SCIENCE FOUNDATIONS

Measurement and uncertainty

Difficulty level: Intermediate

Science Foundations

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Overview of the concept

This is how you report a measurement honestly, like the length of a board cut for a shelf, by saying how far off the reading could be instead of pretending it is exact. A carpenter who cuts a board to 60 centimetres knows the tape might be off by a millimetre either way, and plans the joint with that in mind. A pharmacist weighing a dose reports the range the scale can actually guarantee. Knowing measurement and uncertainty tells you how much to trust a number, and when a tiny difference is real or just the wobble of the tool.



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Rule

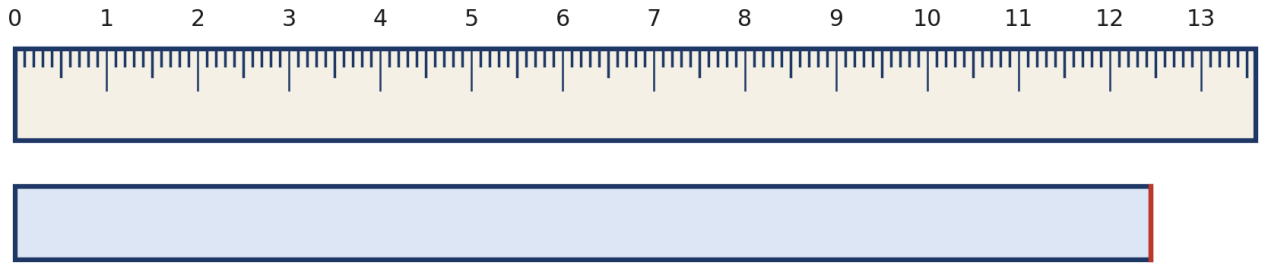
Measurement and uncertainty: uncertainty = $\dfrac{\text{smallest division of the instrument}}{2}$.

A ruler marked every millimetre has an uncertainty of 0.5 mm, and a finer scale always gives a smaller uncertainty.

Worked examples

EXAMPLE 1

Q Read a ruler marked every millimetre: length 12.4 cm.



SOLUTION

Find the smallest division: 1 mm, which is 0.1 cm.

Take half of it as the uncertainty:
0.1 ÷ 2 = 0.05 cm

Write the result as 12.4 cm, ±0.05 cm.

The result is 12.4 cm ±0.05 cm.

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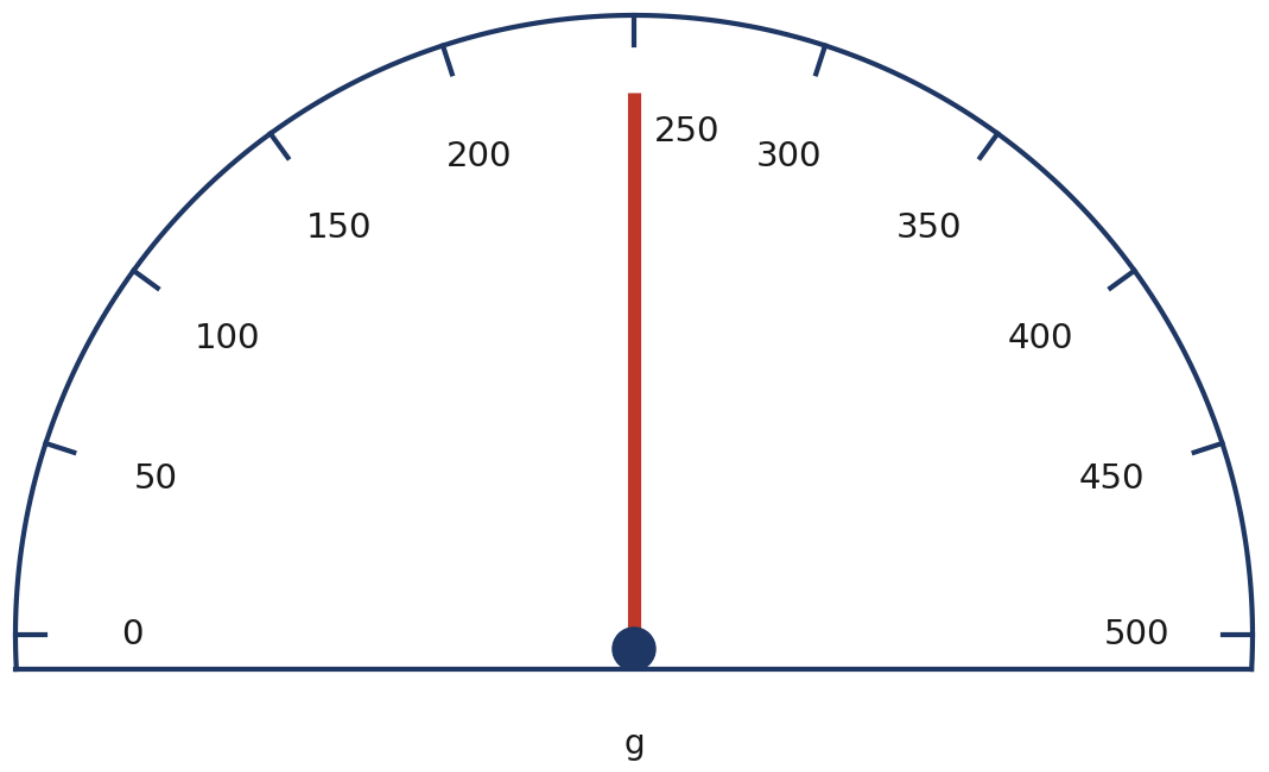
EXAMPLE 2

