

CPI

## Q1

1. We are considering an enhancement to a processor. The new CPU is 10x faster on computation than the original CPU. Assuming that the CPU is busy with computation 40% of the time and waiting for I/O 60% of the time. What is the overall speedup gained by incorporating the enhancement?
2. What if the enhancement can be applied system-wide?
3. What if the enhancement is nearing infinity?

## Q2 Eg – Compare 2 code sequences

- Assume that an ISA has 3 classes of instructions:
  - Class A: CPI =1 (eg- Add)
  - Class B: CPI = 2 (eg- Shift)
  - Class C: CPI = 3 (eg- branch)
- Assume a program having 2 code sequences with the following instruction counts per sequence

	A	B	C
Sequence 1	2	1	2
Sequence 2	4	1	1

- Which sequence is faster? (calculate the number of clock cycles)
- What is the CPI for each sequence?
  - $\text{CPI} = \text{Clock cycles} / \text{Instruction count}$

**Q3**

## **Eg - Instructions and CPI**

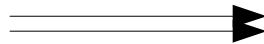
	<b>No of instructions</b>	<b>Cycles</b>
<b>ALU (add, mul etc)</b>	<b>650</b>	<b>1</b>
<b>Load</b>	<b>600</b>	<b>5</b>
<b>Store</b>	<b>100</b>	<b>5</b>
<b>Branch</b>	<b>50</b>	<b>2</b>

For a 2GHz processor, what is the execution time and CPI?

# Q4 – Program, Assembly and CPI

for (i=0; i<100; i=i+1)

{ x[i] = x[i] + s; }



**Loop:**  
LW \$r3, 10(\$r1)  
Add \$r6, \$r2, 100  
LW \$r3, 12 (\$r2)  
Add \$r6, \$r2, \$10  
SW \$r3, 12 (\$r12)  
Add \$r6, \$r2, \$10  
BNE \$r6, \$r2, loop

Assume

	CPI
ALU (add, mul etc)	1
Load	5
Store	3
Branch	2

- Total number of instructions = ?
- Fraction of each instruction type = ?
- Total CPU cycles?
- Average CPI?
- What is the execution time for a clock frequency of 2 Ghz?

# Practice questions

## Exercise 1.3

Consider three different processors P1, P2, and P3 executing the same instruction set with the clock rates and CPIs given in the following table.

	Processor	Clock Rate	CPI
<b>a.</b>	P1	3 GHz	1.5
	P2	2.5 GHz	1.0
	P3	4 GHz	2.2
<b>b.</b>	P1	2 GHz	1.2
	P2	3 GHz	0.8
	P3	4 GHz	2.0

**1.3.1** [5] <1.4> Which processor has the highest performance expressed in instructions per second?

**1.3.2** [10] <1.4> If the processors each execute a program in 10 seconds, find the number of cycles and the number of instructions.

For problems below, use the information in the following table.

	Processor	Clock Rate	No. Instructions	Time
<b>a.</b>	P1	3 GHz	20.00E+09	7 s
	P2	2.5 GHz	30.00E+09	10 s
	P3	4 GHz	90.00E+09	9 s
<b>b.</b>	P1	2 GHz	20.00E+09	5 s
	P2	3 GHz	30.00E+09	8 s
	P3	4 GHz	25.00E+09	7 s

**1.3.4** [10] <1.4> Find the IPC (instructions per cycle) for each processor.

**1.3.5** [5] <1.4> Find the clock rate for P2 that reduces its execution time to that of P1.

**1.3.6** [5] <1.4> Find the number of instructions for P2 that reduces its execution time to that of P3.



## Exercise 1.4

Consider two different implementations of the same instruction set architecture. There are four classes of instructions, A, B, C, and D. The clock rate and CPI of each implementation are given in the following table.

		Clock Rate	CPI Class A	CPI Class B	CPI Class C	CPI Class D
<b>a.</b>	P1	2.5 GHz	1	2	3	3
	P2	3 GHz	2	2	2	2
<b>b.</b>	P1	2.5 GHz	2	1.5	2	1
	P2	3 GHz	1	2	1	1

**1.4.1** [10] <1.4> Given a program with  $10^6$  instructions divided into classes as follows: 10% class A, 20% class B, 50% class C, and 20% class D, which implementation is faster?

**1.4.2** [5] <1.4> What is the global CPI for each implementation?

**1.4.3** [5] <1.4> Find the clock cycles required in both cases.

		No. Instructions				
		Compute	Load	Store	Branch	Total
<b>a.</b>	Program1	600	600	200	50	1450
<b>b.</b>	Program 2	900	500	100	200	1700

**1.5.4** [5] <1.4> Assuming that computes take 1 cycle, loads and store instructions take 10 cycles, and branches take 3 cycles, find the execution time on a 3 GHz MIPS processor.

**1.5.5** [5] <1.4> Assuming that computes take 1 cycle, loads and store instructions take 2 cycles, and branches take 3 cycles, find the execution time on a 3 GHz MIPS processor.

## Exercise 1.6

Compilers can have a profound impact on the performance of an application on given a processor. This problem will explore the impact compilers have on execution time.

	Compiler A		Compiler B	
	No. Instructions	Execution Time	No. Instructions	Execution Time
a.	1.00E+09	1.8 s	1.20E+09	1.8 s
b.	1.00E+09	1.1 s	1.20E+09	1.5 s

**1.6.1** [5] <1.4> For the same program, two different compilers are used. The table above shows the execution time of the two different compiled programs. Find the average CPI for each program given that the processor has a clock cycle time of 1 ns.

**1.6.2** [5] <1.4> Assume the average CPIs found in 1.6.1, but that the compiled programs run on two different processors. If the execution times on the two processors are the same, how much faster is the clock of the processor running compiler A's code versus the clock of the processor running compiler B's code?