OCR
Oxford Cambridge and RSA

Thursday 15 May 2025 – Afternoon

AS Level Mathematics A

H230/01 Pure Mathematics and Statistics

Time allowed: 1 hour 30 minutes

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You must have:
- the Printed Answer Booklet
- a scientific or graphical calculator

QP

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided in the **Printed Answer Booklet**. If you need extra space use the lined pages at the end of the Printed Answer Booklet. The question numbers must be clearly shown.
- Fill in the boxes on the front of the Printed Answer Booklet.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.
- Give non-exact numerical answers correct to **3** significant figures unless a different degree of accuracy is specified in the question.
- The acceleration due to gravity is denoted by $g\,\text{m}\,\text{s}^{-2}$. When a numerical value is needed use $g = 9.8$ unless a different value is specified in the question.
- Do **not** send this Question Paper for marking. Keep it in the centre or recycle it.

INFORMATION
- The total mark for this paper is **75**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **8** pages.

ADVICE
- Read each question carefully before you start your answer.

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Formulae
AS Level Mathematics A (H230)

Binomial series

$$(a+b)^n = a^n + {}^n\mathrm{C}_1 a^{n-1}b + {}^n\mathrm{C}_2 a^{n-2}b^2 + \ldots + {}^n\mathrm{C}_r a^{n-r}b^r + \ldots + b^n \qquad (n \in \mathbb{N}),$$

where ${}^n\mathrm{C}_r = {}_n\mathrm{C}_r = \binom{n}{r} = \dfrac{n!}{r!(n-r)!}$

Differentiation from first principles

$$\mathrm{f}'(x) = \lim_{h \to 0} \frac{\mathrm{f}(x+h) - \mathrm{f}(x)}{h}$$

Standard deviation

$$\sqrt{\frac{\Sigma(x-\overline{x})^2}{n}} = \sqrt{\frac{\Sigma x^2}{n} - \overline{x}^2} \quad \text{or} \quad \sqrt{\frac{\Sigma f(x-\overline{x})^2}{\Sigma f}} = \sqrt{\frac{\Sigma f x^2}{\Sigma f} - \overline{x}^2}$$

The binomial distribution

If $X \sim \mathrm{B}(n, p)$ then $P(X = x) = \binom{n}{x} p^x (1-p)^{n-x}$, mean of X is np, variance of X is $np(1-p)$

Kinematics

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$s = \frac{1}{2}(u+v)t$

$v^2 = u^2 + 2as$

$s = vt - \frac{1}{2}at^2$

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Section A
Pure Mathematics

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

Solve the following equations.

(a) $\sqrt{x^2 - 11} = 5$ **[2]**

(b) $y^6 + 7y^3 - 8 = 0$ **[4]**

(c) $2^{3z-10} = 16$ **[2]**

2 It is given that $\int_0^5 (ax^2 - 2x + 4)\,\mathrm{d}x = 45$, where a is a constant.

Determine the value of a. **[3]**

3 **(a)** Express $x^2 - 6x$ in the form $(x+p)^2 + q$, where p and q are constants. **[2]**

(b) Hence or otherwise determine the centre and radius of the circle with equation $x^2 + y^2 - 6x - 16 = 0$. **[3]**

4 **(a)** Show that $\frac{\cos\theta}{1-\sin\theta} - \frac{1}{\cos\theta} \equiv \tan\theta$ (where $\theta \neq 90n°$ for any odd integer n). **[3]**

(b) Hence solve the equation $\frac{\cos 3x}{1-\sin 3x} - \frac{1}{\cos 3x} = 1$ for $0 \leqslant x \leqslant 90°$. **[4]**

5 **(a)** Find the coefficient of x^7 in the expansion of $(2x+3)^9$. **[2]**

(b) The following questions are about the binomial expansion of $(1+x)^{21}$ in ascending powers of x.

(i) Two consecutive terms have equal coefficients.

