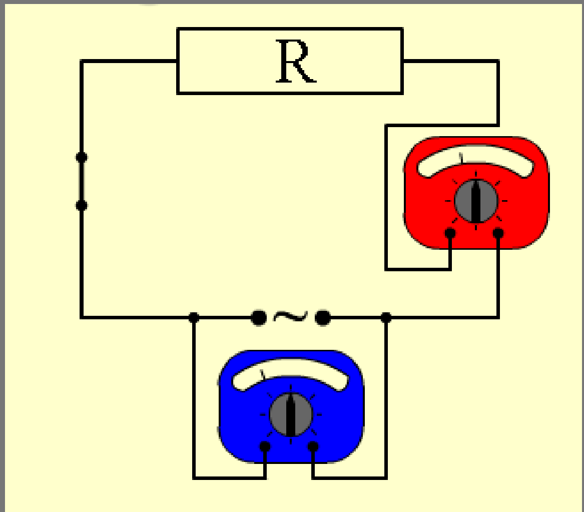
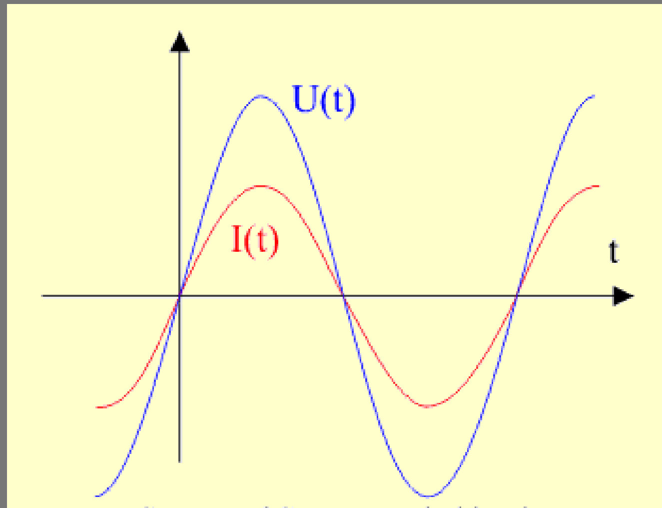
Wechselstromwiderstände R





Bei sinusförmiger Spannung $U(t) = \hat{U} \cdot \sin(\omega \cdot t)$ (1) gilt:

$U(t) = U_R(t)$ und

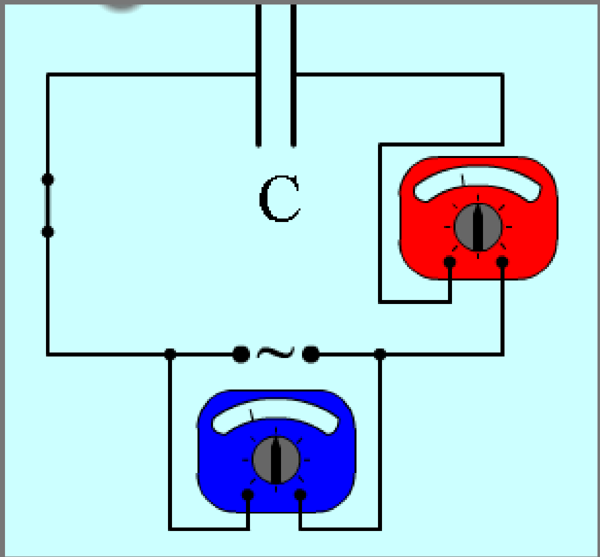
$U(t) = R \cdot I(t)$ (2)

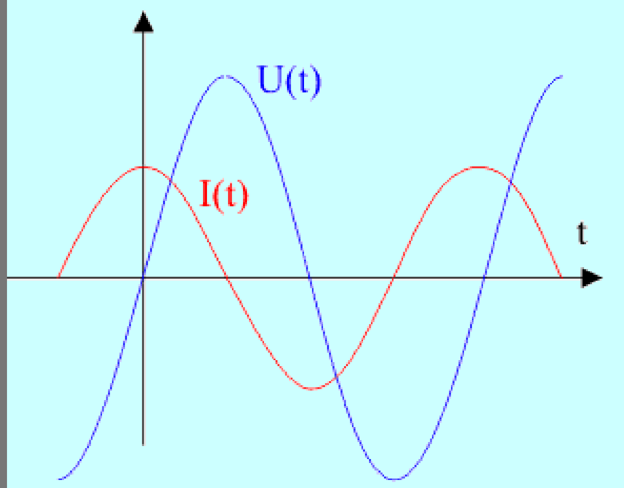
$$\hat{U} \cdot \sin(\omega \cdot t) = R \cdot I(t) \Rightarrow I(t) = \frac{\hat{U}}{R} \cdot \sin(\omega \cdot t)$$

also: $\hat{I} = \dfrac{\hat{U}}{R}$ und somit:

$$\boxed{X_R = \frac{\hat{U}}{\hat{I}} \Rightarrow X_R = R \qquad \Delta\varphi = 0}$$

Wechselstromwiderstände C





Der Strom eilt der Spannung voraus

$$\hat{U} \cdot \omega \cdot \cos(\omega \cdot t) = \frac{I(t)}{C} \quad \Rightarrow \quad I(t) = \hat{U} \cdot \omega \cdot C \cdot \cos(\omega \cdot t)$$

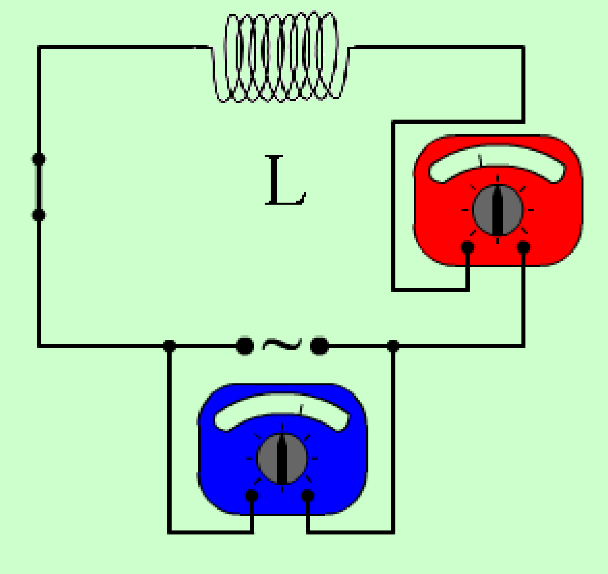
mit $\cos(\omega \cdot t) = \sin(\omega \cdot t + \frac{\pi}{2})$ folgt:

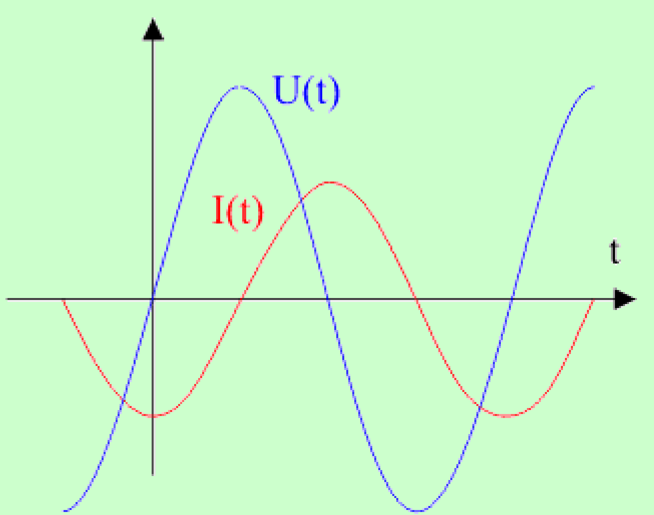
$$I(t) = \hat{I} \cdot \sin(\omega \cdot t + \tfrac{\pi}{2}) \qquad \text{mit} \quad \hat{I} = \hat{U} \cdot \omega \cdot C$$

$$X_C = \frac{\hat{U}}{\hat{I}} \quad \Rightarrow \quad X_C = \frac{1}{\omega \cdot C}$$

$$\Delta\varphi = +\frac{\pi}{2}$$

Wechselstromwiderstände L





Der Strom hinkt der Spannung nach

$$\hat{U}\cdot\sin(\omega\cdot t) = L\cdot\dot{I} \quad\Rightarrow\quad \dot{I} = \frac{\hat{U}}{L}\cdot\sin(\omega\cdot t)$$

$$I(t) = -\frac{\hat{U}}{\omega\cdot L}\cdot\cos(\omega\cdot t)$$

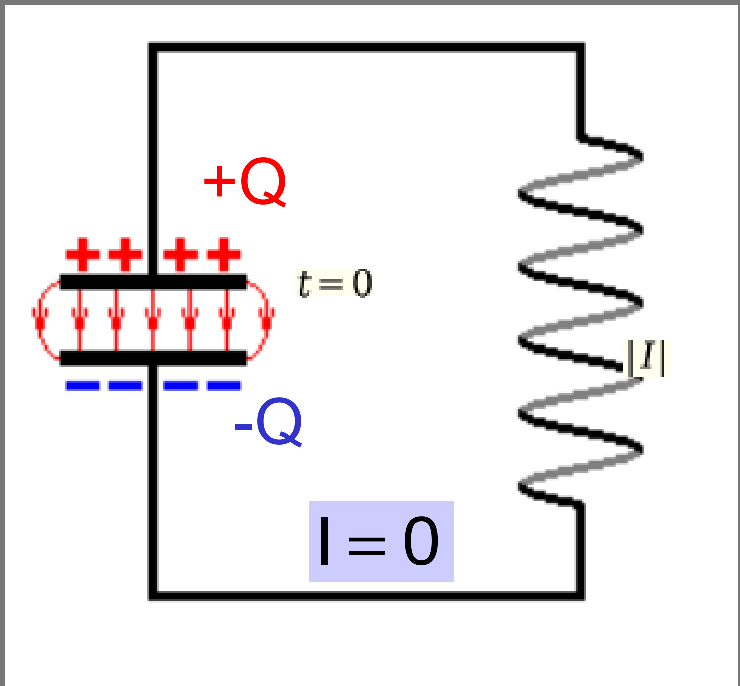
$$I(t) = \frac{\hat{U}}{\omega\cdot L}\cdot\sin\left(\omega\cdot t - \tfrac{\pi}{2}\right)$$

$$X_L = \frac{\hat{U}}{\hat{I}} \quad\Rightarrow\quad X_L = \omega\cdot L$$

$$\Delta\varphi = -\frac{\pi}{2}$$

Die Phasen des Schwingkreises

$t = 0$



$U_c = -\hat{U}$ $Q = \hat{Q}$ $B = 0$

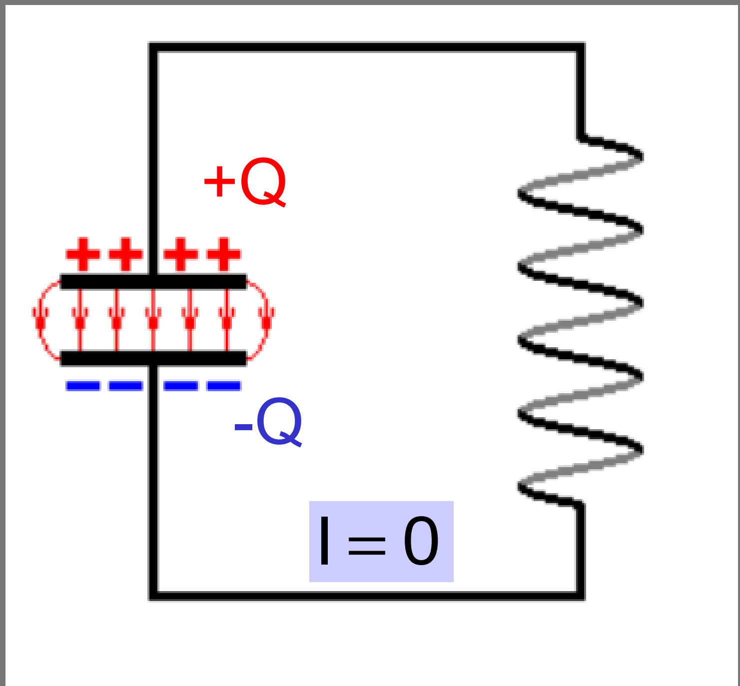
$E_{el} = \frac{1}{2} C U_C^2 = \hat{E}_{el}$ $E_{mag} = 0$

