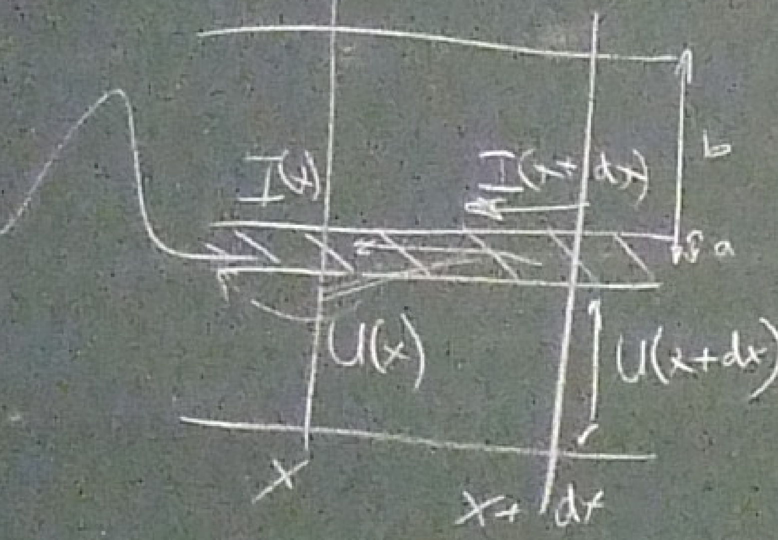
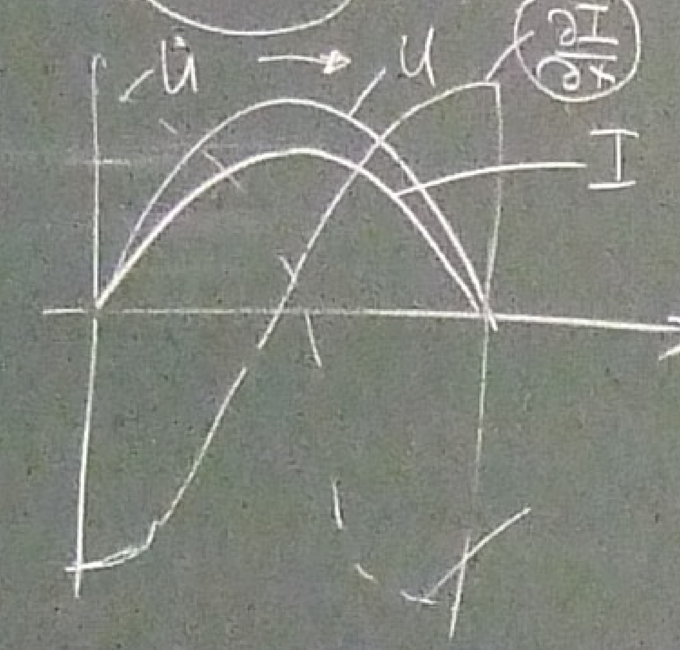
Nachtrag



$dU = -L\,dx\,\frac{\partial I}{\partial t}$ (Ind) $\quad U' = -\dot I$

$-dI = +C\,dx\,\frac{\partial U}{\partial t}$ (Kond) $\quad \frac{\partial I}{\partial x} = -C\frac{\partial U}{\partial t}$



