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People's Democratic Republic of Algeria
وزارة التعليم العالي والبحث العلمي
Ministry of Higher Education and Scientific Research
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كلية التكنولوجيا
FACULTY OF TECHNOLOGY

Faculty of Technology
Vice Deanship of Post-Graduation, Scientific Research and External Relations

كـلية التكنـــولـــوجيـــا
نيابة العمادة لما بعد التدرج والبحث العلمي والعلاقات الخارجية

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شهادة ادارية

المصادقة على تقارير خبرة للموافقة على مطبوعة بيداغوجية

بعد الإطلاع على تقارير لجنة الخبراء للموافقة على المطبوعة البيداغوجية للأستاذة : **ديلمي اسماعيل – أستاذ محاضر قسم ب** ، بالقاعدة المشتركة بكلية التكنولوجيا بجامعة محمد بوضياف بالمسيلة والتي كانت كلها ايجابية ، تمّ تقرير التّالي:

1-المصادقة على تقارير لجنة الخبراء للموافقة المطبوعة البيداغوجية والمعنونة بـــ:

Practical Work of Physics 2
Common Base ST– Cycle License

2- حيث تمّ تشكيل هذه اللجنة بناء على اجتماع المجلس العلمي للكلية المنعقد بتاريخ **2026/02/17** المكونة من السّادة الآتية أسماؤهم:

- **قرماط نوبيل،** أستاذ ، جامعة محمد بوضياف- المسيلة
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- **بومحرز فاروق،** أستاذ محاضر "أ"، جامعة 8 ماي 1945- قالمة

وتمت الموافقة بالاجماع على هذه المطبوعة.

رئيس المجلس العلمي للكلية

المجلس العلمي

د. علي جريوي

PEOPLE’S DEMOCRATIC REPUBLIC OF ALGERIA
MINISTRY OF HIGHER EDUCATION & SCIENTIFIC RESEARCH
UNIVERSITY OF MOHAMED BOUDIAF - M’SILA
FACULTY OF TECHNOLOGY
DEPARTMENT OF COMMON BASE

Practical Work of Physics 2

First Year License (LMD) Science and Technology, Common Base

Dr. Smail Dilmi

Academic Year : 2025/2026

Contents

GENERAL INTRODUCTION

Electricity is a fundamental domain of physics that deals with the study of electric charges, electric fields, and electrical circuits [1-3]. It plays a central role in modern science, engineering, and technology [4], forming the basis of countless applications ranging from power systems to electronic devices [5, 6]. As with all areas of physics, a solid understanding of electricity relies not only on theoretical knowledge but also on experimental investigation.

Practical work in electricity allows students to verify theoretical laws through direct measurement and observation. By performing laboratory experiments, students learn how to use electrical measuring instruments, assemble circuits correctly, and interpret experimental results. These activities help develop essential scientific skills such as precision in measurement, data analysis, error evaluation, and critical thinking.

This module is intended for first-year science and technology students in the common base. Its objective is to provide a strong foundation in experimental electricity by familiarizing students with basic electrical components, measuring devices, and circuit analysis techniques [7-9]. The practical sessions reinforce concepts introduced in lectures and prepare students for more advanced studies in physics, electronics, and electrical engineering.

Throughout this module, students will conduct a series of classical experiments on direct current (DC) circuits, transient phenomena, and signal analysis. The practical works include:

- Presentation and correct use of electrical measuring instruments.
- Verification of Kirchhoff’s laws (current and voltage laws).
- Application of Thévenin’s theorem in electrical networks.
- Study of the charging and discharging of a capacitor in RC circuits.
- Observation and measurement of electrical signals using an oscilloscope.

By the end of these practical works, students will strengthen their understanding of fundamental electrical principles and gain hands-on experience in experimental techniques. This practical foundation is essential for developing analytical skills and pursuing further studies in physics, electronics, and engineering.

PRACTICAL WORK N°1: PRESENTATION OF ELECTRICAL MEASURING INSTRUMENTS

1.1.Objectives

By the end of this practical work, the student will be able to:

- Identify the main electrical measuring instruments used in the laboratory.
- Understand the function and operating principle of each instrument.
- Distinguish between analog and digital measuring devices.
- Correctly connect voltmeters, ammeters, and ohmmeter in simple electric circuits.
- Use laboratory tools safely and properly.

1.2.Introduction

Electrical measurements are essential in experimental physics to analyze and verify electrical phenomena. In electrical circuits, quantities such as voltage, current, resistance, frequency, and waveform shape must be measured accurately. This practical work introduces the basic instruments used for these measurements and explains their roles in electrical experiments.

1.3.Measuring Instruments

1.3.1. Voltmeter

A voltmeter is an electrical measuring instrument used to measure the electric potential difference (voltage) between two points in an electric circuit. It is connected in parallel with the component or section of the circuit under test and is designed with a very high internal resistance to ensure that it draws negligible current and does not disturb the circuit operation. Voltage is measured in volts (V), and voltmeters can be analog or digital, and used for direct current (DC) and alternating current (AC) measurements.

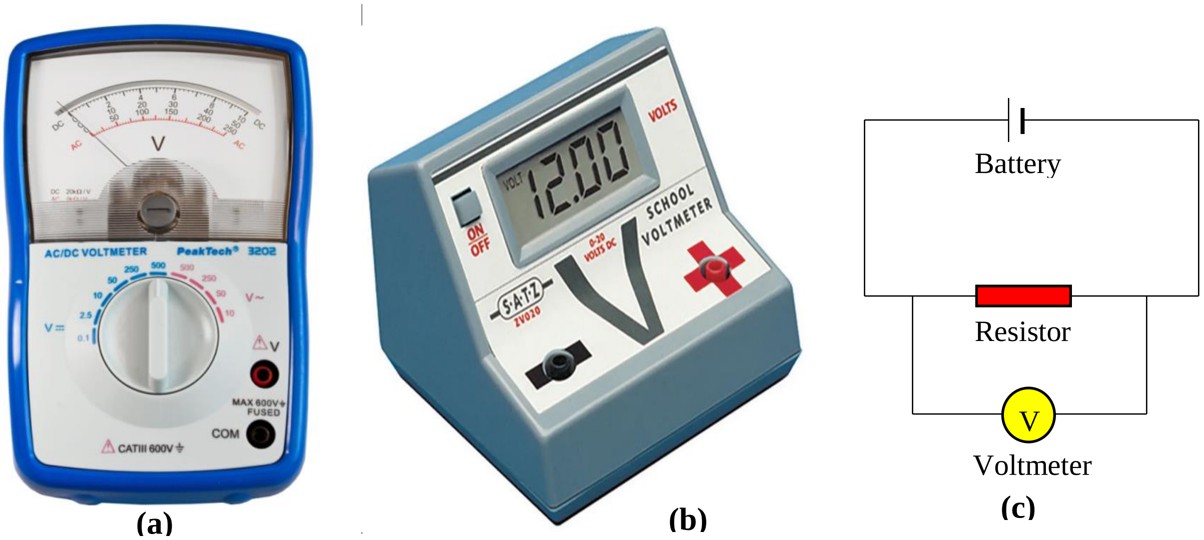


Figure 1.1. Voltmeter: (a) analog voltmeter, (b) digital voltmeter, and (c) voltmeter wiring diagram.

1.3.2. Ammeter

An ammeter is an electrical measuring instrument used to measure the electric current flowing through a circuit. It is connected in series with the circuit so that the same current passes through the instrument. An ammeter is designed with a very low internal resistance to minimize voltage drop and avoid altering the circuit behavior. The measured quantity is expressed in amperes (A), and ammeters may be analog or digital, suitable for measuring DC and AC.

