A4

Determining Significant Figures

DEARBORN | SCIENCE LEARNING CENTER

After this module, you will be able to:

1. Report the result of a measurement with the correct number of significant figures

2. Distinguish between significant and non-significant zeros

3. Determine the appropriate number of significant figures in a calculation

Application To Real Life

How far do you live from the UM-Dearborn campus?

Which would be a reasonable answer?

- "15 miles"
- "15.3922 miles"

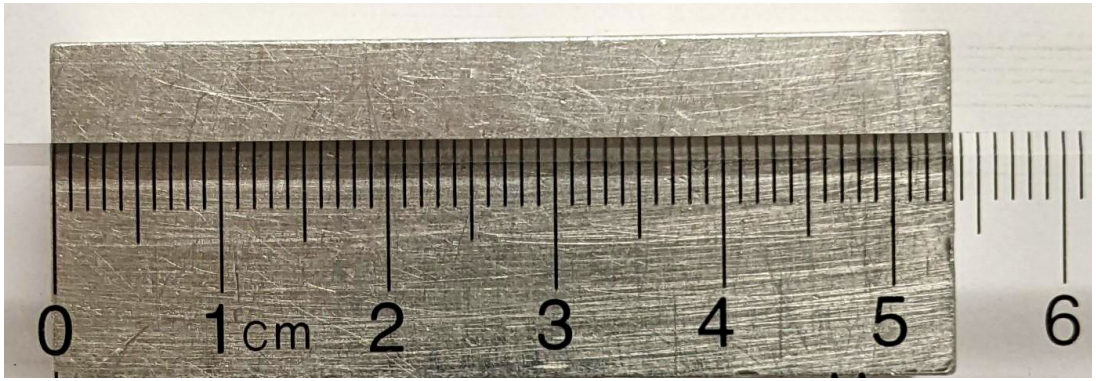
The number of **significant figures** reflects **how precisely** we know a number.

In scientific calculations, the number of digits should match our **uncertainty** level.

Note: "Significant figures" are also known as "sig figs" or "significant digits".

Measurements and Uncertainty

How long is this block?



5	cm?
5.3	cm?
5.35	cm?
5.354	cm?

We can usually estimate one digit beyond the smallest division. (Here, maybe 5.35 or 5.36 cm.)

The **uncertain** digit should be the **last** significant digit. Observers may disagree about the **last** number, but should agree about all others.

5.3**5** cm (3 sig figs) would be reasonable here.

Which Digits are Significant?

We need to know what counts as

"significant": All **nonzero** digits are significant.

Zeros are often, but not always, significant:

✓ Zeros appearing **between** significant digits are significant.

Examples	
40.7 3 significant figures	**87,009** 5 significant figures
200.1 4 significant figures	**102** 3 significant figures

Zeros as Significant Digits

- ✓ **Final** zeros **after the decimal point** are significant.
  - Writing 5.350 instead of 5.35 communicates that we know the value more precisely.

Examples	
40.7**0** 4 significant figures	87,009.**0** 6 significant figures
200.1**0** 5 significant figures	102.**0** 4 significant figures

Which Digits are NOT Significant?

✗ Placeholding zeros are **not** significant.

- Zeros before the first nonzero number
- Zeros after the last nonzero number, **if there is no decimal point**

Examples	
0.0470 3 significant figures	0.00470 3 significant figures
4700 2 significant figures	47000 2 significant figures
470. 3 significant figures	470.0 4 significant figures

Standard Exponential Notation

We can use **standard exponential notation** or **scientific notation** to avoid any ambiguity for a number like 45600

All digits in scientific notation are significant

Normal notation	Significant Figures	Scientific notation
45600.	5	**4.5600** x 10^4
45600	3	**4.56** x 10^4
0.0**45**	2	**4.5** x 10^{-2}

Summary: Rules for Zeros

- Zeros **between** two nonzero numbers are significant.

  The number **2.035** has *4 significant figures*
  The number **30007** has *5 significant figures*

- Zeros appearing **at the end of a number and to the right of a decimal point** indicate precision and are significant.

  The number **4.700** has *4 significant figures*

- Zeros appearing in front of nonzero numbers are just placeholders; they are **not** significant.

  The number **0.0567** has only *3 significant figures*

- If there is no decimal point, zeros appearing after the last nonzero number are just placeholders; they are **not** significant.

  The number **1200** has *2 significant figures*
  The number **1200.** has *4 significant figures*
  The number **1200.0** has *5 significant figures*

Practice Problem 1

How many significant figures are in each of the following numbers?

a) 1.234
b) 1.2340
c) 0.12
d) 120
e) 1234
f) 12340
g) 0.012340
h) 10234

Solutions at end of packet

Calculations

Ok, but how do we keep track of significant figures in calculations?

