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INTERNATIONAL A LEVEL MATHEMATICS • STATISTICS 1

Statistics 1

Exam Questions by Topic

Pearson Edexcel International Advanced Level (WST01/01) • Calculator and Statistical Tables allowed

Multi-step exam questions at the difficulty of the real WST01 paper, with a full mark scheme

Chapters (tap a chapter to jump to it)	Qs	Marks	Page	My score
1 Mathematical Modelling Not examined on its own: modelling ideas are tested within Chapters 2 to 7	—	—	Not applicable	
2 Measures of Location and Spread Averages, quartiles, interpolation, standard deviation, coding	10	83	2	
3 Representations of Data Histograms, stem and leaf, box plots, outliers, skewness, comparisons	10	80	28	
4 Probability Venn and tree diagrams, conditional probability, independence	10	80	54	
5 Correlation and Regression PMCC, least squares regression, interpretation, coding	10	84	80	
6 Discrete Random Variables Probability and cumulative distributions, $E(X)$, $\text{Var}(X)$, uniform	10	82	106	
7 The Normal Distribution Standardising, tables, finding μ and σ , conditional problems	10	83	132	

[Full mark scheme](#)

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Class

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CHAPTER 2 • KEY SKILLS

2

Measures of Location and Spread

Specification S1: summary of data • 10 questions • 83 marks • about 100 minutes

1 Types of data and classes

Discrete: counted. Continuous: measured. For “150–159” to the nearest cm the class boundaries are 149.5 and 159.5

2 Averages from tables

$\bar{x} = \frac{\sum fx}{\sum f}$, using class midpoints for grouped data (an estimate).

3 Quartiles for discrete data

$\frac{n}{4}$ not whole: round up. $\frac{n}{4}$ whole: halfway between that value and the next. Same for $\frac{n}{2}$, $\frac{3n}{4}$

4 Interpolation

For grouped data the median is the $\frac{n}{2}$ th value: lower boundary + $\frac{\text{values needed}}{\text{class frequency}} \times \text{class width}$

5 Variance and standard deviation

$\sigma^2 = \frac{\sum x^2}{n} - \bar{x}^2 = \frac{S_{xx}}{n}$; for tables use $\frac{\sum fx^2}{\sum f} - \bar{x}^2$

6 Coding

If $y = \frac{x-a}{b}$ then $\bar{x} = b\bar{y} + a$ and $\sigma_x = b \sigma_y$
Variances scale by b^2 .

7 Combining data sets

Work with totals: $\sum x = n\bar{x}$ and $\sum x^2 = n(\sigma^2 + \bar{x}^2)$, then add.

8 Changing the data

A value equal to the mean leaves $\bar{x}$ unchanged but reduces σ . Correct a value by changing $\sum x$ and $\sum x^2$.

9 Choosing a measure

Median and IQR resist extreme values. The mean uses all the data. Always interpret in context.

Skills map every skill above is tested at least once; interleaved skills come from GCSE or other chapters

Skill	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Marks	6	5	5	6	5	12	11	10	11	12
1 Types of data and classes		•				•				
2 Averages from tables	•	•				•		•	•	
3 Quartiles for discrete data	•								•	
4 Interpolation		•				•		•		
5 Variance and standard deviation	•		•		•	•		•	•	•
6 Coding				•			•			•
7 Combining data sets					•		•			•
8 Changing the data			•				•		•	•
9 Choosing a measure								•	•	•
Interleaved: probability without replacement (GCSE, Chapter 4)						•				
Interleaved: linear and simultaneous equations (P1)									•	
Interleaved: percentages and claims in context								•		•

Exam difficulty. Questions 1 to 5 check each skill on its own. Questions 6 to 10 are multi-part questions built like the 11 to 14 mark questions on a real WST01 paper, where one part leads into the next and skills are combined.

Must learn. You may use the formula booklet and a calculator. Give inexact answers to 3 significant figures unless told otherwise, and write interpretations in the context of the question.



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1. The number of goals scored by a football team in each of 40 matches is summarised below.

Number of goals, x	0	1	2	3	4	5
Frequency, f	7	12	10	6	3	2

- (a) Find the median and the interquartile range of the number of goals.

(3)

- (b) Find the mean and the standard deviation of the number of goals.

(3)

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Question 1 continued

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(Total for Question 1 is 6 marks)



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Height (cm)	150–159	160–169	170–179	180–194	195–209
Frequency	8	22	30	15	5

- (a) Write down the class boundaries and the midpoint of the 180–194 class. (1)
- (b) Calculate an estimate of the mean height. (2)
- (c) Use linear interpolation to estimate the median height. (2)

Question 2 continued

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3. The times, x minutes, taken by 25 people to complete a task are summarised by

$$\sum x = 1150 \quad \sum x^2 = 53850$$

- (a) Find the mean and the standard deviation of x .

(3)

It is then found that one of the times was recorded as 38 minutes when it should have been 58 minutes.

- (b) Find the correct mean of the 25 times.

(2)

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Question 3 continued

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4. The masses, x grams, of 16 apples are coded using $y = \frac{x - 200}{5}$ and summarised by

$$\sum y = 64 \quad \sum y^2 = 544$$

- (a) Find the mean of x . (2)
- (b) Find the standard deviation of x . (3)
- (c) Write down the variance of x . (1)

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Question 4 continued

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(Total for Question 4 is 6 marks)



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5. Two classes sat the same test. The results are summarised below.

	Number of students	Mean mark	Standard deviation
Class A	12	64	5
Class B	8	59	4

- (a) Find the mean mark of all 20 students.

(2)

- (b) Find the standard deviation of the marks of all 20 students.

(3)

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Question 5 continued

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(Total for Question 5 is 5 marks)



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6. The masses, m grams, of a random sample of 60 potatoes are summarised below.

Mass, m (g)	Frequency, f
$100 \leq m < 120$	6
$120 \leq m < 140$	15
$140 \leq m < 150$	18
$150 \leq m < 170$	13
$170 \leq m < 200$	8

(You may use $\sum fx^2 = 1\,311\,150$, where x is the midpoint of each class.)

- (a) Use linear interpolation to estimate the median and the interquartile range of the masses. (4)
- (b) Estimate the mean and the standard deviation of the masses. (4)
- (c) Estimate the number of potatoes with a mass of more than 160 g. (2)
- Two of the 60 potatoes are chosen at random.
- (d) Find the probability that both of them have a mass in the class $140 \leq m < 150$ (2)



Question 6 continued

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Question 6 continued

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(Total for Question 6 is 12 marks)



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7. The weights, w grams, of 40 parcels are coded using $y = \frac{w - 50}{4}$ and summarised by

$$\sum y = 58 \quad \sum y^2 = 262$$

- (a) Show that the mean of w is 55.8 g (2)
- (b) Find the standard deviation of w . (3)
- (c) Find the values of $\sum w$ and $\sum w^2$ (3)
- A 41st parcel, of weight 55.8 g, is added to the sample.
- (d) State, giving a reason in each case, the effect this has on
- (i) the mean weight,
 - (ii) the standard deviation of the weights. (3)



Question 7 continued

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Question 7 continued

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(Total for Question 7 is 11 marks)



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8. A bank records how long, t minutes, each of 50 customers waits to be served.