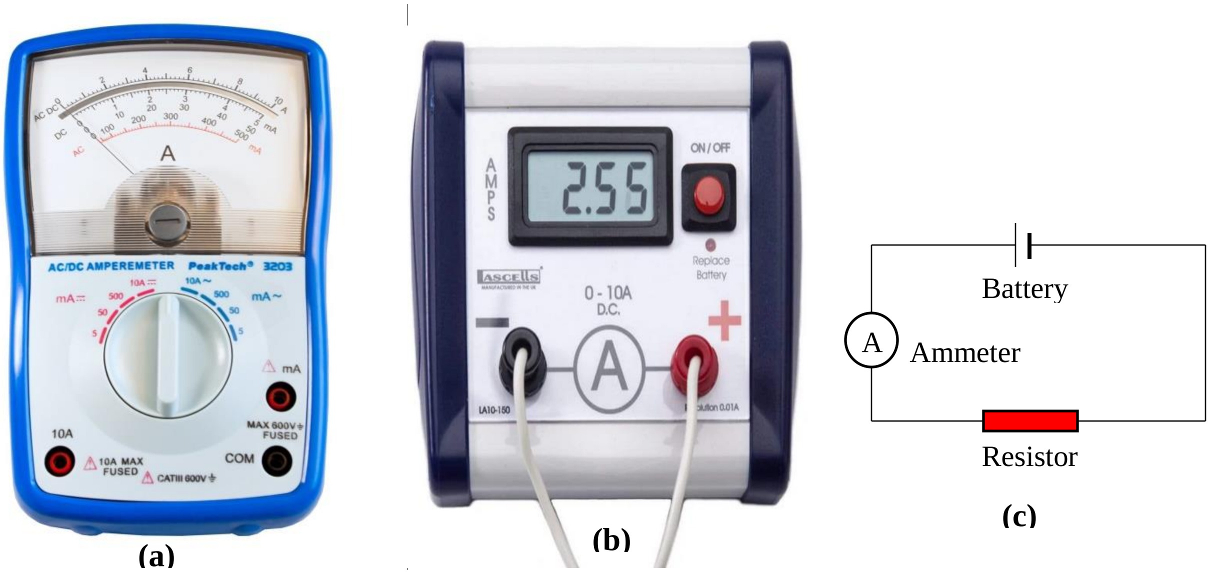
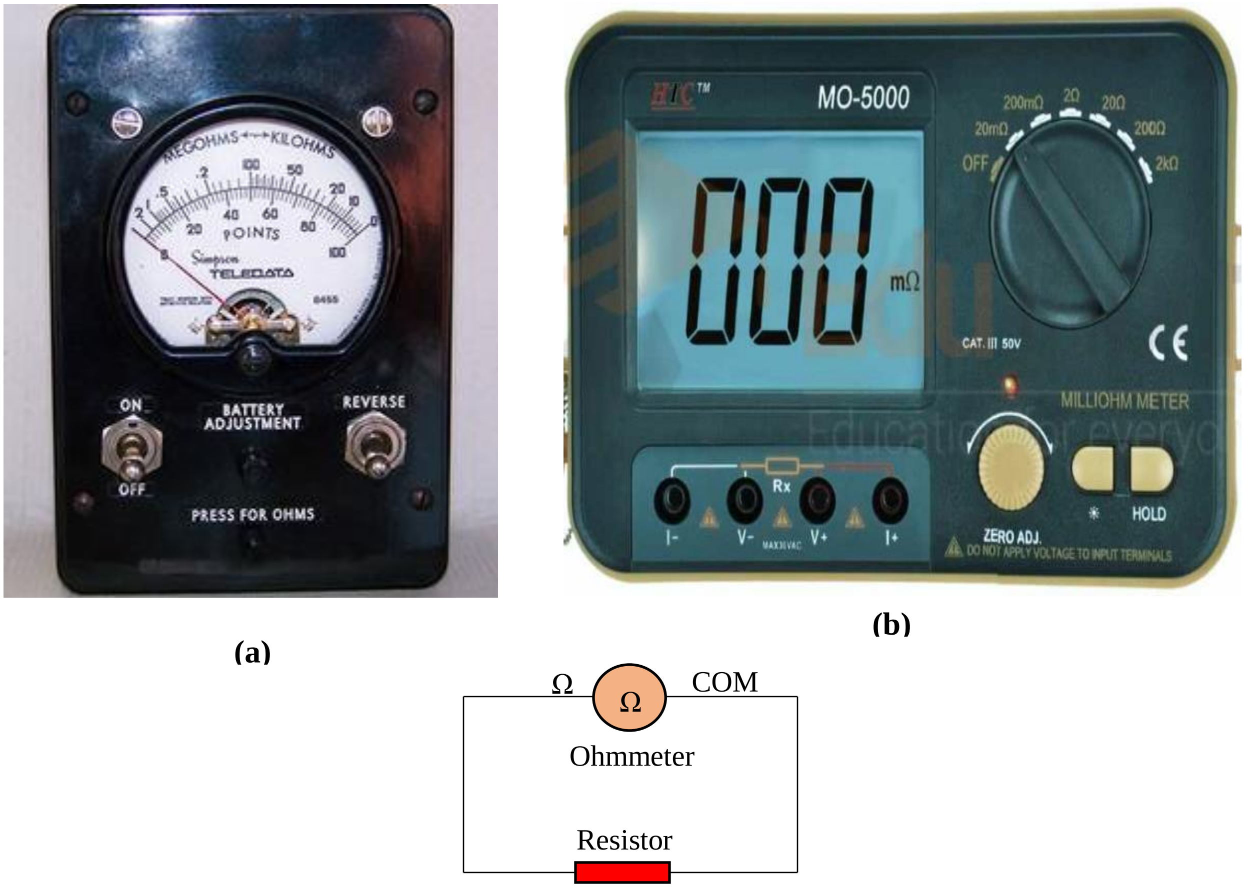


Figure 1.2. Ammeter: (a) analog ammeter, (b) digital ammeter, and (c) ammeter wiring diagram.

1.3.3. Ohmmeter

An ohmmeter is an electrical measuring instrument used to measure the electrical resistance of a component or conductor. It operates by applying an internal voltage source to the component and measuring the resulting current to determine resistance according to Ohm's law. Resistance is expressed in ohms (Ω). An ohmmeter must be connected across (in parallel with) the component being tested, and the circuit must be powered off during measurement to avoid damage and inaccurate readings.



(b)

(a)

(c)

Figure 1.3. Ohmmeter: (a) analog ohmmeter, (b) digital ohmmeter, and (c) ohmmeter wiring diagram.

1.3.4. Multimeter

A multimeter is a versatile electrical measuring instrument that combines several measurement functions in a single device. It is used to measure voltage (AC/DC), electric current (AC/DC), and resistance, and may also measure additional quantities such as continuity, capacitance, and diode characteristics. Multimeters can be analog or digital, with digital multimeters being the most commonly used due to their accuracy and ease of use. They are essential tools for circuit testing, troubleshooting, and laboratory experiments in physics and electronics.

(a) **(b)**

Figure 1.4. Multimeter: (a) analog multimeter and (b) digital multimeter.

