MOHAMED KHIDER UNIVERSITY – BISKRA-
FACULTY EXACT SCIENCES AND SCIENCES OF THE NATURE AND LIFE
DEPARTMENT OF SCIENCES OF THE NATURE AND LIFE

1st year common core Biology

Year 2023/2024

TP01: Measurements and Uncertainties

I-Objectives of TP

1. Learn to estimate measurement error.
2. Know how to represent a measurement result.
3. Master the use of basic length measuring instruments.
4. Calculate the volumes, densities, and relative uncertainly for objects of different shapes.

❖ Mathematical reminder

Errors and Uncertainties

When we measure a property such as length, weight, or time, we can introduce errors in our results. Errors, which produce a difference between the real value and the one we measured, are the outcome of something going wrong in the measuring process.

an example

use appropriate equipment, e.g a micrometer has higher resolution (0.01mm) than a ruler (1mm)

different types of uncertainty calculations

- **ABSOLUTE UNCERTAINTY:**

The absolute uncertainty in a quantity is the actual amount by which the quantity is uncertain, e.g.if L = 6.0 ± 0.1 cm, the absolute uncertainty in L is 0.1 cm. Note that the absolute uncertainty of a quantity has the same units as the quantity itself.

- **RELATIVE UNCERTAINTY:**

This is the simple ratio of uncertainty to the value reported. As a ratio of similar quantities, the relative uncertainty has no units.

- **Estimating Uncertainty in Repeated Measurements** $\text{Average(mean)} = \frac{X_1+X_2+\cdots\ldots+X_N}{N}$

- **CALCULATION OF ABSOLUTE UNCERTAINTY:**

To calculate the absolute uncertainty of a physical quantity $f(x; y; z; \ldots)$, which depends on the measurable variables x; y; z…, we use the differential method by following the following steps:

- We calculate the partial derivatives $\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z}, \ldots.$

- We write the differential according to these partial derivatives:

$$df = \left|\frac{\partial f}{\partial x}\right| dx + \left|\frac{\partial f}{\partial y}\right| dy + \left|\frac{\partial f}{\partial z}\right| dz + \cdots ..$$

- We approximate the differential df to its absolute uncertainty Δf: $df = \Delta f$. Likewise for the differentials of the variables $dx = \Delta x, dy = \Delta y, \ldots$
- We calculate the absolute uncertainty from the expression:

$$\Delta f = \left|\frac{\partial f}{\partial x}\right| \Delta x + \left|\frac{\partial f}{\partial y}\right| \Delta y + \left|\frac{\partial f}{\partial z}\right| \Delta z + \cdots ..$$

- We can then use the absolute uncertainty Δf to calculate the relative uncertainty $\frac{\Delta f}{f}$.

❖ CALCULATION OF RELATIVE UNCERTAINTY :

To calculate the relative uncertainty of a physical quantity $f(x; y; z; \ldots)$ we use the logarithmic differential method by following the following steps:

- We write the logarithm lnf according to the logarithms of the variables lnx, lny, lnz ...
- We calculate the differential $d(lnf)$ in functions of the differentials $d(lnx), d(lny)$, $d(lnz)$ ...
- Knowing that for example: $d(lnf) = \frac{df}{f}$, we replace the logarithmic differentials by the differentials: $\frac{df}{f}, \frac{dx}{x}, \frac{dy}{y}, \frac{dz}{z}, \ldots.$
- The relative uncertainty $\frac{\Delta f}{f}$ is obtained by replacing the differentials $\frac{df}{f}, \frac{dx}{x}, \frac{dy}{y}, \frac{dz}{z}$.., with the relative uncertainties $\frac{\Delta f}{f}, \frac{\Delta x}{x}, \frac{\Delta y}{y}, \frac{\Delta z}{z}, \ldots$
- We can then use the relative uncertainty $\frac{\Delta f}{f}$ to calculate the absolute uncertainty Δf.

EXEMPLE

Sub-topic 1.2 — Uncertainties and errors

If: $y = a \pm b$

then: $\Delta y = \Delta a + \Delta b$

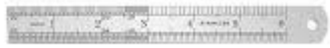
If: $y = \frac{ab}{c}$

then: $\frac{\Delta y}{y} = \frac{\Delta a}{a} + \frac{\Delta b}{b} + \frac{\Delta c}{c}$

If: $y = a^n$

then: $\frac{\Delta y}{y} = \left|n \frac{\Delta a}{a}\right|$

II-Material (table1)

Objects to measure	Measuring instruments	الخطا المطلق للجهاز Absolute error of the instrument
cube $V= d^2$ cylinder $V=\pi.\ h.\ (d/2)^2$ sphere $V=4/3\pi.(d/2)^3$	   	$\Delta d=\Delta\ h=0.1mm$ $\Delta d=\Delta\ h=1mm$ $\Delta d=\Delta\ h=0.01mm$ $\Delta m=0.1g$

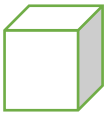
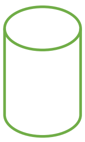
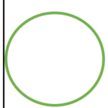
III- Manipulation

Measure the weights of the three objects, the length of the cube(d), the diameter (d)and height (h) of the cylinder, and the diameter (d) of the sphere three times using previous instruments in Table 1, continuing in the same manner and with the same care (especially avoiding parallax errors).

Questions:

1- Fill in the measured values in the table below with explanation.
2- Compare the three cases of the shapes used. What is your conclusion?
3- Compare the instruments used in measuring and which instruments are more accurate.
4- What do you conclude?

(1)The ruler (2)Caliper (disambiguation) (3)Micrometer

Shapes	m (g)	Δm (g)	Δm/m	(1) Ruler, (2)Caliper ,(3) Micrometer	The diameter or the length d(mm)	heigh h(mm)	Volume V (mm^3)	ΔV/V	density ρ (g/mm^3)	Δρ/ρ
				1						
				2						
				3						
				1						
				2						
				3						
				1						
				2						
				3						