

Measures of Dispersion

Name: _____ Date: _____ Score: _____ / 30

Q Quick Review

Spread (also called dispersion) tells you how stretched out or how clumped together the data is. Two data sets can have the same mean and still look completely different – that’s what spread captures.

Range is the simplest: range = max – min. Fast to compute but easily blown up by a single outlier.

IQR is $Q_3 - Q_1$, the width of the middle half. It *ignores* the bottom 25% and top 25%, so a single extreme value doesn’t move it – it’s *resistant* to outliers.

Variance and **standard deviation** measure typical distance from the mean. For a population: $\sigma^2 = \frac{1}{n} \sum (x_i - \mu)^2$ and $\sigma = \sqrt{\sigma^2}$. For a sample: $s^2 = \frac{1}{n-1} \sum (x_i - \bar{x})^2$ (divide by $n - 1$, not n – this is the *Bessel correction*).

Why squared? Squaring kills the signs (positive and negative deviations would otherwise cancel) and punishes big deviations more than small ones. The square root at the end gets you back to the same units as the data.

Shift vs. stretch. Adding a constant c to every value shifts the mean by c but *does not change* the spread (everyone moved the same amount). Multiplying every value by k *does* scale the standard deviation by $|k|$ and the variance by k^2 .

Common slips. Reporting variance when standard deviation was asked (you forgot the square root). Saying the standard deviation grew when only the mean shifted. Calling a negative number a variance (variances are sums of squares – always ≥ 0).

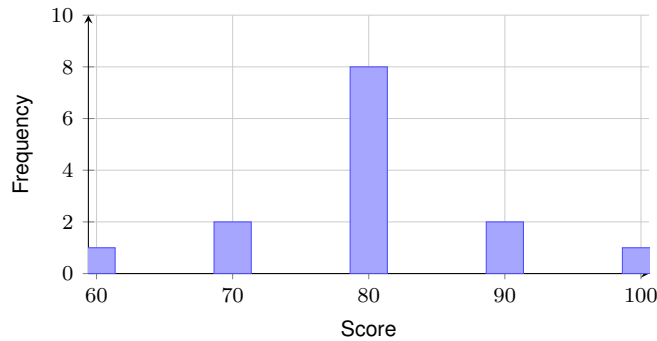
PRACTICE

Compute the requested measure; show work where natural.

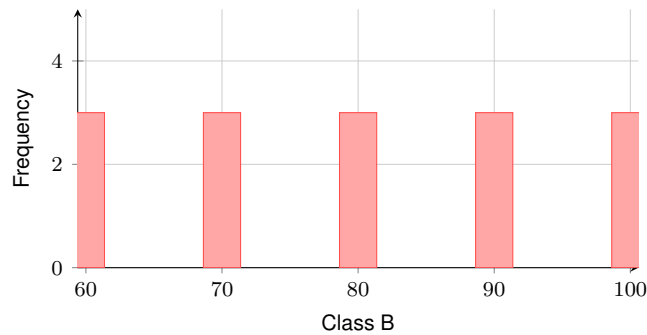
1. Range of {12, 15, 18, 9, 22, 11} _____
2. If the variance is 25, find the standard deviation. _____
3. Population std dev of {2, 4, 4, 4, 5, 5, 7, 9} _____
4. Which measure of spread is most sensitive to outliers? _____
5. If every value in a data set is the same number, what is the std dev? _____
6. Sample variance of {2, 4, 6, 8} _____
7. Sample std dev of {2, 4, 6, 8} _____
8. Add 10 points to every score. How does the std dev change? _____
9. Multiply every value by 3. How does the std dev change? _____
10. Mean of {6, 9, 10, 12, 13, 15, 18} _____
11. IQR of {6, 9, 10, 12, 13, 15, 18} _____



