## EXPERIMENTAL WORK 2

Subject. Measuring of volumes of solid objects, liquids and bulk materials.

## Theoretical data and practical advice

Volume is a physical quantity that characterizes the property of an object to occupy part of the space.

The unit of volume in the International System of Units $(S I)$ is the cubic meter $\left(m^{3}\right)$. There are multiple and divided units of volume:

$$
\begin{gathered}
1 \mathrm{dm}^{3}=0.1 \mathrm{~m} \times 0.1 \mathrm{~m} \times 0.1 \mathrm{~m}=0.001 \mathrm{~m}^{3} ; \\
1 \mathrm{~cm}^{3}=0.001 \mathrm{dm}^{3}=0.000001 \mathrm{~m}^{3} .
\end{gathered}
$$

Litre is a non-systemic unit of volume ( L ):

$$
\begin{gathered}
1 \mathrm{~L}=1 \mathrm{dm}^{3} \\
1 \mathrm{~mL}=1 \mathrm{dm}^{3}
\end{gathered}
$$

Volumes of solids, liquids and bulk materials can be determined by direct measurements using a measuring cylinder, a measuring vessel.

To measure the volume of liquid or bulk material with a measuring cylinder, we need:

1. To pour out the liquid or pour out the loose material into a measuring vessel. Liquid, loose material will take the form of a vessel, and their free surface will settle at a certain height;
2. To determine in front of which scale marks the surface of the liquid column or bulk material is located;
3. Knowing the value of the scale division, find out the volume of liquid or bulk material;
To measure the volume of a solid with a measuring vessel, we need:
4. To pour water into the measuring vessel with a volume of $V_{1}$, water should be poured so that the under study object is completely submerged and the water does not pour over the edge of the vessel;
5. To submerge the object into the water and measure the total volume of $V_{2}$ water with the object;
6. Calculate the volume $V$ of water displaced by the object as a difference of measurements of the volume of water before and after submerging: $V=V_{2}-V_{1}$.
The volume of water V displaced by the object is equal to the volume of the object.
If the object has the correct geometric shape, its volume can be determined by indirect measurements: measure the linear dimensions of the object using a ruler and calculate the volume of the object according to the corresponding mathematical formulas. For example, the volume $V$ of an object having the shape of a rectangular parallelepiped is calculated by the formula:

$$
V=l d h,
$$

where $l$ - is the length; $d$-is the width; $h$ - is the height of the object.
The absolute error, during one direct measurement, is equal to the value of the scale division of the measuring device.

Subject. Measuring of volumes of solid objects, liquids and bulk materials.
Target: to measure the volumes of solids (regular and irregular forms), liquids and loose materials.

Equipment: measuring cylinder, graded glass, ruler (treadmill), threads, an object of irregular geometric form (object 1), object of parallelepiped form (object 2), water, millet, sand.


Figure 1

Figure 3



Figure 2


Figure 4

The results of the measurements I'm writing down into the table:
Table 1

| No. of the <br> experiment | Substance | Volume of liquid or bulk material $V_{\text {measur, }} \mathrm{cm}^{3}$ |
| :---: | :---: | :--- |
| 1 | Sand |  |
| 2 | Millet |  |
| 3 | Water |  |

Table 2

| Object | Direct measurements |  |  | Indirect measurements |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Initial <br> volume of <br> water <br> $V_{1}, \mathrm{~cm}^{3}$ | Object <br> volume <br> with water <br> $V_{2}, \mathrm{~cm}^{3}$ | Object <br> volume <br> $=V_{2}-V_{1}$, <br> $\mathrm{cm}^{3}$ | Object <br> length <br> $l, \mathrm{~cm}$ | Object <br> width <br> $d, \mathrm{~cm}$ | Object <br> height <br> $h, \mathrm{~cm}$ | Object <br> volume <br> $=l d h, \mathrm{~cm}^{3}$ |
|  |  |  |  | - | - | - | - |
| Object 2 |  |  |  |  |  |  |  |

1. I'm determining the value of the scale division of the measuring cylinder and the value of the scale division of the ruler:
$C_{\text {m.c. }}=\square=$ $\qquad$ , $C_{\mathrm{rul} .}=\square=$ $\qquad$ .
2. Using a measuring vessel I'm measuring the volume of bulk materials:

- sand: $V_{\text {sand }}=$ $\qquad$
- millet: $V_{\text {millet }}=$ $\qquad$
- water: $V_{\text {water }}=$ $\qquad$

3. I'm measuring the volume of a solid object of irregular geometric shape (object 1)
by direct measurements: $V_{\mathrm{Ob} 1}=V_{2}-V_{1} ; V_{\mathrm{Ob} 1}=$ $\qquad$ - $\qquad$ $=$ $\qquad$ .
4. I'm measuring the volume of a solid object of irregular geometric shape (object 2) by direct measurements: $V_{\mathrm{Ob} 2}=V_{2}-V_{1} ; \quad V_{\mathrm{Ob} 2}=$ $\qquad$ - $\qquad$ $=$ $\qquad$ .
5. I'm measuring the volume of a solid object of the correct geometric shape (object
2) by indirect measurements: $V_{\mathrm{Ob} 2}=l d h ; \quad l=$ $\qquad$ ; $d=$ $\qquad$ ; $h=$
$\qquad$ ;
$V_{\mathrm{Ob} 2}=$ $\qquad$ . $\qquad$ . $\qquad$ $=$ $\qquad$ .
6. I'm estimating the absolute and relative errors of measurement results:
$V=V_{\text {meas. }} \pm \Delta V$, where $\Delta V-$ an absolute error;
Sand: $\quad V_{\text {sand }}=$ $\qquad$ $\pm$ $\qquad$ ;
Millet: $\quad V_{\text {millet }}=$ $\qquad$
$\qquad$ ;

Water: $\quad V_{\text {water }}=$ $\qquad$ $\pm$ $\qquad$ .
7. Analyzing the results of the experiment:
$\qquad$

