EE105 – Microelectronic Devices and Circuits
Spring 2026, Homework #2

Assigned: **February 3, 2026**
Due: **February 10, 2026 at 11:59 PM on Gradescope**

1 Notes

Upload your notes from Lectures 4 and 5.

2 Problem Set

2.1 Problem 1: Laplace Properties

The Laplace transform maps a time domain function $f(t)$ to an s-domain function $F(s)$ with the following equation:

$$\mathcal{L}\{f(t)\} = F(s) = \int_0^\infty e^{st} f(t)dt$$

(a) Prove the following Laplace transform property: $\mathcal{L}\{f'(t)\} = sF(s) - f(0)$.
Hint: Integration by parts.
(b) Prove the following Laplace transform property: $\mathcal{L}\{f(t-t_0)u(t-t_0)\} = e^{-t_0 s}F(s)$.
Hint: Change of variable.
(c) **Optional**: Prove the following Laplace transform property: $\mathcal{L}\{\int f(t)\} = \frac{F(s)}{s}$.
Hint: Integration by parts.

2.2 Problem 2: Laplace and Inverse Laplace Transform Practice

(a) Find a solution, y(t), for the following differential equation by transforming the ODE into the Laplace domain, simplifying it via partial fraction decomposition, and then mapping it back into the time domain using Inverse Laplace transform.

$$y'' + 9y = 27u(t),\ y(0) = 0,\ y'(0) = 0$$

(b) Find $f(t)$, the Inverse Laplace transform of $F(s)$, the Laplace domain function defined by the following equation:

$$F(s) = \frac{(7s+1)}{(2s+1)(s+5)}$$

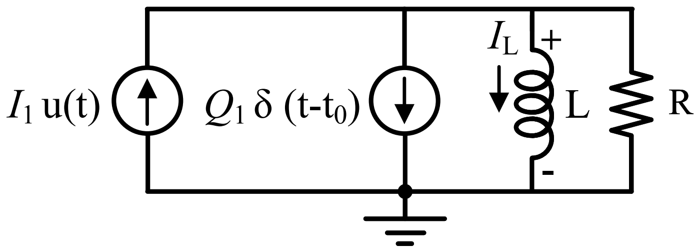
(c) Find $f(t)$, the Inverse Laplace transform of $F(s)$, the Laplace domain function defined by the following equation:

$$F(s) = \frac{(s+2)+8}{(s+2)^2+16}$$

Additional resources to solve Laplace Transform / Inverse Laplace equations: Check Ed Discussion.

2.3 Problem 3: An LTI System Solved Both Ways

Below is an RL circuit with 2 independent current sources.



(a) Considering $u(t)$ is the step function, $\delta(t)$ is the impulse function and $t_0 > 0$, find $I_L(t)$.
Hint: Consider the effect of each source independently on $I_L(t)$ and use the concept of superposition to derive the total response.

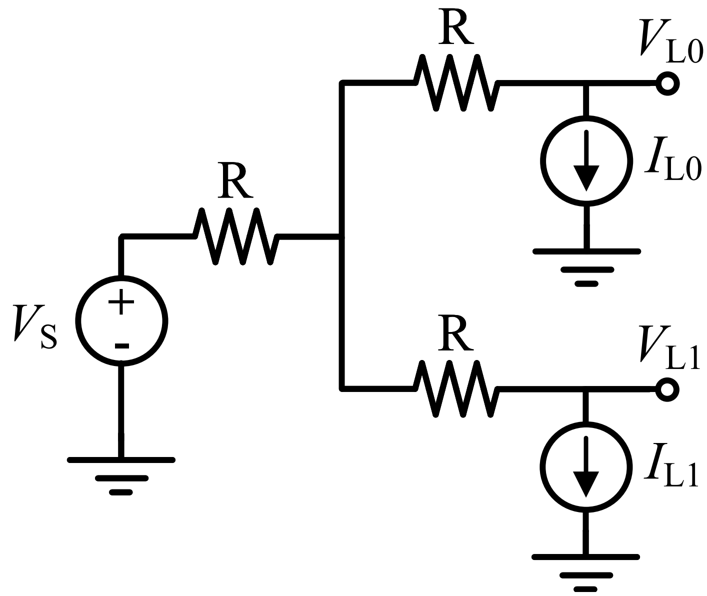
(b) Now, replace all components and signals in the circuit with their Laplace domain equivalents and solve for $I_L(s)$.

(c) Using the inverse Laplace transform, use $I_L(s)$ from part (b) to solve for $I_L(t)$.

