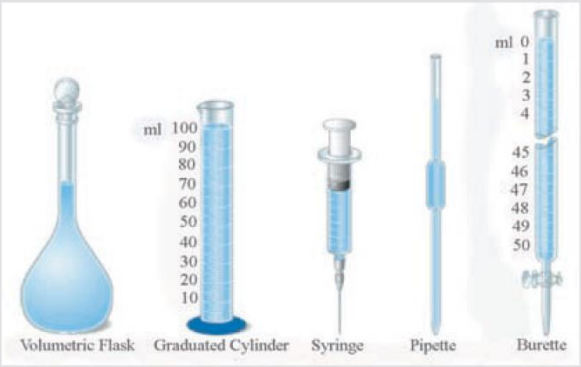
Precision Of Laboratory Equipment And Types Of Error

Quick Check

Volumetric devices measure liquids with a wide variety of precisions.



1. Which of these is likely the *most precise*?

   _____

2. Which is likely the *least precise*?

   _____

3. Is the *most precise* device necessarily the *most accurate*?

   _____

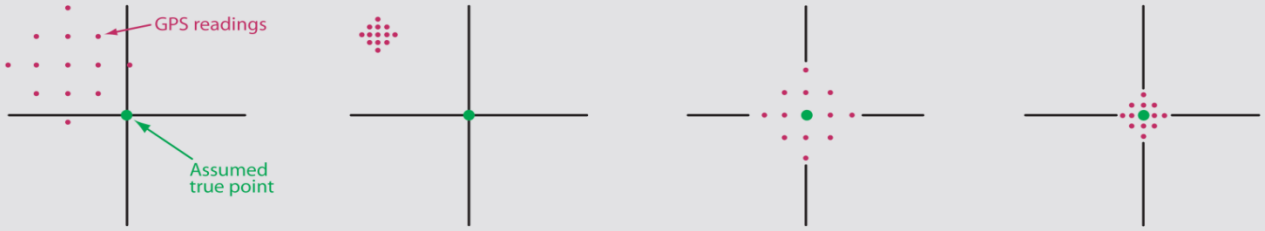
4. Discuss your answers.

   _____

1) syringe
2) graduated cylinder
3) No
4) Syringe is the most precise of all b/c it is the most exact one, giving the most number of decimal places.
Graduated Cylinder is the least precise.

Quick Check

Four groups of Earth Science students use their global positioning systems (GPS) to do some geocaching. The diagrams below show the students' results relative to where the actual caches were located.



1. Comment on the precision of the students in each of the groups. (In this case, we are using the "reproducibility" definition of precision.)

   _____

2. What about the accuracy of each group?

   _____

3. Which groups were making systematic errors?

   _____

4. Which groups made errors that were more random?

   _____

1) Group 1 & 3 → low precision, points are spread apart
Group 2 & 4 → high precision, the points are close together (within close range)
2) Group 1 & 2 → low accuracy, far from the assumed true point
Group 3 & 4 → high accuracy, points are around the assumed true point
3) Group 1, group 2
4) Group 3, Group 4

Quick Check

A student weighs a Canadian penny and finds the mass is 2.57 g. Data from the Canadian Mint indicates a penny from that year should weigh 2.46 g.

1. What is the absolute uncertainty of the penny's mass?

2. What is the percentage error of the penny's mass?

3. Suggest a reasonable source of the error.

_____

1) $\pm 0.11\text{g}$
2) $\frac{0.11\text{g}}{2.46\text{g}} \times 100\% = 4.5\%$
3) uncertainty of measurement

Questions:

1. A zinc slug comes from a science supply company with a stated mass of 5.000 g. A student weighs the slug three times, collecting the following values: 4.891 g, 4.901 g, and 4.890 g. Are the student's values accurate? Are they precise (consider both meanings)?

Not accurate, but precise (consider both meanings)

2. A student doing experimental work finds the density of a liquid to be 0.1679 g/cm^3. The known density of the liquid is 0.1733 g/cm^3. What is the absolute error of the student's work? What is the percent error?

Absolute error $= -0.0054\text{g/cm}^3$
$\%\text{ error} = \frac{0.0054\text{ g/cm}^3}{0.1733\text{ g/cm}^3} \times 100\% = 3.1\%$

3. Two students weigh the same object with a known mass of 0.68 g. One student obtains a mass of 0.72 g, while the other gets a mass of 0.64 g. How do their percent errors compare? How do their absolute errors compare?

1) (same/opposite direction)
|error| of $0.72\text{g} = 0.04\text{g}$
|error| of $0.63\text{g} = -0.04\text{g}$
} % error = 6%

4. In an experiment to determine the density of a liquid, a maximum error of 5.00% is permitted. If the true density is 1.44 g/cm^3, what are the maximum and minimum values within which a student's answer may fall into the acceptable range?

$\frac{5.00}{100}(1.44) = 0.0720\ g/cm^3$

Maximum: $1.512 \rightarrow 1.519/cm^3$

Minimum: $1.368 \rightarrow 1.37\ g/cm^3$

5. What is the mass, including uncertainty, arrived at as the result of summing 45.04 g +/– 0.03 g, and 39.04 g +/– 0.02 g?

$84.08\ g \pm 0.05\ g$

6. What is the smallest number that could result from subtracting 22 m +/– 2 m from 38 m +/– 3 m?

$35 - 24 = 11\ m$

7. The dimensions of a rectangle are measured to be 19.9 cm +/– 0.1 cm and 2.4 +/– 0.1 cm. What is the area of the rectangle, including the range uncertainty?

max: $20.0 \times 2.5 = 50.0\ cm^2$

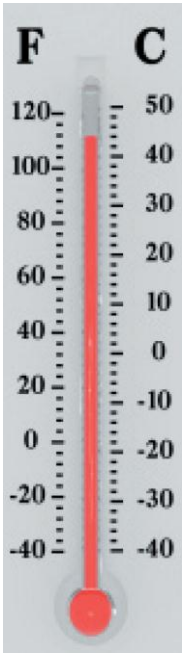
min: $19.8 \times 2.3 = 45.54\ cm^2$

average: $47.77 \pm 2.23\ cm^2$

$\therefore\ 48 \pm 3\ cm^2$

8. Read each of the following devices, including a reasonable range uncertainty:

$14.3\ mL \pm 0.5\ mL$



$112°F \pm 2°F$ or $44°C \pm 1°C$