Lab 1: Basic electrical measurements (version 1.3)

WARNING:

- *Do not make voltage measurements while the multimeter is set for current measurements as this will blow the current limiting fuse.*
- *Do not turn on the power supply until you have double-checked your circuit.*
- *Do not allow the test leads to touch each other as this could cause a disastrous short circuit.*
- *Do not attempt to make a current measurement across a voltage supply as this can damage (blow fuse) in the current meter.*

Equipment:
DC Power Supply
Digital Multimeter
Circuit breadboard
Resistors & Jumper wires

Concepts:
Ohm's & Kirchhoff's Laws
Loaded Circuit: Thevetin Theorem
Voltage and Current measurements

Lab Goals
Build simple circuits. Measure voltage and current at every part of the circuit. Use Ohm's and Kirchhoff's Laws to calculate the expected voltage and current given the input voltage and measured resistors.

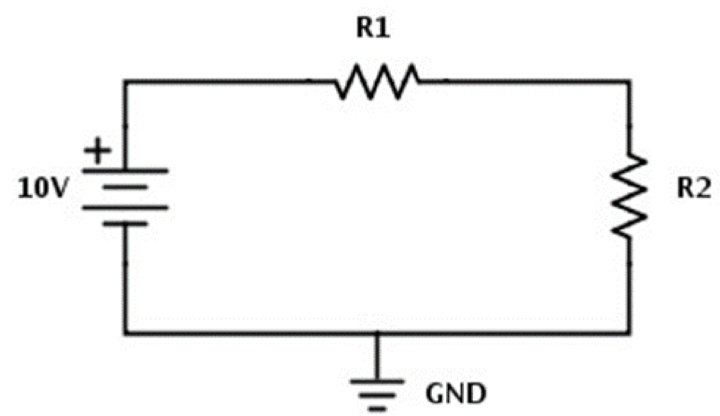
Key steps:

- Measure the resistance of each resistor before you assemble the circuit. You cannot reliably measure the resistance of individual resistors while they are part of a circuit.
- Make an estimate of the maximum power dissipated in any resistor (most of our resistors will have a ¼ W maximum power specification).
- Verify power supply voltage by measuring voltage.
- Assemble circuit on breadboard.
- Measure voltage between all points in the circuit.
- Measure current at all points in the circuit.

Elementary circuits
Select three different resistors with values in the range 300—3000 Ω. Resistance is read using the color band code described in the Appendix below. Always directly measure individual

components before placing them in a circuit, or isolated (otherwise measurements will be affected by other components in the circuit). Compare them with expected values.

Construct the circuit below (Fig 1, **Circuit 1)** in the breadboard using the resistors and a DC voltage supply. Use Ohm's and Kirchhoff's Law to calculate the current and voltages across each component. There are three sets of measurements (across R1, across R2, and across both R1 and R2). Compare with measurements. Repeat using the three variations of the resistors (there are three possible pairs of resistors out of the batch of three, ignoring the ordering).



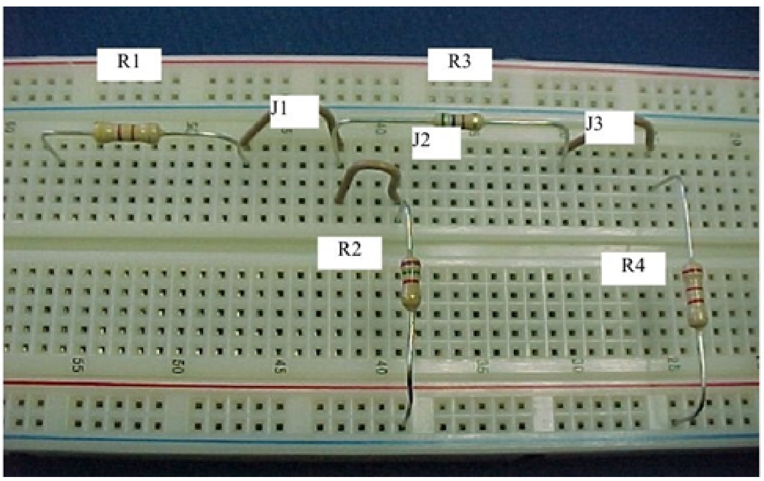


Fig. 1. (top) **Circuit 1**. (bottom) **Example** of a common resistor circuit with jumper wires.