(d) Which method did you personally prefer: solving directly for $I_L(t)$ in the time domain (part (a)), or solving for $I_L(s)$ and then applying the inverse Laplace transform (parts (b) and (c))?

2.4 Problem 4: Power Delivery Network and Bypass Caps

Electrical loads can often be modeled as current sources that draw a certain amount of current from their supply input. The figure below shows a very simplified network consisting of two electrical loads, L_0 and L_1 with load currents I_{L0} and I_{L1} respectively, the DC supply source V_S, and the distribution network which is modeled as resistances R. These resistances can model the resistance of wires in a large-scale DC circuit, or that of copper traces on a PC board/metal paths in an integrated circuit. Ideally, the designer wants to design the system such that each load receives the nominal DC supply voltage (here V_S without any disturbance added by other elements. However in this problem, we will demonstrate that this is not an easy task considering circuit parasitics.



(a) Assuming $I_{L0} = I_{L1} = 0\ A$, what are the voltages V_{L0} and V_{L1} received by the local blocks?

(b) Now, assume $I_{L1}(t) = 0\ A$ and $I_{L0}(t) = Q\delta(t)$, where $\delta(t)$ is the Dirac delta function (also known as an impulse function). What are $V_{L0}(t)$ and $V_{L1}(t)$? Does $V_{L1}(t)$ change in response to the impulse on the other load?

Hint: Use KCL/KVL as normal.

To avoid any local supply disturbances, we can add "bypass" capacitors to both loads, as shown in the updated figure below, Figure 1.

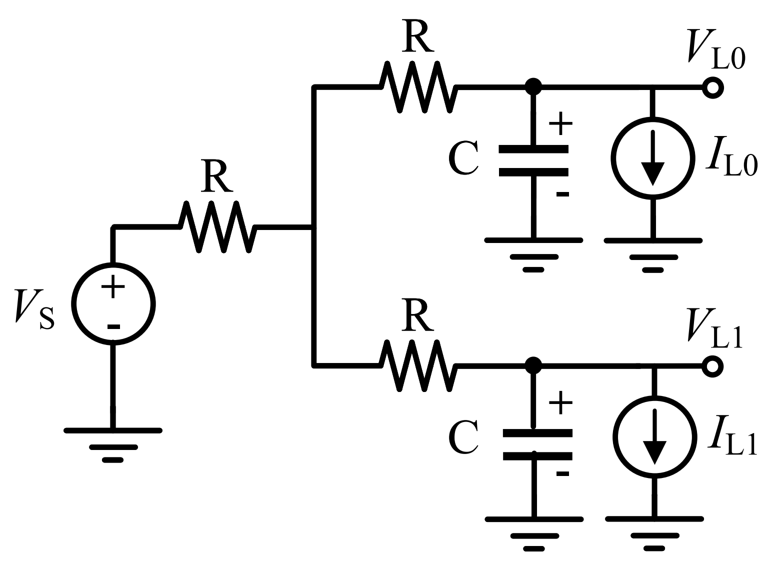


Figure 1: Updated figure of the power delivery network including bypass capacitors.

(c) Assume that $I_{L1}(t) = 0\ A$ and $I_{L0}(t) = Q\delta(t)$. Replace all components and signals with their frequency domain equivalents ($s = j\omega$) and find the impulse response of $V_{L0}(s)$

to $I_{L0}(t) = Q\delta(t)$ as a function of R_w, C and Q. No expansion or simplification of $V_{L1}(s)$ is necessary in this part.

Hint: You can disregard all initial conditions and zero out/null V_s when solving for this question.

(d) Find the impulse response of $V_{L1}(s)$ to $I_{L0}(t) = Q\delta(t)$ as a function of R, C and Q. No expansion or simplification of $V_{L1}(s)$ is necessary in this part.

Hint: You can disregard all initial conditions and zero out/null V_s when solving for this question.

Hint: You may use Thevenin/Norton equivalent circuits.

(e) **Optional**: You are told that when expanded, the denominator of $V_{L0}(s)$ and $V_{L1}(s)$ can be factored as:

$$(3RC\ s + 1)(RC\ s + 1).$$

Write the partial fraction of expansion $V_{L0}(s)$ and $V_{L1}(s)$ as a function of R, C and Q.

(e) **Optional**: Perform the inverse Laplace Transform on $V_{L0}(s)$ and $V_{L1}(s)$ to find $V_{L0}(t)$ and $V_{L1}(t)$ as a function of R, C and Q.

(f) **Optional**: Now re-consider the effect of the DC supply V_s on the circuit. What are the updated and final expression for $V_{L0}(t)$ and $V_{L1}(t)$? Hint: you can sum answers from part (a) and (f).