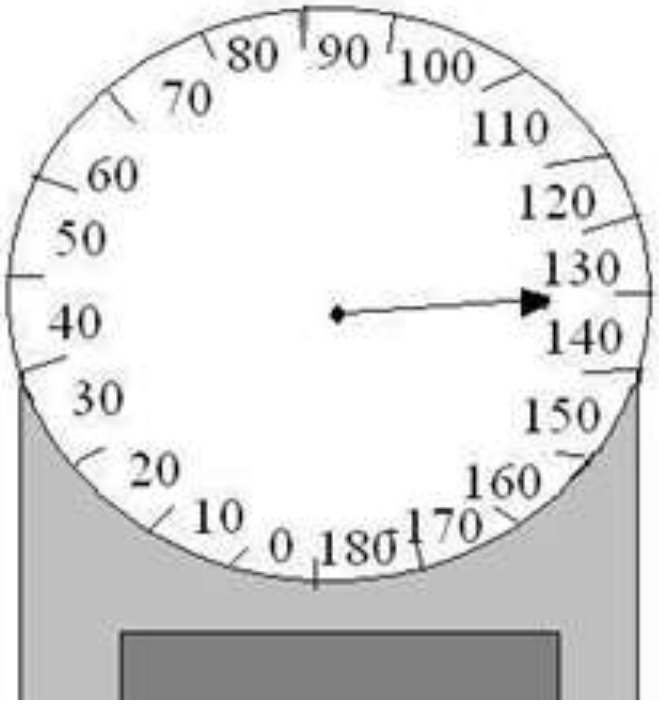
Scientific Measurement, 2010

Objectives

- **I can Distinguish** between accuracy and precision
- **I can precisely perform measurements using metric measuring tools.**
- **I can Perform** measurements using the correct number of decimal places (correct number of significant digits).
- **I can convert between different metric units (milli, centi, base units, kilo)**

Measurements

All measurements have some uncertainty.



This is caused by two factors:

- **the limitation of the measuring instrument (precision)**
- **What is the precision of this scale?**

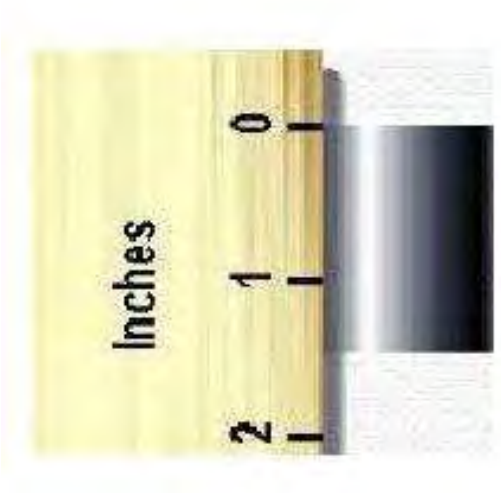
•and the skill of the experimenter making the measurements (accuracy).

ment

Which of the following best describes the length of the beetle's body in the picture

- Between 0 and 2 in
- Between 1 and 2 in
- Between 1.5 and 1.6 in
- Between 1.54 and 1.56 in
- Between 1.546 and 1.547 in

Precision And Uncertainty Of Measurements



We Estimate:1.4 inches

One figure we know for sure, the 1

One figure is guess, the .4

1.45 inches

two figures we know for sure,

The 1 and the .4

one figure (the 0.05) is a guess.

When we guess, we only guess once! It is 1.45 not 1.455

The greater the number of marks on a ruler, the greater the precision (the ability to reproduce measurements).

ment

Which of the following best describes the length of the beetle's body in the picture

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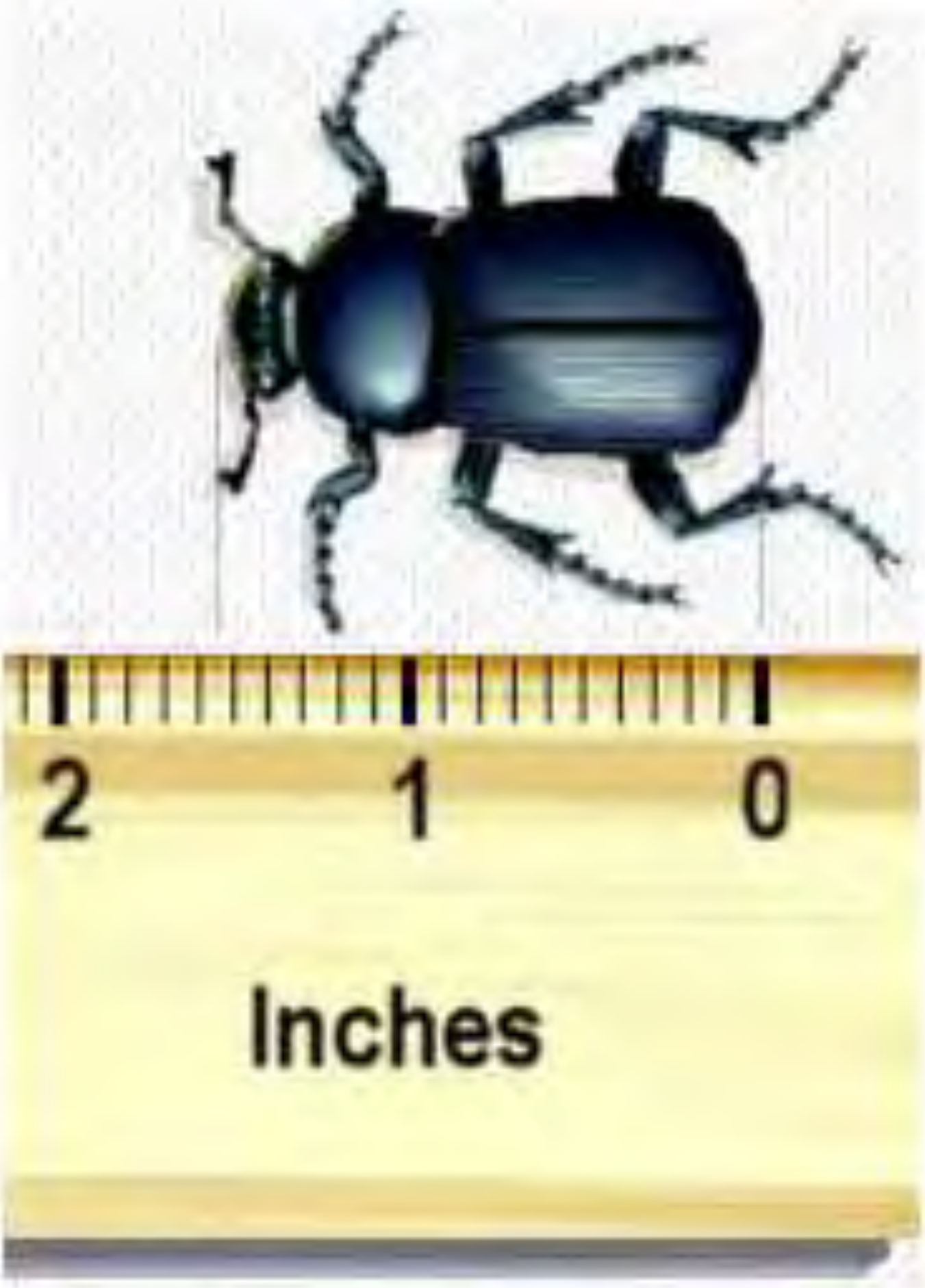

2
1
0
Inches

ment

Which of the following best describes the length of the beetle's body in the picture

- Between 0 and 2 in
- Between 1 and 2 in
- Between 1.5 and 1.6 in
- Between 1.54 and 1.56 in
- Between 1.546 and 1.547 in

Measuring Rules

- **Measure to the nearest mark on the meter stick.**
- **If the measurement falls in between the marks, you must estimate.**
- **Only estimate one time (only make one guess). Only one digit for an estimate allowed**
- **The final digit is always an estimate , even if you are estimating zero.**
- If you think your measurement falls exactly on the mark, end you measurement with a zero
    - Example: 2.10 cm


0
1
2
Inches
1.55, not 1.555

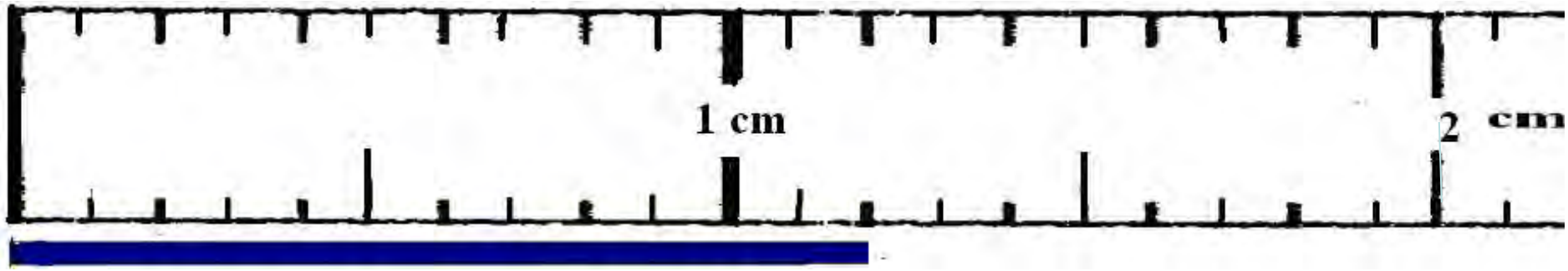
If you thought the the bug lined up with the arrow: record 1.50, not 1.5

Bell Work, Wednesday, Jan 16

Use the ruler & line from Wed..

Record the length of the blue line and the red line in centimeters (cm) using one uncertain digit.

Underline the uncertain digit.



Blue line: 1.20 mm, **Red line:** 2.00 cm

Conversions

- **You need a relationship to convert units**
- **A relationship tells you how many of the unit you start with (the given) equals how many of the unit you want to convert to.**
  - Suppose you want to convert 10¢ to $
  - The given is (what are you staring with)?
    - 10¢
  - What unit are you starting with? ¢
  - What unit are you converting to? $
- How many ¢ = how many $??
- **The relationship is $1 = 100¢**

Conversions

- Suppose you want to convert 10¢ to $
  - The given is (what are you staring with)? **10¢**
  - What unit are you converting to? **$**
- What is the relationship between $ and ¢
- How many ¢ = how many $??
- **The relationship is $1 = 100¢**
- **What is the bigger unit, $ or ¢ ?**
- convert 10¢ to $
- **Are you converting:**
- **from small unit to big unit?**
- **Or big unit to small unit?**

¢ → $

Conversion Rules

1. Determine the relationship between the units

– Example: to convert ¢ to $, the relationship is

– 1 dollar = 100 cents

2. Converting smaller unit to a bigger unit = smaller number (answer is a smaller #) **Small unit → big unit = smaller number**

- To get a smaller number – multiply or divide?
- Divide by the relationship number.