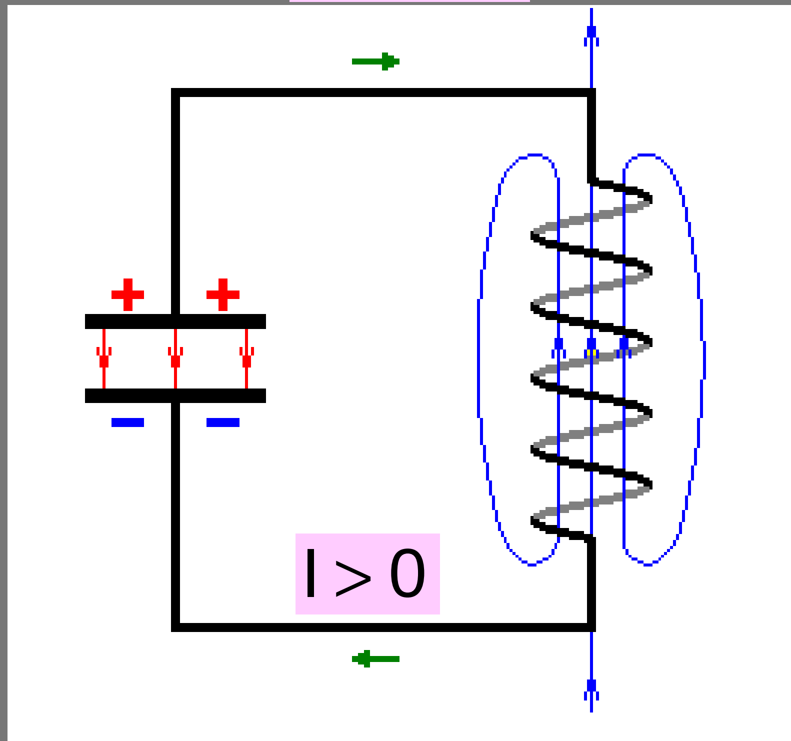
Die Phasen des Schwingkreises

$t = 0$

$0 < t < \frac{T}{4}$

http://nibis.ni.schule.de





$U_c = -\hat{U}$ $Q = \hat{Q}$ $B = 0$

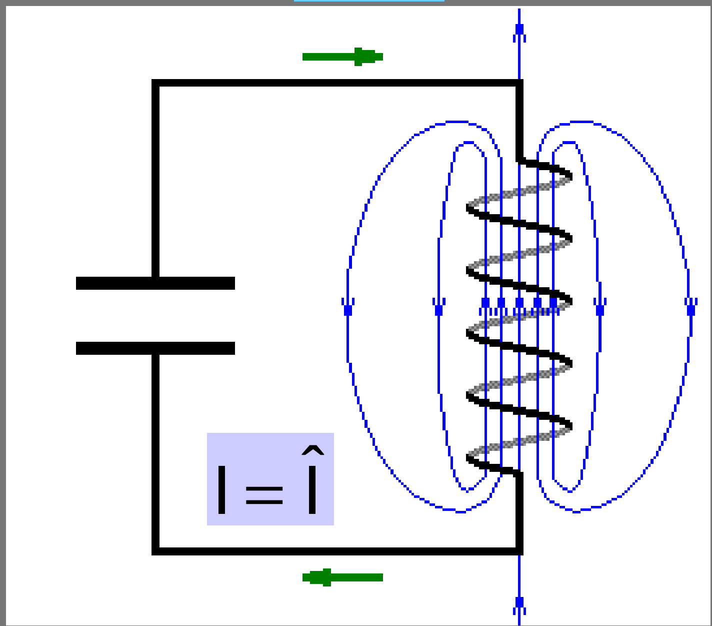
$E_{el} = \frac{1}{2} C U_C^2 = \hat{E}_{el}$ $E_{mag} = 0$

$-\hat{U} < U_c < 0$ $0 < Q < \hat{Q}$ $E_{mag} = \frac{1}{2} L I^2$

$0 < B < \hat{B}$ $0 < E_{el} < \hat{E}_{el}$

Die Phasen des Schwingkreises

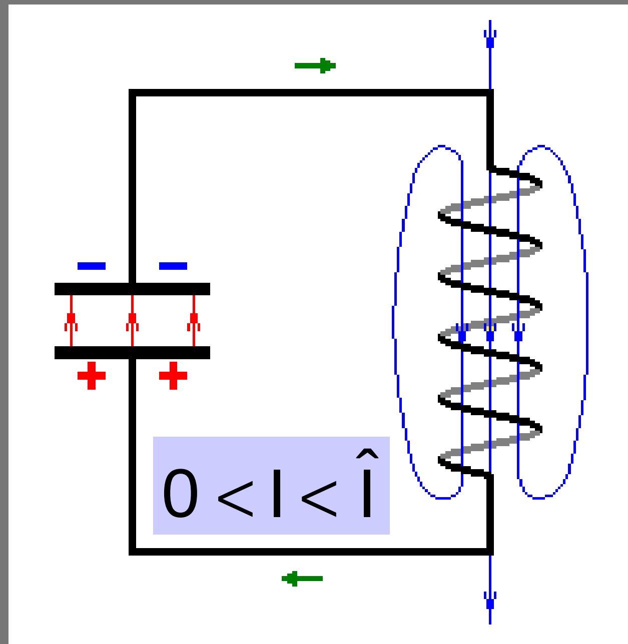
$t = \frac{T}{4}$



$U_c = 0$ $Q = 0$ $B = \hat{B}$

$E_{el} = 0$ $E_{mag} = \frac{1}{2} L \hat{I}^2$

$\frac{T}{4} < t < \frac{T}{2}$

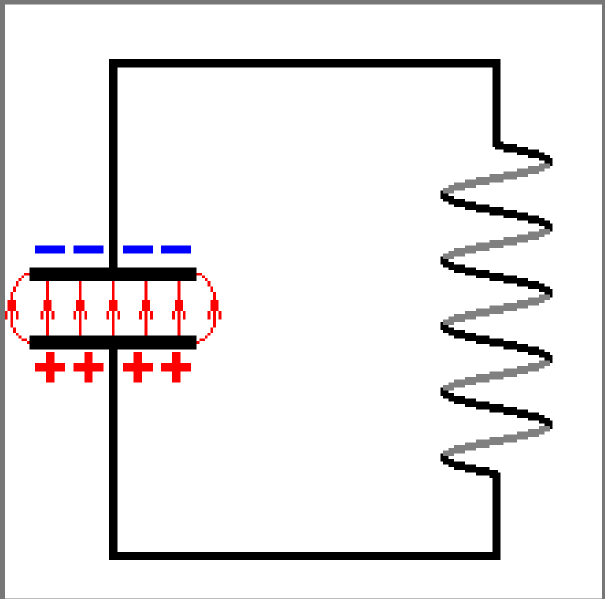


$-\hat{U} < U_c < 0$ $0 < B < \hat{B}$

$E_{el} = \frac{1}{2} U_c^2$ $E_{mag} = \frac{1}{2} L I^2$

Die Phasen des Schwingkreises

$$t = \frac{T}{2}$$



$$U_c = -\hat{U}$$ $$Q = \hat{Q}$$ $$B = 0$$

$$E_{el} = \frac{1}{2} C U_C^2 = \hat{E}_{el}$$ $$E_{mag} = 0$$

Die Thonsomsche Schwingungsgleichung

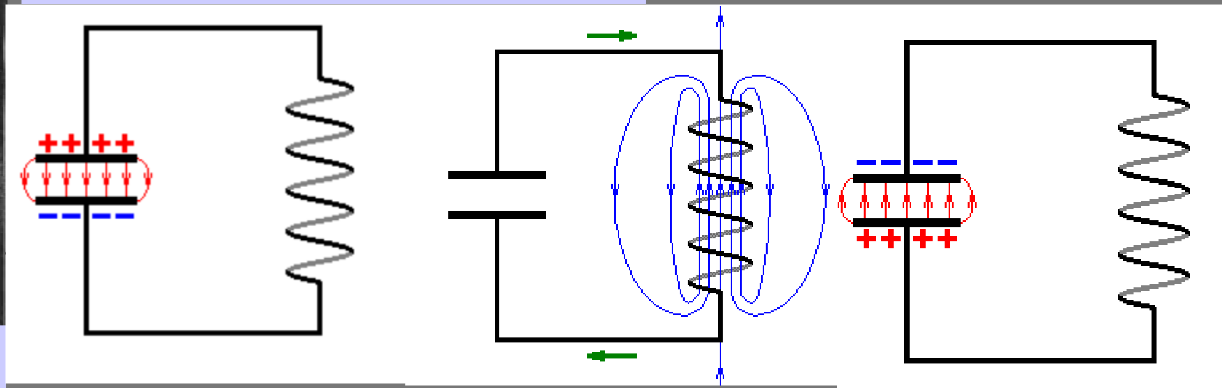
1856-1940

Nobelpreis Physik

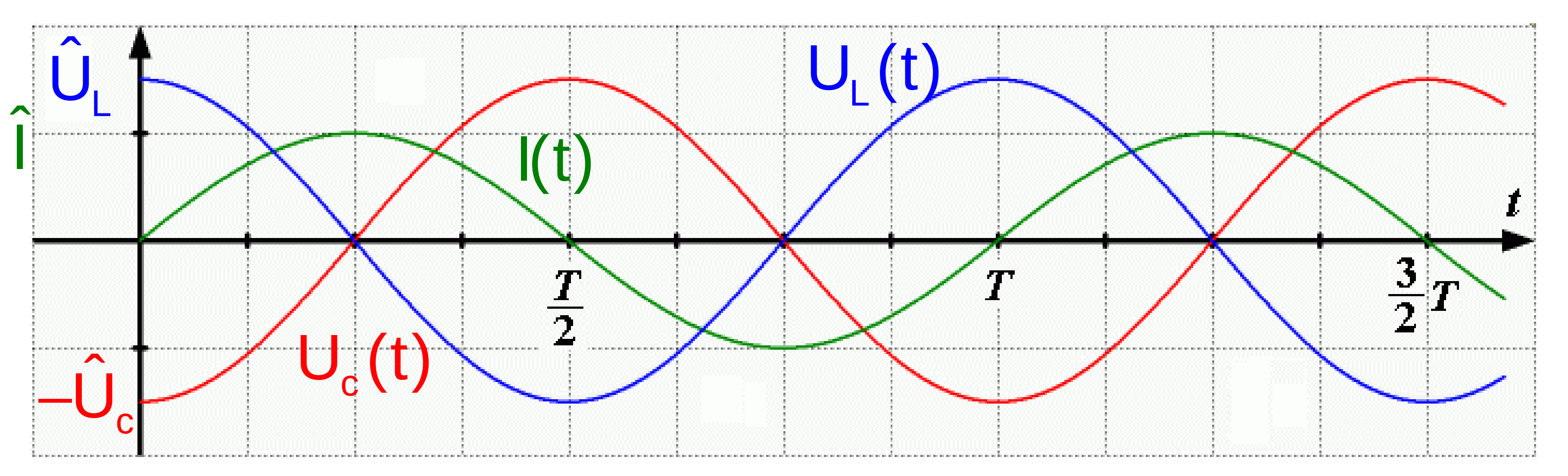
1906

$$T = 2\pi\sqrt{L \cdot C}$$

$$f = \frac{1}{2\pi\sqrt{L \cdot C}}$$



Verlauf von Strom und Spannung



$U_c(t) = -\hat{U} \cdot \cos(\omega t)$

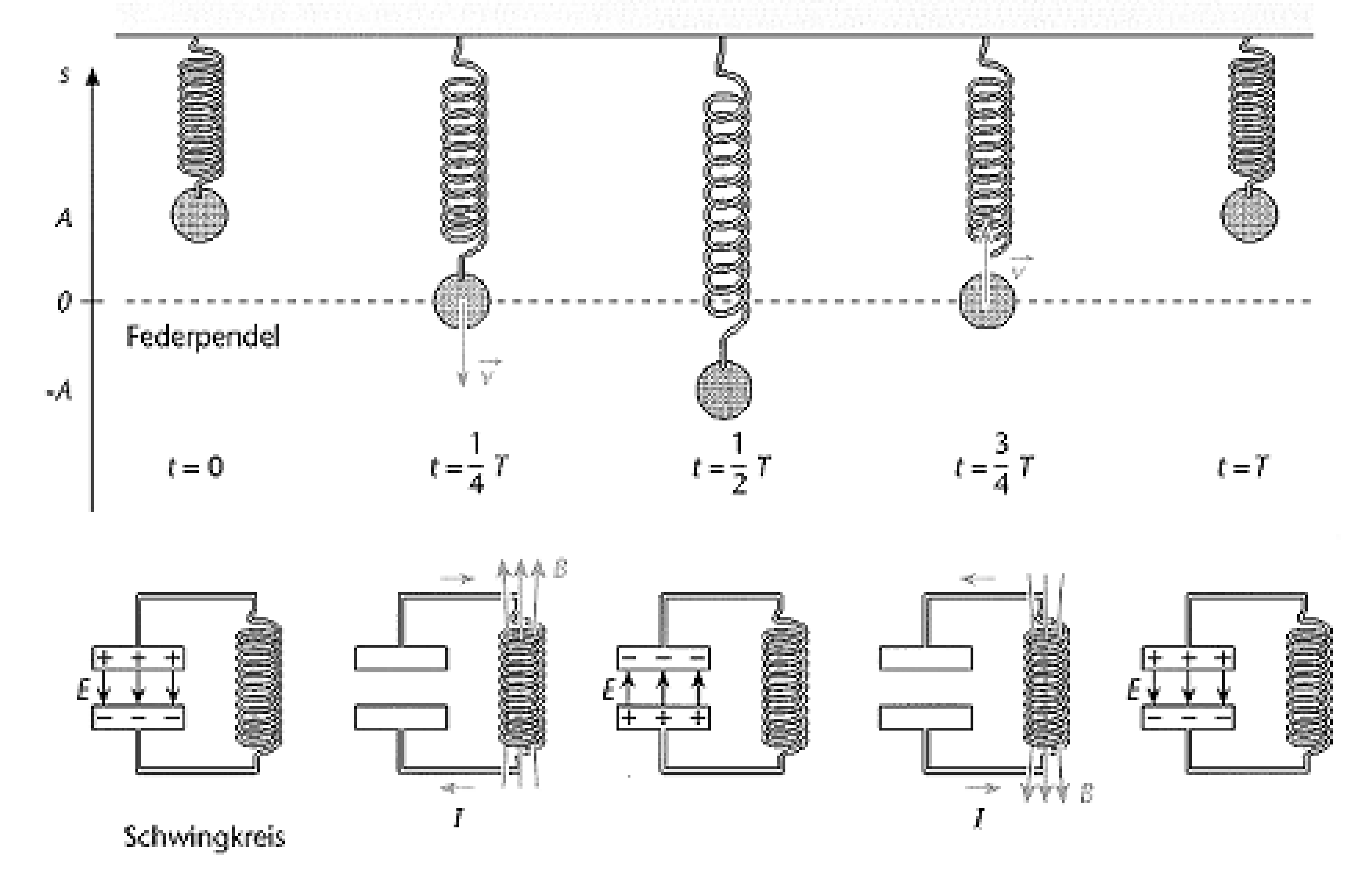
$U_L(t) = \hat{U}_L \cdot \cos(\omega t)$

$I(t) = \hat{I} \cdot \sin(\omega t)$

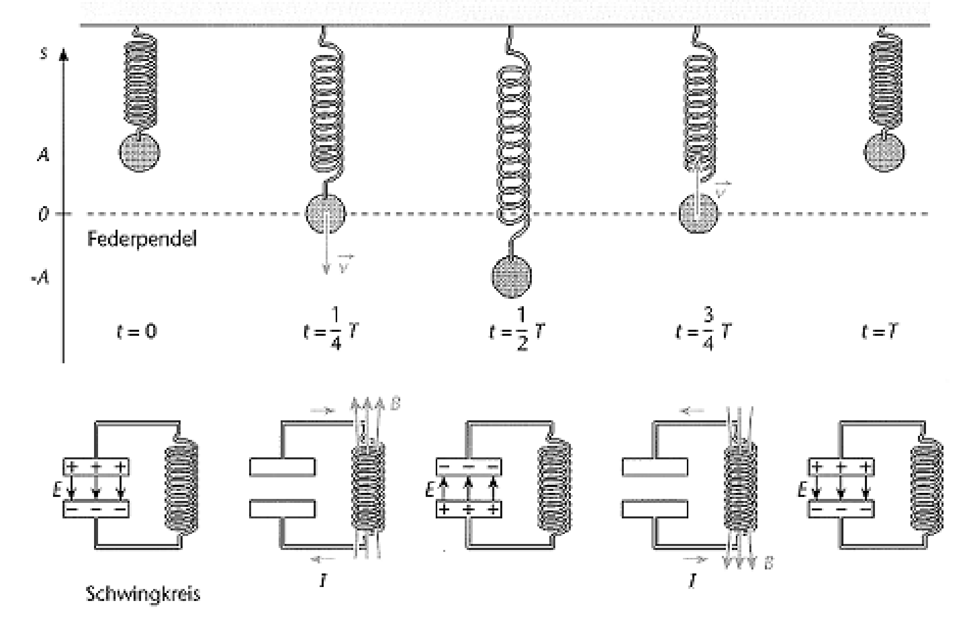
$$T = 2\pi\sqrt{L \cdot C}$$

$$f = \frac{1}{2\pi\sqrt{L \cdot C}}$$

Federpendel-Schwingkreis

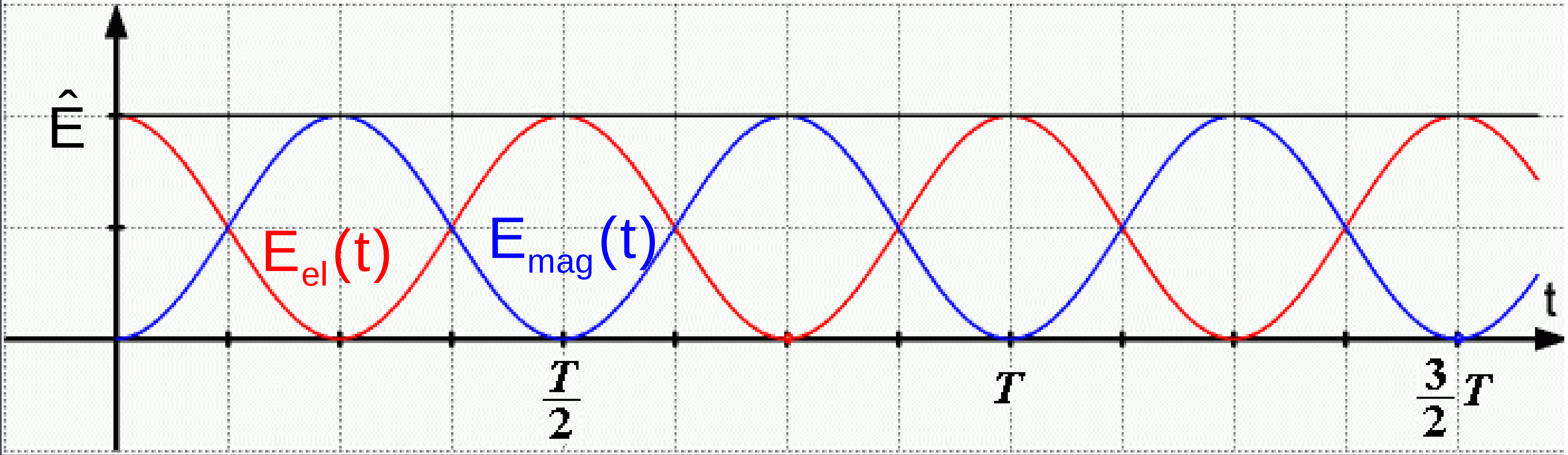


Federpendel-Schwingkreis

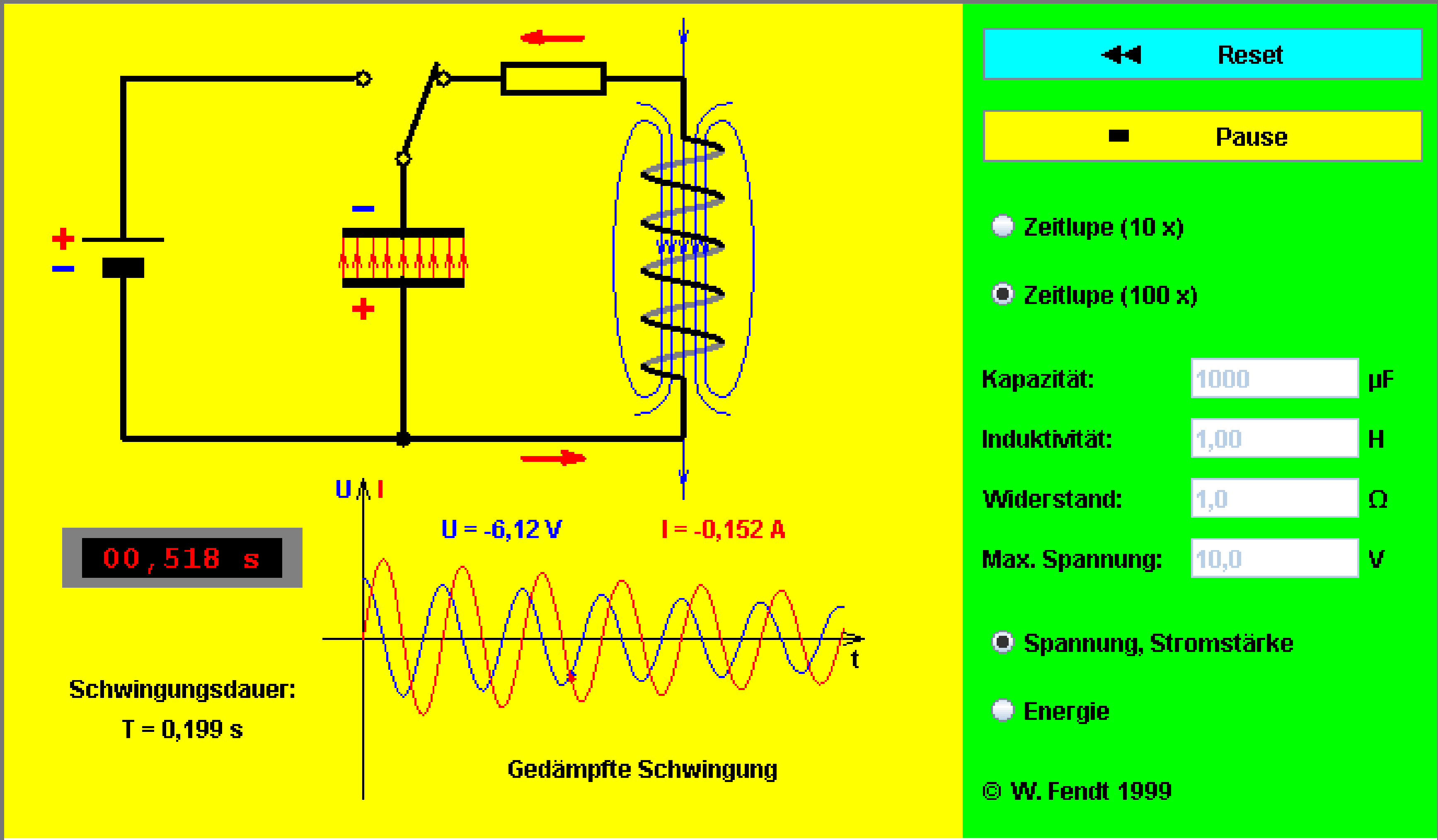


Schwingkreis	Federpendel
Kondensator	Feder
elektrische Feldenergie	Spannenergie
Spannung	Rückstellkraft
Spule	Pendelkörper
magnetische Feldenergie	kinetische Energie
Stromstärke	Geschwindigkeit

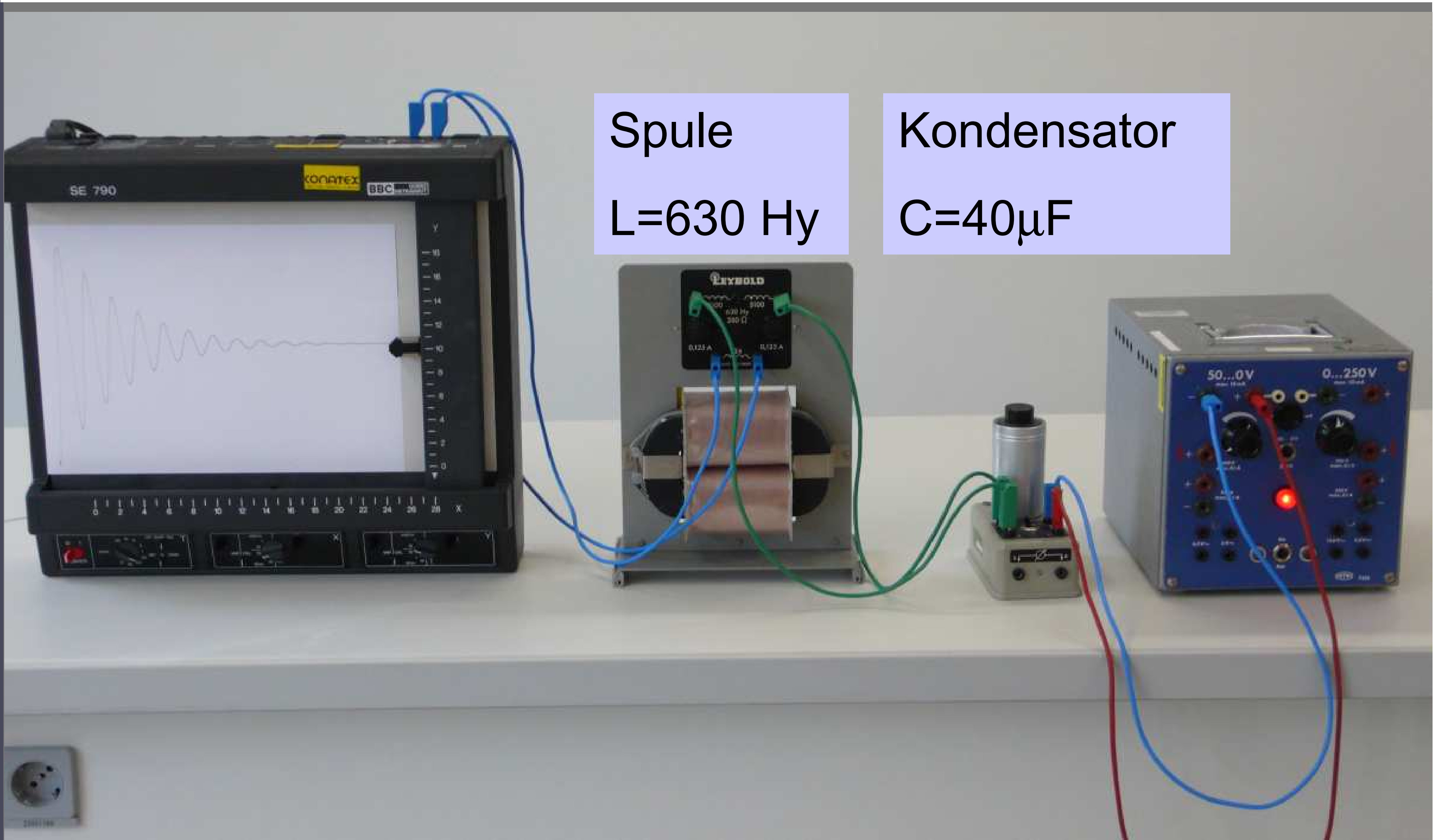
Elektrische und magnetische Energie



Applet zur Simulation



Experiment: Schwingkreis f=1 Hz



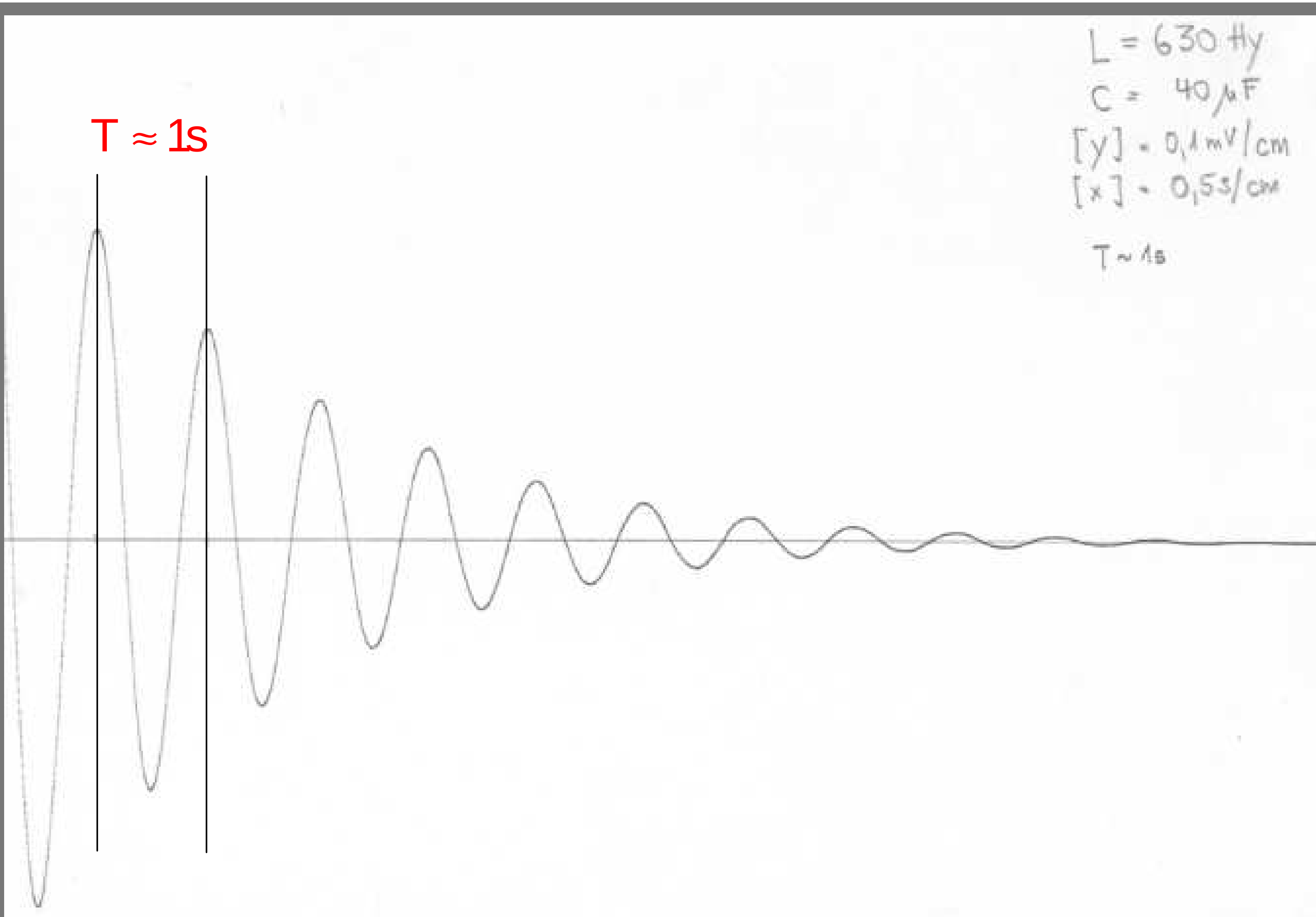
Spule

L=630 Hy

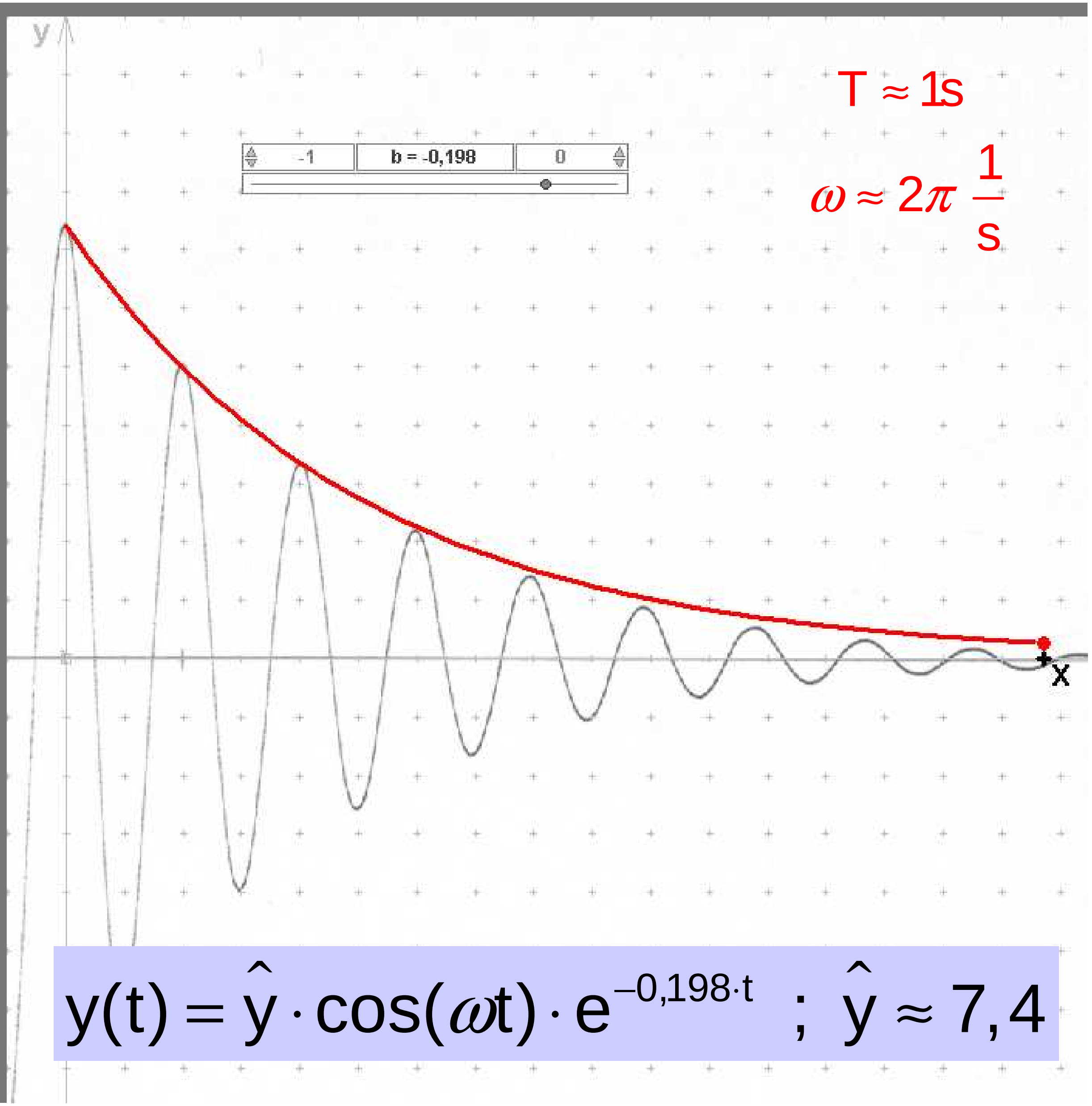
Kondensator

C=40µF

Experiment: Schwingkreis f=1 Hz



Exponentielle Dämpfung

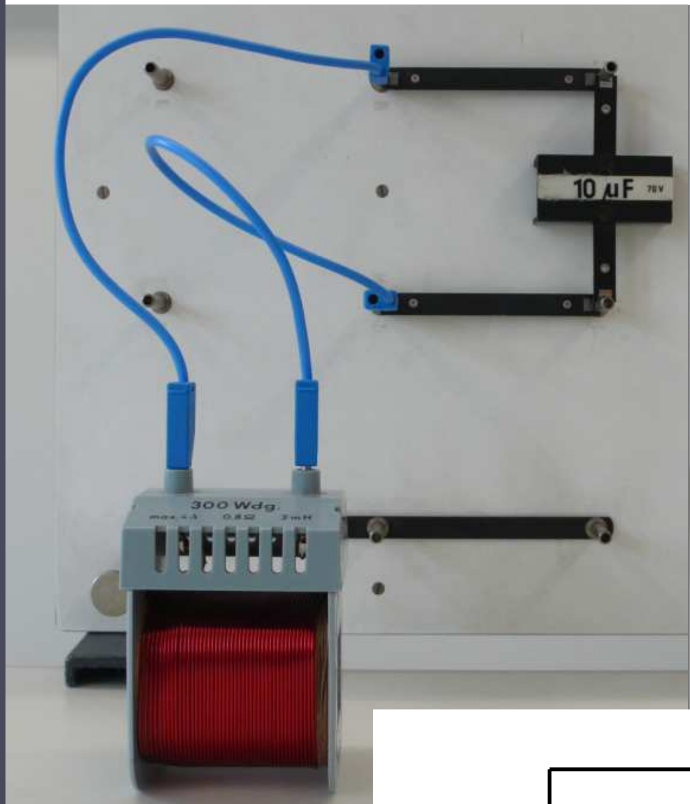


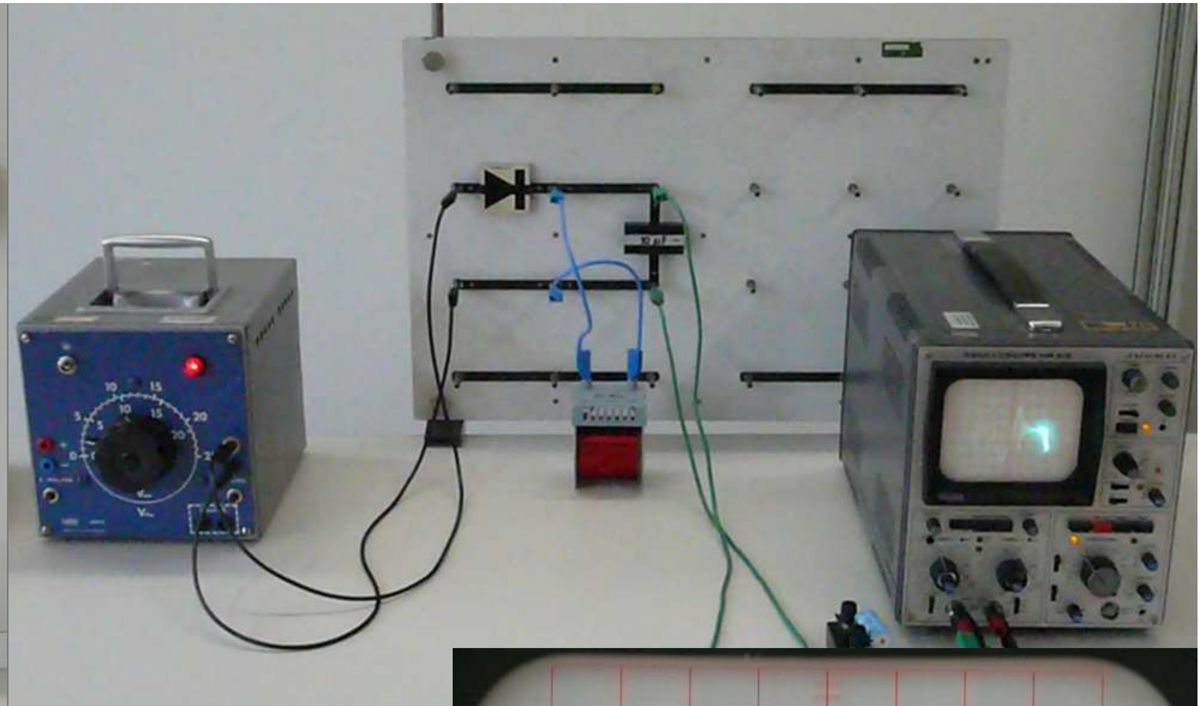
$T \approx 1s$

$\omega \approx 2\pi \frac{1}{s}$

$$y(t) = \hat{y} \cdot \cos(\omega t) \cdot e^{-0,198 \cdot t} \quad ; \quad \hat{y} \approx 7,4$$

Experiment: Schwingkreis f>1kHz





$$T = 2\pi \cdot \sqrt{LC}$$
$$= 2\pi\sqrt{2 \cdot 10^{-3} \cdot 10^{-5}}\ \mathrm{s}$$
$$\approx 9 \cdot 10^{-4}\,\mathrm{s}$$

$$f \approx 1125\ \mathrm{Hz}$$