Problem 1.

Consider two different machines, with two different instruction sets, both of which have a clock rate of 200 MHz. The following measurements are recorded on the two machines running a given set of benchmark programs:

Instruction Type	Instruction Count (millions)	Cycles per Instruction
Machine A		
Arithmetic and logic	8	1
Load and store	4	3
Branch	2	4
Others	4	3
Machine B		
Arithmetic and logic	10	1
Load and store	8	2
Branch	2	4
Others	4	3

a. Determine the effective CPI, MIPS rate, and execution time for each machine.
b. Comment on the results.

Answer:

a.

$$CPI_A = \frac{\sum CPI_i \times I_i}{I_c} = \frac{(8\times 1 + 4\times 3 + 2\times 4 + 4\times 3)\times 10^6}{(8+4+2+4)\times 10^6} \approx 2.22$$

$$MIPS_A = \frac{f}{CPI_A \times 10^6} = \frac{200\times 10^6}{2.22\times 10^6} = 90$$

$$CPU_A = \frac{I_c \times CPI_A}{f} = \frac{18\times 10^6 \times 2.2}{200\times 10^6} = 0.2 \text{ s}$$

$$CPI_B = \frac{\sum CPI_i \times I_i}{I_c} = \frac{(10\times 1 + 8\times 2 + 2\times 4 + 4\times 3)\times 10^6}{(10+8+2+4)\times 10^6} \approx 1.92$$

$$MIPS_B = \frac{f}{CPI_B \times 10^6} = \frac{200\times 10^6}{1.92\times 10^6} = 104$$

$$CPU_B = \frac{I_c \times CPI_B}{f} = \frac{24\times 10^6 \times 1.92}{200\times 10^6} = 0.23 \text{ s}$$

b. Even though machine B has a higher MIPS than machine A, it needs a longer CPU time to execute the similar set of benchmark programs (instructions).

Problem 2.

A program is run on a 40 MHz processor. The object code consists of 100000 instructions, with the following instruction mix and clock cycle count.

Instruction type	**Instruction count**	**Clock cycle count**
Integer arithmetic	**45000**	**1**
Data transfer	**32000**	**2**
Floating point	**15000**	**2**
Control transfer	**8000**	**2**

Determine the effective CPI, MIPS and execution time of the program.

CPI =∑(Instruction count*Cycle per instruction)/The number of instructions the program contains

=(45000*1+32000*2+15000*2+8000*2)/100000

CPI=1.55

#

MIPS =f/CPI*10^6

= (40*10^6)/ (1.55*10^6)

=25.8

Program execution time, T=I_c * CPI * t

= 100000*1.55*1/f

=(100000*1.55)/40*10^6

=3.875 ms

Problem 3.

When a CPU operates at a clock frequency of 500MHz, requires an average of 5 CPI for executing one instruction, what is the performance (in MIPS) of the CPU?

**Average executing time of one instruction:

= CPI * Clock time

= 5 clocks/instruction * (1sec/500 000 000 clocks)

=5/500000000

=0.00000001 seconds/instruction.

> 500 000 000 clocks in 1 sec
>
> So, 1 clock = 1/500 000 000 sec.

**Number of instructions that can be executed in 1 sec =

= 1 second /Average execution time of one instruction

= 1/0.00000001 second

=100 000 000 instruction

=100 MIPS

[1 clock cycle means the time it takes to turn a transistor OFF and back ON again]

Problem 4.

When the instruction mix of a CPU in the values that are shown in the table below:

1. What is the average executing time of one instruction?
2. What is the performance of CPU?

Instruction type	Instruction execution time	Occurrence rate
Register to register operation	0.3 microsecond	30%

Register to /from memory operation	0.5 microsecond	50%
Unconditional branch	0.2 microsecond	20%

Average execution time of one instruction
=∑(instruction execution time * Occurrence rate)
=0.3*0.30 + 0.5*0.5 + 0.2 * 0.2
= 0.38 microsecond

CPU performance = 1/Average instruction execution time

=1/0.38

=100/38

=2.6315 MIPS