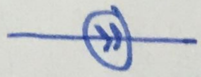
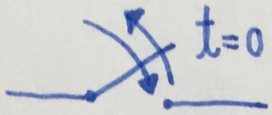
20.12.2016

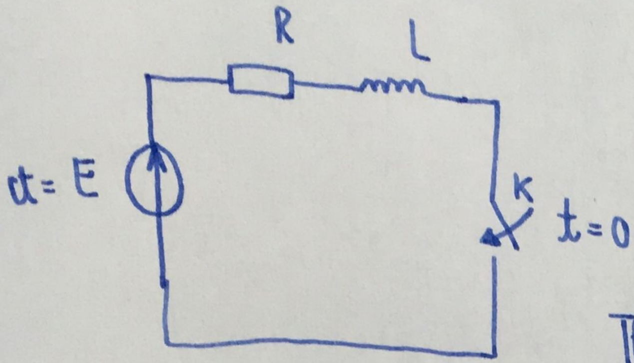
The transient state (gen. time-variable)

$e(t)$

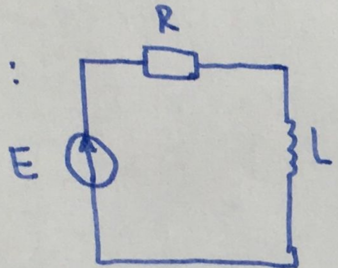


$i_s(t)$





$t>0$:



The method of direct integration

$$E = \underbrace{R \cdot i_L}_{u_R} + \underbrace{L \frac{di_L}{dt}}_{u_L} \quad \Big| : R$$

$$\frac{E}{R} = i_L + \frac{L}{R} \frac{di_L}{dt}$$

$$A = A \qquad A/s$$

$$\frac{L}{R} = \tau \quad \text{time constant of the circuit}$$

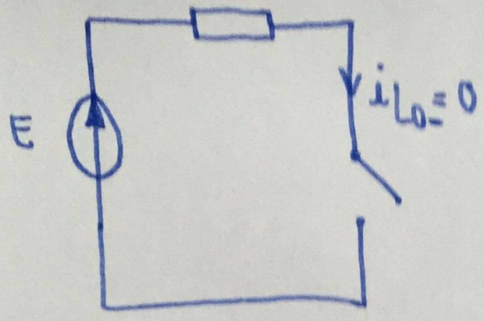
$$\frac{E}{R} = i_L + \tau \cdot i_L' \qquad \text{I degree diff. equation}$$

$$i_L(t) = \underbrace{i_{L\infty}}_{\text{the steady-state solution}} + (i_{L0+} - i_{L\infty})\, e^{-\frac{t-t_0}{\tau}} \qquad i_{L0+\varepsilon} = i_{L0-\varepsilon}$$

