Comp 120 Fall 2004 Final Exam

Don't Panic! Read the entire exam and ask questions in the first few minutes to avoid disturbing others with questions later. Write your answers on a separate sheet of paper. Do not waste time by copying the questions onto your answer sheet; just number the answers to correspond to the questions. **Pledge your paper.** The number in brackets indicates the number of points for the question.

- 1. [6] For a cache of fixed size, as the block size increases from really small to somewhat larger, the hit rate improves. Why? If we continue increasing the block size the hit rate eventually starts going back down. Why?
- 2. [3] In a pipelined processor implementation an instruction in the pipeline may need the result of a previous instruction before it is available. What is the name for this pipeline *hazard*?
- 3. [6] Explain why floating point addition and subtraction may result in loss of precision but multiplication and division do not.
- 4. [6] Give two reasons why a CPU designer might choose to have separate instruction and data caches.
- 5. [6] What functions of virtual memory help the operating system with the task of allowing multiple programs to apparently run simultaneously?
- 6. [8] What happens, step-by-step, on the MIPS instruction LB 15,0x7003(0) assuming virtual memory and a physical address data cache. Assume the data cache and TLB are empty, that the address is legal, and that the page is in memory starting at physical address 0x10000. Assume the 16 kilobyte data cache is direct mapped using physical addresses with 16 byte blocks and that the virtual page size is 1024 bytes. Hint: The effect of the instruction is to load a byte from virtual address 0x7003 into register 15; I want you to tell me everything that has to go on in the memory system to make that happen.
- 7. [4] A compiler designer is trying to decide between two code sequences for a particular machine. Based on the hardware implementation, there are three different classes of instructions: Class A, Class B, and Class C, and they require one, two, and three cycles (respectively). The first code sequence has 5 instructions: 2 of A, 1 of B, and 2 of C. The second sequence has 6 instructions: 4 of A, 1 of B, and 1 of C. Which sequence will be faster? How much? What is the CPI for each sequence?
- 8. [3] If you negate 0x1234ABCD (2's complement), what hex number do you get?
- 9. [5] What characteristics of the branches in real programs justify the choice of PC-relative addressing?
- 10. [6] What are the relative advantages and disadvantages of direct-mapped versus 2-way set associative organization for caches?
- 11. [4] A processor with cycle time of 1 nanosecond and CPI of 1 when there are no misses has a cache-hit rate of 90% and a cache-miss penalty of 50 nanoseconds. What is the effective CPI including the misses?
- 12. [5] How does pipelining improve processor performance? What limits the amount of performance improvement available from pipelining?

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- 13. [3] State Amdahl's Law with an equation and explain what it means.
- 14. [6] Suppose you have access within your computer to an accurate timer with resolution of 1 millisecond. Describe an experimental approach to determining the CPI for floating point addition on a machine with 1GHz clock rate. Be careful to avoid spurious effects such as memory system performance.
- 15. [5] Virtual memory and cache memory systems solve similar problems (making a larger slower memory look faster using a smaller but faster memory) but typical virtual memory systems are very different in organization from typical data caches. Why?
- 16. [3] Soon we will all have computers with multiple processors. This will allow us to run some kinds of programs faster. Suppose your computer has N processors and that a program you want to make faster has some fraction, F, of its computation that is inherently sequential (either all the processors have to do the same work thus duplicating effort, or the work has to be done by a single processor while the other processors are idle). What speedup can you expect to achieve on your new computer?
- 17. [5] Show, step by step, how to add -127 (negative 127) and 20 (positive 20) using 2's complement arithmetic and 8 bit integers.
- 18. [6] Many floating point algorithms rely on a machine dependent estimate of numerical precision, epsilon, that is the largest number such that 1.0 + epsilon = 1.0. How might you estimate epsilon in a program without requiring knowledge of the particular floating point representation used on the hardware?
- 19. [5] Give the truth table for a logical function that takes two 2-bit numbers and produces a 4-bit result that is their product.
- 20. [5] Why are conditional branches problematic for pipelined processors?
- 21. [bonus 1] The 11th president of the United States was a UNC graduate and the subject of a song by They Might Be Giants. What was his name?
- 22. [bonus 1] How many pottles are in 1 gallon?