Lecture 3

Data Processing, Errors, Propagation of Uncertainty

9.25×10^4 3 significant figures

9.250×10^4 4 significant figures

$9.250\,0 \times 10^4$ 5 significant figures

0.0050 Two significant figures

7/3 = **2.3333…**

Deviation

Uncertainty

Error

Mistake

Result = mean ± uncertainty

Mean

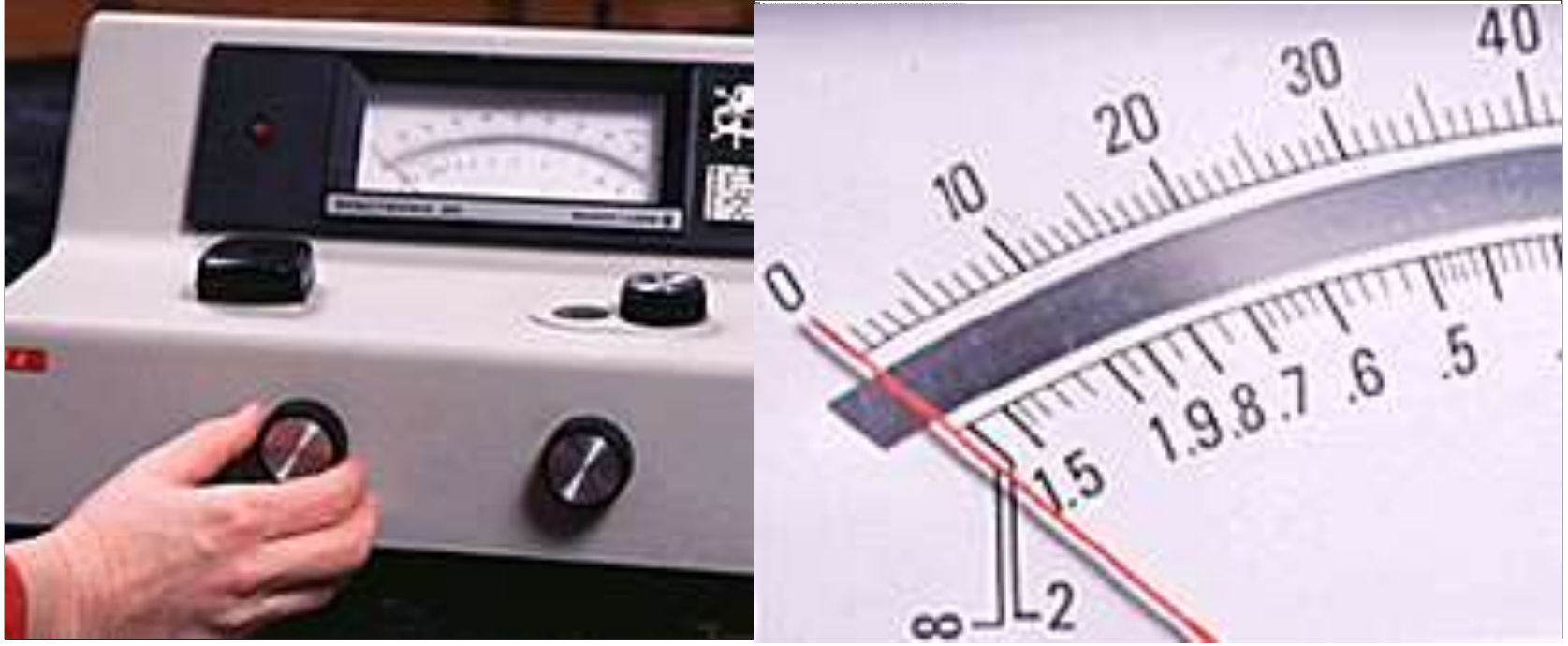
Average

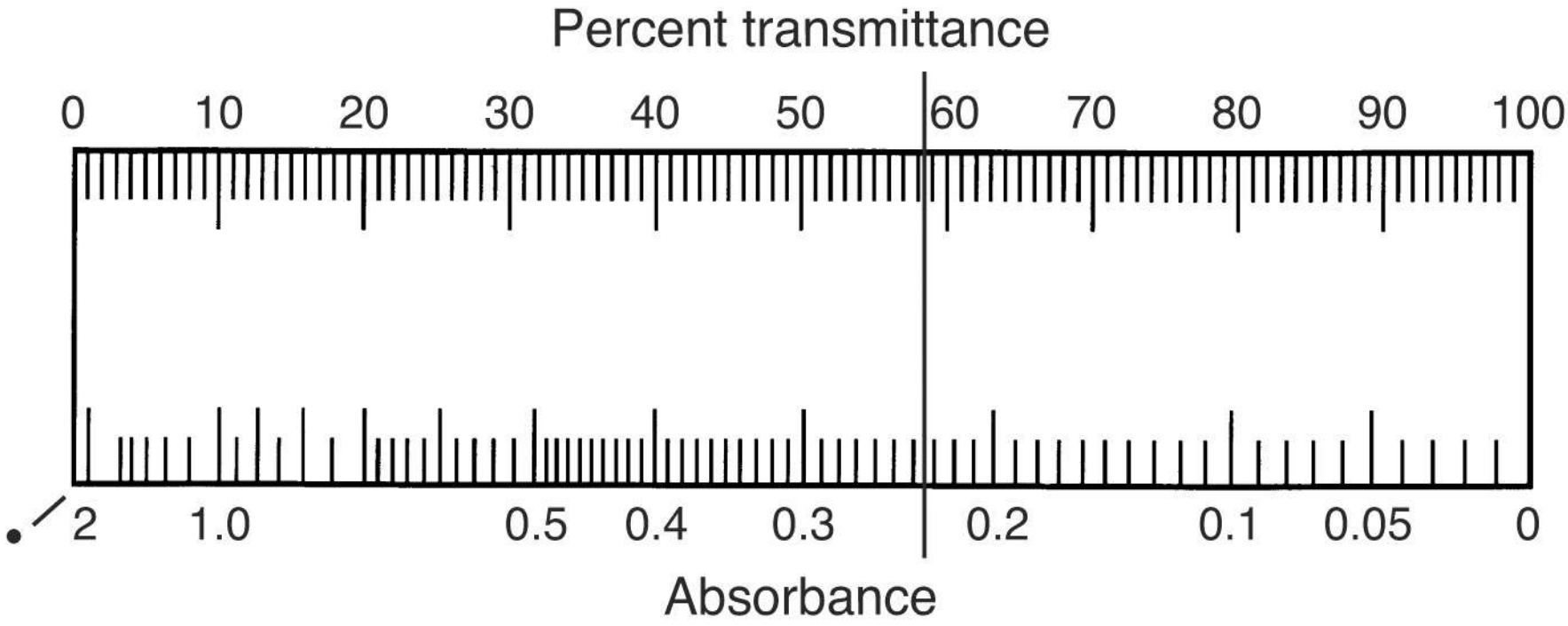
Three sources of numbers:

Counting

Digital display

Analog (scale) reading


0
10
20
30
40
1.5
1.9
.8
.7
.6
.5
∞
2


Percent transmittance
0
10
20
30
40
50
60
70
80
90
100
2
1.0
0.5
0.4
0.3
0.2
0.1
0.05
0
Absorbance

Classification of Components of Uncertainty

In general, the result of a measurement is only an approximation or estimate of the value of the specific quantity subject to measurement. Thus the result is complete only when accompanied by a quantitative statement of its uncertainty.
The uncertainty of the result of a measurement generally consists of several components whichmay be grouped into two categories:

A. evaluated by statistical methods,

B. evaluated by other means.

There is not always a simple correspondence between the classification of uncertainty components into categories A and B and the commonly used classification of uncertainty components as "random" and "systematic." The nature of an uncertainty component is conditioned by the use made of the corresponding quantity, that is, on how that quantity appears in the mathematical model that describes the measurement process.

