Precision vs Accuracy

Name: _____ **Class:** _____ **Date:** _____

Quick Review

In science, measurements should be both accurate and precise.

- **Accuracy:** How close a measurement is to the true or accepted value.
- **Precision:** How close repeated measurements are to one another.
- **Systematic error:** An error that consistently shifts measurements in one direction, often because of incorrect calibration or a faulty method.
- **Random error:** Unpredictable variation between measurements, caused by factors such as small changes in technique or instrument readings.

A set of measurements can be accurate but not precise, precise but not accurate, both, or neither.

Part A — Multiple Choice

1. What does accuracy describe?

A. How quickly a measurement is taken
B. How close a measurement is to the true value
C. How many times an experiment is repeated
D. How close repeated measurements are to one another

2. What does precision describe?

A. How close repeated measurements are to one another
B. How close a measurement is to the accepted value
C. How expensive the measuring equipment is
D. How large the measurement is

3. A balance always reads 2 g too high. What type of error is this?

A. Random error
B. Human variation
C. Systematic error
D. No error

4. A student measures the same object several times and gets slightly different results because of small changes in technique. What type of error is this?

A. Systematic error
B. Random error
C. Calibration error
D. Zero error

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5. Which action is most likely to improve measurement accuracy?

A. Using an incorrectly calibrated instrument
B. Recording fewer measurements
C. Ignoring the accepted value
D. Calibrating the measuring instrument correctly

Part B — Matching

Match each term with the correct description.

Term	Answer	Descriptions
1. Accuracy	_____	A. Adjusting or checking an instrument against a known standard
2. Precision	_____	B. Unpredictable changes between repeated measurements
3. Systematic error	_____	C. Closeness of a measurement to the true value
4. Random error	_____	D. A consistent bias in measurements
5. Calibration	_____	E. Closeness of repeated measurements to each other

Part C — Analysing Experimental Data

Three students measure an object with an accepted mass of **50.0 g**.

Student	Trial 1	Trial 2	Trial 3	Trial 4
A	50.1 g	50.0 g	49.9 g	50.0 g
B	54.0 g	54.1 g	54.0 g	53.9 g
C	47.0 g	52.0 g	49.0 g	52.0 g

1. Which student has the most accurate average measurement?

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2. Which student has the least precise measurements?

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3. Which student shows high precision but poor accuracy?

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4. Calculate the mean mass measured by Student B. Show your working.

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5. Suggest one possible reason why Student B's measurements are consistently too high.

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Part D — Identifying Errors

For each situation, identify whether the error is mainly **systematic** or **random**.

Situation	Type of error
1. A thermometer consistently reads 3°C too high.	_____
2. A student's reaction time varies when using a stopwatch.	_____
3. A ruler has a damaged end, causing every length to be overestimated.	_____
4. Small vibrations cause a balance reading to fluctuate.	_____
5. A measuring cylinder is consistently read from the wrong viewing angle.	_____

6. Explain how systematic errors affect accuracy.

7. Explain how random errors affect precision.

Part E — Improving Measurements

A student measures the time taken for a pendulum to complete one oscillation using a handheld stopwatch.

1. Suggest two ways to improve the precision of the measurements.

a) _____

b) _____

2. Suggest two ways to improve the accuracy of the measurements.

a) _____

b) _____

3. Why is it useful to repeat measurements several times?

4. Can repeating measurements remove a systematic error? Explain.

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Exit Ticket

1. What is the difference between accuracy and precision?

2. Can measurements be precise but inaccurate? Give an example.

3. What is one way to reduce random error?

4. What is one way to reduce systematic error?

5. Why should scientists consider both accuracy and precision when evaluating experimental results?

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Precision vs Accuracy — Answer Key

Part A — Multiple Choice

1. B — How close a measurement is to the true value.
2. A — How close repeated measurements are to one another.
3. C — Systematic error.
4. B — Random error.
5. D — Calibrating the measuring instrument correctly.

Part B — Matching

Term	Answer	Description
1. Accuracy	C	Closeness of a measurement to the true value
2. Precision	E	Closeness of repeated measurements to each other
3. Systematic error	D	A consistent bias in measurements
4. Random error	B	Unpredictable changes between repeated measurements
5. Calibration	A	Adjusting or checking an instrument against a known standard

Part C — Analysing Experimental Data

The accepted mass is 50.0 g.

1. Which student has the most accurate average measurement?

Student A.

Student A's average is exactly 50.0 g, matching the accepted value. Student C's average is also 50.0 g, so Student C is equally accurate when comparing averages.

Accept A and C as the technically correct answer. Student A has the better overall measurements because they are also more precise.