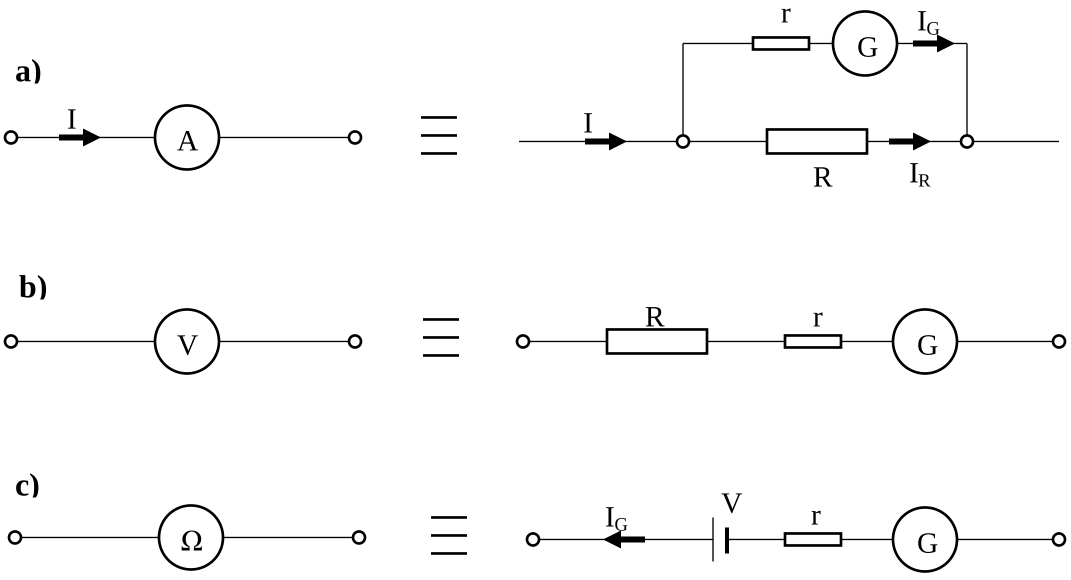


Figure 1.5. The three operating modes of a multimeter: (a) ammeter, (b) voltmeter, and (c) ohmmeter.

The figure 1.5 illustrates the three operating modes of a multimeter, which correspond to its use as an ammeter, voltmeter, and ohmmeter. Each mode is obtained by changing the internal connections of the multimeter.

a) Ammeter Mode (Current Measurement)

In ammeter mode, the multimeter measures the electric current flowing in a circuit.

- **Principle:**
  The multimeter contains a sensitive galvanometer G with a small internal resistance r. A shunt resistor (R) is connected in parallel with the galvanometer so that most of the current flows through the shunt, protecting the meter.

b) Voltmeter Mode (Voltage Measurement)

In voltmeter mode, the multimeter measures the potential difference between two points.

- **Principle:**
  A large series resistance (R) is added in series with the galvanometer G and its internal resistance r. This limits the current through the meter when measuring voltage.

c) Ohmmeter Mode (Resistance Measurement)

In ohmmeter mode, the multimeter measures the electrical resistance of a component.

- Principle:
  The multimeter uses an internal voltage source (battery). The current flowing through the unknown resistance is measured by the galvanometer G, and the resistance is deduced.

1.3.5. Oscilloscope

An oscilloscope is an electronic measuring instrument used to visualize and analyze electrical signals by displaying voltage as a function of time on a screen. It allows observation of signal waveform shape, and measurement of key parameters such as amplitude, period, frequency, phase difference, and time intervals. Oscilloscopes are widely used to study AC signals, transient phenomena, and signal behavior in electronic circuits. They can be analog or digital, and are essential tools for signal analysis and troubleshooting in physics and electronics laboratories.

(a)

(b)

Figure 1.6. Oscilloscope: (a) analog oscilloscope and (b) digital oscilloscope.

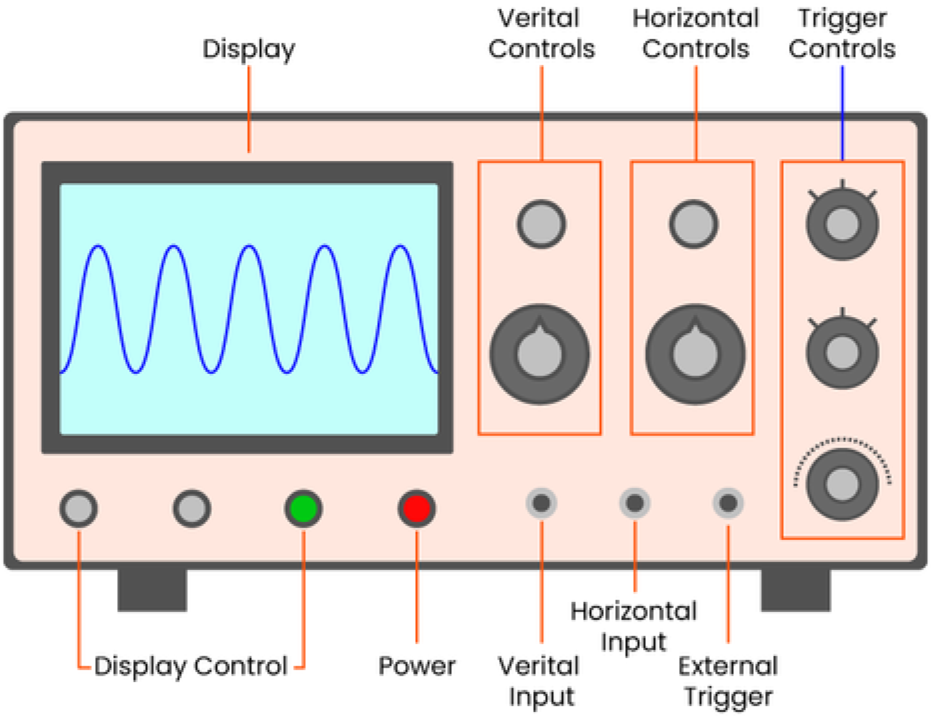


Figure 1.7. Layout of the oscilloscope controls.

1.3.6. Signal Generator (Function Generator)

A signal generator, also known as a function generator, is an electronic instrument used to produce electrical signals of various waveforms for testing and analyzing electronic and electrical circuits. It can generate common waveforms such as sine, square, and triangular waves, with adjustable frequency, amplitude, and offset. Signal generators are essential for studying AC circuit behavior, frequency response, and dynamic characteristics of systems in physics and electronics laboratories.

Figure 1.8. Signal Generator (Function Generator).

1.4.Safety Instructions

- Always check connections before powering the circuit.
- Do not touch live circuits with bare hands.
- Use appropriate ranges on measuring instruments.
- Switch off the power before modifying the circuit.

1.5.Experimental Tasks

1- Identify each instrument available in the laboratory.
2- Write down the measurement range each device.
3- Practice correct connection of voltmeter, ammeter, and ohmmeter in a simple circuit.
4- Observe signal waveforms using the oscilloscope and generator.

Questions

1) Why must a voltmeter have a high internal resistance?

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2) What happens if an ammeter is connected in parallel?

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3) State two differences between analog and digital instruments.

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1.6.Conclusion

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PRACTICAL WORK N°2: VERIFICATION OF KIRCHHOFF'S LAWS (MESH LAW AND KNOT LAW)

2.1.Objectives

By the end of this practical work, the student will be able to:

- Understand and state Kirchhoff's Current Law (KCL) and Kirchhoff's Voltage Law (KVL).
- Apply Kirchhoff's laws to simple DC electrical circuits.
- Measure currents and voltages using electrical measuring instruments.
- Compare theoretical calculations with experimental results.

2.2.Basic Concepts

Kirchhoff's laws are fundamental principles used to analyze complex electrical circuits. They are based on the conservation of charge and energy.

2.2.1. Kirchhoff's Current Law (KCL) – Knot Law

Kirchhoff's Current Law states that the sum of the intensities of the currents entering a node is equal to the sum of the intensities of the currents leaving the node.

$$\sum I_{in} = \sum I_{out} \qquad (2.1)$$

This law is a direct consequence of the conservation of electric charge.

