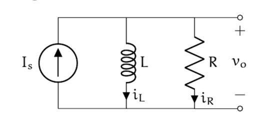
can.exe Exercises for Chapter can

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 $i_L(0) = 0$.

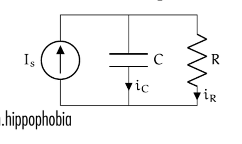
(a) Write the elemental, KCL, and KVL equations.
(b) Write the differential equation for $i_L(t)$ arranged in the standard form and identify the time constant τ.
(c) Solve the differential equation for $i_L(t)$ and use the solution to find the output voltage $v_o(t)$.



Exercise can.theocratically

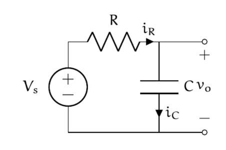
Use the diagram below to answer the following questions and imperatives. Let $I_s = A_0$, where $A_0 \in \mathbb{R}$ is a known constant. Perform a full circuit analysis, including the transient response. The initial capacitor voltage is $v_C(0) = v_{C0}$, a known constant.

(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 $v_C(t)$.



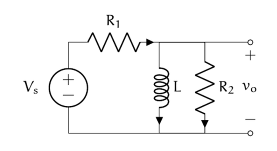
Exercise can.hippophobia

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 $v_C(t)$.



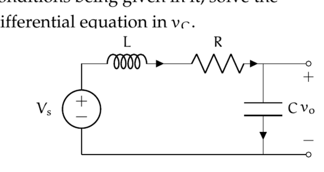
Exercise can.fruitarianism

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 $i_L(t)$.



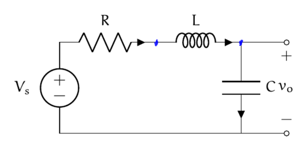
Exercise can.gastrolobium

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.



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.



$$\frac{dV_c}{dt} = \frac{1}{C} I_c \qquad V_o = V_c$$

$$V_s = V_R + V_L + V_c$$

$$\frac{d^2 V_c}{dt^2} = \frac{1}{C}\frac{dI_c}{dt} = \frac{1}{C}\frac{dI_L}{dt}$$

$$\frac{d^2 V_c}{dt^2} + a_1 \frac{dV_c}{dt} + a_0 V_c = b_0\, 3\sin(10t)$$

$K_1 =$

$K_2 =$

$$V_{cp} = K_1 \sin(10t) + K_2 \cos(10t)$$

$$\frac{dV_{cp}}{dt} =$$

$$\frac{d^2 V_{cp}}{dt^2} =$$

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

Elemental Eqs $\quad \frac{dI_L}{dt} = \frac{1}{L} V_L \quad V_R = R I_R \quad \frac{dV_c}{dt} = \frac{1}{C} I_c$

KCL $\quad I_R = I_L = I_c \qquad$ KVL $\quad V_R + V_c + V_L = V_s$

$$\frac{d^2 V_c}{dt^2} = \frac{1}{C}\frac{dI_c}{dt} = \frac{1}{CL} V_L = \frac{1}{CL}(V_s - V_R - V_c) = \frac{1}{CL}(V_s - R I_R - V_c) = \frac{1}{CL}\left(V_s - RC\frac{dV_c}{dt} - V_c\right)$$

$$\frac{d^2 V_c}{dt^2} + \frac{R}{L}\frac{dV_c}{dt} + \frac{1}{CL} V_c = \frac{1}{CL} 3\sin(10t)$$

$$\lambda^2 + \frac{R}{L}\lambda + \frac{1}{CL} = 0 \Rightarrow \lambda = \lambda_1, \lambda_2 \qquad \lambda_1 \neq \lambda_2$$

$$V_{ch} = C_1 e^{\lambda_1 t} + C_2 e^{\lambda_2 t}$$

$$V_{cp} = K_1 \sin(10t) + K_2 \cos(10t)$$

$$\frac{dV_{cp}}{dt} = 10 K_1 \cos(10t) - 10 K_2 \sin(10t)$$

$$\frac{d^2 V_{cp}}{dt^2} = -100 K_1 \sin(10t) - 100 K_2 \cos(10t)$$

$$-100 K_1 - \frac{R}{L} 10 K_2 + \frac{1}{CL} K_1 = \frac{3}{CL}$$

$$-100 K_2 + \frac{R}{L} 10 K_1 + \frac{1}{CL} K_2 = 0$$

$$\left(\frac{1}{CL} - 100\right) K_1 - 10\frac{R}{L} K_2 = \frac{3}{CL}$$

$$\left(\frac{1}{CL} - 100\right) K_2 + 10\frac{R}{L} K_1 = 0$$

$$K_1 = \frac{-L}{10R}\left(\frac{1}{CL} - 100\right) K_2$$

$$\left(\frac{1}{CL} - 100\right)\left(\frac{-L}{10R}\right)\left(\frac{1}{CL} - 100\right) K_2 - 10\frac{R}{L} K_2 = \frac{3}{CL}$$

$$K_2 = \frac{3}{CL\left(\left(\frac{1}{CL} - 100\right)\left(\frac{-L}{10R}\right)\left(\frac{1}{CL} - 100\right) - R/L\right)}$$

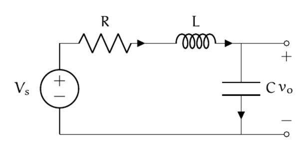
$$V_{cg} = C_1 e^{\lambda_1 t} + C_2 e^{\lambda_2 t} + K_1 \sin(10t) + K_2 \cos(10t)$$

$$V_{cg}(0) = 0 \qquad \left.\frac{dV_{cg}}{dt}\right|_{t=0} = 0$$

$$V_{cg}(0) = C_1 + C_2 + K_2 = 0$$

$$\frac{dV_{cg}}{dt} = C_1\lambda_1 e^{\lambda_1 t} + C_2 \lambda_2 e^{\lambda_2 t} + 10 K_1 \cos(10t) - 10 K_2 \sin(10t)$$

$$\left.\frac{dV_{cg}}{dt}\right|_{t=0} = C_1\lambda_1 + C_2\lambda_2 + 10 K_1 = 0$$



Exercise can.photochromascope

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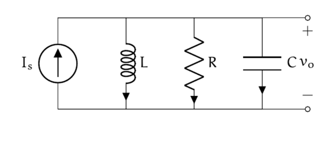
Use the circuit diagram below to answer the following questions and imperatives. Let $I_s = A_0$, where $A_0 > 0$ is a known constant. Perform a full circuit analysis, including the transient response. The initial inductor current is $i_L(0) = 0$ and the initial capacitor voltage is $v_C(0) = 0$. Assume 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.



ssan

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.