (a) (i)

6 During some research the size, P, of a population of insects, at time t months after the start of the research, is modelled by the following formula.

$$P = 100e^t$$

(a) Use this model to answer the following.

(i) Find the value of P when $t = 4$. **[1]**

This question was answered correctly by almost all candidates.

Question 6 (a) (ii)

(ii) Find the value of t when the population is 9000. **[2]**

This question was answered correctly by most candidates. Some started correctly with $100e^t = 9000$ but went on to write $e^t = 900$.

Question 6 (b) (i)

(b) It is suspected that a more appropriate model would be the following formula.

$P = ka^t$ where k and a are constants.

(i) Show that, using this model, the graph of $\log_{10} P$ against t would be a straight line. **[2]**

Some candidates tried to answer this by taking particular values, or by drawing a graph. These did not score. Others took logs of both sides, but then made an error, such as $\log_{10} P = t \log_{10} ka$. However, many candidates obtained the correct equation and gave a good explanation as to why this was in the form $y = mx + c$.

Question 6 (b) (ii)

Some observations of t and P gave the following results.

t	1	2	3	4	5
P	100	500	1800	7000	19 000
$\log_{10} P$	2.00	2.70	3.26	3.85	4.28

(ii) On the grid in the Printed Answer Booklet, draw a line of best fit for the data points $(t, \log_{10} P)$ given in the table. **[2]**

Almost all candidates plotted the points correctly, and most drew a reasonable line of best fit. The acceptable limits for the line are shown in the mark scheme.

Question 6 (b) (iii)

(iii) Hence estimate the values of k and a. **[4]**

Those candidates who understood what was required answered this question well. Other candidates used values from the table, despite their line not going through these points, to form two simultaneous equations from which they obtained values of *k* and *a*. This method did not score any marks because the word "Hence" required candidates to use their line of best fit to answer this question.

Those candidates who had given a good explanation in part 6(b)(i) (such as "Plotting $\log_{10}P$ against t produces a straight line with gradient $\log_{10}a$ and y-intercept $\log_{10}k$") were more likely than others to gain full marks in Question 6 (b) (iii).

Question 7 (a)

7 (a) In this question you must show detailed reasoning.

Find the range of values of the constant m for which the simultaneous equations $y = mx$ and $x^2 + y^2 - 6x - 2y + 5 = 0$ have real solutions. **[5]**

Many candidates began this question by rearranging the equation into the form $(x - a)^2 + (y - b)^2 = r^2$. This was unnecessary, although full marks could still be scored using this form. Some candidates attempted some sort of algebraic solution that did not involve substituting mx for y in the second equation. They were not able to make any progress. Many candidates, however, did make the substitution, but some did not know how to proceed from there. A good number of candidates did attempt to form the discriminant, although some candidates' discriminant was in terms of both x and m, which is incorrect. Those candidates who formed the discriminant in terms of m only were generally successful, although some made minor errors in the algebra.

A few candidates found the correct critical values of m but lost the final mark by giving an incorrect final answer such as [$-\frac{1}{2} < m < 2$] or [$m \le -\frac{1}{2}$ and $m \ge 2$].

Question 7 (b)

(b) Give a geometrical interpretation of the solution in the case where $m = 2$. **[3]**

Many candidates did not appreciate what a "geometrical interpretation" involves. Some just solved the equations in the case where $m = 2$, and gave the solution $x = 1$, without commenting on the fact that this was a repeated solution. Some attempted to draw a sketch of a circle and a line. Although their circle was roughly correct in many cases, the line was often incorrect, not even passing through the origin.

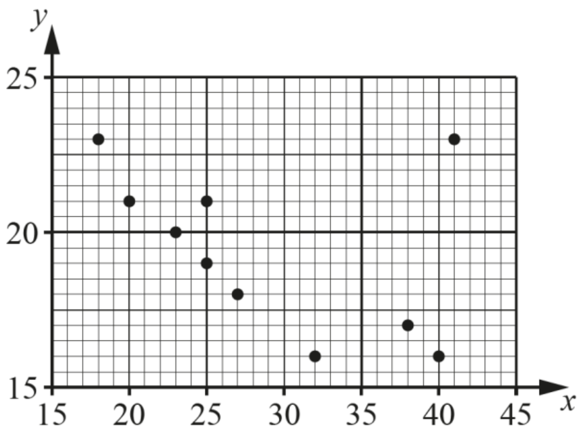
Many candidates used a different approach, substituting $m = 2$ into their expression for the discriminant. If their expression was correct, this led to a value of 0, and most drew the correct conclusion that the line was a tangent to the circle.