$U \sim \sin(\omega t - kx)$

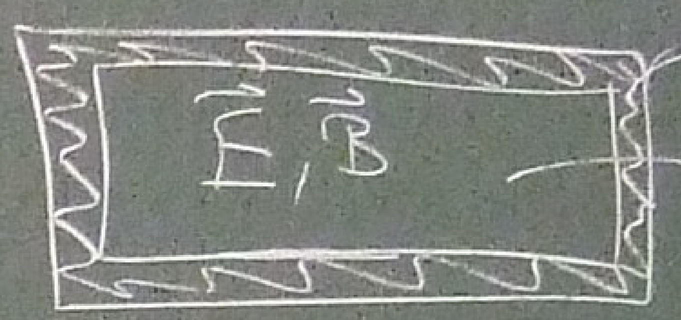
$\dot U \sim \cos(\omega t - kx)$

$\frac{\partial I}{\partial x} \sim -\cos(\omega t - kx)$

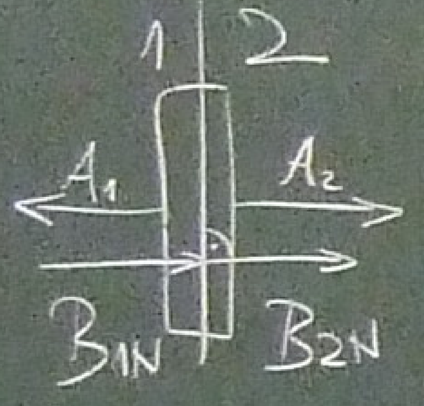
$I \sim \sin(\omega t - kx)$

$I \sim U$ Phasengl. Ausbreitung

Elektromagnetische Wellen in Hohlleitern



Wegen $\mathrm{div}\,\vec B = 0 \rightsquigarrow \Delta B_{Normal} = 0$



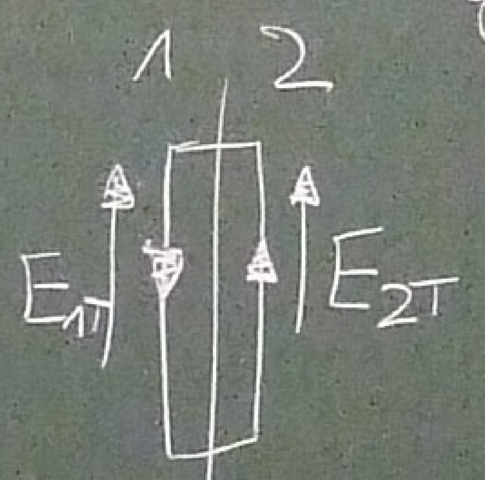
aus $B_{N\,Leiter} = 0$ (Leiter)

