# task_tb6pi8dgh0m2e2pw_with_calculation

## Student Group

| First Name | Surname | Matrikel Nr. |
| --- | --- | --- |
| | | |
| | | |
| | | |

## Table of Contents

Charging Capacitors, dc network analysis, pure resistor network simplification, delta wye transformation, exam ee1 WS2022

**Exercise E1 Charging Capacitors**
**(written test, approx. 16 % of a 60-minute written test, WS2022)**

4. Now, consider the light bulb as a resistor of $R_B = 20 \Omega$ and switch $S_2$ is closed. $S_2$ is open. The voltage across the capacitor is again $0 ~\rm{V}$ at the moment $t_0=0 ~\rm{s}$ when the switch $S_1$ is closed. Calculate the voltage $u_c (t_2)$ across the capacitor at $t_2=1 ~\rm{ms}$ after closing the switch.

Result

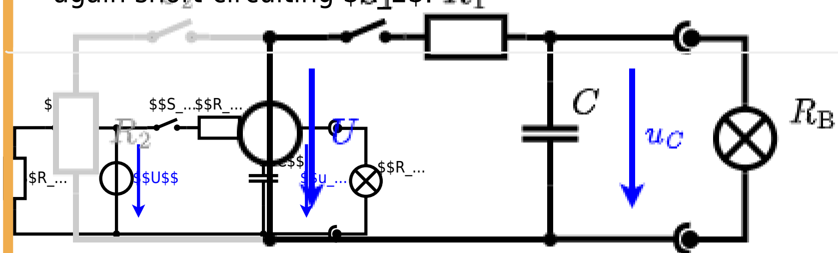
Hint: To solve this, first create an equivalent linear voltage source from $U$, $R_1$, and $R_\rm B$.

\begin{align*} \Delta W_R = 3.792 \rm{mJ} \end{align*}

Solution

\begin{align*} \Delta W_R &= \Delta W_C \\ &= {{1}\over{2}}\cdot C \cdot U^2 \\ &= {{1}\over{2}}\cdot 100 ~\rm{µF} \cdot (12 ~\rm{V})^2 \end{align*}

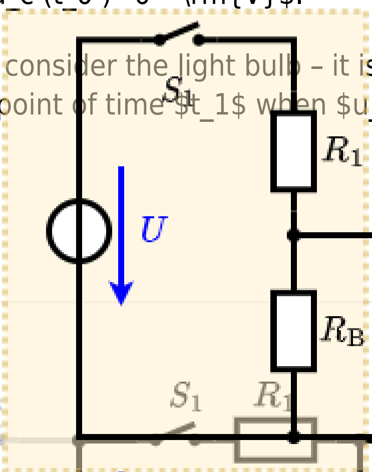
On an alternative view, one can try to create an equivalent linear voltage source again. Then, the internal resistance is given by substituting the ideal voltage source is again short-circuiting $R_2$.

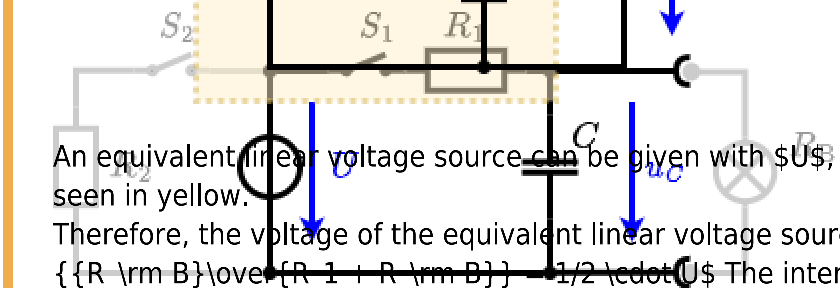


The circuit contains a voltage source $U=12 ~\rm{V}$, a switch $S_1$, a resistor of $R_1=20 ~\Omega$ and a capacitor of $C=100 ~\rm{µF}$.
The switch $S_2$ to an additional consumer $R_2$ will be considered to be open for the first tasks. At the moment $t_0=0 ~\rm{s}$ the switch $S_1$ is closed, the voltage across the capacitor is $u_c (t_0 )=0 ~\rm{V}$.

1. First do not consider the light bulb – it is not connected to the RC circuit.
Calculate the point of time $t_1$ when $u_c (t_1)=0.5\cdot U$.

Solution





An equivalent linear voltage source can be given with $U$, $R_1$, and $R_\rm B$ as seen in yellow.
Therefore, the voltage of the equivalent linear voltage source is: $U_s = U \cdot {{R_\rm B}\over{R_1 + R_\rm B}} = 1/2 \cdot U$ The internal resistance is given by substituting the ideal voltage source with its resistance ($=0 ~\Omega$, short-circuit).

So, here only R_1 and C gives the time constant: $\tau = R_1 \cdot C$
\begin{align*} R_1 &= R_1 || R_m \\ &= 10 ~\Omega \end{align*}

The following formula describes the time course of $u_C(t)$, which has to be $u_C(t_1)=0.5\cdot U$: \begin{align*} u_C(t) = U \cdot (1-e^{-t/\tau}) = 0.5\cdot U
\begin{align*} u_C(t_2) &= U_\cdot (1- e^{-t_2/(R_1\cdot C)}) \\ &= {{1}\over{2}} \cdot U \cdot (1- e^{-t/\tau}) = 0.5 \cdot U \end{align*}
\end{align*} It has to be rearranged to $t$ \begin{align*} (1- e^{t/\tau}) &= 0.5 \\ e^{t/\tau} &= 0.5 \\ t/\tau &= ln(0.5) \\ t &= \tau \cdot ln(0.5) \\ t &= R_1 \cdot C \cdot ln(0.5) \end{align*}