SCIENCE FOUNDATIONS

Identifying sources of error

Difficulty level: Intermediate

Science Foundations

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Overview of the concept

This is how you figure out why your measurements came out wrong in a lab, like a scale that was never zeroed or a stopwatch started late, so you can fix it next time. A cook whose cake keeps sinking checks whether the oven runs hot before blaming the recipe. A student whose titration keeps overshooting looks for the step where the extra drop creeps in. Knowing sources of error tells you whether your result is wrong because of your tools, your method, or just the normal wobble of measuring, and what to change.



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Rule

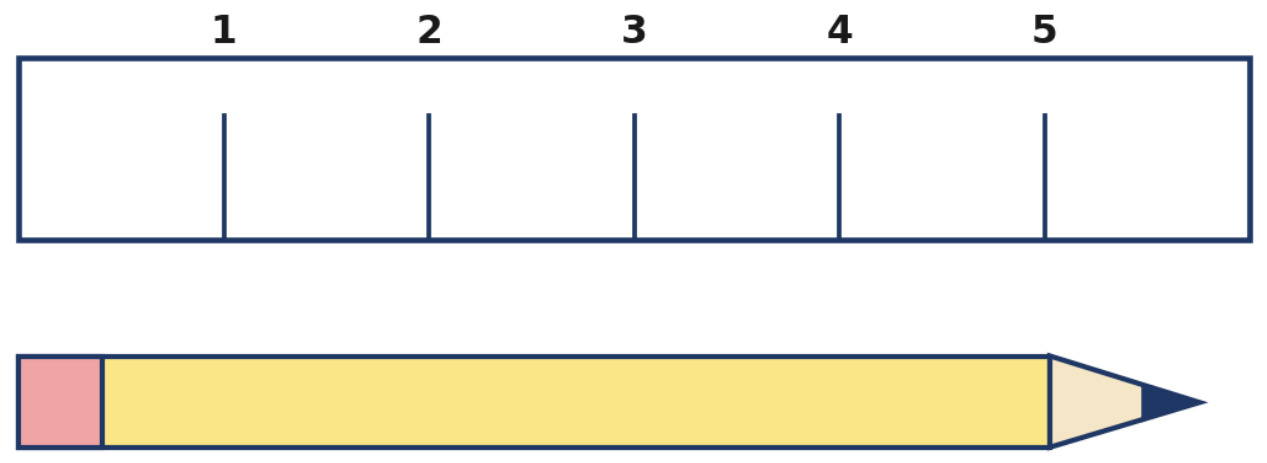
Sources of error: a systematic error shifts every reading the same way, such as a ruler that starts at 1 cm instead of 0 cm, so every length reads 1 cm too long.

A random error varies by chance, sometimes early and sometimes late, such as reaction times on a stopwatch. Fix a systematic error by correcting the instrument. Fix a random error with repeats and an average.

Worked examples

EXAMPLE 1

Q **You measure with a ruler that starts at 1 cm, not 0 cm. What type of error is this, and how can it be fixed?**



SOLUTION

Check the instrument: the zero mark is missing from the start.

Ask how it affects readings: every length reads 1 cm too long.

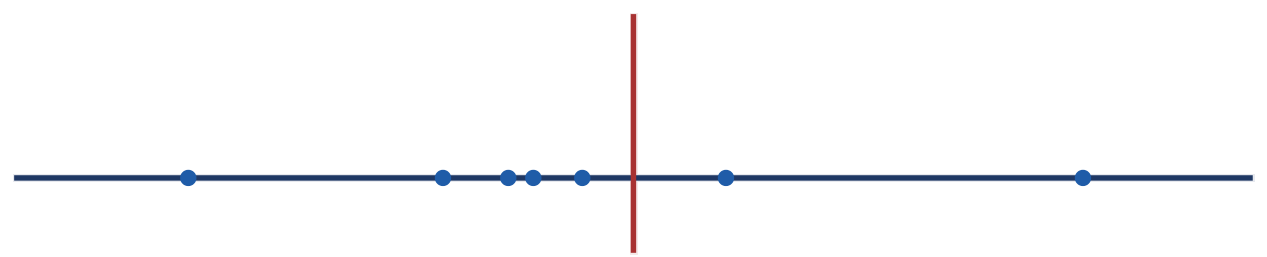
Classify it: the same shift every time means systematic error.

The result is systematic error; fix by starting at the true zero or subtracting 1 cm.

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EXAMPLE 2

Q When you time with a stopwatch, your reaction times vary from one trial to the next. What type of error is this?



SOLUTION

Check the readings: they scatter around the true time.

Ask how it affects readings: sometimes early, sometimes late.

Classify it: varying by chance means random error.

The result is random error; fix with repeats and an average.

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Practice questions

1 A scale always reads 5 g high. What kind of error?

- **A** Random
- **B** Systematic
- **C** Human error
- **D** Zero error

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2 Repeated measurements of a pencil length give 15.1 cm, 15.4 cm, 14.9 cm and 15.2 cm. What kind of error is this?

- **A** Systematic
- **B** Human error
- **C** Random
- **D** Zero error

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3 A student misreads a ruler once. What kind?

- A Human error
- B Systematic error
- C Zero error
- D No error at all

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4 How do you reduce random error?

- A Calibrate once
- B Take one reading
- C Repeat and average
- D Use a broken instrument

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5 How do you reduce systematic error?

- A Repeat and average
- B Find the fault and calibrate the instrument
- C Take more readings
- D Ignore the shift

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6 What is a systematic error?

- A Readings varying by chance
- B A one-off misread
- C No shift at all
- D The same shift in every reading

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7 What is a random error?

- A Readings varying by chance
- B The same shift in every reading
- C A broken scale
- D A zero error

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8 A thermometer is broken and reads low always. Fix?

- A Repeat and average
- B Take one reading
- C Replace it or calibrate it
- D Ignore the readings

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9 Why repeat measurements?

- A To find a systematic error
- B To average out random variation
- C To use up time
- D To calibrate the instrument

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10 Name one human error in timing.

- A The scale reading 5 g high
- B The ruler starting at 1 cm
- C Repeating the measurement
- D Starting the stopwatch late

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ANSWER KEY

1. Systematic

2. Random

3. Human error

4. Repeat and average

5. Find the fault and calibrate the instrument

6. The same shift in every reading

7. Readings varying by chance

8. Replace it or calibrate it

9. To average out random variation

10. Starting the stopwatch late

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