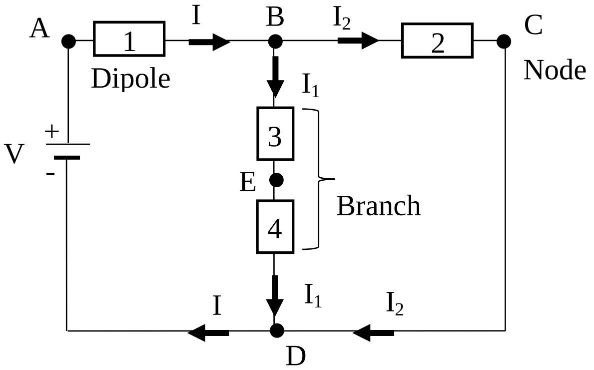

Figure 2.1. Example Kirchhoff's Current Law.

The dipoles in the same branch are traversed by an electric current of the same intensity. A node is a point of intersection of several branches.

A current of intensity I_1 flows through dipoles 3 and 4 of branch *BED*. At node *B* or node *D*: $I = I_1 + I_2$.

2.2.2. Kirchhoff's Voltage Law (KVL) – Mesh Law

Kirchhoff's Voltage Law states that the algebraic sum of all voltages around any closed loop in a circuit is zero.

$$\sum V = 0 \qquad (2.2)$$

This law is based on the conservation of energy.

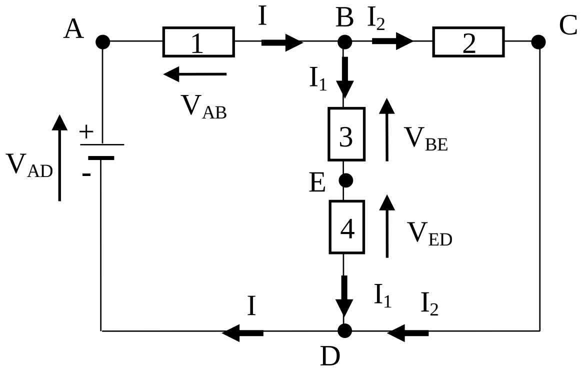

Figure 2.2. Example Kirchhoff's Voltage Law.

Within the *ABED* network, the law is expressed: $V_{AD}-V_{AB}-V_{BE}-V_{ED} = 0$.

And consequently: $V_{AD} = V_{AB}+V_{BE}+V_{ED}$.

2.3.Theoretical Preparation

a. Exercise 1: Kirchhoff's Current Law

A current source supplies a total current of I = 1.5 A to three parallel branches.

- $I_1 = 0.4$ A
- $I_2 = 0.6$ A

Questions:

1) Draw the circuit and indicate the direction of the currents.
2) Using KCL, determine the current I_3.

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3) Verify that Kirchhoff's Current Law is satisfied.

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b. Exercise 2: Kirchhoff's Voltage Law

A closed loop contains:

- A voltage source E = 12 V.
- Two resistors $R_1 = 4\ \Omega$ and $R_2 = 2\ \Omega$.

Questions:

1) Draw the loop and indicate current direction.
2) Write the KVL equation.

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3) Calculate the loop current.

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4) Verify that Kirchhoff's Voltage Law is satisfied.

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2.4.Manipulation

2.4.1. Apparatus and Components

- DC power supply.
- Two Resistors ($R_1 = 1.5\ k\Omega$ and $R_2 = 1.2\ k\Omega$).
- Multimeter.
- Breadboard.
- Connecting wires.
- Switch.

2.4.2. Experiment 1: Verification of Kirchhoff's Current Law

1- Assemble the circuit as shown in the figure 2.3.
2- Set the DC power supply to a 12 (V).
3- Close the switch.
4- Measure the total current.
5- Measure the current in each branch.

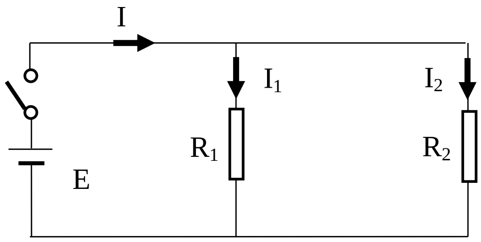

Figure 2.3. Circuit to Verify Kirchhoff's Current Law.

Questions:

1) Complete the table 2.1.

Table 2.1. Current Measurements.

Current	I	I_1	I_2
Experimental			
Theoretical			
$Error\ (\%) \ = \frac{\lvert I_{Theoretical} - I_{Exp} \rvert}{I_{Theoretical}}$			

2) Compare experimental values with theoretical calculations.

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3) Verify Kirchhoff's Current Law.

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2.4.3. Experiment 2: Verification of Kirchhoff's Voltage Law

1- Assemble the circuit as shown in the figure 2.4.
2- Close the switch.
3- Measure the supply voltage.
4- Measure the voltage drop across each resistor.

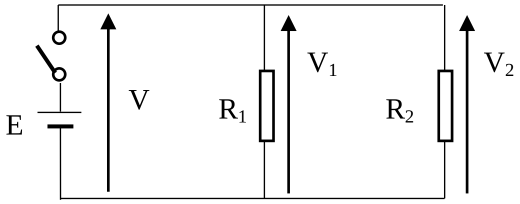

Figure 2.4. Circuit to Verify Kirchhoff's Voltage Law.

Questions:

1) Complete the table 2.2.

Table 2.2. Voltage Measurements.

Voltage	V	V_1	V_2
Experimental			
Theoretical			
$Error\ (\%)\ = \frac{\lvert V_{Theoretical} - V_{Exp} \rvert}{V_{Theoretical}}$			

2) Compare experimental values with theoretical calculations.

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3) Verify Kirchhoff's Voltage Law.

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2.5.Conclusion

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PRACTICAL WORK N°3:
THÉVENIN’S THEOREM

3.1.Objectives

By the end of this practical work, the student will be able to:

- Understand the concept of Thévenin’s theorem.
- Determine the Thévenin equivalent voltage and Thévenin equivalent resistance.
- Replace a complex linear circuit by its Thévenin equivalent.
- Verify experimentally that the load current and voltage remain unchanged.

3.2.Basic Concepts

3.2.1. Thévenin’s Theorem

Any linear electrical circuit containing sources and resistors can be replaced by an equivalent circuit consisting of a single voltage source V_{Th} in series with a resistance R_{Th}, as seen from two terminals.

Take for example the setup in the figure 3.1 (a):

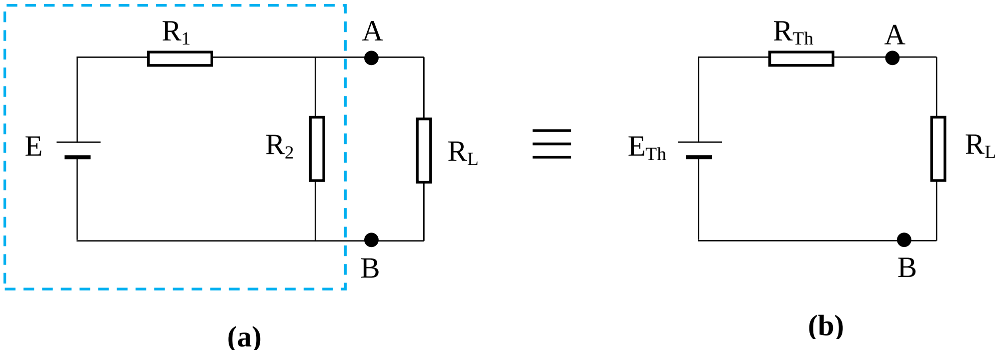

Figure 3.1. Example of application of Thévenin’s theorem: (a) Original circuit, (b) Thévenin equivalent circuit.

The original circuit (figure 3.1 (a)) consists of:

- A DC voltage source E.
- Two resistors inside the dashed box R_1 and R_2.
- A load resistor R_L connected between terminals *A* and *B*.

According to Thévenin’s theorem the electrical network inside the dashed box (source E, resistors R_1 and R_2) can be replaced, as seen from terminals *A*–*B*, by a single voltage source V_{Th}

in series with a single resistance R_{Th} (figure 3.1 (b)). This equivalent circuit produces the same voltage and current in the load resistor R_L as the original circuit.

