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ANSWER BOOK

# Measures of location and spread

Statistics · Year 12–13

6 questions · 21 marks

NAVY EDITION

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## SECTION A · Warm-up

**A1** Mean $40/5 = 8$. Median 7, the middle of the ordered list. Mode 7, the most frequent value. B1 B1 B1 for the three measures. Three different answers from one small set, because the three measures genuinely measure different things. The 13 drags the mean above the median, which is what a high straggler always does. [3]

**A2** The mean is $450/25 = 18$. The variance is $8500/25 - 18^2 = 340 - 324 = 16$, so $\sigma = \sqrt{16} = 4$. B1 for the mean, M1 for the variance formula, A1 for $\sigma = 4$. Take the mean of the squares and subtract the square of the mean, in that order. Reversing the two gives a negative variance, which is the instant sign that the formula has been written the wrong way round. Squaring is what stops the deviations above and below the mean cancelling to zero, and it is also why one wild value moves $\sigma$ so much. [3]

## SECTION B · Standard

**B1** The median position is $n/2 = 20$. The first class holds 8, so the 20th value sits 12 into the second class, which holds 14 spread across a width of 10. Interpolating, the median is $10 + (12/14) \times 10 = 18.6$ minutes. M1 for the position $n/2 = 20$, M1 for a correct interpolation fraction, A1 for 18.6. The answer has to land inside 10 to 20, and if it does not, the running total has gone astray. For grouped continuous data Edexcel uses $n/2$ rather than $(n + 1)/2$, so use 20 here, not 20.5. [3]

**B2** Uncode in reverse, so $x = 100 + 5y$. The mean becomes $100 + 5 \times 4 = 120$ and the standard deviation becomes $5 \times 2 = 10$. B1 for the mean 120, M1 for scaling the standard deviation, A1 for 10. Subtracting 100 slid the whole data set along without stretching it, so only the division by 5 touched the spread. This is the general rule in miniature. Adding a constant shifts the mean and leaves the standard deviation alone; multiplying by a constant scales both. [3]

**B3** The centres agree, since both average 500 g. The spreads do not. Machine A's bags stay within a few grams of the target while machine B's stray four to five times as far, so machine A is much the more consistent filler. B1 for comparing the means, B1 for comparing the spreads, B1 for the context and units. Both sentences need the context and the units to score. Equal means say nothing about reliability, and it is the standard deviation that carries that part of the story. [3]

## SECTION C · Stretch

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**C1** Work back to the sums, because those are what combine. $\Sigma x = 20 \times 15 = 300$. [6]
For the squares, $\sigma^2 = \Sigma x^2/n - \bar{x}^2$ rearranges to $\Sigma x^2 = n(\sigma^2 + \bar{x}^2) = 20(9 + 225) = 4680$. Adding the new value: $\Sigma x$ becomes $300 + 36 = 336$ and $\Sigma x^2$ becomes $4680 + 1296 = 5976$, with n now 21. The new mean is $336/21 = 16$. The new variance is $5976/21 - 16^2 = 284.57 - 256 = 28.57$, so the new standard deviation is 5.35. M1 for recovering $\Sigma x$, M1 for recovering $\Sigma x^2$, M1 for updating both sums, A1 for the new mean 16, M1 for the new variance, A1 for 5.35. Averaging the old standard deviation with anything is worth nothing, because standard deviations do not add. Only $\Sigma x$ and $\Sigma x^2$ do. A single value 7 standard deviations out has lifted the mean by 1 and nearly doubled the spread, which shows how little it takes to distort both.

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