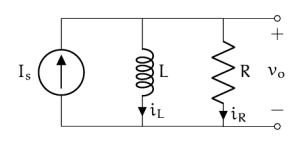


**can.exe Exercises for Chapter can**

Exercise can.mod

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  $i_L(0) = 0$ .

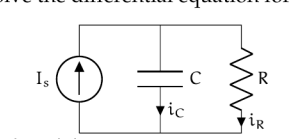
- (a) Write the elemental, KCL, and KVL equations.
- (b) Write the differential equation for  $i_L(t)$  arranged in the standard form and identify the time constant  $\tau$ .
- (c) Solve the differential equation for  $i_L(t)$  and use the solution to find the output voltage  $v_o(t)$ .



Exercise can.theoretically

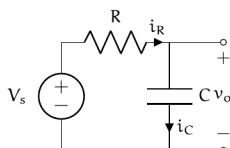
Use the diagram below to answer the following questions and imperatives. Let  $I_s = A_0$ , where  $A_0 \in \mathbb{R}$  is a known constant. Perform a full circuit analysis, including the transient response. The initial capacitor voltage is  $v_C(0) = v_{C0}$ , a known constant.

- (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  $v_C(t)$ .



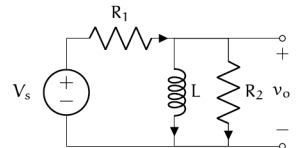
Exercise can.hippophoto

For the RC circuit diagram below, perform a complete circuit analysis to solve for  $v_o(t)$  if  $v_C(t) = A \sin \omega t$ , 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  $v_C(t)$ .



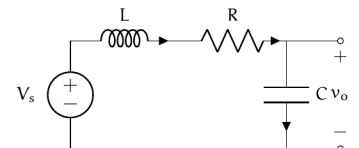
Exercise can.frustration

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  $i_L(t)$ .



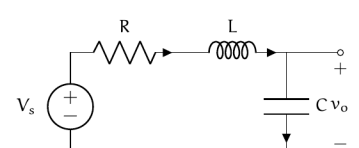
Exercise can.gstholobium

For the circuit diagram below, perform a complete circuit analysis to solve for  $v_o(t)$  if  $V_s(t) = 0$ . Let  $v_C(t)|_{t=0} = 5 \text{ V}$  and  $dv_C/dt|_{t=0} = 0 \text{ V/s}$  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  $v_C$ .



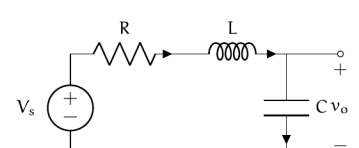
Exercise can.thyppotic

For the circuit diagram below, perform a complete circuit analysis to solve for  $v_o(t)$  if  $V_s(t) = 3 \sin(10t)$ . Let  $v_C(t)|_{t=0} = 0 \text{ V}$  and  $dv_C/dt|_{t=0} = 0 \text{ V/s}$  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.hamogenesis

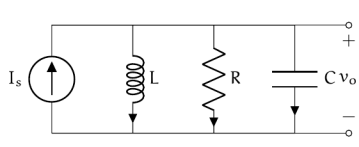
For the circuit diagram below, solve for  $v_o(t)$  if  $V_s(t) = A \sin \omega t$ , where  $A = 2 \text{ V}$  is the given amplitude and  $\omega \in \mathbb{R}$  is a given angular frequency. Let  $R = 50 \Omega$ ,  $L = 50 \text{ mH}$ , and  $C = 200 \text{ nF}$ . Let the circuit have initial conditions  $v_C(0) = 1 \text{ V}$  and  $i_L(0) = 0 \text{ A}$ . 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  $\omega = 400 \text{ rad/s}$  (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.



Exercise can.photomicroscope

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  $\omega_n$  and damping ratio  $\zeta$ .
- (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  $\omega_n$  and  $\zeta$ .



—/20 p.

a. Elemental eq's

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

$$v_R = R i_R$$

$$\frac{dv_C}{dt} = \frac{1}{C} i_C$$

KCL

$$I_s = i_L + i_R + i_C$$

KVL

$$v_L = v_R = v_C = v_o$$

b.

$$\frac{di_L}{dt} = \frac{1}{L} v_L = \frac{1}{L} v_o$$

$$\frac{d^2 i_L}{dt^2} = \frac{1}{L} \frac{dv_o}{dt} = \frac{1}{LC} i_C = \frac{1}{LC} (I_s - i_L - i_R)$$

$$= \frac{1}{LC} (I_s - i_L - \frac{v_o}{R}) = \frac{1}{LC} (I_s - i_L - \frac{v_L}{R})$$

$$= \frac{1}{LC} (I_s - i_L - \frac{L}{R} \frac{di_L}{dt})$$

$$\frac{d^2 i_L}{dt^2} + \frac{1}{RC} \frac{di_L}{dt} + \frac{1}{LC} i_L = \frac{1}{LC} I_s$$