2. Which student has the least precise measurements?

Student C.

Student C's results range from 47.0 g to 52.0 g, showing the greatest variation.

3. Which student shows high precision but poor accuracy?

Student B.

The measurements are tightly grouped around 54.0 g, but the accepted value is 50.0 g.

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4. Calculate the mean mass measured by Student B. Show your working.

Mean = (54.0 + 54.1 + 54.0 + 53.9) ÷ 4

Mean = 216.0 ÷ 4

Mean = 54.0 g

5. Suggest one possible reason why Student B's measurements are consistently too high.

Acceptable answers include:

- The balance was incorrectly calibrated.
- The balance had a positive zero error.
- The student failed to tare the container before weighing.
- The measuring instrument had a systematic error.

Part D — Identifying Errors

Situation	Answer
1. A thermometer consistently reads 3°C too high.	Systematic
2. A student's reaction time varies when using a stopwatch.	Random
3. A ruler has a damaged end, causing every length to be overestimated.	Systematic
4. Small vibrations cause a balance reading to fluctuate.	Random
5. A measuring cylinder is consistently read from the wrong viewing angle.	Systematic

6. Explain how systematic errors affect accuracy.

Systematic errors consistently shift measurements away from the true value, reducing accuracy.

For example, a thermometer that always reads 3°C too high produces inaccurate results even if its readings are very consistent.

7. Explain how random errors affect precision.

Random errors cause unpredictable variations between repeated measurements, reducing precision.

For example, variations in reaction time when starting and stopping a stopwatch can produce slightly different results for the same event.

Part E — Improving Measurements

1. Suggest two ways to improve the precision of the measurements.

Accept any two reasonable answers:

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- Time 10 or 20 complete oscillations instead of one, then divide by the number of oscillations.
- Use the same reference point for starting and stopping the timer.
- Keep the pendulum's release angle small and consistent.
- Use an electronic timer or light gate to reduce reaction-time variation.
- Repeat the experiment using a consistent method.

2. Suggest two ways to improve the accuracy of the measurements.

Accept any two reasonable answers:

- Check or calibrate the stopwatch against a reliable time standard.
- Use a light gate or electronic timing system to reduce human timing bias.
- Time several complete oscillations and divide by their number to reduce the effect of a fixed start/stop timing error.
- Use a clearly defined reference point to avoid consistently starting or stopping at the wrong moment.

3. Why is it useful to repeat measurements several times?

Repeating measurements helps identify unusual results and assess precision.

Calculating the mean can also reduce the influence of random errors, making the final estimate more reliable.

4. Can repeating measurements remove a systematic error? Explain.

No.

Repeating measurements does not automatically remove a systematic error because the same bias affects each measurement.

For example, if a stopwatch consistently runs 2% too fast, repeated measurements will still contain that error.

The instrument or experimental method must be corrected.

Exit Ticket

1. What is the difference between accuracy and precision?

Accuracy describes how close a measurement is to the true or accepted value.

Precision describes how close repeated measurements are to one another.

2. Can measurements be precise but inaccurate? Give an example.

Yes.

For example, if an object's true mass is 50.0 g, repeated readings of 54.0 g, 54.1 g, and 53.9 g are precise because they are close together, but inaccurate because they are far from the true value.

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3. What is one way to reduce random error?

Acceptable answers:

- Repeat measurements and calculate the mean.
- Use an instrument with better resolution.
- Control environmental conditions.
- Use electronic timing to reduce reaction-time variation.

4. What is one way to reduce systematic error?

Acceptable answers:

- Calibrate measuring instruments.
- Correct zero errors.
- Check the measuring method against a known standard.
- Avoid consistent parallax errors by reading scales at eye level.

5. Why should scientists consider both accuracy and precision when evaluating experimental results?

Scientists need accurate measurements to obtain values close to the truth and precise measurements to ensure results are consistent and repeatable.

A set of measurements can be precise but inaccurate, or have an accurate average despite considerable variation.

Considering both provides a more complete assessment of experimental quality.

Teacher Notes

Important clarification for Part C, Question 1: Both Students A and C have an average of 50.0 g. Therefore, both have equally accurate mean values. However, Student A's individual measurements are consistently closer to the accepted value and are much more precise. This distinction makes a useful classroom discussion.

Another important distinction: Repeating measurements and averaging can reduce the influence of random errors on the final estimate, but does not necessarily improve the precision of the individual measurements. Likewise, a highly precise instrument can still give inaccurate readings if it has not been calibrated correctly.

For the pendulum questions, students should distinguish between improving the timing method and simply repeating a flawed method. Electronic timing and checking calibration are particularly strong answers.

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