3.2.2. Determination of the Thévenin Voltage V_{Th}

The Thévenin voltage is the open-circuit voltage across terminals *A*–*B*.

Procedure:

- Disconnect the load resistor R_L.
- No current flows through terminals *A*–*B*.
- The voltage measured between *A* and *B* is the Thévenin voltage: $V_{Th} = V_{AB}$.

Since R_1 and R_2 form a voltage divider:

$$V_{Th} = E\frac{R_2}{R_1+R_2} \tag{3.1}$$

3.2.3. Determination of the Thévenin Resistance R_{Th}

Procedure:

1. Deactivate the independent source:
    - Replace the voltage source E with a short circuit.
2. Observe the resistance seen from terminals *A*–*B*.

Equivalent Resistance:

With the source short-circuited:

- R_1 and R_2 are in parallel.

$$R_{Th} = \frac{R_1R_2}{R_1+R_2} \tag{3.2}$$

3.2.4. Load Current Using the Thévenin Equivalent

Once the load R_L is connected:

$$I_L = \frac{V_{Th}}{R_{Th}+R_L} \tag{3.3}$$

This current is identical to the current obtained using the original circuit.

3.3.Theoretical Preparation

Consider the electrical circuit shown in the figure 3.2, which consists of:

- A DC voltage source E = 15 V.
- Three resistors R_1 = 4.4 kΩ, R_2 = 8.2 kΩ, and R_3 = 3.3 kΩ.
- A load resistor R_L = 4.7 kΩ.

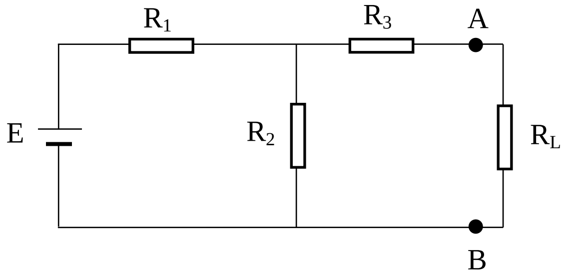

Figure 3.2. Example electrical circuit used for Thévenin's theorem analysis.

Questions:

1) Draw the Thévenin equivalent circuit.
2) Prove that the formula of E_{Th} is given by the following expression: $E_{Th} = E.\frac{R_2}{R_1+R_2}$.

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3) Prove that the formula of R_{Th} is given by the following expression: $R_{Th} = R_3 + \frac{R_1 R_2}{R_1+R_2}$.

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4) Calculate E_{Th} and R_{Th}.

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5) Calculate the load current I_L.

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3.4.Manipulation

3.4.1. Apparatus and Components

- DC power supply: 12 V.
- Four Resistors: $R_1 = R_2 = R_3 = R_4$ = 1 kΩ.
- Load Resistor: R_L = 1 kΩ.
- Multimeter.
- Breadboard.

- Connecting wires.

Part A: Original Circuit Measurements

1- Assemble the circuit as shown in the figure 3.3.

2- Measure and record the load current I_L:

I_L = ……………………………………………………………….

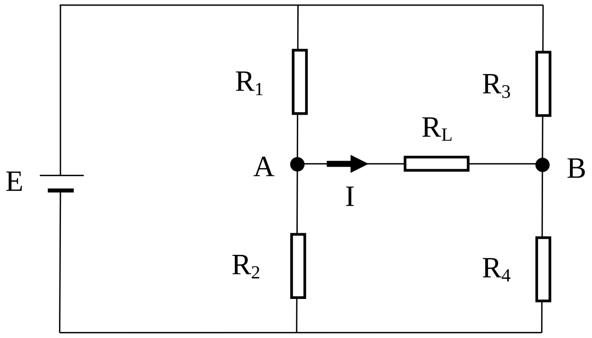

Figure 3.3. Original circuit.

Part B: Determination of Thévenin Voltage V_{Th}

1- Disconnect the load resistor R_L.

2- Measure the voltage between terminals *A* and *B*.

3- Record this value as:

$V_{Th\_exp} = V_{AB}$ = …………………………………………………

Part C: Determination of Thévenin Resistance R_{Th}

1- Turn OFF the power supply.

2- Replace the voltage source E with a short circuit.

3- Measure the equivalent resistance seen from terminals *A*–*B* using the multimeter.

4- Record this resistance as:

R_{Th_exp} = ……………………………………

Part D: Thévenin Equivalent Circuit

1- Assemble the circuit as shown in the figure 3.4.

2- Measure and record the load current I'_L:

I'_L = ……………………………………………

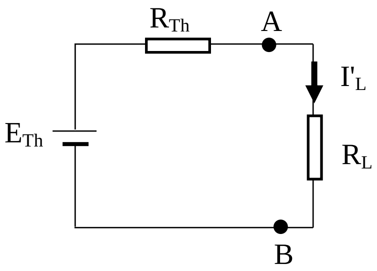

Figure 3.4. Thévenin equivalent circuit.

Questions:

1) Prove that the theoretical formula for E_{Th} is given by the following expression: $E_{Th\_\text{theoretical}} = E\left(\frac{R_2}{R_1+R_2} - \frac{R_4}{R_3+R_4}\right)$.

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2) Calculate the theoretical value of E_{Th} and compare it with the experimental value.

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3) Prove that the theoretical formula for R_{Th} is given by the following expression: $R_{Th\_\text{theoretical}} = \frac{R_1 R_2}{R_1+R_2} + \frac{R_3 R_4}{R_3+R_4}$.

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4) Calculate the theoretical value of R_{Th} and compare it with the experimental value.

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5) Compare the current I_L measured in the original circuit and the current I'_L measured in the Thévenin equivalent circuit.

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6) Is Thévenin's theorem satisfied?

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3.5.Conclusion

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PRACTICAL WORK N°4:
CHARGING AND DISCHARGING OF A CAPACITOR

4.1.Objectives

By the end of this practical work, the student will be able to:

- Study the charging and discharging process of a capacitor in an RC circuit.
- Determine experimentally the time constant (τ = R·C) of the circuit.
- Observe and record the voltage across the capacitor as a function of time.

4.2.Basic Concepts

A capacitor is an electrical component that stores energy in an electric field. Its basic relationship is:

$$Q = C.V \qquad (4.1)$$

Where Q is the charge stored in the capacitor (Coulombs), C is the capacitance (Farads), and V is the voltage across the capacitor (Volts).

The current flowing into a capacitor is related to the rate of change of voltage:

$$I = C\frac{dV}{dt} \qquad (4.2)$$

4.2.1. Charging of a Capacitor

Consider the series circuit (figure 4.1). The capacitor is initially discharged. To charge the capacitor, we supply the circuit with electrical current by turning the switch to position 1.

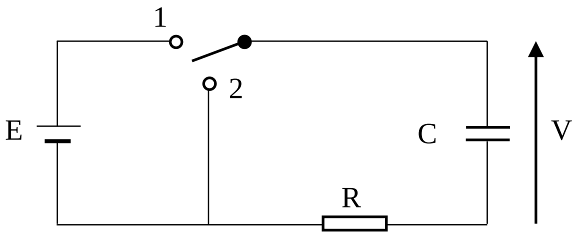

Figure 4.1. Electrical circuit for studying the charging and discharging of a capacitor.

By Kirchhoff’s voltage law:

$$E = V_R + V_C \qquad (4.3)$$

Where $V_R = R.I$ is the voltage across resistor and $V_C = {}^{Q}/_{C}$ is the voltage across capacitor.

Since $I = \frac{dQ}{dt}$, we can write:

$$E = R.\frac{dQ}{dt} + \frac{Q}{C} \qquad (4.4)$$

This is a first-order linear differential equation:

$$\frac{dQ}{dt} + \frac{1}{RC}Q = \frac{E}{R} \qquad (4.5)$$

Solution:

$$Q(t) = CE\left(1 - e^{-t/\tau}\right) \qquad (4.6)$$

Where $\tau = RC$ is the time constant.