3. Converting bigger unit to a smaller unit = bigger number (answer is a bigger #)

Big unit → small unit = bigger number

To get a bigger number - multiply or divide?
Multiply by the relationship number.

Conversions

2. How many meters is 1.20 cm?

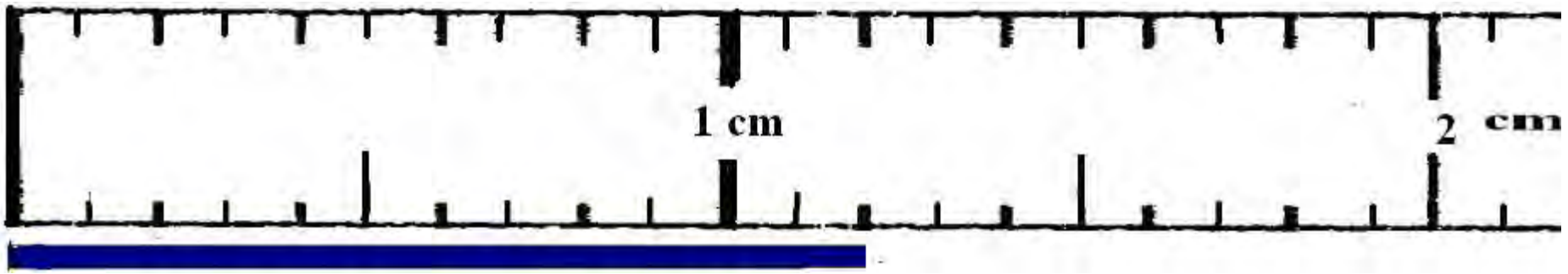
Big unit to small unit, or small unit to big unit?

1.20 cm → ? m *S → B = S 10¢ → $? = bigger or smaller number for the answer?*

1.20 cm

How many cm = how many m? 100 cm = 1 m

____ ÷ 100 = 0.0120 m



Bell Work, Thursday, Jan 17

m = meter, cm = centimeter, mm = millimeter, dm = decimeter, km = kilometer

1. How many dm = 1 meter? **10 dm = 1m**

2. How many cm = 1 meter? **100 cm = 1m**

3. How many mm = 1 meter? **1000 mm = 1m**

4. How many mm = 1cm **10 mm = 1 cm**

5. How many micrometers (µm) = 1 meter

1,000,000 µm = 1m

6. How many meters = 1 km? **1000 m = 1km**

Conversion Rules

Converting smaller unit to a bigger unit = smaller number (answer is a smaller #)

- To get a smaller number – divide or multiply?
- Divide by the relationship number.
- **The relationship is $1 = 100¢**
- Divide by 1 or divide by 100?
- Will dividing by 1 change anything?
- Divide by 100.
- Divide what by 100?
- The given. 10¢
- 10/100 = $0.1
- Is number 0.1 smaller than 10?

Example Conversion

- **Convert 10 meters to centimeters**.
- What unit are we beginning with? **meters**
- What is the bigger unit: m or cm?
- What is the rule?
- **big→ small= bigger number**
- **How do you get a bigger number,**
- **Multiply or divide?**
- **How much do you multiply by?**
- **Use the relationship for meters & centimeters.**
  - **relationship is** 100 cm =1m
- Multiply 100 times 10 = 1000 cm

Conversion Rules

- **Determine the relationship between the units**

  (100 ¢ = 1$, 100cm = 1 m, 60 sec = 1 min)

- **If you are converting from a smaller unit to a bigger unit, the answer is a smaller number**

  small → big = smaller number

  To get a smaller number – Divide by the relationship

- **If you are converting from a bigger unit to a smaller unit, the answer will be a bigger number**

  big → small = bigger number

  To get a bigger number -

  Multiply by the relationship number

Practice Problems

Should the answer be bigger or smaller than the given for the following conversions?

a. 0.25 meters to millimeters.

b. How many centimeters are 9.8 millimeters?

c. 35 milliliters to liters.

d. How many meters are in 4.2 decimeters

e. 6.7 kilograms to grams

f. 0.25 seconds to milliseconds

Solve the problems by filling in

Bell Work, **Thursday,** Jan 24

How many milligrams is 1.20 grams?

Big unit →small unit, or small unit to big unit?

1.20 g → ? mg ***B → S = BIG #***

1.20g

How many g= how many mg? **1000 mg = 1 g**

$$\frac{\text{Given}}{\text{B} \rightarrow \text{S= B}} \times \frac{\text{Relationship (1000mg = 1 g)}}{} = \text{1200 mg}$$

1000

Practice

1. 0.25 g is equivalent to

a. 250 kg. c. 0.025 mg.

b. 250 mg. d. 0.025 kg.

2. 1.06 L of water is equivalent to

a. 0.001 06 mL. c. 106 mL.

b. 10.6 mL. d. 1060 mL.

3. The number of grams equal to 0.5 kg is

a. 0.0005. c. 500.

b. 0.005. d. 5000.

4. The number of significant figures in the measurement 0.000 305 kg is

a. 2. c. 6.

b. 3. d. 7.

5. The number of significant figures in the measured value 0.032 0 g is

a. 2. c. 4.

b. 3. d. 5.

b. B, d, c

Units of Length

- the basic unit of length, or linear measure, is the **meter (m)**.

- All measurements of length can be expressed in meters.

- For very large and very small lengths, however, it may be more convenient to use a unit of length that has a prefix.

Measurement

The table below lists the prefixes in common use.

Commonly Used Metric Prefixes

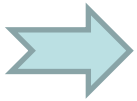
Prefix	Symbol	Meaning	Equals 1 meter
mega	M	1 million times larger than the unit it precedes	M÷10^6
kilo	**k**	**1000 times larger than the unit it precedes**	**k÷1000**
deci	**d**	**10 times smaller than the unit it precedes**	**d x 10**
centi	**c**	**100 times smaller than the unit it precedes**	**c x 100**
milli	**m**	**1000 times smaller than the unit it precedes**	**m x 1000**
micro	**μ**	**1 million times smaller than the unit it precedes**	**μ x 10^6**
nano	n	1 billion times smaller than the unit it precedes	n x 10^9

10^6 = 1 million, 10^9 = 1 billion

Prefixes

Prefix	Symbol	Factor of Base Unit	
giga-	G	1 000 000 000	base units = 1 giga-
mega-	M	1 000 000	base units = 1 mega-
kilo-	k	1000	base units = 1 kilo
hecto-	h	100	base units = 1 hecto
deka-	da	10	base units = 1 deka-
Base unit: meter (m), gram (g)*, liter (L*)			***NOTE: BASE UNITS ARE NOT PREFIXES***
deci-	d	0.1	10 d = base unit
centi-	c	0.01	100 c = base unit
milli-	m	0.001	1000 m = base unit
micro-	μ	0.000 001	1,000,000 μ = base unit
nano-	n	0.000 000 001	1,000,000,000 n = base unit
pico-	p	0.000 000 000 001	1,000,000,000,000 p = base un

* not SI units



Examples of using metric prefixes

- **The chart says centi** is **100 times smaller than the unit it precedes**
- **Thus if we write "centimeter" "centi" comes before (precedes) "meters"**
- **Centimeter means 100 times smaller than a meter or**

a centimeter is $^{1}/_{100}$ meter.

What is the bigger unit: centimeter or meter?

100 cm = 1 meter

or 1cm = 1/100 m

Examples of using metric prefixes

- **The chart says milli** is **1000 times smaller than the unit it precedes**
- **Thus if we write "millimeter" "milli" comes before (precedes) "meters"**
- **millimeter means 1000 times smaller than a meter or**

a milliimeter is $^{1}/_{1000}$ meter.

What is the bigger unit: millimeter or meter?

1000 mm = 1 meter

or 1mm = 1/1000 m

Examples of using metric prefixes

- **The chart says kilo** is **1000 times larger than the unit it precedes**
- **Thus if we write "kilometer" "kilo" comes before (precedes) "meters"**
- **kilometer means 1000 times larger than a meter or a kilometer is 1000 meters.**

What is the bigger unit: kilometer or meter?

1000 meter (m) = 1 kilometer (km)

Units of Volume

Volume is the amount of space occupied by an object.

The relationships among common metric units of volume are shown in the table below.

Metric Units of Volume

Unit	Symbol	Relationship	Example
Liter	**L**	**base unit**	**quart of milk ≈ 1 L**
Milliliter	**mL**	**10^3 mL = 1 L**	**20 drops of water ≈ 1 mL**
Cubic centimeter	**cm3**	**1 cm3 = 1 mL**	**cube of sugar ≈ 1 cm3**
Microliter	μL	10^3 μL = 1 L	crystal of table salt ≈ 1 μL

Units of Volume

These figures give you some idea of the relative sizes of a liter and a milliliter.

1 mL

1 L

Units of Volume

- there are 1000 mL in 1 L.
- **1 milliliter (mL) and 1 cubic centimeter (cm^3) are the same volume.**
- The units milliliter and cubic centimeter are thus used interchangeably.
- **1 mL = 1 cm^3**

Units of Mass

The relationships among units of mass are shown in the table below.

Metric Units of Mass			
Unit	**Symbol**	**Relationship**	**Example**
Kilogram	**kg**	**1 kg = 1000 g**	**small textbook ≈ 1 kg**
Gram	**g**	**1 g = 0.001 kg**	**dollar bill ≈ 1 g**
Milligram	**mg**	**1000 mg = 1 g**	**ten grains of salt ≈ 1 mg**
Microgram	μg	10^6 μg = 1 g	particle of baking powder ≈ 1 μg

Units of measure

In this class, the following are the base units

Length

meter (m)

Mass

gram (g)

Volume

liter (L)

Time

second (s)

Identify the SI unit that would be most appropriate for expressing the length of the following.

1. width of a gymnasium
2. length of a finger
3. distance between Algiers & Texas
4. Thickness of a nickel
5. length of a bacterial cell

km m cm mm µm

kg g mg µg mL µL

kL

L

Identify the SI unit that would be most appropriate for measuring the mass of each of the following objects.