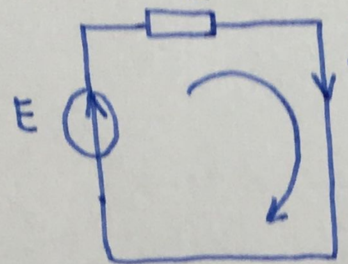
→ continuity of the solution

$\simeq 3\tau$

$t<0$



$t>0,\ t\to\infty$

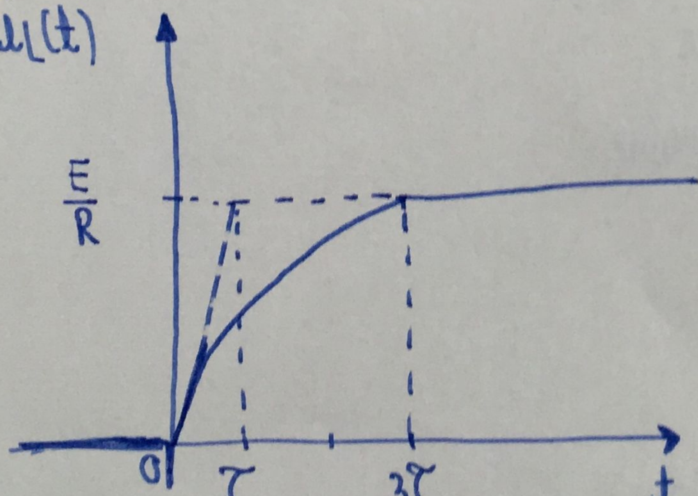


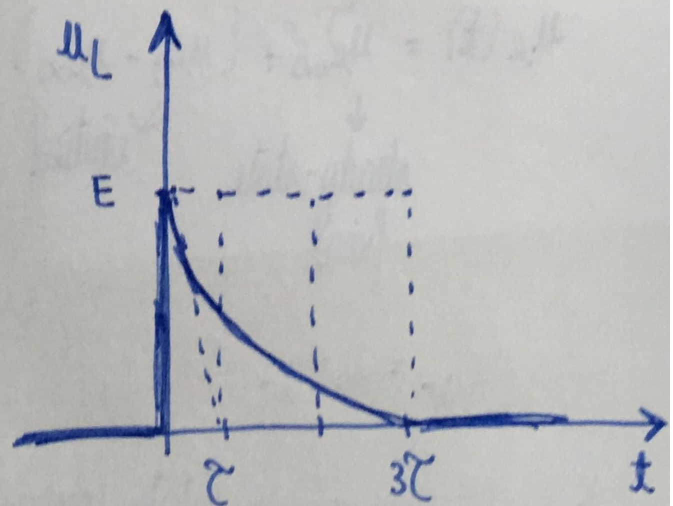
$i_{L\infty} = \frac{E}{R}$

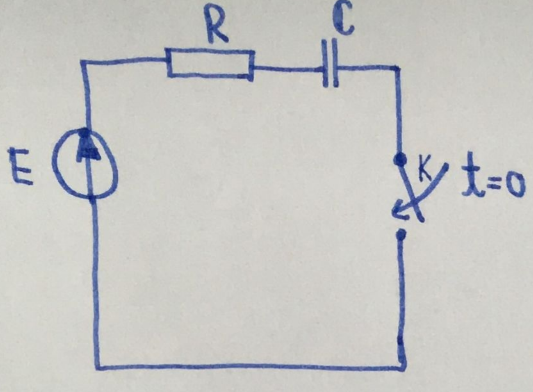
$$i_L(t) = \frac{E}{R} + \left(0 - \frac{E}{R}\right) e^{\frac{-t}{\tau}} = \frac{E}{R}\cdot\left(1 - e^{\frac{-t}{\tau}}\right)$$

$$u_L(t) = L\,\frac{di_L}{dt} = L\,\frac{E}{R}\cdot\left(0 - \left(-\frac{1}{\tau}\cdot e^{\frac{-t}{\tau}}\right)\right) \qquad \frac{1}{\tau} = \frac{R}{L}$$

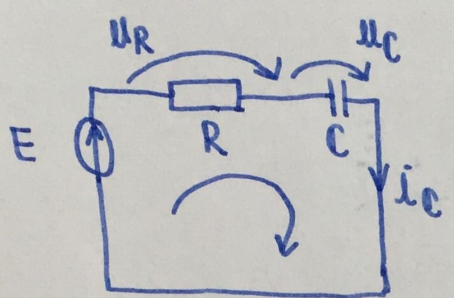
$$= E\cdot e^{\frac{-t}{\tau}}$$







$t>0$



$$E = \underbrace{u_R}_{R \cdot i_C} + u_C$$

$$E = R \cdot i_C + u_C$$

$$i_C = C \frac{di_C}{dt}$$

$$E = \underset{\tau}{\underset{\downarrow}{RC}} \frac{du_C}{dt} + u_C$$

$$V \quad \tau \quad V/s \quad V$$

$$E = \tau \cdot u_C' + u_C$$

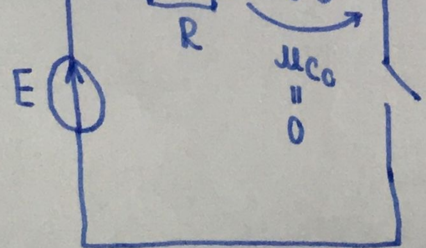
$$u_C(t) = u_{C\infty} + (u_{C0} - u_{C\infty})\, e^{-\frac{t-t_0}{\tau}}$$

$u_{C\infty}$ → steady-state final

u_{C0} → initial value

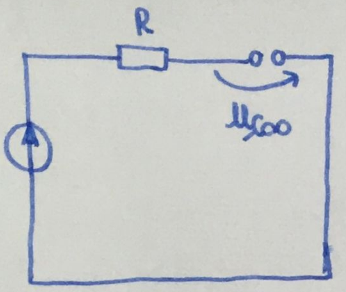
$$u_{C0+} = u_{C0-}$$

$t<0$ (permanent state conditions)



$$u_{C0-} = 0 \Rightarrow u_{C0+} = 0$$

$t>0\ ,\ t\to\infty$



$u_{C\infty} = E$

$$u_C(t) = E + (0-E)\,e^{\frac{-t}{\tau}} = E\left(1-e^{\frac{-t}{\tau}}\right)$$

$$i_C = C\,\frac{du_C}{dt} = C\cdot E\left(0-\left(-\frac{1}{\tau}\right)e^{\frac{-t}{\tau}}\right)$$

$$i_C = CE\left(\frac{1}{RC}\right)e^{\frac{-t}{\tau}} = \frac{E}{R}\,e^{\frac{-t}{\tau}}$$