The voltage across the capacitor is:

$$V_C(t) = \frac{Q(t)}{C} = E\left(1 - e^{-t/\tau}\right) \qquad (4.7)$$

- $V_C(0) = 0$ (initially uncharged).
- $V_C(\infty) = E$ (fully charged).

The current during charging:

$$I(t) = \frac{dQ}{dt} = \frac{E}{R}e^{-t/\tau} \qquad (4.8)$$

- Maximum current at $t = 0$: $I_{max} = E/R$.
- Exponentially decreases to zero as $t \to \infty$.

4.2.2. Discharging of a Capacitor

When a charged capacitor is disconnected from the voltage source and connected through resistor R by turning the switch to position 2, the capacitor discharges.

By Kirchhoff’s voltage law:

$$V_R + V_C = 0 \Rightarrow I.R + V_C = 0 \qquad (4.9)$$

Since $I = \frac{dQ}{dt}$ and $V_C = {}^{Q}/_{C}$:

$$R.\frac{dQ}{dt} + \frac{Q}{C} = 0 \Rightarrow \frac{dQ}{dt} = -\frac{Q}{RC} \qquad (4.10)$$

Solution:

$$Q(t) = Q_0 e^{-t/\tau} \qquad (4.11)$$

$$V_C(t) = \frac{Q(t)}{C} = Ee^{-t/\tau} \qquad (4.12)$$

- $V_C(0) = E$ (initial voltage).
- $V_C(\infty) = 0$ (fully discharged).

Current during discharging:

$$I(t) = \frac{dQ}{dt} = -\frac{E}{R}e^{-t/\tau} \qquad (4.13)$$

- Maximum current at $t = 0$: $I_{max} = -E/R$.
- Exponentially decreases to zero as $t \to \infty$.

4.3.Theoretical Preparation

a. Exercise 1: Charging Process

An RC circuit consists of a resistor R = 2 kΩ and a capacitor C = 220 µF, connected to a DC source E = 12 V.

Questions:

1) Write the expression of the capacitor voltage $V_C(t)$ during charging.

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2) Prove that at $t = \tau$ the capacitor voltage $V_C(t) = 0.63E$.

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3) Prove that the relationship between $t_{\frac{1}{2}}$ and τ given by the following expression: $t_{\frac{1}{2}} = \tau \ln(2)$.

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4) Calculate the capacitor voltage at $t = \tau$, $t = t_{\frac{1}{2}}$, and $t = 5\tau$.

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5) Determine the time required for the capacitor to reach 90% of its final voltage.

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6) Plot the graph $V_C(t)$ vs. t.

b. Exercise 2: Discharging Process

The capacitor in Exercise 1 is fully charged to 12 V, then disconnected from the source and allowed to discharge through the resistor.

1) Write the expression of the capacitor voltage $V_C(t)$ during discharging.

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2) Prove that at $t = \tau$ the capacitor voltage $V_C(t) = 0.37E$.

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3) Calculate the capacitor voltage at $t = \tau$, $t = t_{\frac{1}{2}}$, and $t = 5\tau$.

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4) Determine the time at which the capacitor voltage becomes 3V.

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5) Plot the graph $V_C(t)$ vs. t.

4.4. Manipulation

4.4.1. Apparatus and Components

- DC power supply: 12 V.
- Capacitor: C = 1 μF.
- Resistor: R = 10 MΩ.
- Multimeter.
- Switch.
- Breadboard.
- Connecting wires.
- Stopwatch.

4.4.2. Charging the Capacitor

1- Assemble the circuit as shown in the figure 4.1.

2- Close the switch to start charging.

3- Measure the voltage across the capacitor at regular interval (every 10 s).

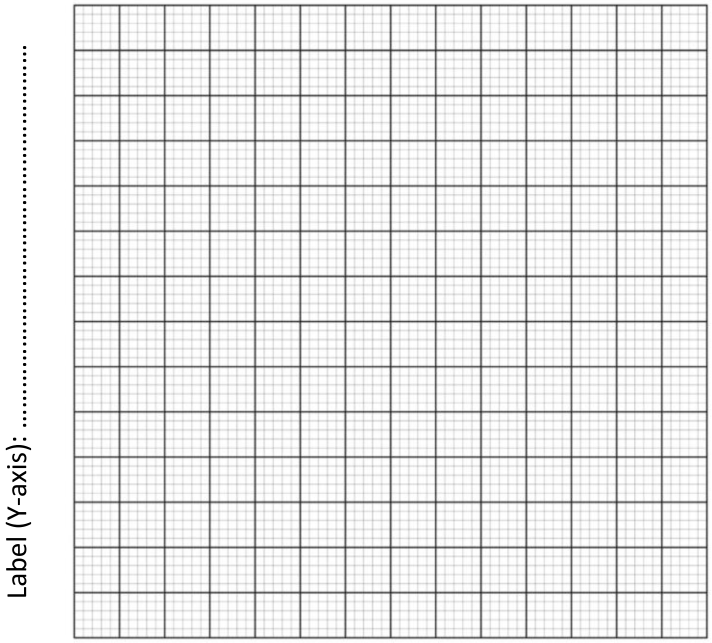
Table 4.1. Voltage during charging.

t(s)	0	10	20	30	40	50	60	70	80
V_C(V)									

Questions:

1) Complete the table 4.1.
2) Plot the graph $V_C(t)$ vs. t (Figure below).

Title: ……………………………………………………



Label (X-axis): ……………………………………………………

3) Determine the time constant experimentally $\left(\tau_{exp}\right)$ using the formula: $\tau = t$ which $V_C = 0.63E$.

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4) Calculate the theoretical time constant $\tau_{theoretical} = RC$.

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5) Calculate the relative error of τ and compare the experimental and theoretical values.

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4.4.3. Discharging the Capacitor

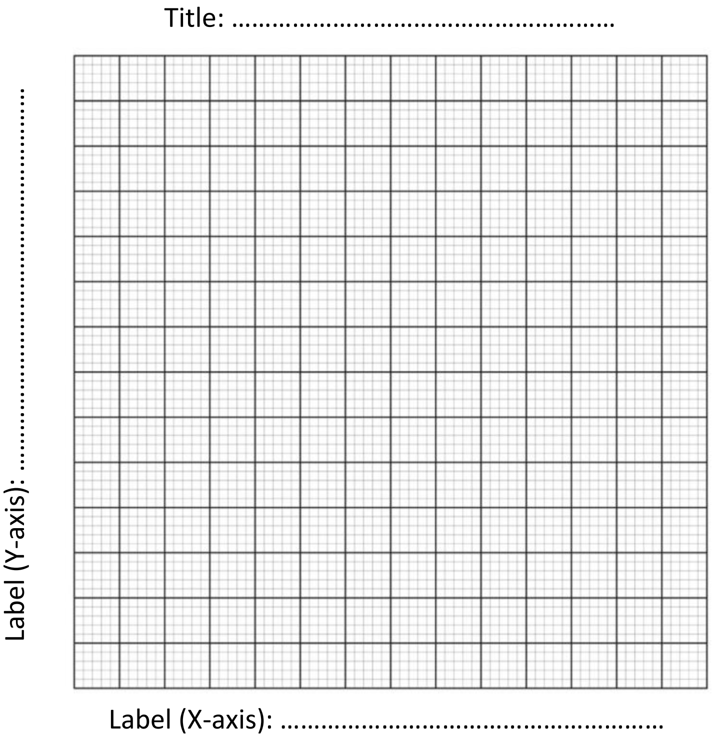
1- After the capacitor is fully charged, disconnect the DC source.
2- Close the switch across R and C to allow discharging.
3- Measure the voltage across the capacitor at regular interval (every 10 s).