Section B overview

Candidates were generally able to extract information from a statistical diagram or table fairly well. On the other hand, using a given probability distribution to calculate probabilities of possible events, was found difficult by many candidates. Most candidates had clearly been taught how to carry out a hypothesis test, and some did this perfectly. Others, however, knew some of the vocabulary but appeared not to have understood the principles that they had been taught.

Question 8 (a)

8 A random sample of 10 students from a college was chosen. They were asked how much time, x hours, they spent studying, and how much money, £y, they earned, in a typical week during term time. The results are shown in the scatter diagram.



(a) Comment on the relationship shown by the diagram between hours spent studying and money earned, during term time, by these 10 students. **[2]**

Many candidates commented correctly on the negative correlation shown in the diagram. A few just stated "negative correlation" without context. In order to gain the first mark, the comment had to be given in context, referring to the two variables explicitly. Some candidates stated, incorrectly, that the two variables were in inverse proportion. Most candidates did not gain the second mark which was for noting that, although there was negative correlation overall, there was one student whose data did not fit this pattern.

Question 8 (b)

The coordinates of the points in the diagram are (18, 23), (20, 21), (23,20), (25, 19), (25, 21), (27,18), (32, 16), (38, 17), (40, 16) and (41, 23).

(b) Find the mean and standard deviation of the number of hours spent per week studying during term time by these 10 students. **[2]**

Many candidates used their calculator's statistical functions and wrote down the answers without working which, as explained earlier, was acceptable in this question. A few gave incorrect answers without working. Perhaps they used the calculator functions but did not repeat the process as a check. Some candidates showed working, and many of these either made arithmetical errors or only calculated the mean.

Question 9 (a) (i)

9 Last year, market research showed that 8% of adults living in a certain town used a particular local coffee shop. Following an advertising campaign, it was expected that this proportion would increase. In order to test whether this had happened, a random sample of 150 adults in the town was chosen.

The random variable X denotes the number of these 150 adults who said that they used the local coffee shop.

(a) (i) Assuming that the proportion of adults using the local coffee shop is unchanged from the previous year, state a suitable binomial distribution with which to model the variable X. **[1]**

Most gave the correct answer. However, a number of incorrect answers suggested that, although candidates may be familiar with calculating binomial probabilities by rote, they are unaware of the distribution that lies behind the calculations. Examples of incorrect answers were:

P(X = 0.8), P(X > 0.8), $\binom{150}{x}0.92^{(150-x)}0.08^{x}$, $\binom{n}{x}0.92^{(n-x)}0.08^{x}$, B ~ X(150, 0.08),

$X \sim \mathrm{N}(150, 0.08)$, B ~ X(150, $\frac{8}{150}$), 150 × 0.08 = 12,

X = 0.08 & n = 150, P = 12(150, 0.08).

Question 9 (a) (ii)

(ii) The probabilities given by this model are the terms of the binomial expansion of an expression of the form $(a+b)^n$.

Write down this expression, using appropriate values of a, b and n. **[1]**

This question was intended to test candidates' understanding of the relationship between the binomial distribution (in statistics) and the binomial expansion (in pure maths). Many candidates answered correctly, but some answers suggested a lack of understanding of this relationship. Examples of incorrect answers were: $\mathrm{P}(X = x) = \binom{150}{x} 0.92^{(150-x)} 0.08^{x}$, $(1 - 0.08)^{150}$, $(150 + 12)^{0.08}$, $(1 - 0.92)^{1}$, $(1 - 0.08)^{150}$, $150 \times 0.08 = 12$, $(a + b)^{0.08}$.

Question 9 (b)

It was found that 18 of these 150 adults said that they use the local coffee shop.

(b) Test, at the 5% significance level, whether the proportion of adults in the town who use the local coffee shop has increased. **[7]**

The mark scheme for this question (as for all hypothesis test questions) is long and complicated and would reward careful study.

A good number of candidates answered this question correctly. Several lost just one or two marks, sometimes by not defining p in the hypotheses, or by omitting to show explicitly the comparison with 0.05, or by giving a "definite" conclusion such as "The proportion using the coffee shop has not increased." Although a large number of candidates showed familiarity with the relevant terminology, they showed little understanding of the process required for a hypothesis test.

Content statement 2.05a in the specification states that the hypotheses for a hypothesis test must be stated in terms of the relevant parameter. In addition to this, the parameter must be defined in context and must be clearly described as the <u>population</u> value. In this question, many candidates did not define the relevant parameter clearly, thus losing a mark. Others gave the hypotheses in words, not in terms of the parameter.