Waiting time, t (min)	Frequency, f
$0 \leq t < 5$	6
$5 \leq t < 10$	14
$10 \leq t < 15$	16
$15 \leq t < 20$	9
$20 \leq t < 30$	5

- (a) Estimate the mean and the standard deviation of the waiting times.

(4)

The bank claims that “only 10% of our customers wait longer than 18 minutes”.

- (b) By calculating a suitable percentile, comment on this claim.

(3)

- (c) Estimate the number of customers who waited more than one standard deviation above the mean.

(3)



Question 8 continued

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Question 8 continued

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9. The number of books, x , read by each member of a book club in one month is summarised below, where p is a positive integer.

Number of books, x	1	2	3	4	5
Frequency	4	p	10	7	3

The mean number of books read is exactly 3

- (a) Show that $p = 5$ (3)

- (b) Find the median and the interquartile range. (3)

- (c) Find the standard deviation of the number of books read. (3)

A new member joins the club and reads k books in that month. The mean for all the members then becomes 3.1

- (d) Find the value of k . (2)



Question 9 continued

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Question 9 continued

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A random sample of 20 bags from machine B has masses x grams, coded using $y = x - 500$, with

$$\sum y = 30 \quad \sum y^2 = 245$$

- (c)** Find the standard deviation of the masses of all 50 bags. **(4)**

(d) Find the corrected mean mass of the bags from machine *A*, and state, with a reason, whether the corrected standard deviation for machine *A* is greater or less than 3 g. **(3)**



Question 10 continued

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Question 10 continued

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(Total for Question 10 is 12 marks)

TOTAL FOR CHAPTER 2 IS 83 MARKS

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3

CHAPTER 3 • KEY SKILLS

Representations of Data

Specification S1: representation of data • 10 questions • 80 marks • about 95 minutes

1 Histograms

Area is proportional to frequency:

$$\text{frequency density} = \frac{\text{frequency}}{\text{class width}}$$

Scale widths *and* heights.**2 Estimating from histograms**

Count a part of a bar by area: $\frac{2}{5}$ of a 5-unit-wide bar holds $\frac{2}{5}$ of its frequency.

3 Stem and leaf diagrams

Read with the key. Leaves in order; back to back diagrams read outwards on the left.

4 Quartiles from diagrams

Use the discrete rules: $\frac{n}{4}$, $\frac{n}{2}$, $\frac{3n}{4}$ (round up, or average two values if whole).

5 Outliers

Use the rule given, e.g.

$$> Q_3 + 1.5(Q_3 - Q_1) \text{ or outside } \bar{x} \pm 2\sigma.$$

State which values are outliers.

6 Box plots

Box Q_1 to Q_3 with the median; whiskers to the most extreme non-outliers; outliers marked $\times$

7 Skewness

Positive: $Q_3 - Q_2 > Q_2 - Q_1$, or mean $>$ median. Measures:

$$\frac{3(\text{mean} - \text{median})}{\text{sd}}, \frac{Q_3 - 2Q_2 + Q_1}{Q_3 - Q_1}$$

8 Comparing distributions

Compare a location *and* a spread, with values, in context. Median with IQR; mean with sd.

9 Cleaning data

Remove an anomaly only with a reason, then recalculate n , $\sum x$ and $\sum x^2$

Skills map every skill above is tested at least once; interleaved skills come from GCSE or other chapters

Skill	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Marks	5	5	5	5	5	11	11	11	10	12
1 Histograms	•						•			
2 Estimating from histograms	•						•			
3 Stem and leaf diagrams		•			•	•		•		
4 Quartiles from diagrams		•	•		•	•		•		
5 Outliers		•				•		•	•	•
6 Box plots			•			•				•
7 Skewness			•	•		•		•		
8 Comparing distributions			•	•				•	•	•
9 Cleaning data									•	
Interleaved: interpolation, mean and sd (Chapter 2)						•	•		•	
Interleaved: inequalities (P1)										•
Interleaved: mean or median in context (Chapter 2)				•		•				

Exam difficulty. Questions 1 to 5 check each skill on its own. Questions 6 to 10 are multi-part questions built like the 11 to 14 mark questions on a real WST01 paper, where one part leads into the next and skills are combined.

Must learn. Always use the outlier rule given in the question. A comparison needs context, a named statistic and its values for *both* data sets.



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- (a) Find the width and the height of the bar for the $42 \leq t < 50$ class. (3)
- (b) Estimate the number of runners who took between 38 and 45 minutes. (2)

Question 1 continued

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2. The ages of the 19 members of a club are shown in the stem and leaf diagram.

Key: 2 | 3 means 23 years

1	5 8 9	(3)
2	1 3 4 6 6 8	(6)
3	0 2 2 5 7	(5)
4	1 4 6	(3)
5		(0)
6	3	(1)
7	2	(1)

- (a) Find the median and the quartiles of the ages.

(3)

An outlier is a value that is more than $1.5 \times (Q_3 - Q_1)$ above Q_3 or below Q_1

- (b) Show that there is exactly one outlier.

(2)



Question 2 continued

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The box plot displays the distribution of marks for two schools. The horizontal axis represents the mark, ranging from 10 to 100. For School A, the minimum mark is 12, the first quartile (Q1) is 35, the median is 48, the third quartile (Q3) is 60, and the maximum mark is 85. For School B, the minimum mark is 25, the first quartile (Q1) is 42, the median is 50, the third quartile (Q3) is 55, and the maximum mark is 70. There is an outlier for School B at a mark of 94, indicated by an 'x'.

Statistic	School A	School B
Minimum	12	25
First Quartile (Q1)	35	42
Median	48	50
Third Quartile (Q3)	60	55
Maximum	85	70
Outlier	-	94

Figure 1

(a) Write down the median and the interquartile range of the marks for school A.

(2)

(b) Compare the marks at the two schools.

(2)

(c) Describe, with a reason, the skewness of the marks for school *B*.

(1)

Question 3 continued

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4. The daily sales of a café are summarised by

Q_1	Q_2	Q_3	mean	standard deviation
21	26	38	29.4	11.2

- (a) Calculate $\frac{3(\text{mean} - \text{median})}{\text{standard deviation}}$ and describe the skewness it shows. (2)
- (b) Calculate $\frac{Q_3 - 2Q_2 + Q_1}{Q_3 - Q_1}$, giving your answer to 2 significant figures. (2)
- (c) State, with a reason, whether the median and interquartile range, or the mean and standard deviation, are more suitable to summarise these data. (1)



Question 4 continued

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5. The times, in minutes, that 16 people spent in a museum are

34 41 28 45 37 52 31 39 44 29 36 48 41 33 27 40

- (a) Draw a stem and leaf diagram to represent these data.

(2)

- (b) Find the median and the interquartile range.

(3)

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6. The number of emails received by an office on each of 30 days is summarised in the stem and leaf diagram.

Key: 2 | 4 means 24

0	7 8 9	(3)
1	2 3 5 5 6 8 9	(7)
2	0 1 3 3 <i>w</i> 6 7 8	(8)
3	0 2 4 5 7 9	(6)
4	1 3 6 8	(4)
5	2	(1)
6	8	(1)

The quartiles are $Q_1 = x$, $Q_2 = 25.5$ and $Q_3 = y$

- (a) Find the values of w , x and y .