Q Read a balance to the nearest gram: mass 250 g.



SOLUTION

Find the smallest division: 1 g.

Take half of it as the uncertainty:
1 ÷ 2 = 0.5 g

Write the result as 250 g, ±0.5 g.

The result is 250 g ±0.5 g.

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Practice questions

1 **A ruler is marked every 1 mm. A length measures 15.7 cm. What is the uncertainty, and how is the length reported?**

- **A** Uncertainty 0.1 cm; 15.7 cm ±0.1 cm
- **B** Uncertainty 0.05 cm; 15.7 cm ±0.05 cm
- **C** Uncertainty 0.01 cm; 15.7 cm ±0.01 cm
- **D** Uncertainty 0.5 cm; 15.7 cm ±0.5 cm

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2 **A student measures a board with a ruler marked every 1 mm and records the length as 15.70 cm. Is this reported correctly? Explain.**

- **A** Yes, writing more digits always makes a measurement better.
- **B** No, the ruler can only be read to 0.1 cm, so 15.70 cm claims more precision than the ruler gives.
- **C** No, the board is too long for the ruler.
- **D** No, the ruler cannot measure centimetres at all.

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3 **A mass is reported as 180 g ± 0.5 g. Between which two values could the true mass lie?**

- **A** 179.5 g and 180.5 g
- **B** 179 g and 181 g
- **C** 180 g and 180.5 g
- **D** 175 g and 185 g

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4 **A balance reads to the nearest 10 g. One student says the uncertainty is 10 g, and another says it is 5 g. Who is right, and why?**

- **A** The first student: uncertainty equals the smallest division.
- **B** The second student: uncertainty is half the smallest division, 10 ÷ 2 = 5 g.
- **C** Neither: uncertainty is always 1 g.
- **D** The first student: uncertainty is the reading itself.

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5 **A time is reported as 12.34 s ± 0.005 s. A second timing of the same event gives 12.36 s. Do the two measurements agree? Explain.**

- **A** Yes, both timings are about 12 s.
- **B** No, a stopwatch cannot time the same event twice.
- **C** No, 12.36 s lies outside 12.335 s to 12.345 s, so they disagree.
- **D** Yes, 12.36 s lies inside 12.335 s to 12.345 s.

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6 Why report uncertainty at all?

- **A** To make the reading look bigger
- **B** To hide the true value
- **C** To show how much the reading could really vary
- **D** To round the reading to a whole number

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7 Which is more precise: a ruler marked in millimetres or one marked in centimetres?

- **A** The centimetre ruler
- **B** The millimetre ruler
- **C** Both are equally precise
- **D** Neither ruler is precise

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8

Thermometer A reads to the nearest 0.5 degrees C and thermometer B reads to the nearest 0.1 degrees C. What are their uncertainties?

A. A: 0.5 degrees C, B: 0.1 degrees C

B. A: 0.05 degrees C, B: 0.25 degrees C

C. A: 0.25 degrees C, B: 0.05 degrees C

D. A: 0.25 degrees C, B: 0.25 degrees C

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9 What is the smallest division of an instrument?

- A The largest number on the instrument
- B The smallest marked step on the instrument
- C The length of the instrument
- D The number of marks on the instrument

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10 Can uncertainty ever be zero? Explain.

- A Yes, a perfect instrument has none
- B Yes, if the reading is exact
- C No, every instrument has a limit
- D No, only rulers have uncertainty

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ANSWER KEY

1. Uncertainty 0.05 cm; 15.7 cm ±0.05 cm

2. No, the ruler can only be read to 0.1 cm, so 15.70 cm claims more precision than the ruler gives.

3. 179.5 g and 180.5 g

4. The second student: uncertainty is half the smallest division, 10 ÷ 2 = 5 g.

5. No, 12.36 s lies outside 12.335 s to 12.345 s, so they disagree.

6. To show how much the reading could really vary

7. The millimetre ruler

8. A: 0.25 degrees C, B: 0.05 degrees C

9. The smallest marked step on the instrument

10. No, every instrument has a limit

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