When the corresponding quantity is used in a different way, a **"random"** component may become a "**systematic"** component and *vice versa*. Thus the terms **"random uncertainty**" and "**systematic uncertainty**" can be misleading when generally applied. An alternative nomenclature that might be used is

"component of uncertainty **arising from a *random* effect,“**

"component of uncertainty **arising from a *systematic* effect,"**

where a random effect is one that gives rise to a possible random error in the ***current measurement process*** and a systematic effect is one that gives rise to a possible systematic error in the ***current measurement process***.

Evaluation of Standard Uncertainty

A Type B evaluation of standard uncertainty is usually based on scientific judgment using all the relevant information available, which may include

- **previous measurement data,**
- **experience with, or general knowledge of, the behavior and property of relevant materials and instruments,**
- **manufacturer's specifications,**
- **data provided in calibration and other reports, and**
- **uncertainties assigned to reference data taken from handbooks.**

Relative uncertainty:

$$\text{Relative uncertainty} = \frac{\text{absolute uncertainty}}{\text{magnitude of measurement}}$$

$$RSD = \frac{\sigma}{\mu}$$

Relative standard deviation = (st.dev) / mean

Percent relative uncertainty:

$$\text{Percent relative uncertainty} = 100 \times \text{relative uncertainty}$$

Propagation of Uncertainty

Uncertainty in addition and subtraction

$$u_{res} = \sqrt{u_1^2 + u_2^2 + u_3^2}$$

Uncertainty in multiplication and division

$$RSD_{res} = \sqrt{RSD_1^2 + RSD_2^2 + RSD_3^2}$$