(3)

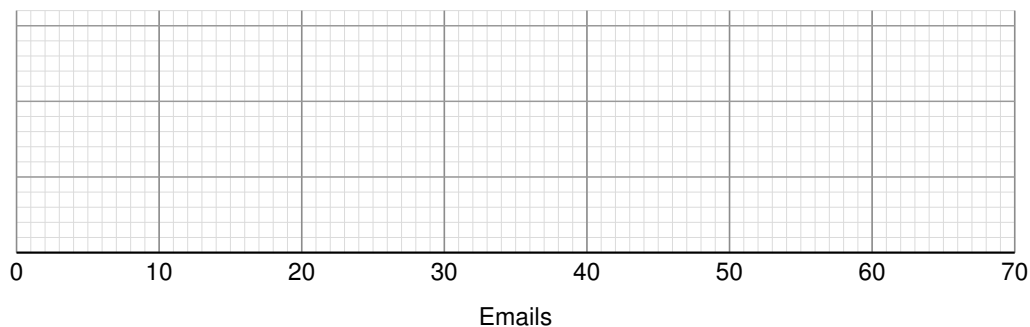
Outliers are defined as values greater than $Q_3 + 1.0 \times (Q_3 - Q_1)$

- (b) Showing your working, identify any outliers.

(2)

- (c) Draw a box plot for these data on the grid below.

(3)



- (d) Use $\frac{(Q_3 - Q_2) - (Q_2 - Q_1)}{Q_3 - Q_1}$ to find the skewness of these data, giving your answer to 2 significant figures.

(2)

The manager wants to estimate the total number of emails the office will receive in a year.

- (e) Explain why the manager should use the mean rather than the median.

(1)



Question 6 continued

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Question 6 continued

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7.

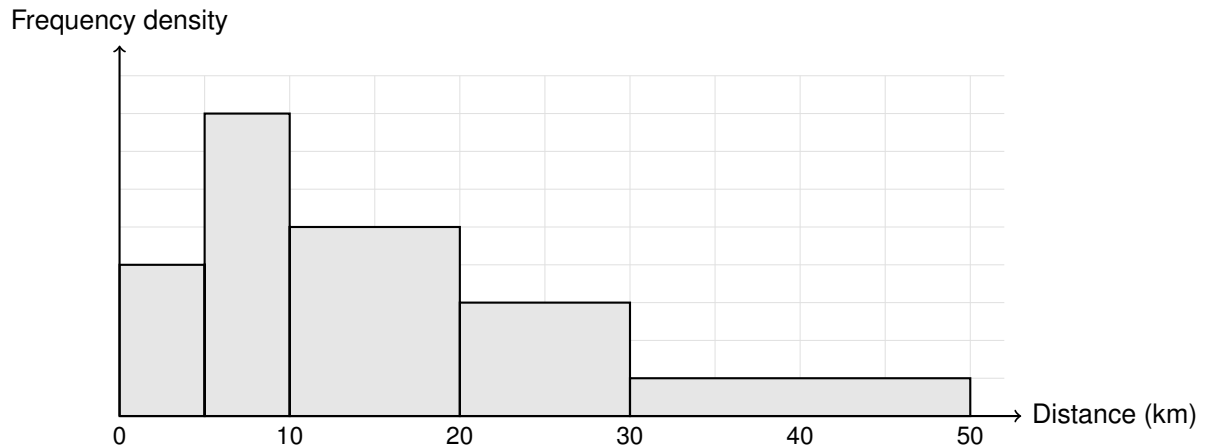
**Figure 2**

Figure 2 shows a histogram of the distances, in km, that a group of people travel to work.

Exactly 40 people travel between 5 km and 10 km.

- (a) Find the total number of people in the group. (3)
- (b) Estimate the number of people who travel between 8 km and 25 km. (3)
- (c) Use linear interpolation to estimate the median distance. (3)
- (d) Estimate the mean distance travelled. (2)



Question 7 continued

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Question 7 continued

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8. The resting pulse rates, in beats per minute, of 15 athletes and 15 non-athletes are shown below.

Key: 8 | 5 | 2 means 58 for athletes and 52 for non-athletes

Athletes		Non-athletes
8 5	4	
9 8 6 5 5 3 2 0	5	8
4 3 1 0	6	2 4 6 7 8
0	7	0 2 2 5 6 9
	8	1 4
	9	
	10	1

For the athletes, $Q_1 = 52$, $Q_2 = 56$ and $Q_3 = 61$

- (a) Find the median and the quartiles of the pulse rates of the non-athletes.

(3)

An outlier is a value more than $1.5 \times (Q_3 - Q_1)$ above Q_3 or below Q_1

- (b) Show that the non-athletes have exactly one outlier.

(2)

- (c) Compare the pulse rates of the two groups.

(3)

- (d) Use the quartiles to describe the skewness of each distribution.

(2)

A person has a resting pulse rate of 69 beats per minute.

- (e) State, with a reason, which group this person is more likely to belong to.

(1)



Question 8 continued

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(Total for Question 8 is 11 marks)



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9. The heights, x cm, of 12 seedlings grown in tray P are

12 14 15 15 16 17 18 18 19 20 21 42

(You may use $\sum x = 227$ and $\sum x^2 = 4949$)

- (a) Find the mean and the standard deviation of the heights.

(3)

An outlier is a value that lies more than 2 standard deviations from the mean.

- (b) Show that 42 is an outlier.

(2)

The value 42 was a recording error, so it is removed from the data.

- (c) Find the mean and the standard deviation of the remaining 11 heights.

(3)

Seedlings in tray Q have a mean height of 15.2 cm and a standard deviation of 3.9 cm.

- (d) Using your answers to part (c), compare the heights of the seedlings in the two trays.

(2)



Question 9 continued

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Question 9 continued

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(Total for Question 9 is 10 marks)**Join students already acing their exams.**Book your FREE lesson at www.eclassroom.org.uk

10. The growths, in cm, of 25 plants of type *A* are summarised below.

Smallest value	Q_1	Q_2	Q_3	Two largest values
8	14	18	22	33 and 36

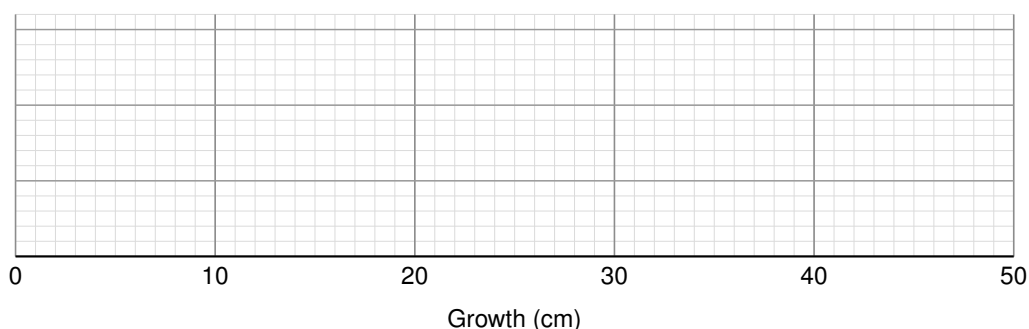
An outlier is a value more than $1.5 \times (Q_3 - Q_1)$ above Q_3 or below Q_1

- (a) Show that there is exactly one outlier for type *A*.

