EXERCISE 29	DETERMINATION OF THERMAL EXPANSION COEFFICIENT AND INVESTIGATION OF HEAT TRANSFER

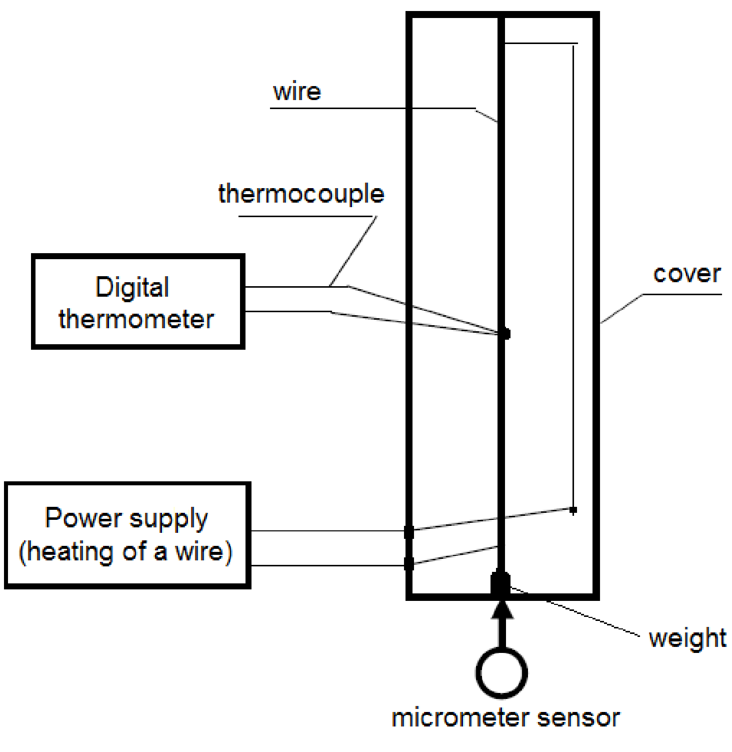
1. List of equipment

- Micrometer sensor for measurements of a wire extension
- DC power supply: maximum current = 5A , output voltage = 10V
- Voltmeter
- Digital thermometer.

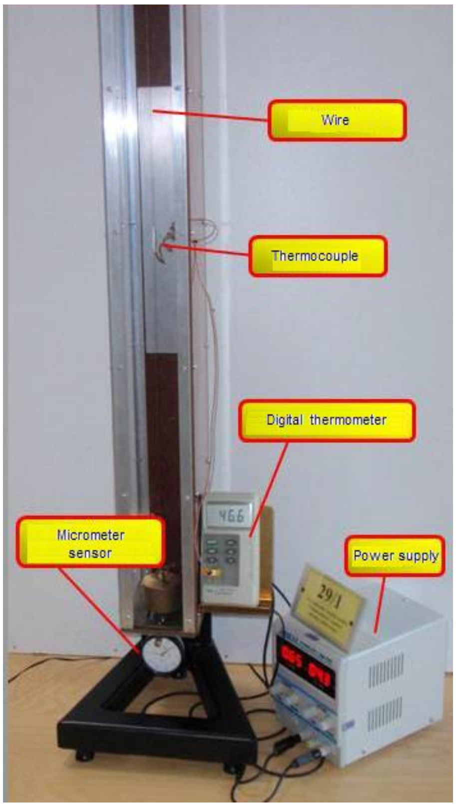
2. Aim of the exercise

Determination of thermal expansion coefficient of an investigated metal.

3. Scheme of a measurement setup



Rys. 1. Scheme of a measurement setup.



Rys. 2. Measurement setup.

4. Preparation of the measurement setup:

4.1 Check the conformity of the equipment with the above list.
4.2 Adjust the micrometer sensor so that its bigger tip coincides with the "0" number of its scale. To do this, turn carefully the ring of the sensor.
Note: During measurements do not touch the micrometer sensor.

