**CAPACITANCE AND DIELECTRICS**

A capacitor is a device that stores electrical energy temporarily in an electric field. Basically it is an arrangement of any two conductors separated by an insulator (called dielectric)

If a voltage V is applied across the metal plates of a capacitor, the two plates become charged. One of the plates will acquire a negative charge (-Q) and the other will acquire an equal amount of positive charge (+Q)

It is found that the charge on each capacitor is proportional to the potential difference between the conductors

where c is called the capacitance of the capacitor. The capacitance of a capacitor is its ability to store charges. The unit of capacitance is coulomb per volt and this unit is also called the Farad (F).

**FACTORS THAT AFFECT CAPACITANCE**

1. Size of the conductors

2. Shape of the conductors

3. Relative position of the two conductors

4. Dielectric that separates conductors

**TYPES OF CAPACITORS**

1. Parallel plate capacitor

2. Cylindrical capacitor

3. Concentric spherical capacitor

4. Isolated sphere

**PARALLEL PLATE CAPACITORS**

A parallel plate capacitor consists of two parallel metallic plates of **equal area** separated by a distance d. When battery terminals of potential difference V are connected to the plates, one acquires a negative charge while the other acquires an equal amount of positive charge

The electric field strength E between the plates is given by.

From Gauss’ law

But surface charge density,

And

But

From the above it can be seen that capacitance can be increased by

1. Increasing the area of the plates

2. Decreasing the distance between the plates

**CYLINDRICAL CAPACITORS**

A cylindrical capacitor consists of an inner conductor that is a cylinder of radius and coaxial outer conductor with inner radius

Both cylinders are of equal length

The length of these cylinders is greater than the gap between them

l >> R\_a – R\_b

When connected to a battery, with one cylinder (let’s say the inner one) have a +ve charge and the other having a negative charge

We know that the electric field intensity **outside a long wire** has a magnitude

R = R

Potential difference,

C = Q over V

**CONCENTRIC SPHERICAL CAPACITOR**

A spherical conductor consists of two thin concentric spherical conducting shells of radii and

The inner sphere carries a positive charge +Q

The electric field outside a uniformly charged conducing sphere is

Note the following table to remember the capacitance of different values

| Object Name | Electric Field Strength | Voltage (Potential Difference) | Capacitance | **Specific Notes** |
| --- | --- | --- | --- | --- |
| Parallel Plate Capacitor |  |  |  |  |
| Cylindrical Capacitor | or |  |  |  |
| Concentric Spherical Capacitor |  |  |  | This is a capacitor with one inner ball(or sphere) inside another ball(sphere) |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**CAPACITORS IN SERIES AND PARALLEL**

Capacitors can be connected in different ways. The two most common ways are in series and parallel

**CAPACITORS IN SERIES**

In series connection, capacitors are connected one to another. Charges therefore flow from one positive plate of c1 to the negative plate of c1 then to the positive plate of c2 etc.

The net charge is zero

The charge on all the plates is equal. The total capacitance or equivalent capacitance

V = Q over C

The potential differences on the capacitors are V1+V2+V3. The total potential difference applied across the capacitors V is

V = V1+V2+V3

For Each capacitor

Q = C1V1 + C2V2 +C3V3

So the following should be noted of capacitors in series

1. They have the same charge

2. The total voltage is the sum of voltage in each capacitor

3.

4.

**CAPACITORS IN PARALLEL**

For capacitors in parallel,

1. The have the same voltage

2. The total charge is the sum of charges in each capacitor

3.

4.

**ENERGY STORED IN A CAPACITOR**

The energy stored in a capacitor is equal to the work done in charging the capacitor.

The work done to increase the charge on an uncharged capacitor to Q when a potential difference V is across the capacitor is

But

On integrating

But

But,

For a parallel plate capacitor,

Volume = Ad

Note the major formulae:

1.

2.

3.

4.

5.

**USES OF CAPACITORS**

1. For tuning in radio receivers

2. Filters in power supplies

3. To eliminate sparking in automobile ignition systems/switches

4. For timing circuits

5. For storing energy in electronic flashes

**DIELECTRICS**

A dielectric is a non-conducting material such as glass, rubber or waxed paper

1. When a dielectric material is inserted between the plates of a capacitor, the capacitance increases by a factor K, called the dielectric constant. The capacitance is given as

2. The dielectric constant has no unit. It is the characteristic of a given material

3. If is the permitivity of free space and is the permitivity of the dielectric, then

4. The energy density becomes

5. At constant charge, the voltsge he will decrease

6. If the potential difference is kept unchanged, we can say that the charge increases at a constant voltage

6. The electric field strength also decreases by a factor of K

The net field induced in the dielectric is given as

E = E\_o – E\_{ind}

E\_ind = E\_o – E

E = E\_o over K

E\_ind = E\_o(1 – {1 over K})

Similarly, for induced Charge and induced surface charge density

**CHARACTERISTICS OF A GOOD DIELECTRIC**

1. K is also called the relative permitivity of the dielectric material.

2. Dielectric strength: This is the maximum electric field intensity that a pure material can withstand under ideal conditions without breaking down

**LEARN DIPOLE CONCEPTS AND DIPOLES**.

**QUESTIONS**

1. What is capacitance?

2. What is a capacitor?

3. State the factors that affect the capacitance of a capacitor

4. Mention 3 types of capacitors and give the formulae for capacitance for each

5. A 1uF and a 2uF capacitor are connected in series across a 1000volt supply line. Find the charge on each capacitor and the voltage across each. Answers: