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**Class : Tuesday – 17 : 05 – 18 : 45**

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**Lab Report : 1 – Exercise No. 100A**

**DENSITY DETERMINATION OF SOLIDS**

**INTRODUCTION**

The density of a solid metal cylinder is found from the measurements made of its mass and volume. A double pan balance is used to find the mass, and a caliper is used to measure the height and the two diameters of the cylinder in order to emphasize the relative differences in the uncertainties of the two measuring instruments. These uncertainties are shown to propagate through the calculation resulting in an uncertainty associated with the determination of density.

The density of a homogeneous material is defined as the mass per unit volume, or

*p = volume*

*mass*

*m*

=

*v*

The units associated with the density are kg/m3, g/cm3, and slug/ft3.

Whenever measurements are performed, two factors contribute to the total uncertainty associated with those measurements. First, an uncertainty exists which is associated with the instrument itself and its construction.

**APPARATUS**

● Digital weighing machine

● Caliper

● Micrometer screw

● Solid hollow metal cylinder

**Calculation Table:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | d[m] | width[m] | H[m] | M[kg] | V (m^3) | d(kg/m^3) | d(g/cm^3) |
| 1 | 0.0120 | 0.0186 | 0.0223 | 0.00965 | 0.00000354 | 2728.14 | 2.73 |
| 2 | 0.0119 | 0.0185 | 0.0223 | 0.00977 | 0.00000351 | 2780.24 | 2.78 |
| 3 | 0.0119 | 0.0185 | 0.0224 | 0.00965 | 0.00000353 | 2733.83 | 2.73 |
| 4 | 0.0119 | 0.0188 | 0.0223 | 0.00965 | 0.00000371 | 2601.03 | 2.60 |
| 5 | 0.0118 | 0.0187 | 0.0224 | 0.00966 | 0.00000370 | 2609.10 | 2.61 |
| 6 | 0.0119 | 0.0185 | 0.0225 | 0.00967 | 0.00000355 | 2727.32 | 2.73 |
| 7 | 0.0118 | 0.0185 | 0.0228 | 0.00965 | 0.00000364 | 2654.51 | 2.65 |
| 8 | 0.0119 | 0.0186 | 0.02281 | 0.00978 | 0.00000366 | 2671.46 | 2.67 |
| 9 | 0.0120 | 0.0186 | 0.02282 | 0.00978 | 0.00000362 | 2701.89 | 2.70 |
| 10 | 0.0117 | 0.0185 | 0.02281 | 0.00965 | 0.00000368 | 2622.99 | 2.62 |
| 11 | 0.0120 | 0.0185 | 0.02283 | 0.00967 | 0.00000355 | 2720.30 | 2.72 |
| Average: | 0.0119 | 0.01857272727 | 0.02257 | 0.009689090909 | 0.00000361 | 2685.25 | 2.69 |
| Standart Deviation: | 0.000094 | 0.000101 | 0.000241 | 0.000057 | 0.000000074 |  |  |
| Resolution: | 0.0001 | 0.0001 | 0.0001 | 0.00001 |  |  |  |
| type B | 0.000058 | 0.000058 | 0.000058 | 0.0000058 |  |  |  |
| A+B | 0.00011 | 0.00012 | 0.00025 | 0.000057 | 0.000000074 |  |  |
|  |  |  |  |  |  | 57.29 |  |
|  |  |  |  |  |  | 114.57 |  |

**Calculations**

Density:

The formula for calculating the density is:

And the formula for volume is:

Where;

* the width,
* the “d”,

From the data table.

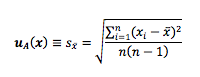
Example for measurement “1”:

= 0.00000354 [m^3]

=2728.14 [kg/m^3]

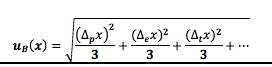
Uncertainties:

The formula for uncertainty type A (standard deviation):



Calculated using Excel formula “stdev()” for each variable.

The formula for uncertainty type B:



Where we only considered the calibration uncertainty (e.g. uncertainty of used instrument)

Summation of A and B are done by:



Uncertainty of density:



Translates to:

**CONCLUSION**

**Discussion**

The purpose of this exercise is to determine the uncertainty of the results. We can observe that for the measured parameters the value of uncertainty is much smaller than measured. What is important this is true for both calliper and micrometer. In case of volume, its quantity is calculated by use of determined diameter, The uncertainty is smaller more than 100 times to. And finally for density – its value is determined by volume and mass – the uncertainty is exactly the same like the result. We can assume that the uncertainty is relatively bigger for parameters which are determined by combination of measured values that already consist of some uncertainty.

**Results and the Uncertainty**

We found the density of the material to be 2685.25 ± 114.57 [kg/m^3]. Using the method outlined in the calculations sections.

Afterwards the uncertainty that we found for density is expended by “k=2” due to the formula:

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