(2)

- (b) Draw a box plot for type *A* on the grid below.

(3)



Plants of type *B* have $Q_1 = 17$, $Q_2 = 24$ and $Q_3 = 28$, with smallest value 10 and largest value 38

- (c) Compare the growths of the two types of plant.

(2)

A plant of type *A* is chosen. Its growth, g cm, is greater than the upper quartile for type *B*, and it is *not* an outlier.

- (d) Find the range of possible values of g .

(2)

- (e) Using the same outlier rule, find the set of values of the growth, h cm, of a type *B* plant that would be an outlier.

(3)



Question 10 continued

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Question 10 continued

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(Total for Question 10 is 12 marks)**TOTAL FOR CHAPTER 3 IS 80 MARKS****Join students already acing their exams.**Book your FREE lesson at www.eclassroom.org.uk

4

CHAPTER 4 • KEY SKILLS

Probability

Specification S1: probability • 10 questions • 80 marks • about 95 minutes

1 Venn diagrams

Fill from the middle outwards. Every region needs a value, including 0 and the region outside all sets.

2 The addition rule

$$P(A \cup B) = P(A) + P(B) - P(A \cap B)$$

3 Mutually exclusive

A and B cannot both happen:

$$P(A \cap B) = 0, \text{ so } P(A \cup B) = P(A) + P(B)$$

4 Independence

$P(A \cap B) = P(A)P(B)$, or $P(A|B) = P(A)$.
Show the numbers when testing it.

5 Conditional probability

$P(A|B) = \frac{P(A \cap B)}{P(B)}$: restrict to B , then
find the part that is also A .

6 Tree diagrams

Multiply along branches, add across outcomes. Complete every branch before you start.

7 Reverse conditionals

$P(\text{first} | \text{second}) = \frac{P(\text{both})}{P(\text{second})}$, adding
every route to the second event.

8 Sequences of trials

“Wins on the 2nd turn” needs every earlier failure: a product of several probabilities. Without replacement, change the numbers.

9 Equations for unknown regions

Write each given probability as a sum of regions; independence gives a product. Solve simultaneously and check that $0 \leq p \leq 1$.

Skills map every skill above is tested at least once; interleaved skills come from GCSE or other chapters

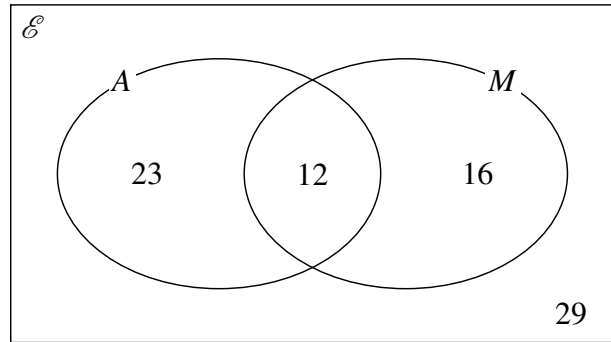
Skill	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Marks	5	5	5	5	5	11	11	10	11	12
1 Venn diagrams	•				•	•		•	•	
2 The addition rule		•		•	•	•			•	
3 Mutually exclusive						•				
4 Independence	•	•		•	•	•		•	•	•
5 Conditional probability	•					•	•		•	•
6 Tree diagrams			•				•			•
7 Reverse conditionals							•			•
8 Sequences of trials			•				•			•
9 Equations for unknown regions				•	•	•		•	•	•
Interleaved: quadratic equations (P1)				•	•					
Interleaved: linear and simultaneous equations (P1)						•		•	•	•
Interleaved: frequencies and counts (Chapters 2, 3)	•							•		

Exam difficulty. Questions 1 to 5 check each skill on its own. Questions 6 to 10 are multi-part questions built like the 11 to 14 mark questions on a real WST01 paper, where one part leads into the next and skills are combined.

Must learn. Never assume independence unless you are told it or have shown it. Label every probability you find, e.g. $P(A \cap B) = 0.21$, and give exact answers where they are simple fractions.



1.

**Figure 1**

The Venn diagram in Figure 1 shows the numbers of students in a group of 80 who study Art, A , and who study Music, M .

A student is chosen at random from the group.

- (a) Find the probability that the student studies neither Art nor Music. (1)
- (b) Given that the student studies Music, find the probability that the student also studies Art. (2)
- (c) Showing your working, determine whether the events A and M are independent. (2)



Question 1 continued

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2. The events A and B are such that $P(A) = 0.4$, $P(B) = 0.35$ and $P(A \cup B) = 0.61$

(a) Find $P(A \cap B)$

(2)

(b) Show that A and B are independent.

(2)

(c) Find $P(A' \cap B)$

(1)

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3. A bag contains 5 red counters and 3 blue counters. Two counters are taken at random from the bag, one after the other, without replacement.

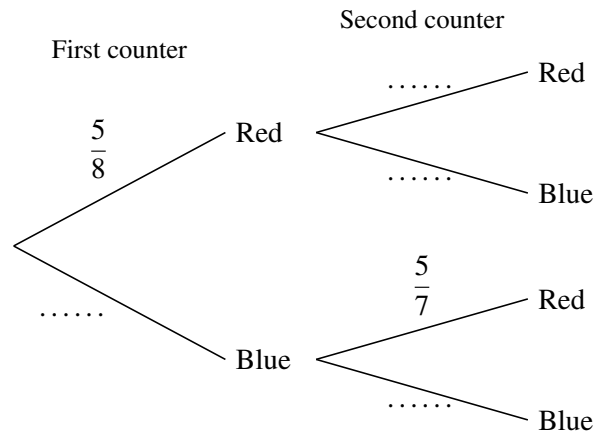


Figure 2

- (a) Complete the tree diagram in Figure 2. (2)
- (b) Find the probability that both counters are the same colour. (2)
- (c) Find the probability that at least one counter is blue. (1)



Question 3 continued

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4. The events A and B are independent, with $P(A) = 3P(B)$ and $P(A \cup B) = 0.68$

Let $P(B) = p$

- (a) Show that $3p^2 - 4p + 0.68 = 0$

(2)

- (b) Hence find $P(B)$, explaining why one solution of the equation must be rejected.

(2)

- (c) Find $P(A' \cap B')$

(1)

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(Total for Question 4 is 5 marks)



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$\mathcal{E}$

A Venn diagram with two overlapping circles, labeled A and B . The region inside circle A but outside circle B is labeled 0.3 . The region inside circle B but outside circle A is labeled 0.2 . The intersection of the two circles is labeled x .

Figure 3

(a) Show that $x^2 - 0.5x + 0.06 = 0$

(3)

(b) find the value of x .

(2)

Question 5 continued

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(Total for Question 5 is 5 marks)



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6. The events F and G are independent, with

$$P(F) = \frac{2}{5} \quad P(F \cup G) = \frac{7}{10}$$

- (a) Show that $P(G) = \frac{1}{2}$ (4)

The event K is such that $P(K) = \frac{1}{10}$ and $P(F \cap K) = P(K)$

- (b) Find $P(K' | F)$ (2)

Given also that G and K are mutually exclusive,

- (c) draw a Venn diagram to represent the events F , G and K , giving the exact probability of each region. (5)



Question 6 continued

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Question 6 continued

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7. A factory tests every item it makes. 3% of the items are faulty.

The test correctly identifies a faulty item with probability 0.95. It wrongly identifies a good item as faulty with probability 0.04

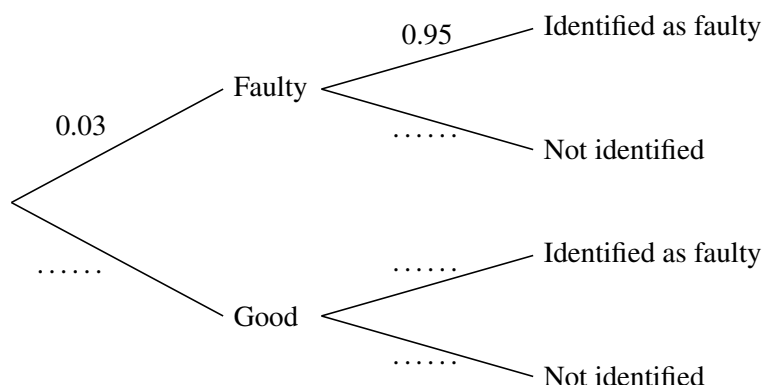


Figure 4

- (a) Complete the tree diagram in Figure 4. (2)
- (b) Find the probability that a randomly chosen item is identified as faulty. (2)
- (c) Given that an item is identified as faulty, find the probability that it really is faulty. (3)
- Every item identified as faulty is tested a second time. The second test is independent of the first and has the same probabilities.
- (d) Given that an item is identified as faulty by both tests, find the probability that it really is faulty. (4)



Question 7 continued

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Question 7 continued

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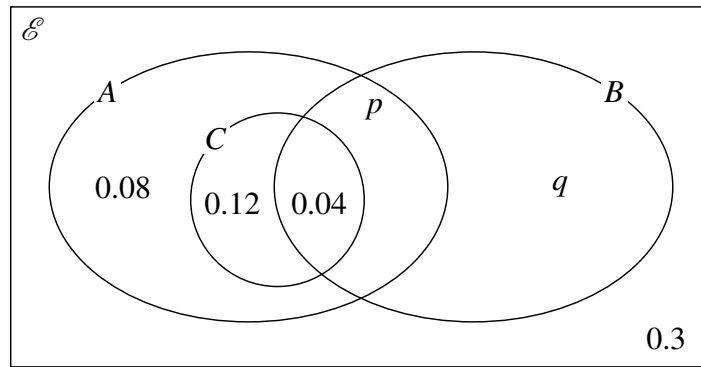


Figure 5

The Venn diagram in Figure 5 shows the probabilities of three events A , B and C , where p and q are probabilities.

The events A and B are independent.

(a) Find the value of p and the value of q . (4)

(b) Find the probability that exactly one of the events A and B occurs. (2)

(c) Showing your working, determine whether the events B and C are independent. (2)

In a survey of people using this model, 96 people are in the event C .

(d) Estimate the number of these people who are in both A and B . (2)



Question 8 continued

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Question 8 continued

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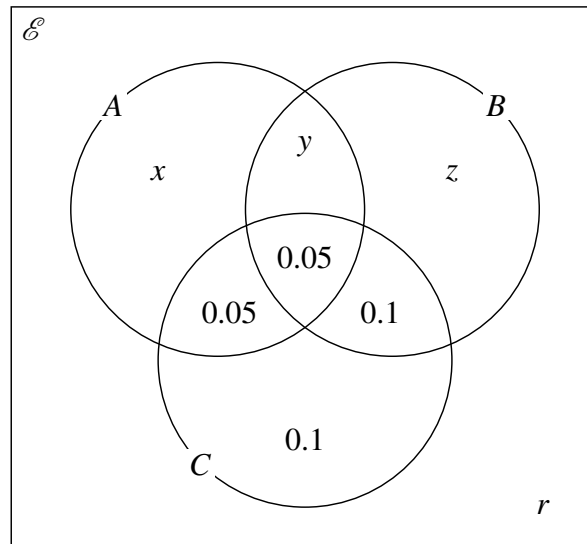


Figure 6

The Venn diagram in Figure 6 shows three events A , B and C and their probabilities, where x , y , z and r are probabilities.

Given that

- $P(A) = 0.4$ and $P(A \cup B) = 0.7$
- the events A and B are independent

(a) use $P(A)$ and $P(A \cup B)$ to show that $z = 0.2$

(2)

(b) find the value of y and the value of x ,

(4)

(c) write down the value of r .

(1)

(d) Determine whether the events B and C are independent. Show your working clearly.

(2)

(e) Find $P(A | B \cup C)$

(2)



Question 9 continued

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Question 9 continued

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10. On any day, the probability that it rains is x .

If it rains, the probability that Tom's bus is late is 0.4. If it does not rain, the probability that the bus is late is 0.1

The probability that the bus is late on a randomly chosen day is 0.19

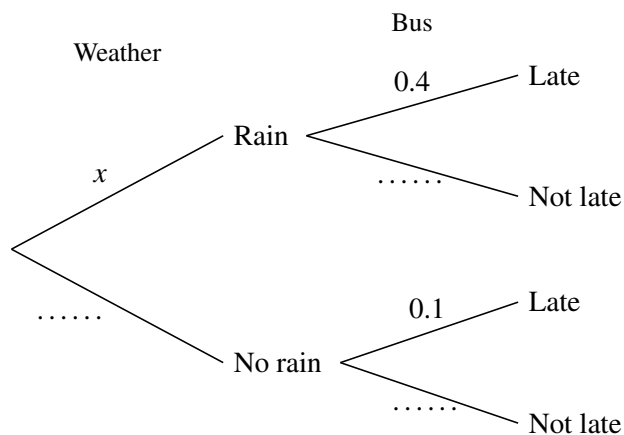


Figure 7

The tree diagram in Figure 7 shows this information.

- (a) Show that $x = 0.3$ (3)
- (b) Given that the bus is late, find the probability that it rained. (2)
- (c) Find the probability that the bus is late on exactly one of two randomly chosen days. You may assume that days are independent. (2)
- If the bus is late, Tom walks, and is then late for school with probability 0.5. If the bus is not late, Tom is late for school with probability 0.05
- (d) Find the probability that Tom is late for school on a randomly chosen day. (2)
- (e) Given that Tom is late for school, find the probability that it rained that day. (3)



Question 10 continued

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TOTAL FOR CHAPTER 4 IS 80 MARKS

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5

CHAPTER 5 • KEY SKILLS

Correlation and Regression

Specification S1: correlation and regression • 10 questions • 84 marks • about 100 minutes

1 Scatter diagrams

Describe the direction and strength of the correlation, and name both variables in context.

2 Summary statistics

$$S_{xx} = \sum x^2 - \frac{(\sum x)^2}{n},$$

$$S_{xy} = \sum xy - \frac{\sum x \sum y}{n}$$

3 The PMCC

$r = \frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}}$, with $-1 \leq r \leq 1$. Give r to at least 3 s.f.

4 Interpreting r

r measures *linear* correlation only. Correlation does not show that one variable causes the other.

5 The regression line

$$y = a + bx \text{ with } b = \frac{S_{xy}}{S_{xx}} \text{ and } a = \bar{y} - b\bar{x}.$$

Write the final equation.