12. Range of the histogram below (bar centers). _____



13. Which class – A (tightly clustered around 80) or B (uniform across 60–100) – has the larger std dev? _____



14. Sample size n , what denominator does s^2 use? _____

15. Can a variance be negative? Why or why not? _____

16. Compare data sets $X = \{5, 5, 5, 5, 5\}$ and $Y = \{1, 3, 5, 7, 9\}$. Std devs? _____

17. Mean of $\{2, 4, 4, 4, 5, 5, 7, 9\}$ _____

18. IQR of $\{3, 5, 7, 8, 10, 12, 14, 16, 45\}$ _____

19. Variance is 49. Std dev? _____

20. Range of $\{-3, 0, 2, 5, 8\}$ _____

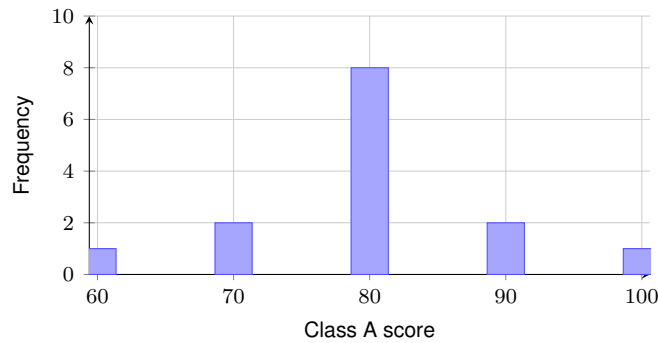
◆ Word Problems

21. A factory packages cereal in boxes labeled 400 g. A quality-control sample of five boxes weighs 398, 401, 399, 402, 400 grams. Find the sample standard deviation (rounded to two decimals). _____

22. A teacher adds 10 bonus points to every test in her class. The class had a mean of 74 and a standard deviation of 8 before the bonus. What are the new mean and the new standard deviation? _____



23. The histogram below shows Class A's test scores. Without computing the actual std dev, decide which is larger: Class A's std dev or that of a class with scores uniformly spread from 50 to 100? Explain briefly. _____



24. A scientist measures the same length five times and gets 12.1, 12.0, 12.2, 12.0, 12.2 cm. She then realizes her ruler was off by 0.5 cm and adds that to every measurement. How does the standard deviation of the corrected data compare with the original? _____

Additional Practice

- 25. Find the mean of 4, 6, 8, 10. _____
- 26. Find the median of 3, 9, 4, 10, 7. _____
- 27. Find the range of 12, 5, 9, 20. _____
- 28. Find the mode of 2, 3, 3, 5, 8. _____
- 29. Find z for $x = 72$, mean 60, standard deviation 6. _____
- 30. Interpret $z = -1.5$. _____



Answer Keys

1. 13

2. 5

3. 2

4. range

5. 0

6. $\frac{20}{3}$

7. $\sqrt{20/3}$

8. no change

9. multiplied by 3

10. $\frac{83}{7}$

11. 6

12. 40

Additional Practice Answers

25. 7

26. 7

27. 15

13. Class B

14. $n - 1$

15. No – it's a sum of squares

16. $\sigma_X = 0, \sigma_Y > 0$

17. 5

18. 9

19. 7

20. 11

21. $s \approx 1.58 \text{ g}$

22. new mean 84, new std dev 8

23. the uniform class has the larger std dev

24. unchanged

28. 3

29. 2

30. 1.5 SD below mean

Additional Practice: Answers for all numbered items, including the added practice, are shown in the grid above.

Step-by-Step Explanations

1. A careful way to see it: Range = $22 - 9 = 13$. Use just the max and min. This is the part to check before moving on, because it keeps the answer tied to the original question.

2. Keep the rule visible: $\sigma = \sqrt{25} = 5$. Standard deviation is the square root of the variance – always non-negative. That gives a quick check on the answer.

3. Mean: $\frac{40}{8} = 5$. Squared deviations from 5: 9, 1, 1, 1, 0, 0, 4, 16. Sum = 32.

Population variance: $\frac{32}{8} = 4$. Std dev: $\sqrt{4} = 2$.

4. Range depends only on the max and min. A single extreme value can yank it sky-high. IQR uses only the middle 50% and is the most resistant.

5. All values equal the mean, so every deviation is 0. Sum of squared deviations = 0, so variance = 0 and std dev = 0.

6. Mean = 5. Squared deviations: 9, 1, 1, 9, sum = 20. Sample variance uses $n - 1 = 3$ in the denominator: $\frac{20}{3}$.

7. Standard deviation is the square root of the variance, so take the sample variance $\frac{20}{3}$ (the one with the $n - 1$ divisor) and root it: $\sqrt{\frac{20}{3}} \approx 2.58$. Keep the same $n - 1$ convention you used for the variance – don't switch to the population formula partway through.

8. Adding a constant shifts everyone by the same amount, so the distances between values and the mean are unchanged. Spread stays the same – it's the mean that shifts up by 10.

