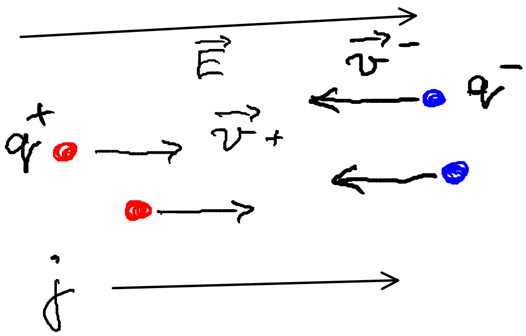
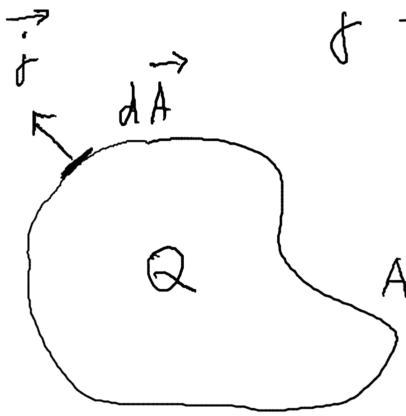
Die Stromdichte

$$\vec{j} = \rho_{el}\,\vec{v} \quad ; \quad \rho_{el} = \rho_{el}^{+} + \rho_{el}^{-} = n^{+}q^{+} + n^{-}q^{-}$$

z.B. $q^{-} = -e$

$$\vec{j} = n^{+}q^{+}\vec{v}^{+} + n^{-}q^{-}\vec{v}^{-}$$





Der Strom durch eine geschlossene Oberfläche A

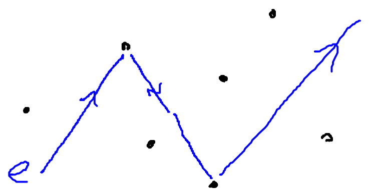
$$I = \oint \vec{j}\cdot d\vec{A} = -\frac{dQ}{dt} = -\frac{d}{dt}\int \rho_{el}\,dV$$

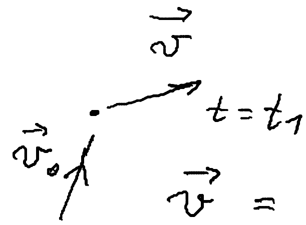
$$I = \oint \vec{j}\cdot d\vec{A} = \int \operatorname{div}\vec{j}\,dV$$

Kontinuitätsgleichung

$$\boxed{\operatorname{div}\vec{j}(\vec{r},t) = -\frac{\partial}{\partial t}\rho_{el}(\vec{r},t)}$$

Elektronen in einem Leiter





$$\vec{v} = \vec{v}_0 - \frac{e\vec{E}t_1}{m}$$

$$\langle \vec{v} \rangle = \underbrace{\langle \vec{v}_0 \rangle}_{=0} - \frac{e\vec{E}\langle t_1 \rangle}{m}$$

$$\langle t_1 \rangle = \tau$$

die mittlere Zeit zwischen zwei Stößen

Driftgeschwindigkeit

$$\langle \vec{v} \rangle = -\frac{e\vec{E}}{m}\tau$$

$$\langle \vec{j} \rangle = -ne\langle \vec{v} \rangle$$

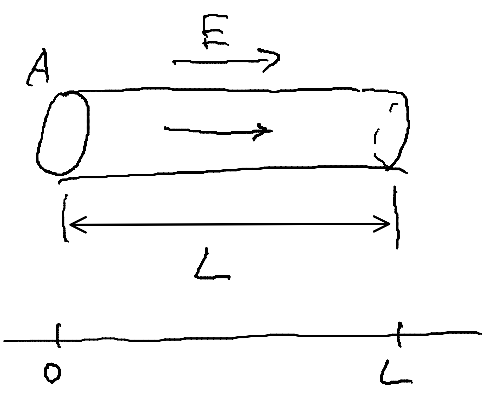
$$\vec{j} = \frac{e\vec{E}}{m}\tau n e = \frac{ne^2\tau}{m} \cdot \vec{E}$$

elektrische Leitfähigkeit $\sigma = \frac{ne^2\tau}{m}$

$$[\sigma] = 1\,A \cdot V^{-1} \cdot m^{-1}$$

$$\langle \vec{v} \rangle \equiv v_D = \mu \cdot \vec{E}$$

μ = Beweglichkeit $\mu = \frac{\sigma}{ne}$



$$U = \int_0^L E\,dx = E \cdot L$$

$$I = \int_A \vec{j} \cdot d\vec{A} = j\,A$$

$$I = \frac{\sigma \cdot A}{L} \cdot U$$

Das Ohmsche Gesetz

Das Ohmsche Gesetz

$$\boxed{\vec{j} = \sigma \vec{E}} \qquad \boxed{I = \frac{U}{R}} \qquad R = \frac{L}{\sigma A}$$

