ECE 30

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Agenda

- Electric Potential Cont.
- Potential Difference - Voltage
- Capacitance
- Charge Storage

Electric Potential Cont.

If bringing a charge from infinity, the potential energy is equal to $\frac{k_e Q q_0}{r}$ for any r.

Voltage

If the initial distance is not infinity, then

$$\frac{\Delta E_p}{q_0} = \Delta V$$

In other words, voltage is the difference in potential energy.

Capacitance

If we create a voltage difference between two metal plates, a uniform electric field forms between them.

The constant of proportionality was defined as

$$C \triangleq \frac{q}{\Delta V}$$

Both q and ΔV are defined to be positive, which implies C is always positive.

C is measured in $\mathrm{C/V}$ which is also known as a Farad F which is a very large unit. Most capacitors are measured in $\mu\mathrm{F}$ or mF

$$\Delta V = \int_A^B \vec{\epsilon} \cdot d\vec{r} = \epsilon d$$

We saw by experiment $E \propto \frac{q}{A}$ where A is the area of the plates.
The factor of proportionality is $\frac{1}{\epsilon_0}$ where ϵ_0 is the permitivity of free space. Therefore we have the equation:

$$E = \frac{q}{\epsilon_0 A}$$

Therefore :

$$\Delta V = \frac{qd}{\epsilon_0 A}$$

For a smaller area you require less voltage for the same charge.

Since:

$$C = \frac{q}{\Delta V}$$

Then:

$$C = \frac{\epsilon_0 A}{d}$$

Capacitance decreases with distance, and increases with area. This is useful for accelerometers and touch screens.

Capacitors with dialectric.

A dialectric is a material that doesn't conduct, ex: rubber, glass, concrete, etc.

A voltmeter is like an open switch which doesn't allow charge to flow.

We find that adding a dialectric increases the capacitance. The capacitance increases linearly with permitivity of the dialectric material.

Some common materials used have permitivity values:

- Vacuum 1.0
- Glass 5.60
- Rubber 6.70

Energy Storage

We create a potential difference between the plates of a capcitor, the electric field between the plates can do work. It can be used as a battery.

We know:

$$W = \Delta E_p = \Delta V_{q_0}$$

When we connect a voltage electrons move and deposit on the sides of the capcitors. As the power begins to flow more and more electrons move and the voltage climbs until it eventually matches the circuit.

Assuming zero resistance the Voltage difference is linear with time.