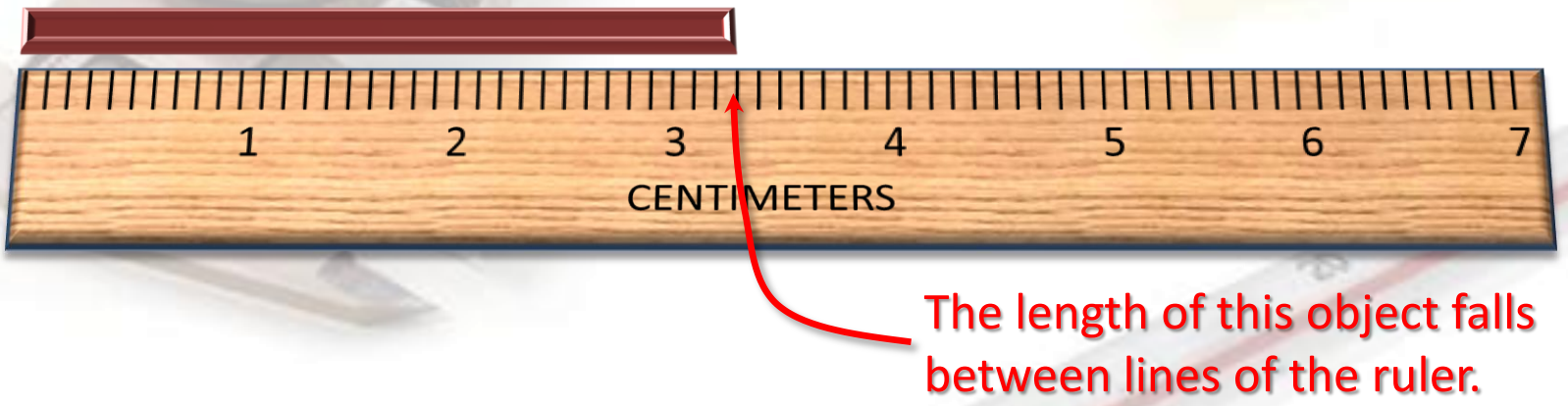
Errors of Measurement

The Ugly Truth Behind Even the Most Careful Measurements

Errors are unavoidable

- Measuring instruments have limitations:



- It is necessary to estimate one place beyond the finest measurement of the measuring device to get the object's length. This is always the case.
- As a result, there are always errors of measurement.

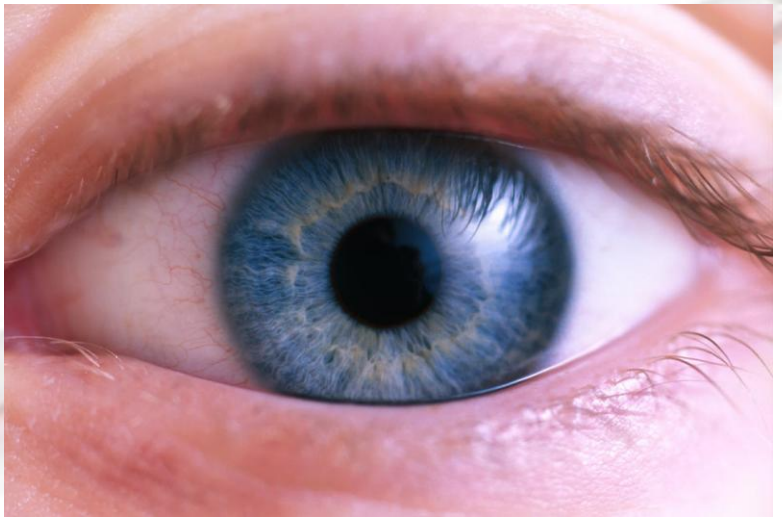
NOT ALL ERRORS ARE CREATED EQUAL

Consider the following two errors:

- You fly from New York to San Francisco.

- Your plane is blown off course by 3 cm.

- You are an eye surgeon.



- Your scalpel misses its mark by 3 cm.

The errors sound equal! Are they??

ABSOLUTE ERROR

- The error is 3 cm in each of the previous examples, but they are not equivalent!
- This type of error is called the ***absolute error***.
- It is the absolute value of the difference between the ***measured value*** and the ***accepted value***.

Absolute Error = |measured value – accepted value|

  - The accepted value is most probable value or the value based on references
  - Only the size of the error matters, not the sign.

Significance of an Error

- The absolute error tells you how far you are from the accepted value.
- It does not tell you how significant the error is.
  - Being off course by 3 cm on a trip to San Francisco is insignificant, because San Francisco is very big.
  - Being off by 3 cm in eye surgery means you are operating on the wrong eye.
- It is necessary to compare the size of the error to the size of what is being measured to understand the significance of the error.

PERCENTAGE ERROR

- The percentage error compares the absolute error to the size of what is being measured.
- It is the absolute value of the difference between the ***measured value*** and the ***accepted value*** all divided by the ***accepted value*** and multiplied by ***100 %***.

$$\text{Percentage Error} = \frac{|\text{measured value} - \text{accepted value}|}{\text{accepted value}} \times 100\ \%$$

SAMPLE PROBLEM

- Aluminum has a density of 2.7 $^{g}/_{mL}$. A student measured some aluminum, and determined that a sample of aluminum with a mass of 21.6 g occupied 4.0 mL. How big is the error?
- $$D = \frac{m}{V} = \frac{21.6g}{4.0mL} = 5.4\,{}^{g}/_{mL}$$
- $$\%\ error = \frac{|measured\ value - accepted\ value|}{accepted\ value} \times 100\%$$

$$\%\ error = \frac{|5.4\,{}^{g}/_{mL} - 2.7\,{}^{g}/_{mL}|}{2.7\,{}^{g}/_{mL}} \times 100\% = \frac{2.7\,{}^{g}/_{mL}}{2.7\,{}^{g}/_{mL}} \times 100\% = 100\%$$

- The error is as big as what is being measured!!