$\rightsquigarrow \boxed{B_{N\,Luft} = 0}$

$$\frac{B_{1T}}{\mu_1} - \frac{B_{2T}}{\mu_2} = \mu_0 \frac{N}{L} I$$

Wegen $\mathrm{rot}\,\vec E = -\dot{\vec B}$

↑ finit an Grenzflächen



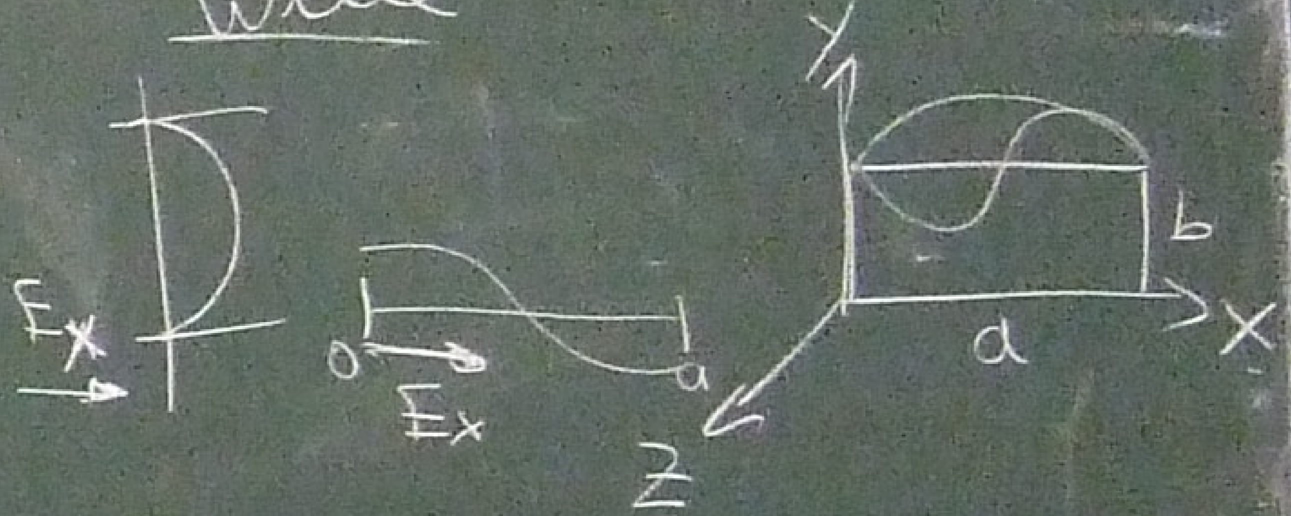
$\Delta E_{Tangential} = 0$

aus $E_{T\,Leiter} = 0$

$\rightsquigarrow \boxed{E_{T\,Luft} = 0}$

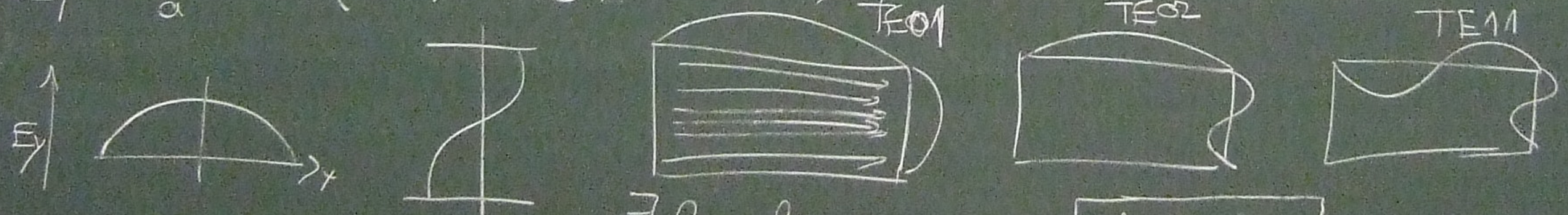
$$\varepsilon_1 E_{1N} - \varepsilon_2 E_{2N} = \frac{\sigma}{\varepsilon_0}$$ ← Ladungsflächendichte

Transversal-Elektrische Welle



$$E_x = -\frac{m E_0}{b}\cdot\cos\left(\frac{n\pi}{a}x\right)\sin\left(\frac{m\pi}{b}y\right)\cdot\sin(\omega t - kz)$$

$$E_y = \frac{n E_0}{a}\sin\left(\frac{n\pi}{a}x\right)\cos\left(\frac{m\pi}{b}y\right)\cdot\sin(\omega t - kz)$$



∃ Grenzfrequenz $\omega_G = c\sqrt{\left(\frac{m\pi}{b}\right)^2 + \left(\frac{n\pi}{a}\right)^2}$

