Exercise 4B
Temperature coefficient of resistance

Aim

To determine temperature coefficient of resistance of metal. To investigate range of validity of Ohm's law.

Required theoretical knowledge

Ohm's law, electric current, resistance and resistivity, temperature dependence of resistivity, difference between metals and semiconductors, methods of resistance measurements, heat transfer, black body radiation, Wien law.

Equipment

The measurement set up is shown in Fig. 1a. It consists of power supplier, steel spring and thermal camera. View from thermal camera is shown in Fig. 1b, temperature at crosshair is in left upper corner of the display.

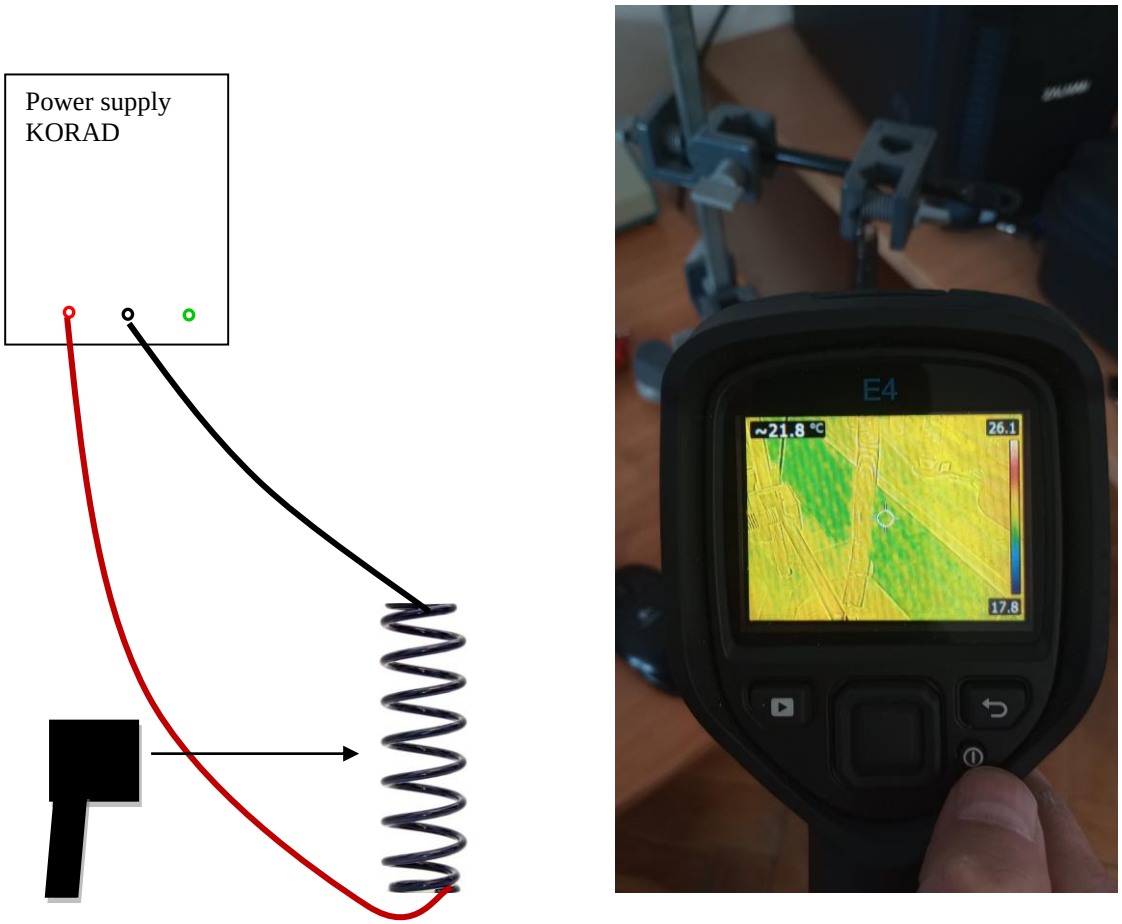

Fig. 1. a) The measurements setup, b) thermal camera, power-on button on the right.

Problems for discussion:

Principals of operation of thermal camera. Ohm's law.
Dependence of resistivity of metals on temperature (including physical origin)

Measurement plan:

1. Turn on the computer and run application *Calc* of *Open Office* suite.
2. Use micrometer screw to measure thickness *d* of steel wire. Use caliper to measure spring diameter *D*. Count number of windings *n*. Calculate steel wire cross-section *s* and length *l*, write results to the Table 2.
3. Connect ends of steel spring to the power supply.
4. Open camera lens cover (cover shutter below lens), turn on thermal camera by pressing power-on button, wait for calibration. Camera is ready to use, if temperature is shown in °C. Crosshair should point directly at spring.
5. Turn on the power supply, set voltage to **0**, by pressing the current button, set the current limit to **0.9 A**. Afterwards, by pressing the voltage button, set it to 0.1 V setting precision.
6. By adjusting the voltage of power supply in a range from **0** to **4 V** with step **of 0.5 V** write down the values of voltage, current and temperature in Table 1. Caution, do not touch the spring, it may be hot. Note, that temperature is increasing slowly with time, note down few values of temperature after some period of time, for example 30 s. Proceed to next step of voltage, when temperature is only fluctuating.
7. After finishing whole measurement, set the voltage to **0**. Cover camera lens and turn off camera.

Problems for discussion:

Definition of resistance and how it depends on the geometrical dimensions of the element? With known diameter of spring and numbers of coils, derive formula for spring wire length.

Data processing:

1. In *Calc*, calculate the resistance of each measurement pair (V,I) (in a separate column)
2. Calculate average temperature for each (V, I) measurement (take into account only fluctuating values, reject first, increasing values)
3. Calculate difference between measured average temperature and 20 °C.
4. Draw a dependence of resistance (R) vs. temperature difference (T_d)
5. Using two parameters regression method calculate coefficients of the equation: $R = aT_d+b$, and their uncertainties Δa and Δb. This equation is related with temperature coefficient α and resistance R_0 at room temperature, because $R = R_0(1+\alpha T_d)$
6. Use results of linear regression to calculate values of R_0 and α. Using propagation of uncertainties principle, calculate $\Delta\alpha$.
7. Calculate steel resistivity ρ and its uncertainty.
8. Compare obtained ρ and α with table values for various steel alloys.

Literature

1. Halliday, Resnick "Fundamentals of Physics - 8th edition", John Wiley 2007,