Practical Session n°4: DIFFRACTION

1- EQUIPMENT

A laser source, a screen, and a slide containing a series of 6 slits of different widths are available:

a = width of each slit (in mm)	0.07	0.04	0.05	0.10	0.12	0.28

Caution: Take care when using the laser beam. Mind yours eyes!

A computer with the OpenOffice software can enable you to plot a graph, to make its model and to display the equation of this model.

2- OBJECTIVE

We aim at investigating the phenomenon of light diffraction and determining the wavelength of a laser beam.

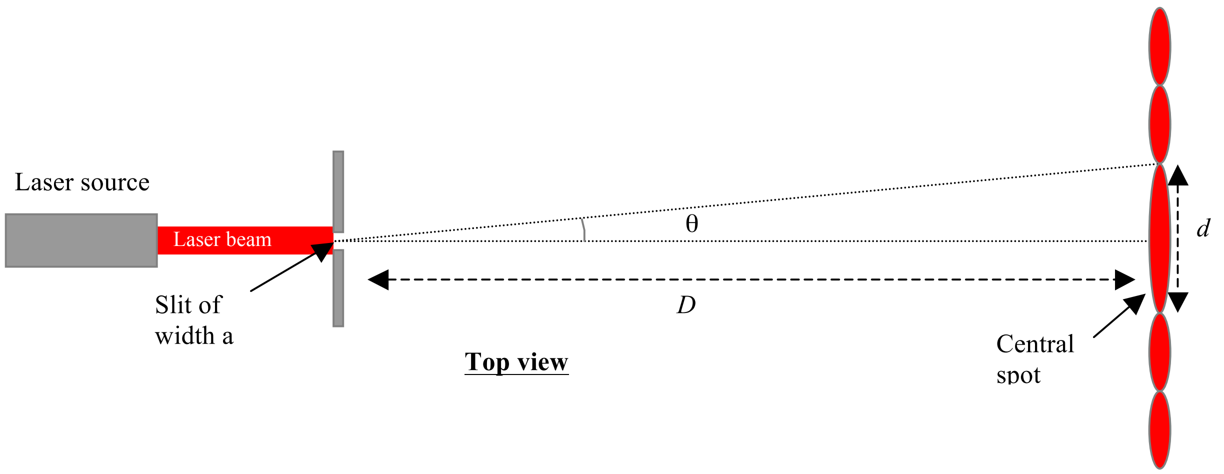
The idea is to use the set up described below to show that θ is proportional to $\frac{1}{a}$ and then to deduce that the proportionality constant is equal to λ. This relation can be written as follow:

$\theta = b \times \frac{1}{a}$ where θ: angle (expressed in radians) between the centre of the central spot and the centre of the first dark region (see diagram below)

b: proportionality constant (It is the slope of the curve $\theta = f(\frac{1}{a})$) and is equal to λ.)

a: width of the slit

λ: wavelength of the laser beam



Remarks:
- For small angles, we can assume that θ ≈ tan(θ) if θ is expressed in radians.
- tan() can be obtained by calculating the ratio opposite side over adjacent side.
- The distance D between the slit and the screen should remain constant. You can set it at 2.0 meters for instance.

3- THE WORK TO BE DONE

3.1- Analysing the problem and finding an experimental procedure

With the available equipment, propose an experimental procedure to achieve the objective previously described.

Remark: *You must explain how to use the equipment, the software, and how to perform your measurements and calculations.*

Call your teacher for checking or in case of any difficulty.

3.2- Carrying out the experiment

Carry out your procedure.

Call your teacher to present your experimental results or in case of any difficulty.

3.3- Communicating on you work and your results

Express your result under the following form: $b = b_{mean} \pm \Delta b$

Where b_{mean} is the mean value of the slope b taking into account the results of all the groups of the class.

Δb is the uncertainty on b_{mean} (see the help card: How to express a result)

Compare this value to the wavelength of the laser given by your teacher. Conclude.

Help card: How to express a result for a series of independent measurements

The **final result** is not only a single numerical value. We have to define **a range of values** within which the **true value** has a high probability to be found. Therefore, we need to give a **measurement uncertainty** to estimate the width of this interval.

Expression of the result

$b = b_{mean} \pm \Delta b$

where b_{mean} is the mean value (= average value)
and Δb is the uncertainty on this average value

Δb will be rounded to the higher value with only one significant figure.
b_{mean} will be rounded by retaining as last significant figure the digit that is at the same position as the one of Δb.

For example:
If $v_{mean} = 238.53\ m.s^{-1}$ and $\Delta v = 3.4\ m.s^{-1}$
We should write $v = 239 \pm 4\ m.s^{-1}$

The measurement uncertainty is defined by the relation $\Delta b = 2 \times \frac{\sigma_{n-1}}{\sqrt{n}}$ where σ_{n-1} is the **standard deviation** (SD) of the measurements series and n the number of measurements

Method

In the spreadsheet, calculate b_{mean}, σ_{n-1} (SD) and Δb

Syntax of the OpenOffice spreadsheet

Mean value: =MOYENNE()
Standard deviation: =ECARTYPE()
Square root: =RACINE()

Syntax of your calculator

See the help card to know how to use statistical functions.
Remark: For a casio calculator, standard deviation is denoted *xσn-1*

Significant figures

In a number, every digit is significant except the zeros which are placed before the first non-nil digit.

Examples

5.3	2 significant figures
5.30	3 significant figures
5300	4 significant figures
0.053	2 significant figures