Maritime University of Szczecin

Faculty of Marine Engineering

Department of Physics and Chemistry

Physics Laboratory

Laboratory Description

Determination of solids density using Nicholson's aerometer

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Szczecin 2017

Objectives:

- Familiarization with mechanical stability conditions – balance of forces and moment of force (torque).
- Determination of density of solids using Archimedes' principle

Questions and problems to solve:

- Density, weight, specific gravity and mass – the relationship between these quantities.
- Conditions of mechanical stability
- Archimedes' principle
- Determination of solids density using Nicholson's aerometer.

Short description:

Nicholson's aerometer (see figure 1) is made of a metal float *P;* two pans *A* and *B* and connecting rod. The metal float and the pan *A* are immersed in distilled water. The system is in a state of equilibrium when the sum of forces acting on it is equal to zero.

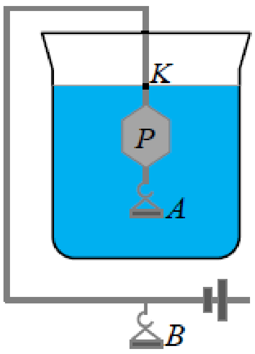

Fig. 1. Schematic view of Nicholson's aerometer

The pan *B* has to be loaded with weights of mass m_1 so that the position of the marker *K* is at the level of water surface. The total weight of the aerometer *Q* and weight $Q_1 = m_1 g$ is balanced by buoyant force *W* acting on submerged parts of the aerometer:

$$Q + Q_1 = W \quad (1)$$

We remove the weights from the pan *B* and put on a body of unknown weight Q_c and a volume V_c. We load the pan *B* with weights of a mass m_2 so that the position of the marker *K* was again at the level of water surface. In this case, buoyancy force is balanced by the weights: Q (of the aerometer), $Q_2 = m_2 g$ (of weights) and Q_c (of the examined body).

$$Q + Q_2 + Q_c = W \quad (2)$$

Then we remove the body from the pan *B* and attach it to the submerged part of the aerometer *A*. We have to do it carefully in order to avoid bubbles gathering on the examined body. Now we load the pan B with mass m_3. The connecting rod dives again to the level *K*. Now, the total weight of all the elements of the system is balanced by the buoyant force W acting on submerged parts of aerometer and by the buoyant force W_c acting on the submerged body:

$$Q + Q_3 + Q_c = W + W_c \qquad (3)$$

Using the equations (1)-(3) we can obtain the relation for weight of the examined body and for the buoyant force acting on this body:

$$Q_c = Q_1 - Q_2,$$

$$W_c = Q_3 - Q_2 \qquad (4)$$

The weight of the body and the buoyant force acting on it can be determined by using formulas: $Q_c = m_c g = \rho_c V_c g$ and $W_c = \rho_w V_c g$, where ρ_c and ρ_w are the examined body density and the density of distillated water, respectively:

$$d = \frac{\rho_c}{\rho_w} = \frac{Q_c}{W_c} = \frac{Q_1 - Q_2}{Q_3 - Q_2} = \frac{m_1 - m_2}{m_3 - m_2} \qquad (5)$$

Knowing the array density of distillated water ρ_w at a given temperature (corresponding to the temperature at the time point when the measurements were performed), we can calculate the body density ρ_c:

$$\rho_c = d\rho_w \qquad (6)$$

Density of a homogenous body can be also determined from the definition of density, after measuring its mass m_c and volume V_c:

$$\rho_c = \frac{m_c}{V_c} \qquad (7)$$

Literature:

1. Resnick R., Halliday D., Walker J., *Fundamentals of Physics*, John Wiley & Sons, INC (available editions).