Note: Before wiring it to the breadboard, set the voltage to the input voltage. The circuit must be in the form of a closed loop. Current flowing from the positive terminal requires a path back to the power supply negative terminal. In the circuit diagram, the negative terminal of the power supply is connected to GND (ground). Because potential (voltage) is a relative measurement, the ground point is a reference point.

DC voltage & measurements

- Measure the voltage drops across R1, R2, and R1+R2, and compare to calculated values.
- Measure the current in different points of the circuit and compare to the calculated values.
- In your notebook make a table compiling the resistor values, calculated voltage, measured voltage, calculated current, and measured current. There will be nine rows of data. Three measurement locations x three possible pairs of resistors.

WARNING: Do not make voltage measurements while the multimeter is set for current measurements as this could blow the current limiting fuse.

Note. A current measurement is distinctly different from voltage measurement and uses a different input port. A voltage measurement is made by placing the test lead across a component, i.e. the meter is in *parallel*. Current, in contrast, is measured by inserting the meter *in series*. To do this, the loop is broken open at a point and the meter is then inserted to complete the circuit.

<u>Circuit 2</u>

Construct the circuit below (Fig. 2, **Circuit 2)** using four resistors. Repeat the analysis for the following circuit:

- Make a table with the calculated values of voltage drop and current for all four resistors (8 values total).
  Build the circuit and measure the current and voltage.
- Compare the measurements with calculations.
- In your notebook make a table compiling the resistor values, calculated voltage, measured voltage, calculated current, and measured current. There will be four rows of data, one for each resistor.

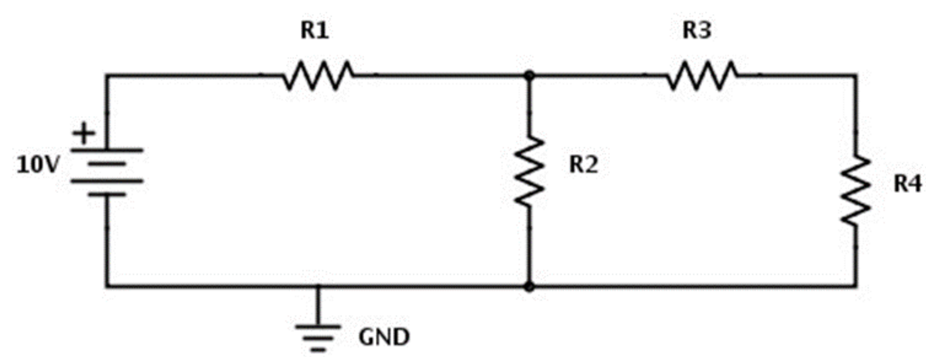
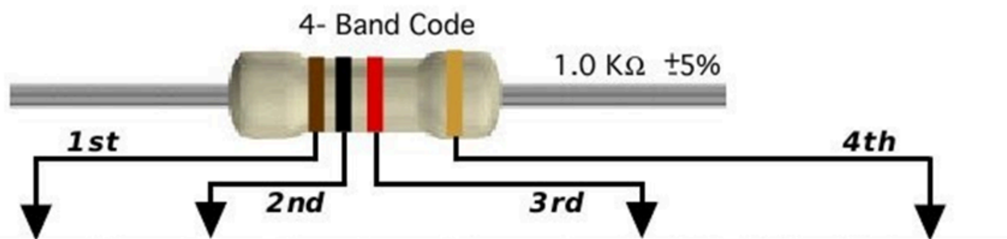


Fig. 2: **Circuit 2**.

Appendix

Manufacturers use colored bands to label resistors. The most common scheme uses 4 bands. Bands 1 and 2 specify the numerical value and Band 3 is the decimal multiplier. Band 4 indicates the production tolerance and is often offset from the other bands. Sometimes the bands are placed asymmetrically to put Band 1 in the outermost position.

In the example below, Bands 1—3 are brownblackred. This is decoded as 10 x 100 = 1000 Ω. Band 4 indicates it will have a value in the range 1000 ± 50 Ω.



Color	1st Band	2nd Band	3rd Band	Decimal Multiplier	Tolerance
Black	0	0	0	1 1	
Brown	1	1	1	10 10	± 1 %
Red	2	2	2	100 100	± 2 %
Orange	3	3	3	1K 1,000	
Yellow	4	4	4	10K 10,000	
Green	5	5	5	100K 100,000	
Blue	6	6	6	1M 1,000,000	
Violet	7	7	7	10M 10,000,000	
Gray	8	8	8	100,000,000	
White	9	9	9	1,000,000,000	
Gold				0.1	± 5 %
Silver				0.01	± 10 %
None					± 20 %