Die Wellengleichung wird erfüllt, falls

$$\Delta\vec E = -\frac{1}{c^2}\ddot{\vec E}$$

m+n=0,1

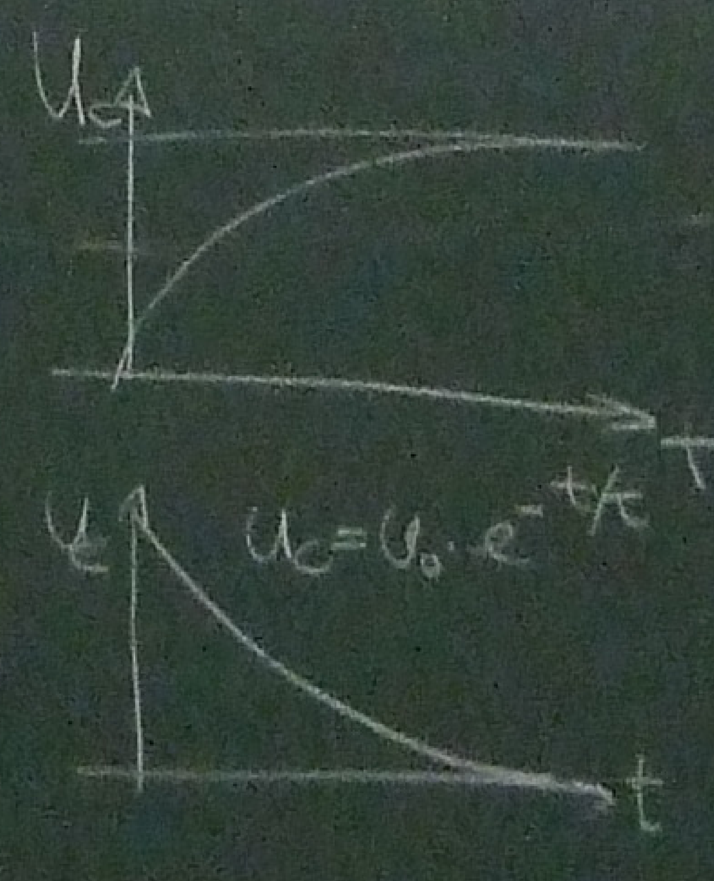
m=0,1

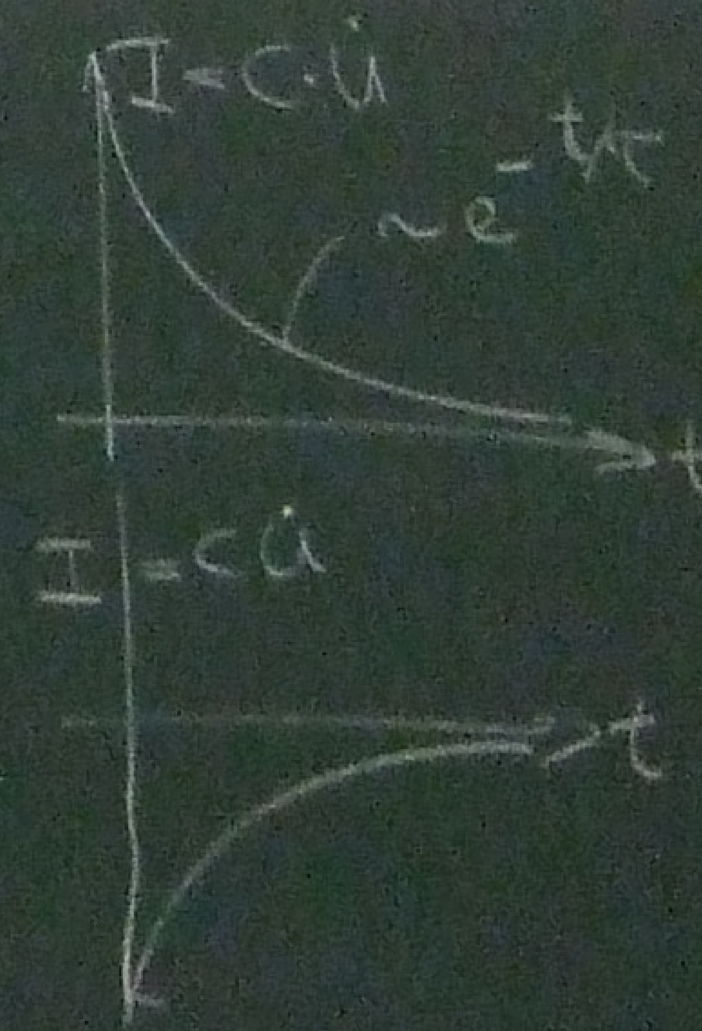
$$\frac{\omega^2}{c^2} = k^2 + \left(\frac{m\pi}{b}\right)^2 + \left(\frac{n\pi}{a}\right)^2$$

Aufladen & Entladen eines Kondensators

$$\left\{\begin{matrix} U_0 \\ 0 \end{matrix}\right\} = U_C + IR = U_C + \underbrace{RC}_{\tau = RC}\,\dot{U}_C = U_C + \tau \dot{U}_C$$

