Course Outline

I. Coupled Inductors (2 Hrs.)

1. Linear time-invariant (LTI) coupled (mutual) inductors; power and energy; passivity; initial condition models; series and parallel connections of branches; equivalent models.
2. Analysis of simple circuits with LTI coupled inductors.
3. Time-varying and nonlinear coupled inductors.

II. State Equations (8 Hrs.)

1. State-space formulation of dynamic circuits.
2. Complex frequency; complex exponential function.
3. Natural frequencies.
   Bounded/unbounded responses; modes and mode excitation.
4. Particular solutions for complex exponential inputs.
   Phasors; KVL and KCL in the phasor domain; phasor domain elements, impedance and admittance; phasor domain circuits.
5. State transition matrix. Zero-input and zero-state solutions.

III. Analysis of LTI Dynamic Circuits (8 Hrs.)

1. Laplace transformation.
   Real rational functions; poles and zeros; partial fraction expansion.
2. Solution to state-equation by Laplace transformation.
3. Node, modified (polynomial) node, and mesh analyses.

IV. Sinusoidal Steady-State (SSS) Analysis (12 Hrs.)

1. Periodic functions; average and effective values.
2. Responses of LTI dynamic circuits to sinusoidal excitations; transient/steady-state responses.
3. Analysis of phasor domain circuits; phasor diagrams.
4. Passive one-ports: resistive, inductive, and capacitive one-ports.
5. Superposition in the SSS.
6. Instantaneous, average, complex, real, reactive, and apparent powers; power factor; conservation of power.
7. Power calculations in the SSS; superposition in power calculations.
8. Power factor correction.
9. Maximum power transfer.

V. Balanced Three-Phase Circuits (6 Hrs.)

1. Three-phase voltage sources and loads; Y and Δ connections.
2. Analysis of balanced three-phase circuits; phasor diagrams.
3. Power calculations.

VI. Complex Frequency Domain Analysis (8 Hrs.)

1. Complex frequency domain voltages and currents; KVL and KCL in the complex frequency domain; complex frequency domain elements, impedance and admittance; complex frequency domain circuits.
2. Analysis of complex frequency domain circuits.
3. System functions: input and transfer functions; impulse response and convolution integral; step response; SSS response.
4. Two-port circuits: impedance, admittance, hybrid, chain, and scattering representations.

VII. Frequency Response (12 Hrs.)

1. Frequency response functions; magnitude, phase, and group-delay characteristics.
2. First order lowpass, highpass, and allpass passive LC filters.
   Second order lowpass, highpass, bandpass, bandstop, and allpass passive LC and active RC filters.
3. Parallel and series resonance; resonant frequency, quality factor, resonant circuits with finite-Q capacitors and inductors.
4. Magnitude and frequency scalings.
5. Bode plots.