6. car
7. coin

h. a human cell

Identify the SI unit for volume most appropriate

8. Measuring the volume of liquid in a cell
9. Measuring the amount of water in a swimming pool
10. Measuring the volume of a 5 drops of water

Identify the SI unit that would be most appropriate for expressing the length of the following.

1. width of a gymnasium **m**
2. length of a finger **cm**
3. distance between Algiers & Texas **km**
4. Thickness of a nickel **mm**
5. length of a bacterial cell **µm**

Identify the SI unit that would be most appropriate for measuring the mass of each of the following objects.

6. car **kg**
7. coin **g**

h. a human cell **µg**

Identify the SI unit for volume most appropriate

8. Measuring the volume of liquid in a cell **µL**
9. Measuring the amount of water in a swimming pool **kL**
10. Measuring the volume of a 5 drops of water **mL**

Match each metric unit with the best estimate of its length or distance

1. Height of a stove top above the floor

2. Thickness of about 10 sheets of paper

3. Distance from school to Barataria Blvd

4. Width of a key on a computer keyboard

a. 1 km

b. 1 m

c. 1 cm

d. 1 mm

Match each unit with the object who would be closest to that unit.

1. Interior of an oven
2. A box of cookies
3. One-quarter teaspoon

Unit of Volume

a. 1 L (liter)

b. 1 m^3 (cubic meter)

c. 1 mL (milliliter)

Mass

4. A few grains of sand

5. two pounds of shrimp

6. Five aspirin tablets

Unit of Mass

a. 1 kilogram (kg)

b. 1 gram (g)

c. 1 milligram (mg)

7. Which of these is the smallest?

a. one liter

b. one microliter

c. one milliliter

Units of Measurement		
Quantity	**Base Unit**	**Symbol**
Length		
Mass		
Time		
volume		

Accuracy and Precision

Which ruler is more precise?

A. Ruler 1

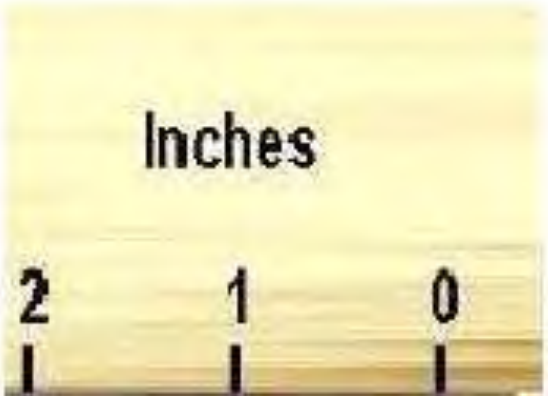
B. Ruler 2

Why?

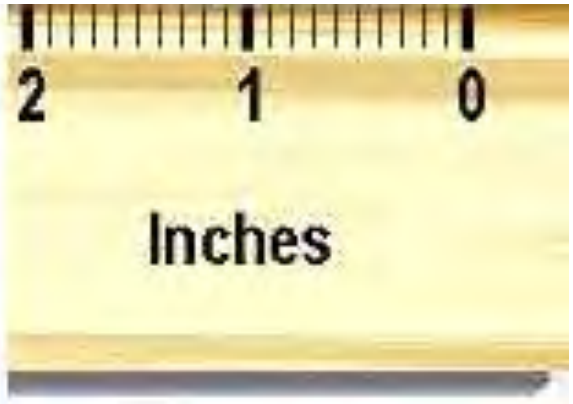
C. Not enough info

Ruler two has lines for whole number inches (1,2, etc) and lines for 1/10 inches (0.1, 0.2, 0.3, etc).

Which ruler is more accurate & precise?



Ruler 1

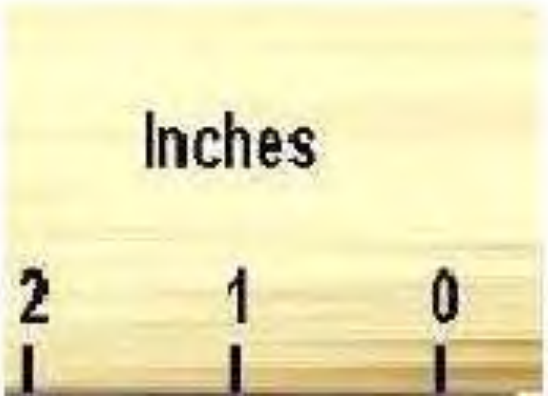


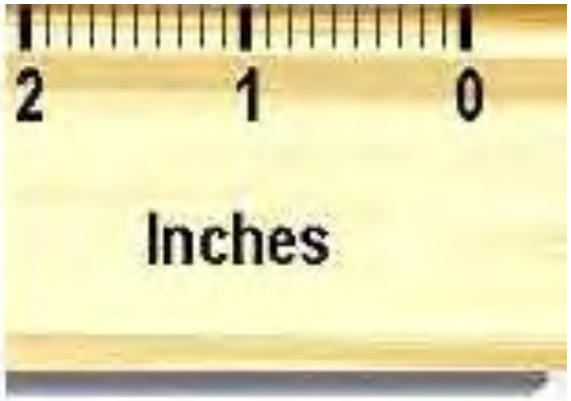
Ruler 2

If you determine the area of a rectangle by measuring the length with the ruler 1 and the width with ruler 2:

- **Which ruler would be the source of the most uncertainty and error?**
- **Would making all measurements be more accurate if only ruler 2 was used? Why?**

Which ruler is more accurate & precise?





Ruler 1 **Ruler 2**

If you determine the area of a rectangle by measuring the length with the ruler 1 and the width with ruler 2:

- **Which ruler would be the source of the most uncertainty and error?** **Ruler 1 Why?** **Less lines**
- **Would making all measurements be more *accurate* if only ruler 2 was used? Why?**

Yes, ruler 2 has more lines to mark the 1/10 (0.1) inches

Accuracy & Precision

- **Accuracy** *refers to the closeness of measurements to the correct or accepted value of the quantity measured.*
- **Precision *refers to the closeness of a set of measurements***
- *Precision is the ability reproduce a measurement.*
- *Example: Being able to measure 1.5 kilograms of sugar every time we measure.*
- *We measure the sugar five times and we get: 1.50kg, 1.51kg, 1.50kg, 1.49kg, 1.51kg*
  - *Average = 1.50kg+1.51kg+1.50kg+1.49kg+1.51kg/***5**
- *= 1.502*
- ***Report answers with the same number of decimals that the measurements have.***

Two decimal places,1.502kg = 1.50kg

(a)

Darts within small area
= High precision

Area covered on bull's-eye
= High accuracy

(b)

Darts within small area
= High precision

Area far from bull's-eye
= Low accuracy

(c)

Darts within large area
= Low precision

Area far from bull's-eye
= Low accuracy

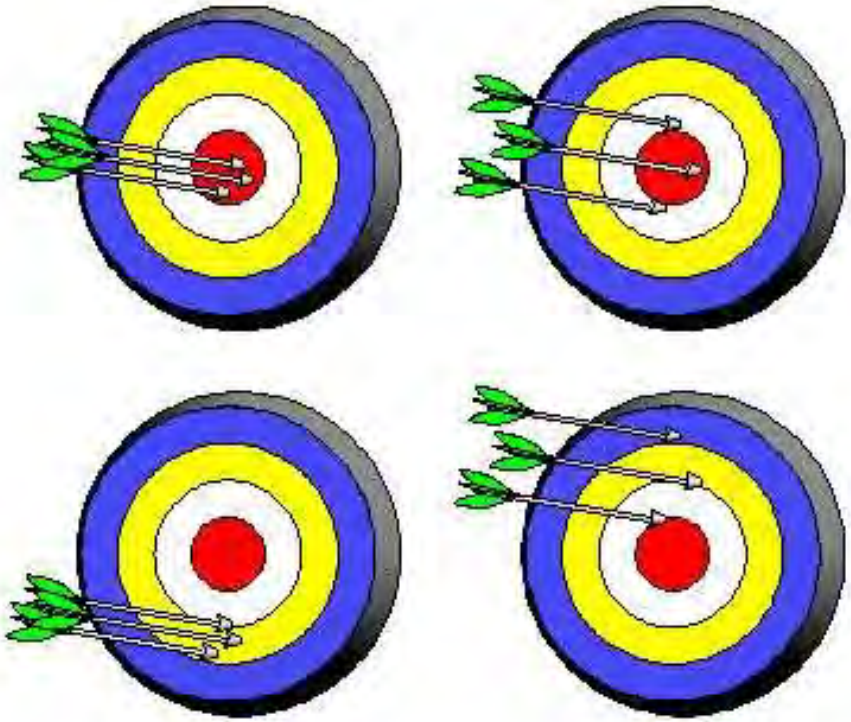
(d)

Darts within large area
= Low precision

Area centered around bull's-eye

Acceptable accuracy (on average)

Precision vs. Accuracy



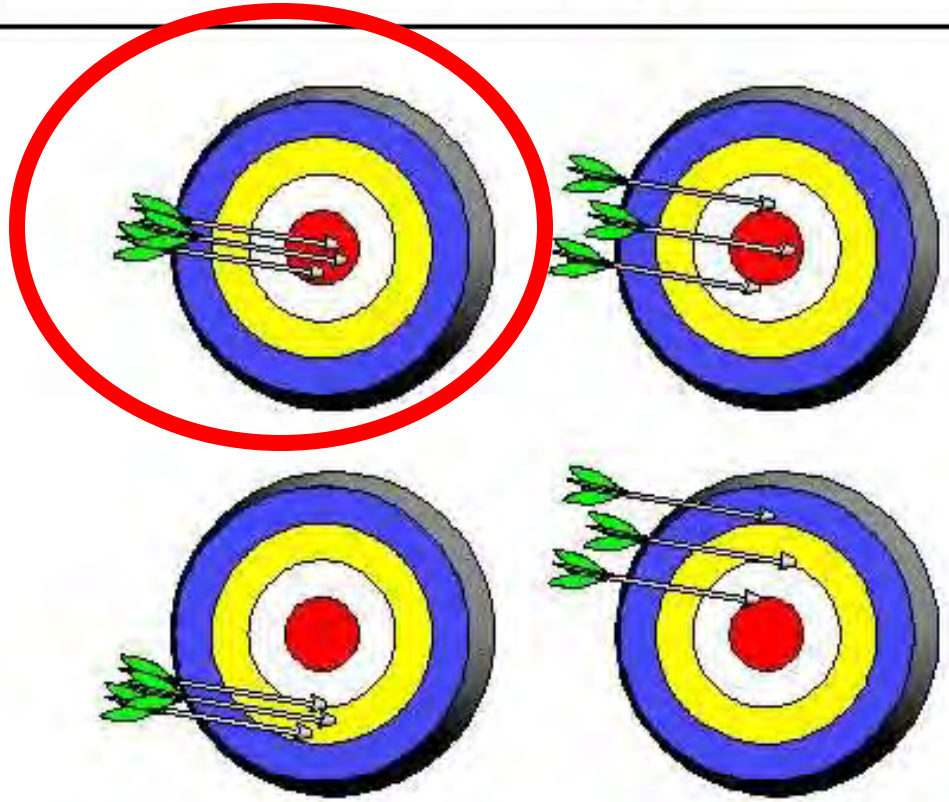
A. Good precision & good accuracy.

B. Poor precision & good accuracy

C. Good precision & poor accuracy

D. Poor precision & poor accuracy

Precision vs. Accuracy



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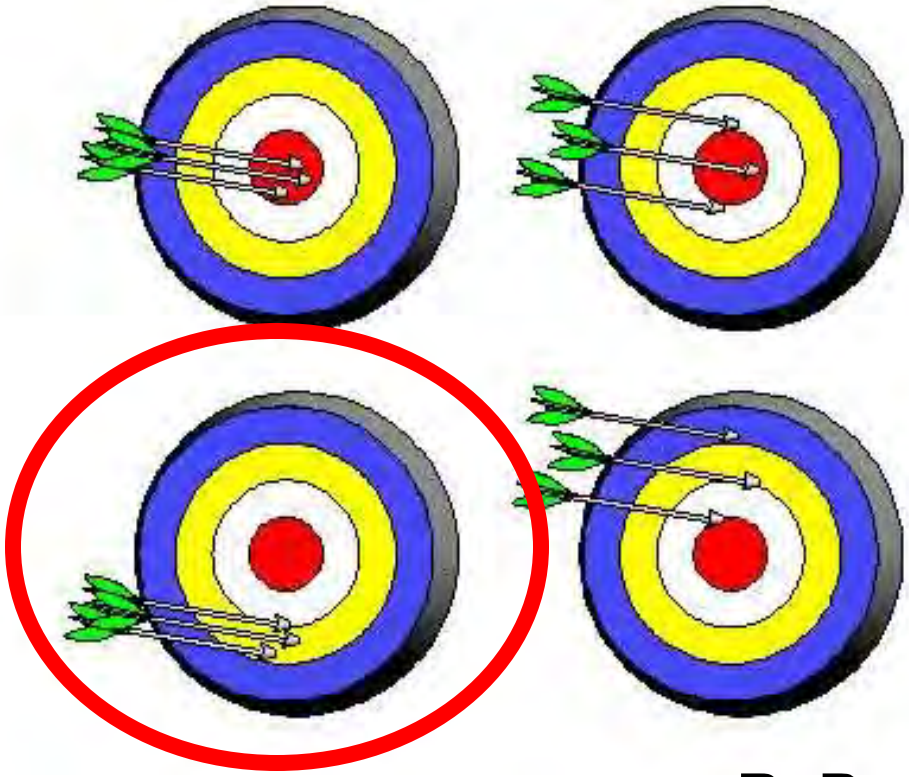
Precision vs. Accuracy



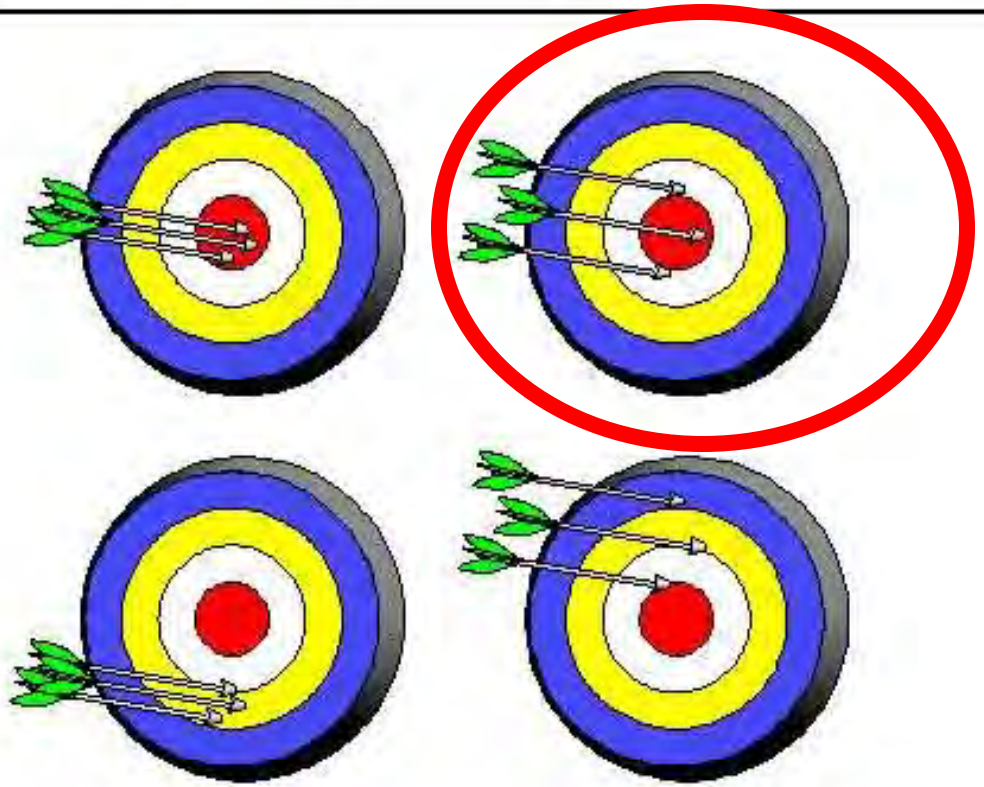
A. Good precision & good accuracy.

B. Poor precision & good accuracy

C. Good precision & poor accuracy

D. Poor precision & poor accuracy

Precision vs. Accuracy



A. Good precision & good accuracy.

B. Poor precision & good accuracy

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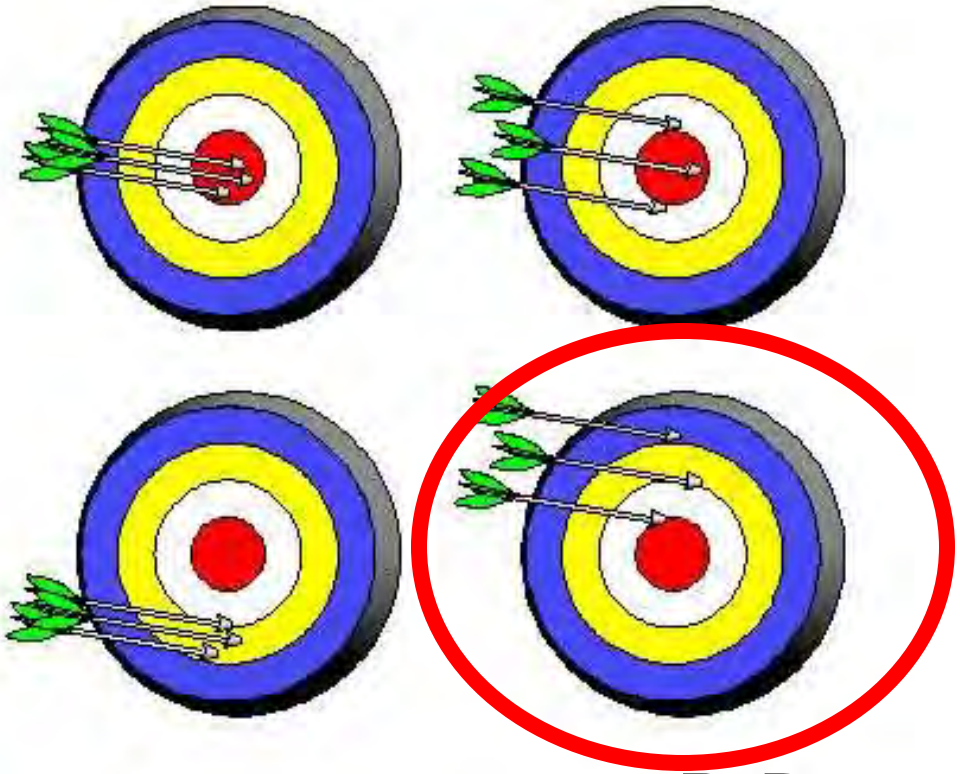
Precision vs. Accuracy



A. Good precision & good accuracy.

B. Poor precision & good accuracy

C. Good precision & poor accuracy

D. Poor precision & poor accuracy

Precision & Accuracy

Using a balance, a chemist obtained the values 5.224 g, 5.225 g, and 5.230 g for the mass of a sample. These measurements have:

a. good precision.
b. good accuracy.
c. poor precision.
d. poor accuracy.

- Good precision. The measurements are within 2% of each other.
- Cannot tell about the accuracy because the true value is not known.

Mass Data of Sample

	Trial 1	Trial 2	Trial 3	Trial 4	
Student A	1.43 g	1.52 g	1.47 g	1.42 g	Range 10
Student B	1.43 g	1.40 g	1.46 g	1.44 g	Range 3
Student C	1.54 g	1.56 g	1.58 g	1.50 g	Range 8
Student D	0.86 g	1.24 g	1.52 g	1.42 g	Range 36

Four students each measured the mass of one 1.43 g sample four times. The results in the table above indicate that the data collected by _____ reflect the greatest accuracy and precision.

a. Student A

b. Student B

c. Student C

d. Student D

Student B

Measurements

- Scientists all over the world have agreed on a single measurement system.