Kondensator: $I = \dot{Q} = C\dot{U}$





$C = 79\,\mu F$

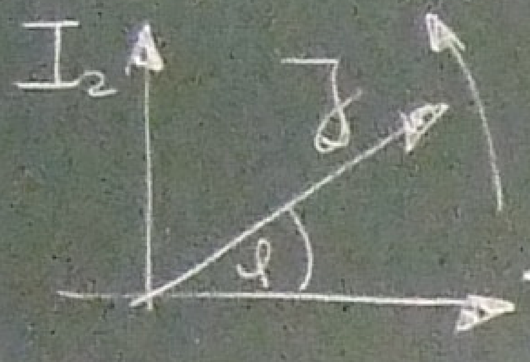
$R = 20\,k\Omega$

$\boxed{\tau = 1{,}6\,s}$

Übergang zur komplexen Schreibweise

z.B. Reihenschwingkreis Lösung $I_1=\hat{I}_1\left(e^{-\frac{R}{2L}t}\right)\cos(\omega t+\varphi)$

Genau so gut zweite Lösung: $I_2=\hat{I}_2\left(e^{-R/2L\cdot t}\right)\sin(\omega t+\varphi)$

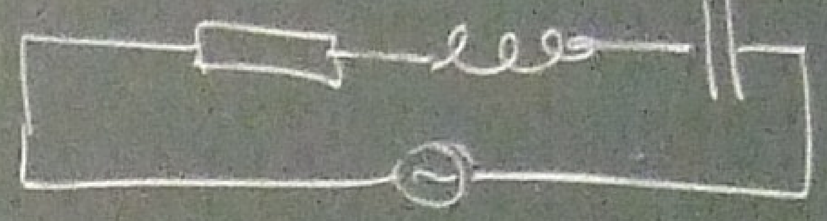


$$\boxed{\mathcal{J}=I_1+iI_2}=\hat{I}e^{-R/2L\,t}\cdot e^{i(\omega t+\varphi)}$$

Physikalische Sachverhalt: $\mathrm{Re}(\mathcal{J})$ oder $\mathrm{Im}(\mathcal{J})$

Für die Diff.- & Integration gilt

$$\frac{d}{dt}\mathcal{J}=i\omega\cdot\mathcal{J} \qquad \int\mathcal{J}\,dt=\frac{1}{i\omega}\mathcal{J}$$



$$\mathcal{U}=\hat{U}e^{i\omega t}=R\cdot\mathcal{J}+L\dot{\mathcal{J}}+\frac{1}{C}\int\mathcal{J}\,dt$$
$$=R\mathcal{J}+i\omega L\mathcal{J}+\frac{1}{i\omega C}\cdot\mathcal{J}$$