State the powers of x in these two terms. **[1]**

(ii) Given that the terms in x^r and x^{r+5} have equal coefficients, find r. **[2]**

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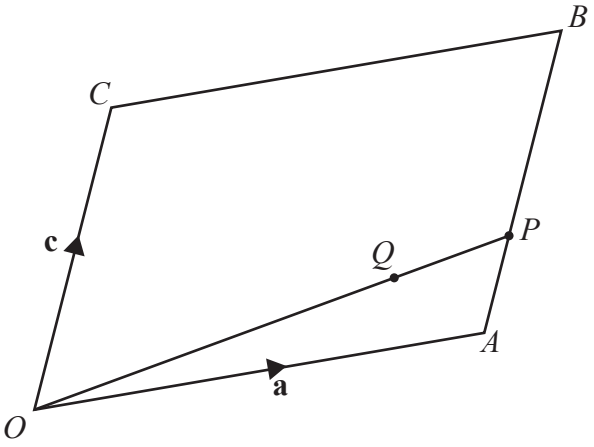
6 **In this question you must show detailed reasoning.**

Solve the following equations.

(a) $\log_3(x+32) - \log_3(2x) + \log_3 2 = 2$ **[4]**

(b) $\log_y\left(\frac{1}{8}\right) = -\frac{3}{2}$ **[3]**

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



The diagram shows a parallelogram $OABC$. The position vectors of A and C are **a** and **c** respectively.

- The point P lies on AB such that $AP = \frac{1}{3}AB$.
- The point Q lies on OP such that $OQ = \frac{3}{4}OP$.

(a) Show that $\overrightarrow{OQ} = \frac{3}{4}\mathbf{a} + \frac{1}{4}\mathbf{c}$. **[4]**

(b) Hence show that Q lies on AC. **[3]**

8 A curve with equation $y = x^3 + 3x^2 - 9x - 12$ has stationary points A and B.

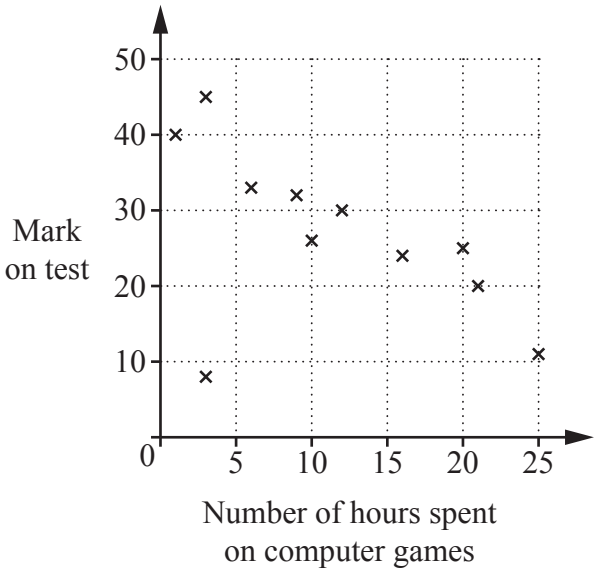
Determine the coordinates of the point where the line through A and B meets the x-axis. **[8]**

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Section B
Statistics

9 Sasha collected data from 11 students about the time they spent on computer games during the previous week and their marks in a test. The results are represented in the scatter diagram.



(a) Give **two** comments about the relationship between the mark scored on the test and the number of hours spent on computer games. **[2]**

A teacher says, "The overall pattern of the points shows that, for most students, spending a long time playing computer games has a bad effect on your school work."

A student responds, "But correlation does not imply causation."

The teacher replies, "So why are the points in this overall pattern?"

(b) Suggest an answer to the teacher's question. **[1]**

The table shows the data that are represented in the diagram.

Number of hours spent on computer games	1	3	10	20	12	25	6	21	3	16	9
Mark on test	40	45	26	25	30	11	33	20	8	24	32

(c) Find the median and inter-quartile range of the marks. **[2]**

It is given that the quartiles of the number of hours spent on computer games are 3 and 20.

(d) Use the inter-quartile ranges to determine whether there are any outliers amongst the marks or the number of hours spent on computer games. **[1]**

Sasha says, "The diagram shows that there is one outlier."

(e) Comment on Sasha's statement in the light of your conclusion in part **(d)**. **[1]**

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10 Researchers investigated the change in the numbers of people in employment using underground, metro, light rail or tram (UMLRT) between 2001 and 2011.

The data are combined for those Local Authorities (LAs) with UMLRT stations into five regions: Birmingham, Liverpool, Manchester, Sheffield and Rotherham, and Tyne and Wear.

Fig. 1 shows the total numbers of people in employment in those LAs.

Fig. 2 shows the total numbers of people in employment who use UMLRT in those LAs.

