IC220: HW 4

Due: 8 Feb 2019

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Preliminary: Carefully do the assigned reading for Chapter 2 (2.1-2.3,2.5-2.10,2.12)

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1. **[5 points]** A program runs in 10 seconds on a machine with 100 MHz clock. How many clock cycles does the program require?

2. Our favorite program runs in 10 seconds on computer A, which has a 400 MHz clock. We are trying to help a computer designer build a new (faster) machine B. The designer can increase the clock rate, but this increase will cause machine B to require 1.2 times as many clock cycles to complete the program as machine A.

   (a) **[7 points]** What clock rate is neccesary for machine B if the program were to complete in 6 seconds?

(b) **[3 points]** Why might machine B need more clock cycles to run the program?

3. We wish to compare the performance of two different computers: M1 and M2. The following measurement have been made on these computers:

	Time M1	Time M2
Program 1	2.0 s	1.5 s
Program 2	5.0 s	10.0 s

(a) **[5 points]** Which computer is faster for each program, and how many times as fast is it?

(b) **[5 points]** Assume the following additional measurements were made:

	Instructions executed on ...	
	M1	M2
Program 1	5x10^9	6x10^9

What is the instruction execution rate (instructions per seconds) for each of the computers?

(c) **[10 points]** Suppose that M1 cost $500 and M2 costs $800. If you need to run Program 1 a large number of times, which computer would you by in large quantities and why?

4. Two different compilers are being tested for a 100 MHz machine that has three difference classes of instructions: Class A, B and C, which require one, two, and three cycles (respectively). Both compilers are used to produce code for a large piece of software.

   - Compiler 1: uses 5 million Class A insts., 1 million Class B insts, and 1 million Class C insts.
   - Compiler 2: uses 10 million Class A insts, 1 million Class B insts, and 1 million Class C insts.

   (a) **[5 points]** Which sequence will be faster according to execution time?

   (b) **[5 points]** Which sequence will be faster according to MIPS?
   (MIPS = inst. count/ (Exection Time * 10^6))

5. **[5 points]** Program A runs in 0.34 seconds on a 500 MHz machine. You know that this program requires 100 million instructions of which:

   - 10% are mult. instructions that take an unknown number of cycles
   - 60% are other arithmetic instructions taking 1 cycle
   - 30% are memory instructions taking 2 cycles

   How many cycles does multiplication take on this machine?

6. **[5 points]** Program A runs in 2 seconds on a certain machine. You know that this program requires 500 million instructions of which:

   - 30% are mult. instructions that take 10 cycles
   - 40% are other arithmetic instructions taking 1 cycle
   - 30% are memory instructions taking 2 cycles

   Suppose multiplication could be improved to take just 1 ccle. How much faster would the new machine be compared to the old one?

7. **[10 points]** Consider two different implementations, P1 and P2, of the same instruction set. There are five classes of instructions (A-E) which have the following average CPI on the two machines.

	CPI	
	P1	P2
Class A	1	2
Class B	2	2
Class C	3	2
Class D	4	4
Class E	3	4

   P1 has a clock rate of 4 GHz, and P2 has a clock rate of 6 GHz. If the number of instructions executed in a certain program is divided equally among the classes of instructions except for class A, which occurs twice as often as each of the others, how much faster is P2 than P1?

8. Suppose you wish to run a program P with $7.5 * 10^9$ instructions on a 5 GHz machine with a CPI of 0.8.
   (a) **[5 points]** What is the expected CPU time?

   (b) **[5 points]** When you run P, it takes 3 seconds of wall clock time to complete. What is the percentage of the CPU time P received?

9. **[5 points]** Suppose we enhance a machine making all floating-point instructions run five times faster. If the execution time of some benchmarks before the floating-point enhancement is 10 seconds, what will the speedup be if 4 seconds of the 10 seconds is spent execution floating-point instructions?

   Formula:
   Time after Improved = Exec. Time Unaffected + (Exe. Time Affected / Amount of Improvement)

10. **[5 points]** We are looking for a benchmark to show off the new floating-point unit described above (which makes floating-point 5 times faster), and we want the overall benchmarks to show a speedup of 3x. One benchmark we are considering runs for 100s with the old floating-point hardware. How much of the execution time would floating-point instructions have to account for in this program in order to yield our desired speedup on this benchmark?

11. You are going to enhance a computer, and there are two possible improvements: either make multiply instructions run four times faster than before, or make memory access instructions run two times faster than before. You repeatedly run a program that takes 100 seconds to execute. Of this time, 20% is used for multiplication, 50% for memory access instructions, and 30% for other tasks.

    (a) **[5 points]** What will the speedup be if you improve only multiplication?

    (b) **[5 points]** What will the speedup be if both improvements are made?