EEL 6764 Principles of Computer Architecture
Midterm Exam

Name: _____ **UID**: _____

Problem	Points	Your Points
1	21	
2	22	
3	24	
4	18	
Total	85	

- **Exam time** is 75 minute long.
- **Closed textbook, and closed notes**.
- **Other than scientific calculators, all electronics must be turned off**.
- Make sure that your writing is legible; otherwise you grades may be negatively affected.
- Show all work to get partial credits except problems requiring only simple answers.
- You are allowed to bring one 8.5" $\times$ 11" sheet with notes you deem to be necessary.
- Use the back of the exam paper as necessary. But indicate clearly which problems that the answers on the back correspond to.

Problem 1 ($3 \times 7 = 21$ points) Answer the following questions *precisely* and *concisely*.

1. Explain the wall clock time and CPU time, and in what situation one should be used instead of the other one.

2. Let E, P, and f be dynamic energy, dynamic power and clock frequency. Show the energy-power relation using these three parameters.

3. Explain the difference(s) between **critical word first** and **early restart**, and what cache parameter(s) these techniques intend to optimize.

4. Explain the purpose(s) of TLB.

5. Given a cache of fixed size, how does a larger cache block size affect the cache performance parameters?

6. In virtual memory, what write policy is used, and why?

7. How would CISC and RISC affect the parameters used to determine the CPU time?

Problem 2 (22 points) Amdahl's law and Performance

1. [$6 \times 2 = 12$ **points**] Assume that we make an enhancement to a computer that improves some mode of execution by a factor of 20. Enhanced mode is used 60% of the time, measured as a percentage of the execution time when the enhanced mode is *in use*.

   (a) What is the speedup we have obtained from the enhanced mode?

   (b) What percentage of the original execution time has been converted to the enhanced mode?

2. [10 **points**] Suppose we have made the following measurements:

   - Frequency of FP (floating point) operations = 25%
   - Frequency of FPSQR = 2%
   - Avergage CPI of FP operations = 6
   - CPI of FPSQR = 20
   - Average CPI of all other instructions = 1.5

   Assume that there are two alternative designs, one can decrease the CPI of FPSQR to 2, while the other one can decrease th average CPI of all FP operations to 4. Decide which alternative leads to better performance.

Problem 3 (24 points) Cache Design

1. [10 **points**] Consider the following information.

   - The average memory accesses per instruction is 1.5,
   - The ideal CPI = 1 cycle,
   - Clock rate = 1GHz,
   - Main memory access time is 100ns,
   - The hit time of L2 cache = 10 cycles,
   - The local miss rates of L1 and L2 caches are 2% and 40%m, respectively.

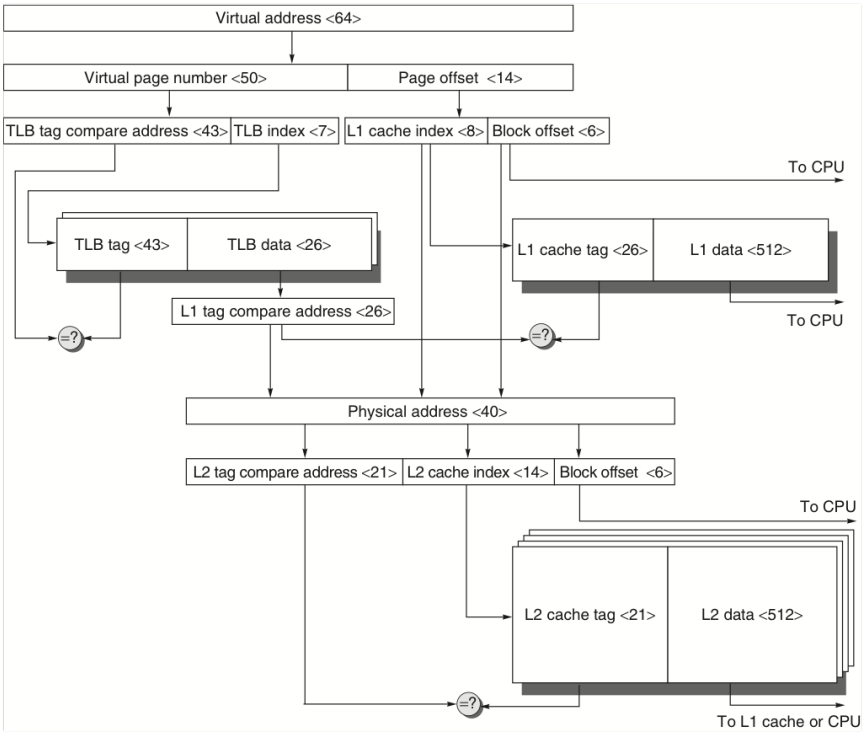
   Find the effective CPIs *with* and *without* L2 cache.

2. [14 **points**] Consider a 128KB cache with 64B blocks. Suppose that this cache can be organized as 1-way or 2-way set associative. Also assume the following information.

   - Clock cycle time$_{1-way}$ = 1 ns,
   - Clock cycle time$_{2-way}$ = 1.6 × Clock cycle time$_{1-way}$,
   - The ideal CPI = 1.6 cycles with a perfect cache,
   - The average number of memory references per instruction = 1.4,
   - Hit time = 1 clock cycle
   - Miss penalty = 100 ns,
   - Miss rate$_{1-way}$ = 2.1%, and miss rate$_{2-way}$ = 1.5%.

   Evaluate the cache performance by calculating its **average memory access time** and the **CPU time** for both cache organizations. Compare the results. If one cache organization is slower than the other, explain the cause of the slowdown.

Problem 4 (18 **points)** Consider the memory organization as shown below, and answer the following questions. Your answer should be precise and concise!



1. [2 **points**] What is the cache block size in bytes?

2. [5 **points**] What is the size of the L1 cache? How to increase the L1 cache size without changing the virtual memory system?

continuing to the next page

3. [2 **points**] What is the page size in bytes?

4. [5 **points**] Describe how the physical address is determined?

5. [4 **points**] How is the requested page located?

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