Fig. 1

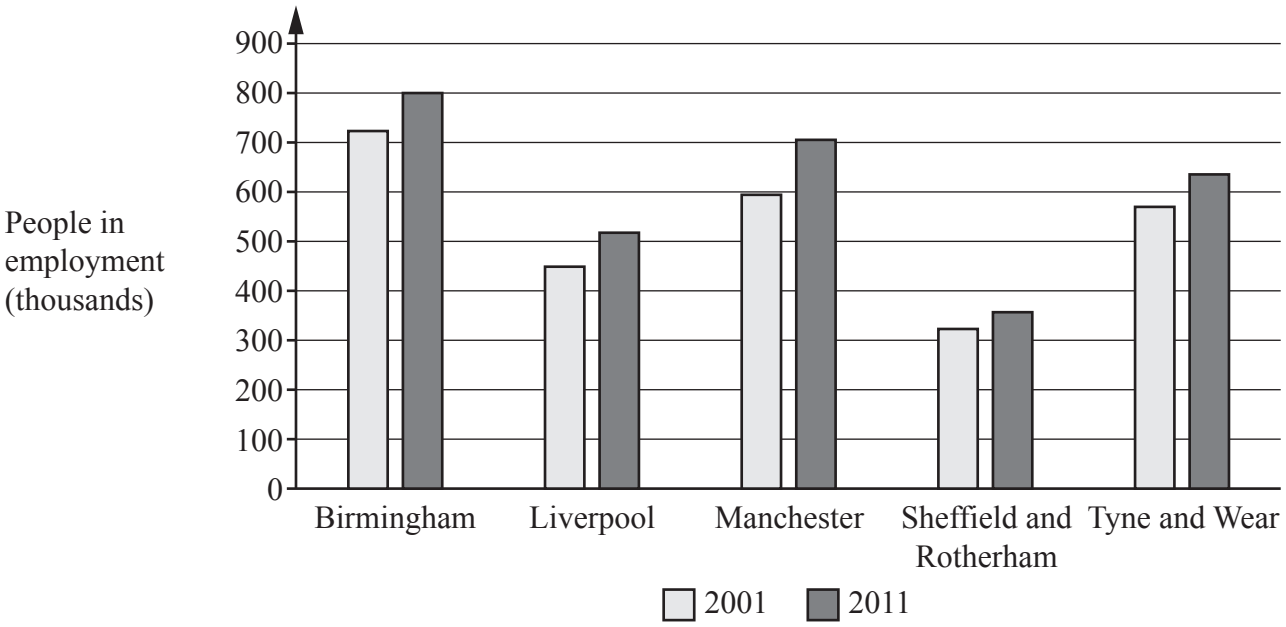
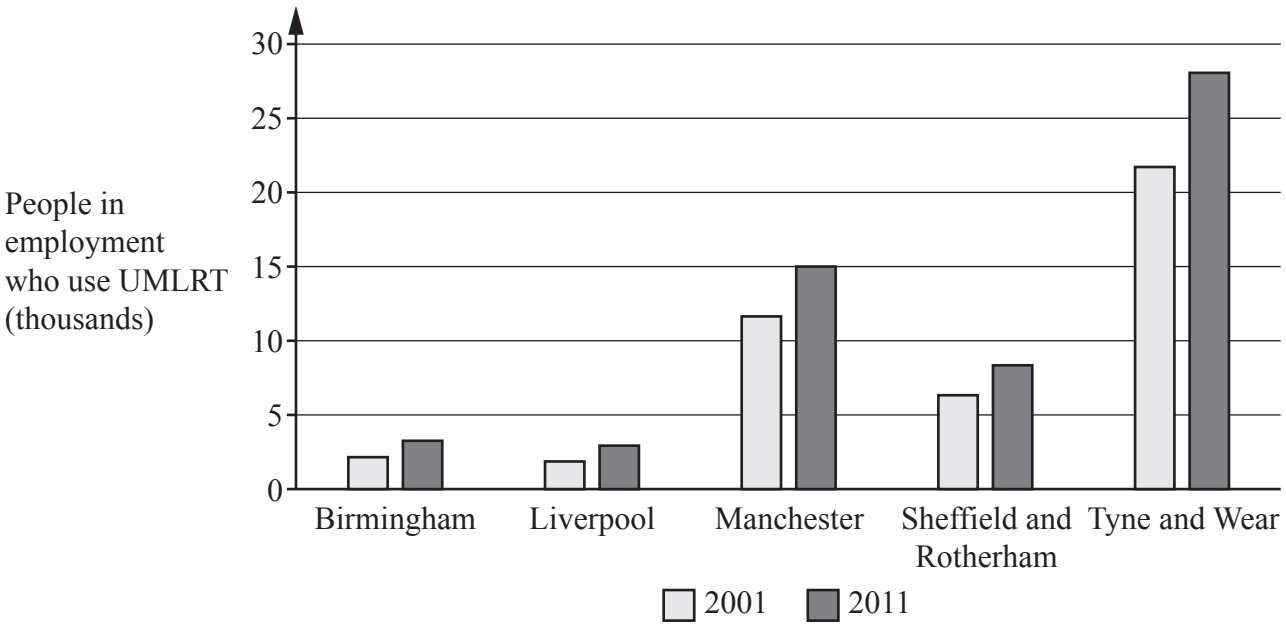