6 Explanatory variable

The explanatory variable (x) is set or controlled; the response (y) depends on it. Only predict y from x .

7 Interpreting a and b

b : the change in y for each increase of 1 in x , in context and units. a may be meaningless if $x = 0$ is impossible.

8 Predictions

Within the data (interpolation) is reliable; outside it (extrapolation) is not. Check that the prediction is possible.

9 Coding

Coding does not change r . Substitute the codes into the coded line to get the line in the original variables.

Skills map every skill above is tested at least once; interleaved skills come from GCSE or other chapters

Skill	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Marks	5	5	5	5	5	13	11	13	10	12
1 Scatter diagrams			•							
2 Summary statistics	•					•		•		•
3 The PMCC	•			•		•	•	•	•	•
4 Interpreting r			•			•			•	•
5 The regression line		•				•	•	•	•	•
6 Explanatory variable			•						•	
7 Interpreting a and b				•	•	•	•		•	
8 Predictions		•			•	•	•	•		
9 Coding				•				•		
Interleaved: coding and correcting data (Chapter 2)				•				•		•
Interleaved: straight lines, rearranging (P1)				•				•	•	
Interleaved: units and conversions					•		•			

Exam difficulty. Questions 1 to 5 check each skill on its own. Questions 6 to 10 are multi-part questions built like the 11 to 14 mark questions on a real WST01 paper, where one part leads into the next and skills are combined.

Must learn. Every interpretation must name the variables and use their units. In “show that” questions give values to more accuracy than the answer you are shown.



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1. For 10 pairs of observations (x, y) :

$$n = 10 \quad \sum x = 55 \quad \sum y = 320 \quad \sum x^2 = 385 \quad \sum y^2 = 10\,650 \quad \sum xy = 1920$$

- (a) Find S_{xx} , S_{yy} and S_{xy}

(3)

- (b) Calculate the product moment correlation coefficient between x and y .

(2)

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2. For a set of data with x values between 2 and 10:

$$\bar{x} = 6 \quad \bar{y} = 20 \quad S_{xx} = 40 \quad S_{xy} = 96$$

- (a) Find the equation of the regression line of y on x in the form $y = a + bx$

(3)

- (b) Estimate the value of y when $x = 7$

(1)

- (c) Give a reason why an estimate of y when $x = 25$ may be unreliable.

(1)

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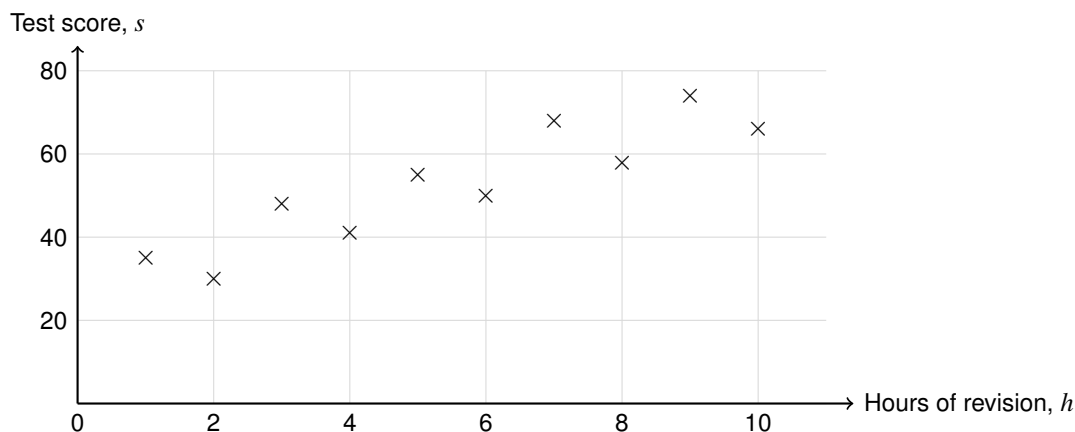


Figure 1

Figure 1 shows the number of hours of revision, h , and the test score, s , for 10 students. The product moment correlation coefficient for these data is 0.902

- (a) Interpret this value in the context of the question. (1)
- (b) State which variable is the explanatory variable, giving a reason. (1)
- (c) A teacher says: “This shows that revising for longer causes higher test scores.” Comment on this statement. (1)
- For a different group, the product moment correlation coefficient between h and s is -0.12
- (d) Interpret this value. (1)
- (e) State one limitation of the product moment correlation coefficient as a measure of the relationship between two variables. (1)



Question 3 continued

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4. Data on two variables x and y are coded using $u = x - 100$ and $v = \frac{y}{10}$

The product moment correlation coefficient between u and v is 0.72, and the regression line of v on u is $v = 2.1 + 0.35u$

- (a) Write down the product moment correlation coefficient between x and y . (1)
- (b) Find the equation of the regression line of y on x in the form $y = a + bx$ (3)
- (c) Interpret the value of b in your line. (1)

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Question 5 continued

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Question 6 continued

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Question 6 continued

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7. A biologist measures the length, L cm, and the mass, m grams, of 9 fish. The lengths are between 22 cm and 48 cm. The data are summarised by

$$\sum L = 315 \quad \sum m = 3880 \quad S_{LL} = 586 \quad S_{mm} = 234\,889 \quad S_{Lm} = 11\,670$$

- (a) Calculate the product moment correlation coefficient between L and m . (2)
- (b) Show that the regression line of m on L is $m = -266 + 19.9L$, with coefficients given to 3 significant figures. (4)
- (c) Estimate the mass of a fish of length 0.36 m. (2)
- (d) Explain why the regression line should not be used to estimate the mass of a fish of length 10 cm. (2)
- (e) Interpret the value 19.9 in context. (1)



Question 7 continued

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Question 7 continued

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8. The price, £ p , of a product in year t was recorded every 4 years from 2000 to 2020. The data are coded using

$$x = \frac{t - 2000}{4} \quad y = \frac{p - 200}{10}$$

and summarised by

$$n = 6 \quad \sum x = 15 \quad \sum y = 41 \quad \sum x^2 = 55 \quad \sum y^2 = 371.9 \quad \sum xy = 141.8$$

- (a) Find S_{xx} , S_{yy} and S_{xy} (3)
- (b) Calculate the product moment correlation coefficient between x and y . (2)
- (c) Write down the product moment correlation coefficient between t and p , giving a reason. (1)
- (d) Find the equation of the regression line of y on x . (3)
- (e) Hence find the equation of the regression line of p on t in the form $p = c + d(t - 2000)$ (2)
- (f) Use your line to estimate the price in 2030, and comment on the reliability of your estimate. (2)



Question 8 continued

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Question 8 continued

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9. A doctor records the age, a years, and the systolic blood pressure, s mmHg, of 12 patients aged between 25 and 70. The data are summarised by

$$\sum a = 540 \quad \sum s = 1560 \quad S_{aa} = 2250 \quad S_{ss} = 1200 \quad S_{as} = 1350$$

- (a) Calculate the product moment correlation coefficient between a and s . (2)
- (b) Find the equation of the regression line of s on a . (3)
- (c) Interpret the gradient of your line in context. (1)
- (d) Using your line, find the increase in age that corresponds to an increase in blood pressure of 9 mmHg. (2)
- (e) Explain why the line should not be used to estimate the age of a patient from their blood pressure. (1)
- (f) The doctor says: "The value of r proves that getting older causes blood pressure to rise." Comment on this statement. (1)



Question 9 continued

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Question 9 continued

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$$\Sigma x = 60 \quad \Sigma y = 350 \quad \Sigma x^2 = 440 \quad \Sigma y^2 = 13050 \quad \Sigma xy = 2280$$

- The student then found that the pair recorded as (8, 30) should have been (8, 45)

- (c) Calculate the correct product moment correlation coefficient, and describe the effect of the correction. (3)

- (d)** Find the equation of the correct regression line of y on x . **(3)**

Question 10 continued

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TOTAL FOR CHAPTER 5 IS 84 MARKS

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6

CHAPTER 6 • KEY SKILLS

Discrete Random Variables

Specification S1: discrete random variables • 10 questions • 82 marks • about 100 minutes

1 Probability distributions

All probabilities are between 0 and 1 and add to 1: $\sum P(X = x) = 1$ finds an unknown.

