Assignment: Computer Architecture and Organization

Title: Design and Analysis of a Basic CPU Architecture

Objectives:

- Understand the basic components and operations of a CPU.
- Design a simple CPU architecture using fundamental building blocks.
- Implement the CPU architecture using a hardware description language (HDL) or a schematic drawing tool.
- Analyze the performance and efficiency of the designed CPU.

Instructions:

1. **Introduction and Theory (10 points)**
    - Research and provide an overview of CPU architecture, including its main components (ALU, control unit, registers, memory, etc.).
    - Explain the concept of instruction set architecture (ISA) and its significance in CPU design.
2. **Design Specification (20 points)**
    - Define the instruction set for your CPU. Include at least the following instructions: ADD, SUB, LOAD, STORE, and JUMP.
    - Specify the bit-width of the data bus and address bus.
    - Describe the register set and their purposes (e.g., general-purpose registers, program counter, etc.).
    - Create a detailed block diagram of your CPU architecture, showing how the components are connected.
3. **Implementation (30 points)**
    - Using a hardware description language (e.g., Verilog or VHDL) or a schematic drawing tool (e.g., Logisim), implement your CPU architecture.

- Ensure your implementation includes the ALU, control unit, registers, and necessary data paths.
- Write a test program using your defined instruction set to demonstrate the functionality of your CPU.

4. **Simulation and Testing (20 points)**
   - Simulate your CPU design using appropriate simulation software (e.g., ModelSim for HDL, Logisim for schematic).
   - Test each instruction in your instruction set to verify correct operation.
   - Provide screenshots or simulation logs showing the results of your tests.
5. **Performance Analysis (10 points)**
   - Analyze the performance of your CPU. Consider factors such as clock cycles per instruction (CPI) and overall execution time for your test program.
   - Discuss any bottlenecks or limitations observed in your design and suggest possible improvements.
6. **Documentation and Presentation (10 points)**
   - Prepare a detailed report documenting your design process, implementation, testing, and analysis.
   - Include diagrams, code snippets, and simulation results as necessary.
   - Create a presentation summarizing your work and present it to the class or submit a recorded presentation.

Deliverables:

- A written report in PDF format.
- HDL code or schematic files.
- Simulation results and analysis.
- Presentation slides in PowerPoint or PDF format.

Tools and Resources:

- HDL (Verilog or VHDL) software: ModelSim, Xilinx Vivado, or equivalent.
- Schematic drawing tool: Logisim or equivalent.
- Reference materials: Textbook on computer architecture, online tutorials, and academic papers.

Submission Deadline:

- 31st August 2024.

Evaluation Criteria:

- Completeness and correctness of the design specification.
- Functionality and accuracy of the CPU implementation.
- Thoroughness of the simulation and testing process.
- Depth of the performance analysis.
- Clarity and organization of the documentation and presentation.

Additional Notes:

- Collaborate in pairs or small groups (up to four students per group).
- Ensure all work is original and properly cited if referencing external sources.
- Contact the instructor for any clarifications or assistance needed throughout the assignment.