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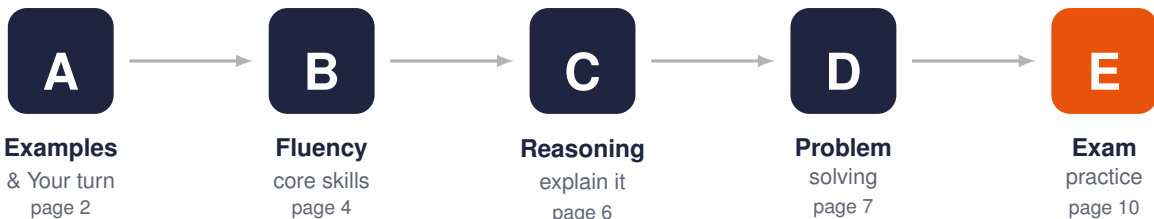
A-LEVEL MATHEMATICS • STATISTICS 1

Location and Spread

Worksheet

Pearson Edexcel International A Level (WST01) & A Level (9MA0) • Calculator and statistical tables allowed: show every step

Free Measures of Spread and Location worksheet for A-Level and International A-Level Maths, with full worked solutions



Tap a section to jump straight to it

By the end of this worksheet you can: find the mean, median and mode, including grouped data • find quartiles and percentiles, by interpolation where needed • calculate the variance and standard deviation • *Stretch:* use coding, combine data sets, and explain the effect of adding or correcting values.

Which questions are for me?

CORE The methods every A-level student must secure. Start here.

STRETCH Interpolated quartiles, coding both ways, combined and corrected data, and reasons that use the right statistic.

Every section has both, clearly labelled. Questions get harder as you go, and every skill in Sections A to D is needed in Section E.

Track your progress

Section	B	C	D	E
Core marks	23	10	13	21
Stretch marks	16	14	17	13
My score				

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Statistics 1 exam questions

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Name

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A

Worked examples & Your turn

Read each example carefully. Cover it up, then answer the question beside it using the same method.

CORE

Secure the method

Worked example A1: averages from a table

Find the mean, median and mode of the goals scored per match.

Goals	0	1	2	3	4
Matches	3	7	6	3	1

$n = 20$: $\sum fx = 0 + 7 + 12 + 9 + 4 = 32$; the median is halfway between the 10th and 11th values.

Cumulative: 3, 10, 16: the 10th is 1 and the 11th is 2

$$\bar{x} = 1.6, \text{ median } 1.5, \text{ mode } 1$$

Your turn A1

Find the mean, median and mode of the number of pets owned.

Pets	1	2	3	4	5
People	4	6	9	5	1

Worked example A2: the median by interpolation

Find the median waiting time.

Time (min)	0–	10–	20–	30–50
Frequency	8	14	12	6

$n = 40$, so the median is the 20th value, in the class 10–20 (8 below it).

$$10 + \frac{20 - 8}{14} \times 10$$

$$18.6 \text{ minutes}$$

Your turn A2

Find the median mass.

Mass (g)	10–	20–	25–	30–40
Frequency	5	12	15	8

Worked example A3: standard deviation from sums

$n = 10$, $\sum x = 84$, $\sum x^2 = 754$. Find the mean and the standard deviation.

$$\sigma^2 = \frac{\sum x^2}{n} - \bar{x}^2, \text{ then square root.}$$

$$\bar{x} = 8.4; \sigma^2 = 75.4 - 70.56 = 4.84$$

$$\bar{x} = 8.4, \sigma = 2.2$$

Your turn A3

$n = 12$, $\sum x = 150$, $\sum x^2 = 1983$. Find the mean and the standard deviation.



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STRETCH

Worked example A4: sd from a frequency table

Find the mean and sd of the number of faults.

Faults	1	2	3	4
Frequency	5	8	4	3

$$\sum fx = 45, \sum fx^2 = 121: \sigma^2 = \frac{121}{20} - 2.25^2$$

$$\bar{x} = 2.25, \sigma = 0.994$$

Your turn A4

Find the mean and sd of the number of calls.

Calls	2	3	4	5
Frequency	6	10	3	1

Worked example A5: coding

$y = \frac{x-50}{5}$, with $\bar{y} = 2.4$ and $\sigma_y = 1.6$. Find $\bar{x}$ and σ_x

$x = 5y + 50$: the sd only feels the $\times 5$

$$\bar{x} = 62, \sigma_x = 8$$

Your turn A5

$y = \frac{x-200}{10}$, with $\bar{y} = -1.5$ and $\sigma_y = 0.7$. Find $\bar{x}$ and σ_x

Worked example A6: combining two groups

A: $n = 10$, mean 12, sd 3. B: $n = 15$, mean 17, sd 2. Find the mean and sd of all 25

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

$$\sum x = 375, \sum x^2 = 5925: \sigma^2 = \frac{5925}{25} - 15^2 = 12$$

$$\text{mean } 15, \text{ sd } 3.46$$

Your turn A6

A: $n = 8$, mean 20, sd 4. B: $n = 12$, mean 25, sd 3. Find the mean and sd of all 20

Worked example A7: percentiles

For the waiting times in A2, find the 10th to 90th interpercentile range.

P_{10} is the 4th value; P_{90} is the 36th value.

$$P_{10} = 0 + \frac{4}{8} \times 10 = 5; P_{90} = 30 + \frac{2}{6} \times 20 = 36.7$$

$$31.7 \text{ minutes}$$

Your turn A7For the masses in A2's *Your turn*, find the 10th to 90th interpercentile range.

B**Fluency**

Each question is a designed sequence. From one part to the next, ask yourself: what changed, and what did it do to the answer?

CORE*Secure the method*

B1 The data are 4, 7, 7, 9, 11, 12, 13

(a) Find the mean.

(b) Find the median.

(c) Find the mode.

(d) The value 21 is added. Find the new mean.

[4 marks]

B2 The 15 values are 2, 3, 5, 6, 6, 7, 8, 8, 9, 10, 11, 12, 14, 15, 18

(a) Find Q_1

(b) Find Q_2

(c) Find Q_3

(d) Find the interquartile range.

[4 marks]

B3 The heights, in cm, of 40 plants are summarised below.

Height (cm)	150–	155–	160–	165–175
Frequency	4	11	15	10

(a) Estimate the median.

(b) Estimate Q_1

(c) Estimate Q_3

(d) Estimate the interquartile range.

[4 marks]

B4 Find the standard deviation in each case.

(a) $n = 8$, $\sum x = 96$, $\sum x^2 = 1220$

(b) $n = 20$, $\sum x = 250$, $\sum x^2 = 3205$

(c) $n = 10$, $S_{xx} = 90$

(d) the data 2, 4, 6, 8, 10

[4 marks]

B5 The number of breakdowns of 20 machines is shown.

Breakdowns	0	1	2	3
Machines	6	9	3	2

(a) Find the mean.

(b) Find the standard deviation.

(c) State the mode.

[3 marks]



B6 Find the mean and standard deviation of x in parts (a) to (c), and of y in part (d).

(a) $y = x - 100$, with $\bar{y} = 3.2$ and $\sigma_y = 1.5$

(b) $y = \frac{x}{10}$, with $\bar{y} = 4.5$ and $\sigma_y = 0.8$

(c) $y = \frac{x-30}{2}$, with $n = 20$, $\sum y = 40$ and $\sum y^2 = 360$

(d) $y = 2x + 5$, with $\bar{x} = 10$ and $\sigma_x = 3$

[4 marks]

STRETCH

B7 The times, in minutes, that 40 people spent in a shop are summarised below.

Time (min)	0–	10–	20–	30–40
Frequency	5	15	12	8

(a) Estimate the mean.

(b) Estimate the standard deviation.

(c) Estimate the median.

(d) Describe the skewness, with a reason.

[4 marks]

B8 (a) 12 values have mean 40 and 8 values have mean 45. Find the mean of all 20

(b) 10 values have mean 25. The value 30 is removed. Find the new mean.

(c) 20 values have $\sum x = 800$ and $\sum x^2 = 33\,000$. One value was recorded as 25 instead of 52. Find the correct mean.

(d) Find the correct standard deviation of the data in (c).

[4 marks]

B9 For the data in B7, estimate

(a) the 10th percentile

(b) the 90th percentile

(c) the 10th to 90th interpercentile range

(d) the interquartile range

[4 marks]

B10 25 values of x are coded with $y = \frac{x-60}{4}$, giving $\sum y = 30$ and $\sum y^2 = 136$

(a) Find the mean and standard deviation of x

(b) Find $\sum x$

(c) Find $\sum x^2$

(d) A 26th value equal to the mean of x is added. Find the new standard deviation.

[4 marks]



C**Reasoning**

Show your working and explain your thinking. A correct answer without a reason does not score full marks.

CORE*Secure the method*

- C1** For $n = 10$, $\sum x = 60$ and $\sum x^2 = 400$, Amir writes “the standard deviation is 4”
Explain his error, and give the correct standard deviation. [2 marks]
- C2** For the waiting times in A2, Bea says “the 20th value is in the class 10–20, so the median is 15”
Explain why this is not acceptable, and say what she should do instead. [2 marks]
- C3** A data set has mean 18 and standard deviation 5. Every value has 4 subtracted.
Carl says the new mean is 14 and the new standard deviation is 1. Explain his error, and give the correct values. [3 marks]
- C4** Two groups combine to give $n = 20$, $\sum x = 400$ and $\sum x^2 = 8180$. Dina writes “variance = $\frac{8180}{20} - 20 = 389$ ”
Find her error, and give the correct standard deviation. [3 marks]

STRETCH

- C5** A data set has $n = 10$, mean 30 and standard deviation 6. A value of 30 is added.
Eli says “the mean and the standard deviation do not change”. Explain whether he is right, and find the new standard deviation. [3 marks]
- C6** 50 values of w are coded with $y = \frac{w - 20}{10}$ and $\sum y = 104$. Faye writes “ $\sum w = 10 \times 104 + 20 = 1060$ ”
Explain her error, and find $\sum w$ and the mean of w [3 marks]
- C7** The salaries of 9 staff include one very high value. Gita says “the mean is the best average because it is more accurate”.
Explain why her reason is wrong, and say which average and which measure of spread she should use, with a reason. [3 marks]
- C8** (a) Show that $\sum (x - \bar{x})^2 = \sum x^2 - n\bar{x}^2$ (2)
- (b) Hence show that adding a constant k to every value leaves the variance unchanged, and that multiplying every value by k multiplies the variance by k^2 (3)
- [5 marks]



D**Problem solving**

You decide the method. Read the whole question first, and show every step.

CORE

Secure the method

- D1** A running club has two training groups for its members. Group *A* has 18 runners and group *B* has 12 runners. Every runner in the club completes the same timed 5 km run, and the time taken, in minutes, by each runner is recorded. The mean time for the 18 runners in group *A* is 24.5 minutes, and the mean time for the 12 runners in group *B* is b minutes. The club secretary calculates that the mean time for all 30 runners in the club is 26 minutes.

(a) Show that $b = 28.25$

(2)

On the next run, every runner in group *B* takes exactly 1 minute longer than before, and the times of the runners in group *A* do not change.

(b) Without carrying out any further calculations, state, giving a reason, the effect this change has on the mean time for all 30 runners in the club.

(1)

[3 marks]

- D2** An office manager records the length, x minutes, of each of the 80 phone calls made from the office on one day. The results are summarised in the table below.

Length (min)	0–	2–	5–	10–	20–30
Frequency	12	26	24	14	4

(a) Use linear interpolation to estimate the median length of these phone calls, and comment on the manager's claim that half of the calls made from the office last less than 5 minutes.

(2)

(b) Use linear interpolation to estimate the lower quartile and the upper quartile, and hence estimate the interquartile range of the lengths of these phone calls. Give your answer to 3 significant figures.

(2)

[4 marks]

- D3** A teacher records the score, out of 70, of each of the 21 students in her class in a test. The scores are shown in the stem-and-leaf diagram in Figure 1, where a is a constant, and the leaves in each row are in ascending order. The teacher calculates that the total of the 21 scores is 902

(a) Find the value of a

(1)

(b) Find the median and the interquartile range of the scores of these 21 students.

(2)

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

Key: 3 | 4 means 34

Figure 1

[3 marks]



- D4** A race organiser records the time, x minutes, taken by each of the 25 runners who completed a cross-country race. The times are shown in the stem-and-leaf diagram in Figure 2. For these times $\sum x = 1150$ and $\sum x^2 = 54\,200$

(a) Write down the mode, and find the mean and the standard deviation of the times taken by these 25 runners.

(2)

Stem	Leaf	
3	2 5 6 8 9	(5)
4	0 1 2 3 4 4 4 5 6 7 8	(11)
5	0 1 2 2 3 4 6 8	(8)
6	0	(1)

Key: 4 | 4 means 44 minutes

Figure 2

One measure of skewness is found using $\frac{\text{mean} - \text{mode}}{\text{standard deviation}}$

(b) Evaluate this measure and describe, giving a reason, the skewness of the times taken by these runners.

(1)

[3 marks]

STRETCH

- D5** A quiz is played by 23 players and the score of each player is recorded. The scores are shown in the stem-and-leaf diagram in Figure 3. The quiz organiser defines an outlier as a score that is greater than $Q_3 + 1.5(Q_3 - Q_1)$ or less than $Q_1 - 1.5(Q_3 - Q_1)$

(a) Find the lower quartile, the median and the upper quartile of the scores of these 23 players.

(2)

Stem	Leaf	
1	2 5 8	(3)
2	1 2 4 5 6 7 7 8	(8)
3	0 1 1 3 4 5 6 8	(8)
4	0 1 3	(3)
5		(0)
6	8	(1)

Key: 2 | 5 means 25

Figure 3

(b) Show that there is exactly one outlier in these data, stating its value. You must show your working clearly.

(2)

[4 marks]

- D6** A researcher measures the reaction time, x hundredths of a second, of each of a sample of 30 volunteers. The 30 reaction times have mean 18.2 and standard deviation 4.1. The researcher then measures the reaction times of two further volunteers, and each of these two new times is exactly 18.2 hundredths of a second.

(a) Without carrying out any further calculations, state, giving a reason, the effect that adding these two values has on the mean of the reaction times.

(1)

(b) State, giving a reason, whether the standard deviation of the reaction times increases, decreases or stays the same when these two values are added, and find the new standard deviation of all 32 reaction times.

(3)

[4 marks]



- D7** A scientist takes 20 measurements, x mm, of the length of a component made on one machine. These 20 measurements have mean 14 mm and standard deviation 3 mm. The scientist then takes a further 30 measurements, y mm, of the length of components made on a second machine. The mean of all 50 measurements is 15.2 mm and the standard deviation of all 50 measurements is 3.5 mm.

(a) Show that $\sum y = 480$

(1)

(b) Showing your working, find $\sum y^2$, and hence find the standard deviation of the 30 measurements made on the second machine.

(3)

[4 marks]

- D8** A post office records the mass, x grams, of each of the 60 letters posted on one morning. The masses are summarised in the table below.

Mass (g)	0–	10–	20–	30–	40–50
Frequency	8	20	18	10	4

To simplify the calculations, the midpoint of each class is coded using $y = \frac{x - 25}{10}$

(a) Use the coding to find estimates of the mean and the standard deviation of the masses of these 60 letters.

(3)

(b) Use linear interpolation to estimate the median mass of these 60 letters.

(1)

(c) Use your answers to parts (a) and (b) to describe, giving a reason, the skewness of the masses of these letters.

(1)

[5 marks]



E**Exam practice**

Full-size exam questions in the style of WST01. Write your answers in the spaces, and show every step.

CORE

Exam questions for everyone

- E1** A company records the time, in minutes, that each of its 80 employees took to travel to work on one Monday. The histogram in Figure 4 shows these times. No vertical scale is shown on the histogram. The company knows that 12 of these employees took between 10 and 20 minutes to travel to work.

(a) Estimate the number of employees who took between 25 and 50 minutes to travel to work. You must show your working clearly.