Fig. 2



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(a) Use these charts to explain which of Birmingham and Liverpool has the larger proportion of people in employment who used UMLRT in 2011. **[2]**

One of the researchers says, "Between 2001 and 2011, the increase in the number of people in employment who use UMLRT is greatest in Tyne and Wear."

Sam says, "But what matters more is which region has the greatest increase in the **proportion** of people in employment who use UMLRT."

(b) Give a reason why the planners responsible for the building of trains and the maintenance of infrastructure might **disagree** with Sam. **[1]**

(c) Explain whether those responsible for encouraging the greater use of public transport would agree with Sam. **[2]**

(d) The charts are compiled from data in the Large Data Set by using those LAs which contain UMLRT stations in each region.

Explain a disadvantage of using these data. **[1]**

Turn over for questions 11 and 12

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11 A spinner has sides numbered 1, 2, 3, 4. When the spinner is spun the score is given by the number of the side on which it lands. The spinner is biased, as shown in the table.

Score	1	2	3	4
Probability	$\frac{1}{8}$	$\frac{3}{8}$	$\frac{1}{6}$	$\frac{1}{3}$

In a fairground game, each player has two spins. They win a prize if the total of the scores on the two spins is greater than 5.

Zayn says, "If I play, it's more likely that I'll win a prize than I won't win a prize."

Determine whether Zayn is correct. **[4]**

12 A school contains 552 students. In the past the proportion of students who bought lunch at the school canteen was $\frac{1}{3}$. Following a change in the lunches provided in the canteen, the governors want to test whether this proportion has increased. They decide to allow one term for the students to become used to the new system. They note the number of students who buy lunch at the school canteen on the last day of term. They use this number to carry out a hypothesis test.

(a) State suitable null and alternative hypotheses for the test. **[2]**

The number of students who buy lunch at the school canteen on the last day of term is 201.

(b) Carry out the test at the 5% significance level. **[5]**

(c) Suggest **one** reason why the conclusion of the test may **not** be reliable. **[1]**

END OF QUESTION PAPER

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Surname	StemUp Model Solution
Answer booklet	Write the question number in the left-hand margin at the start of each answer.

Question number

1 (a) $\sqrt{(x^2 - 11)} = 5$

$x^2 - 11 = 25$ (squaring both sides)

$x^2 = 36 \Rightarrow x = \pm 6$

1 (b) Let $u = y^3$: $(y^3)^2 + 7y^3 - 8 = 0 \Rightarrow u^2 + 7u - 8 = 0$

$(u + 8)(u - 1) = 0 \Rightarrow u = -8$ or $u = 1$

$y^3 = -8$ or $y^3 = 1$

$y = -2$ or $y = 1$

1 (c) $2^{3z - 10} = 16 = 2^4$

$3z - 10 = 4 \Rightarrow 3z = 14$

$z = \frac{14}{3}$ (= 4.67 to 3 s.f.)

2 $\int_0^5 (ax^2 - 2x + 4)\,dx = \left[\frac{ax^3}{3} - x^2 + 4x\right]_0^5$

$= \left(\frac{125a}{3} - 25 + 20\right) - 0 = \frac{125a}{3} - 5$

$\frac{125a}{3} - 5 = 45 \Rightarrow \frac{125a}{3} = 50 \Rightarrow 125a = 150$

$a = \frac{150}{125} = \frac{6}{5}$ (= 1.2)

