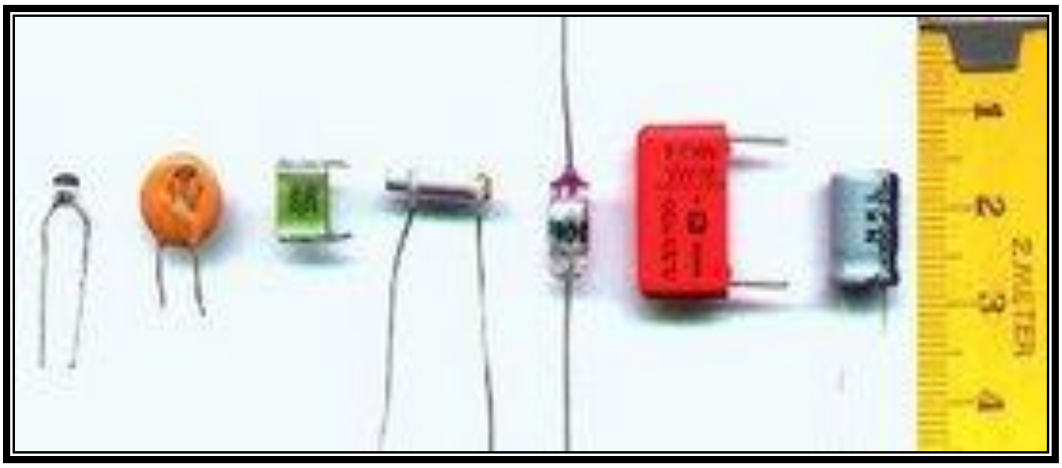
To show that the behavior of a capacitance in an a.c. circuit is analogous to that of a resistor which obeys Ohm's law, and hence to measure capacitance

Capacitor

An electronic component that stores an electronic charge and releases it when required, consisting in general of **two** metallic plates separated and insulated from each other by a dielectric.

It comes in a huge variety of sizes and types for use in regulating power as well as for conditioning, smoothing and isolating signals. **Capacitors** are made from many different materials, and virtually every electrical and electronic system uses them.



A **capacitor** occasionally referred to using the older term (**condenser**) is a device that stores energy in the electric field created between a pair of conductors on which equal but opposite electric charges have been placed. Intentional **capacitors** have thin conducting plates (**usually made of metal**) stacked or rolled to form a compact device, but every multi-conductor geometry has **capacitance**.

Physics of the Capacitor

Capacitors act like tiny storage batteries. Typical designs consist of **two** electrodes or plates, each of which stores an opposite charge. These **two** plates are conductive and are separated by an insulator or dielectric. The charge is stored at the surface of the plates, at the boundary with the dielectric. Because each plate stores an equal but opposite charge, the total charge in the device is always zero.

Capacitance

The **capacitor's capacitance** (***C***) is the measurement of the amount of charge (***Q***) stored on each plate for a given potential difference or voltage (***V***) which appears across the plates: -

$$C = \frac{Q}{V}$$

In **SI** units is **Farad**. Since the **Farad** is a very large unit, values of **capacitors** are usually expressed in microfarads (**µF**), nanofarad (**nF**) or picofarad (**pF**).

The Capacitance in the Electric Circuit

In the case of **constant voltage** (**DC**), equilibrium is soon reached, where the charge of the plates corresponds with the applied voltage by the relation ***Q=CV*** and no further current will flow in the circuit. Therefore **direct current** cannot pass.

However, effectively **alternating current** (**AC**) can: every change of the voltage gives rise to a further charging or a discharging of the plates and therefore a current. The amount of "**resistance**" of a capacitor to **AC** is known as "**capacitive reactance**", and varies depending on the **AC** frequency.

- ***In D.C. Circuit.***

It acts as open key.

- ***In A.C. Circuit.***

It acts as close key.

Capacitive Reactance

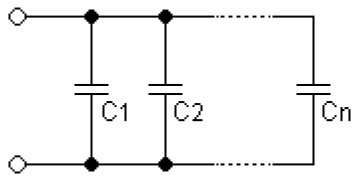
Capacitive reactance is defined as: -

$$X_C = \frac{1}{2\pi f C}$$

Where $\boldsymbol{X_C}$ is the **capacitive reactance** in **Ohms**, $\boldsymbol{f}$ is the **frequency** in **Hertz**, and $\boldsymbol{C}$ is the **capacitance** in **Farads**.

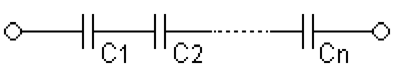
Capacitor Networks

Capacitors in a **parallel** configuration each have the same potential difference (**voltage**). To find their total equivalent capacitance ($\boldsymbol{C_{eq}}$): -



$$C_{eq} = C_1 + C_2 + \cdots + C_n$$

The current through **capacitors** in **series** stays the same, but the voltage across each **capacitor** can be different. The sum of the potential differences (**voltage**) is equal to the total voltage. To fine their total capacitance ($\boldsymbol{C_{eq}}$): -

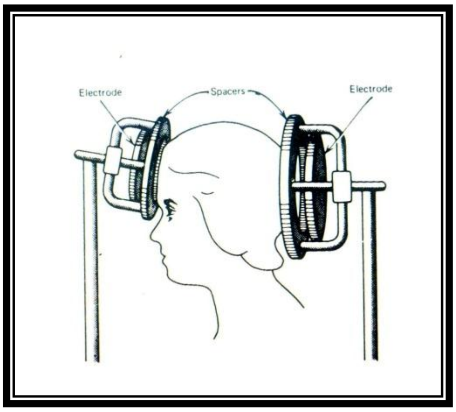


$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n}$$

The Medical Applications of Capacitance

1. **In capacitance method of short-wave diathermy: -**

It is considered one of the methods that are used for transferring the electromagnetic energy into the body in short-wave diathermy.