A common error was $\mathrm{P}(X \geq 18) = 0.031$. This comes from the incorrect step $\mathrm{P}(X \geq 18) = 1 - \mathrm{P}(X \leq 18)$. Candidates who made this error could, nevertheless, score a possible 6 marks out of 7.

Another common error was to find $\mathrm{P}(X = 18)$ rather than $\mathrm{P}(X \geq 18)$. This led to the loss of most of the marks. Some candidates wrote

"$\mathrm{P}(X = 18)$", but actually calculated $\mathrm{P}(X \geq 18)$.

Some candidates found the correct probability (0.055) and made the correct explicit comparison, $0.055 > 0.05$, but then drew the wrong conclusion, rejecting H_0.

Question 9 (c)

It was later discovered by a statistician that the random sample of 150 adults had been chosen from shoppers in the town on a Friday and a Saturday.

(c) Explain why this suggests that the assumptions made when using a binomial model for X may not be valid in this context. **[1]**

To gain the mark, there needed to be an implication that one of the two binomial conditions (constant probability of success or independent events) was not satisfied. This required a reasonable explanation either for why the clientele on Friday and Saturday might be different from other days, or for why the Friday clientele might be different from the Saturday clientele or for why one adult's use of the coffee shop might not be independent of another's. Two categories of answers that were not accepted were these: Any suggestion that there may be more people in town on Fridays and Saturdays than other days, or that there might be people from outside town who come in on Fridays and Saturdays. For a more detailed list of acceptable and non-acceptable answers, please refer to the published mark scheme.

Question 10 (a)

10 The table shows the increases, between 2001 and 2011, in the percentages of employees travelling to work by various methods, in the Local Authorities (LAs) in the North East region of the UK.

Geography code	Local authority	Work mainly at or from home	Underground, metro, light rail or tram	Bus, minibus or coach	Driving a car or van	Passenger in a car or van	On foot
E06000047	**County Durham**	0.74%	0.05%	−1.50%	4.58%	−2.99%	−0.97%
E06000005	**Darlington**	0.26%	−0.01%	−3.25%	3.06%	−1.28%	0.99%
E08000020	**Gateshead**	−0.01%	−0.01%	−2.28%	4.62%	−2.35%	−0.18%
E06000001	**Hartlepool**	0.03%	−0.04%	−1.62%	4.80%	−2.38%	−0.26%
E06000002	**Middlesbrough**	−0.34%	−0.01%	−2.32%	2.19%	−1.33%	0.67%
E08000021	**Newcastle upon Tyne**	0.10%	−0.23%	−0.67%	−0.48%	−1.51%	1.75%
E08000022	**North Tyneside**	0.05%	0.54%	−1.18%	3.30%	−2.21%	−0.60%
E06000048	**Northumberland**	1.39%	−0.08%	−0.95%	3.50%	−2.37%	−1.44%
E06000003	**Redcar and Cleveland**	−0.02%	−0.01%	−2.09%	4.20%	−2.06%	−0.49%
E08000023	**South Tyneside**	−0.36%	2.03%	−3.05%	4.50%	−2.41%	−0.51%
E06000004	**Stockton-on-Tees**	0.14%	0.03%	−2.02%	3.52%	−2.01%	−0.15%
E08000024	**Sunderland**	0.17%	1.48%	−3.11%	4.89%	−2.21%	−0.52%

Increase in percentage of employees travelling to work by various methods

The first two digits of the Geography code give the type of each of the LAs:

06: Unitary authority
07: Non-metropolitan district
08: Metropolitan borough

(a) In what type of LA are the largest increases in percentages of people travelling by underground, metro, light rail or tram? **[1]**

Most candidates gave the correct response. Some misread the question and gave the name of one particular Local Authority as their answer.

Question 10 (b)

(b) Identify two main changes in the pattern of travel to work in the North East region between 2001 and 2011. **[2]**

Many correct answers (as listed on the mark scheme) were seen. The most common unacceptable answer was "The percentage of people working from home has generally decreased". Although this is true, it was not felt that this was one of the "main" changes, as required by the question.

Question 10 (c)

Now assume the following.

- The data refer to residents in the given LAs who are in the age range 20 to 65 at the time of each census.
- The number of people in the age range 20 to 65 who move into or out of each given LA, or who die, between 2001 and 2011 is negligible.

