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**2 YL Physics (S3), 2024-2025**

# PW N° 1 : Measurement of Currents and Voltages

## Objectives :

- Use a voltmeter and ammeter correctly.
- Properly wiring an electrical circuit.
- Interpret the results found.

## Evaluation criteria :

- Correct wiring.
- The student's working method.
- Accuracy of results.

## Material used :

- Resistance.
- Voltage generator.
- Voltmeter, ammeter and multimeter.

## Reminder :

### 1) The electrical voltage:

It is a potential difference (d.d.p) between two points, which reflects an electrical imbalance or different electric charges, it is measured by a voltmeter.

The voltmeter is a device that connects in parallel with the component or dipole whose voltage is to be measured at its terminals. There are two types of voltmeters:

• The analog voltmeter (needle or deflection).
• The voltmeter with digital display.

The insertion of a voltmeter into a circuit generates errors in the measurement, in fact, when subjected to a voltage Uv, the voltmeter of resistance Rv consumes a current Iv such that :

$$I_V = \frac{U_V}{R_V}$$

To decrease the error, we must decrease the current Iv and consequently increase the resistance Rv. In summary, a voltmeter must have a very high resistance Rv in relation to the internal resistance of the dipole whose voltage is to be measured.

Remarks:

- A perfect voltmeter admits an infinite Rv resistance.
- To determine the resistance Rv of each caliber of an analog voltmeter, the manufacturer provides us with the specific resistance S of each device indicated in the middle of the dial expressed in Ohm per volt (Ω/V).

Example: for C = 30V, S = 20000 ➔ Rv = 20000*30 = 60KΩ.

**2) Electric current :**

Electric current results from the movement of electrical charges between two points in a branch. Its intensity reflects the flow rate of the moving charges, it is measured by an ammeter.

The ammeter is a device that is connected in series with the component(s) through which the current is to be measured. There are two types of ammeters :

• The analog ammeter (needle or deflection).
• The digital display ammeter.

The insertion of an ammeter in a circuit generates errors in the measurement in fact, crossed by a current I, the $R_A$ resistance ammeter causes a drop in voltage $U_A$ in the circuit such that :

$$\mathbf{U_A = R_A.I}$$

To decrease the error, we must decrease the UA voltage and consequently decrease the RA resistance. In summary, an ammeter must have a very small $R_A$ resistance compared to the sum of the internal resistances of the dipoles traversed by the same current to be measured.

**Note :** A perfect ammeter admits an $R_A$ resistance of zero.

**3) Evaluation of a measure :**

In the case of a digital device: whether it is a voltmeter or a digital ammeter, the measurement is read directly on the dial of the device, to be accurate you just have to choose the right caliber.

In the case of an analog device: using this type of device the measurement is not direct, to determine it, the following relationship must be applied :

$$Size = \frac{Caliber\ x\ Reading}{Scale}$$

with:

- Quantity: the quantity to be measured (voltage U or current I).
- Caliber: denoted C, this is the caliber used.
- Reading: denoted L, this is the deflection of the needle.
- Scale: denoted E, this is the scale used that corresponds to the maximum deviation.

## 4) Error Assessment :

Other than the error caused by the insertion of a device into a circuit, there are other errors that cannot be avoided, namely errors caused by the device itself and errors made by the operator.

- In the case of digital cameras: to assess the absolute uncertainty, reference must be made to the technical instructions of the device, the manufacturer mentions for each calibre (range) the relationship that must be applied. The general form of these relations is as follows :

$$\Delta G_{Measure} = X\%\ (Reading) + Y\%\ of\ points\ (Range)$$

$$\Delta G_{measure} = \frac{Measured\ value.X}{100} + \frac{Range.Y}{Total\ Points}$$

- In the case of analogue devices: the absolute uncertainty is the sum of the class uncertainty and the reading uncertainty.

$$\Delta G_{Measure} = \Delta G_{Class} + \Delta G_{Reading}$$

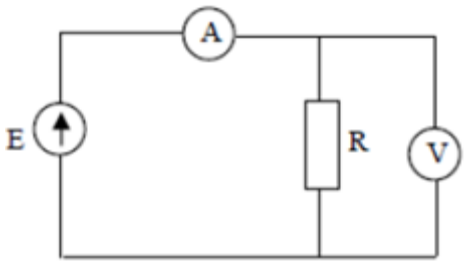
$$\Delta G_{Class} = \frac{Class.Caliber}{100}, \qquad \Delta G_{Reading} = \frac{Caliber.Estimated\ number\ of\ graduations}{Scale}$$

with:

- Class: denoted Cl, this is the class of the device indicated on the dial.
- Number of ticks: denoted n, this is the number of ticks estimated as an error value.

## Manipulation :

On considère le circuit suivant :




1) Assemble the previous circuit (the values of the resistors and emfs are set by the teacher).
2) Complete the following tables:

| E (V) | R (Ω) | I (mA) | U(V) |
|---|---|---|---|
| 5 | 1000 | | |
| 8 | 1500 | | |
| 11 | 2000 | | |
| 15 | 2500 | | |
| 20 | 3000 | | |