**University of Tlemcen**
**Faculty of Sciences**
**Department of Mathematics**

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**1st Year LMD-M and MI**

# Supervised work N° 1 of Mecanics

## Dimensional analysis and uncertainty calculation

**Exercise 1**

Find the dimension of the following physical quantities:

Surface, Volume, Density, Frequency, Linear Velocity, Angular Velocity, Linear Acceleration, Angular Acceleration, Force, Work, Energy, Power, and Pressure.

**Exercise 2**

The characteristic equation of a constant temperature fluid is as follows:

$$\left(p + \frac{a}{V^2}\right)(V - b) = c$$

Or p is the pressure and V is the volume.
Determine the dimensions of quantities a, b and c.

**Exercise 3**

Check the homogeneity of this formula:

$$p = \rho g h_1 + h_2 F$$

Such as: P pression, ρ density, g an acceleration of gravity, $h_1$ and $h_2$ are heights and F a force.

**Exercise 4**

1. In a fluid, a ray ball (نصف القطر) r animated by a velocity v, is subjected to a friction force given by $F=-6\pi\eta rv$ , where η is the viscosity of the fluid.
   What is the dimension of η?
2. When the ball is dropped without initial speed at the moment t = 0, its speed is written to t > 0: $v = a\left(1 - exp\left(-\frac{t}{b}\right)\right)$

Where a and b are two quantities that depend on the characteristics of the fluid. What are the dimensions of a and b?

**Exercise 5**

The sound emitted by the wire of a guitar is characterized by its frequency f. This frequency is a function of the force F of the wire tension, the length L and the density ρ of the wire.
Find the expression of frequency f assuming the form:

$$f = K F^a L^b \rho^c$$

(With K a dimensionless constant and the frequency dimension $[f]=T^{-1}$).

**Exercise 6**

**A.** The momentum P (P=m.v where m is mass and v is velocity) associated with a photon depends on its frequency f according to the following expression :

$$P = \sigma^{\alpha} f^{\beta} c^{\gamma}$$

Where c is the speed of light and σ has the following dimension $[\sigma] = \mathrm{M}.\mathrm{L}^2.\mathrm{T}^{-1}$.

Using dimensional analysis, find the exponents $\boldsymbol{\alpha, \beta \text{ et } \gamma}$.

**B.** The average velocity of a gas molecule is given by the following formula:

$$\vartheta = \sqrt{\frac{PV}{m}}$$

**m** being the mass of the molecule, V the volume, and P the pressure of the gas.

**1-** Calculate the relative uncertainty of **ϑ** as a function of **Δp, Δm et ΔV.**

**Exercise 7**

The speed limit reached by a weighted parachute is a function of its weight P and its surface S, is given by: $v = \sqrt{\frac{P}{K.S}}$

1) Give the dimension of the constant k.

2) Calculate the speed limit of a parachute having the following characteristics:

M=90 kg, S=80 m2, g=9,81 m/s2, and k=1,15 MKS.

3) The weight being known to the nearest 2 % and the surface to 3 %, calculate the relative uncertainty Δv/v on the velocity v, thus the absolute uncertainty Δv and deduce the condensed writing of this velocity.

**Suplimentary Exercises**

**Exercise 1**

The height H of a liquid of mass M contained in a cylinder of radius R is given by the relation:

$$H = \frac{(2.\sigma.cos\alpha)}{(R.g.\rho)}$$

Where α is the liquid-cylinder contact angle, ρ the density of the liquid and g the gravity acceleration.

1- Using the dimensional equations, find the dimension of σ.
2- Determine relative uncertainty on σ based on absolute uncertainties ΔR, Δg, ΔM and Δα.

**Exercise 2**

The resonance frequency f of an electric circuit is given by the formula:

$$f = \frac{1}{2\pi\sqrt{L.C}}$$

L and C are known with absolute uncertainties ΔL and ΔC.

Determine as a function of L, C, ΔL and ΔC absolute and relative uncertainties on f with the two differential methods.