

1. **(20 pts)** Briefly explain the following classifications on parallelism. Please give program examples to explain each type of parallelism.
 - (a) Instruction-level parallelism
 - (b) Data-level parallelism
 - (c) Thread-level parallelism
 - (d) Request-level parallelism

2. **(10 pts)** Explain why the cache memory can speed-up the program execution performance.

3. **(15 pts)** Give an example to explain why a multi-core processor needs cache-coherence protocol.

4. **(15 pts)** Explain how a branch-prediction mechanism speeds up the execution performance of a pipelined processor. Give an example with a sample program to explain the design concept.

5. **(20 pts)** Explain the concepts about data hazard through answering the following questions.
 - (a) What is a data hazard? List all types of data hazards with examples for each hazard.
 - (b) Give a program example to explain how data hazards slow-down the execution of an instruction-level parallel processor.
 - (c) Explain how a compiler overcomes the data hazards to exploit instruction-level parallelism. Give a program example to explain the concepts.
 - (d) Explain how a hardware mechanism overcomes the data hazards to exploit instruction-level parallelism. Draw simple hardware diagram to explain the concepts.

6. **(20 pts)** Briefly explain the design philosophy of RISC (Reduced Instruction Set Computer) processors.