Summary of Complex Frequency Domain (s-domain)

- Complex frequency domain is needed when analyzing circuits containing sources of damped sinusoidal form; $Ae^{\sigma t}\cos(\omega t + \theta)$. If the exponential is not there ($\sigma = 0$) then normal $j\omega$-frequency domain is enough to get the steady state response.
- The complex frequency ($s$-domain) is a generalization for the $j\omega$-frequency domain.
- The impedances of the circuit components in $s$-domain are:

| $Z_R = R$ | $Z_L = sL$ | $Z_C = 1/(sC)$ |

where: $s = \sigma + j\omega$ ($\sigma$ is found from the exponential term; $\omega$ is the angular frequency). $L = \text{inductance}$, $C = \text{capacitance}$, $R = \text{resistance}$.

- After converting the circuit you can use any tech. studied in "Circuit I" such as source transformation, Thevinan and Norton equivalent circuits.
- The transfer function $H(s) = \frac{\text{output as a function of } s}{\text{input as a function of } s}$.
- The output or the input in the transfer function can be voltage or current.
- Definitions:
  - **Zeros**: the values that make the nominator of the transfer function equals to zero.
  - **Poles**: the values that make the denominator of the transfer function equals to zero.
- The location of the poles is very important because it determines the type of response of the circuit. To understand this point, use Matlab rlcdemo (type rlcdemo and hit enter) the change the type of circuit and the values of $R$, $L$, and $C$. Observe the effect on the circuit response and the location of the poles/zeros.
- For stable operation no poles should appear on the right-half of the $s$-plane. *Why?*
- For plotting the zeros we use o, while for plotting the poles we use X.

This is not a comprehensive summary. It is meant to help you visualize the main ideas.

*Regards, Dr. Muqaibel*