Unit I: Mathematical Logic

Introduction to Mathematical Logic

- - Mathematical Logic is the study of formal logical systems.
- - Used in engineering for circuit design, algorithms, and AI.
- - Helps in developing precise and error-free reasoning.

Importance of Mathematical Logic in Engineering

- - Foundation for computer science and digital systems.
- - Essential for programming, software development, and databases.
- - Helps in the design and analysis of logical circuits.

Basic Logical Operators

- - AND ($\wedge$): True if both operands are true.
- - OR ($\vee$): True if at least one operand is true.
- - NOT ($\neg$): Negates the truth value.
- - XOR ($\oplus$): True if exactly one operand is true.
- - IMPLICATION ($\rightarrow$): If A then B.
- - BICONDITIONAL ($\leftrightarrow$): A if and only if B.

Propositional Logic

- - Statements that can be either true or false.
- - Examples:
- - 'If it rains, the ground is wet.' (Implication)
- - 'A number is even if and only if it is divisible by 2.' (Biconditional)
- - Logical equivalences help in simplifying expressions.

Predicate Logic

- - Extends propositional logic with variables and quantifiers.
- - Universal Quantifier (∀x P(x)): True for all x.
- - Existential Quantifier (∃x P(x)): True for at least one x.
- - Used in AI, database queries, and theorem proving.

Applications in Engineering

- - Digital Circuits: Logic gates use Boolean algebra.
- - Software Development: Logical expressions in programming.
- - Artificial Intelligence: Automated reasoning and decision-making.
- - Control Systems: Logical conditions in automation.

Logic Circuits and Gates

- - Basic Logic Gates: AND, OR, NOT, XOR.
- - Combinational Circuits: Multiplexers, Encoders.
- - Sequential Circuits: Flip-Flops, Counters.

Logical Reasoning and Proof Techniques

- - Direct Proof: Show $P \rightarrow Q$ directly.
- - Contrapositive Proof: Prove $\neg Q \rightarrow \neg P$.
- - Contradiction Proof: Assume $\neg P$ and derive a contradiction.
- - Mathematical Induction: Prove for base case and assume for n to prove for n+1.

Thank you