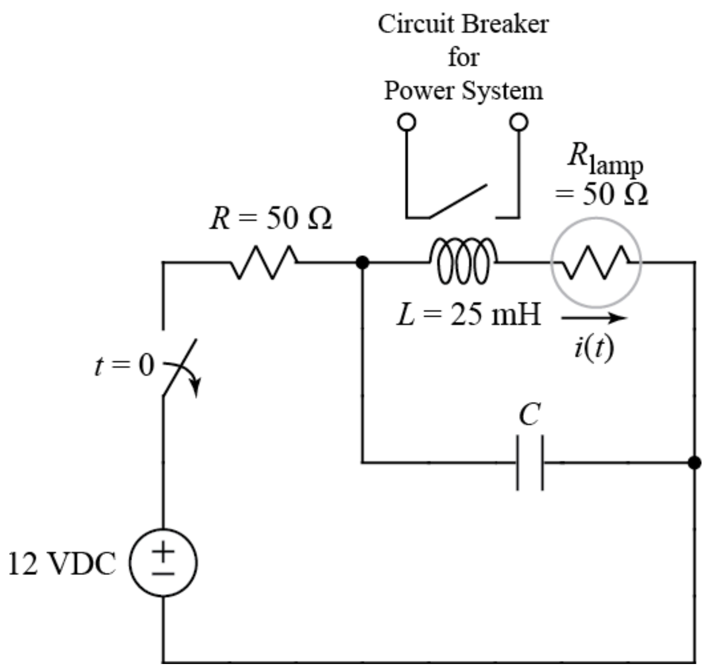
HOMEWORK #9

1.



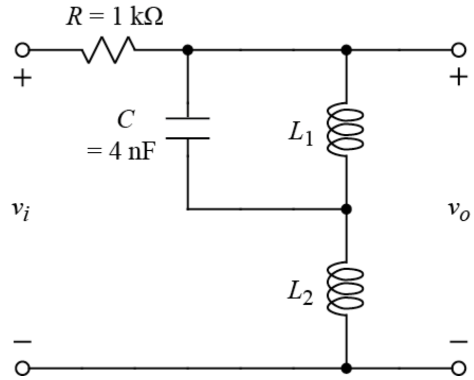
After being closed for a long time, the switch opens at $t = 0$.

The above circuit shows an inductor acting as the electromagnet for a relay that holds a circuit breaker closed for a power system. A 6 V, 120 mA lamp, modeled as a 50 Ω resistor in the above diagram indicates whether the relay is on. When the switch is opened to turn off the relay, the capacitor in the circuit prevents a current spike from the inductor that would otherwise arc across the switch contacts. To turn the relay off as quickly as possible, the value of the capacitor is chosen to make the circuit critically damped.

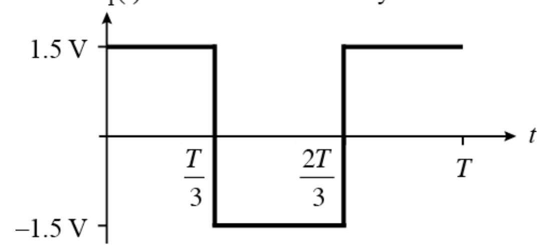
Find the value of C that makes the circuit critically-damped after the switch is opened at $t = 0$.

2. Using the C value from problem 1, find a numerical expression for the lamp current, $i(t)$, for $t > 0$.

3.



$v_1(t)$ = waveform for binary 1



T = one period of $v_i(t) = 2\pi$ ns

$$v_1(t) = \begin{cases} 1.5\text{ V} & 0 \le t < T/3 \\ -1.5\text{ V} & T/3 \le t < 2T/3 \\ 1.5\text{ V} & 2T/3 \le t \le T \end{cases}$$

The above filter circuit is being considered for use in a communication system to detect whether received signals represent binary zeros or binary ones. The plan is to use an inexpensive design with rectangular waveforms (rather than sinusoids). A zero will be signaled by a square wave (not shown), and a one will be signaled by a rectangular wave having 2/3 duty cycle (shown above). The filter for detecting a zero is designed to pass the fundamental frequency of the waveforms, which is the same as the fundamental frequency of the waveform shown above. The issues addressed in this problem are the design of the filter and how well it blocks the waveform representing a "one".

Find values of $L_1 \neq 0$ and $L_2 \neq 0$ such that the magnitude of the filter's transfer function, H, equals one for the fundamental frequency, ω_0, and zero for frequency $3\omega_0/2$, (which the engineer proposing the circuit believes is present in the signal for a "one").

4. Find the numerical value of coefficient a_V, (the DC input to the filter), of the signal into the filter for the Fourier series for $v_1(t)$ in problem 3:

$$v_1(t) = a_V + \sum_{k=1}^{\infty} a_k \cos(k\omega_0 t) + b_k \sin(k\omega_0 t)$$

5. Find the numerical value of the magnitude, $\sqrt{a_1^2 + b_1^2}$, of the fundamental-frequency of the signal into the filter in problem 3.