# task_tb6pi8dgh0m2e2pw_with_calculation

## Student Group

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

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.

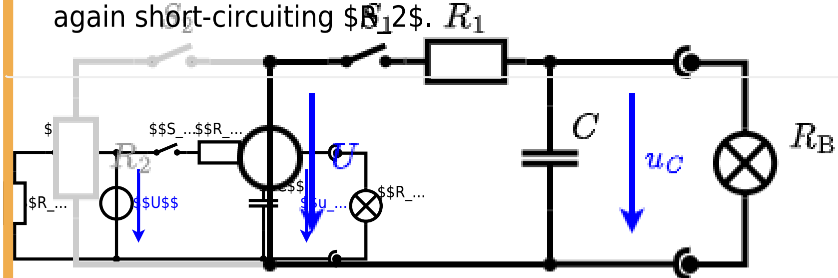
Result

Hint: To solve this, first create an equivalent linear voltage source from $U$, $R_1$, and $R_B$.

Solution

$U=12 ~\rm{V}$ independent of this resistor.

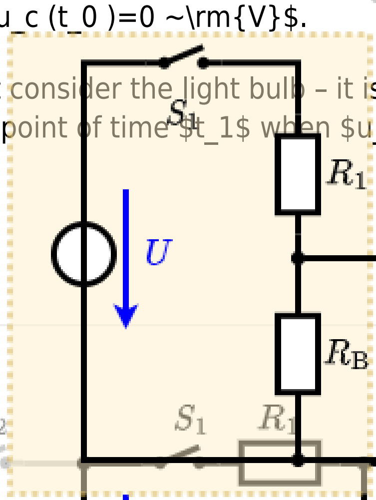
On an alternative view, one can try to create an equivalent linear voltage source again. Then, the internal resistance is given by substituting the ideal voltage source is again short-circuiting $R_2$.




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 $R_B$ as seen in yellow.
Therefore, the voltage of the equivalent linear voltage source is: $U_s = U \cdot {{R_B}\over{R_1 + R_B}} = 1/2 \cdot U$ 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_i &= R_1 || R_B \\ &= 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 &= U \cdot (1- e^{t/\tau}) \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*}
\begin{align*} \tau_2 &= R_i \cdot C \\ &= {1 \over {2}} \cdot 10 ~\Omega \cdot 100 ~\mu F \end{align*}