

**EE513**  
**Audio Signals and Systems**

**Digital Signal Processing (Systems)**

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# Laplace to begin with

The Laplace transform is used to characterize and analyze signal and system interactions. If  $x(t)$  is the time domain signal, its Laplace transform is defined as:

$$\tilde{X}(s) = \int_{-\infty}^{\infty} x(t) \exp(-st) dt$$

where  $s$  belongs to the set of complex numbers over which the integral converges. What is the Laplace transform of a system impulse response? What does the Laplace transform become if it is evaluated along the imaginary axis?

# Z-Transform

If the Laplace transform is made discrete by sampling the time axis with interval  $T_s$ , it becomes:

$$\tilde{X}(s) \approx \sum_{n=-\infty}^{\infty} x(nT_s) \exp(-snT_s) T_s$$

Now let:

$$z = \exp(sT_s)$$

$$s = \text{RE}[s] + j \text{IM}[s] = \sigma + j\omega$$

$$z = \exp(\sigma T_s + j\omega T_s) = \exp(\sigma T_s) \exp(j\omega T_s)$$

$$z^n = (\exp(\sigma T_s) \exp(j\omega T_s))^n = \exp(\sigma n T_s) \exp(j\omega n T_s)$$