1 Exercise A

In this first simple exercise, we will use a voltage source, a "Fluke" multimeter and a voltage-divider circuit to measure the resistance of a resistor.

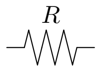

Figure 1: A resistor.

A simple passive element of an electronic circuit is a resistor, illustrated in Figure 1; the unit of the resistance is $[R] = \text{Ohm}$. A resistor obeys Ohm's law:

$$U = R \cdot I, \tag{1}$$

where U is the Voltage $[V]$ and I is the Current $[A]$ (Ampère). Furthermore, you should know Kirchhoff's law, that states that the sum of all currents flowing into a node equals the sum of all currents flowing out of that node, i.e. no charge is lost.

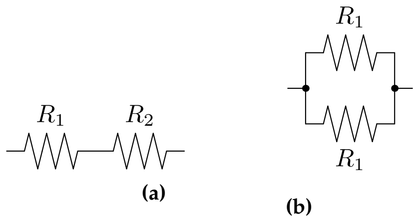

Figure 2: Two ways of connecting resistors: in (a) the resistors are hooked in series, in (b) in parallel.

Resistors can be connected in parallel or in series (Figure 2). We can derive from Ohm and Kirchhoff's law, that

$$R = R_1 + R_2 \tag{2}$$

holds for resistors connected in series and

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \tag{3}$$

for resistors in parallel. In a voltage-divider circuit (Figure 3), two resistors are connected in series to voltage source (battery).

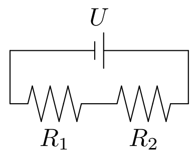

Figure 3: A voltage divider.

- Assume $R_1 \gg R_2$; describe the resistance R of the whole circuit, when R_1 and R_2 are connected in series and parallel.
- The resistance and the precision of a resistor is given by a color code. How does this code work?
- By looking at the color codes, find a resistor of $5\text{k}\Omega$ resistance (R_1) and measure it with a Fluke multimeter. Is the measured resistance within the given precision? Do the same for a $1\text{k}\Omega$ resistor (R_2).
- Setup a voltage-divider circuit with R_1 and R_2 connected in series. Use a voltage source to apply a constant voltage $U = 1\text{V}$. Measure the voltage drop U_2 accross R_2.
- Use Ohm's law to calculate the resistance R_2 as funtion of U, U_2 and R_1, $R_2 = f(U, U_2, R_1)$.
- Vary U in steps of 100mV from 100mV to 1V, measure U_2 and calculate R_2. Are the results constant? Calculate a 95% confidence interval for the mean resistance. Compare this result with the resistance measured with the multimeter.
- If $y = f(u, v, \dots)$, then a small error $\Delta u, \Delta v, \dots$ will influence the result: $\Delta y = \frac{\partial f}{\partial u}\Delta u + \frac{\partial f}{\partial v}\Delta v + \dots$. Assume there is a error in the voltage measurement of U_2. Write down the formula of error propagation for the function $f(U, U_2, R_1)$ derived above; use a linear approximation to calculate how a small error of U_2 influences the value of the function.