- It is called the *Le Système International d'Unités*, abbreviated **SI**

SI Base Units

Quantity	Quantity symbol	Unit name	Unit abbreviation
Length	*l*	meter	m
Mass	*m*	kilogram	kg
Time	*t*	second	s
Amount of substance	*n*	mole	mol

Units of measure

In this class, the following are the base units

Length

meter (m)

Mass

gram (g)

Volume

liter (L)

Time

second (s)

Prefixes

Prefix	Symbol	Factor of Base Unit	
giga-	G	1 000 000 000	base units = 1 giga-
mega-	M	1 000 000	base units = 1 mega-
kilo-	k	1000	base units = 1 kilo
hecto-	h	100	base units = 1 hecto
deka-	da	10	base units = 1 deka-
Base unit: meter (m), gram (g)*, liter (L*)			***NOTE: BASE UNITS ARE NOT PREFIXES***
deci-	d	0.1	10 d = base unit
centi-	c	0.01	100 c = base unit
milli-	m	0.001	1000 m = base unit
micro-	μ	0.000 001	1,000,000 μ = base unit
nano-	n	0.000 000 001	1,000,000,000 n = base unit
pico-	p	0.000 000 000 001	1,000,000,000,000 p = base unit

* not SI units

Identify the SI unit that would be most appropriate for expressing the length of the following.

- a. width of a gymnasium **m**
- b. length of a finger **cm**

c. distance between Algiers & Texas **km**

d. Thickness of a nickel **mm**

e. length of a bacterial cell **µm**

Identify the SI unit that would be most appropriate for measuring the mass of each of the following objects.

a. car **kg**

b. coin **g**

c. a human cell **µg**

Identify the SI unit for volume most appropriate

a. Measuring the volume of liquid in a cell **µL**

b. Measuring the amount of water in a swimming pool **kL**

c. Measuring the volume of a 5 drops of water **mL**

Accuracy & Precision

- **Accuracy** *refers to the closeness of measurements to the correct or accepted value of the quantity measured*.

- Precision *refers to the closeness of a set of measurements*
- *Precision is the ability reproduce a measurement.*
- *Example: Being able to measure 1.5 kilograms of sugar every time we measure.*
- *1.50, 1.51, 1.50, 1.49, 1.51*
  - *Mean = 1.502*
  - *Using significant figures we round of to:* **1.50**

(a)

Darts within small area
= High precision

Area covered on bull's-eye
= High accuracy

(b)

Darts within small area
= High precision

Area far from bull's-eye
= Low accuracy

(c)

Darts within large area
= Low precision

Area far from bull's-eye
= Low accuracy

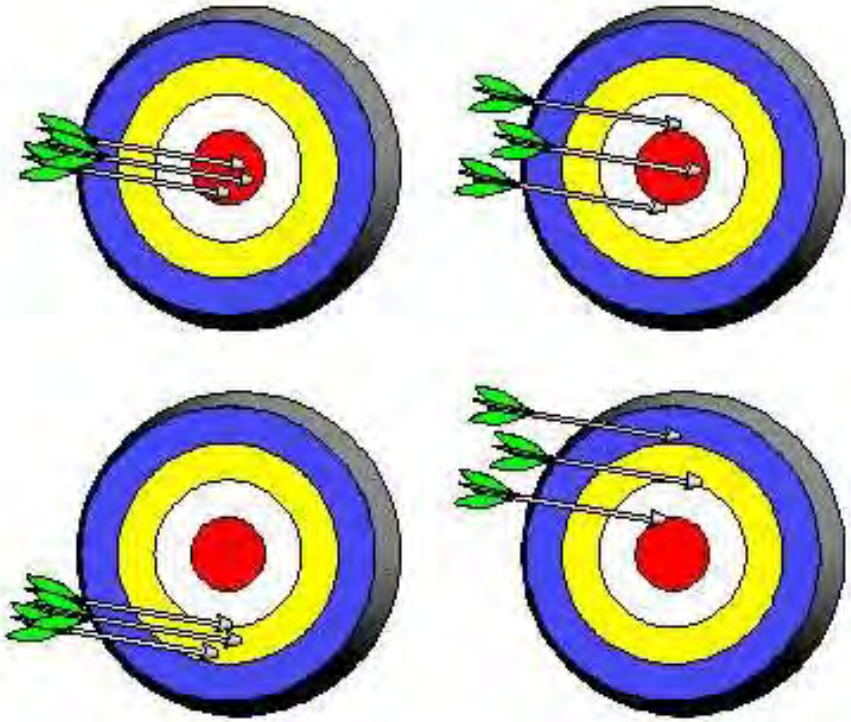
(d)

Darts within large area
= Low precision

Area centered around bull's-eye

Acceptable accuracy (on average)

Precision vs. Accuracy



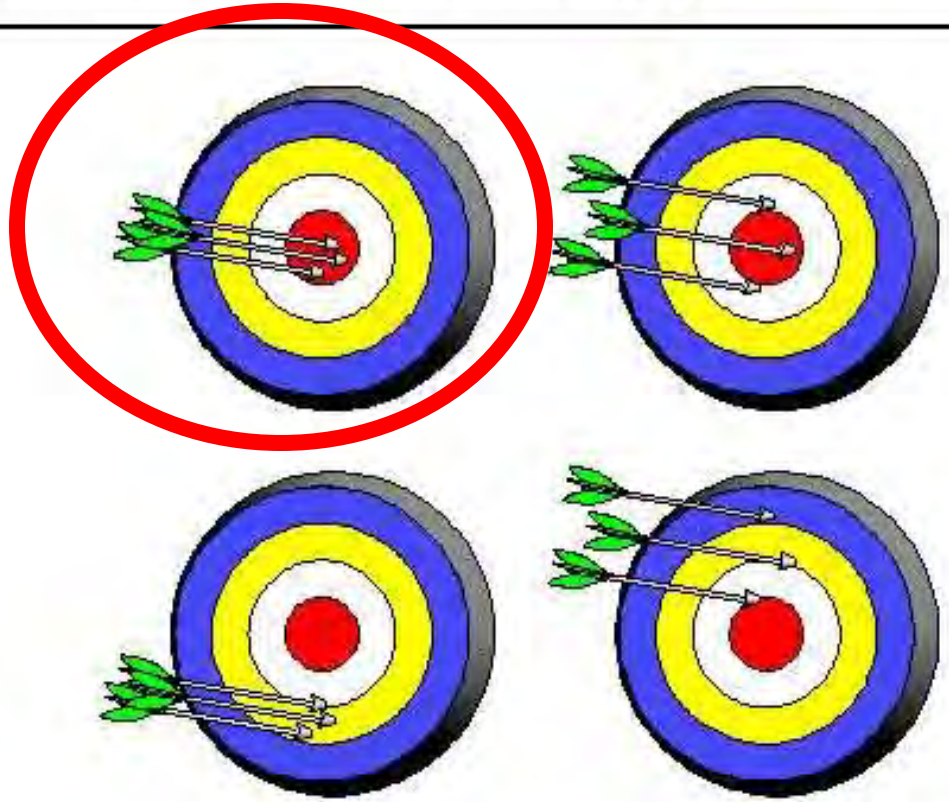
A. Good precision & good accuracy.

B. Poor precision & good accuracy

C. Good precision & poor accuracy

D. Poor precision & poor accuracy

Precision vs. Accuracy



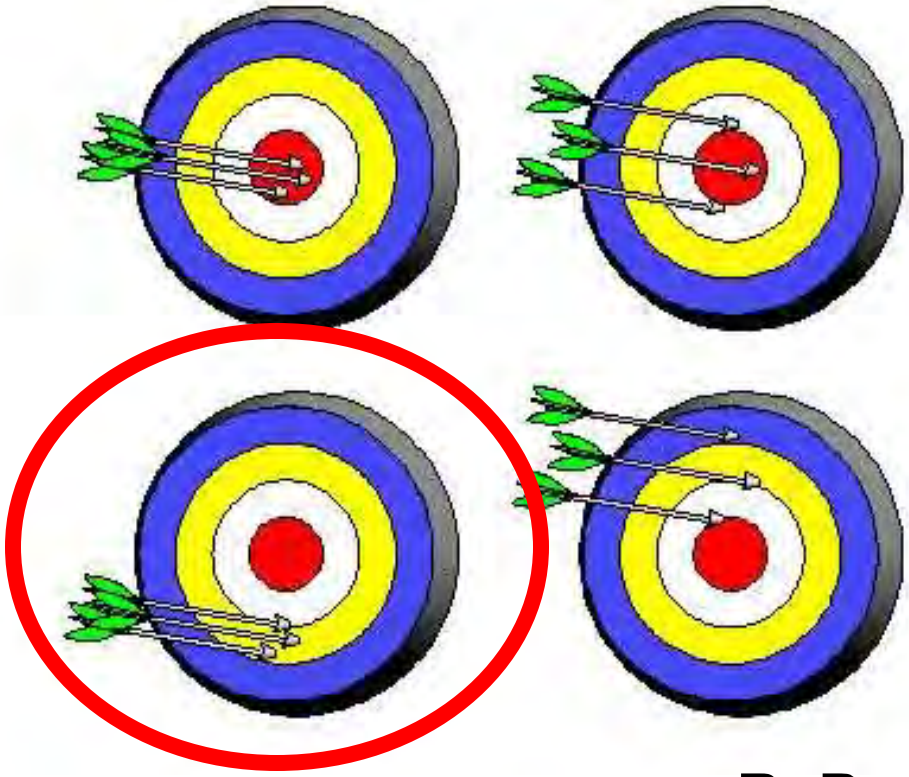
A. Good precision & good accuracy.

B. Poor precision & good accuracy

C. Good precision & poor accuracy

D. Poor precision & poor accuracy

Precision vs. Accuracy



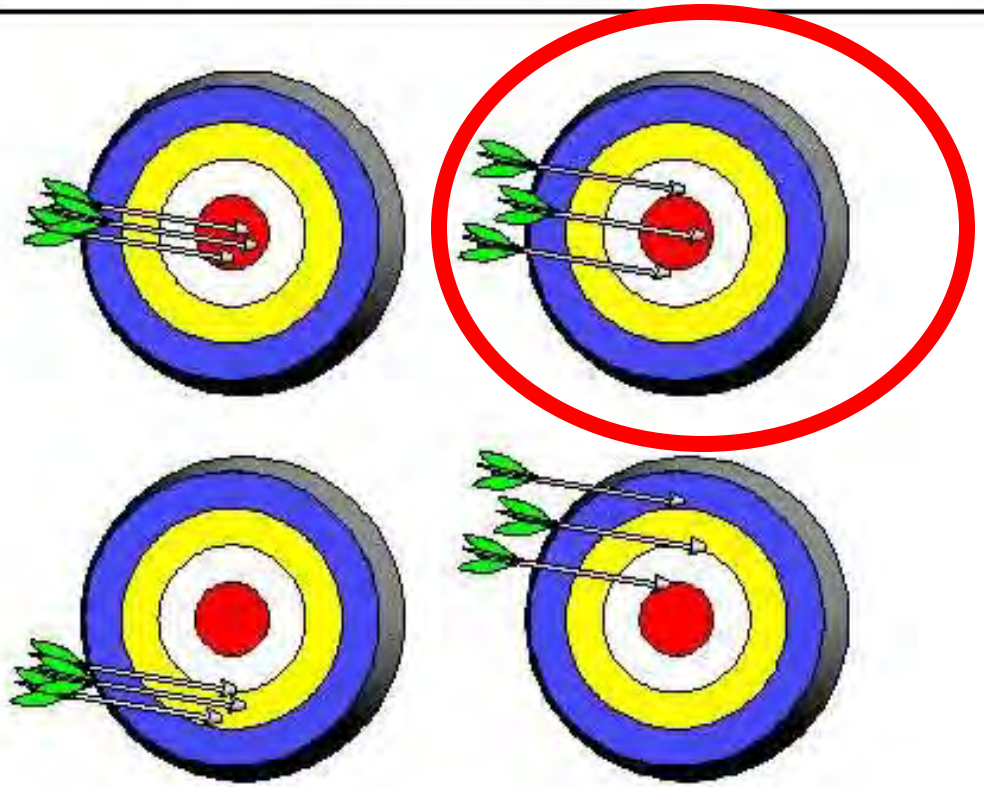
A. Good precision & good accuracy.

