SEMESTER - 6

Comprehensive Lesson Plan: Digital and Analog Circuits and Instrumentation

DSE-1B

Overall Learning Objectives:

- Understand the fundamental concepts of digital circuits and their applications.
- Analyze and design basic digital circuits using Boolean algebra and logic gates.
- Gain knowledge of semiconductor devices and their operation principles.
- Design and analyze basic transistor amplifier circuits.
- Understand the characteristics and applications of operational amplifiers.
- Apply operational amplifiers to perform various circuit functions.
- Get familiar with basic electronic instruments and their functionalities.
- Design and analyze power supply circuits and voltage regulation techniques.
- Understand the operation and applications of timer integrated circuits.

Materials and Resources:

- Textbook: Digital Electronics by Morris Mano or similar resource.
- Lecture slides and handouts.
- Breadboard kits with electronic components (resistors, capacitors, diodes, transistors, integrated circuits).
- Function generators, oscilloscopes, multimeters (for laboratory sessions).
- Computer with simulation software (optional).

Assessment/Evaluation:

- Quizzes and assignments throughout the course to assess understanding of concepts.
- Midterm exam covering Units 1 and 2.

- Final exam covering all units.
- Laboratory reports documenting experiments and results.
- Project (optional): Design and build a simple digital circuit or application.

Differentiation:

- Provide additional practice problems and explanations for struggling students.
- Offer challenging projects and in-depth explorations for advanced learners.
- Encourage group work and peer learning to benefit from diverse learning styles.

Lecture Schedule:

Unit 1: Digital Circuits (18 Lectures)

- Learning Objectives:
  - Differentiate between analog and digital signals.
  - Understand binary number system and conversions.
  - Analyze the operation of basic logic gates (AND, OR, NOT).
  - Implement logic gates using diodes and transistors (optional).
  - Apply De Morgan's theorems and Boolean algebra for logic simplification.
  - Design combinational circuits using sum-of-products and Karnaugh maps.
  - Perform binary addition, subtraction using 2's complement method.
  - Analyze the operation of half adders, full adders, and subtractors.
  - Design multi-bit adders and subtractor circuits.
- Activities:
  - Interactive demonstrations of analog and digital signals.
  - Binary number system conversions (practice problems).
  - Logic gate truth table analysis and circuit simulations (using software or breadboard).
  - De Morgan's theorem proofs and application exercises.
  - Boolean algebra simplification problems (practice worksheets).
  - Combinational circuit design using Karnaugh maps (hands-on exercises).

- Binary addition and subtraction by hand and using circuits.
- Design and analysis of multi-bit adder/subtractor circuits (assignments).

Unit 2: Semiconductor Devices and Amplifiers (24 Lectures)

- Learning Objectives:
  - Understand the operation principles of p-n junctions and diodes.
  - Analyze diode characteristics (forward and reverse bias).
  - Explain the working of LEDs, photodiodes, and solar cells.
  - Understand the structure and characteristics of bipolar junction transistors (BJTs).
  - Analyze BJT operation in common base (CB), common emitter (CE), and common collector (CC) configurations.
  - Design transistor biasing circuits using voltage dividers.
  - Analyze single-stage CE amplifier circuits using h-parameter equivalent model.
  - Calculate amplifier parameters like gain, impedance, and power.
  - Differentiate between Class A, B, and C amplifier operation.
- Activities:
  - Demonstrations and simulations of p-n junction formation and diode behavior.
  - Analysis of diode I-V characteristics and applications (practice problems).
  - Explanation of LED, photodiode, and solar cell functionalities (presentations).
  - BJT structure and characteristic curve analysis (interactive lectures).
  - Biasing circuits design and simulations for BJT amplifiers.
  - Hands-on laboratory experiments with BJTs and transistor testers (if available).
  - Analysis of single-stage CE amplifier circuits using h-parameters (assignments).
  - Design projects for different amplifier classes (optional).

Unit 3: Operational Amplifiers (12 Lectures)

- Learning Objectives:
  - Understand the ideal and practical characteristics of operational amplifiers.

- Analyze the concepts of open-loop and closed-loop gain.
- Explain the principle of virtual ground in Op-Amp circuits.
- Design and analyze inverting and non-inverting amplifier circuits.
- Apply Op-Amps for basic mathematical operations (addition, subtraction).
- Design integrator and differentiator circuits using Op-Amps.
- Understand the functionality of a zero-crossing detector circuit.

- Activities:
- Lecture and Discussion:
- Ideal and practical Op-Amp characteristics.
- Open-loop and closed-loop gain analysis.
- Concept of virtual ground and its implications.
- Derivation of gain equations for inverting and non-inverting amplifiers.
- Problem-Solving:
- Design and analyze inverting and non-inverting amplifier circuits for given specifications.
- Calculate the output voltage for different input signals.
- Design adder, subtractor, integrator, and differentiator circuits.
- Simulation (Optional):
- Simulate Op-Amp circuits using software like LTspice or Multisim to verify theoretical calculations.
- Laboratory Experiment (if available):
- Build and test basic Op-Amp circuits (inverting, non-inverting, adder) on a breadboard.

Unit 4: Instrumentation (13 Lectures)

- Learning Objectives:
- Understand the basic principles of operation of a Cathode Ray Oscilloscope (CRO).
- Use a CRO to measure voltage, current, frequency, and phase difference.

- Understand the operation of different types of rectifiers (half-wave, full-wave).
- Analyze the performance of rectifier circuits (ripple factor, rectification efficiency).
- Understand the concept of filtering and its importance in power supplies.
- Understand the operation of Zener diodes and their use in voltage regulation.
- Understand the operation of the 555 timer IC in astable and monostable configurations.

- Activities:
  - Lecture and Demonstration:
    - Introduction to CRO: Block diagram, basic operation, controls.
    - Half-wave and full-wave rectifier circuits: Analysis and waveforms.
    - Capacitor filtering: Ripple factor calculations.
    - Zener diode characteristics and voltage regulator circuits.
    - 555 timer IC: Pin diagram, astable and monostable configurations.
  - Laboratory Experiments:
    - Use a CRO to measure voltage, current, frequency, and phase difference.
    - Build and test half-wave and full-wave rectifier circuits.
    - Design and implement a simple power supply with filtering.
    - Experiment with 555 timer IC to generate different waveforms (square wave, pulse).

Unit 5: Sinusoidal Oscillators (5 Lectures)

- Learning Objectives:
  - Understand the concept of self-sustained oscillations.
  - Understand Barkhausen's criterion for oscillation.
  - Analyze the operation of RC oscillators (e.g., phase-shift oscillator, Wien bridge oscillator).
- Activities:
  - Lecture and Discussion:
    - Barkhausen's criterion for oscillation.

        - Analysis of RC oscillator circuits (phase-shift oscillator, Wien bridge oscillator).
    - Simulation (Optional):
        - Simulate RC oscillator circuits using simulation software.

Closure:

- Review and Summary:
    - Review key concepts covered in the course.
    - Conduct a comprehensive review session.
- Final Exam:
    - Assess student understanding of all topics covered in the course.
    - Include theoretical questions, problem-solving, and design-related questions.

Note: