Topic	ID	Goals
		Students can…
Complex Numbers	A1	express complex numbers using the cartesian form (real and imaginary components)
	A2	express complex numbers using the polar/exponential form (magnitude and angle)
	A3	plot and visualize complex numbers in the 2-D complex plane
	A4	convert between the different complex number representations using Euler's formula
	A5	operate on complex numbers using (+,-,x,/)
Continuous-Time Signals	B1	define the terms (in the context of continuous-time signals): signal, signal space, signal domain, signal range, continuous-time, discrete-time, continuous-amplitude, discrete-amplitude, analog, digital, even function, odd function, periodic, aperiodic, fundamental period, DC, fundamental frequency, harmonic frequencies, (finite) energy signal, (finite) power signal, causal, noncausal (aka acausal) and anticausal.
	B2	classify and describe signals according to the terms in the previous cell.
	B3	represent signals using appropriate mathematical notation.
	B4	define and apply the following basic signal operations: (amplitude) scaling, time-shifting (both advance and delay), time-scaling (including expansion, contraction and time reversal), differentiator, integrator, addition, windowing and convolution.
	B5	compute the decomposition of a signal into even and odd components.
	B6	compute the energy and power in signals.
	B7	define the terms: complex exponential, sinusoids, singularity functions, (unit) impulse (aka Dirac Delta), unit step (aka Heaviside), ramp, unit pulse (aka gate or rectangle functions), impulse train, and sinc (or cardinal sine), sifting property.
	B8	use the relationship between basic signals in the previous cell (e.g., sinusoids expressed as complex exponentials, integral/differential relationships between the impulse, unit step and ramp functions, the pulse as a linear combination of heaviside functions, "sifting property", etc.)
	B9	sketch any of the basic signals as well as composite signals after applying basic signal operations.
Continuous-Time Systems	C1	define the terms (in the context of CT systems): system, deterministic, stochastic, memoryless, nonmemoryless, continuous-time, discrete-time, hybrid, linear (including homogeneous and additive), nonlinear, time-invariant, time-varying, causal, acausal, anticausal, stability (BIBO, internal, asymptotic and marginal).
	C2	classify and describe systems according to the terms in the previous cell.
	C3	define the terms: convolution integral, impulse response, step response, complete response, zero-state-response (ZSR, aka forced response), zero-input-response (ZIR, aka natural response), steady-state response, transient response.
	C4	compute the ZSR of an LTI system as the convolution of the input with the system impulse response.
	C5	develop mathematical models of LTI circuits involving resistors, capacitors, inductors and operational amplifiers.
	C6	represent systems mathematically based on input-output relationships.
	C7	represent an LTI system using different mathematical tools and be able to convert between them (in particular, block diagrams, ODEs, impulse response, transfer function, frequency response, state-space models).
	C8	define the terms: cascade, parallel, feedback, open-loop and closed-loop.
	C9	construct systems through interconnections of subsystems.
Laplace Transforms	D1	define the terms: time-domain, (complex) frequency-domain, Laplace Transform (one-sided and two-sided), Inverse Laplace Transform, partial franction expansion, region of convergence, initial conditions.
	D2	use the LT and ILT to convert between time-domain differential equations and frequency-domain algebraic equations (this is an example of C7).
	D3	use look-up tables of LT properties and LT pairs to convert between time-domain and frequency-domain signals. In particular, apply the following properties: linearity, time-shifting, frequency-shifting, differentiation (either in time or frequency), integration, temporal scaling, apply the initial and final value theorems.
	D4	define the terms: transfer function, characteristic polynomial, pole (simple, repeated, and complex-conjugate pairs), zero and eigenfunction.
	D5	employ the LT along with Initial Conditions to determine a system's complete response.
	D6	represent the complete response in the frequency-domain as the sum of the ZSR and ZIR or as the sum of the steady-state and transient.
	D7	describe the relationship between a system's causality, region of convergence and Initial Conditions.
	D8	for LTI systems, determine BIBO stability based on equivalent conditions on the impulse response, RoC and system poles.

Fourier Analysis for Continuous-Time Signals and Systems (including Fourier Series & Fourier Transforms)	E1	define the terms: Fourier Series, complex exponential and trigonometric representations, fundamental period, fundamental frequency, harmonics, Parseval's power relation, spectral representation (magnitude, phase line and/or power), band-limited.
	E2	describe the common orthonormal basis functions (either as complex exponentials or as trigonmetric functions) for periodic functions. Observe that every complex exponential function is an eigenfunction of an LTI system while a pure sinusoid is a linear combination of a complex-conjugate pair of such eigenfunctions.
	E3	find the Fourier series representation of periodic signals using either of the basis function sets (i.e., compute the FS coefficients).
	E4	apply the Dirichlet conditions establishing sufficient conditions for conditions for Fourier convergence.
	E5	describe the relationship between a function's even/odd decomposition and its Fourier representation.
	E6	define the terms: frequency response, magnitude response, phase response
	E7	for LTI systems, determine the frequency response (and hence, the magnitude and phase responses) from the transfer function and apply this to determine the output for an input with known frequency components.
	E8	determine the resultant signal Fourier representation after adding, multiplying or convolving periodic signals.