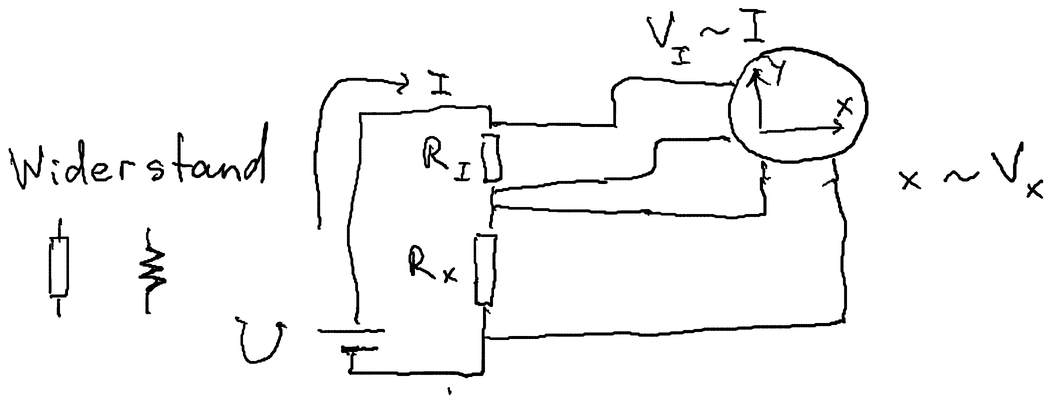
elektrische Widerstand

spezifische Widerstand

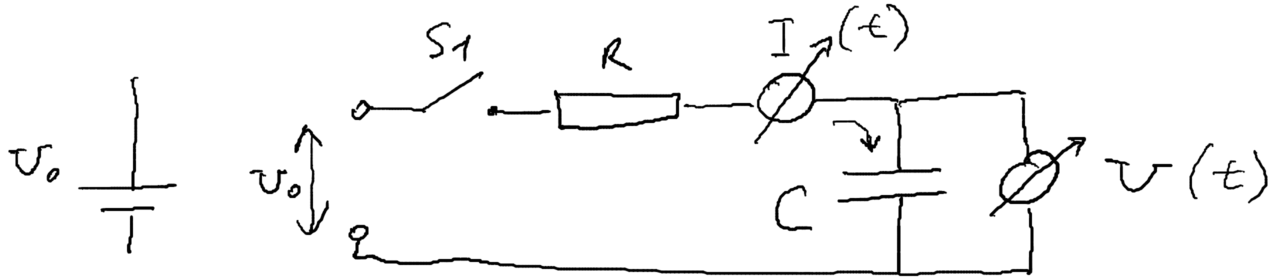
$$\rho_s = \frac{1}{\sigma} \quad (\text{Material}) \quad \Bigg\} \quad R = \rho_s \frac{L}{A}$$

$$[R] = \left[\frac{U}{I}\right] = \frac{1V}{1A} \equiv \underline{1\,\text{Ohm} = 1\,\Omega}$$

$$[\rho_s] = 1\,\Omega \cdot 1\,\text{m}$$



Beispiel 1: Aufladung eines Kondensators



$t = 0 \qquad U(0) = 0$

$$Q(t) = C \cdot U(t)$$

$$I(t) = \frac{U_0 - U(t)}{R} = \frac{U_0}{R} - \frac{Q(t)}{R \cdot C}$$

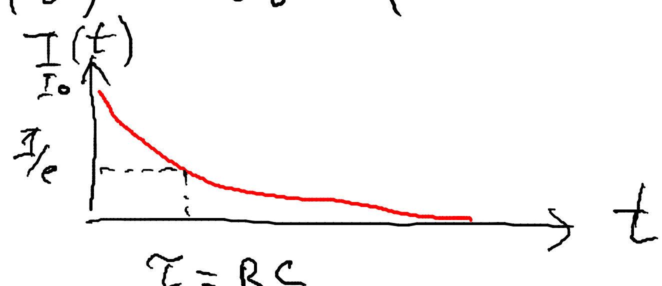
$$I(t) = \frac{dQ(t)}{dt} \qquad \downarrow$$