(2)

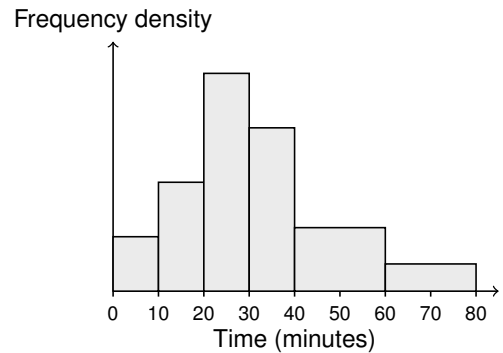


Figure 4

(b) Use linear interpolation to estimate the median time taken by these 80 employees to travel to work.

(2)

(c) Use linear interpolation to estimate the lower quartile and the upper quartile of these times, and hence estimate the interquartile range.

(3)

An estimate of the mean time taken by these 80 employees is 32 minutes.

(d) Describe, giving a reason, the skewness of the times taken by these employees to travel to work.

(1)

Using the midpoints of the classes, the company calculates that $\sum fx^2 = 104\,300$

(e) Estimate the standard deviation of the times taken by these 80 employees to travel to work.

(2)

(Total for Question E1 is 10 marks)



E2 As part of a study, each of 25 students completes the same puzzle and the time taken, x seconds, by each student is recorded. The times are shown in the stem-and-leaf diagram in Figure 5. For these times $\sum x = 915$ and $\sum x^2 = 37993$

(a) Find the median and the interquartile range of the times taken by these 25 students.

(2)

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

Key: 3 | 2 means 32 seconds

Figure 5

(b) Show that the standard deviation of the times taken by these 25 students is 13.4 seconds, to 3 significant figures.

(2)

An outlier is defined as a value that is greater than $Q_3 + 1.5(Q_3 - Q_1)$ or less than $Q_1 - 1.5(Q_3 - Q_1)$

(c) Show that there are no outliers in these data.

(2)

A second group of 15 students then completes the same puzzle. The mean time taken by the students in this second group is 40.2 seconds and the standard deviation of their times is 9.5 seconds.

(d) Find the mean time taken by all 40 students.

(2)

(e) Find the standard deviation of the times taken by all 40 students.

(3)

(Total for Question E2 is 11 marks)



STRETCH

- E3** A manager trains two groups of new staff, group *A* and group *B*, using two different training methods. Each person then completes the same task and the time taken, in minutes, is recorded. The back-to-back stem-and-leaf diagram in Figure 6 shows the times for the 15 people in group *A* and the 15 people in group *B*. The manager defines an outlier as a value that is greater than $Q_3 + 1.5(Q_3 - Q_1)$ or less than $Q_1 - 1.5(Q_3 - Q_1)$

Totals	Group A		Group B	Totals
(1)	8	1		(0)
(4)	8 7 5 2	2	1 4 6 9	(4)
(6)	9 6 3 1 1 0	3	0 1 2 3 5 5 6 7	(8)
(3)	7 4 1	4	0 2 5	(3)
(0)		5		(0)
(0)		6		(0)
(1)	1	7		(0)

Key: 1 | 3 | 0 means 31 minutes for group *A* and 30 minutes for group *B*

Figure 6

- (a) Find the lower quartile, the median and the upper quartile of the times for group *A*

(2)

- (b) Show that there is exactly one outlier in group *A*, stating its value.

(2)

One measure of skewness is found using $\frac{Q_3 - 2Q_2 + Q_1}{Q_3 - Q_1}$

- (c) Evaluate this measure for the times of group *A*, and describe the skewness of these times.

(2)

For the times of group *B*, $Q_1 = 29$, $Q_2 = 33$ and $Q_3 = 37$

- (d) Compare the times taken by the people in the two groups, stating the values of any statistics you use, and explain why the median and the interquartile range are suitable measures to use for the times of group *A*

(2)

For the times, x minutes, of group *A*, $\sum x = 523$ and $\sum x^2 = 20541$

- (e) Find the mean and the standard deviation of the times of group *A*

(3)

The manager finds that the time recorded as 71 minutes was an error, and the correct time is 17 minutes.

- (f) Find the correct mean time for group *A*, and state, giving a reason, the effect of this correction on the median time for group *A*

(2)

(Total for Question E3 is 13 marks)



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