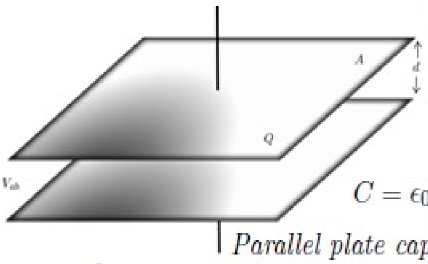
Chapeter 24

Capacitors and capacitance

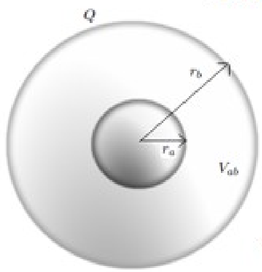
Definition of capacitance

$$C = \frac{Q}{V_{ab}}$$



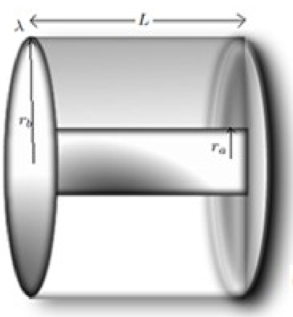
$$C = \epsilon_0 \frac{A}{d}$$

Parallel plate capacitor



$$C = 4\pi\epsilon_0 \left(\frac{r_a r_b}{r_a - r_b}\right)$$

Spherical capacitor



$$C = \frac{2\pi\epsilon_0}{\ln(r_b/r_a)}$$

Cylindrical capacitor

Capacitors in series - parallel

Capacitors in series

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

$$Q_{eq} = Q_1 = Q_2 = \cdots = Q_n$$

$$V_{eq} = V_1 + V_2 + \cdots + V_n$$

Capacitors in parallel

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

$$Q_{eq} = Q_1 + Q_2 + \cdots + Q_n$$

$$V_{eq} = V_1 = V_2 = \cdots = V_n$$

Energy in a capacitor

Energy stored in a capacitor

$$U = \frac{Q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}QV \qquad (J)$$

Energy density

$$u = \frac{1}{2}\epsilon_0 E^2 \qquad (J/m^3)$$

Dielectrics

Parallel plate capacitor filled with dielectric

$$C = KC_0 = K\epsilon_0 \frac{A}{d}$$

Energy density of a capacitor with dielectric

$$u = \frac{1}{2}K\epsilon_0 E^2 = \frac{1}{2}\epsilon E^2 \qquad (J/m^3)$$

$E = \dfrac{\sigma}{K\epsilon_0}$ *Electric field in a parallel plate capacitor filled with a dielectric*

$E = \dfrac{Q}{4\pi K\epsilon_0 r^2}$ *Electric field in a Spherical capacitor filled with a dielectric*

$E = \dfrac{\lambda}{2\pi r K\epsilon_0}$ *Electric field in a cylindrical capacitor filled with a dielectric*

$\oint K\vec{E} \cdot d\vec{A} = \dfrac{Q_{enc_free}}{\epsilon_0}$ *Gauss's law in a dielectric*

Chapeter 25

Current and current density

Current

$$I = \frac{dQ}{dt} = n|q|v_d A \qquad (A)$$

Current density

$$J = \frac{I}{A} = n|q|v_d \qquad (A/m^2)$$

Resistivity

$$\rho = \frac{E}{J} \qquad (\Omega \cdot m)$$

$$\rho(T) = \rho_0 \left[1 + \alpha (T - T_0)\right]$$

Resistors

$$V = IR$$

$$R = \frac{\rho L}{A}$$

Energy and power in circuits

General circuit element

$$P = V_{ab} I \qquad (W)$$

Power dissipated in a resistor

$$P = V_{ab} I = I^2 R = \frac{V_{ab}^2}{R}$$

Conduction in metals

Mean free time between collisions

$$\tau_c = \frac{m}{nq^2\rho} \qquad (s)$$

Chapeter 26

Resistors in series - parallel

$R_{eq} = R_1 + R_2 + \cdots + R_n$ *Resistors in series*

$\dfrac{1}{R_{eq}} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \cdots + \dfrac{1}{R_n}$ *Resistors in parallel*

Kirchoff's rules

$\sum I = 0$ *Curent/junction rule*

$\sum V = 0$ *Voltge/loop rule*

R-C Circuits

Charging capacitor

$$q = Q\left(1 - e^{-t/RC}\right)$$

$$i = Ie^{-t/RC}$$

Discharging capacitor

$$q = Qe^{-t/RC}$$

$$i = -Ie^{-t/RC}$$