Problem 1

$$CPI = \frac{\sum_{i=1}^{n} (CPI_i \times I_i)}{I_c}$$

I_c is the instruction count of the program

CPI_i and I_i are the average cycles per instruction and instruction count for the respective type of instruction.

Using the formula, CPI for the program turns out to be **1.55**

$$MIPS = \frac{f}{CPI \times 10^6}$$

Given that f = 40MHz, MIPS is calculated to be **25.806**

Execution time = (Total no. of instruction cycles) / (Cycles executed per second) = **0.0038 sec**

Execution time can also be calculated using the formula **$T = I_c \times CPI \times t$**

Problem 2:

Machine A

$$\text{CPI} = (\frac{8}{18}) \times 1 + (\frac{4}{18}) \times 3 + (\frac{2}{18}) \times 4 + (\frac{4}{18}) \times 3 = 2.22$$

$$MIPS = \frac{f}{CPI \times 10^6} = \frac{200 \times 10^6}{2.22 \times 10^6} = 90$$

$$\text{Execution time} = \frac{(18 \times 10^6) \times 2.22}{200 \times 10^6} = 0.2\, secs$$

Machine B

$$\text{CPI} = (\frac{10}{24}) \times 1 + (\frac{8}{24}) \times 2 + (\frac{2}{24}) \times 4 + (\frac{4}{24}) \times 3 = 1.92$$

$$MIPS = \frac{f}{CPI \times 10^6} = \frac{200 \times 10^6}{1.92 \times 10^6} = 104$$

$$\text{Execution time} = \frac{(24 \times 10^6) \times 1.92}{200 \times 10^6} = 0.23\, secs$$

(b) Although machine B has higher MIPS than machine A, it requires a longer CPU time to execute the same set of benchmark programs. This is partially due to the fact that the machine B has more number of instructions for the same (benchmark) program.

Problem 3

Average CPI = (1×0.6) + (2×0.18) + (4×0.12) + (8×0.1) = **2.24**

MIPS = $(400\times10^6) / (2.24\times10^6)$ = **178**

Problem 4

$$Speedup = \frac{1}{(1-f)+\frac{f}{N}}$$

Note that f is not the processor speed here. It is the fraction of instructions that can be processed parallelly.

Total single core processor cycles required = 5280000

Total single core processor cycles required after including coordination and synchronization instructions = 5755000

f = 5755000/5280000 = 0.9175

Theoretical speedup is calculated to be **5.07**