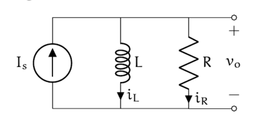
can.exe Exercises for Chapter can

Exercise can.mad

Use the diagram below to answer the following questions and imperatives. Let $I_s = A_0$, where $A_0 \in \mathbb{R}$ is a known constant. Perform a full circuit analysis, including the transient response. The initial inductor current is $i_L(0) = 0$.

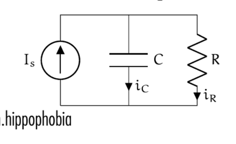
(a) Write the elemental, KCL, and KVL equations.
(b) Write the differential equation for $i_L(t)$ arranged in the standard form and identify the time constant τ.
(c) Solve the differential equation for $i_L(t)$ and use the solution to find the output voltage $v_o(t)$.



Exercise can.theocratically

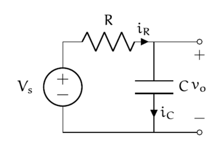
Use the diagram below to answer the following questions and imperatives. Let $I_s = A_0$, where $A_0 \in \mathbb{R}$ is a known constant. Perform a full circuit analysis, including the transient response. The initial capacitor voltage is $v_C(0) = v_{C0}$, a known constant.

(a) Write the elemental, KCL, and KVL equations.
(b) Write the differential equation for $v_C(t)$ arranged in the standard form.
(c) Solve the differential equation for $v_C(t)$.



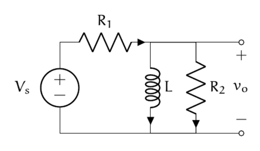
Exercise can.hippophobia

For the RC circuit diagram below, perform a complete circuit analysis to solve for $v_o(t)$ if $V_S(t) = A \sin \omega t$, where $A \in \mathbb{R}$ is a given amplitude and $\omega \in \mathbb{R}$ is a given angular frequency. Let $v_C(t)|_{t=0} = v_{C0}$, where $v_{C0} \in \mathbb{R}$ is a given initial capacitor voltage. Hint: you will need to solve a differential equation for $v_C(t)$.



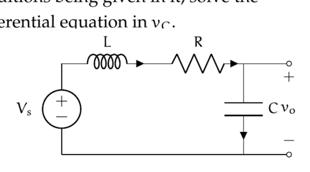
Exercise can.fruitarianism

For the circuit diagram below, perform a complete circuit analysis to solve for $v_o(t)$ if $V_s(t) = A \sin \omega t$, where $A \in \mathbb{R}$ is a given amplitude and $\omega \in \mathbb{R}$ is a given angular frequency. Let $i_L(t)|_{t=0} = 0$ be the initial inductor current. Hint: you will need to solve a differential equation for $i_L(t)$.



Exercise can.gastrolobium

For the circuit diagram below, perform a complete circuit analysis to solve for $v_o(t)$ if $V_s(t) = 0$. Let $v_C(t)|_{t=0} = 5$ V and $dv_C/dt|_{t=0} = 0$ V/s be the initial conditions. Assume the characteristic equation has distinct roots. Recommendation: due to the initial conditions being given in it, solve the differential equation in v_C.



Elemental Eq's

$V_R = i_R R$

$\frac{dv_c}{dt} = \frac{1}{C} i_c = \frac{1}{C} i_L$

$\frac{di_L}{dt} = \frac{1}{L} V_L$

KCL $i_L = i_R = i_c$

KVL $V_s = V_L + V_R + V_c$

$$\frac{d^2 V_c}{dt^2} = \frac{1}{C}\frac{di_L}{dt}$$
$$= \frac{1}{C}\frac{1}{L} V_L$$
$$= \frac{1}{CL}(V_s - V_R - V_c)$$
$$= \frac{1}{CL}(V_s - i_c R - V_c)$$
$$= \frac{1}{CL}\left(V_s - RC\frac{dv_c}{dt} - V_c\right)$$
$$\frac{d^2 V_c}{dt^2} + \frac{R}{L}\frac{dv_c}{dt} + \frac{1}{CL}V_c = \frac{1}{CL}V_s = 0$$

$$\lambda^2 + \frac{R}{L}\lambda + \frac{1}{CL} = 0$$

assume $\lambda = \lambda_1, \lambda_2$ $\quad \lambda_1 \neq \lambda_2$

$V_{ch} = c_1 e^{\lambda_1 t} + c_2 e^{\lambda_2 t} = V_c$ $\quad \frac{dv_c}{dt} = \lambda_1 c_1 e^{\lambda_1 t} + \lambda_2 c_2 e^{\lambda_2 t}$