B. Poor precision & good accuracy

C. Good precision & poor accuracy

D. Poor precision & poor accuracy

Precision vs. Accuracy



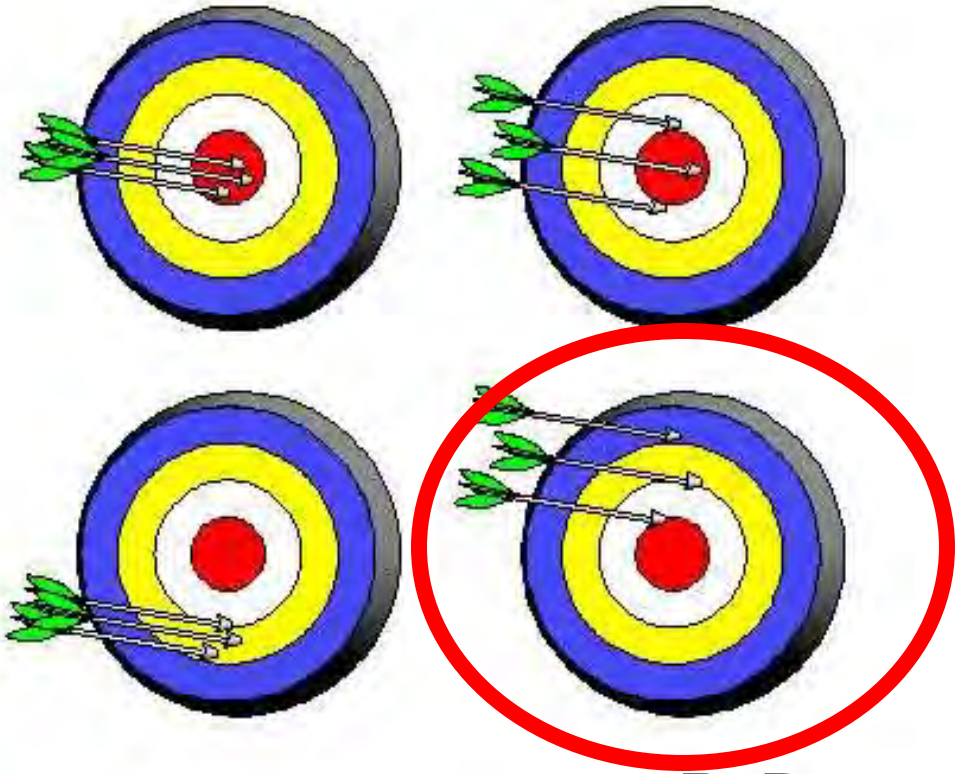
A. Good precision & good accuracy.

B. Poor precision & good accuracy

C. Good precision & poor accuracy

D. Poor precision & poor accuracy

Precision vs. Accuracy



A. Good precision & good accuracy.

B. Poor precision & good accuracy

C. Good precision & poor accuracy

D. Poor precision & poor accuracy

Precision & Accuracy

Using a balance, a chemist obtained the values 5.224 g, 5.225 g, and 5.230 g for the mass of a sample. These measurements have:

a. good precision.
b. good accuracy.
c. poor precision.
d. poor accuracy.

- Good precision. The measurements are within 2% of each other.
- Cannot tell about the accuracy because the true value is not known.

Mass Data of Sample

	Trial 1	Trial 2	Trial 3	Trial 4	
Student A	1.43 g	1.52 g	1.47 g	1.42 g	Range 10
Student B	1.43 g	1.40 g	1.46 g	1.44 g	Range 3
Student C	1.54 g	1.56 g	1.58 g	1.50 g	Range 8
Student D	0.86 g	1.24 g	1.52 g	1.42 g	Range 36

Four students each measured the mass of one 1.43 g sample four times. The results in the table above indicate that the data collected by _____ reflect the greatest accuracy and precision.

a. Student A

b. Student B

c. Student C

d. Student D

Student B

Which ruler is more precise?

A. Ruler 1

B. Ruler 2

C. Not enough info

Precision And Uncertainty Of Measurements

We Estimate:1.4 inches

One figure we know for sure, one figure is guess.

Two significant figures.

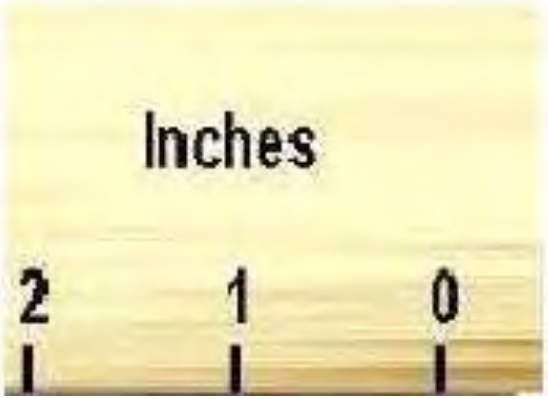
1.45 inches

two figure we know for sure, one figure is guess.

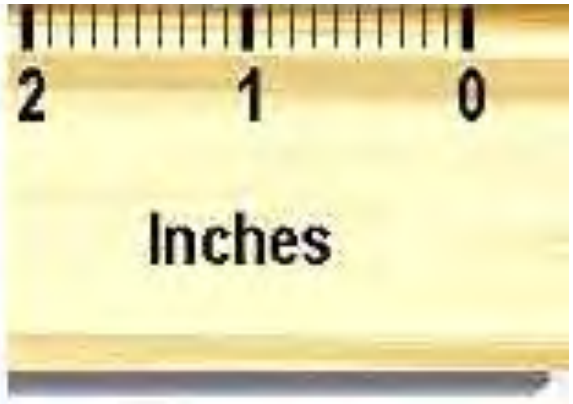
Three significant figures.

The greater the significant figures, the greater the precision (the ability to reproduce measurements).

Which ruler is more accurate & precise?



Ruler 1



Ruler 2

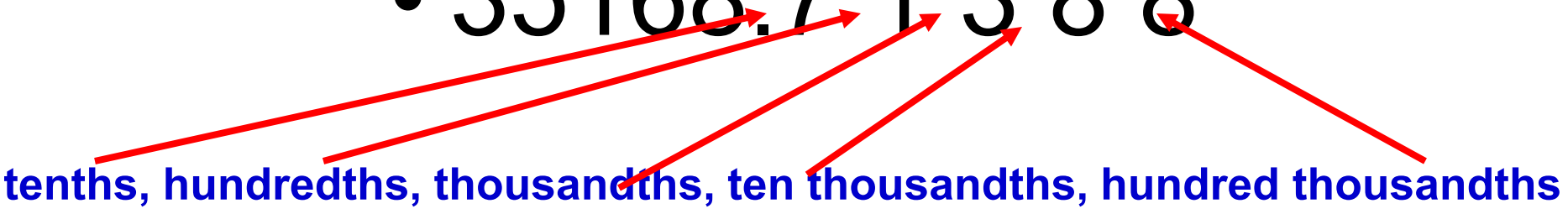
If you determine the area of a rectangle by measuring the length with the ruler 1 and the width with ruler 2:

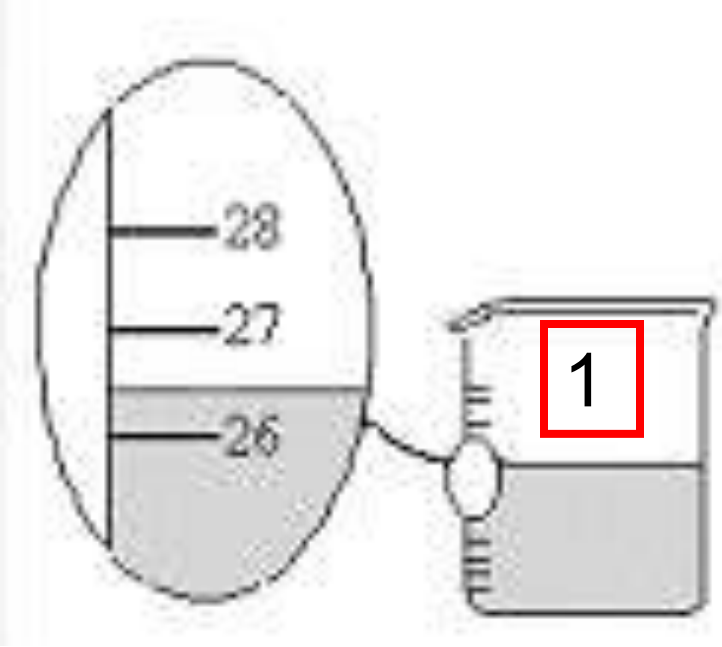
- **Which ruler would be the source of the most uncertainty and error?**
- **Would making all measurements be more accurate if only ruler 2 was used? Why?**

