clock time = clock cycles / clock period

$\frac{1}{\text{clock cycle}}$ = clock rate (s^{-1}) Hz

Program Execution Time (~~CPU execution time~~)
It is time taken including disk access, memory access, i/o activities & OS overhead.

CPU execution time is a time cpu spends computing a task and that does not include time span waiting for i/o & running other programs.
The CPU time is the actual time which CPU spends executing a task.

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CPU time = CPU clock cycle for a program * clock cycle time

$$\text{CPU time} = \frac{\text{CPU clock cycles}}{\text{clock rate}}$$

Que A program runs in 10 seconds on a computer "A" which has a 2 GHz clock. We are trying to build a computer B which will run this program in 6 seconds. It is determined that a substantial ↑se in the clock rate is possible but this effect will effect the rest to the CPU ~~time~~ design causing "B" to require 1.2 times as many clock cycles as "A", for this program what clock rate should be target

⇒

$$10 = \frac{\text{clock cycle}}{2\ \text{GHz}}$$

clock cycles = 20 G

giga → 10^9

$$6 = \frac{20 \times 1.2\ \text{G}}{f}$$

$$f = 4\ \text{GHz}$$

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IC:- instruction count

If we know the number of clock cycles & IC we can calculate avg number of cycles per instructions (CPI)

$$\text{CPU time} = IC \times CPI \times \text{clock cycle time}$$

eg:- two implementations of the same instruction set architecture computer 'A' has a clock cycle of 250 ps & and a CPI of 2 cycle/inst^n & a CPI of 2 for same program where B has a clock cycle time of 500 ps & a CPI of 1.2 times. Which computer is faster for this program

Sol:

$$\text{CPU time}_A = 500 \times IC \text{ ps}$$
$$\text{CPU time}_B = 600 \times IC \text{ ps}$$

A is faster by 100 ps

$$\rightarrow \text{CPU Performance}_A = \frac{1}{\text{exec time}_A}$$

$$\rightarrow \text{CPU performance}_B = \frac{1}{\text{exec time}_B}$$

$$\frac{\text{CPU performance A}}{\text{CPU performance B}} = \frac{\text{Exec time B}}{\text{Exec time A}} = \frac{600 \times IC_B}{500 \times IC_B}$$

A is 1.2 times faster

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Que Given two code sequences for a particular computer the H/w designers have supplied the following facts

	CPI for each IClass		
	A	B	C
CPI	1	2	3

for a particular high level lang stmt the compiler writer is considering two code sequences that require the following instruction count

code sequence	Inst^n count for Inst^n class		
	A	B	C
1	2	1	2
2	4	1	1

Calculate clock cycle & CPI for both ~~progra~~ code sequences

⇒ $(CS_1)_{CPI} \rightarrow 2\times1 + 1\times2 + 2\times3 = 10$

$(CS_2)_{CPI} \rightarrow 4\times1 + 1\times2 + 1\times3 = 9$

$$\text{CPU clock cycle} = \sum_{i=1}^{n} (CPI_i \times IC_i)$$

CPU clock cycles$_1$ = 10 cycles

CPU clock cycles$_2$ = 9 cycles

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$CPI_1 = 10/5 = 2$

$CPI_2 = 9/6 = 1.5$

→ Assignment

Que Consider 3 different processors executing the same instruction set with the clock rate and CPI given in the following table.

Processor	clock rate	CPI
P_1	2 GHz	1.5
P_2	1.5 GHz	1.0
P_3	3 GHz	2.5

(1) calculate which processor has the highest performance
(2) if each processor executes a program in 10 seconds find the number of cycles and the number of inst^{n}s.
(3) we are trying to reduce the time by 30% but this leads to an use of 20% in CPI. what clock rate should we have get this time reduction.

$x = x + y - (y = x)$

$x = 5$

$y = \cancel{y/5}$ $\quad y = 4$

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$\frac{3}{2}$ +

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Instruction Count:-

⇒ Total number of instruction execution involved in a program.

eg:- suppose a program takes 1B instructions to execute on a processor running at 2 GHz. Also suppose that 50% of instructions execute in 3 clock cycles, 30% executes in 4 clock cycles and 20% in 5 clock cycles what is the execution time for the programe.

$$\text{execution time} = 3.7 \times 10^9 \times \frac{1}{2 \times 10^9}$$

CPI =

Que 2:-

load	5 cycles
R type	4 cycles
store	4 —11—
Branch	3 —11—
Jump	3 —11—

If a program has
50% load
15% R-type
25% store type
8% Branch
2% Jump.

CPI = ??

$$\frac{50 \times 5 + 15 \times 4 + 100 + 24 + 6}{100} =$$

$$\frac{250 + 60 + 100 + 30}{100} = \frac{250 + 190}{100} = \frac{440}{100} = 4.4$$

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Amdahl's law

Amdahl's law states that the performance improvement to be gained from using some faster mode of execution is limited by the fraction of the time the faster mode can be used.

$$\text{speedup} = \frac{1}{(1-P) + P/S}$$

P = fraction enhanced
S = speedup enhanced

Que what is overall speedup if you mak 10%. of the program 900 times faster.

$$t \text{ sec} \Rightarrow \frac{t}{10}, \frac{9t}{10}$$

$$\frac{t}{900} + \frac{9t}{10} = \frac{t + 810t}{900} = \frac{811t}{900}$$

$$\text{overall speedup} = \frac{1}{(1-0.1) + \left(\frac{0.1}{90}\right)}$$

$$= \frac{1 \times 90}{0.9 * 90 + 0.1} = \frac{90}{81 + 0.1}$$

$$= \frac{90}{81.1}$$

Que :- We are considering an enhancement to the processor of a web server. The new cpu is 20 times faster on such queries ~~and~~ than the old processor. The old processor is busy with such queries 70% of the time. What is the

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speedup gained by integrating the enhanced CPU.

$\Rightarrow$ 20x

$$\frac{1}{(1-0.3)+\frac{0.3}{20}} = \frac{20}{14.3}$$

Que Suppose that when program A is running the user CPU time is 3 sec the elapse wall-clock time is 4 sec and the system performance is 10 M ~~Flops/sec~~ flops/sec. Assume that there are no other processes taking any significant amount of time and the computer is either doing calculations in the CPU or doing I/O operations, but it can not do both at same time. We now replace the processor with one that runs 6 times faster but doesn't affects the I/O speed what will be the user CPU time.

Que:- Suppose you have ~~x~~ design a new processor the ~~b~~ clock of the processor runs at 200 MHz the following table gives inst^n ~~sequencing~~ frequency for

Inst^n type	Frequency	Cycles
load & store	30%	6
Arithmatic	50%	4
all others	20%	3

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for this problem assume that processor only executes 1 instruction at a time. Calculate

(a) the CPI for the program.

(b) The CPU execution time on the Benchmark is exactly 11 sec. what is the processor speed for the benchmark in million Inst^n / sec. (MIPS)

(c) The H/w expert says that if you double the number of registers the cycle time muste be increased by 20%. what would be the new clock speed in MHz.

(d) The compiler expert says that if you double the number of registers then the compiler will generate code that requires only half the no of load and store inst^n what is new CPI.

(e) How many CPU seconds will the benchmark take if we double the num of regs. taking into account both changes above

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