In this method, the part of the body to be treated is placed between two metal plate-like electrodes energized by the high-frequency voltage. The body tissue between the plates acts like an electrolytic solution. The charged particles are attached to one plate and then the other depending upon the sign of the alternating voltage on the plates; this results in resistive (**joule**) heating. Different body materials react differently to the waves, and this effect provides some selectively in treatments.

2. **In pulp tester: -**

A system for testing the dental pulp of a tooth by electrically stimulating the pulp with a pulsating signal.

The Pulp Vitality Test is a method for pulp examination through admission of fixed increased by amplitude electrical impulses. The electricity passes through hard dental tissues and causes irritation into pulp's nerve receptors.

3. **In other medical devices.**

The Name of exp. : -

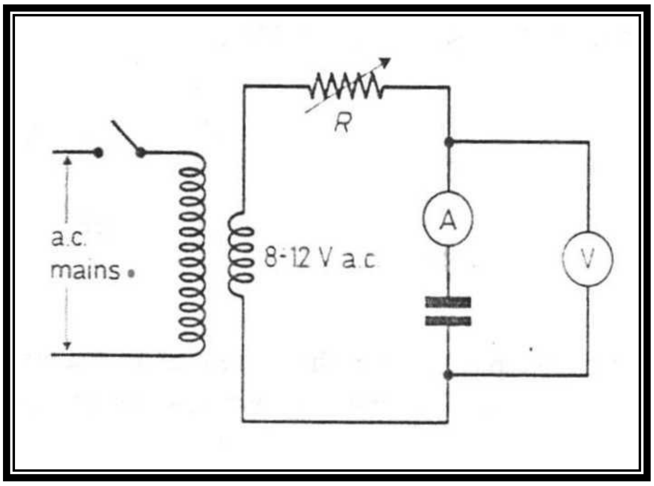
To show that the behavior of a capacitance in an a.c. circuit is analogous to that of a resistor which obeys Ohm's law, and hence to measure capacitance

The Aim: -

1. To show that the behavior of a capacitance in an a.c. circuit.
2. To measure the capacitance.

The Apparatus: -

1. A.C. Source.
2. Fixed Capacitor.
3. Resistance Box.
4. Ammeter.
5. Voltmeter.



The Method and the Record: -

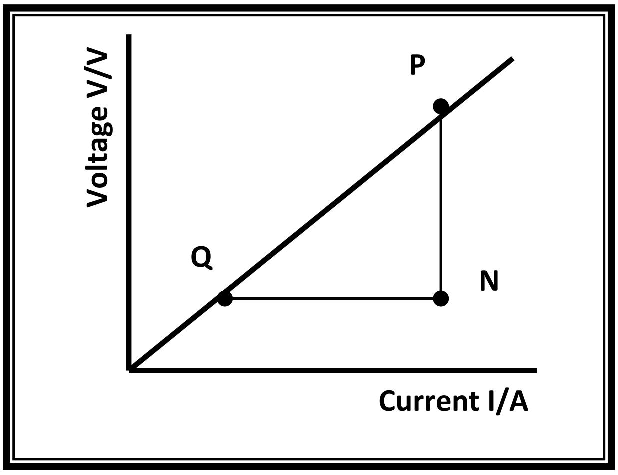
Connect up the circuit as shown in the diagram, remembering to complete all the circuit connections before inserting the mains plug or closing the mains circuit switch.

Set the variable resistance R to its minimum value. Switch on the current and record the readings of the ammeter and voltmeter. Vary R and take further readings making as full use as possible of the ammeter and voltmeter scales.

Tabulate the readings: -

Resistance (R/Ω)	
Current (I/A)	
Voltage (V/V)	

Plot a graph with values of voltage V/V as ordinates against the corresponding values of current I/A as abscissae.



The Theory and the Calculation: -

The fact that the graph is a straight line through the origin verifies that the current in the circuit is directly proportional to the voltage across the capacitor, i.e. that Ohm's law applies.

From two convenient and well-separated points P and Q on the straight line obtain the slope PN/QN.

This is the average numerical value of the ratio V/I for the capacitor in the circuit and is the magnitude of the *capacitive reactance* X_C of the capacitor.

Since: - $$X_C = \frac{V/V}{I/A}$$

Where: - $$X_C = \frac{1}{2\pi f C}$$

f = is the frequency of the current (50Hz).

C = is the capacitance, the value of C can be found from: -

$$C = \frac{1}{2\pi f X_C} \ldots\ldots\ldots\ldots F$$