2 Probability functions

$P(X = x) = k(x + 1)$: substitute each value of x , add, and set equal to 1

3 Cumulative distribution

$F(x) = P(X \leq x)$.

$P(X = x) = F(x) - F(x - 1)$; $F(2.7) = F(2)$ for whole-number X

4 Expectation

$E(X) = \sum xP(X = x)$,

$E(X^2) = \sum x^2P(X = x)$

5 Variance

$\text{Var}(X) = E(X^2) - [E(X)]^2$. $E(X^2)$ is not $[E(X)]^2$

6 Linear functions

$E(aX + b) = aE(X) + b$

$\text{Var}(aX + b) = a^2 \text{Var}(X)$: b disappears, a is squared

7 Discrete uniform

n equally likely values $1, 2, \dots, n$:

$E(X) = \frac{n+1}{2}$, $\text{Var}(X) = \frac{n^2 - 1}{12}$

8 Unknown probabilities

Sum to 1 and a given $E(X)$ give two simultaneous equations.

9 Combining observations

Independent observations multiply; list every pair that gives the event (a sample space helps).

Skills map every skill above is tested at least once; interleaved skills come from GCSE or other chapters

Skill	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Marks	5	5	5	5	5	12	12	11	10	12
1 Probability distributions	•	•	•			•	•	•	•	•
2 Probability functions	•									
3 Cumulative distribution			•			•	•			•
4 Expectation	•	•		•	•	•	•	•	•	•
5 Variance				•	•	•		•	•	•
6 Linear functions				•	•	•		•		•
7 Discrete uniform					•		•	•		
8 Unknown probabilities		•				•		•		•
9 Combining observations						•	•		•	
Interleaved: conditional probability (Chapter 4)							•		•	
Interleaved: simultaneous and quadratic equations (P1)		•						•		•
Interleaved: linear inequalities (P1)					•					•

Exam difficulty. Questions 1 to 5 check each skill on its own. Questions 6 to 10 are multi-part questions built like the 11 to 14 mark questions on a real WST01 paper, where one part leads into the next and skills are combined.

Must learn. Give exact answers as fractions when the probabilities are fractions. Show $E(X^2)$ before finding $\text{Var}(X)$.



1. The discrete random variable X has probability function

$$P(X = x) = k(x + 1) \quad x = 1, 2, 3, 4$$

where k is a constant.

(a) Show that $k = \frac{1}{14}$

(2)

(b) Find the exact value of $E(X)$.

(2)

(c) Find $P(X \geq 3)$

(1)

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Question 1 continued

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2. The discrete random variable X has the probability distribution

x	1	2	3	4
$P(X = x)$	0.1	a	0.3	b

where a and b are constants. Given that $E(X) = 2.9$

- (a) write down two equations involving a and b , (2)
- (b) find the value of a and the value of b , (2)
- (c) find $P(1 < X \leq 3)$ (1)



Question 2 continued

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3. The discrete random variable X has cumulative distribution function $F(x)$ given below.

x	1	2	3	4	5
$F(x)$	0.15	0.35	0.6	0.85	1

- (a) Find the probability distribution of X .

(2)

- (b) Write down $F(2.7)$

(1)

- (c) Find $P(2 \leq X < 5)$

(2)

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Question 3 continued

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4. The random variable X has $E(X) = 2.4$ and $\text{Var}(X) = 1.3$

Find

(a) $E(5 - 2X)$

(1)

(b) $\text{Var}(5 - 2X)$

(2)

(c) $E(X^2)$

(2)

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5. A fair 12-sided die has faces numbered 1 to 12. The random variable X is the score when the die is rolled once.

(a) Write down the name of the distribution of X , and find $E(X)$ and $\text{Var}(X)$.

(2)

The random variable $Y = 4X - 3$

(b) Find $E(Y)$ and $\text{Var}(Y)$.

(2)

(c) Find $P(Y > 30)$

(1)

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Question 5 continued

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6. The discrete random variable X has probability function $p(x)$ and cumulative distribution function $F(x)$ given in the table below.

x	1	2	3	4	5
$p(x)$	0.1	a	0.25	b	0.15
$F(x)$	0.1	0.3	c	0.85	1

- (a) Find the values of a , b and c .

(3)

- (b) Find $E(X)$.

(2)

- (c) Show that $\text{Var}(X) = 1.46$

(3)

The random variable $Y = 3X - 1$

- (d) Find $E(Y^2)$

(2)

Two independent observations, X_1 and X_2 , are taken from the distribution of X .

- (e) Find the probability that X_1 and X_2 are both odd.

(2)



Question 6 continued

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Question 6 continued

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7. A red die has four faces numbered 1, 2, 3 and 4. A blue die has four faces numbered 2, 4, 6 and 8. Both dice are fair.

The random variable R is the score on one roll of the red die and B is the score on one roll of the blue die. The dice are rolled together.

- (a) Find $P(R + B \leq 5)$ (2)

- (b) Find $P(R^2 < B)$ (3)

The random variable $D = |R - B|$ is the size of the difference between the two scores. Its cumulative distribution function is shown below.

d	0	1	2	3	4	5	6	7
$F(d)$	$\frac{1}{8}$		$\frac{1}{2}$	$\frac{5}{8}$		$\frac{7}{8}$	$\frac{15}{16}$	1

- (c) Complete the table. (2)

- (d) Find $E(D)$. (3)

- (e) Given that $R + B \leq 5$, find the probability that $D \leq 1$ (2)



Question 7 continued

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8. The discrete random variable X has the probability distribution

x	1	2	3
$P(X = x)$	p	0.5	p

- (a) Find the value of p . (1)

- (b) Show that $E(X) = 2$ and $\text{Var}(X) = 0.5$ (4)

The random variable Y has a discrete uniform distribution over the values 1, 2, 3, 4 and 5

- (c) Write down $E(Y)$ and find $\text{Var}(Y)$. (2)

The random variable $W = aX + b$, where a and b are constants and $a > 0$. Given that $E(W) = E(Y)$ and $\text{Var}(W) = \text{Var}(Y)$,

- (d) find the value of a and the value of b . (4)



Question 8 continued

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- | | | | |
|------------|-----|-----|-----|
| x | 0 | 1 | 3 |
| $P(X = x)$ | 0.3 | 0.5 | 0.2 |

- (c) Given that Sanjay wins the prize, find the probability that he scored 3 points in each of the last two rounds. (3)

Question 9 continued

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10. The discrete random variable X takes only the values 1, 2, 3 and 4 and has cumulative distribution function

$$F(x) = \frac{(x+k)^2}{36} \quad x = 1, 2, 3, 4$$

where k is a positive constant.