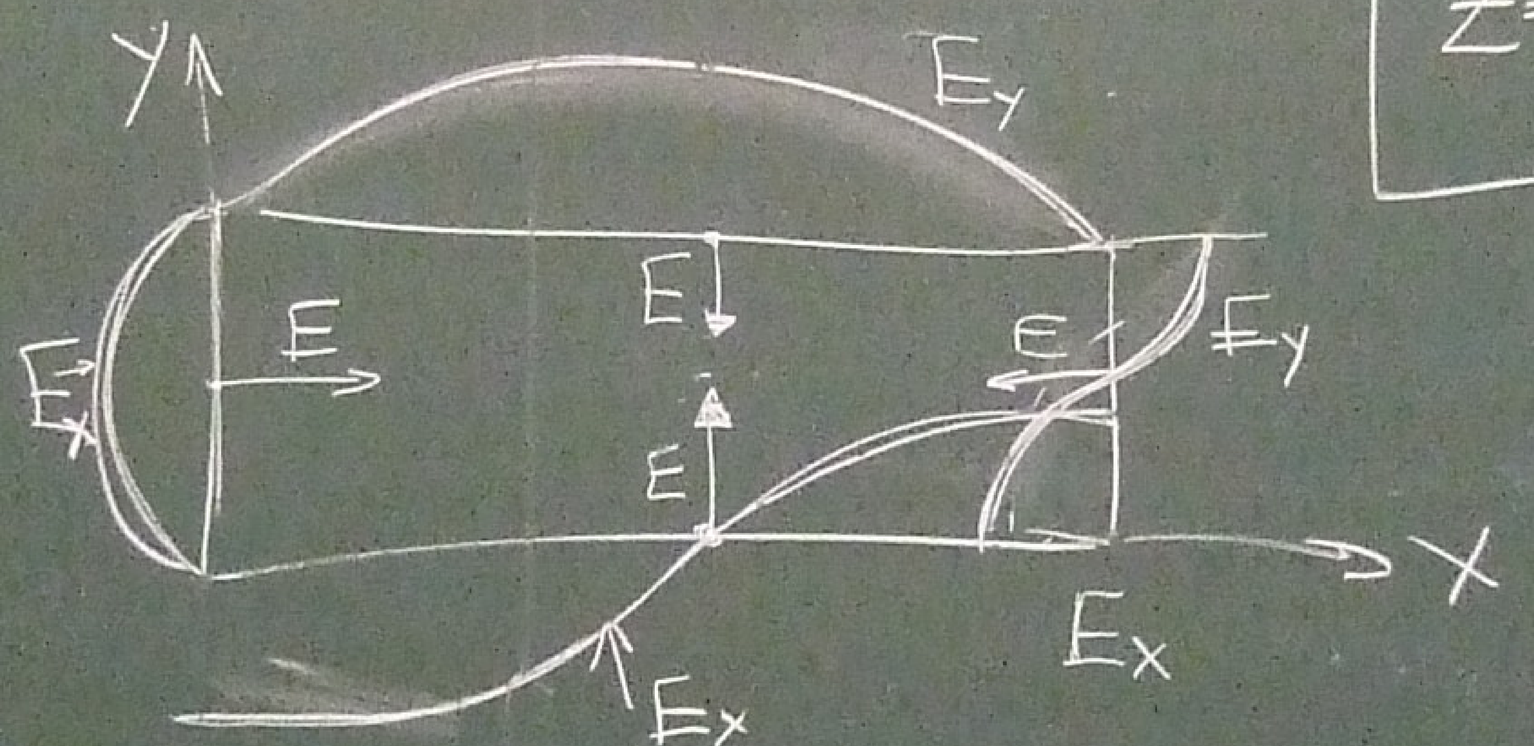
$$\boxed{Z=\frac{\mathcal{U}}{\mathcal{J}}=\left(R+i\omega L+\frac{1}{i\omega C}\right)} \quad |Z| \quad \tan\varphi=\frac{\mathrm{Im}\,Z}{\mathrm{Re}\,Z}$$