4.3 Turn on the digital thermometer and write down the initial temperature (room temperature) t_o. The initial length L_o of a given wire in room temperature is as follows:

L_{o1} = (0,885 ± 0,004)[m]
L_{o2} = (0,915 ± 0,004)[m]
L_{o3} = (0,905 ± 0,004)[m]
L_{o4} = (0,875 ± 0,004)[m]
L_{o5} = (0,880 ± 0,004)[m]
L_{o6} = (0,875 ± 0,004)[m]
L_{o7} = (0,875 ± 0,004)[m]

5. Measurements:

5.1 In the presence of the teacher set the current limit knob to the left end position, what corresponds the value of current of 0 A. Then, set the voltage control knob to the right end position, what corresponds the maximum value of voltage, equal to 15V.
5.2 Turn on the power supply.
5.3 Change the current values with a step of 0,1A or 0,2A up to temperature of a wire of ~150°C.
5.4 Write down the values of voltage corresponding given values of current.
5.5 After each change of the current wait for ~5 min until temperature stabilizes. Then, write down the temperature of the wire as t as well as indication of the micrometer sensor ΔL, what corresponds the elongation of the wire.
5.6 Continue the measurements up to **150°C**.
5.7 Open the front wall of the measurement system and repeat all measurements from point 5.2 to 5.5. Write down the measurement results in a separate table.

6. Data handling:

6.1 Plot a graph of relative elongation dependence versus temperature change ΔT, where $\Delta T = t - t_o$. For the obtained experimental points mark error bars.
6.2 Fit the experimental data by the straight line: $\boldsymbol{y = Ax \pm B}$ (where: $\boldsymbol{y} = \Delta L/L_o$, $\boldsymbol{x} = \Delta T$, $\boldsymbol{A} = \alpha$, niepewność $u(\boldsymbol{A}) = u(\alpha)$). The slope determines the value of the thermal expansion coefficient α.
6.3 Put the the results of the measurements and calculations into the table.
6.4 Knowing the value of α describe the material from which the investigated wire was built.
6.5 Knowing the values of current and voltage calculate the power P and its uncertainty $u_c(P)$.
6.6 Plot a graph of dependence of $P = f(\Delta T)$ for closed and opened setup. For the obtained experimental points mark error bars.

7. Proposed tables

Table 1. The values of parameters obtained in the experiment: L_0 – initial length of a wire, t_0 – initial temperature of a wire, I – current, U – voltage, P – power, ΔT – temperature changes, ΔL – wire elongation, $\Delta L/L_0$, – relative elongation of a wire, α – thermal expansion coefficient.

Table 1. The values of physical quantities related to determination of thermal expansion coefficient α.

lp.	L_o [m]	t_0 [^{0}C]	t [^{0}C]	ΔT [^{0}C]	ΔL 10^{-3} [m]	$\frac{\Delta L}{L_0}$	$u_C\left(\frac{\Delta L}{L_0}\right)$	α [1/^{0}C]
1								
2								
3								
⋮								
n								
$\Delta_p X$								
$u(X)$								
$u_c(X)$								

Table 2. The values of physical quantities needed to plot a graph of dependence of $P = f(\Delta T)$.

lp.	t_0 [^{0}C]	I [A]	U [V]	P [W]	t [^{0}C]	ΔT [^{0}C]
1						
2						
3						
⋮						
n						
$\Delta_p X$						
$u(X)$						
$u_c(X)$						

$\Delta_p X$ – uncertainty of a given measurement device, e.g. wire's length uncertainty, temperature uncertainty etc.
$u(X)$ – standard uncertainty of a given physical quantity X, e.g. $u(I)$, $u(U)$, etc.
$u_c(X)$ – complex uncertainty of a given physical quantity X, e.g., np. $u_c(\Delta T)$, $u_c(\alpha)$, etc.

The temperature was measured using a digital thermometer of type: ……………………………….,
Assume that the temperature uncertainty is ±1K.