- (a) Show that $k = 2$ (2)
- (b) Find the probability distribution of X . (3)
- (c) Find the exact value of $E(X)$. (2)
- (d) Find $P(3X - 3 > X + 4)$ (2)
- (e) Find $\text{Var}(5 - 3X)$, giving your answer to 3 significant figures. (3)



Question 10 continued

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(Total for Question 10 is 12 marks)**TOTAL FOR CHAPTER 6 IS 82 MARKS****Join students already acing their exams.**Book your FREE lesson at www.eclassroom.org.uk

CHAPTER 7 • KEY SKILLS

7

The Normal Distribution

Specification S1: the Normal distribution • 10 questions • 83 marks • about 100 minutes

1 StandardisingIf $X \sim N(\mu, \sigma^2)$ then $Z = \frac{X - \mu}{\sigma} \sim N(0, 1^2)$. Note σ^2 is the variance.**2 Using the table** $P(Z < z) = \Phi(z)$. For negative z : $\Phi(-z) = 1 - \Phi(z)$. $P(Z > z) = 1 - \Phi(z)$ **3 Ranges** $P(a < X < b) = \Phi(z_b) - \Phi(z_a)$. Draw a sketch and shade the region.**4 Percentage points**From a probability to a value: use the percentage points table in full, e.g. 5% gives $z = 1.6449$ **5 Finding μ or σ** Write $\frac{x - \mu}{\sigma} = \pm z$ with the correct sign (below the mean: negative) and solve.**6 Finding μ and σ**

Two probabilities give two equations: solve them simultaneously.

7 SymmetryThe curve is symmetrical about μ : $P(X < \mu) = 0.5$ and $P(\mu - k < X < \mu + k) = 2\Phi\left(\frac{k}{\sigma}\right) - 1$ **8 Conditional probability** $P(X > a | X > b) = \frac{P(X > a)}{P(X > b)}$ for $a > b$.

Find the numerator from the overlap.

9 Samples and countsSeveral independent items: multiply (or use $1 - \dots$). Expected number $= n \times \text{probability}$.**Skills map** every skill above is tested at least once; interleaved skills come from GCSE or other chapters

Skill	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Marks	5	5	5	5	5	12	12	11	11	12
1 Standardising	•	•	•	•		•	•	•	•	•
2 Using the table	•	•	•	•	•	•	•	•	•	•
3 Ranges	•					•	•		•	•
4 Percentage points		•		•	•	•	•	•		•
5 Finding μ or σ			•	•				•		•
6 Finding μ and σ							•			
7 Symmetry			•		•			•	•	•
8 Conditional probability						•	•	•	•	•
9 Samples and counts						•		•		•
Interleaved: tree diagrams and conditionals (Chapter 4)						•			•	
Interleaved: quartiles and outliers (Chapters 2, 3)					•			•		
Interleaved: simultaneous and linear equations (P1)							•			•

Exam difficulty. Questions 1 to 5 check each skill on its own. Questions 6 to 10 are multi-part questions built like the 11 to 14 mark questions on a real WST01 paper, where one part leads into the next and skills are combined.**Must learn.** Quote table values in full (4 decimal places). Round z to 2 decimal places for the Φ table. Always sketch the curve and shade the region you want.

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1. The random variable $X \sim N(50, 4^2)$

Find

(a) $P(X < 56)$

(2)

(b) $P(44 < X < 58)$

(3)

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2. The random variable $X \sim N(120, 15^2)$

(a) Find $P(X > 99)$

(2)

(b) Find the value of a such that $P(X > a) = 0.05$

(3)

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3. The random variable $X \sim N(30, \sigma^2)$. Given that $P(X < 36) = 0.8413$

(a) find the value of σ ,

(3)

(b) write down $P(X < 24)$, giving a reason.

(2)

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4. The random variable $X \sim N(\mu, 5^2)$. Given that $P(X > 40) = 0.2$

(a) find the value of μ ,

(3)

(b) find $P(X < 30)$

(2)

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5. The random variable $X \sim N(80, 12^2)$

(a) Find the lower quartile and the interquartile range of X .

(3)

An outlier is a value more than $1.5 \times$ the interquartile range above the upper quartile.

(b) Find the probability that a randomly chosen value of X is an outlier of this kind.

(2)

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Question 6 continued

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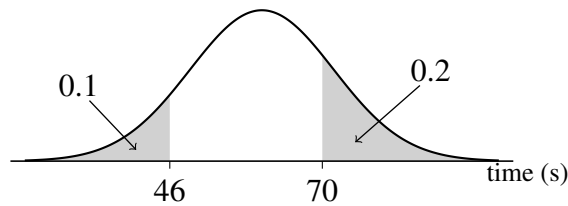
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7.

**Figure 1**

The times, T seconds, taken by students to solve a puzzle are modelled by $T \sim N(\mu, \sigma^2)$.

Figure 1 shows that 10% of students take less than 46 seconds and 20% take more than 70 seconds.

- (a) Show that $46 = \mu - 1.2816\sigma$ and write down a second equation in μ and σ . (3)
- (b) Find the value of μ and the value of σ . (3)
- (c) Find $P(50 < T < 65)$ (3)
- (d) Given that a student takes more than 50 seconds, find the probability that the student takes more than 65 seconds. (3)



Question 7 continued

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8. The heights of a type of plant are normally distributed with mean 25 cm. 80% of the plants have a height between 20 cm and 30 cm.
- (a) Show that the standard deviation of the heights is 3.90 cm, to 3 significant figures. (3)
- (b) Find the probability that a randomly chosen plant is taller than 32 cm. (2)
- (c) Given that a plant is taller than 25 cm, find the probability that it is taller than 30 cm. (2)
- (d) Four plants are chosen at random. Find the probability that at least one of them is taller than 30 cm. (2)
- (e) Find the value of k such that 50% of the plants have a height between $(25 - k)$ cm and $(25 + k)$ cm. (2)



Question 8 continued

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9. A factory has two machines. Machine A makes 60% of the bolts and machine B makes the rest. The lengths, in mm, of bolts from machine A are distributed $N(50, 0.4^2)$ and the lengths of bolts from machine B are distributed $N(50.2, 0.5^2)$.
- A bolt is acceptable if its length is between 49.5 mm and 50.5 mm.
- (a) Find the probability that a bolt from machine A is acceptable. (3)
- (b) Find the probability that a bolt from machine B is acceptable. (3)
- A bolt is chosen at random from the factory's output.
- (c) Find the probability that it is acceptable. (2)
- (d) Given that the bolt is acceptable, find the probability that it was made by machine A . (3)

Question 9 continued

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Question 9 continued

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(Total for Question 9 is 11 marks)**Join students already acing their exams.**Book your FREE lesson at www.eclassroom.org.uk

- (3)**

Question 10 continued

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Question 10 continued

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(Total for Question 10 is 12 marks)**TOTAL FOR CHAPTER 7 IS 83 MARKS****Join students already acing their exams.**Book your FREE lesson at www.eclassroom.org.uk