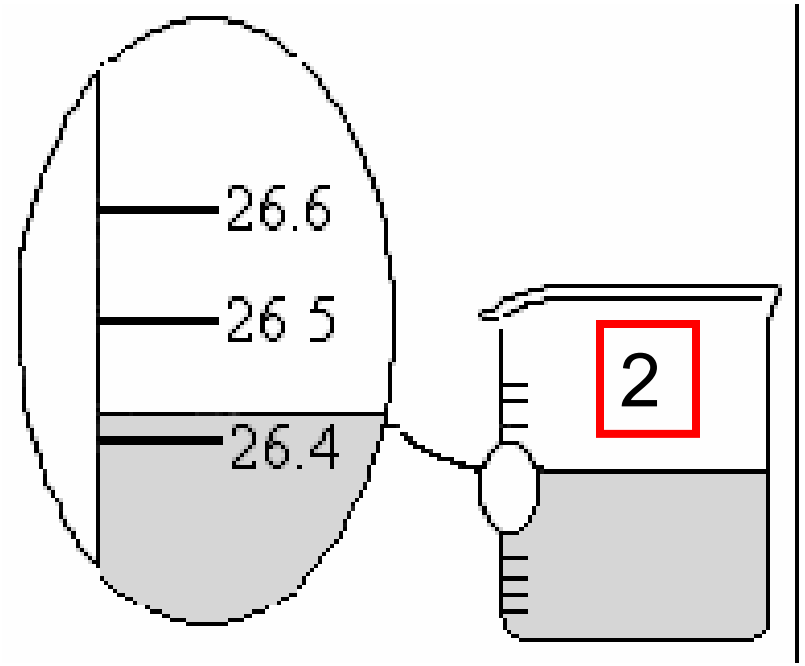
Check This

- Volume of the table top is, in centimeters
  182.55 x 75.55 x 2.55 = **35168.71388 cm^3**
- If all these figures are significant that means the last 8 was estimated and all the other decimal digits appear on the ruler:

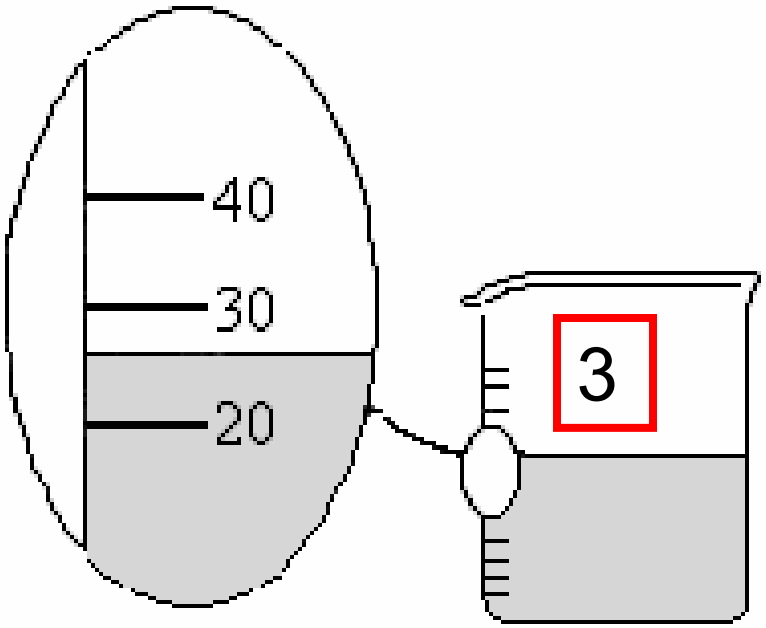
• 35168.7 1 3 8 8



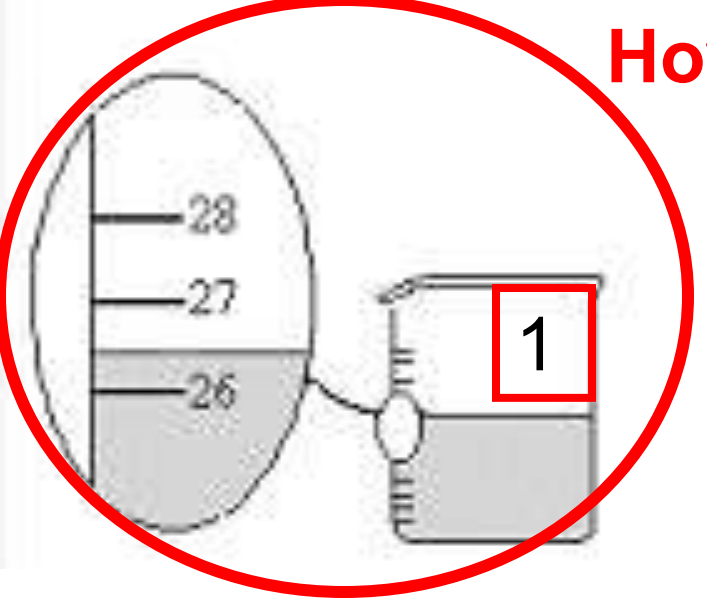


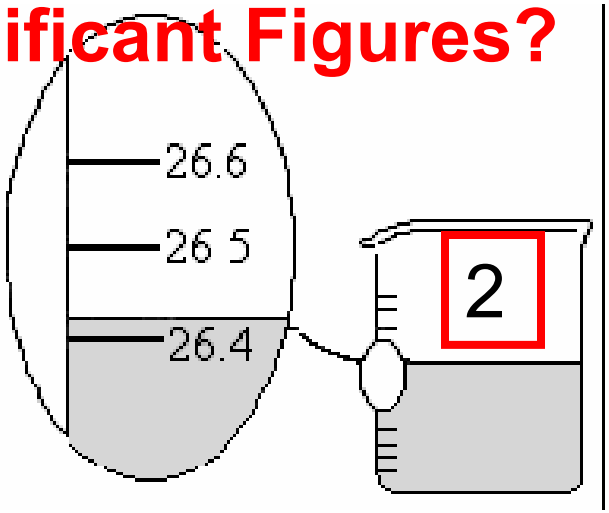


Which is the most precise?



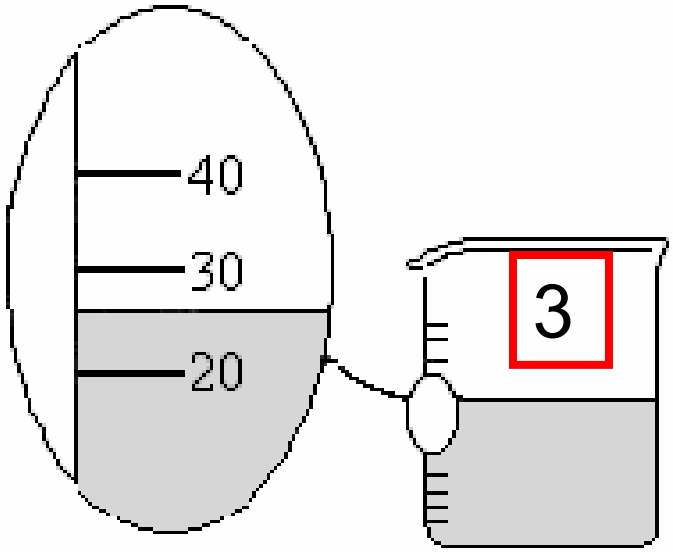
How Many Significant Figures?



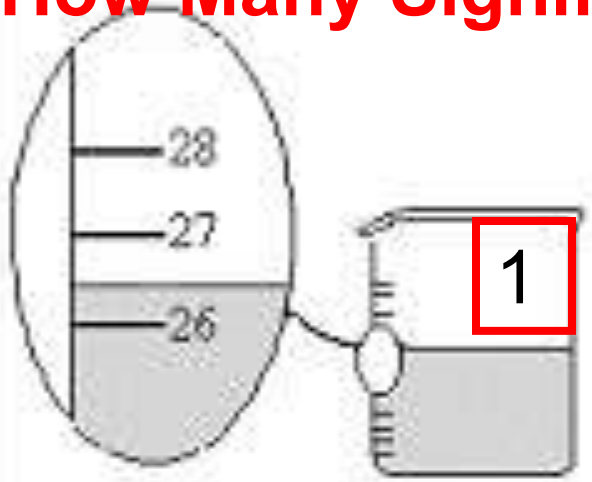


26.4 mL ± 0.1 mL

3 sig. fig.s

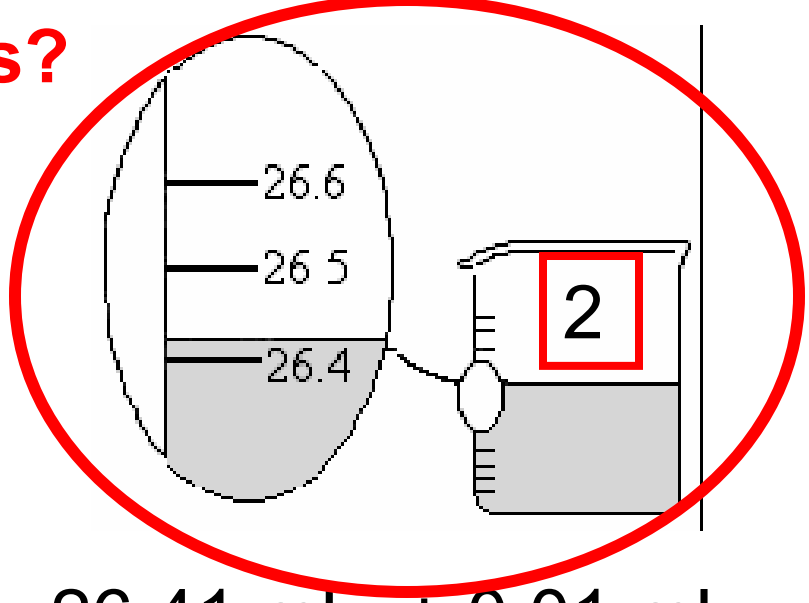


How Many Significant Figures?