3 (a) $x^2 - 6x = (x - 3)^2 - 9$

Question number	
3 (b)	$x^2 + y^2 - 6x - 16 = 0$
	$(x - 3)^2 - 9 + y^2 - 16 = 0$
	$(x - 3)^2 + y^2 = 25$
	Centre $(3, 0)$, radius $= \sqrt{25} = 5$
4 (a)	$\text{LHS} = \dfrac{\cos\theta}{1 - \sin\theta} - \dfrac{1}{\cos\theta} \equiv \dfrac{\cos^2\theta - (1 - \sin\theta)}{(1 - \sin\theta)\cos\theta}$
	$\equiv \dfrac{(1 - \sin^2\theta) - 1 + \sin\theta}{(1 - \sin\theta)\cos\theta} \equiv \dfrac{-\sin^2\theta + \sin\theta}{(1 - \sin\theta)\cos\theta}$ (using $\cos^2\theta \equiv 1 - \sin^2\theta$)
	$\equiv \dfrac{\sin\theta(1 - \sin\theta)}{(1 - \sin\theta)\cos\theta} \equiv \dfrac{\sin\theta}{\cos\theta} \equiv \tan\theta = \text{RHS}$ as required
4 (b)	Using part (a) with $\theta = 3x$: $\tan 3x = 1$
	$0 \leqslant x \leqslant 90° \Rightarrow 0 \leqslant 3x \leqslant 270°$
	$\tan^{-1}(1) = 45° \Rightarrow 3x = 45°$ or $3x = 45° + 180° = 225°$
	$x = 15°$ or $x = 75°$
5 (a)	Term in x^7: ${}^9C_7 (2x)^7 (3)^2$
	${}^9C_7 \times 2^7 \times 3^2 = 36 \times 128 \times 9 = 41472$
	Coefficient of x^7 is 41472
5 (b)(i)	x^{10} and x^{11} (since ${}^{21}C_{10} = {}^{21}C_{11}$)
5 (b)(ii)	${}^{21}C_r = {}^{21}C_{r+5}$ with $r \neq r + 5 \Rightarrow r + (r + 5) = 21$
	$2r = 16 \Rightarrow r = 8$
6 (a)	$\log_3(x + 32) - \log_3(2x) + \log_3 2 = 2$
	$\log_3\left(\dfrac{2(x + 32)}{2x}\right) = 2 \Rightarrow \log_3\left(\dfrac{x + 32}{x}\right) = 2$

Question number

$\frac{x+32}{x} = 3^2 = 9 \quad \Rightarrow \quad x + 32 = 9x \quad \Rightarrow \quad 8x = 32$

$x = 4$

6 (b)

$\log_y\left(\frac{1}{8}\right) = -\frac{3}{2} \quad \Rightarrow \quad y^{-3/2} = \frac{1}{8}$

$y^{3/2} = 8$

$y = 8^{2/3} = (\sqrt[3]{8})^2 = 2^2 = 4$

7 (a)

$\overrightarrow{AB} = \overrightarrow{OC} = \underline{c}$, so $\overrightarrow{AP} = \frac{1}{3}\overrightarrow{AB} = \frac{1}{3}\underline{c}$

$\overrightarrow{OP} = \overrightarrow{OA} + \overrightarrow{AP} = \underline{a} + \frac{1}{3}\underline{c}$

$\overrightarrow{OQ} = \frac{3}{4}\overrightarrow{OP} = \frac{3}{4}\left(\underline{a} + \frac{1}{3}\underline{c}\right)$

$\overrightarrow{OQ} = \frac{3}{4}\underline{a} + \frac{1}{4}\underline{c}$ as required

7 (b)

$\overrightarrow{AQ} = \overrightarrow{OQ} - \overrightarrow{OA} = \frac{3}{4}\underline{a} + \frac{1}{4}\underline{c} - \underline{a} = \frac{1}{4}\underline{c} - \frac{1}{4}\underline{a}$

$\overrightarrow{AC} = \overrightarrow{OC} - \overrightarrow{OA} = \underline{c} - \underline{a}$

So $\overrightarrow{AQ} = \frac{1}{4}\left(\underline{c} - \underline{a}\right) = \frac{1}{4}\overrightarrow{AC}$

AQ is a scalar multiple of AC, so AQ is parallel to AC, and they share the common point A, so A, Q and C are collinear.

Hence Q lies on AC.

