5 Performance Evaluation [20 points]

You are the leading engineer of a new processor. Both the design of the processor and the compiler for it are already done. Now, you need to decide if you will send the processor to manufacturing at its current stage or if you will delay the production to introduce last-minute improvements to the design. To make the decision, you meet with your team to brainstorm about how to improve the design. Together, after profiling the target applications for the processor, you come up with two options:

- **Keep the current project.** For version A of the processor, the clock frequency is 600 MHz, and the following measurements are obtained:

Instruction Class	CPI	Frequency of Occurrence
A	2	40%
B	3	25%
C	3	25%
D	7	10%

- **Include optimizations to the design.** For version B of the processor, the clock frequency is 700 MHz. The ISA for processor B includes three new types of instructions. Those three new types of instructions increase the total number of executed instructions for processor B by 50%, in comparison to processor A. The following measurements are obtained:

Instruction Class	CPI	Frequency of Occurrence
A	2	15%
B	2	15%
C	4	10%
D	6	10%
E	1	10%
F	2	20%
G	2	20%

(a) [7 points] What is the CPI of each version? Show your work.

CPI_A:

3

CPI_B:

2.5

$$CPI_A = 2 \times 0.4 + 3 \times 0.25 + 3 \times 0.25 + 7 \times 0.1 = 3$$
$$CPI_B = 2 \times 0.15 + 2 \times 0.15 + 4 \times 0.1 + 6 \times 0.1 + 1 \times 0.1 + 2 \times 0.2 + 2 \times 0.2 = 2.5$$

(b) [6 points] What are the MIPS (Million Instructions Per Second) of each version? Show your work.

$MIPS_A$:

200

$MIPS_B$:

280

$MIPS_A = \frac{600MHz}{3*10^6} = 200$

$MIPS_B = \frac{700MHz}{2.5*10^6} = 280$

(c) [7 points] Considering your team is aiming to release to the market the processor that gives better performance when executing the target application, which processor version will you choose as the final design? Show your work.

Processor A.

Explanation:
We calculate the execution time for each processor, $Time = N_{instr.} \times CPI \times \frac{1}{clockfrequency}$
Since the compiler for processor B generates 50% more instructions than the compiler for processor A, the total execution time for processor B is larger than the total execution time for processor A.

$Time_A = N_{instr.} \times 3 \times \frac{1}{600*10^6}$

$Time_B = 1.5N_{instr.} \times 2.5 \times \frac{1}{700*10^6}$