	E9	define the terms: Fourier Transform, Inverse Fourier Transform, Parseval's Energy relation, energy spectrum, duality
	E10	compute the FT of any signal (whether periodic or aperiodic) and visualize the FT as a special (limiting) case of a FS.
	E11	use look-up tables of FT properties and FT pairs to convert between time-domain and frequency-domain signals.
	E12	apply the concept of duality between the time-domain and frequency-domain to describe the relationship between different FT properties and to generate new FT pairs.
	E13	compare and constrast the application of the LT, FS and FT (this includes relating the FS coefficients of a periodic signal to the LT of a single period and describing the limitations of the different tools).
Sampling Theory	F1	define the terms: sampling, sampling period, sampling frequency, reconstruction, impulse generator, ideal interpolator, aliasing, Nyquist-Shannon Sampling Theorem, Nyquist (aka folding) frequency, Nyquist (sampling) rate.
	F2	describe sampling and reconstruction as steps in converting between continuous-time and discrete-time signals.
	F3	mathematically relate an original continuous-time signal to a sampled discrete-time one and to a reconstructed continuous-time signal.
	F4	describe the conditions under which aliasing (distortion) occurs and reconstruct a continuous-time signal from a sampled signal using an ideal interpolator.
	F5	use the Nyquist-Shannon Sampling Theorem to determine if/when a sampled signal can be used to perfectly reconstruct the original signal.
Discrete-Time Signals & Systems	G1	extend concepts from CT signals and systems to Discrete-time signals and systems. Compare and contrast all concepts.
	G2	define the terms (in the context of DT signals): signal space, signal domain, even function, odd function, periodic, aperiodic, fundamental period, fundamental frequency, harmonic frequencies, (finite) energy signal, (finite) power signal, causal, noncausal (aka acausal) and anticausal.
	G3	classify and describe signals according to the terms in the previous cell.
	G4	define and apply the following basic signal operations: (Amplitude) scaling, time-shifting (both advance and delay), time-scaling (decimation and downsampling vs interpolation and upsampling), difference operator, accumulator, addition, windowing/modulation and convolution.
	G5	define the terms (in the context of DT signals): DT complex exponential, DT sinusoid, (unit) sample (aka impulse or Kronecker Delta), unit step and sifting property.
	G6	use the relationship between basic signals in the previous cell, including application of the "sifting property".
	G7	sketch any of the basic signals as well as composite signals after applying basic signal operations.
	G8	define the terms (in the context of DT systems): memoryless, nonmemoryless, linearity (including homogeneity and additivity), nonlinearity, time-invariant, time-varying, causal, acausal, anticausal, stability (BIBO, internal, asymptotic and marginal).
	G9	classify and describe systems according to the terms in the previous cell.
	G10	define the terms: DT convolution (or convolution sum), impulse response (both FIR/non-recursive and IIR/recursive), moving average, autoregression, ZSR, ZIR, steady-state response, transient response.
	G11	compute the ZSR of an LTI system as the convolution of the input with the system impulse response.
	G12	represent DT systems mathematically based on input-output relationships

	G13	represent an LTI system using different mathematical tools and be able to convert between them (in particular, block diagrams, difference equations, impulse response, transfer function, frequency response, state-space models).
	G14	construct systems through interconnections of subsystems.
Z-Transforms	H1	define the terms Z-transform (one-sided and two-sided), Z-plane, RoC (in the Z-plane), causal, anti-causal, two-sided, (DT) transfer function.
	H2	describe the Z-transform as an extension/limiting case of the Laplace transform for DT signals.
	H3	compare and contrast the LT and ZT.
	H4	use look-up tables (ZT Properties and Pairs) to convert between DT signals and Z-domain signals.
	H5	employ the ZT along with Initial Conditions to determine a system's complete response.
	H6	represent the complete response in the Z-domain as the sum of the ZSR and ZIR or as the sum of the steady-state and transient.
	H7	describe the relationship between a system's causality, region of convergence and Initial Conditions.
	H8	for LTI systems, determine BIBO stability based on equivalent conditions on the impulse response, RoC and system poles.
Fourier Analysis for Discrete-Time Signals	I1	define the terms: DFS (discrete Fourier Series), DFT (discrete Fourier Transform), DTFT (discrete-time Fourier Transform), DT frequency response (both magnitude and phase).
	I2	compare and contrast the use of all 4 Fourier transforms.
	I3	use look-up tables for the DT Fourier representations of signals.
	I4	compare and constrast the application of the ZT, DFT and the DTFT.
State-Space & Applications	J1	define the terms: state, state variable, state-space realization, controllability/observability (both of the system and individual state variables), controllability matrix, observability matrix, state-transition matrix, state/output response (including decomposition into zero-input and zero-state components), canonical forms
	J2	generate a state-space realization [A,B,C,D] for a system based on a differential (or difference) equation, a transfer function, an impulse response, a block model representation, or other dynamic models (e.g., a circuit diagram); also do the converse
	J3	determine system controllability based on [A,B] and system observability based on [A,C]
	J4	compute the state-transition matrix and use it to determine the State Response and Output Response
	J5	apply a similarity transformation to convert between equivalent state-space realizations
	J6	determine system internal stability based on the A matrix
Computing Tools	K1	use computational packages (e.g., Matlab, Simulink) to computationally solve problems.
	K2	recognise how computational packages can be used to explore concepts in signals and systems.