$$\frac{dI(t)}{dt} = -\frac{I(t)}{RC}$$

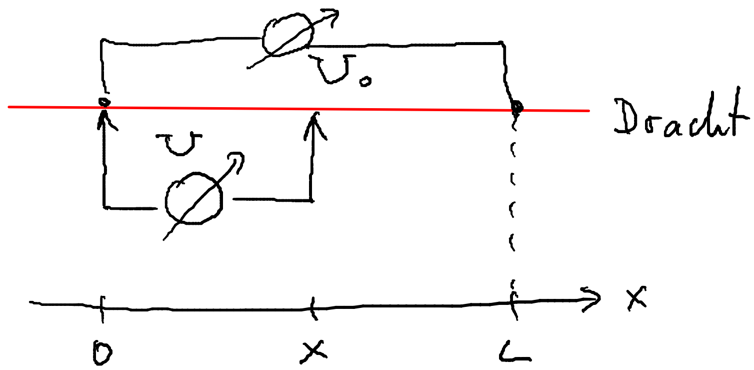
Anfangsbedingung $\quad I(0) = I_0$

$$I(t) = I_0 \, e^{-\frac{t}{RC}}$$

$$U(t) = U_0 \cdot \left(1 - e^{-t/(RC)}\right).$$



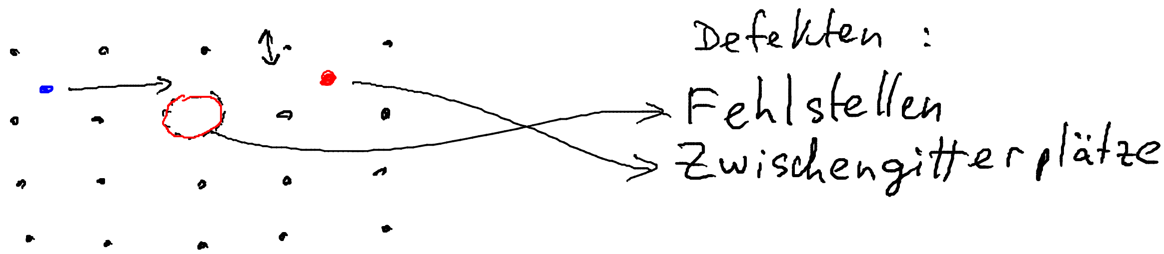
Beispiel 2: Kontinuierlicher Spannungsteiler



$$U(x) = \frac{x}{L} U_0$$

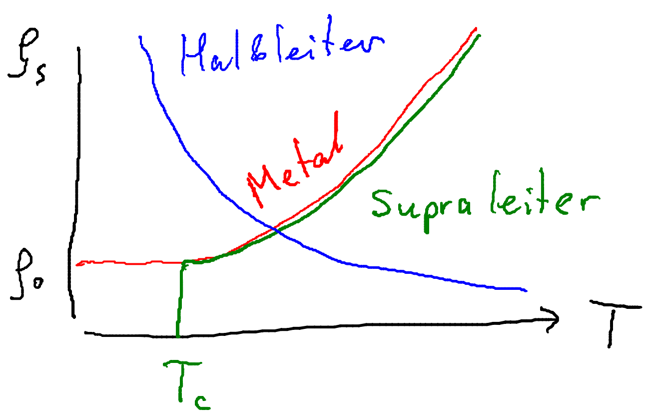
Temperaturabhängigkeit des elektrischen
Widerstandes fester Körper

Phononen $\equiv$ Kristallschwingungen



$$\rho_s = \rho_{Ph} + \underset{\text{Störstellen}}{\rho_{St}}$$

$$\rho_s \approx \rho_0 \left(1 + \underbrace{\alpha T} + \ldots\right)$$



$$\frac{\rho(T = 300\,K)}{\rho(4{,}2\,K)}$$