Assumed that we have a resistor with resistance we need to calculate. We can use **Ohm’s law** to calculate the resistance, given that we know both the voltage and the current flow through the resistor under that current. It is possible to determine the value of the current and voltage, using an Amperemeter and a Voltmeter.

In theory, an ideal Voltmeter would have infinitely large inner resistance, so that the current we trying to measure does not flow through it. As opposed to that, an ideal Amperemeter would have its inner resistance as zero, so it does not consume any energy at all and the current flows through it will not drop. However, in reality, the meters are not ideal. They both will consume some of the energy carried by the current (because they both have inner resistance).

So, to overcome this “error” (due to the energy consumed by the meters) we will use two different configurations of circuits to measure the current and voltage of the resistor: one type of coupling that is called short coupling and another called long coupling. After gathering the information by long and short coupling, we can derive equations that take into account the internal resistances of meters and can be used to correct methodological errors.

In a short coupling (figure a below), we connect a voltmeter and the resistor parallel to each other, and then an ammeter is connected directly outside this circuit. It is clear that now, the voltmeter will measure the correct voltage of the resistor. As opposed to this fact, as the ammeter measures its current, the ammeter in this case will show the total current that is divided between the resistor and the voltmeter.

So, in this case, we can use **Kirchhoff’s first rule** to give an equation that describes the relationship between the 3 currents: the current that flows thought the ammeter I\_a, the current flows through the resistor I and the current flows through the voltmeter I\_v:

I\_a = I + I\_v (1)

Using **Ohm’s law**, we can rewrite I\_v as a function of U and R\_v. And since the voltmeter and the resistor are parallel to each other, their voltage is going to be equal:

U = U\_v

I\_v = U\_v/R\_v = U/R\_v (2)

Substitute (2) into (1) gives:

I\_a = I + U/R\_v

Which gives the current flowing through the resistor as:

I = I\_a – U/R\_v

This equation is used when the methodological error correction is calculated for the current values obtained using the short coupling.

In long coupling (figure b below), we connect an ammeter directly next to the resistor so that the ammeter measures the current flowing through the resistor. We then connect a voltmeter parallel to that (the ammeter and the resistor), which is used to measure U\_v. This U\_v is the sum of voltages across the resistor (which is U) and the ammeter (which is U\_a). Now, we can use **Kirchhoff’s second law** to make an equation that describes the relationship of these values:

U\_v – U\_r – U\_a = 0

Since the ammeter is next to the resistor, the ammeter will measure the current that flows through the resistor, so we have

I\_a = I\_R = I

Which can then be used to calculate the voltage of the ammeter:

U\_a = I\_a \* R\_a = R\_a \* I

And thus, we can get an equation for the voltage of the resistor:

U = U\_v – R\_a \* I

**ERROR EVALUATION**

\_Draw the line of best fit to measuring points using **LEAST-SQUARE REGRESSION**

\_Draw the line that **represents the resistance from the multimeter**

\_

**QUALITATIVE CONCLUSIONS**

From the graph of long and short couplings, we can reach some conclusions:

* With long coupling, we can see that with the same current, the voltage is higher. This makes sense because, in the long coupling, the voltmeter reads the sum of voltages of the ammeter and the resistor, that’s why it has a higher voltage (this means a steeper slope for the line of best fit)
* With short coupling, the opposite phenomenon occurs. With the same current, the voltage is lower. Or, if put correctly, with the same voltage, the current is bigger. This is because the current measured by the ammeter is the sum of currents going through the voltmeter and the resistor, which makes it higher. This means a less steep slope for the line of best fit of the graph.
* Another conclusion is that, when using the large resistor, the actual resistance of the resistor is closer to the resistance we get from the long coupling. In this case, the resistance of the ammeter is much, much smaller than that of the resistor, so we can say that R\_a approx. 0, which makes the long coupling result much closer than the actual resistance.
* And from this, we can conclude that the opposite occurred with short-coupling. When we put the large resistance parallel to the voltmeter, which the resistance of the large resistor being so large, the voltmeter’s resistance can’t be considered infinite in comparison. That’s why the line from the short-coupling is much further away, compared to the line from the long-coupling.

**RESISTANCE VALUES OF RESISTORS:**

1. Large resistor:

* Color code: Green – Blue – Brown – Gold: 560 Ohm +- 5% which is +- 28 Ohm
* Multimeter: 551 Ohm +- 6 Ohm from the class error

1. Small resistor:

* Color code: Blue – Grey – Red – Gold: 6800 Ohm +- 5% which is +- 340 Ohm
* Multimeter: 6890 Ohm +- 70 Ohm from the class error