$E=0$

$E_y=0$

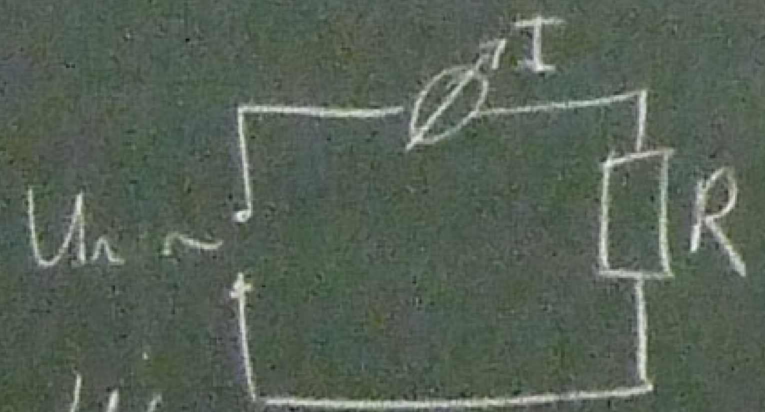
$E_x\sim\cos(\cdot x)\sin(\cdot y)$

$E_y\sim\sin(\cdot x)\cos(\cdot y)$



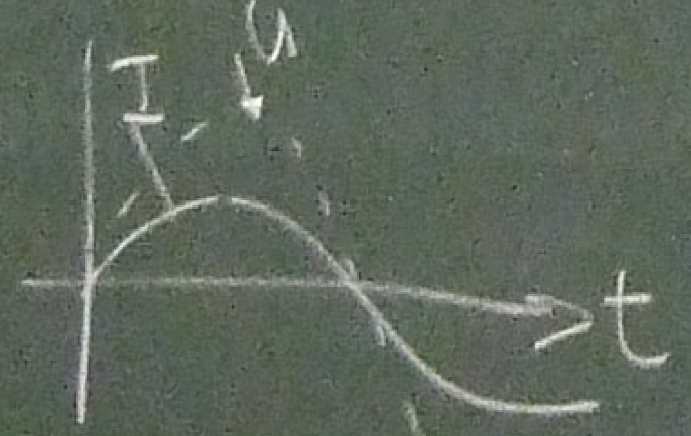

$Z=R+i\omega L$

I Der Wechselstromwiderstand

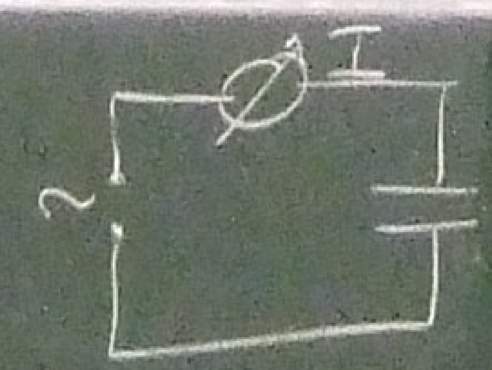


$I=U/R \qquad U_n=\hat{U}\sin(\omega t)$

$I=\hat{U}/R\,\sin\omega t$



Strom & Spannung in Phase



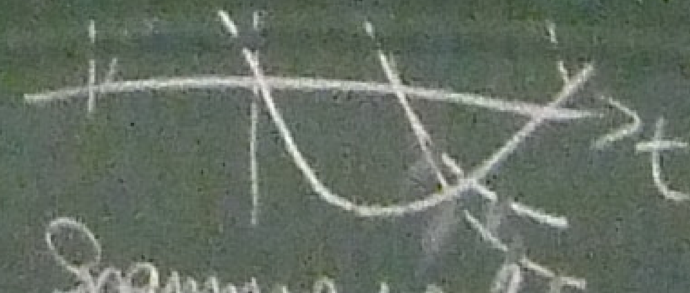
[redacted]

$\dot{Q}=I=C\dot{U}$

$U=\hat{U}\sin\omega t$

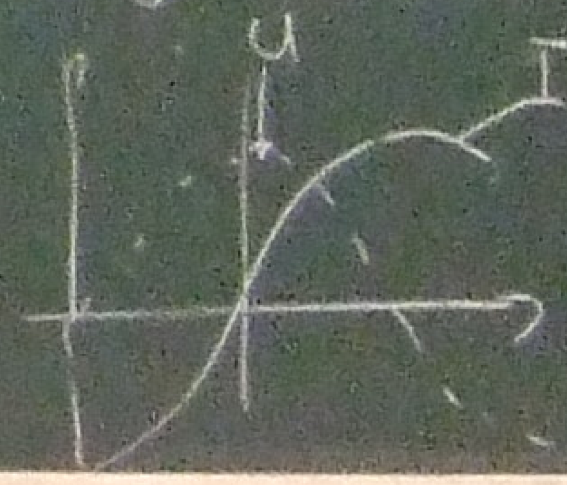
$\dot{U}=\omega\hat{U}\cos\omega t$

$R_C=\frac{\hat{U}}{\hat{I}}=\frac{1}{\omega C}$



Spannung nach dem Strom um 90° phasenverschoben

$U=L\cdot\dot{I} \to I=\frac{1}{L}\int U\,dt$



Spannung vor dem Strom