Homework 1

Due on September 9 (Thursday), 2021

Problem 1.

Another commonly used performance metric is called “millions of instructions per second (MIPS).

Question 1:
For a given CPU clock rate, *f*, and *CPI* (cycles per instruction), write a simple formula to express MIPS.

Question 2:
A benchmark program of 100,000 instructions is run on a 40 MHz processor with the following instruction type mix and CPI for each type.

Instruction types	Instruction count	CPI for the type
Integer type	45,000	1
Data load	32,000	2
Floating type	15,000	2
Control	8,000	2

Determine the effective overall CPI, MIPS, and the execution time for this program

Problem 2.

In a processor, the multiplication instruction takes 12 cycles, counting 25% of the program execution, and the rest of 75% instructions need 6 cycles per instruction.

Question 1:

What percentage of time does the processor spend on multiplication in the program execution?

Question 2:

If we are able to reduce the number of cycles for the multiplication to 10, but have to increase additional 20% cycles for all instructions. What percentage of time does CPU spend on multiplication? Is this design acceptable for performance improvement? Why?

Problem 3.

We are working on two machines M1 of unknown clock rate and M2 of 3 GHz. Both machines use the same instruction set architecture (ISA). We also have three choices of compilers, C1, C2, and C3. There are three classes of instructions, namely A, B, and C in the execution. The average CPI for each instruction class on M1 and M2, and average proportion of instruction classes generated by three different compilers are given in the following table:

Class	CPI on M1	CPI on M2	C1 Usage	C2 Usage	C3 Usage
A	2	1	40%	40%	50%
B	3	2	40%	20%	25%
C	5	2	20%	40%	25%

For a given program, each compiler uses the same number of instructions, but may have a different proportion for each class.

Question 1:

Using compiler C1 to run a program on both machines M1 and M2, what is the minimum clock rate of M1 in order for M1 to be faster than M2 for program execution? Please make a rounding in your final clock rate as an integer, e.g. 4.2 or 4.5 => 5.

Question 2:

Using compiler C2 to run the program on both machines M1 and M2, and using the clock rate you calculated in question 1 for M1, which machine M1 or M2 is faster, and how much faster?

Question 3:

Using compiler C3 to run the program on both machines M1 and M2, what is the effective overall CPI on each machine? Based on the CPIs of C1, C2, and C3 on M1 and M2, what compiler you would use on M1 or/and M2?

Problem 4.

Program P has $7.5X10^9$ instructions and runs on a 5GHz machine with a CPI of 0.8.

Question 1

What is the expected CPU execution time for running program P?

Question 2

How many instructions of P could you run in 1 second if the CPI increased to 0.9?

Problem 5.

We run five programs (1, 2, 3, 4 and 5) on three computers (A, B, and C). The measured execution time for each program is listed in the following Table.

	Execution time in seconds		
Program	Computer A	Computer B	Computer C
Program 1	50	100	500
Program 2	200	400	600
Program 3	250	500	500
Program 4	400	800	800
Program 5	5,000	4,100	3,500

Give a speed-ranking list of the three computers based on the above table.

		Execution time in seconds		
Program	Execution frequency	Computer A	Computer B	Computer C
Program 1	50%	50	100	500
Program 2	30%	200	400	600
Program 3	10%	250	500	500
Program 4	5%	400	800	800
Program 5	5%	5,000	4,100	3,500

Give you speed-ranking list of the three computers based on the above table with execution frequency for each program.