(c) Estimate the percentage of the people in the age range 20 to 65 in 2011 whose data appears in both 2001 and 2011. **[2]**

In order to gain any marks, candidates had to recognise that the relevant age ranges were of length 35 years and 45 years (although 36 and 46 were also allowed), giving an answer of 78%, correct to two significant figures. Many answers showed incorrect proportions, such as $\frac{35}{65}$, $\frac{25}{45}$, $\frac{20}{65}$, $\frac{10}{45}$, $\frac{20}{45}$, $\frac{30}{45}$ and 50%. In some cases, no working was shown so that no marks could be given except for an answer that was correct to two significant figures. This included unsupported answers such as "approximately 80%", which might well have come from correct working, but since this working was not seen, no marks could be given.

Question 10 (d)

(d) In the light of your answer to part **(c)**, suggest a reason for the changes in the pattern of travel to work in the North East region between 2001 and 2011. **[1]**

An ideal answer would refer to the new cohort of 20–30-year-olds in 2011, probably stating that they were more likely to drive cars or own cars than the corresponding cohort in 2001. Some answers seemed to imply an assumption that the people in the 20-65 age range were the same in 2001 as in 2011. These answers were not accepted, although in some cases where the intention was unclear, candidates were given the benefit of the doubt. One type of answer that was clearly incorrect was one that stated or implied that the relevant group of people were "getting older".

Question 11 (a) (i)

11 Alex models the number of goals that a local team will score in any match as follows.

Number of goals	0	1	2	3	4	More than 4
Probability	$\frac{3}{25}$	$\frac{1}{5}$	$\frac{8}{25}$	$\frac{7}{25}$	$\frac{2}{25}$	0

The number of goals scored in any match is independent of the number of goals scored in any other match.

(a) Alex chooses 3 matches at random. Use the model to determine the probability of each of the following.

(i) The team will score a total of exactly 1 goal in the 3 matches. **[2]**

Many correct solutions were seen.

One partially correct solution that was also common was $\frac{1}{5}\times\left(\frac{4}{5}\right)^2$, which ignores the three possible orders. A very common incorrect solution was $\left(\frac{1}{5}\right)^3$, which is P(exactly 1 goal will be scored in each of the 3 matches) rather than P(a total of exactly 1 goal will be scored in the 3 matches). A few candidates added probabilities instead of multiplying.

Question 11 (a) (ii)

(ii) The numbers of goals scored in the first 2 of the 3 matches will be equal, but the number of goals scored in the 3rd match will be different. **[3]**

The "standard" method is to consider five cases, P(0, 0) × (1 − P(not 0)) + P(1, 1) × (1 − P(not 1)) etc, giving $\left(\frac{3}{25}\right)^2 \times \frac{22}{25} + \left(\frac{1}{5}\right)^2 \times \frac{4}{5} + \ldots$ Many candidates used this method successfully, although some omitted one or more of the five cases. A few candidates used an incorrect variation on this method, $\left(\frac{3}{25}\right)^2 \times \frac{19}{25} + \left(\frac{1}{5}\right)^2 \times \frac{3}{5} + \ldots\ldots$

Many other candidates used the "long" method of considering all 20 cases (0, 0, 1), (0, 0, 2), etc. Many of these made arithmetical errors. Others gave up after a few calculations, presumably feeling daunted by the large number of individual products that would need to be found. Candidates who showed all 20 cases but did not show at least eight of the actual products, gained one mark.

Some candidates used the rather neat method of P(the first two are the same) − P(all three are the same), usually successfully. Two related incorrect methods were 1 − P(all three are the same) and P(the first two are the same).

Question 11 (b)

During the first 10 matches this season, the team scores a total of 31 goals.

(b) Without carrying out a formal test, explain briefly whether this casts doubt on the validity of Alex's model. **[1]**

One way to gain the mark was to refer to the model as a whole, showing that 3.1 was an unlikely value for the mean in 10 matches. This could be implied by reference to the mean ("2" or "about 2") or by a statement such as "The model implies that fewer than 3 goals is more likely than more than 3." Another way to gain the mark was to state or imply that, in order to achieve a mean of about 3, the probability of scoring 4 goals would be likely to be greater than 0.

Some common unacceptable answers were as follows. "The most common score is 2", "P(3 goals) is small", "3 is not the most likely number of goals", "P(scoring 3 goals in each of 10 matches is $\left(\frac{7}{25}\right)^3$ which is tiny".

A common response that, although true, was considered inadequate was "According to the model, a mean of about 3 is unlikely".

Supporting you

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