Introduction to Mechanics
Unit Conversion
Order of Magnitude

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De Anza College

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Last time

- symbols for scaling units
- measurement uncertainty and significant figures
- precision and trueness

Overview

- significant figures
- scientific notation
- unit conversions (non-SI units)
- order of magnitude

Significant Figures

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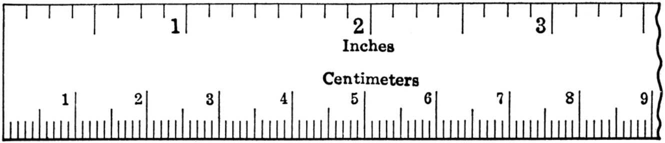
The number of digits in a value that are meaningful for representing the precision of a measurement.

Measurement Uncertainty and Significant Figures

All measuring devices are only so precise.

For example, a ruler has millimeter (mm) marks, but not micrometer (μm) marks.



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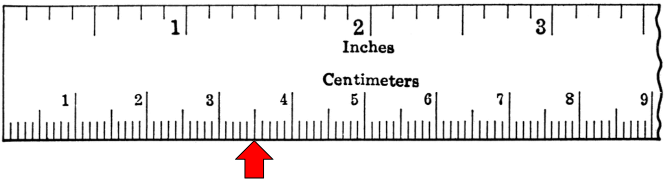

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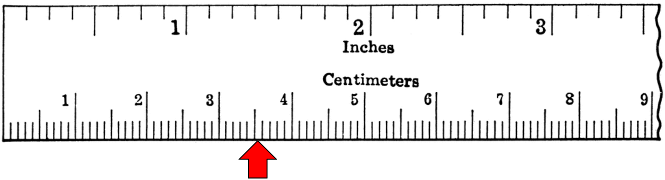

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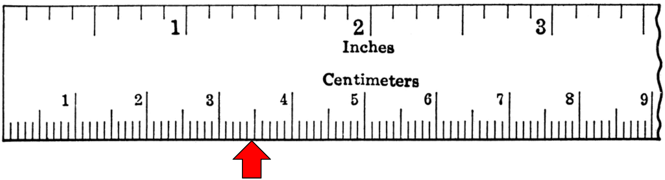

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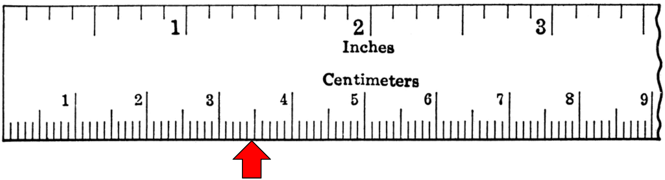

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35 mm. The uncertainty in this ruler measurement is ± 0.5 mm.

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No. Quote it as $\boxed{35\text{ mm}}$ or in an experiment $\boxed{35.0 \pm 0.5\text{ mm}}$

In this case, that's just 2 significant figures.

Significant Figures in Calculations

For this course, use this simple rule:

Give the answer to the problem to the same number of significant figures as the least precise input value.

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If inputs to a problem or experiment are given to 3 significant figures, give the output to 3 significant figures.

If some inputs are given to 2 significant figures and other to 3 significant figures, give answer to 2 significant figures, etc.

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This is the same thing.

$$10^8 = 100,000,000$$

so,

$$3.00 \times 100{,}000{,}000 = 300{,}000{,}000 \text{ m/s}$$

Scientific Notation: One digit only before decimal!

One reason to use scientific notation is to clearly convey the number of **significant figures** in a value.

When a number is in scientific notation, there is **one digit**, followed by a decimal point, followed by more digits, if there is more than one significant figure.

Here there are two significant figures:

$$3.0 \times 10^8 \text{ m/s}$$

Here there are 4 significant figures:

$$\underset{\substack{\uparrow \\ \textbf{one digit}}}{2}.998 \times 10^8 \text{ m/s}$$

one digit before the decimal + 3 digits after the decimal = 4 s.f.s

Scientific Notation vs Unit Scaling Prefixes

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where 1 Mm is one mega-meter,
or use kilometers:

$$300,000 \text{ km/s}$$

or use a prefix with scientific notation:

$$3.00 \times 10^5 \text{ km/s}$$

Unit Conversion

[L] represents any length unit, whereas [m] is specifically meters.