Table 4.2. Voltage during discharging.

t(s)	0	10	20	30	40	50	60	70	80
V_C(V)									

Questions:

1) Complete the table 4.2.
2) Plot the graph $V_C(t)$ vs. t (Figure below).



3) Determine the time constant experimentally (τ_{exp}) using the formula: $\tau = t$ which $V_C = 0.37E$.

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4) Calculate the theoretical time constant $\tau_{theoretical} = RC$.

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5) Calculate the relative error of τ and compare the experimental and theoretical values.

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4.5.Conclusion

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PRACTICAL WORK N°5:
OSCILLOSCOPE

5.1.Objectives

By the end of this practical work, the student will be able to:

- Become familiar with the basic operation of an oscilloscope.
- Observe electrical signals in the time domain.
- Measure signal parameters such as amplitude, period, frequency, and phase difference.
- Understand the effect of oscilloscope controls on signal display.

5.2.Basic Concepts

5.2.1. What is an Oscilloscope?

An oscilloscope is an electronic instrument used to visualize and analyze electrical signals. It displays the signal voltage as a function of time.

- Vertical axis (Y-axis): Voltage (V).
- Horizontal axis (X-axis): Time (s).

5.2.2. General Presentation of the Oscilloscope

Figure 5.1 shows the front panel of an oscilloscope. The front panel is divided into the display, vertical, horizontal, and triggering control sections.

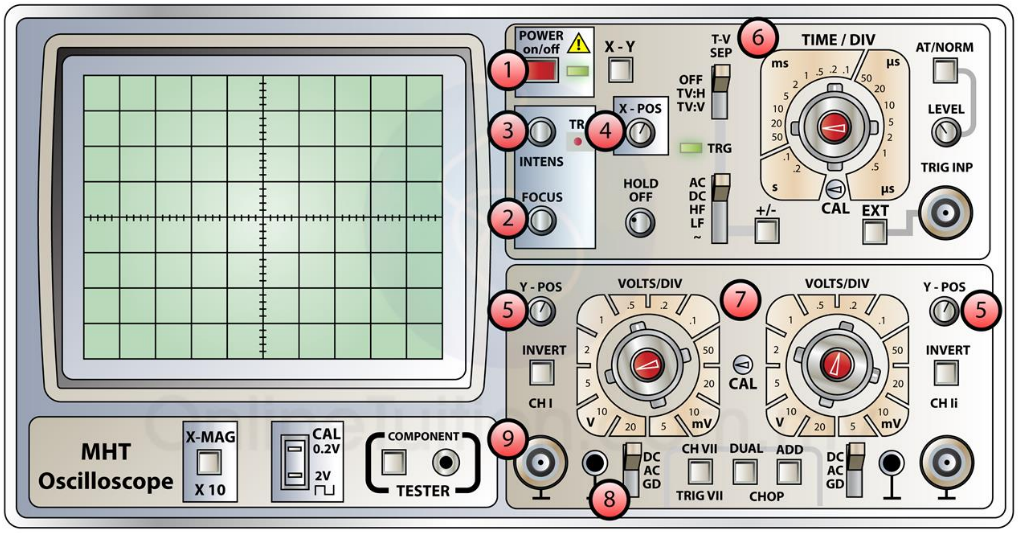
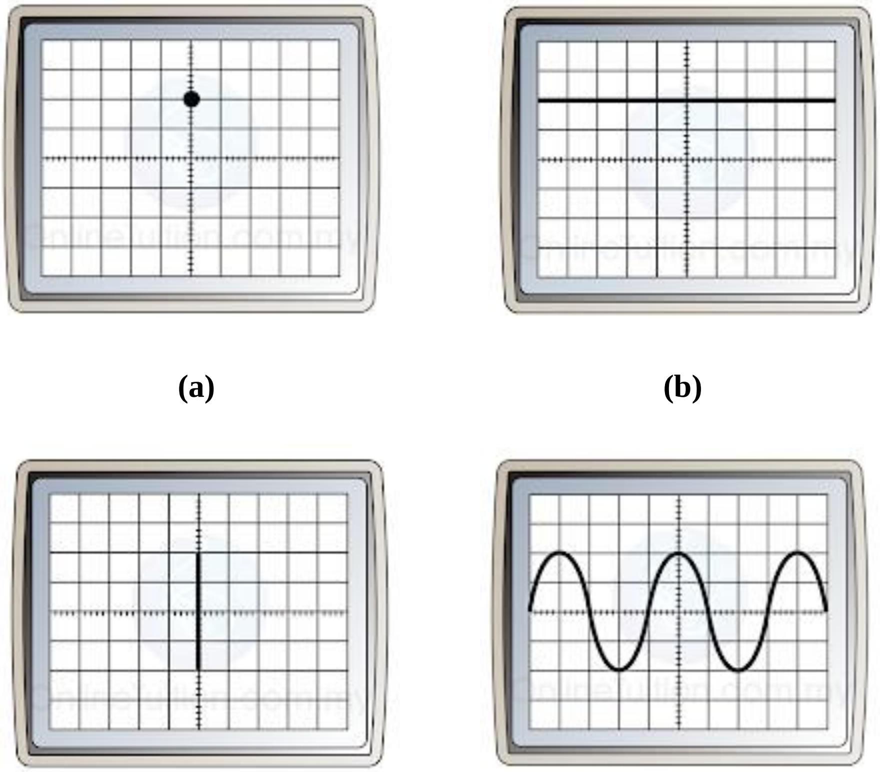


Figure 5.1. The front panel of an oscilloscope.

1- Power ON/OFF

This switch turns the oscilloscope ON or OFF. When powered ON, the cathode ray tube is activated and the screen becomes illuminated. Figure 5.2 shows an example of displaying direct current (DC) and alternating current (AC) when the time base is switched ON and OFF.



(a) **(b)**

(c) **(d)**

Figure 5.2. shows an example of displaying direct current (DC) and alternating current (AC) when the time base is switched ON and OFF: (a) Direct Current (Time Base Switched OFF), (b) Direct Current (Time Base Switched ON), (c) Alternating Current (Time Base Switched OFF), and (d) Alternating Current (Time Base Switched ON).

2- Focus Control

Adjusts the sharpness of the trace on the screen. Proper focusing ensures a thin and clear waveform.

3- Intensity Control

Controls the brightness of the trace on the screen. Excessive intensity should be avoided to prevent damage to the phosphor screen.

4- Horizontal Position (X-POS)

Moves the displayed waveform horizontally (left or right) on the screen without changing its shape.

5- Vertical Position (Y-POS)

Adjusts the vertical position of the waveform (up or down) for each channel independently.

6- Time/DIV (Time Base Control)

Sets the horizontal scale of the display, i.e., the time represented by one horizontal division (s/div, ms/div, or µs/div). It determines how fast the trace sweeps across the screen.

7- Volts/DIV (Vertical Sensitivity Control)

Adjusts the vertical scale of the signal. It determines the voltage corresponding to one vertical division (V/div or mV/div).

8- Input Coupling Selector (AC / DC / GND)

Selects the type of input coupling:

- DC: Displays both AC and DC components.
- AC: Blocks the DC component and displays only AC variations.
- GND: Disconnects the signal and grounds the input to set the reference level.

9- BNC input connector of Channel (CH)

The input terminal where the probe is connected to the circuit under test. The measured signal enters the oscilloscope through this connector.

10- Additional Functional Blocks

- **Trigger Controls:** Used to stabilize the waveform by synchronizing the sweep with the input signal.

- **X–Y Mode:** Allows one channel to control horizontal deflection and the other vertical deflection.
- **Calibration Output (CAL):** Provides a known reference signal for probe calibration.
- **Channel Selection (CH I / CH II / DUAL / ADD):** Determines how one or both channels are displayed.