9. Multiplication stretches the data, so the std dev scales by the same factor. Variance scales by $3^2 = 9$.

10. Keep the rule visible: Sum: $6 + 9 + 10 + 12 + 13 + 15 + 18 = 83$. Mean = $\frac{83}{7} \approx 11.86$. This is the part to check before moving on, because it keeps the answer tied to the original question.

11. One steady path is: $n = 7$. Median is the 4th value: 12. Lower half {6, 9, 10}: $Q_1 = 9$. Upper half {13, 15, 18}: $Q_3 = 15$. IQR = $15 - 9 = 6$. That gives a quick check on the answer.

12. The bar centers run from 60 (lowest) to 100 (highest). Range of bin centers = $100 - 60 = 40$.

13. Class A's scores are bunched near the mean of 80, so its deviations are small. Class B is spread evenly across all bins, so values land far from the mean often. More distance from the mean \Rightarrow larger std dev.

14. Sample variance divides by $n - 1$ (Bessel correction), not n . This makes s^2 an unbiased estimator of the true population variance.

15. Variance is built from squared deviations. Squares are non-negative; their sum (and any positive divisor) keeps the result ≥ 0 . The minimum is 0, attained when every value equals the mean.

16. Start with the key idea: X has no spread (all values equal), so $\sigma_X = 0$. Y swings symmetrically around the same mean of 5, so its deviations are nonzero and $\sigma_Y > 0$ (specifically, the population std dev is $\sqrt{8} \approx 2.83$). That gives a quick check on the answer.

17. A careful way to see it: Sum = 40, count = 8, mean = $\frac{40}{8} = 5$. This is the part to check before moving on, because it keeps the answer tied to the original question.

18. Lower half {3, 5, 7, 8}: $Q_1 = 6$. Upper half {12, 14, 16, 45}: $Q_3 = 15$. IQR = $15 - 6 = 9$. (Notice how the outlier 45 doesn't distort the IQR – that's why it's resistant.)

19. One steady path is: $\sqrt{49} = 7$. Quick check: $7 \times 7 = 49$. This is the part to check before moving on, because it keeps the answer tied to the original question.

20. Start with the key idea: Range = $8 - (-3) = 11$. Watch the negative sign – it adds to the range, doesn't subtract. That gives a quick check on the answer.

21. Mean: $\frac{398 + 401 + 399 + 402 + 400}{5} = \frac{2000}{5} = 400$. Squared deviations:

$(-2)^2 = 4, 1^2 = 1, (-1)^2 = 1, 2^2 = 4, 0^2 = 0$. Sum = 10. Sample variance $s^2 = \frac{10}{5 - 1} = \frac{10}{4} = 2.5$. $s = \sqrt{2.5} \approx 1.58 \text{ g}$. So a typical box lands about 1.6

grams away from the label weight – nice and tight.

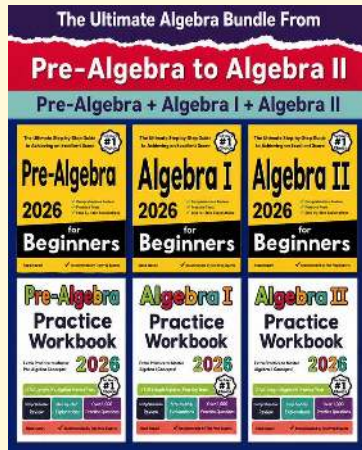
22. Adding a constant shifts every score by that amount, so the mean shifts: $74 + 10 = 84$. But *everyone* moved up by 10 together, so the distances between scores and the mean stay the same. Standard deviation is unchanged at 8. (Watch out for the temptation to bump the std dev by 10 too – that's the classic trap.)

23. Class A's scores are tightly clustered around 80, so most deviations from the mean are small. A class spread uniformly from 50 to 100 has many scores far from the mean (75), so larger squared deviations on average. More distance from the mean \Rightarrow larger std dev. (For a clean visual: a tall narrow peak says "small std dev"; a flat wide spread says "large.")

24. Adding the same constant (0.5 cm) to every measurement shifts the mean up by 0.5 but leaves all the spreads between measurements exactly the same. So the standard deviation doesn't budge. (A systematic shift is *bias*, not *noise* – different things.)



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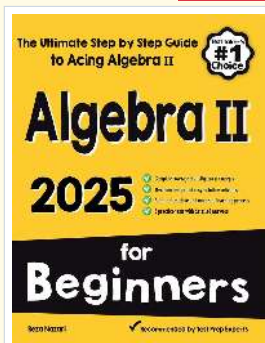
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