

Introduction to Electrical Engineering

Problem Solving

Introduction to Electrical Engineering Problem Solving

Designed as a quick-reference guide for students and beginners

1. What Is Problem Solving in Electrical Engineering?

Aspect	Description
Goal	Translate a real-world requirement into a mathematically-sound solution that can be built, tested, and refined.
Typical Tasks	• Circuit analysis (DC, AC, transient) • Power-system calculations • Signal-processing design • Control-system synthesis • Electromagnetic field evaluation
Key Attributes	Systematic, quantitative, iterative, and validated against specifications.

2. General Problem-Solving Framework

1. Define the Problem

- Identify *what* is required (output voltage, power, frequency, etc.).
- List *given* data (component values, source characteristics, constraints).
- Clarify *unknowns* and performance criteria (efficiency, tolerance, cost).

2. Model the System

- Choose an appropriate abstraction: circuit diagram, block diagram, differential equations, or phasor model.
- Apply idealizations (linear components, steady-state, lossless) when justified; note the assumptions.

3. Select Analysis Tools

Introduction to Electrical Engineering

- **Circuit techniques:** Ohm's law, Kirchhoff's Voltage/Current Laws (KVL/KCL), node voltage, mesh current, superposition, Thevenin/Norton equivalents.
- **Frequency domain tools:** Phasors, impedance, Bode plots, Laplace transforms.
- **Time domain tools:** Differential equations, state space, transient response formulas.
- **Numerical tools:** SPICE simulation, MATLAB/Octave, Python (NumPy, SciPy), Power System simulators.

Problem Solving

4. Solve Mathematically

- Write equations based on the chosen model.
- Reduce the system (substitution, matrix methods, symbolic manipulation).
- Compute numerical results or derive symbolic expressions.

5. Validate the Solution

- Check units, sign conventions, and physical plausibility.
- Verify against boundary conditions and limiting cases (e.g., zero load, infinite frequency).
- Use simulation or a prototype to confirm.

6. Iterate / Optimize

- If specifications are not met, adjust component values, topology, or control parameters.
- Perform sensitivity analysis to see how tolerances affect performance.
- Re-solve and re-validate until the design satisfies all criteria.

7. Document & Communicate

- Provide schematics, calculations, simulation results, and design rationale.
- Highlight assumptions, trade-offs, and potential failure modes.

3. Core Analytical Techniques

Technique	When to Use	Key Equations / Concepts
Ohm's Law	Simple resistive networks	$(V = IR)$

Introduction to Electrical Engineering

Technique	When to Use	Key Equations / Concepts
Problem Solving		
KVL / KCL	Any circuit analysis	Sum of voltages around a loop = 0; Sum of currents at a node = 0
Node Voltage Method	Large networks with many nodes	Write KCL at each essential node; solve linear system ($\mathbf{G}\mathbf{V} = \mathbf{I}$)
Mesh Current Method	Planar circuits with many loops	Write KVL for each mesh; solve for mesh currents
Thevenin/Norton	Source transformation, load analysis	Replace network by (V_{th}) and (R_{th}) (or (