5.2.3. Signal Parameters

- **Peak-to-Peak Voltage**

$$V_{pp} = V_{max} - V_{min} \qquad (5.1)$$

- **Amplitude**

$$V_{max} = \frac{V_{pp}}{2} \qquad (5.2)$$

- **The effective value of a voltage**
  - **Sinusoidal voltage:**

$$V_{eff} = \frac{V_{max}}{\sqrt{2}} \qquad (5.3)$$

  - **Square Wave Voltage:**

$$V_{eff} = V_{max} \qquad (5.4)$$

  - **Triangular Wave Voltage:**

$$V_{eff} = \frac{V_{max}}{\sqrt{3}} \qquad (5.5)$$

- **Period**

$$T = Number\ of\ divisions \times (Time/Div) \qquad (5.6)$$

- **Frequency**

$$f = \frac{1}{T} \qquad (5.7)$$

- **Phase Shift (Two Signals)**

$$\Delta\varphi = \frac{\Delta t}{T} \times 360^{\circ} \qquad (5.8)$$

5.3.Theoretical Preparation

a. Exercise 1

An oscilloscope screen has 10 horizontal divisions and 8 vertical divisions.

Questions:

1) If the time base is set to 2 ms/div, determine the total time displayed on the screen.

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2) If a sinusoidal signal occupies 5 horizontal divisions for one period, calculate its period and frequency.

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3) If the vertical sensitivity is 1 V/div and the peak-to-peak height is 6 divisions, calculate V_{pp} and V_{max}.

……………………………………………………………………………………………

b. Exercise 2

Two sinusoidal signals of the same frequency are displayed on an oscilloscope.

1) Write the relation between the phase shift φ, the period T, and the time delay Δt.

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2) If the period is 4 ms and the measured delay is 0.5 ms, calculate the phase shift in degrees.

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3) Indicate whether the second signal is leading or lagging the first one.

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5.4.Manipulation

5.4.1. Apparatus and Components

- Oscilloscope (2 channels).
- Function Generator (GBF).
- Oscilloscope Probes (×1 / ×10).
- Voltmeter.
- Connecting cables.

- Switch.
- Breadboard.

5.4.2. Experiment 1

1- Assemble the circuit as shown in the figure 5.3.

2- Set the function generator to generate a sinusoidal signal:

  - Frequency: 1 kHz
  - Amplitude: 2 Vpp

3- Adjust:

  - Volts/Div
  - Time/Div
  - Trigger settings

4- Display a stable waveform.

5- Repeat steps for:

  - Square wave
  - Triangular wave

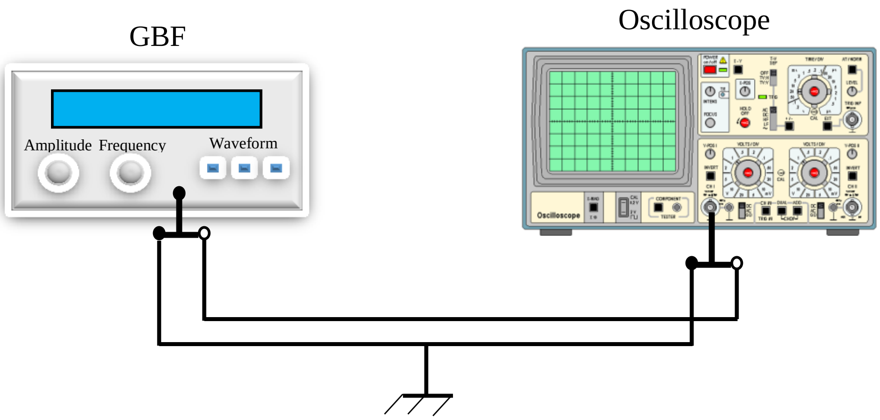

Figure 5.3. Diagram of the circuit for measuring a voltage.

Table 5.1. Voltage and Time Measurements.

Signal Type	**Volts/Div**	**Time/Div**	**T (s)**	**f (Hz)**	**V_{pp} (V)**	**V_{max} (V)**	**V_{eff} (V)**	**V (of Voltmeter)**
Sine								
Square								
Triangle								

Questions:

1) Complete the table 5.1.
2) Compare measured values with generator settings.

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3) Compare the two voltages V_{eff} and V (of Voltmeter)

……………………………………………………………………………………………………

5.4.3. Experiment 2

1- Assemble the RC circuit as shown in Figure 5.4, using $R = 2\ k\Omega$ and $C = 1\mu F$.
2- Connect the function generator (GBF) to the input of the RC circuit.
3- Connect Channel I (CH1) of the oscilloscope to the input voltage V_e (generator output).
4- Connect Channel II (CH2) across the capacitor to observe the voltage V_C.
5- Ensure that the generator and both oscilloscope channels share a common ground.
6- Set the function generator to deliver a sinusoidal signal with a fixed amplitude (e.g. 5 V_{pp}).
7- Choose an initial frequency (e.g. 1 kHz).
8- Set the oscilloscope:
  - Select DUAL mode to display both channels,
  - Adjust Volts/div for each channel to obtain readable amplitudes,
  - Adjust Time/div to clearly display one or two signal periods,
  - Adjust the trigger for a stable display.
9- Measure on the oscilloscope screen:
  - The period T of the signal,

- The time delay Δt between corresponding points of V_e and V_C (zero crossing or maximum).

10- Calculate the experimental phase shift: $\varphi_{exp} = \frac{\Delta t}{T} \times 360^{\circ}$

11- Repeat the measurements for different values of R.

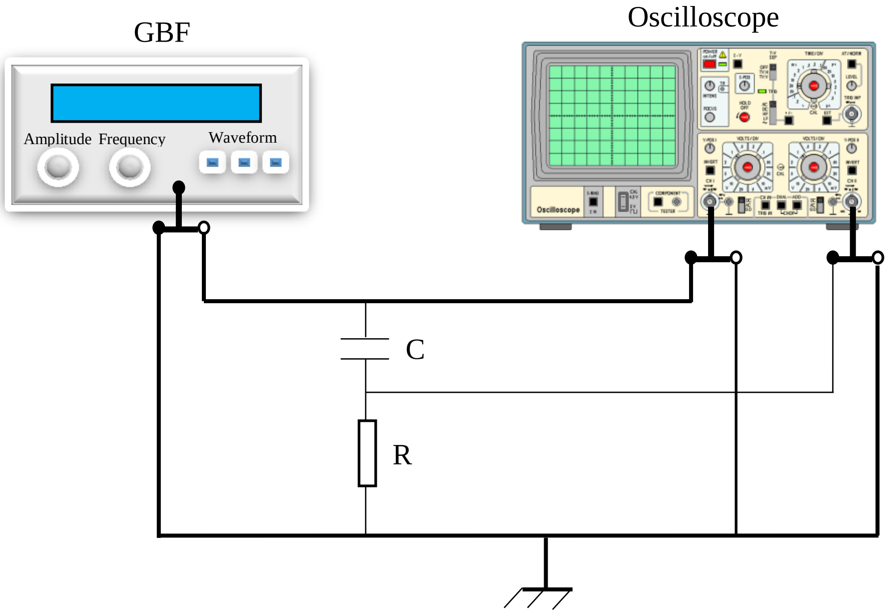

Figure 5.4. Diagram of the phase shift measurement setup.

Table 5.2. Measurement of phase shift in an RC circuit.

R (kΩ)	2	4	6	8
Time/Div				
T (s)				
Δt (s)				
φ_{exp} (°)				

Questions:

1) Complete the table 5.2.
2) Compare the experimental phase shift with the theoretical value: $\varphi_{th} = -\arctan(2\pi f RC)$

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3) Discuss how the phase shift changes as the resistance R varies.

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5.5.Conclusion

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