There are other units of length such as feet, inches, miles, bu, li, parsecs, etc.

It is sometimes necessary to change units.

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3/4 of a foot, or 0.75 feet.

12 in = 1 ft.

$$(9\ \text{inches}) \times \left(\frac{1\ \text{foot}}{12\ \text{inches}}\right) = \frac{9}{12}\ \text{ft}$$

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Unit Conversion Examples

To solve that problem, we multiplied the value we wished to convert by 1.

$$(9 \text{ inches}) \times \underbrace{\left(\frac{1 \text{ foot}}{12 \text{ inches}}\right)}_{\substack{\uparrow \\ \mathbf{1}}} = 0.75 \text{ ft}$$

Any number times 1 remains unchanged.

The value remains the same, but the units change, in this case, from inches to feet.

Unit Conversion Examples

The distance between two cities is 100 mi. What is the number of kilometers between the two cities?

A smaller than 100

B larger than 100

C equal to 100

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Example: **how many seconds are there in a day?**

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$$(1 \text{ day}) \left(\frac{24 \text{ hr}}{1 \text{ day}}\right) \left(\frac{60 \text{ min}}{1 \text{ hr}}\right) \left(\frac{60 \text{ s}}{1 \text{ min}}\right)$$

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$$= 1 \times 24 \times 60 \times 60\ \text{s}$$

$$= 86,400\ \text{s}$$

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$$(60.0\text{ mi/hr})\left(\frac{1.609\text{ km}}{1\text{ mi}}\right)\left(\frac{1000\text{ m}}{1\text{ km}}\right)\left(\frac{1\text{ hr}}{60\text{ min}}\right)\left(\frac{1\text{ min}}{60\text{ s}}\right)$$

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$$= \frac{60.0 \times 1.609 \times 1000}{60 \times 60}\ \text{m/s}$$

$$= 26.8\ \text{m/s}$$

Order of Magnitude

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For example, the number 1337 has an **order of magnitude of 3**, since:

$$1337 = 1.337 \times 10^3$$

In physics, we would say it is: "on the order of 10^3."

If the number is written in scientific notation, we just have to look at the exponent of the "10", simple as that!

Order of Magnitude Calculation

One way to get a **hypothesis** what an answer should be: do an Order of Magnitude Calculation.

This is a useful tool for estimating the answer.

The goal is just to get an idea of how big the answer should be.

Order of magnitude examples

About how many times does your heart beat during your life?

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Your heart rate?

Order of magnitude examples

About how many times does your heart beat during your life?

Your heart rate? Call it 100 (10^2) beats per minute for simplicity.

How many minutes in a life...?

$$\text{years in a life} \times \text{minutes in a year} \times \text{beats in a minute}$$

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Years in a life?

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Years in a life? Optimistic: $100 = 10^2$.

Minutes in a year:

$$365 \times 24 \times 60 \approx 400 \times 25 \times 50 = 500,000 = 5 \times 10^5 \text{ min/year}$$

Order of magnitude examples

About how many times does your heart beat during your life?

Total heart beats in your life:

$$\text{years in a life} \times \text{minutes in a year} \times \text{beats in a minute}$$

$$\begin{aligned}(10^2 \text{ years}) \times (5 \times 10^5 \text{ min/year}) \times (10^2 \text{ beats/min})\\ = 5 \times 10^9 \text{ beats}\\ = 5 \text{ billion beats}\end{aligned}$$

[1] vendian.org

Summary

- significant figures
- scientific notation
- unit conversions with non-SI units
- order of magnitude calculations

Quiz *Tuesday*, in class.

Homework

- unit conversion worksheet, due Tuesday, Jan 14.

Walker Physics: (this ↴ will not be collected)

- Ch 1, onward from page 14. Problems: 15, 23, 25, 49, 39