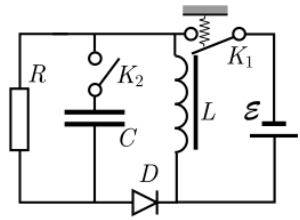
1. DC-DC CONVERTER (8 points) In order to obtain high voltage supply using a battery, the following circuit is used.



An electromagnetic switch K_1 connects a battery of electromotive force $\mathcal{E}$ to an inductor of inductance L: it is closed if there is no current in the inductor (a spring keeps it closed), but if the inductor current reaches a critical value I_0, magnetic field created by the inductor pulls it open. Due to inertia, once the key is open, it takes a certain time τ_K to close again even if the current falls to zero.

For the diode D you may assume that its current is zero for any reverse voltage ($V_D < 0$), and also for any forward voltage smaller than the opening voltage V_0 (i.e. for $0 < V_D < V_0$). For any non-zero forward current, the diode voltage V_D remains equal to V_0.

You may express your answers in terms of L, $\mathcal{E}$, I_0, V_0, and the capacitance C (see figure).

i) *(1 point)* At first, let the key K_2 be open. If the initial inductor current is zero, how long time τ_L will it take to open the key K_1?

ii) *(1 point)* Assuming (here and in what follows) that $L/R \ll \tau_K \ll \tau_L$, plot the inductor current as a function of time t (for $0 \le t < 3\tau_L$).

iii) *(1 point)* What is the maximal voltage $V_{\max}$ on the resistor R?

iv) *(2 points)* Assuming that $V_{\max} \gg V_0$, what is the average power dissipation on the diode?

v) *(2 points)* Now, let the key K_2 be closed, and let us assume simplifyingly that $V_0 = 0$; also, $RC \gg \tau_L$ and $\tau_K > \pi\sqrt{LC}$. Suppose that the circuit has been operated for a very long time. Find the average voltage on the resistor.

vi) *(1 point)* Find the amplitude of voltage variations on the resistor.