The result can only be as "precise as the least precise number". *You're only as strong as your weakest link!*

There are **different** rules:

for **addition & subtraction**

+ −

for **multiplication & division**

× ÷

Calculations: Addition and Subtraction

When **adding** or **subtracting:**

The "weakest link" is the number with the **fewest** digits **after the decimal.**

Your **final answer** should have the same number of digits **after the decimal**.

Example	
26.**46** + 4.123 30.**58**3	fewest is 2 places after decimal
Final answer: 30.**58**	round to 2 places after decimal

Calculations: Addition and Subtraction

For this rule, the decimal place is what matters:

Example
2.634 − 0.02 2.614
Final answer: 2.61

When subtracting the number 0.02, we count **two** places after the decimal, even though only one of the digits is significant.

We round our final answer to **two** places after the decimal.

Practice Problem 2

Complete the following arithmetic operations and express the answer with the **correct** number of significant figures:

a) $1.421 + 0.4372 =$

b) $0.0241 + 0.11 =$

c) $0.14 + 1.2243 =$

d) $760.0 + 0.011 =$

e) $1.0123 - 0.002 =$

f) $123.69 - 20.1 =$

g) $463.231 - 14.0 =$

h) $47.2 - 0.01 =$

Solutions at end of packet

Calculations: Multiplication and Division

When **multiplying** or **dividing**:

The "weakest link" is the number with the **fewest** significant digits **overall**

Your **final answer** should have the same number of significant digits **overall**.

Example	
2.61 × **1.2** = **3.1**32	2.61 ÷ **1.2** = **2.1**75
Round down to: **3.1**	Round up to: **2.2**

Note: For this rule, it doesn't matter where the decimal point is.

Practice Problem 3

Complete the following arithmetic operations and express the answer with the **correct** number of significant figures:

a) 42.3 x 2.61 =

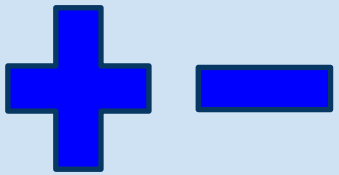
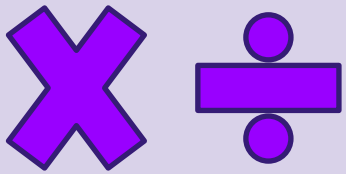
b) 0.61 x 42.1 =

c) 46.1 / 1.21 =

d) 23.2 / 4.1 =

Solutions at end of packet

Review of Rules for Calculations

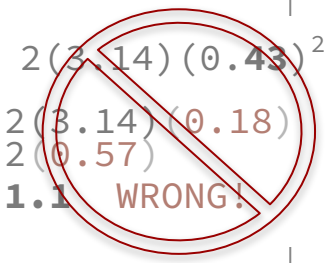
Addition / subtraction 	Determine which number in the calculation has the **fewest** digits **after the decimal**. Your result will have the same number of digits **after the decimal**.	234.**7** + 1.623 236.323 Result: 236.**3**
Multiplication / Division 	Determine which number in the calculation has the **fewest** significant figures **overall**. Your result will have the same number of significant figures **overall**.	**44.2** x 2.662 117.6604 Result: **118**

Other Important Information

Exact constants don't affect the number of sig figs in your answer

For **non-exact constants** use at least one extra significant figure

For a **series** of calculations, keep at least one extra sig fig, and only round your **final answer**.

Example
Find the total area of **two** circles with radius 0**.43** m **2** (πr^2) **2** is exact
π = 3.14159… Based on 0.43, we'll need 2 sig figs in our final answer, so use at least 3 sig figs for π
$2((3.14)(0.43)^2)$ $2((3.14)(0.1849))$ $2(0.5806)$ **1.1**612 
Final answer: **1.2** m^2

Practice Problem 1: Solution

How many significant figures are in each of the following numbers?

a) 1.234 = 4

b) 1.2340 = 5

c) 0.12 = 2

d) 120 = 2

e) 1234 = 4

f) 12340 = 4

g) 0.012340 = 5

h) 10234 = 5

Practice Problem 2: Solution

Complete the following arithmetic operations and express the answer with the **correct** number of significant figures:

a) 1.421+ 0.4372 = 1.858

b) 0.0241 + 0.11 = 0.13

c) 0.14 + 1.2243 = 1.36

d) 760.0 + 0.011 = 760.0

e) 1.0123 - 0.002 = 1.010

f) 123.69 - 20.1 = 103.6

g) 463.231 - 14.0 = 449.2

h) 47.2 - 0.01 = 47.2

Practice Problem 3: Solution

Complete the following arithmetic operations and express the answer with the **correct** number of significant figures:

a) 42.3 x 2.61 = 110.

b) 0.61 x 42.1 = 26

c) 46.1 / 1.21 = 38.1

d) 23.2 / 4.1 = 5.7

Take the Posttest!

You are now *finished* with this module. If you haven't already done the practice problems, we recommend you try them.

When you're done, obtain a *posttest* from the Science Learning Center personnel and complete it.

GOOD LUCK!