8

$\frac{dy}{dx} = 3x^2 + 6x - 9$

Question number

Stationary points: $\frac{dy}{dx} = 0 \Rightarrow 3x^2 + 6x - 9 = 0 \Rightarrow x^2 + 2x - 3 = 0$

$(x + 3)(x - 1) = 0 \Rightarrow x = -3$ or $x = 1$

$x = -3$: $y = -27 + 27 + 27 - 12 = 15$

$x = 1$: $y = 1 + 3 - 9 - 12 = -17$

$A(-3, 15)$ and $B(1, -17)$

Gradient of $AB = \frac{15 - (-17)}{-3 - 1} = \frac{32}{-4} = -8$

Line AB: $y - 15 = -8(x + 3) \Rightarrow y = -8x - 9$

Meets x-axis when $y = 0$: $0 = -8x - 9$

$x = -\frac{9}{8}$ Meets the x-axis at $(-\frac{9}{8}, 0)$

9 (a) There is (fairly good) negative correlation between the number of hours spent on computer games and the mark on the test: students who spent more hours on games tended to get lower marks.
This is true except for one point, (3, 8), which does not fit the overall pattern.

9 (b) There may be a third factor affecting both the time spent on games and the mark, e.g. the more able students may have been away last week (on a school trip), so they did not spend much time playing computer games.

9 (c) Marks in order: 8, 11, 20, 24, 25, 26, 30, 32, 33, 40, 45 ($n = 11$)
Median = 6th value = 26
LQ = 3rd value = 20, UQ = 9th value = 33
IQR = 33 − 20 = 13

9 (d) Marks: UQ + 1.5 × IQR = 33 + 1.5 × 13 = 52.5
LQ − 1.5 × IQR = 20 − 1.5 × 13 = 0.5

Question number	
	All marks lie between 0.5 and 52.5 (8 to 45).
	Hours: IQR = 20 − 3 = 17
	UQ + 1.5 × IQR = 20 + 1.5 × 17 = 45.5
	LQ − 1.5 × IQR = 3 − 1.5 × 17 = −22.5
	All hours lie between −22.5 and 45.5 (1 to 25).
	So there are no outliers in the marks or in the hours.
9 (e)	Sasha's outlier (3 hours, 8 marks) is not an outlier for the marks or the hours on their own (part (d)); it is only an outlier with regard to the correlation, i.e. it does not fit the overall pattern of the relationship.
10 (a)	Liverpool. Both have a similar number of people in employment who use UMLRT in 2011 (about 3 thousand), but Liverpool has a smaller number of people in employment (about 520 thousand compared with about 800 thousand), so the proportion is larger in Liverpool (about 3/520 compared with 3/800).
10 (b)	The demand on trains and infrastructure depends on the actual number of passengers, not on the proportion, so the planners care most about the number of people using UMLRT.
10 (c)	Yes, to some extent: a greater increase in the proportion means that the message to use public transport is getting across to more of the working population, which is what they want. But the proportion alone may be unclear: in larger areas a small increase in proportion means many more people, so the overall numbers matter too.
10 (d)	Only people who live in those LAs are included, so people who live outside those LAs but still use the UMLRT system are not included (and everyone in an LA is counted even if they live far from a station).

Question number

11

Total > 5: (2, 4), (4, 2), (3, 3), (3, 4), (4, 3), (4, 4)

$P(\text{win}) = \frac{3}{8} \times \frac{1}{3} + \frac{1}{3} \times \frac{3}{8} + \frac{1}{6} \times \frac{1}{6} + \frac{1}{6} \times \frac{1}{3} + \frac{1}{3} \times \frac{1}{6} + \frac{1}{3} \times \frac{1}{3}$

$= \frac{1}{8} + \frac{1}{8} + \frac{1}{36} + \frac{1}{18} + \frac{1}{18} + \frac{1}{9} = \frac{9 + 1 + 4 + 4}{36} = \frac{18}{36} = \frac{1}{2}$

$P(\text{no prize}) = 1 - \frac{1}{2} = \frac{1}{2}$

Winning and not winning a prize are equally likely,

so Zayn is not correct.

12 (a)

H_0: $p = \frac{1}{3}$ H_1: $p > \frac{1}{3}$

where p is the proportion of students who buy lunch at the canteen

12 (b)

X = number of students buying lunch; under H_0, $X \sim B(552, \frac{1}{3})$

$P(X \geq 201) = 1 - P(X \leq 200) = 0.068893... = 0.0689$

$0.0689 > 0.05$, so the result is not significant.

Do not reject H_0.

There is insufficient evidence at the 5% level that the proportion

of students buying lunch at the school canteen has increased.

12 (c)

The last day of term may not be typical (e.g. not every student may be in

school on the last day of term), and it is based on only a single day's data.