ECE 30
Day 10 Notes

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Agenda

- Finish Lecture 9
- Electric Current
- Ohm's Law
- Terms and Symbols for Electric Circuits

Lecture 9 Cont.

When a capacitor is connected to a potential difference, Δv, q (charge in the plates) changes.

Initially $q = 0\text{C}$ and it eventually reaches $Q = cv$.

$$dw = \Delta v dq$$

The total Work done to charge a capacitor:

$$W = \int_0^Q \frac{q}{c} dq = \frac{1}{c} \int_0^Q q dq$$

$$W = \frac{Q^2}{2c} \text{J}$$

We also know:

$$c = \frac{Q}{\Delta v}$$

Therefore:

$$W = \frac{1}{2} c \Delta v^2$$

For a given capacitance, energy stored is equivalent to the square of the voltage difference, and directly proportional to the square of the charge.

Electric Current

$$\vec{E} = \frac{\vec{F}}{q} = \frac{m\vec{a}}{q}$$

Let $q = \overline{e}$ (charge of an electron)

Then $\vec{a} = \frac{-\overline{e}\vec{E}}{m}$

$\vec{E}$ in copper is effectively constant

We also know that $\vec{a} = \frac{d\vec{v}}{dt}$ We can expand using the chain rule to:

$$\vec{a} = \frac{dv}{dx} \cdot \frac{dx}{dt} = \frac{\vec{v}dv}{dx}$$

Therefore:

$$\vec{a}dx = \vec{v}dv$$

$$a \int_{x_0}^{x} dx = \int_{v_0}^{v} v dv$$

Therefore:

$$a(x - x_0) = \frac{v^2}{2} - \frac{v_0^2}{2}$$

Letting $v_0 = 0$ and $x_0 = 0$ then:

$$2ax = v^2$$
$$v = \sqrt{2ax} = \sqrt{\frac{2eEx}{m}}$$

When electrons flow they collide with atoms, which causes the atoms to vibrate converting some of the electrical energy into thermal energy.

For a conductor $\overline{e}$ collides with w atoms and give off kinetic energy $K = \frac{1}{2}mv^2$ and the conductor will heat up.

We define: $i = \frac{dq}{dt}$ where i uses units of $\mathrm{C/s} \triangleq A$ or Amps. Amps are units of Current.

Amps are large! Usually mA or nA, or $\mu\mathrm{A}$ are used.

Resistance

$\vec{E}$ in a conductor is uniform, and $\Delta v = \int_{s_1}^{s_2} \vec{E} \cdot d\vec{s}$ whre $\vec{s}$ is displacement in the direction of the field.

Therefore:

$$\Delta v = E(s_2 - s_1) = EL$$

Where L is the length of the conductor.

Therefore, as Δv increases E increases. Since $\vec{E} = \frac{\vec{F}}{q}$ the electrons in a conductor are accelerated more as Δv increases.

Therefore $\Delta v \propto i = \frac{dq}{dt}$ We therefore have a factor of propotionality, written R for resistance.

$R \triangleq \frac{V}{i}$ with units called Ohms(Ω) Which comes from the name Ohms' Law.

Circuit Symbols

Battery: The voltage decreases from the short to the long side. In this case it goes from right to left. measured in Volts (V)

Capacitor: Non directional. Measured in Farads (F)

Resistor: A component which has a specific resistance, usually higher than the material the circuit is made out of. Measured in Ohms (Ω)

Voltmeter: V $R = \infty$

Ammeter: A $R = 0$

Conductor: ______ carries current. Arrows sometimes added to indicate the flow of positive charge.

Switch: Can be open or closed to indicate whether electrons can flow.