$V_c(0) = 5 = c_1 + c_2$

$\left.\frac{dv_c}{dt}\right|_{t=0} = 0 = \lambda_1 c_1 + \lambda_2 c_2 = \lambda_1(c_2 - 5) + \lambda_2 c_2$
$= \lambda_1 c_2 + 5\lambda_1 + \lambda_2 c_2 = 0$

$c_1 = c_2 - 5$

$(\lambda_2 - \lambda_1) c_2 = 5\lambda_1$

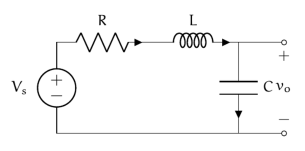
$c_2 = \frac{5\lambda_1}{\lambda_2 - \lambda_1}$

$$c_1 = \frac{5\lambda_1}{\lambda_2 - \lambda_1} - 5 = \frac{5\lambda_1 - 5\lambda_2 + 5\lambda_1}{\lambda_2 - \lambda_1} = \frac{10\lambda_1 - 5\lambda_2}{\lambda_2 - \lambda_1}$$

$$V_c = \frac{10\lambda_1 - 5\lambda_2}{\lambda_2 - \lambda_1} e^{\lambda_1 t} + \frac{5\lambda_1}{\lambda_2 - \lambda_1} e^{\lambda_2 t}$$

Exercise can.thyroprivic

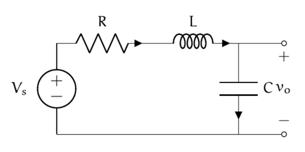
For the circuit diagram below, perform a complete circuit analysis to solve for $v_o(t)$ if $V_s(t) = 3\sin(10t)$. Let $v_C(t)|_{t=0} = 0$ V and $dv_C/dt|_{t=0} = 0$ V/s be the initial conditions. Assume the characteristic equation has distinct, complex roots. Recommendation: due to the initial conditions being given in it, solve the differential equation in v_C. Also, consider which, if any, of your results from Exercise can. apply and re-use them, if so.



Exercise can.hemogenesis

For the circuit diagram below, solve for $v_o(t)$ if $V_s(t) = A \sin \omega t$, where $A = 2$ V is the given amplitude and $\omega \in \mathbb{R}$ is a given angular frequency. Let $R = 50\ \Omega$, $L = 50$ mH, and $C = 200$ nF. Let the circuit have initial conditions $v_C(0) = 1$ V and $i_L(0) = 0$ A. Find the steady-state ratio of the output amplitude to the input amplitude A for $\omega = \{5000, 10000, 50000\}$ rad/s. This circuit is called a low-pass filter—explain why this makes sense. Plot $v_o(t)$ in MATLAB, Python, or Mathematica for $\omega = 400$ rad/s (you think this won't be part of the quiz, but it will be!). Hint: either re-write your system of differential-algebraic equations and initial conditions as a single second-order differential equation with initial conditions in the differential variable or re-write it as a system of two first-order differential equations and solve that.

low−pass filter



Exercise can.photochromascope

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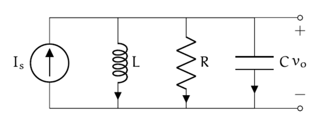
Use the circuit diagram below to answer the following questions and imperatives. Let $I_s = A_0$, where $A_0 > 0$ is a known constant. Perform a full circuit analysis, including the transient response. The initial inductor current is $i_L(0) = 0$ and the initial capacitor voltage is $v_C(0) = 0$. Assume the damping ratio $\zeta \in (0, 1)$; i.e. the system is underdamped and the roots of the characteristic equation are complex.

(a) Write the elemental, KCL, and KVL equations.
(b) Write the second-order differential equation for $i_L(t)$ arranged in the standard form and identify the natural frequency ω_n and damping ratio ζ.
(c) Convert the initial condition in v_C to a second initial condition in i_L.
(d) Solve the differential equation for $i_L(t)$ and use the solution to find the output voltage $v_o(t)$. It is acceptable to use a known solution and to express your solution in terms of ω_n and ζ.



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Steady−state circuit analysis

Steady-state circuit analysis does not require the, at times, lengthy process of solving differential equations. Impedance methods, presented in this chapter, are shortcuts to steady-state analysis. It is important to note that impedance methods do not give information about the transient response.