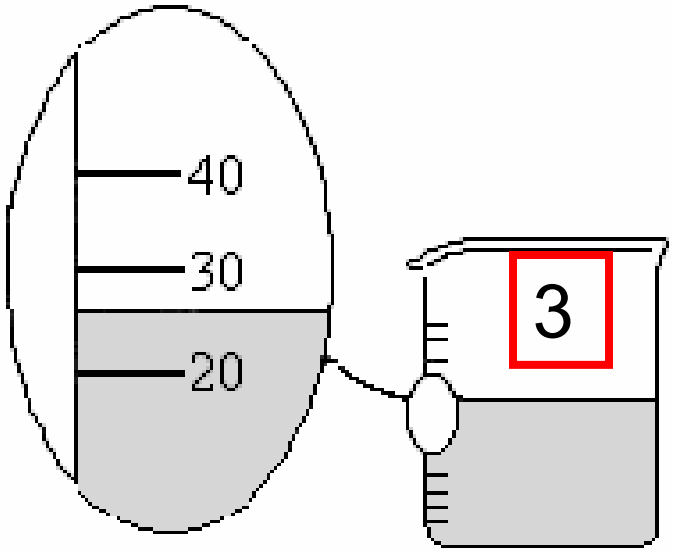
26.4 mL ± 0.1 mL

3 sig. fig.s

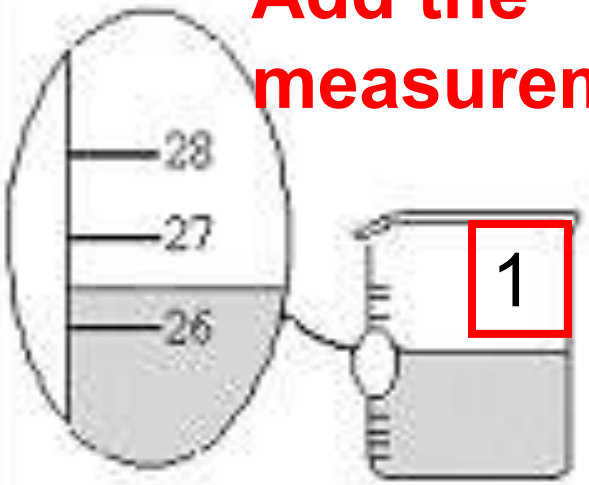


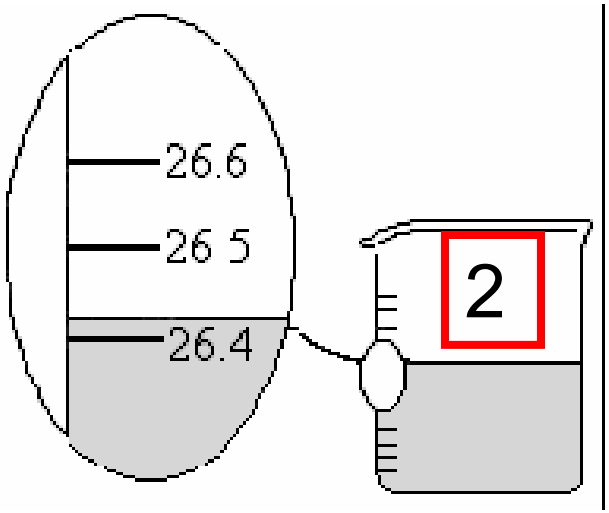
26.41 mL ± 0.01 mL

4 sig. fig.s



Add the measurements:





26.4 mL ± 0.1 mL

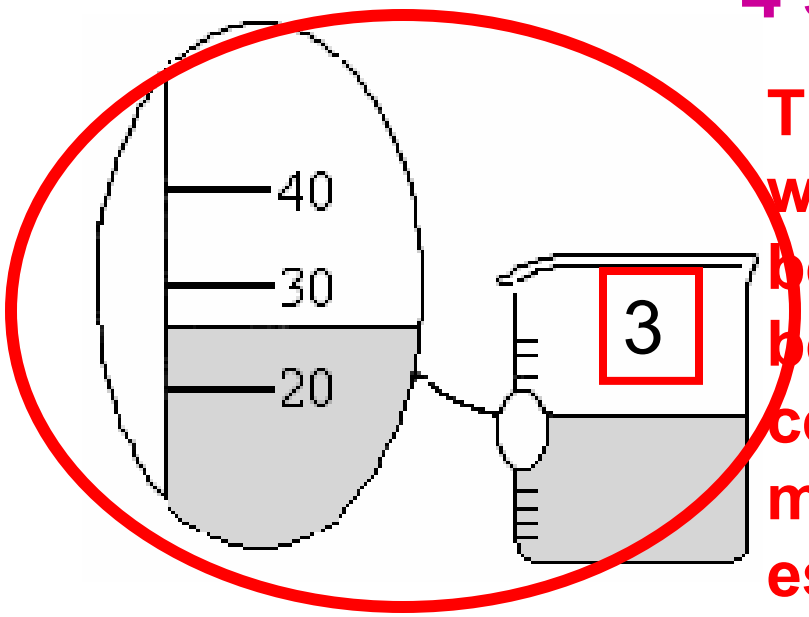
3 sig. fig.s

26.41 mL ± 0.01 mL

4 sig. fig.s

26 mL ± 1 mL

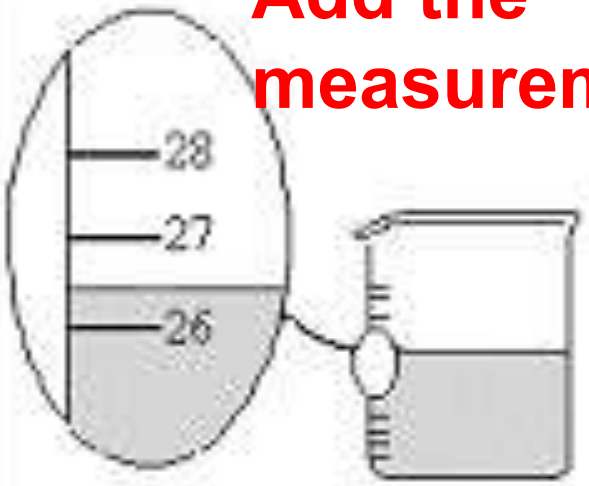
2 sig. fig.s

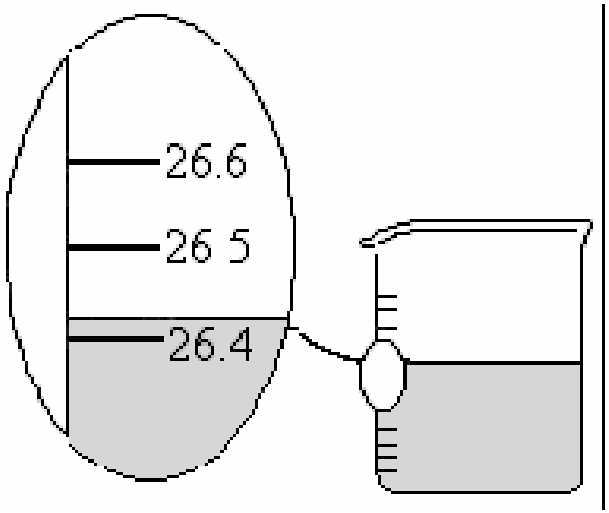


The measurement will read 79 ml because this beaker only is certain in 10s of mL & we are estimating 1-9 mL

26.4 + 26.41 + 26 = 78.81 mL

Add the measurements:



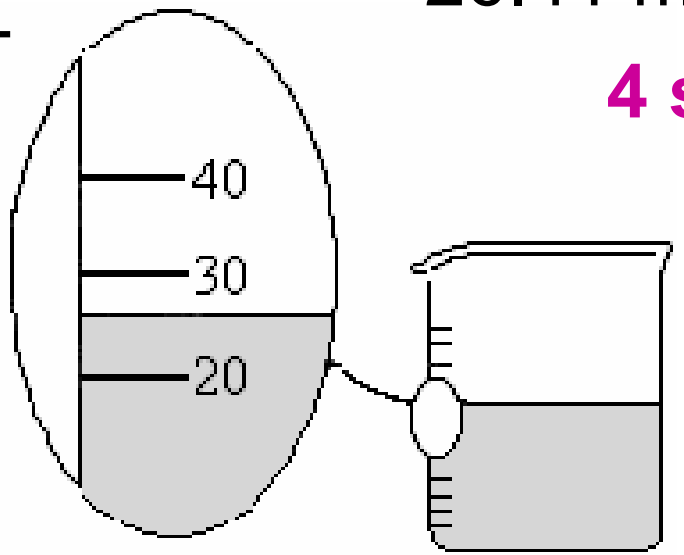


26.4 mL ± 0.1 mL

3 sig. fig.s

26.41 mL ± 0.01 mL

4 sig. fig.s



26 mL ± 1 mL

3 sig. fig.s

The answer must reflect the least precise measurement

26.4 + 26.41 + 26 = 78.81 mL = 79 mL

No decimal places

Scientific Notation

Avogadro's Constant =

602,200,000,000,000,000,000,000

Easier to write:

6.022×10^{23}

Mass of an electron

0.000000000000000000000000000009109 g

9.109×10^{-23} g

Scientific Notation

In **scientific notation,** *numbers are written in the form*

M x 10^n where M = the factor an n = the exponent

where the factor M *is a number greater than or equal to 1 but less than 10,*

and n *is a whole number.*

Which number is correct scientific notation

0.157000×10^4 g M is not a number >=1 < 10

15.7000×10^6 g M is a number > 10

1.57000×10^5 g ***M is a number greater than or equal to 1 but less than 10.***

WebAssign: 1.57000 e5 (e = x 10)

Write 157000 in scientific notation

- Place the decimal point at the right.
- **Move the decimal point so there is only one digit to the left of the decimal.**

157000.

- **Count the number of places you move the decimal point.**

1.57000

- **This count equals the power of ten.**
- **If you move the decimal point to the left, the exponent is positive.**
- **If you move the decimal to the right the exponent is negitive.**

1.57000×10^5 g

Expressing a number that is less than 1 in scientific notation

- **Example: 0.000 12 mm**
- Move the decimal point four places to the right so there is only one digit to the left of the decimal.
- **When you move the decimal point to the right, the power of ten is negative.**

$$0.000\,12\ \text{mm} = 1.2 \times 10^{-4}\ \text{mm}$$

Scientific Notation Summary

- **Scientific notation is especially useful when expressing large and small numbers**
- **The first digit in scientific notation is always a whole number between 1 – 9**
  - ❑ **$125000000.010 = 1.23010 \times 10^{8}$**
  - ❑ **$0.000000000120 = 1.20 \times 10^{-10}$**
- **All digits expressed in scientific notation are significant.**
- **Expressing numbers in scientific notation make it easy to determine significant figures**

Conversions

- If you convert 10¢ to dollars, will the number of dollars be a number bigger or smaller than 10?
  - Recall we started with 10¢
- 10¢ is less than a dollar so our number of dollars will a number smaller than 10 (10¢ ≠ $1)
- How do we get a smaller number?
  - Divide or multiply?
  - What is the relationship for $ and ¢? **100¢ =$1,**
- So we divide by $100
- 10¢ ÷ 100 = $0.1
- 0.1 < 10, our answer is less than our given (10¢).